

# BIOLOGY FORM ONE NOTES

## INTRODUCTION TO BIOLOGY

### What is Biology?

Biology is the branch of science that deals with the study of living things. In Greek, Bios means life while Logos means knowledge.

### Branches of biology

There are two main branches:

1. **Botany:** Study of plants
2. **Zoology:** Study of animals

### The others include:

1. **Ecology:** Study of living things in their surroundings.
2. **Genetics:** The study of inheritance and variation.
3. **Entomology:** Study of insects
4. **Parasitology:** Study of parasites
5. **Taxonomy:** Study of classification of organisms
6. **Microbiology:** Study of microscopic organisms
7. **Anatomy:** Study of structure of cells
8. **Cytology:** Study of cells
9. **Biochemistry:** Study of chemical changes inside living organisms

**Name at least six other smaller branches of biology (6 marks).**

### Importance of Biology

1. **Solving environmental problems** e.g. Food shortage, poor health services, pollution, misuse of environmental resources etc.
2. **Choice of careers** e.g. Medicine, Agriculture, public health, Veterinary, Animal husbandry, Horticulture, Dentistry etc.
3. **Acquiring scientific skills** e.g. observing, identifying, recording, classification, measuring, analyzing, evaluating etc.
4. **International co-operation** e.g. Development of HIV/AIDS vaccine, fight against severe Acute respiratory Syndrome (SARS), fight to save ozone layer from depletion, management of resources through international depletion.

## Others

- Help on study of other subjects
- Learn what living things are made up of and their bodies work
- Acquire knowledge about plant and animal diseases and their treatment.
- Know the effects of our bodies on drug and substance abuse and can kill.
- Learn about HIV\AIDS diseases and other viral diseases e.g. its treatment—balanced diets, proper hygiene, spreading, sexual behavior, cultural practices etc.

**List five professional occupations that require the study of biology. (5 marks)**

### **Characteristics of living things;**

- 1. Nutrition:** Process by which living things acquire and utilize nutrients: plants photosynthesize; animals feed on already manufactured foods.
- 2. Respiration:** energy-producing process occurring in all the cells of living things.
- 3. Gaseous Exchange:** where living things take in air (oxygen) and give out air(carbon iv oxide) across respiratory surfaces.
- 4. Excretion:** Process by which waste or harmful materials resulting from chemical reactions within cells of living things are eliminated. Excess of such materials poison living things.
- 5. Growth and Development: Growth** —is the irreversible increase in size and Mass.—Essential for body function. **Development** — Irreversible change in complexity of the structure of living things.
- 6. Reproduction:** Process by which living things give rise to new individuals of the same kind.
- 7. Irritability:** Is the ability of living things to perceive changes in their surroundings and respond to them appropriately. E.g. reaction to changes in temperature, humidity, light, pressure and to the presence of certain chemicals.
- 8. Movement:** Change in position by either a part or the whole living thing. Locomotion – Progressive change in position by the

whole living thing. In animals, movement include; swimming, walking, running, flying. In plants, closing of leaves, folding of leaves, closing of flowers, growing of shoots towards light etc.

### Question

1. List four uses of energy obtained from the process of respiration. (4 marks).
2. List six characteristics of living things (6 marks).

### Collection of specimens

#### Apparatus used

1. **Sweep net:** for catching flying insects.
2. **Fish net:** For trapping small fish and other small water animals.
3. **Pooter:**For sucking small animals from rock surfaces and tree barks.
4. **Bait trap:** For attracting and trapping small animals e.g. rats.
5. **Pit fall trap:** For catching crawling animals.
6. **Pair of forceps:** picking up small crawling animals e.g. stinging insects.
7. **Specimen bottles:** keeping collected specimen. Larger specimens require large bottles.
8. **The magnifying lens:** Instrument used to enlarge objects. Lenses are found in microscope and the hand lens (magnifier). Its frame is marked e.g. x8 or x10—indicating how much larger will be the image compared to object.

### Precautions during Collection and Observation of specimens

- Collect only the number of specimen you need.
- Do not harm the specimens during the capture or collection exercise.
- Handle dangerous or injurious specimens with care e.g. stinging plants or insects i.e. use forceps or hand gloves.
- The teacher will immobilize highly mobile animals. (diethyl ether, formalin, chloroform)
- Do not destroy the natural habitat of the specimens.

### Practical activity 2

## Practical activity 3

### Comparison between plants and animals

| Plants  | Animals  |
|---|--|
| 1. Green in colour( have chlorophyll)                   | 1. Lack chlorophyll thus feed on readymade food.       |
| 2. Their cells have cellulose cell walls.               | 2. Cells lack cellulose cell walls.                    |
| 3. Respond slowly to changes in the environment.        | 3. Respond quickly.                                    |
| 4. Lack specialized excretory organs.                   | 4. Have complex excretory organs.                      |
| 5. Do not move about.                                   | 5. Move about in search of food and water.             |
| 6. Growth occurs in shoot and root tips.(apical growth) | 6.Growth occurs in all body parts9intercalary growth). |

### Revision questions

## CLASSIFICATION I

### INTRODUCTION

Living things are also known as living organisms.

Organisms (forms of life) have distinguishing characteristics and therefore are grouped.

#### The Magnifying lens

-Is used for enlarging small objects.

#### (Diagram)

#### Procedure of its use

- Place the object on the bench.
- Move the hand lens from the object to the eye.
- An enlarged image is seen.

Drawing magnification =  $\frac{\text{Length of the drawing}}{\text{Length of the object}}$  /  $\frac{\text{drawing Length}}{\text{Actual Length}}$

## (Diagram)

### External features of plants and animals

#### External features of plants

- i) Rhizoids as in moss plant.
- ii) Fronds in ferns.
- iii) Roots, stems, leaves, flowers, seeds, fruits, and cones in higher plants.

#### External features of animals

- i) Tentacles in hydra
- ii) Feathers in birds
- iii) Shells in snails
- iv) Wings in birds
- v) Fur and hair in mammals
- vi) Scales and fins in fish
- vii) Proglotids in tapeworms
- viii) Mammary glands in mammals
- ix) Locomotory Structures e.g. limbs in insects
- x) Body pigmentation

### Practical activity 1

#### To collect and observe animal specimens

#### To collect and observe plant specimens

### What is classification?

-Is an area of biology that deals with the grouping of living organisms according to their structure. Organisms with similar structures are put under one group referred to as a **taxon**—**taxa** (plural).

The groupings also consider evolutionary relationships (phylogeny)—since all living organisms had a common origin at one time.

Taxonomy—Science of classification.

Taxonomist—Biologist who studies taxonomy.

### Need for classification.

#### Reasons

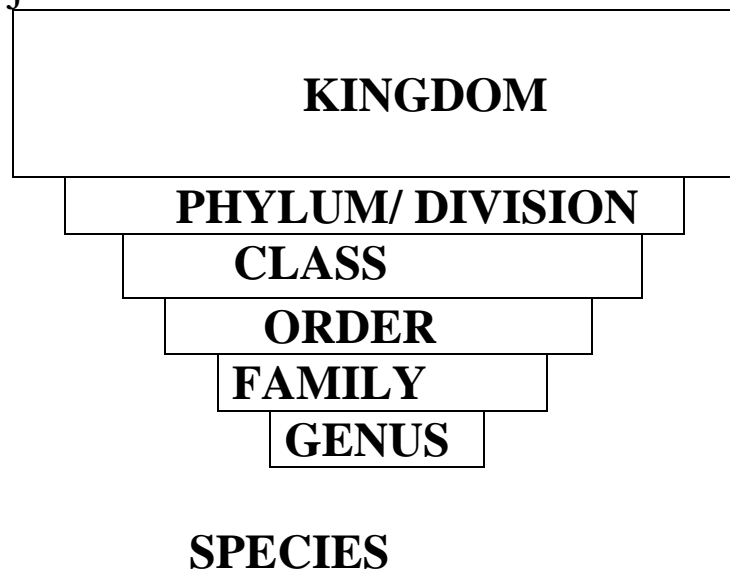
1. To identify living organisms into their correct groups for reference and study
2. To bring together living organisms with similar characteristics but separate those with different features.
3. To arrange information of living organisms in an orderly manner. This avoids chaos and confusion.
4. To understand the evolutionary relationship between different organisms

### Taxonomic Units

Are groups (taxa) into which organisms are placed as a matter of convenience.

Groups are based on observable characteristics common in the group. In a classification scheme (taxonomic units or groups, a hierarchy of groups are recognized starting with the first largest and highest group the **Kingdom** to the smallest and lowest unit; the **species**.

There are 7 major taxonomic units.



### The Kingdom

There are five Kingdoms of living organisms, namely:

1. **Kingdom Monera:** bacteria
2. **Kingdom protocista:** algae, protozoa, amoeba, paramecium
3. **Kingdom Fungi:** Moulds, Yeast, Mushrooms
4. **Kingdom Plantae:** Moss plants, ferns, maize, garden pea, pine, meru oak, bean etc.
5. **Kingdom Animalia:** hydra, tapeworms, bees, human beings etc.

A **kingdom** is divided into **Phyla** in animals or divisions in plants and sorts out organisms based on body plan and form.

Plan is the adaptation to a special way of life.

The **Class** is further divided into small groups; **Orders** using structural features.

Orders are divided **into families** using structural features, then Families into **Genera** (singular genus) –based on recent common ancestral features that are less adaptive.

Genus is divided into **species** i.e. kind of plant, or animal.

Down the hierarchy, the number of organisms in each group decreases but their similarities increases.

The Species group members naturally interbreed to produce fertile off springs.

Minor differences are exhibited in the species groups e.g. on colour of the skin in human beings and varieties of plants.

The groups of the species are termed to as varieties, races or strains.

### Classification of A human being and a maize plant

| <b>Taxonomic unit</b>     | <b>Human being</b> | <b>maize</b>            | <b>bean</b>          |
|---------------------------|--------------------|-------------------------|----------------------|
| <b>kingdom</b>            | <b>Animalia</b>    | <b>plantae</b>          | <b>plantae</b>       |
| <b>Phylum or division</b> | Chordata           | <b>Angiospermaphyta</b> | <b>Angiospermae</b>  |
| <b>class</b>              | <b>Mammalia</b>    | <b>monocotyledonae</b>  | <b>Dicotyledonae</b> |
| <b>order</b>              | Primates           | <b>Graminales</b>       | <b>Rosales</b>       |
| <b>family</b>             | <b>Hominidae</b>   | <b>Graminaceae</b>      | <b>Leguminosae</b>   |
| <b>genus</b>              | <b>homo</b>        | <b>zea</b>              | <b>Phaseolus</b>     |
| <b>species</b>            | <b>sapiens</b>     | <b>mays</b>             | <b>Vulgaris</b>      |

Scientific name *Homo sapiens* *Zea mays*  
*phaseolus vulgaris*

### Scientific Naming Of Living Organisms

Present naming was developed by carolus Linnaeus 18<sup>th</sup> c, where organisms were given 2 names in Latin language.

Living organisms have their scientific names and common names i.e. local or vernacular names.

Scientific naming uses the double naming system—**Binomial system**. In binomial system, an organism is given both the **genus** and **species** name.

**Binomial nomenclature** (Double –naming system)-Is the assigning of scientific names to living organisms governed by a definite set of rules recognized internationally.

**Principles of binomial nomenclature**

- a) The first, genus name, should begin with a capital letter and the second name, species, should begin or written in small letters e.g.  
 Lion---- *Panthera leo*  
 Leopard----- *Panthera pardus*  
 Domestic dog----- *Canis farmiliaris*  
 Human being--- *Homo sapiens*  
 Maize plant---*Zea mays*

Lion and Leopard are closely related ---Same genus but distantly related—different species.

- b) The scientific names must be printed in italics in textbooks and where hand written to be underlined e.g. *Panthera leo*.
- c) The specific name (species) is frequently written with the name of the scientist who first adequately described and named the organism e.g. *Phaseolus vulgaris* i.e. Vulgaris is the scientist who described and named the bean plant.
- d) Biologists should give a Latinized name for a newly described animal or plant species where Latin name is missing e.g.  
*Meladogyne kikuyuensis* – Is a scientific name of a nematode from kikuyu.  
*Aloe kilifiensis* --- A member of Aloeceae family from Kilifi discovery.  
*Garinsoga parviflora waweruensis* --- a member of Macdonald eye family discovered by Waweru.

**Study Question 1**

**Complete the table below**

|         |      |              |            |              |
|---------|------|--------------|------------|--------------|
| Taxon   | Lion | Domestic dog | Garden pea | Napier grass |
| kingdom |      |              |            |              |



|                 |  |  |  |  |
|-----------------|--|--|--|--|
| Phylum/division |  |  |  |  |
| class           |  |  |  |  |
| order           |  |  |  |  |
| family          |  |  |  |  |
| genus           |  |  |  |  |
| species         |  |  |  |  |

Scientific name      -----  
 -----

### Revision Questions:

### CLASSIFICATION 1

- ❖ *Review of the magnification lens*
- ❖ *Calculating Magnification*
- ❖ *External characteristics of plants and animals*

### Diversity of Living Organisms

- Organisms with similar characteristics are placed under one group called **taxon (taxa)**.
- The science of classification is known as **taxonomy**.
- Biologists who study taxonomy are called **taxonomists**.

### Need For Classification

1. Help in identifying living organisms into their correct groups for reference.
2. It brings together organisms with similar characteristics and separates those with different features.
3. Help to organize information about living organisms in an orderly manner avoiding any confusion.
4. Help to understand the evolutionary relationship between different living organisms.

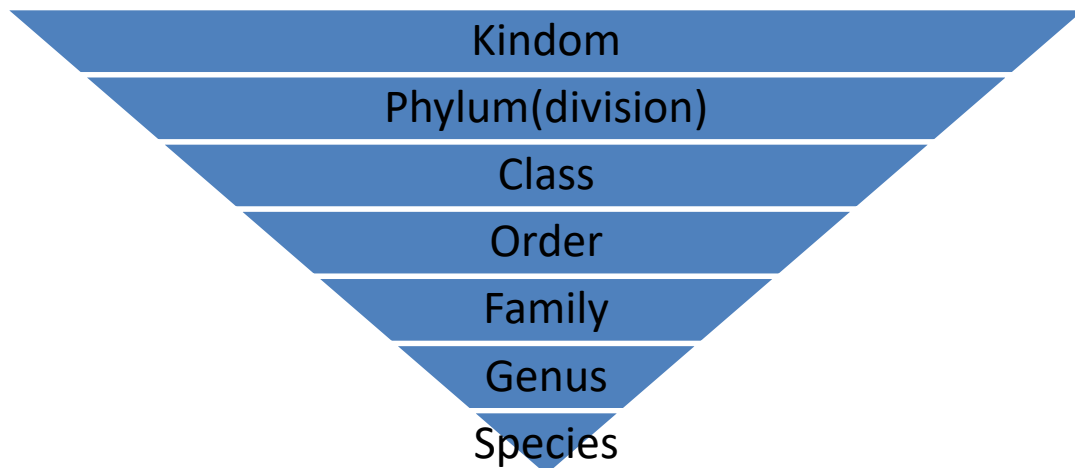
### Historical Background of Classification

- Long time ago classification was artificial where living things were classified as either plants or animals.
- Plants were classified as herbs, shrubs and trees.
- Animals were further divided into carnivores, herbivores and omnivores.

- Today modern classification uses evolutionary relationships between living organisms.

## Taxonomic Units of Classification

- This refers to the groups into which living organisms are placed in classification.
- These units start from the first largest and highest group (**kingdom**) to the smallest and lowest unit (**species**).
- There are seven taxonomic units as shown below.



### 1. Kingdom

*Carolus Linnaeus (1707-1778)* initially introduced the two kingdom system of classification. However many new life forms have been discovered which are neither animals nor plants. This has led to a more accepted classification system that adopts five kingdoms. These are;

- i.) **Monera .eg bacteria**
- ii.) **Protoctista e.g algae and protozoa**
- iii.) **Fungi e.g. mushrooms, moulds and yeast.**
- iv.) **Plantae e.g. maize, ferns and all types of trees.**
- v.) **Animalia e.g. man, cow tapeworm, flies etc.**

Kingdom is further divided into several phyla in animals or divisions in plants.

### 2. Phylum (phyla) or Division in plants.

It is the second largest and further divided into classes.

### 3. Class

Each class is divided into several orders.

### 4. Order

Orders are divided into smaller groups called families.

### 5. Family

Family is divided into several **Genera**.

### 6. Genus

Here members are closely related. It is further divided into the species.

### 7. Species

This is the smallest unit of classification.

*Species is defined as a group of organisms whose members naturally interbreed to produce fertile offspring's.*

Members of a given species have small differences such as skin colour, height etc.

**Classification of Man and Maize plant. ( Table 2.1 Page 15 KLB Bk 1)**

### Scientific Naming of Living Organisms.

- Today organisms are given two names in Latin language. This was developed by **Carolus Linnaeus**.
- Latin language was used because it was widely spoken during his time.
- In scientific naming, an organism is given the **genus** and the **species name**.
- This double naming system is known as *Binomial* system (two name System)

### Binomial Nomenclature.

This is the *double naming* system of organisms where organisms are assigned two names i.e. the *generic* name and the *specific* name.

In binomial nomenclature the following rules are observed.

- i.) Generic name is written first followed by the specific name. First letter in the generic name is in capital and the rest are in small letters. Specific name is written in small letters.
- ii.) The two names are underlined separately when handwritten or italicised when printed.
- iii.) Newly discovered species must be given Latinized names.
- iv.) Specific name is frequently written with the name of the scientist who first adequately described and named the organism.

## Examples

## Revision Questions

### CELL PHYSIOLOGY

- This is the study of the functions of cell structures.

### Membrane Structure and Properties

- A membrane is a surface structure which encloses the cell and organelles. Membranes regulate the flow of materials into out of the cell or organelle.
- Examples of membranes: cell membrane, tonoplast (membrane surrounding the vacuole), nuclear membrane, mitochondrial membrane, chloroplast membrane etc.

### The Cell Membrane

- It has three layers, two protein layers and a phospholipid layer sandwiched in between the two.

### Diagram

### Properties of Cell Membrane

- 1. Semi-permeability.** – It has small pores allowing for the passage of molecules of small size into and out of the cell. **Cell Wall** however allows all materials to pass through it hence it is referred to as being **Permeable**.
- 2. Sensitivity to Changes in Temperature and pH** – Extreme temperature and pH affects the cell membrane since it has some protein layers. Such changes alter the structure of the membrane affecting its normal functioning.
- 3. Possession of Electric Charges** – it has both the negative and positive charges helping the cell to detect changes in the environment. These charges also affect the manner in which substances move in and out of the cell

### Physiological Processes

- The ability of the cell to control the movement of substances in and out of the cell is achieved through physiological processes such as **Diffusion, Osmosis and Active Transport**.

## Diffusion

- *This is a process by which particles move from a region of **high concentration** to a region of **low concentration**.*

### Practical Activity 1

#### To demonstrate diffusion using potassium permanganate (VII)

- The difference in concentration of particles between the region of high concentration and the region of low concentration is known as the **diffusion gradient**.

### Role of Diffusion in Living Organisms

#### 1. Absorption of Materials

- Mineral salts in the soil enter the root by diffusion since their concentration in the soil is greater than in the root hair cells.
- Digested food (glucose and amino acids) diffuse across the wall of the ileum into the blood for transport to rest of the body.

#### 2. Gaseous Exchange in Plants and Animals

- In both plants and animals, respiratory gases (oxygen and Carbon (IV) oxide) are exchanged through simple diffusion depending on their concentration gradient.

#### 3. Excretion of Nitrogenous Wastes

#### 4. Transport of Manufactured Food form Leaves to other Plant Parts.

#### 5.

### Factors Affecting Diffusion

#### a) Diffusion Gradient

- A greater diffusion gradient between two points increases the rate of diffusion.

#### b) Surface Area to Volume Ratio

- The higher the ratio the greater the rate of diffusion and the lower the ratio the lower the rate.
- This means that small organisms expose a large surface area to the surrounding compared to large organisms.
- Small organisms therefore depend on diffusion as a means of transport of foods, respiratory gases and waste products.

### Diagrams

### c) Thickness of Membranes and Tissues

- The thicker the membrane the lower the rate of diffusion because the distance covered by the diffusing molecules is greater. The thinner the membrane, the faster the rate.

- **Size of the Molecules**

- Small and light molecules diffuse faster than large and heavy molecules.

### d) Temperature

- Increase in temperature increases the energy content in molecules causing them to move faster.

## Osmosis

- *This is the process where solvent molecules (water) move from a lowly concentrated solution (dilute) to a highly concentrated solution across a semi-permeable membrane.*

### Diagram fig 4.6

- The highly concentrated solution is known as **Hypertonic Solution**.
- The lowly concentrated solution is called **Hypotonic solution**.
- Solution of the same concentration are said to be **Isotonic**.
- Osmosis is a *special type of diffusion* because it involves the movement of solvent (water) molecules from their region of high concentration to region of low concentration across a semi permeable membrane.

## Practical activity 2

## Practical activity 3

## Osmotic Pressure

- This is the pressure which needs to be applied to a solution to prevent the inward flow of water across a semi permeable membrane. This is the pressure needed to nullify osmosis.
- Osmotic pressure is measured using the **osmometer**.

## Osmotic Potential

- This is the measure of the pressure a solution would develop to withdraw water molecules from pure water when separated by a semi permeable membrane.

## Water Relations in Animals

- Cell membrane of the animal cell is semi permeable just like the dialysis/visking tubing.
- Cytoplasm contains dissolved sugars and salts in solution form.
- If an animal cell e.g. a red blood cell is placed in distilled water (hypotonic solution), water flows in by osmosis.
- The cell would swell up and eventually burst because the cell membrane is weak. The bursting of the red blood cell when placed in hypotonic solution is called **Haemolysis**.
- If a similar red blood cell is placed in a hypertonic solution, water is drawn out of the cell by osmosis. The cell will shrink by a process called **Crenation**.
- Body fluids surrounding the cells must therefore have same concentration as to that which is found inside the cell.

## Diagrams

### Water Relations in Plants

- When a plant cell is placed in a hypotonic solution it gains water by osmosis and distends outwards.
- As the cell gains more water, its vacuole enlarges and exerts an outward pressure called **turgor pressure**. As more water is drawn in, the cell becomes firm and rigid and is said to be **turgid**.
- The cell wall in plant cell is rigid and prevents the cell from bursting unlike the case in animal cells.
- The cell wall develops a resistant pressure that pushes towards the inside. This pressure is equal and opposite the turgor pressure and is called **wall pressure**.

## Diagrams

- When a plant cell is placed in hypertonic solution, water molecules move out of the cell into the solution by osmosis. The cell shrinks and becomes **flaccid**.
- If the cell continues to lose more water, plasma membrane pulls away from the cell wall towards the center.

- The process through which plant cells lose water, shrink and become flaccid is called **plasmolysis**.
- Plasmolysis can be reversed by placing a flaccid cell in distilled water and this process is called **deplasmolysis**.

## Study Question 5

## Practical Activity 4

### Wilting

- When plants lose water through evaporation and transpiration, **cells lose turgidity**, shrink and the plant **droops**. This is called **wilting**.
- If water supply from the soil is inadequate, plants do not recover hence **permanent wilting**.

## Study Question 6

### Role of Osmosis in Organisms

#### 1. Absorption of water from the soil

- Root hair cells of plants absorb water from the soil by osmosis.

#### 2. Support

- Cells of herbaceous plants, which are less woody, absorb water, become turgid hence support.

#### 3. Opening and closing of the stomata

- During the day, guard cells synthesize glucose, draw in water become turgid hence open the stomata.
- During the night, they lose turgidity since there is no photosynthesis. As a result, they shrink thus closing the stomata.

#### 4. Feeding in insectivorous plants

- These plants are able to change their turgor pressure on the leaves which close trapping insects which are digested to provide the plant with nitrogen.

#### 5. Osmoregulation

- In the kidney tubules, water is reabsorbed back to the body by osmosis.



## Factors Affecting Osmosis

- i.) *Concentration of Solutions and Concentration Gradient.* The greater the concentration gradient between two points, the faster the rate of osmosis.
- ii.) *Optimum Temperature as long as it does not destroy the semi-permeability of the membrane.*

## Active Transport

- This is the process that moves substances across cell membranes ***against a concentration gradient.***
- This process ***requires energy*** to move these substances across cell membranes and involves ***carriers.***
- Substances such as amino acids, sugar and many ions are taken in by living organisms through active transport.

## Role of Active Transport

- i.) Re-absorption of sugars and useful substances by the kidney
- ii.) Absorption of some mineral salts by plant roots
- iii.) Absorption of digested food from the alimentary canal into the blood stream
- iv.) Accumulation of substances in the body to offset osmotic imbalance in arid and saline environment
- v.) Excretion of waste products from body cells

## Factors Affecting Active Transport.

- i.) Oxygen concentration.
- ii.) Change in pH.
- iii.) Glucose concentration.
- iv.) Temperature.
- v.) Enzyme inhibitors.

NB/ Any factor affecting energy production affect the rate of active transport.

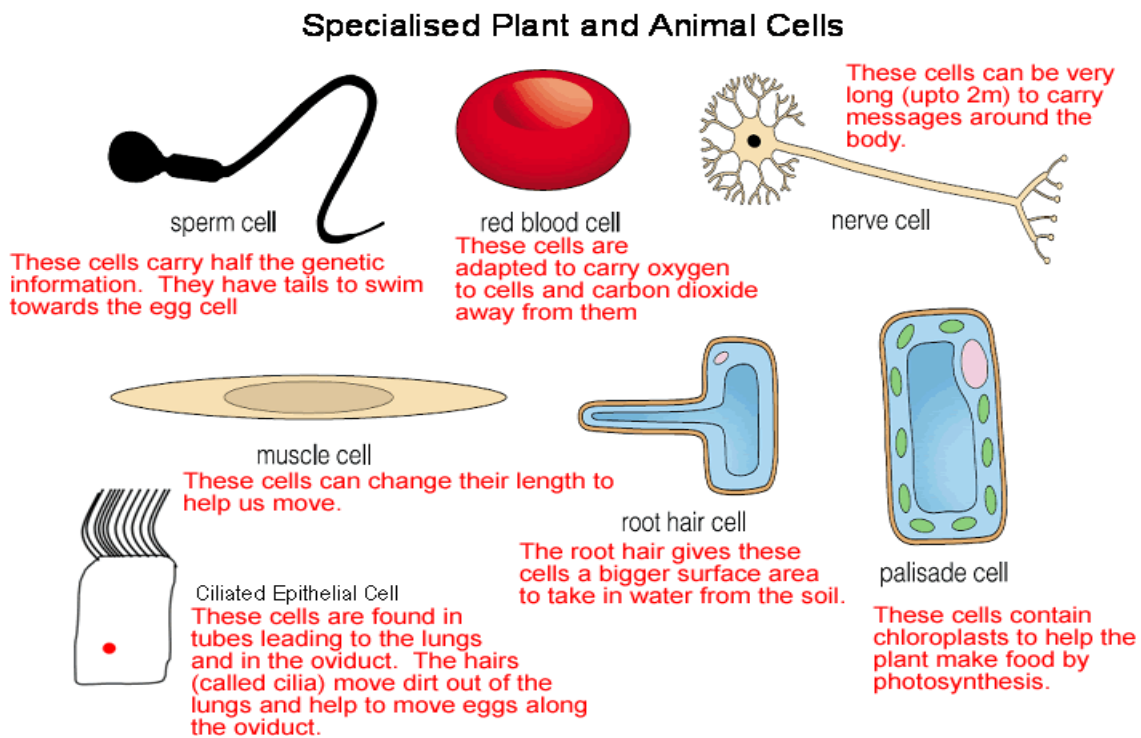
## Revision Questions.

## Cell Specialization, Tissues, Organs and Organ Systems

### 1. Cell specialization

- This is where cells are modified to perform specific functions. Such cells are said to be specialized.

- Examples include the sperm cell which has tail for swimming and the root hair cell which is extended creating large surface area for water absorption.

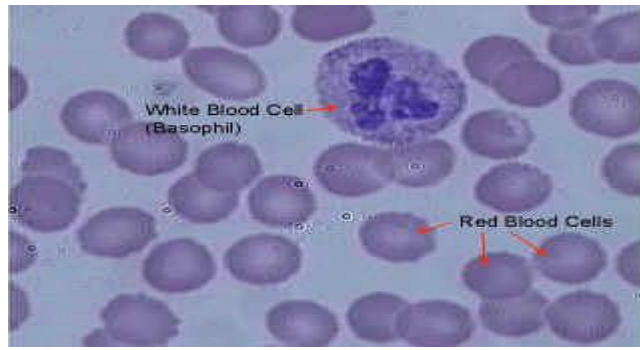


## 2. Tissues.

- These are cells of a particular type that are grouped together to perform the same function.

### Animal tissues include;

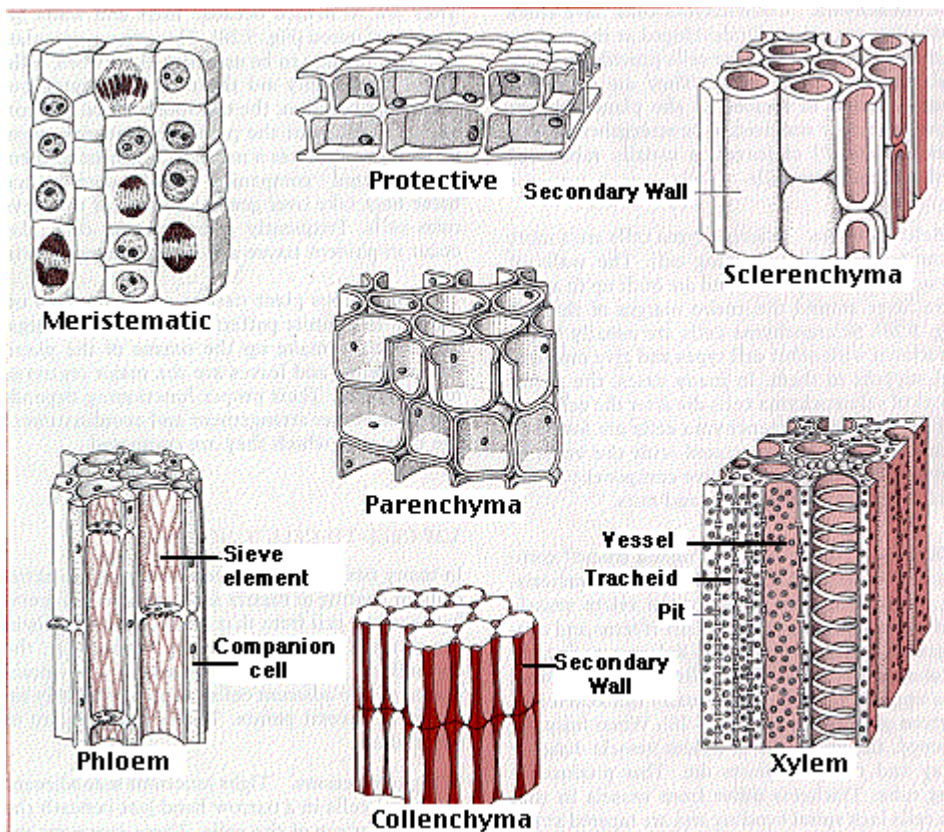
- **Epithelial tissue** – which is a thin continuous layer of cells for **lining and protection** of internal and external surfaces.
- **Skeletal** – it is a bundle of elongated cells with fibres that can contract. Its contraction and relaxation brings about movement.
- **Blood tissue** – this is a fluid containing red blood cells, white blood cells and platelets. It transports many substances and protects the body against infections.



- **Connective tissue** – made up of strong fibres that connect other tissues and organs holding them together.

**Plant tissues include:**

- **Epidermal tissue of a plant** – this is a single layer of cells protecting the inner tissues of the plant.
- **Palisade tissue** – this is a group of cells rich in chloroplasts containing chlorophyll. They absorb light energy during photosynthesis.
- **Parenchyma tissue** – it is made thin walled irregularly shaped cells. They store water and food.
- **Vascular bundle** – consists of the xylem and phloem. Xylem conducts water and mineral salts while phloem conducts food substances.



### 3. Organs

- Many tissues become specialized and grouped together to perform a functional unit called the **organ**.
- Examples of organs in plants include; roots, leaves, flowers and stem.
- In animals they include heart, lungs, kidney, brain, stomach and the liver.

### 4. Organ systems.

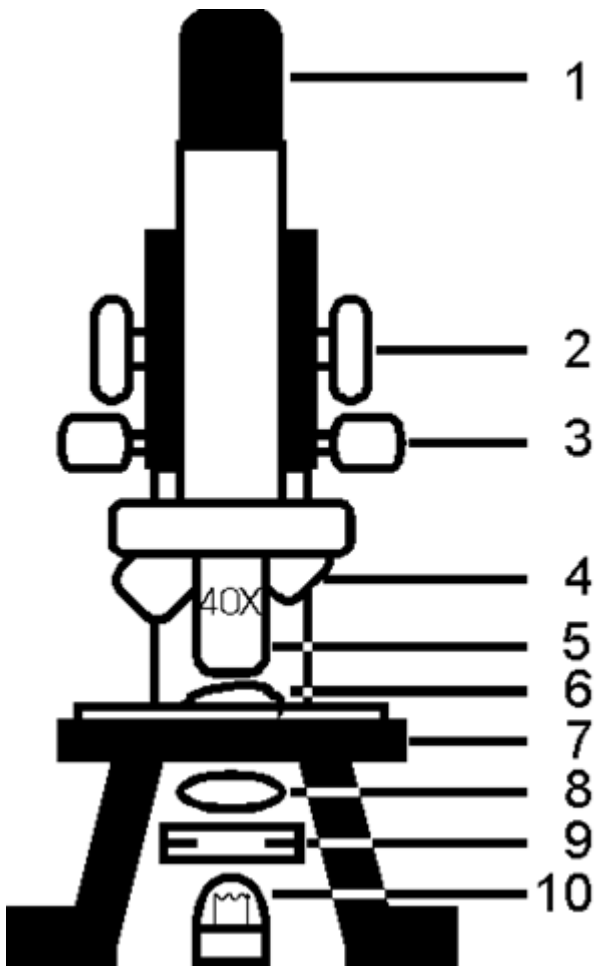
- This is made of several organs whose functions are coordinated and synchronized to realize an effective action is called an **organ system**. Examples include; digestive, circulatory, excretory, respiratory, reproductive and nervous system.

## Revision Questions

### MICROSCOPE

#### Microscope Parts & Function

#### Parts of the *Microscope*

|   |                        |   |
|---|------------------------|---|
|  | 1.<br>Eyepiece         | Contains a magnifying lens that focuses the image from the objective into your eye. |
|   | 2. Course Adjust       | For focusing under low magnification  |
|   | 3. Fine Adjust         | For focusing under high magnification or low  |
|   | 4. Low Power Objective | For large specimens or overview   |

|  |                             |   |
|--|-----------------------------|---|
|  | 5. High Power Objective     | For detailed viewing or small specimens       |
|  | 6. Specimen on glass slide  | What you want to look at                      |
|  | 7. Stage                    | Supports specimen in correct location to lens |
|  | 8. Condenser                | Focuses the light on specimen                 |
|  | 9. Diaphragm (iris or disc) | Regulates amount of light and contrast        |
|  | 10. Light Source            | Illuminates the specimen for viewing          |

## Handling and Care of the Microscope

The following rule should be observed:

1. Use both hand when carrying the microscope. One hand should hold the base and the other holds the limb.
2. Never place the microscope too close to the edge of the bench.
3. Do not touch the mirror and the lenses with the fingers.
4. Clean dirty lenses using soft tissue.
5. Clean other parts using a soft cloth.
6. Do not wet any part of the microscope.

7. Make sure the low power clicks into position in line with the eye piece before and after use.
8. Always store the microscope in a safe place free from dust and moisture.

### Using the Microscope

1. Place 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 the diaphragm is fully open.
4. Look through the eyepiece with one eye. Adjust the mirror to ensure maximum light can pass through.
5. Place the slide containing the specimen on the stage and clip it into position. Make sure the slide is at the centre of the field of view.
6. Again look through the eyepiece while adjusting the mirror to ensure maximum light reach the specimen.
7. Use the coarse adjustment knob to bring the low power objective lens to the lowest point. While viewing through the eyepiece, 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 magnification, turn the medium power into position and adjust the focus using the coarse knob. Use the fine adjustment knob for sharper focus.
11. For even large magnifications, turn the high power objective lens into position. In this case use only the fine adjustment knob to bring details into sharper focus.

### Magnification

- Magnification of the object viewed under the microscope is calculated by;

**Magnification = Eye Piece Lens Magnification X Objective Lens Magnification.**

- If the eyepiece lens has the magnification of x5 and the low power objective lens has a magnification of x10, the total magnification is  $5 \times 10 = 50$ .

### Study Question 1

Fill the table below.

| Eye piece lens magnification | Objective lens magnification | Total magnification |
|------------------------------|------------------------------|---------------------|
| <b>X5</b>                    | <b>X4</b>                    |                     |
| <b>X10</b>                   | <b>X5</b>                    |                     |
| <b>X10</b>                   |                              | <b>X100</b>         |
|                              | <b>X40</b>                   | <b>X600</b>         |
| <b>X10</b>                   | <b>X100</b>                  |                     |

### Practical Activity 1

#### Cell Structures as Seen Under the Light Microscope

- The following cell organelles can be seen under the light microscope.
  - Cell wall.
  - Cell membrane
  - Cytoplasm
  - Nucleus
  - Vacuole.
  - Chloroplasts.

#### Diagrams- plant and animal cells

#### The Electron Microscope.

- It is more powerful than the light microscope.
- It can magnify up to 500,000 times and has high resolving power.
- The high resolving power of the electron microscope enables it to separate objects which lie close to one another.
- Electron microscope uses a beam of electrons instead of light to illuminate the object.

### Study Question 2

#### Practical Activity 2

#### Cell Structures as Seen Under the Electron Microscope

## Diagrams – Plant and Animal Cells

### The Cell Organelles

#### i) *Cell membrane (Plasma Membrane).*

- It has three layers i.e. one layer of phospho-lipid layer sandwiched between two protein layers.
- It is flexible with pores and has the following main functions.
  - a) Encloses all the cell contents.
  - b) It allows selective movement of substances into and out of the cell since it is semi-permeable.

#### Diagram

#### ii) *Cytoplasm*

- It is a fluid medium in which chemical reactions take place.
- It has some movement called cytoplasmic streaming.
- It contains organelles, starch, glycogen, fat droplets and other dissolved substances.

#### iii) *Nucleus*

- It has double membrane called the nuclear membrane.
- The membrane has pores allowing passage of materials into and out of the cell.
- Nucleus has a fluid called *nucleoplasm* in which the *nucleolus and chromatin* are suspended.
- Nucleolus manufactures *ribosomes* while chromatin contains the hereditary material.

#### iv) *Mitochondria (Mitochondrion)*

- They are sausage shaped and are the *respiratory sites*.
- Mitochondrion has two membranes. Inner membrane is greatly folded into *cristae* to increase the surface area for respiration.
- Cells that require a lot of energy have large number of mitochondria e.g. muscle cell, sperm cell, kidney cell etc.

#### Diagram

#### v) *Endoplasmic Reticulum (ER)*



- Some endoplasmic reticulums have granules called **Ribosomes** on their surfaces hence referred to as **rough endoplasmic reticulum**.
- Others do not contain ribosomes hence the name **smooth endoplasmic reticulum**.
- Rough endoplasmic reticulum **transport proteins** while the smooth endoplasmic reticulum **transports lipids**.

## Diagrams

### vi) **Ribosomes**

- They are spherical in shape and form the site for **protein synthesis**.

### vii) **Lysosomes**

- They contain **lytic enzymes** which break down large molecules, destroy worn out organelles or even the entire cell.

### viii) **Golgi Bodies (Golgi apparatus)**

- Their function is to package and transport **glyco-proteins**.
- They are also associated with **secretion** of synthesized **proteins** and **carbohydrates**.

## Diagram

### ix) **Centrioles**

- They are rod shaped structures that are used in **cell division** and in the formation of **cilia and flagella**.
- Plant cells lack the Centrioles.

### x) **Chloroplasts**

- They are egg shaped and contain two membranes.
- Chloroplast has chlorophyll which traps light energy to be used during photosynthesis.

### xi) **Vacuoles**

- These are sacs filled with a fluid called cell sap.
- Animal cells contain small vacuoles while plant cells have large vacuoles.
- Sap vacuoles store sugars and salts.
- Food vacuoles store and digest food while contractile vacuoles excrete unwanted materials from the cell.

### xii) **Cell wall**

- It is a rigid outer cover of the plant cells made of *cellulose*.
- It gives the plant cell a *definite shape* while providing *mechanical support* and *protection*.
- Cell wall also allows water, gases and other materials to pass through it.

### Study Question 3

## Differences between Plant and Animal Cells

### Preparation of Temporary Slides

### Practical Activity 3

### Estimation of Cell Sizes.

## NUTRITION IN PLANTS AND ANIMALS

### Nutrition

- This is the process by which organisms *obtain and Assimilate* nutrients.
- There are two modes of nutrition; **Autotrophism and Heterotrophism.**

### Autotrophism

- This is where living organism *manufacture its own* complex food substances from simple substances such as carbon (iv) oxide, water, *light or chemical energy*.
- Where sunlight is used as a source of energy, the process is referred to as **photosynthesis**.
- **Photo** means light while **synthesis** means to make.
- Some **none green plants** make their own food using energy obtained from certain chemicals through a process called **chemosynthesis**.
- Organisms that make their own food are referred to as **autotrophs**.

### Heterotrophism

- This is where organisms *take in complex food* materials such as carbohydrates, proteins and fats obtained from bodies of plants and animals.
- Organisms that feed on already manufactured foods are called **Heterotrophs**.

## Autotrophism

### External Structure of a Leaf

A leaf is a flattened organ which is attached to the stem or a branch of a plant.

### Diagrams

### Parts of a leaf

**Lamina:** This is the flat surface. It is green in colour and contain the photosynthetic tissue.

**Midrib:** This is a thick structure running through the middle of the leaf

**Veins:** They arise from the midrib to forming an extensive network of veins.

**Leaf Apex:** This is the tip of the leaf and usually it is pointed.

**Petiole:** It attaches the leaf to the stem or branch.

In some monocotyledonous plants the leaves are attached to the stem by the leaf sheath.

### Practical Activity 1: To examine the External Features of a Dicotyledonous and Monocotyledonous leaf

#### Study Question 1

#### Internal Structure of a Leaf

- Internal structure of the leaf is composed of the following parts.
  - Cuticle.**
    - It is a thin waterproof and transparent layer that coats the upper and lower surfaces of the leaf.
    - It reduces excess water loss and protects the inner tissue of the plant against mechanical injury.
    - It also prevents entry of disease causing micro organisms.
    - Since it is transparent, it allows penetration of light for photosynthesis.
  - Epidermis.**

- It is a one cell thick tissue on both the upper and lower leaf surfaces.
- It secretes the cuticle and also protects the inner tissues from mechanical damage and prevents entry of pathogens.
- Epidermal cells have no chloroplast except the **guard cells**.
- Guard cells are special bean shaped cells. They have chloroplast and are able to carry out photosynthesis hence controlling the opening and closing of the stomata.
- Air moves into and out of the leaf through the stomata.

iii.) *Palisade layer.*

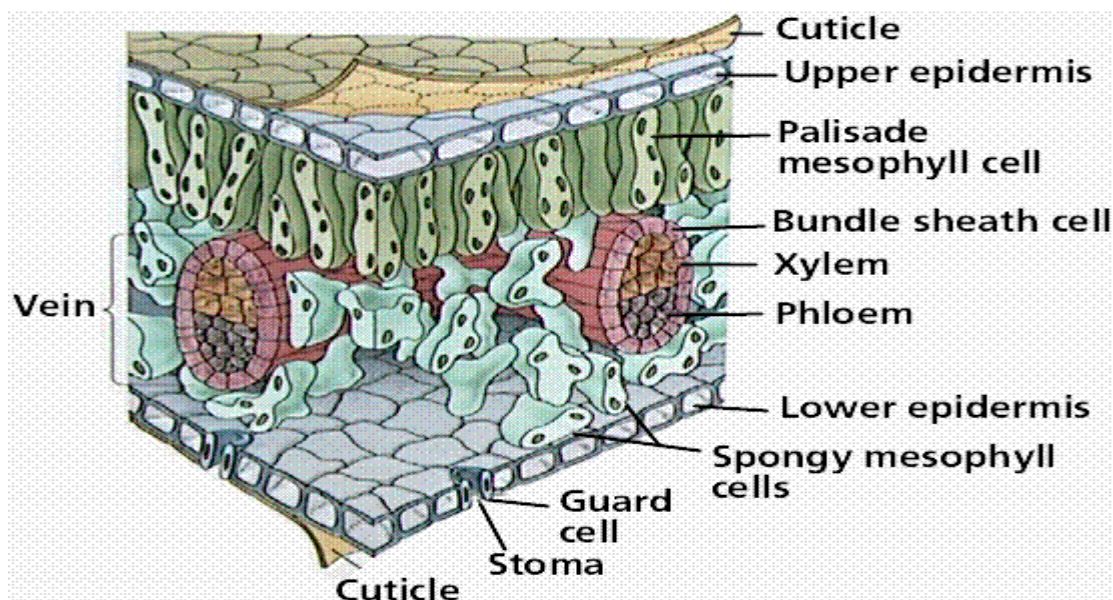
- This is layer of cells located beneath the upper epidermis.
- It is made of cylindrical shaped cells *closely packed* together. They have *numerous chloroplasts* containing chlorophyll.
- Their position and arrangement enables them to receive maximum light.

iv.) *Spongy Mesophyll Layer.*

- This is below the palisade layer. The cells are *irregularly shaped and loosely packed* creating large air spaces in between them.
- The *air spaces allow gases to diffuse* in between the cells. They contain fewer chloroplasts as compared to the palisade cells.

v.) *Leaf Veins.*

- Each vein is a vascular bundle consisting of xylem and phloem.
- Xylem conducts water and mineral salts from the roots to the leaves while the phloem translocates manufactured food from the leaves to the rest of the plant.



## Study Question 2

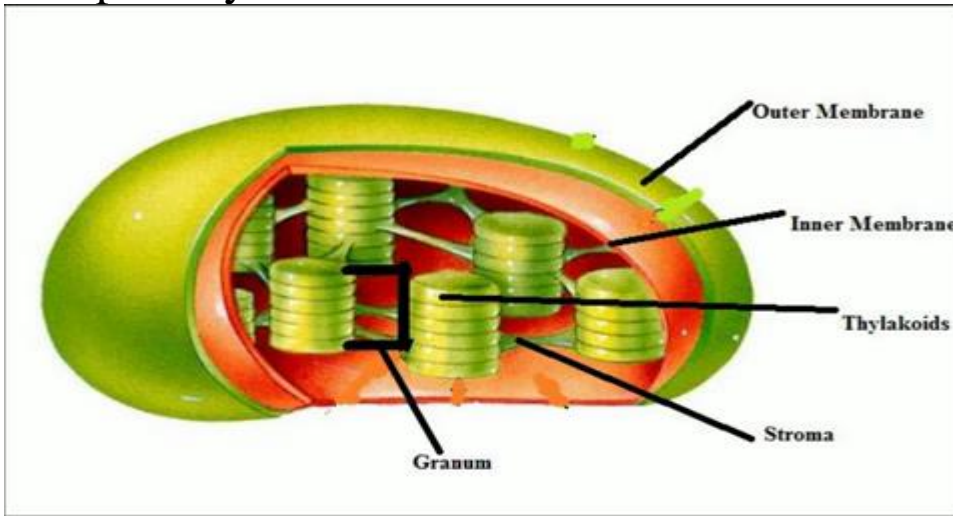
### Adaptations of Leaves to Photosynthesis.

1. Broad and flat lamina to increase surface area of Carbon (IV) oxide and sunlight absorption.
2. Thin transparent cuticle and upper epidermis; to allow easier penetration of light to photosynthetic cells;
3. Thin; for faster diffusion of gases;
4. Palisade cells placed next to the upper surface; to trap maximum light for photosynthesis;
5. Palisade cells with numerous chloroplasts; to trap maximum amount of light for photosynthesis;
6. Large/ intercellular air spaces in the spongy mesophyll layer; for storage of Carbon (IV) oxide for easier gaseous exchange;
7. Waxy water proof cuticle; to reduce water loss sand reflect excess light;
8. Leaf mosaic/ non-overlapping leaves; for maximum exposure to light;
9. Guard cells, modified cells to open and close stomata; to control amount of water loss from the leaf and allows gaseous exchange.
10. Leaves have leaf veins; xylem to conduct water to photosynthetic cells, Phloem to translocate products of photosynthesis to other parts of plant;

### The Chloroplast

- They are disc shaped organelles found in the cytoplasm of plant cells.
- Each chloroplast has a double membrane; the inner and outer membrane.
- Chloroplasts are made of layers of membranes called *lamellae* contained in a fluid matrix called *stroma*.
- Several lamellae come together to form the *granum (grana)*.
- Granum contains *chlorophyll molecules* and other *photosynthetic pigments*.

- The stroma contains *enzymes* that speed up the rate of photosynthesis.



## Practical Activity 2: To Observe Distribution of Stomata

### Study Question 3.

### The Process of Photosynthesis

- The raw materials for photosynthesis are; water and carbon (IV) oxide. The process however requires the presence of sunlight energy and chlorophyll pigment.
- The products of photosynthesis are glucose and oxygen. The process can be summarized using an equation as shown below.



Water + Carbon (IV) oxide  $\longrightarrow$  Glucose + Oxygen.

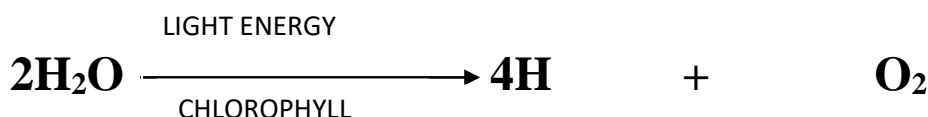
**The above chemical equation translates as:**

**Six molecules of water plus six molecules of carbon (IV) Oxide produce one molecule of sugar plus six molecules of oxygen**

- The process of photosynthesis is however more complex than shown in the above equation and can be divided into two stage; the *light* and *dark* stages.

### Light stage (Light Dependent Stage)

- Occurs in the grana containing chlorophyll which traps / absorbs sun light energy.
- This Energy is used to split water molecules into hydrogen ion and oxygen gas.
- This process is called **photolysis** of water and is shown below.



## (Water)

## Hydrogen atom

## Oxygen

- Hydrogen atoms produced here enter into the dark stage.
- Oxygen gas removed through stomata or is used for respiration within the plant;
- Some Light energy is used in *Adenosine Triphosphate* (ATP) formation; **ATP** an energy rich compound.
- ATP is later used in the dark stage.

### Dark stage. (Light Independent Stage)

- Carbon (IV) oxide combines with hydrogen atoms to form glucose/simple carbohydrate.
- This is called *Carbon (IV) Oxide fixation*.



- This stage takes place in the stroma and proceeds whether light is present or not.
- ATP Energy from light stage is used to provide the required energy in this reaction;
- Simple sugars formed are used for respiration to provide energy or are converted to storable forms e.g lipids, proteins, starch, cellulose, etc.

### Study Question 4

### Practical Activity 3: To Investigate the Presence of Starch in a Leaf.

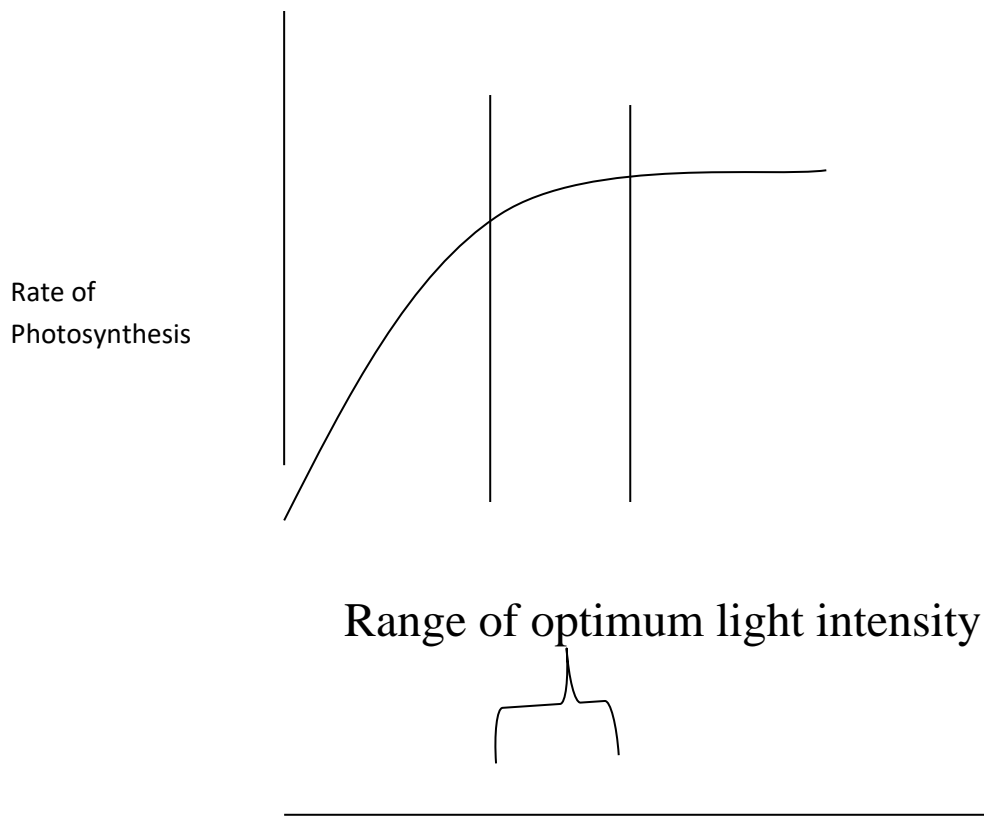
### Study Question 5

### Factors Affecting the Rate of Photosynthesis

#### *i.) Light Intensity.*

- Increase in light intensity increase the rate of photosynthesis up to a certain level where it slows down and finally levels off.
- Very bright sunshine may damage the plant tissues due to high amount of ultra violet light.
- Light quality or light wavelength also affects the rate of photosynthesis.

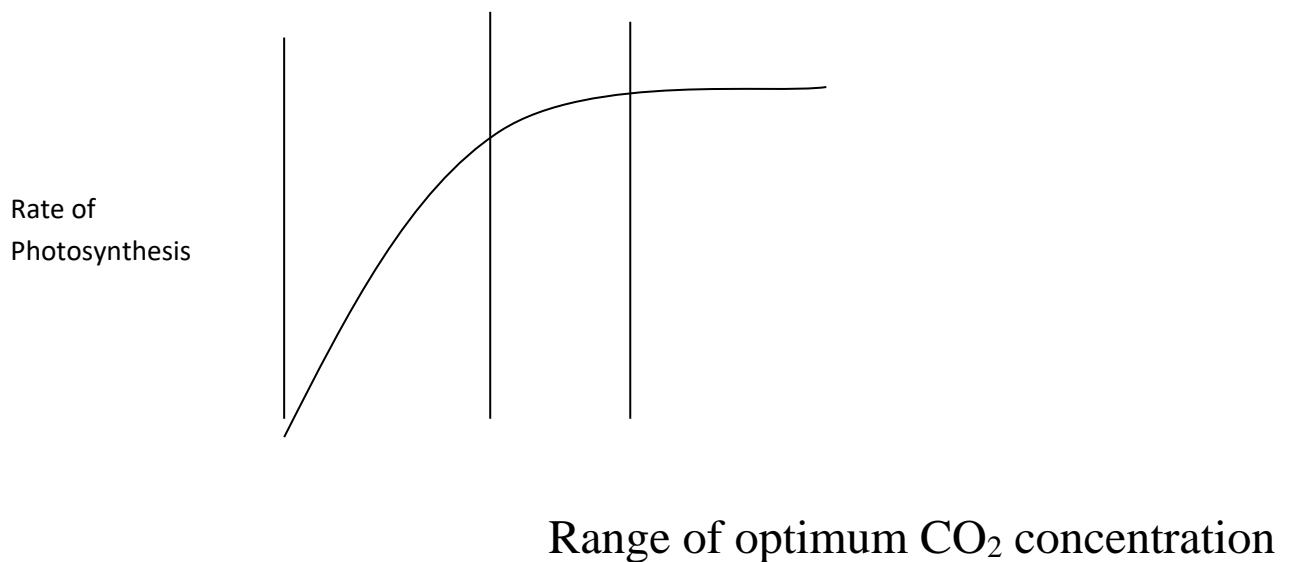
- Red and blue wavelengths of light are required by most plants for photosynthesis.



### *Light intensity*

#### ii.) *Carbon (IV) oxide concentration*

- Increase in Carbon (IV) oxide concentration increases the rate of photosynthesis linearly up to a certain level after which it slows down and levels off.



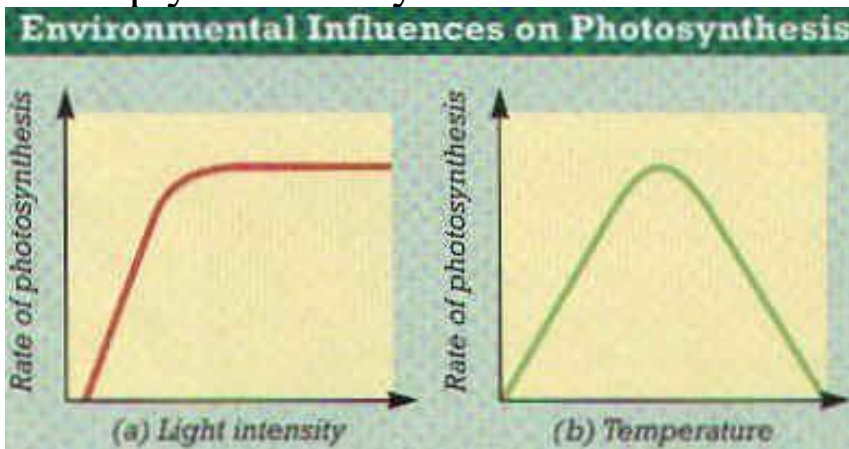




## Carbon (IV) oxide concentration

### iii.) Temperature

- Photosynthesis is an enzyme controlled process, therefore increase in temperature increase the rate of photosynthesis up to the optimum temperature.
- Increase in temperature beyond the optimum decreases the rate sharply as the enzymes become denatured.



### iv.) Water

- Plants need water for photosynthesis. Hydrogen atoms required in the dark stage during Carbon (IV) oxide fixation are derived from water during photolysis.

## Study Question 6

### Practical Activity 4: To Investigate Factors Necessary for Photosynthesis.

#### a) Light

## Study Question 7

#### b) Carbon (IV) oxide.

## Study Question 8

#### c) Chlorophyll.

## Study Question 9

## Study Question 10

### Practical Activity 5: To Investigate the Gas Produced During Photosynthesis.

## Study Question 11

## Chemical Compounds Which Constitute Living Organisms

- Cells, tissues and organs are made of chemicals which are referred to as *chemicals of life*.
- The study of chemical compounds found in living organisms and reactions in which they take part is called *Biochemistry*.
- Chemicals of life include carbohydrates, lipids and proteins.

### a) Carbohydrates

- They are compounds of carbon, hydrogen and oxygen in the ratio of 1:2:1 respectively.
- Carbohydrates have a general formula of  $(\text{CH}_2\text{O})_n$  where  $n$  represents the number of carbon atoms in a molecule of carbohydrate.
- Carbohydrates are divided into three groups; **Monosaccharide's**, **Disaccharides** and **Polysaccharides**.

#### i) Monosaccharides

- They are the simplest carbohydrates and have a general chemical formula of  $(\text{CH}_2\text{O})_n$  where  $n = 6$ .
- Their chemical formula is therefore  $\text{C}_6\text{H}_{12}\text{O}_6$ . They include; glucose, fructose, galactose etc.

### Properties of Monosaccharides

- They are soluble in water to form sweet tasting solutions.
- They are crystallisable.
- They have the reducing property where they reduce copper sulphate in Benedict's solution to red copper (I) oxide.

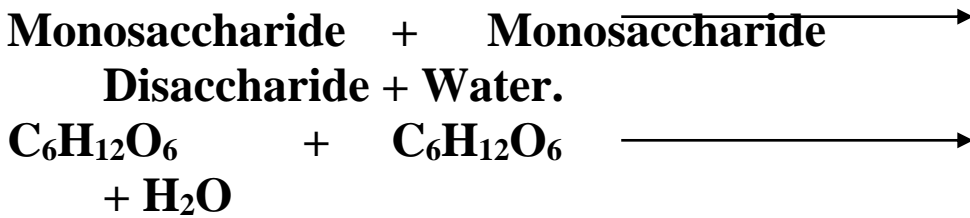
### Functions

- They are oxidized to release energy during respiration.
- When condensed together, they form polysaccharides such as starch, cellulose or glycogen.

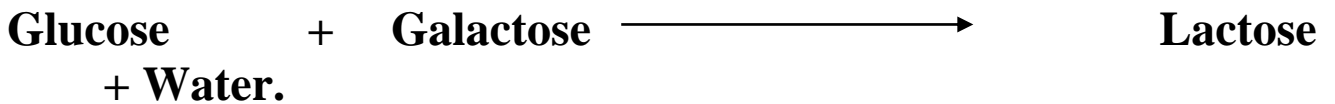
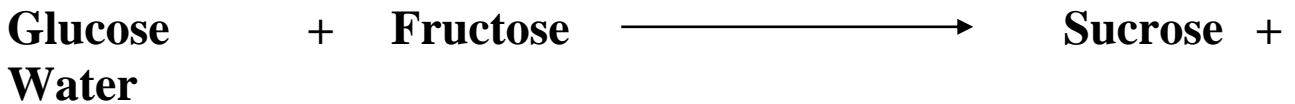
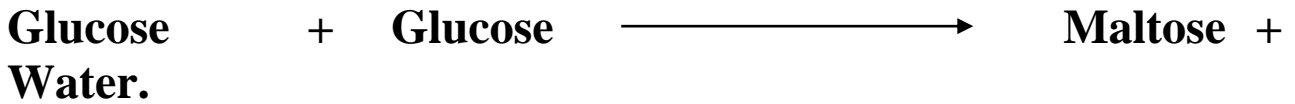
#### ii) Disaccharides

- They are formed by linking two Monosaccharide molecules through the process of condensation where a molecule of water is liberated.

### *Condensation*



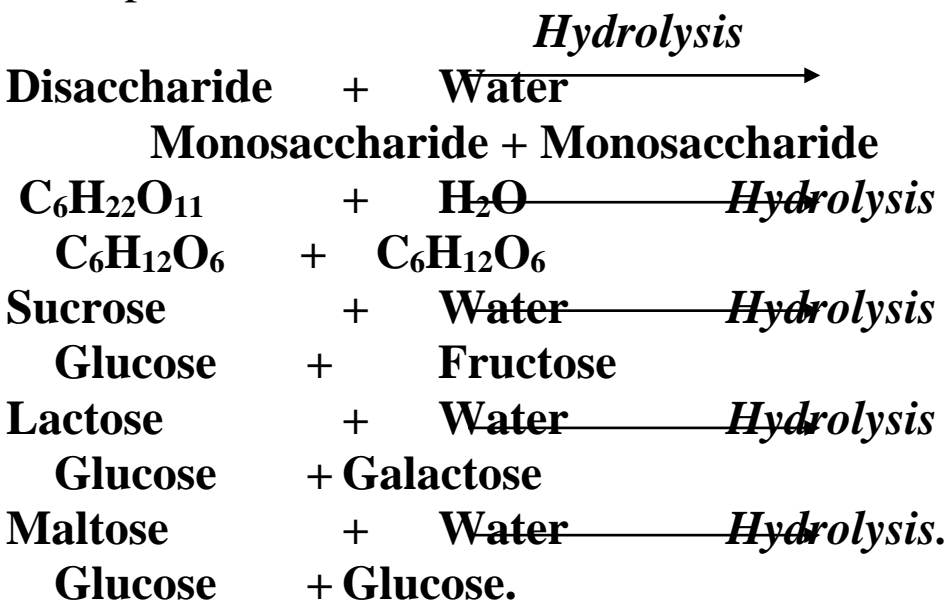
*Examples*



- The type of disaccharide formed depends on the monosaccharide units that condense together.

**Properties of Disaccharides**

- Soluble in water to form sweet tasting solutions
- They are *non reducing sugars*. Some such as the maltose can reduce copper sulphate in Benedict's solution when heated together and are therefore referred to as *complex reducing sugars*.
- They are readily broken into their constituent monosaccharide molecules in a process known as *Hydrolysis* in the presence of water.



- Naturally disaccharides are hydrolyzed by enzymes. In the laboratory, hydrolysis is achieved by boiling them in dilute Hydrochloric acid.

### Functions

- They are hydrolyzed by enzymes into monosaccharide's which are then oxidized to produce energy.

**iii) Polysaccharides.** They are made of many monosaccharide molecules hence are long and more complex.

- They have a general formula of  $(C_6H_{10}O_5)_n$ ; where the value of **n** is a very large number.

### Examples of polysaccharides

#### i) Starch

- It is present as stored food in plant tissues e.g. maize, wheat, potatoes, rice etc.

#### ii) Cellulose

- This is the component of the cell wall in plants. Cellulose gives the plant cells their definite shape.

#### iii) Glycogen

- This is the form in which carbohydrates are stored in animal tissues. Excess glucose is converted into glycogen for storage in the liver.

### Properties of Polysaccharides

- All are insoluble in water.
- Do not have a sweet taste hence are referred to as non-sugars.

### Study Question 12

### Practical Activity 6: To Carry out Food Tests for Carbohydrates

#### i) Starch

#### ii) Reducing sugars

#### iii) Non Reducing Sugars

#### b) Lipids

- These are the fats and oils. Fats are found in animals while oils are found in plants.
- Oils are liquid while the fats are solid at room temperature.

- They contain carbon, hydrogen and oxygen just like the carbohydrates. However they contain fewer number of oxygen atoms than in carbohydrates.
- Lipids are made up of three *fatty acid molecules* and one molecule of *Glycerol*.
- The nature of a lipid formed, depends on the fatty acids it contains. Glycerol remains the same in all lipids.

### Diagram

- Complex lipids are formed through condensation of many lipid molecules just like in carbohydrates.
- Examples of complex lipids include; phospholipids, waxes, steroids and cholesterol.
- Presence of lipids in a food sample is detected using the *grease spot test or emulsion test*.

### Properties of Lipids

1. When fats are heated they change into liquid while oils solidify under low temperature.
2. Both fats and oils are insoluble in water. They however dissolve in organic solvents such as alcohol to form emulsions and suspensions.
3. Lipids are inert hence can be stored in the tissues of organisms.

### Functions of Lipids

#### i) Source of energy

- They give almost twice as much energy as the Monosaccharides.

#### ii) Source of metabolic water

- When oxidized, lipids release more water than Monosaccharides. Such water is referred to as **metabolic water**.

#### iii) Structural compounds

- Lipids are constituents of plasma membrane and protoplasm.

#### iv) Heat insulation

- Fats are deposited under the skin of animals forming the adipose tissue which acts as a heat insulator.
- Mammals in the temperate regions have thick adipose tissue to greatly reduced heat loss.

- Thick adipose tissue in aquatic animals helps them to be buoyant in water.
- v) **Protection**
  - Fat is deposited around the major organs such as kidney, heart etc where they act as shock absorber.
  - Wax in plant cuticles reduces excessive water loss.

### Study Question 13

#### Practical Activity 7: testing for the Presence of Lipids

##### i) The Grease Spot

##### ii) The Emulsion Test

##### c) Proteins

- Like carbohydrates and lipids, proteins are compounds of carbon, hydrogen and oxygen.
- In addition they contain **nitrogen** and sometimes **phosphorous and sulphur**.
- Some proteins such as haemoglobin contain other elements such as iron.
- Proteins are made up of small units called amino acids. There are about 20 different types of amino acids.
- All amino acids contain the amino group ( $-\text{NH}_2$ ) which consists of hydrogen and nitrogen.
- Two amino acids combine to form a **dipeptide molecule** through the process of condensation.
- The bond between two amino acids is called **peptide Bond**. Many amino acids join together to form a long protein chain called **polypeptide chain**.
- The **type and sequence** of amino acids contained in such a chain determine the **uniqueness** of the protein being formed.

#### Properties of Proteins

- They dissolve in water to form **colloidal suspensions** (not true solutions) where particles remain suspended in water.
- They are **denatured by temperatures above 40 °C**. Heat alters the structure of the protein molecule. Chemicals such as detergents, acids, bases and organic solvents also denature proteins.

- iii.) They are ***amphoteric*** whereby they have both acidic and basic properties. This property enables them to combine with non-protein compounds to form ***conjugated proteins*** such as mucus, and haemoglobin. In mucus the non protein compound is a carbohydrate while in haemoglobin, iron is a non protein.

## Functions of Proteins

### i.) *Structural Functions*

- Proteins make the framework of living systems e.g. plasma membrane, connective tissues, muscle fibres, hair, nails, hooves, skeletal materials etc.

### ii.) *Metabolic Regulators*

- These are divided into two

#### a) *Enzymes*

- Enzymes are ***organic catalysts which speed up*** the rate of metabolic reactions such as respiration, photosynthesis, digestion etc.

#### b) *Hormones*

- They are ***chemical messengers which regulate many body processes*** such as growth, reproduction, amount of sugars, salts and water in the blood etc.

### iii.) *Source of Energy*

- Under extreme starvation, proteins are broken down to release energy.

## Study question 14

## Practical Activity 8

## To Test for Proteins

### Enzymes

- They are organic catalysts which are protein in nature. They speed up or slow down the rate of chemical reactions in the body without themselves being used up.
- They are divided into two;
  - a) *Extracellular Enzymes*
    - Extracellular enzymes are produced within the cells but are used outside the cells which produce them e.g. the digestive enzymes.

### b) *Intracellular Enzymes*

- They are secreted and used within the cells which produce them e.g. the respiratory enzymes.

## Naming of the Enzyme

- There are two methods on naming enzymes;

### i) **Trivial Naming**

- Enzymes are given names of persons who discovered them.
- The names end in **-in** such as pepsin, trypsin, ptyalin etc.

### ii) Use of suffix **-ase**

- This is the modern method of naming. The suffix **-ase** is added to the substrate (type of food) or the reaction the enzyme catalyzes.

### Example 1

| Substrate           | Enzyme       |
|---------------------|--------------|
| Carbohydrate        | Carbohydrase |
| Starch e.g. amylose | Amylase      |
| Sucrose             | Sucrase      |
| Maltose             | Maltase      |
| Protein             | Protease     |
| Lipid               | Lipase       |

### Example 2

| Reaction   | Enzyme    |
|------------|-----------|
| Hydrolysis | Hydrolase |
| Oxidation  | Oxidase   |
| Reduction  | Reductase |

## Properties of Enzymes

1. They are protein in nature hence are affected by changes in temperature and pH.
2. They are substrate specific.
3. They are efficient in small amounts as they are not affected by the reactions they catalyze. They can be used again and again.
4. They are catalysts that speed up the rate cellular reactions and are not used up in the reactions they catalyses.
5. Most of the enzyme controlled reactions are reversible.



## Factors Affecting the Rate of Enzyme Controlled Reactions

### i.) *Temperature*

- Enzymes are sensitive to changes in temperature and pH since they are protein in nature.
- Enzymes work best within a narrow range of temperature called the optimum temperature.
- Above the optimum temperature, reaction decreases sharply as the enzymes are denatured.
- Most enzymes have optimum temperature between 35-40°C.
- Very low temperature inactivates the enzymes hence decrease rate of reaction.

### *Diagrams*

#### ii.) *pH*

- Most enzymes have a pH of close to 7.
- Some however work best in acidic pH e.g. pepsin while other work best in alkaline conditions.
- As pH changes from the optimum, enzyme activity decreases
- Extreme acidity or alkalinity denatures most enzymes.

### *Diagrams*

#### iii.) *Specificity*

- Enzymes are specific in nature where a particular enzyme acts on a particular specific substrate.
- For example, sucrose works on sucrose and not any other substrate.

#### iv.) *Substrate Concentration and Enzyme Concentration.*

- When substrate concentration increases, the rate of enzyme reaction also increases upto a certain level.
- Further increase does not increase the rate of reaction as ***all the active sites*** of an enzyme are occupied.
- When enzyme molecules are increased, the rate of reaction increases proportionally.

### *Diagrams*

#### v.) *Enzyme Co-factors and Co-enzymes*

- Co-factors are non protein substances which activates enzymes. They are required in small quantities and they include metallic ions such as those of iron, magnesium, zinc, copper etc. Some are vitamins.
- Co-enzymes are non protein molecules that work in association with particular enzymes. Most co-enzymes are derived from vitamins.

vi.) *Enzyme Inhibitors*

- Inhibitors compete with the normal substrate for the active sites and they take up the active site of the enzyme permanently.
- There are two types of inhibitors;

**a) Competitive Inhibitors**

- These are chemicals closely related to normal substrate and they compete for active sites with the normal substrate. They slow down the rate of reaction.

**b) Non Competitive Inhibitors**

- They do not compete with the substrate. They combine permanently with enzyme molecules thus blocking the active sites. They include poisons such as cyanides, mercury and silver arsenic compounds.

**Importance of Enzymes**

- Enzymes speed up the rate of cellular reactions and also control them. This way, they help prevent violent reactions in the cells.

**Study Question 15**

**Practical Activity 9**

**Study Question 16**

**Study Question 17**

**Practical Activity 10**

# FORM TWO BIOLOGY NOTES

## EXCRETION AND HOMEOSTASIS

**Excretion**-Process by which living organisms separate and eliminate waste products formed during metabolic processes from the body. They include; carbon IV oxide, excess water and mineral salts, nitrogenous wastes etc. accumulation of these substances may become toxic to cells.

**Homeostasis**-This is the maintenance of internal environment of cells under constant conditions E.g. temperature, osmotic pressure, blood sugar and chemical constituents.

**Egestion.** - This is the removal of undigested and indigestible materials from the alimentary Canal of animals.

**Secretion.** - This is the release of certain useful substances produced by cells e.g. hormones, Enzymes, sebum, saliva and mucus.

### Excretion in Plants

- Plants do not have complex organs for excretion because;
  - i. There is very little accumulation of toxic wastes such as nitrogenous wastes.
  - ii. Some waste products are re-used in the same plant such as  $\text{CO}_2$ , oxygen and water.
  - iii. Some of these gases are removed by simple diffusion through the stomata and lenticels.
  - iv. Some plants store wastes in their tissues in non-toxic forms such as nicotine, caffeine, tannins, resins, quinine, morphine etc.

### Economic Importance of Plant Excretory Products

- i. *Tannins* – They are deposited in dead tissues of wood and barks of trees e.g. in acacia and wattle tree. Tannin is used to treat leather.
- ii. *Caffeine* – it is stored in coffee berries and tea leaves. It is used as a stimulant.
- iii. *Quinine* – it is stored in the leaves of aloe and bark of *cinchona* tree. It is used in the treatment of malaria.

- iv. *Cocaine* – it is obtained from the leaves of coca plant and is used as an anesthetic.
- v. *Cannabis* – found in the leaves and flowers of *Cannabis sativa* (bhang). It is used to manufacture some drugs.
- vi. *Nicotine* – found in leaves of tobacco plant and is used in the manufacture of insecticides and narcotic drugs. It also manufactures cigarettes.
- vii. *Rubber* – it is made from latex of rubber plant. It is used in shoe industry and manufacture of chewing gum.
- viii. *Colchicines* – it is used in plant breeding and treating of cancer.
- ix. *Pappain*- it is obtained from raw paw paw and it is used as a meat tenderizer.
- x. *Khat/miraa* – it's chewed and acts as a mild stimulant.

### **Excretion and Homeostasis in Unicellular Organisms**

- Most simple organisms such as the protozoa (amoeba and paramecium) live in aquatic environment.
- They depend mainly on diffusion as the means of excretion.
- Their bodies have a large surface area to volume ratio providing a large surface area for gaseous exchange and excretion to take place by simple diffusion.
- Waste products diffuse from the cytoplasm where they are highly concentrated across the cell membrane into the surrounding water where their concentration is low.
- The organisms also use the contractile vacuole to achieve excretion.
- Amoeba and paramecium live in an aquatic environment that is hypotonic to their body fluids. Water therefore tends to move into their cytoplasm by osmosis.
- The excess water and dissolved chemicals accumulate in the contractile vacuole which releases them to the surrounding water.

### **Diagram**

#### **Excretion in Mammals**

- Mammals have an elaborate excretory system since their bodies are complex.

- The main excretory organs in mammals include; lungs, skin, kidneys and the liver.

## A Structure and Function of the Mammalian Skin

- Skin is the largest body organ covering the whole body surface.
- **It has the following functions.**
  - i. Protection of the underlying tissues from entry of micro-organisms, physical damage and ultra violet rays from the sun.
  - ii. Regulation of body temperature.
  - iii. Excretion of salts, excess water and traces of urea.
  - iv. Reception of stimuli such as heat, cold, pain, touch and pressure.
  - v. Synthesis of vitamin D.
  - vi. Storage of fats.

### Diagram

- The skin is made up of two layers;
  - a) Epidermis (upper and outer layer)
  - b) The dermis (inner layer)

#### a) Epidermis (upper and outer layer)

- It is made up of three other layers;

- i. Cornfield layer.
- ii. Granular layer.
- iii. Malphigian layer.

##### i. Cornfield layer

- The Cornfield layer of the epidermis consist of dead cells which form a tough outer coat; that protects the skin against mechanical damage, bacterial infection and water loss;

##### ii. Granular layer

- It's the middle layer of the epidermis and is made up of living cells that give rise to the Cornfield layer.

##### iii. Malphigian layer

- Malphigian layer consists of actively dividing cells that contain fine granules of melanin; that prevents the skin against ultraviolet light rays from the sun; melanin gives the skin its colour.

#### b) The Dermis (inner layer)

- It is thicker than the epidermis and consists of the following structures;
  - 1) *Sebaceous glands* produce an oily secretion sebum which give hair its water repelling property; that keeps the epidermis supple and prevents it from drying  
Sebum also prevents bacterial attack due to its antiseptic property;
  - 2) *Has blood vessels*; that dilate and contract;  
In hot conditions, they dilate; increasing blood flow near the skin surface enhancing blood flow near the skin surface; minimizing heat loss;  
Blood vessels supply nutrients and oxygen to skin tissues and also remove waste products and carbon IV oxide.
  - 3) *Has Hair follicle* ;hairs stand during cold weather thus trapping a layer of air which prevents heat loss; In hot weather they lie close to the skin surface; to enhance heat loss to the atmosphere.
  - 4) *Have many sensory neurons* which detects environmental changes; increasing sensitivity of the skins.
  - 5) *Has subcutaneous layer*; contains fat which acts as a heat-insulating layer and a fuel storage.
  - 6) *Lymphatic vessels*; they drain excess tissue fluid.
  - 7) *Sweat glands*; are involved in temperature regulation through loss of excess heat by the evaporating water.  
Sweat also excretes excess water, mineral salts, urea and lactic acid.

## **B The Lungs**

- They are involved with the removal of carbon VI oxide which is released by cells during their metabolism.
- Carbon IV oxide would be toxic if it was left to accumulate in the tissues.

## **C Structure and Function of the Kidney**

**Diagram fig. 4.3; generalized urinary system of a mammal (page 88 KLB)**

- Mammals have a pair of kidneys which are bean shaped and dark red in colour.

- The kidneys are surrounded by a layer of fat which cushions them against mechanical injury.
- Above each kidney are the adrenal glands which secrete hormones.
- Renal artery supplies blood to the kidneys and the renal vein removes the blood.
- Ureter transports urine from the kidney to the bladder which temporarily stores the urine.
- The mammalian kidney has three distinct regions; cortex, medulla and pelvis.

***Diagram fig. 4.4(a) and 4.4(b) (page 89 KLB)***

### **Cortex**

- It is the outermost region and is dark red in colour.

### **Medulla**

- It is red in colour and extends to form conical structures called pyramids.
- Pyramids open up into the pelvis.

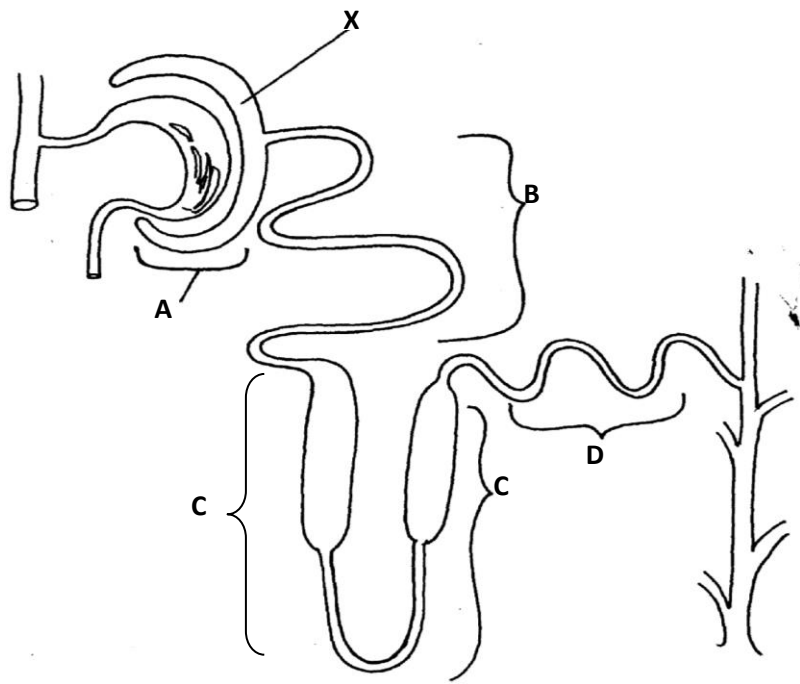
### **Pelvis**

- It's white in colour and narrows down to form the Ureter.
- The human kidney contains urinary tubules called the nephrons.

### **Nephron**

- It is the basic functional unit of the kidney. Each nephron is made up two main parts;
  - Renal tubule
  - Glomerulus.

***Diagram fig. 4.6. The structure of the kidney nephron***



The renal tubule has 5 main parts.

1. Bowman's capsule
2. Proximal convoluted tubule
3. Loop of Henle
4. Distal convoluted tubule
5. Collecting tubule

### 1. Bowman's capsule

- It is a thin walled and cup shaped structure which contains the glomeruli.
- Glomerulus is a fine network of blood capillaries enclosed by the Bowman's capsule.
- It is made the afferent and efferent arterioles.
- Blood entering the kidney via the renal artery is rich in nitrogenous wastes such as urea.
- Also it has dissolved food substances, plasma proteins, mineral ions, hormones and oxygen.
- Afferent arteriole entering the Glomerulus is wider than the efferent arteriole leaving it.
- This creates extremely high pressure in the Glomerulus coupled with the fact that renal artery branches directly from the aorta where blood is at high pressure.

**Diagram: structure of the nephron**



- Due to the high pressure in the glomeruli, the liquid part of the blood and dissolved substances of low molecular sizes including urea, glucose, salts and amino acids are forced out of the Glomerulus into the cavity of the Bowman's capsule.
- The large sized molecules in the plasma such as proteins and blood cells are not filtered out.
- This is because the capillary walls of the Glomerulus and Bowman's capsule have very small pores.
- This process is known as ***ultra-filtration*** and the filtrate formed is called ***glomerular*** filtrate.
- The filtrate then enters the proximal convoluted tubule.

### ***Diagram of ultra-filtration at the Glomerulus***

#### **2. Proximal convoluted tubule**

- As the filtrate flows along the renal tubules, most of the filtered substances in the glomerular filtrate useful to the body are selectively reabsorbed back into the blood.
- The following substances are actively reabsorbed using energy in the proximal convoluted tubule; ***All glucose, Amino acids and Mineral salts.***
- The proximal convoluted tubule is adapted in the following ways for efficient re-absorption of these substances.
  - i) Presence of mitochondria in the cells lining to provide with energy required
  - ii) Cells of the tubule have micro-cilli (infoldings) which increase surface area for re-absorption.
  - iii) Tubule is long and coiled to increase the surface area.
  - iv) Coiling of the tubule reduces the speed of flow of filtrate giving more time for efficient re-absorption.
  - v) Tubule is well supplied with blood capillaries.

#### **3. Loop of Henle**

- This is where particularly sodium chloride is actively reabsorbed into the blood.
- Loop of Henle has counter current flow between the flow of filtrate and the flow of blood i.e. the filtrate and blood flow in opposite directions.

- The hormone *Aldosterone* secreted by the adrenal glands regulate the absorption of sodium salts.
- Low content of sodium salts in the blood stimulates adrenal glands to secrete more *Aldosterone* hormone and therefore more salts are reabsorbed from the filtrate.

#### 4. Distal convoluted tubule

- When the filtrate reaches here, some water is reabsorbed into the blood by osmosis.
- This is made possible by the following;
  - Active intake of sodium salt into the blood at the loop of Henle increases the osmotic potential of the blood.
  - The antidiuretic hormone (ADH) secreted by the pituitary gland. ADH increases the permeability of the tubule and blood capillaries to water
- When there is excess water in the body there is less production of ADH and less water is reabsorbed hence production of large amounts of dilute urine.
- If the body has lost a lot of water such as through sweating, this raises the osmotic pressure of blood. Pituitary gland releases more ADH which increases permeability of the kidney tubules to water. More water is reabsorbed hence production of little but concentrated urine.
- The distal convoluted tubule has large surface area, it has a wall that is one cell thick and is surrounded by many blood capillaries.

#### 5. Collecting tubule

- The filtrate in the collecting tubule becomes the urine and moves to the collecting duct.
- Urine flows into the pelvis via the pyramids and is finally emptied into the urinary bladder through the ureter. About 1-2 litres of urine are formed in a day.
- About 250ml of urine in the urinary bladder initiates the urge to urinate. The sphincter muscles relax and urine pass.

### Urine Composition

| Substance | % |
|-----------|---|
|-----------|---|

|                  | <b>Composition.</b> |
|------------------|---------------------|
| <b>Water</b>     | <b>95%</b>          |
| <b>Urea</b>      | <b>2%</b>           |
| <b>Uric acid</b> | <b>0.03%</b>        |
| <b>Creatine</b>  | <b>0.1%</b>         |
| <b>Salts</b>     | <b>1.4%</b>         |
| <b>Ammonia</b>   | <b>0.04%</b>        |
| <b>Proteins</b>  | <b>0%</b>           |
| <b>Glucose</b>   | <b>0%</b>           |

- The quantity and concentration of the urine in animals is affected by
  - Physiological adaptations.
  - Habitat of an organism e.g. terrestrial, desert or aquatic.
  - Structural adaptations of the animals e.g. a desert rat has long kidney tubules to increase water reabsorption.

### Study Questions. Page 93.

#### Comparison Between Aquatic and Desert Animals

| <b>Fresh Water Animals</b>                            | <b>Desert Animals.</b>                              |
|---|---|
| i) Have many glomeruli to increase ultrafiltration.   | Few glomeruli to reduce ultrafiltration.            |
| ii) Short loop of Henle to reduce water reabsorption. | Long kidney tubules to increase water reabsorption. |
| iii) Produce large quantity of dilute urine.          | Produce small quantity of concentrated urine.       |

#### Comparison of Composition of urine with that of Glomerular Filtrate and Blood Plasma.

| <b>Substance</b> | <b>% Composition of;</b> |                             |              |
|------------------|--------------------------|-----------------------------|--------------|
|                  | <b>Plasma</b>            | <b>Glomerular Filtrate.</b> | <b>urine</b> |
| <b>Urea</b>      | <b>0.03</b>              | <b>0.03</b>                 | <b>2.0</b>   |
| <b>Uric acid</b> | <b>0.005</b>             | <b>0.005</b>                | <b>0.03</b>  |
| <b>Ammonia</b>   | <b>0.001</b>             | <b>0.001</b>                | <b>0.004</b> |
| <b>Glucose</b>   | <b>0.1</b>               | <b>0.1</b>                  | <b>0</b>     |

|                        |             |             |            |
|------------------------|-------------|-------------|------------|
| <b>Amino acids</b>     | <b>0.05</b> | <b>0.05</b> | <b>0</b>   |
| <b>Mineral salts</b>   | <b>0.70</b> | <b>0.70</b> | <b>1.4</b> |
| <b>Blood proteins.</b> | <b>8.00</b> | <b>0</b>    | <b>0</b>   |

### Functions of the kidney include:

- i) Excretion.
- ii) Osmoregulation.
- iii) Ionic balance.
- iv) Regulation of PH

### Kidney Diseases

#### i) *Nephritis*

This is the inflammation of the glomerulus of the kidney. It is caused by bacteria or infections such as small pox and measles.

#### Symptoms

- Headaches and vomiting
- Fever
- Passing coloured urine
- Presence of proteins in urine

#### Treatment

- Use of antibiotics
- ii) Use of just adequate amounts of salts and proteins in diets

#### *Kidney stones*

#### Causes

- Lack of vitamins such as vitamin A and inadequate intake of water
- Chemical salts in urine that crystallize to form hard stones.

#### Symptoms

- Increased frequency in passing out urine
- Pain and soreness in the upper backside
- Difficulty in passing out urine
- Fever

#### Control & Treatment

- Seeking medical assistance

- Taking a balanced diet with adequate amount of water and vitamins
- Dialysis or artificial washing out of the wastes
- Use of laser beam to disintegrate the stones
- Kidney transplant

### iii) *Kidney failure*

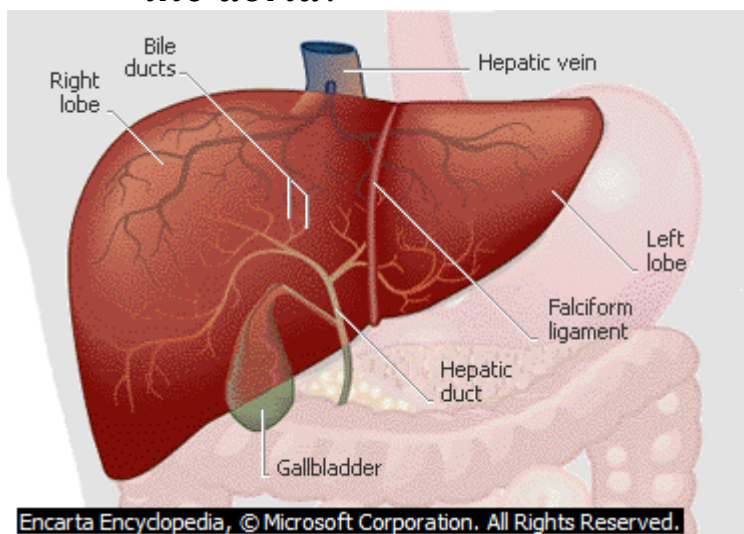
- This is the failure of the kidney to perform as a result of a drop in blood pressure due to heart failure, haemorrhage or shock.
- If failure is due to other causes, the condition can be corrected by;
  - Kidney dialysis
  - Kidney transplant

### iv) *Albiminuria (Proteins in Urine).*

- This is also called *Proteinuria*
- Capillaries of the glomerulus lose their ability to be selective and start allowing blood proteins to pass through into the kidney tubules. These proteins are released in urine.

## D The Liver and its Structure

- This is the second largest excretory organ after the skin. It receives blood from two blood vessels; ***the hepatic portal vein from the alimentary canal and hepatic artery from the aorta.***



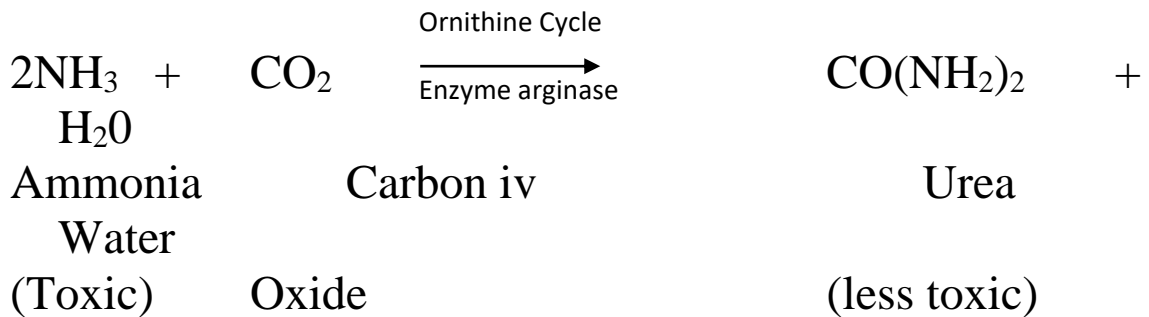
## Homeostatic Functions of the Liver

## ***Regulation of blood sugar level***

- Excess glucose is converted to glycogen ;and stored in the liver under the influence of the hormone insulin secreted by the pancreas. Another hormone called glucagon; stimulates the conversion of glycogen to glucose; when there is shortage of glucose in the body; Glucagon is also secreted by the pancreas

### ***1. Deamination***

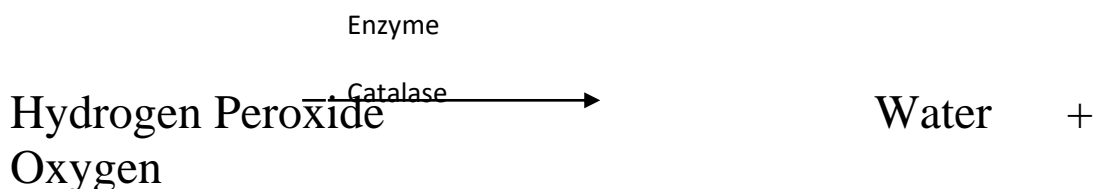
- The liver breaks down excess amino acids; The amino group is removed as ammonia which is toxic;
- Ammonia is changed into urea which is less toxic in the *ornithine cycle*.



- The remaining carbon skeleton oxidized to carbon IV oxide and water; this process leads to release of energy. The carbon skeleton may be converted to glucose to be used during respiration;

### ***2. Detoxification***

- Toxic substances are made harmless in the liver e.g.
- Ammonia from the process of deamination is converted in the liver into urea; which is less toxic.
- Bacterial toxins are converted to less toxic substances by liver cells;
- Hydrogen peroxide produced by respiring cells is broken down into water and oxygen which are harmless by the enzyme catalase found in the liver.



(H<sub>2</sub>O<sub>2</sub>)

(H<sub>2</sub>O)

(O<sub>2</sub>)

### 3. *Regulation of plasma proteins*

- The liver produces most of the proteins found in blood; fibrinogen and prothrombin which play a role in blood clotting. Albumin and globulins are also produced by the liver. Globulins act as antibodies;. Albumin contributes to the maintenance of osmotic pressure in the body; Non essential amino acids are synthesized by the liver;

### 4. *Storage of vitamins A, B,D,E and K and mineral salts*

- The liver store vitamins A, B, D, E and K. Iron released from the breakdown of erythrocytes is stored in the liver cells; in the form of a compound called ferritin. The liver therefore is a good source of these vitamins and iron;

### 5. *Heat production (Thermoregulation)*

- The various metabolic activities of the liver lead to release of heat energy; This energy is distributed by the blood to other parts of the body hence contributing to maintenance of constant body temperature;

### 6. *Inactivation of hormones and drugs*

- After performing their functions, hormones and drugs are chemically modified to inactive compounds; The by-products are eliminated through the kidneys and faeces and via bile;

### 7. *Storage of blood*

- The large size and high capacity for contraction and expansion of its veins enables the liver to hold a large volume of blood; It therefore regulates the volume of blood in the general circulation depending on the body's requirements ;

### 8. *Regulation of cholesterol and fat metabolism*

- When carbohydrates are in short supply in the body, fats in different parts of the body are mobilized and taken to the liver; The fats are oxidized to carbon (IV) oxide and water with the production of energy or modified and sent to tissues for oxidation;

### 9. *Manufacture of red blood cells in foetus.*

## Liver Diseases and Disorders

## 1. Liver Cirrhosis

- This is the hardening of the liver tissues due to death of liver cells.
- This is caused by ingestion of toxic chemicals such as alcohol.
- Bacteria, viruses and parasites such as liver flukes can also cause the disease.

### Control

- Avoid excess alcohol.
- Avoid fatty diets.
- Low salt intake

## 2. Hepatitis

- This is a viral disease causing inflammation of the liver.
- It is transmitted through contaminated food, milk and water.
- There are two types of hepatitis; Hepatitis A and B.

## 3. Jaundice

- This is characterized by the yellowing of the skin due to the failure of the liver to excrete bile.

## Homeostasis

- This is the maintenance of internal environment of cells under constant Conditions E.g. temperature, osmotic pressure, blood sugar and chemical constituents.

## Principles of Homeostasis

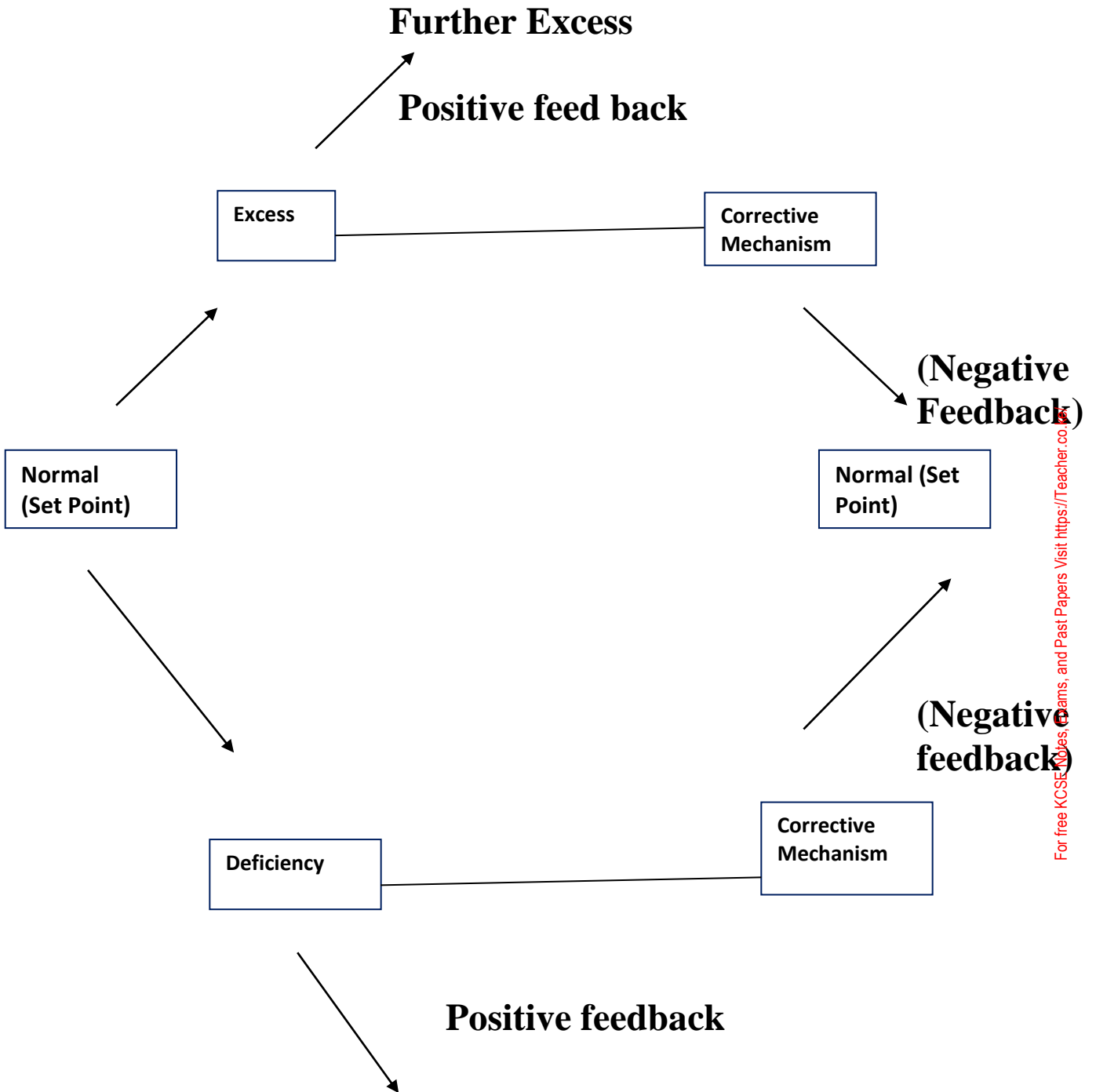
- Various body systems such as circulatory, excretory, endocrine (hormonal) and nervous work in a coordinated way to bring about homeostasis.
- These systems work on a feedback mechanisms. There are two types of feedback mechanisms.

### a) *Negative Feedback Mechanism*

- When a factor in the body such as temperature or blood sugar level falls below normal or rises above the normal, it is detected and corrected via the negative feedback mechanism.
- Such an action is through:



- i) An increase in the level if it is dropping
- ii) A decrease in the level if it is increasing
- This restores the condition to the normal.



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**Further deficiency**

**b) Positive Feedback Mechanism**

- In positive feedback mechanism, a change below or above the normal is not corrected.

*The following are some of the factors regulated through homeostasis.*

- *Temperature*
- *Osmoregulation (water and salt balance)*
- *Ionic content regulation*
- *Blood sugar regulation*

#### a) **Temperature Regulation. (Thermoregulation)**

- Hypothalamus of the brain is the thermoregulatory center. It also controls other homeostatic processes such as Osmoregulation, and blood sugar level.

### **Skin and Thermoregulation**

The skin is adapted in the following ways to effect thermoregulation;

#### **1. It has Hair shaft;**

- Connected to erector pili muscles;
- In low Temperature Erector pili muscle contract raising hair shaft erect;
- Hair traps air which insulates the body/poor conductor of heat;
- In high temperature, the Erector pili muscle relax and extends;
- Hair shaft lies on the skin;
- Little or no air is trapped;
- Skin loses heat through convection /conduction /radiation ;

#### **1. Blood vessels**

- In High temperature they vasodilate;
- More blood flows near skin surface;
- Heat is lost through conduction /convection/ radiation;
- In Low temperature they Vasoconstrict;
- Little blood flows near the skin;
- Less heat or ho heat lost through conduction/convection/ radiation;

### **Diagrams**

#### **3) Sweat gland**

- In High temperature, Sweating occurs and ( evaporates) and Carries latent heat of vaporization; cooling the body;

#### **4) Has subcutaneous layer; contains fat which acts as a heat-insulating layer. Organisms in cold areas have thick subcutaneous layer for heat insulation.**

## Homoiotherms and Poikilotherms

### Homoiotherms (Endotherms)

- They are the animals whose body temperature is maintained at a constant body temperature despite the wide fluctuations in the temperature of the external environment e.g. birds and mammals.

### Poikilotherms (Ectotherms)

- These are organisms with variable body temperature according to the temperature of the local atmosphere e.g. in organisms such as reptiles, amphibians, insects, and fish.

### Methods of Regulating Body Temperature in Animals.

- Metabolic activities of the Body, such as shivering to raise body temperature.
- Insulatory mechanisms such as dilation or constriction of blood vessels, hair movement etc.
- Behavioral activities such as clustering together, burrowing, basking, hibernation, aestivation, putting on warm clothes etc
- Presence of adaptive features such as hair/fur, subcutaneous tissue etc.

**Hibernation** is where animals go into deep sleep for long period of time due to cold.

**Aestivation** is where animals go into deep sleep due to dry and harsh conditions.

### *Differences Between Homoiotherms and Poikilotherms.*

| Poikilotherms   | Homoiotherms  |
|---|---|
| i) They are sluggish under cold conditions.                               | i) They remain active even under cold conditions.   |
| ii) They hibernate to avoid death by freezing under very cold conditions. | ii) Only the small animals hibernate because they have large surface area to volume ratio hence lose a lot of heat. |
| iii) They aestivate under very hot conditions.                            | iii) They do not aestivate because they can maintain constant body  |

|   |   |
|---|---|
|   | temperature.  |
| iv) They are easy prey to predators due to their hibernation and aestivation.         | iv) Not easy to prey because they active always.  |
| v) Require less food because they get heat from the environment to warm their bodies. | v) Require more food because they use it to generate heat for maintaining the temperature constant. |

### b) Osmoregulation (Water and Salt Balance).

- The osmotic pressure of the body fluids must be kept at a constant so as to have a favourable environment for the normal functioning of cells. This is determined by the relative amounts of water and solutes (salts) in the body fluids.
- If the osmotic pressure of these fluids falls below that of the cells, the cells take in water by osmosis, swell and may burst.
- If the osmotic pressure of these fluids was higher than that of the cells, the cells would lose water and shrink.
- The hypothalamus and the Pituitary gland are involved in Osmoregulation in the following ways;
  - i) When the osmotic pressure of the blood rises due to dehydration, the hypothalamus is stimulated and sends an impulse to the pituitary gland which secretes the *Antidiuretic Hormone (ADH) or Vasopressin* into the blood. ADH increases permeability of the kidney tubules to water. More water is reabsorbed, osmotic pressure of the blood falls hence production of little but concentrated urine.
  - ii) When osmotic pressure of the blood falls due to excess water in the body there is less production of ADH and less water is reabsorbed hence production of large amounts of dilute urine.

### Diabetes Insipidus

- This is a condition whereby large quantities of dilute urine are produced when the pituitary gland fails to produce ADH or

produces it in inadequate amounts. This condition is also known as *Diuresis*.

### c) Regulation of Ionic Content

- Important ions must be regulated within narrow ranges for efficient functioning of the cells.
- Ions are involved in processes such as respiration, protein synthesis, muscle contraction etc.
- The level of sodium ions is regulated by a hormone called *Aldosterone* produced by the adrenal glands.
- When the level of sodium ions is low in the blood, more Aldosterone is released which stimulates reabsorption of sodium ions into the blood.
- If sodium ions concentration in the blood rises above the optimum level, adrenal glands produce less Aldosterone into the blood and less amounts of sodium ions are reabsorbed.

### d) Regulation of Blood Sugar Level.

- All sugars such as galactose, lactose and fructose are converted to glucose.
- Glucose is broken down to release energy and excess is converted into glycogen and stored in the liver or converted into fats as stored as adipose tissue.
- Some glucose flows in general circulation of blood and is maintained within a narrow range of 90-100mg per 100cm<sup>3</sup> of blood.
- The pancreas produces two hormones Insulin and Glucagon that are responsible for blood sugar regulation.
- When there is *excess sugar in the blood, insulin is produced* and regulates the blood sugar level by the following;
  - i) Converts excess glucose into glycogen for storage.
  - ii) Inhibits conversion of glycogen to glucose.
  - iii) Converts glucose into fats.
  - iv) Increases breakdown of glucose to release energy.
    - When the level of the *blood sugar falls, glucagon* is secreted and corrects the situation by the following;
      - i) Increases the breakdown of glycogen into glucose.

- ii) Increases the conversion of fats and proteins into glucose.
- iii) Inhibits the conversion of glucose into energy.

NB/. *The hormone adrenaline produced by the adrenal glands also has homeostatic effect on glucose.*

*It is released during emergencies to avail glucose for fight or flight.*

### **Diabetes Mellitus (Sugar Disease)**

- This is due to a deficiency in insulin secretion from the pancreas.
- This leads to very high levels of sugar in the blood that cannot be utilised by cells hence eliminated by kidney in urine.

### **Symptoms**

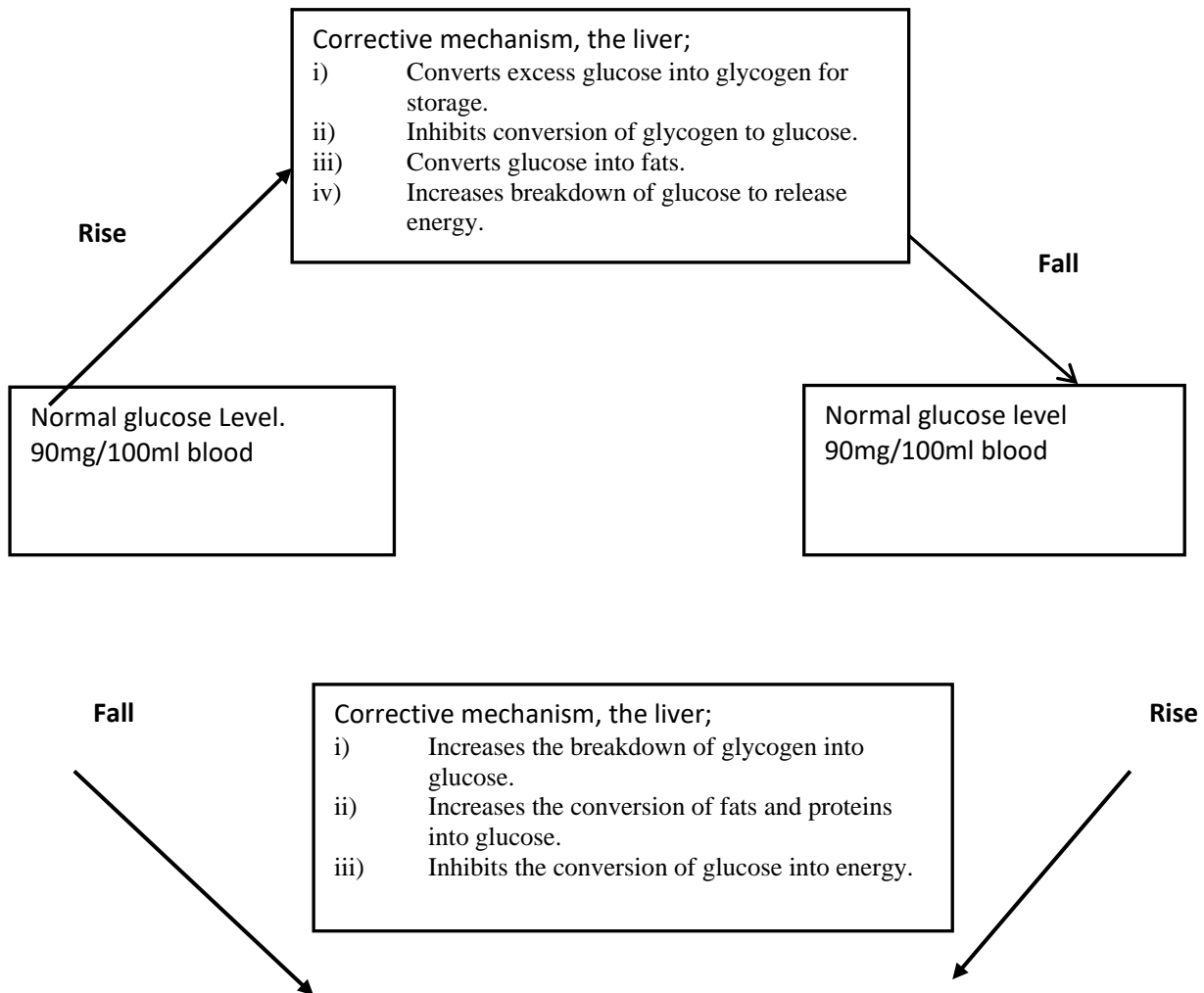
- Presence of glucose in urine
- Loss of body weight due to breakdown of fats and proteins
- Chronic starvation
- Thirst sensation.

### **Control**

- Insulin injection into the blood stream
- Avoid foods rich in sugars.
- Avoid excessive intake of alcohol.

### **Question**

- Explain why insulin is not administered orally (through the mouth)



## ***Revision questions***

### **Gaseous Exchange**

- This is the process by which respiratory gases (oxygen and carbon IV oxide) are passed across the respiratory surface.
- Gases are exchanged depending on their concentration gradient.
- In simple organisms such as amoeba, diffusion is enough to bring about gaseous exchange.
- CO<sub>2</sub> diffuses out into the surrounding water while oxygen diffuses from the water across the plasma membrane into the amoeba.

## **Diagram**

## Importance of Gaseous Exchange

1. Promote oxygen intake for respiration.
2. Facilitate carbon IV oxide removal from the body as a metabolic waste product.

## Gaseous Exchange in Plants

- During the day, green plants take in carbon IV for photosynthesis.
- Oxygen is given out as a byproduct of photosynthesis and is released into the atmosphere.

## Examples of respiratory Surfaces in Plants

- Stomata in leaves
- Roots e.g. pneumatophores
- Lenticels in woody stems

## Structure and Function of the Stomata

- They are tiny openings on the leaf surfaces. They are made up of two guard cells.
- Guard cells are the only epidermal cells containing chloroplasts. They regulate the opening and closing of the stomata.

## Adaptations of Guard Cells

- i) They are bean shaped/sausage shaped.
- ii) Contain chloroplast hence can photosynthesize.
- iii) Inner walls are thicker while outer wall is thin to facilitate the opening and closing of stomata.

## Diagram

## Mechanism of Opening and Closing of Stomata

- There are three theories that try to explain how the stomata open and close.
  - i) Photosynthetic theory
  - ii) Starch Sugar inter-conversion Theory. (effect of changes in pH of guard cells)
  - iii) Potassium Ion Theory.
- i) Photosynthetic theory**
- During the day, guard cells photosynthesize forming glucose.
- This glucose increases the osmotic pressure in the guard cells.
- Guard cells draw in water from the neighbouring epidermal cells and become turgid.



- The stoma opens.
- During the night, there is no photosynthesis due to absence of light.
- Glucose is converted into starch lowering the osmotic pressure in the guard cells.
- Guard cells lose water and become flaccid closing the stomata.

### ii) **Starch Sugar inter-conversion Theory. (effect of changes in pH of guard cells)**

- This is under the influence of pH in the guard cells.
- During the day CO<sub>2</sub> is used up during photosynthesis raising the pH in the guard cells.
- In this high pH, enzymes convert more starch into glucose.
- Osmotic pressure of the guard cells increases and water enters into them, making them turgid hence opening the stomata.
- During the night, there is no photosynthesis. The level of CO<sub>2</sub> increases lowering the pH.
- Enzymes become inactivated and starch is not converted into glucose.
- Osmotic pressure of guard cells falls making them to lose water by osmosis.
- Guard cells become flaccid and stoma closes.

### **Mechanism of Gaseous Exchange in Plants**

- Oxygen diffuses from the atmosphere where it is more concentrated into the plant.
- CO<sub>2</sub> diffuses out as a metabolic waste product along a concentration gradient into the atmosphere.

#### a) **Gaseous Exchange through the Stomata**

- Stomata are modified in number of ways depending on the habitat of the plant.

**Xerophytes:** These are plants adapted to life in dry areas.

- They have less number of stomata that are small in size.
- Stomata may be sunken, hairy and in some they open during the night and close during the day.

**Hydrophytes:** These are the aquatic plants (water Plants)

- They have many stomata that are large in size and mainly found on the upper leaf surface.
- Hydrophytes have the aerenchyma tissue with large air spaces to store air for gaseous exchange.

## Diagrams

**Mesophytes:** They are plants growing in areas with adequate amounts of water.

- They have a fairly large number of stomata found on both leaf surfaces.

### b) Gaseous Exchange through the Lenticels

- They are openings found on woody stems and they are made of loosely packed cells.
- They allow gaseous exchange between the inside of the plant and the outside by diffusion.
- Actual gaseous exchange occurs on some moist cells under the lenticels.

## Diagram

### c) Gaseous Exchange through the Roots

- Plants like the mangroves growing in muddy salty waters have specialized aerial breathing roots called pneumatophores.
- Pneumatophores rise above the salty water to facilitate gaseous exchange.

## Gaseous Exchange in Animals

### Types and Characteristics of Respiratory Surface

- Different animals have different respiratory surfaces depending on the animal's size, activity and the environment in which it operates as shown below.

| Type of Respiratory Surface | Environment/Medium of Operation | Example of Organism |
|-----------------------------|---------------------------------|---------------------|
|-----------------------------|---------------------------------|---------------------|

|                   |       |           |
|-------------------|-------|-----------|
| 1. Cell Membrane. | Water | Amoeba    |
| 2. Gill Filaments | Water | Fish      |
| 3. Tracheoles     | Air   | Insects   |
| 4. Alveoli/Lungs  | Air   | Mammals   |
|                   |       | Birds     |
|                   |       | Frogs     |
|                   |       | Reptiles  |
| 5. Skin           | Water | Frog      |
|                   | Air   | Earthworm |
| 6. Buccal Cavity  | Air   | Frog      |

- The respiratory surface is the basic unit of any breathing system upon which actual gaseous exchange occurs by diffusion.
- Respiratory surfaces have the following main characteristics.
  - i) *Must have a large surface area.*
  - ii) *Must be moist to allow gases to diffuse in solution form.*
  - iii) *Have a dense network of blood capillaries for efficient gaseous exchange.*
  - iv) *Have a thin membrane to reduce the diffusion distance.*

### **Gaseous Exchange in Insects**

Insects have their gaseous exchange system made of many air tubes forming the tracheal system.

- Tracheal system is made up of spiracles and Tracheoles.
- Spiracles are external openings found on both sides of the abdomen and thorax.
- Spiracles have valves to control their opening and closing. They also have hairs to prevent excessive water loss from the body tissue.
- Spiracles open into tubes called trachea. Trachea is reinforced with spiral bands of chitin to keep them open.
- Trachea subdivides into finer air tubes called Tracheoles. Tracheoles are in direct contact with body tissues and organs and they supply individual cells with oxygen.

- Tracheoles do not have bands of chitin and therefore they allow gaseous exchange across their thin moist walls.

## Diagram

### Mechanism of Gaseous Exchange in the Tracheal System of an Insect

- Air is drawn into and out of the tracheal system by muscular movement of the abdominal wall.
- When spiracle valves are open, air is drawn into the tracheal system. The valves close and air is forced along the system by muscle movement.
- Oxygen diffuses into the tissue fluid and into the cells.
- CO<sub>2</sub> diffuses out of the cells and into the tissue fluid then into the tracheal system.

### Gaseous Exchange in Fish

- The breathing system of the fish consists of the following;
  - **Mouth (buccal) cavity.**
  - **Gills.**
  - **Opercular cavity.**
  - **Operculum.**
- Gills are made of a long curved bone called the gill bar.
- Gill filaments arise from one side of the gill bar. They are many and suspend freely in water providing a large surface area for gaseous exchange.
- Gill rakers arise from the other side of the gill bar. They are teeth like and they prevent solids present in water from damaging the delicate gill filaments.
- Blood vessels enter the gill bar and branch into the gill filaments as blood capillaries.
- Operculum is found on either side of the body near the head and it also protects the delicate gills.

## Diagram

### Mechanism of Gaseous Exchange in the Gills of a Bony Fish

- Floor of the mouth cavity is lowered increasing the volume of the mouth cavity but lowering the pressure.
- Water flows into the mouth cavity and the operculum closes.
- Operculum on either side bulge outwards without opening. This increases volume in the gill cavity but the pressure drops.
- Water containing dissolved oxygen flows from the mouth cavity to the gill chamber over the gills.
- The mouth closes and the floor of the mouth cavity is raised.
- The remaining water in the mouth is forced to flow towards the gill chamber.
- Oxygen diffuses from the water into the blood through the thin walls of the gill filaments. It combines with haemoglobin for transportation to all body parts.
- CO<sub>2</sub> diffuses from the blood into the flowing water.
- To ensure maximum gaseous exchange, the water flowing over the gills and the blood in the gills flows in opposite directions.
- This is called counter current flow system and it ensures that at all the points, concentration of oxygen is always higher in the water than in the blood.

### Diagram

- If the water and blood were flowing in the same direction, gaseous exchange will not be that effective.
- Where the oxygen is 50% in water, there is no concentration gradient because blood also has 50% oxygen concentration.

### Diagram

#### Mechanism of Gaseous Exchange in Amphibians

- Amphibians live on both land and water and therefore exhibit the following methods of gaseous exchange.
    1. Gaseous exchange through the lining of the buccal cavity
    2. Gaseous exchange through the lungs
    3. Gaseous exchange through the skin
- a) Gaseous exchange through the mouth (buccal) cavity**

- Air is taken in or expelled from the mouth cavity by raising and lowering of the floor mouth.
- Lining of the mouth cavity is moist to dissolve oxygen.
- There is a rich supply of blood capillaries under the lining of the mouth cavity. Oxygen diffuses into the blood and is carried by haemoglobin to all parts of the body.
- Carbon IV oxide from the tissues is brought by the blood to the mouth cavity where it diffuses out.
- **Gaseous exchange through the lungs**
- The frog has two lungs which are connected to the buccal cavity.
- The inner lining of the lungs is moist, thin and is richly supplied with blood capillaries.
- During inspiration, the floor of the mouth cavity is lowered and nostrils are open. Air rushes through the open nostrils into the mouth cavity.
- Nostrils close and the floor of the mouth cavity is raised. This reduces the volume and increases the pressure in the mouth cavity, forcing air into the lungs.
- Carbon IV oxide from the tissues diffuses into the lung while the oxygen from the lungs diffuses into the tissues.

#### **b) Gaseous exchange through the skin**

- Frogs have a thinner and moist skin than the toads.
- There is a large network of blood capillaries below the skin to carry the respiratory gases.
- Oxygen from the air and water diffuses through the skin into the blood stream.
- Carbon IV oxide diffuses out of the blood capillaries through the moist skin into the surrounding water and air.

#### **Mechanism of Gaseous Exchange in Mammals**

- The following structures are involved in gaseous exchange in mammals;
  - **Nose (Nostrils)**
  - **Larynx**

- **Trachea**
- **Chest cavity (ribs and intercostals muscles)**
- **Diaphragm.**

#### **a) Nose**

- It has two openings called nostrils which let in air into the air passages.
- As air moves in the passages, it is warmed and moistened
- The lining of the nasal cavity has also the sense organs for smell.

#### **b) Larynx**

- It is located on top of the trachea
- It is called the voice box. It controls the pitch of the voice.

#### **c) Trachea**

- It is a tube made of rings of cartilage which prevents it from collapsing during breathing.
- Inside it is lined with ciliated epithelium. Cilia beat in waves and move mucus and foreign particles away from the lungs towards the pharynx.
- As the trachea enters the lungs, it divides into two branches called Bronchi (Bronchus).

#### **d) Lungs**

- They are found in the chest cavity and they are enclosed by a double membrane called the pleural membrane.
- The space between the membranes is called the pleural cavity.
- Pleural cavity is filled with pleural fluid which reduces friction making the lungs to move freely in the chest cavity during breathing.

#### **Diagrams**

- In the lungs each bronchus divides into small tubes called bronchioles.
- Bronchioles branch further to form air sacs called alveoli (alveolus)
- Alveolus is covered by a fine network of blood capillaries.

## The mechanism of breathing

- Breathing is achieved by changes in the volume and air pressure of the thoracic cavity.
- Thoracic cavity is enclosed by ribs.
- Ribs are covered by intercostals muscles.
- The diaphragm is a muscular sheet of tissue below the chest cavity. It curves upwards in the form of a dome shape.
- Breathing mechanism involves two processes.
  - a) Inspiration (Inhalation) i.e. breathing in.
  - b) Expiration (Exhalation) i.e. breathing out.

### Inspiration (Inhalation) i.e. breathing

- This occurs when the volume of thoracic cavity increases and the pressure decreases.
- External intercostals muscles contract while the internal intercostals muscles relax.
- Ribs are pulled upwards and outwards.
- Diaphragm flattens increasing the volume of the thoracic cavity while decreasing the pressure inside it.
- Air rushes into the lungs through the nose and trachea inflating the lungs.

### Diagrams page 62

### Expiration (Exhalation) i.e. breathing out

- Volume of thoracic cavity decreases while pressure increases. This is brought about by the following;
- External intercostals muscles relax while internal ones contract.
- Ribs move downwards and inwards.
- Diaphragm relaxes and regains its original dome shape.
- Volume of the thoracic cavity decrease and pressure increases.
- Air is forced out of the lungs through the air passages to the atmosphere.

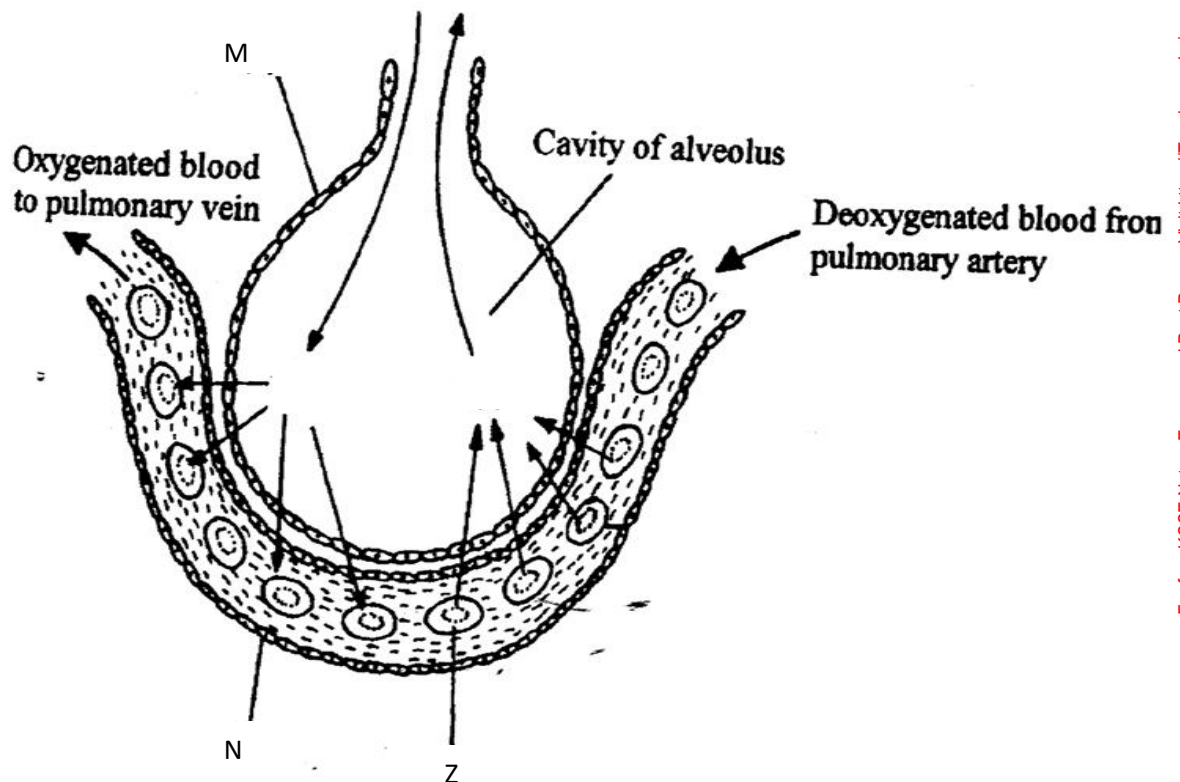
### Gaseous exchange in the alveolus

- Alveoli and blood capillaries are made of very thin walls.



- The wall of the alveolus is covered by a film of moisture which dissolves oxygen in the inhaled air.
- Oxygen diffuses through the epithelium of the alveolus, the capillary wall and through the cell membrane of the red blood cells.
- In the red blood cells it combines with haemoglobin.
- Carbon (iv) oxide is more concentrated in the blood capillaries than in the alveoli.
- It therefore diffuses from the capillaries into the alveoli.
- Water vapour also passes out of the blood by the same process.

**Diagram page 64 KLB**



**Percentage composition of gases in inhaled and exhaled air**

| Gas                      | % in inhaled air. | % in exhaled air |
|--------------------------|-------------------|------------------|
| Oxygen                   | 20                | 16.9             |
| Carbon (iv) oxide        | 0.03              | 4.0              |
| Nitrogen and other gases | 79.97             | 79.97            |

**Regulation of Breathing**

This is controlled by a part of the brain called *Medulla oblongata*.

## Factors affecting the rate of breathing in humans

### 1. Exercise

Breathing rate increases during vigorous activity.

### 2. Age

Younger people have a faster breathing because their bodies have more energy demand.

### 3. Emotions

Things like anxiety, fear and fright increases the breathing rate.

### 4. Temperature

Relatively high temperatures increase the rate of breathing. However, very high temperatures reduce the breathing rate.

### 5. Health

If there is fever (high body temperature), the breathing rate increases. Some respiratory diseases however, make breathing difficult.

## Lung Volumes

#### i) *Lung capacity*

This is the total amount of air the lungs can hold when completely filled. The lungs of an adult have a capacity of about  $5,500\text{cm}^3$

#### ii) *Tidal volume*

This is the amount of air taken in and out of the lungs during normal breathing. Tidal volume is about  $500\text{cm}^3$

#### iii) *Inspiratory reserve volume*

This is an additional volume attained after having a forced inhalation in addition to the tidal volume. It is about  $2000\text{cm}^3$

#### iv) *Inspiratory capacity*

This is the tidal volume +Inspiratory reserve volume.

#### v) *Expiratory reserve volume*

This is air removed after a forced exhalation. It can be up to  $1,300\text{cm}^3$

#### vi) *Vital capacity*

This is the deepest possible exhalation. This air can only be forcibly pushed out of the lungs.

#### vii) *Residual volume*

This is the air that normally remains in the lungs after the deepest exhalation. It is normally about 1,500cm<sup>3</sup>

## Diagram

## Diseases of the Respiratory System

### i) *Asthma*

It is caused by:

- Allergens such as pollen grains, certain foods and drugs
- Infections of the lungs by bacteria and viruses

### Symptoms

- Difficulty in breathing
- Wheezing sound when breathing

### Treatment and Control

- Avoiding the causative agents
- Injection of drugs and oral application of pills
- Spraying directly into the bronchial tubes with a muscle relaxant

### ii) *Bronchitis*

There are two types; Acute and Chronic

### Symptoms

- Production of thick greenish or yellowish sputum
- Difficulty in breathing
- Difficulty in walking and sleeping

### Treatment

- Seeking early medical assistance

### iii) *Whooping cough*

It is caused by a bacterium called *Bordetella pertussis*.

### Symptoms

- Prolonged coughing and vomiting
- Conjunctival haemorrhage (bleeding)
- Convulsions and coma
- Severe pneumonia in the bronchioles
- Ulcers and heart complications

- Emaciation due to repeated vomiting

### **Treatment**

- Use of antibiotics
- Use of a balanced diet on patients

### **Control**

- Children immunization at early age

#### iv) *Pneumonia*

It is caused by a bacterial called *Streptococcus pneumoniae*

### **Symptoms**

- Coughing
- Fever
- Chest pains
- Deposits of fluids in the lungs

### **Treatment**

- Use of antibiotics such as penicillin and sulphonamides

### **Control**

- Avoid overcrowding.
- Good ventilation in living houses

#### v) *Pulmonary Tuberculosis*

It is caused by a bacterium called *Mycobacterium tuberculosis*.

### **Symptoms**

- Weight loss
- Coughing with blood stained sputum.
- Fever

### **Treatment**

- Use of antibiotics such as streptomycin

### **Control**

- Pasteurization of milk
- Immunization using BCG (Bacille Calmette Guerin)
- Use of radiography (X-Ray)

#### vi) *Lung cancer*

Cancer is uncontrolled cell growth in the body causing tumours.

### **Some general causes**

- Smoking

- Inhalation of cancer causing substances such as asbestos
- Exposure to radiations such as X-rays, radioactive substances such as uranium and substances that alter the genetic composition of the cell such as mustard gas

### **Treatment and control**

- Surgery to remove the tumour
- Radiotherapy
- Chemotherapy
- Use of some drugs
- Not smoking

### **Revision Questions**

## **RESPIRATION**

- Process by which food substances are chemically broken down in living cells to release energy, carbon (iv) oxide, water or alcohol.
- Respiration takes place mainly in the mitochondria. It has two membranes, inner and outer.
- Inner membrane is folded into projections called cristae. Cristae provide a large surface area for respiratory enzymes. Respiratory enzymes are bound to the cristae.

### **Diagram**

### **Practical Activity 1**

**To investigate the gas given off when food is burnt.**

### **Types of Respiration**

- **Aerobic Respiration**
- **Anaerobic Respiration.**

### **Aerobic Respiration**

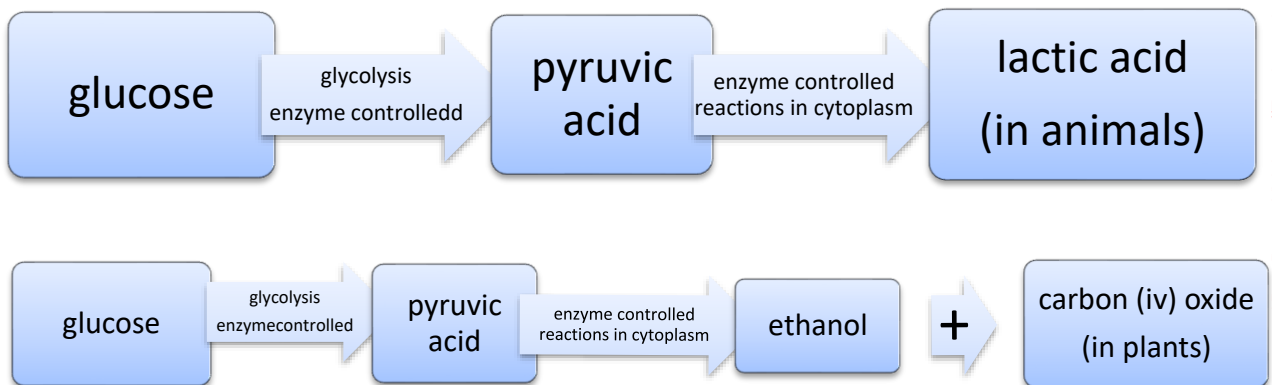
- Process by which food substances such as glucose are broken down in the presence of oxygen to release energy, water and carbon (IV) oxide.
- The energy is stored in the form of a chemical substance called Adenosine Triphosphate (ATP).
- This energy is released in small quantities since a lot of heat energy would burn the body cells.



- Respiration takes place in two phases with each phase consisting of series of reactions.

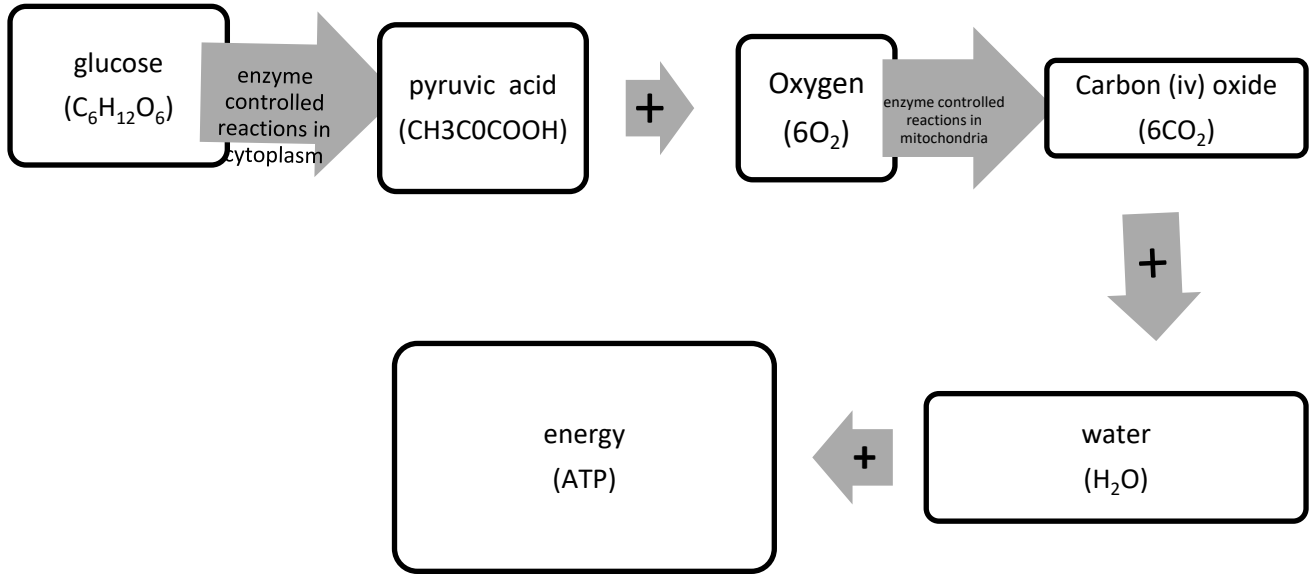
### First Phase (Glycolysis)

- This takes place in the *cell cytoplasm*. *Oxygen is not required* in this stage.
- Glucose is broken down into a 3 carbon compound called Pyruvic acid through a process called glycolysis.
- In glycolysis *one molecule of glucose gives 2 molecules of ATP*.
- In absence of oxygen Pyruvic acid is broken down into lactic acid in animals and into alcohol (ethanol) in plants.



### Second phase (Krebs Cycle)

- This takes place in the *matrix of the mitochondria* and involves a series of enzyme controlled reactions *that require oxygen*.
- Pyruvic acid formed in the first phase is oxidized by oxygen in a series of enzymatic reactions (Krebs cycle) into energy, water and carbon (IV) oxide.
- In this phase *one molecule of glucose gives 38 molecules of ATP*.



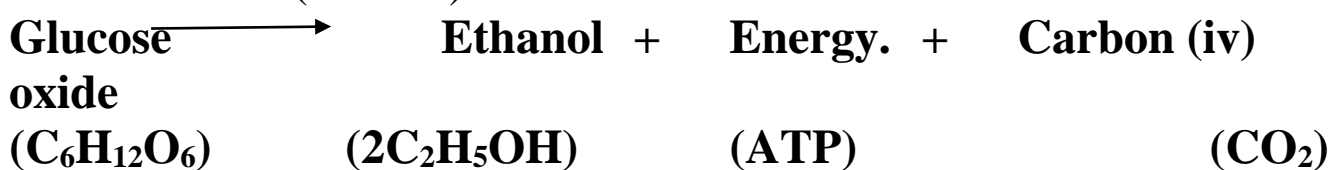
- The following conditions are required in this phase;
  - i. Cells must be provided with glucose/food.
  - ii. Oxygen must be present.
  - iii. Respiratory enzymes must be present to catalyse the reaction.
  - iv. Temperature must be favourable for efficient functioning of enzymes.
  - v. End products of the reaction (energy, water and carbon (iv) oxide) must be constantly removed from the mitochondrion.

### Practical Activity 2

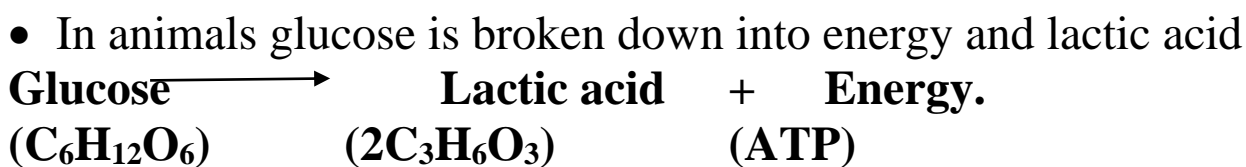
*To investigate heat production in germinating seeds.*

### Anaerobic Respiration in Plants and Animals

- This is the process by which food substances are broken down in the absence of oxygen to release energy.
- The glucose is not completely broken down hence less energy is given out.
- In plants glucose is broken down into energy, carbon (iv) oxide and ethanol (alcohol).



- Anaerobic respiration in plants is also referred to as *fermentation*.



### Oxygen Debt

- This is oxygen required to get rid of the lactic acid that accumulates in the body tissues when the oxygen supply is less than required.
- Accumulation of lactic acid causes fatigue and muscle cramps.
- Oxygen debt is paid back by breathing more quickly and more deeply in order to increase oxygen supply such as during recovery period after a race when a person pants.
- When paying back the oxygen debt, lactic acid is oxidized to energy, water and carbon (iv) oxide or it is taken to the liver and converted into glycogen.

### Application of Anaerobic Respiration

- Baking industry
- Beer brewing and distillery industry.
- Dairy industry in the production of yoghurt and cheese.
- Production of vinegar citric acid, oxalic acid, butyric acid and some drugs.
- Production of power alcohol which is used as a substitute for petrol.
- Silage making.
- Biogas production.
- Making compost manure

### Practical Activity 3

To investigate gas produced during fermentation.

### Comparison between Aerobic and Anaerobic Respiration

| Aerobic Respiration  | Anaerobic Respiration.  |
|--|---|
| i. Oxygen is required  | Oxygen not required   |
| ii. High amount of energy is released as one molecule of glucose yields 38 ATP molecules (2880 KJ) | Low amount of energy is released as one molecule of glucose yields 2 ATP molecules (210 KJ) |
| iii. There is complete   | There is incomplete breakdown   |



|      |  |  |
|------|--|--|
|      | breakdown of the substrate into carbon (iv) oxide and water. | of substrate hence lactic acid or alcohols are produced.               |
| iv.  | End products are energy, water and carbon (iv) oxide         | End products are energy, alcohol in plants and lactic acid in animals. |
| v.   | Water molecules are produced.                                | Water molecules are not produced.                                      |
| vi.  | Over a short period of time, energy is not released faster   | Over short period of time, energy is released faster.                  |
| vii. | Occurs in the cytoplasm and in the mitochondrion.            | Occurs only in the cell cytoplasm.                                     |

## Respiratory Substrates

- These are energy rich foods which when oxidized release energy. They include;

### i. *Carbohydrates* –

- They are the main source of energy mainly in the form of simple sugars such as glucose, fructose and galactose.
- They produce about 17KJ (2898/mole) per gram when completely oxidized.

### ii. *Fats* –

- They produce more energy than carbohydrates or proteins. One gram of fats yields about 38 KJ of energy when completely oxidized.
- They are however not the main substrate because they are not very soluble in water hence not easily transported to the sites of respiration. It also requires more oxygen to oxidize one gram of fats than one gram of glucose.

### iii. *Proteins* –

- They are not normally used in respiration unless in cases of extreme starvation.
- One gram of proteins yields 22KJ of energy when completely oxidized.

## Assignment

- Where do plants and animals get the following from;
  - Carbohydrates.
  - Fats
  - Proteins

## Respiratory Quotient (RQ) and its Significance

- RQ is the ratio showing the relationship between the amounts of carbon (iv) oxide used against the amount of oxygen used in respiration.

$$RQ = \frac{\text{volume of carbon (iv) oxide produced}}{\text{volume of oxygen consumed}}$$

- RQ varies with the type of substrate being oxidized. For example carbohydrates have a RQ of 1.0 when fully oxidized, fats have 0.7 and proteins have 0.9.
- RQ can therefore be used to indicate the type of substrate being oxidized and also whether aerobic respiration or anaerobic respiration is taking place.
- RQ is also affected by factors such as age, health of the organism and the temperature.

## Factors Affecting the Rate of Respiration

- Oxygen concentration.* When the amount of oxygen increases, the respiration rate also increases. Decrease in oxygen concentration will lead to decreased respiration rate.
- Substrate concentration.* Increase in sugar concentration increases respiration and vice versa.
- Hormones.* Presence of some hormones such as **adrenaline and thyroxine** in the body increases the rate of respiration.
- Surface area to volume ratio (Body size).* If the SA/volume ratio is high, the organism would lose more heat energy. As more heat is lost to the surrounding more is required to replace the lost energy hence more respiration.
- Age.* Young people require more energy because their cells are actively dividing hence respiration rate is higher in them than in older people.

- vi. *Occupation.* People engaged in heavier tasks have higher rate of respiration.
- vii. *Sex.* Generally male's have faster respiration rate than females due to presence of more muscles in their bodies.
- viii. *Basal metabolic rate.* This is the energy required to maintain normal body functions such breathing, heartbeat, blood circulation etc while at rest.

## Revision Questions

# FORM THREE BIOLOGY NOTES

## ECOLOGY

### *Introduction*

*Ecology* is the study of the interrelationships of organisms to each other and to their environment (biotic and Abiotic factors).

*Autecology*; study of single species within a community and how it relates with both the biotic and Abiotic factors.

*Synecology.* This is the study of many different species of organisms interacting among themselves within an ecosystem.

Ecology helps to address the following issues.

- Sustainable food production
- Pollution control
- Natural resources conservation
- Pest and disease control
- Population control
- Eco-tourism
- Prediction of adverse weather conditions

### *Concepts of ecology*

- **Biosphere/ecosphere.** This is the part of the earth and atmosphere inhabited by living organisms.
- **Habitat.** This is a specific locality with a particular set of conditions where an organism lives. Habitats can be terrestrial or aquatic.

- **Ecological niche.** This is the position occupied by an organism in a habitat. It includes the *physical space* where an organism is found and *its role* in the habitat.
- **Population.** This refers to all members of a given species in particular habitat.
- **Community.** This refers to all organisms belonging to different species interacting in the same habitat. Many populations make up a community.
- **Ecosystem.** This is a natural unit made of biotic and Abiotic factors whose interactions lead to a self sustaining system. E.g. a tropical rain forest, a small pond etc.
- **Biomass.** This is the total dry weight of living organisms at a particular Trophic (feeding) level or per unit area.
- **Carrying capacity.** This is the maximum number of organisms an area can comfortably support without depletion of the available resources. E.g. the maximum number of cows a pasture land can comfortably hold without overgrazing.

### Study Question 1

#### Factors in an Ecosystem

They are divided into two:

1. Abiotic factors or the non living factors
2. Biotic or the living factors

#### *Abiotic Factors*

- **Light.** This is required by plants and photosynthetic bacteria to manufacture food. The sun is the source of light energy. Light intensity and quality (wavelength) affects the rate of photosynthesis, flowering and germination in plants, while in animals it affects migration, hibernation and reproduction. Light intensity is measured using a **Photographic Light meter** while a **Seechi disc** measures light penetration in water.
- **Atmospheric pressure.** Variation in atmospheric pressure affects the availability of oxygen and carbon (IV) dioxide in the atmosphere. These two gases in turn affect the distribution of

living organisms. Low atmospheric pressure increases the rate of transpiration. Barometer is used to measure it.

- **Humidity.** This is the amount of water vapour in the atmosphere. It affects the rate of water loss from plants and animals surfaces through transpiration and sweating respectively. The higher the humidity the lower the rate of loss and vice versa. It is measured using the **hygrometer**.
- **Salinity.** This refers to the salt concentration of the water. This divides the aquatic environment into *marine, estuarine and fresh water*. Only organisms with adaptable osmoregulatory features can comfortably occupy such habitats. In estuaries, there are fluctuations of salt concentrations at different times. When the sea tide is low, the salt concentrations are low due to the greater diluting effect of the fresh water being discharged. High tide raises the salt level. Estuarine organisms must therefore be adapted to cope with such wide salt variations.
- **Wind.** This is moving air. It increases the rate of water loss from organisms affecting their distribution. It also influences rain formation. It helps in formation of sand dunes in deserts which become habitats for the growth of deserts plants. Its an agent of seed and fruit dispersal
- **Temperature.** This affects the distribution of organisms in any habitat. Very low temperature may inactivate enzymes while very high temperatures denature them. Temperature varies due to seasons, altitude, and latitude and diurnally in hot deserts.

- **pH (hydrogen ion concentration.)**

This is the measure of acidity or alkalinity of water in aquatic habitats or soil solution. This influences the distribution of plants and animals in soil and aquatic habitats. Different organisms have different pH requirements. pH is determined using the pH meter.

## Study Question 2

## Practical Activity 1

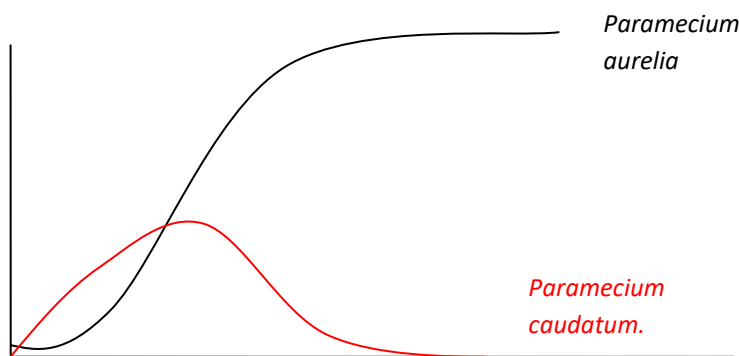
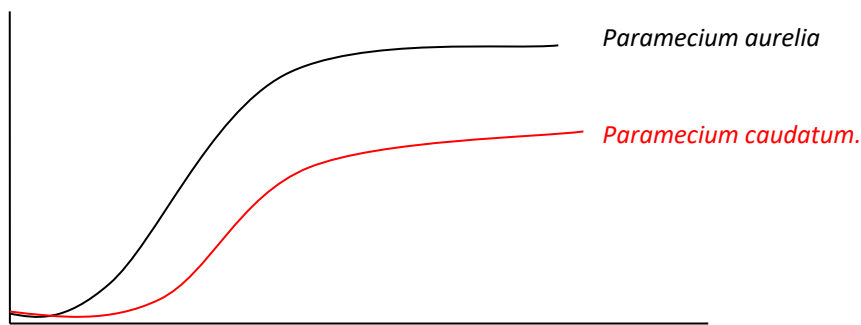
## Study Question 3

## Biotic Inter-Relationships

## Competition

Living organisms compete for resources such as nutrients, space, light and mates. There are two types of competition.

- i.) **Inter-specific competition.** This is the competition between individuals of different species for the same resources. For example. An experiment<sup>6</sup> was carried out on two closely related species of paramecia- *Paramecium caudatum* and *Paramecium aurelia*. It was observed that when each species is grown separately in controlled cultures with constant food supply, they show normal population growth. When they are grown together in the same culture, there is competition and *Paramecium caudatum* is eliminated. See graphs.



However, closely related species can live together without competition. For example, when *Paramecium caudatum* and *Paramecium bursoria* are grown in the same culture, there is no competition because each species occupies a different part of the culture. Similarly, browsers and grazers can occupy same habitat without competition because they feed at different levels of the same plants. For example, the zebras eat the softer shoots, followed by the

wild beasts, and the gazelles which eat the fibrous left over of the same grass.

### Study Question 4

ii.) **Intra-specific competition.** This is the competition between members of the same species for the same resources.

When there is competition the best adapted organisms survive while the less adapted ones may die or be forced to migrate.

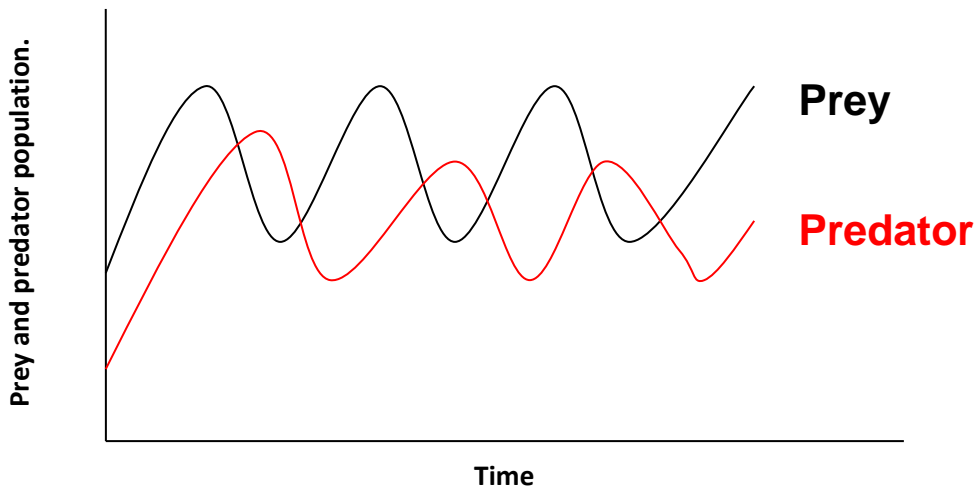
- **Predation**

This is the relationship where one organism kills another for food and feed on it either as a whole or a part of it. The **predator** is the one which kills while the **prey** is the one being killed for food.

Predators have various adaptations to enable them to be efficient in capturing the prey. These include;

- ☞ Sharp eyesight as in eagles, kites and hawk
- ☞ Fast flight,
- ☞ Modified beaks
- ☞ Strong jaws with carnassial's teeth as in leopards and lions.
- ☞ Large claws on strong forelimbs.
- ☞ Colour camouflage such as the spotted pattern of the leopard blends well with the background colour of the bushes and trees.
- ☞ Moving against the wind while stalking the prey. Preys also have structural and behavioural adaptations. These include:
  - ☞ Swift movement e.g. the antelope and gazelle
  - ☞ Camouflage e.g. in gazelles and stripes of the zebra.
  - ☞ Large eyes on the sides of the head to giving them a wide field of view
  - ☞ Confrontational display in porcupine

*NB/. When the number of the prey increases that of the predators also increases. An increase in the number of predators leads to a decrease in the population of the prey. This decrease in prey population leads to a fall in predator population which in turn gives space for the increase in the population of the prey. This is the basis of biological control. See the graph below.*



- **Parasitism**

- This is the relationship where an organism [**parasite**] obtains nutrients from another live organism [**host**] without killing it. The parasite obtains food and shelter from the host causing some harmful effects. Parasites may weaken the host and also transmit diseases which may kill their host thus reducing their number and distribution. There are two types of parasites;

- ☞ **Ecto-parasites**

- ☞ **Endo-parasites**

### Study Question 5

- **Symbiosis**

This is an association between two of different species in which both benefit. For example the association of colon bacteria with humans and other animals, especially plant-eating animals, the ox-pecker bird and the ox etc.

The *Rhizobium* bacteria help the leguminous plants to fix nitrogen while the bacteria obtain shelter and carbohydrates from the plants.

Diagram

- **Saprophytism**

This is where organisms obtain nutrients from dead organisms causing decomposition hence releasing nutrients into the ecosystem.

Saprophytes include the bacteria and fungi.

### The Nitrogen Cycle

This refers to the cycling of nitrogen and its compounds in the natural environment.



- ☞ Although nitrogen is abundant in the atmosphere as nitrogen gas, it cannot be utilised by plants. It has to be converted into a form that can be absorbed by plants through a process called **nitrogen fixation**.
- ☞ Nitrogen fixation is done in two ways;
- ☞ **Biological fixation.** This can occur in two forms
  1. **Nitrogen fixation by symbiotic bacteria** such as *Rhizobium spp.* They are found in the root nodules of legumes. They convert nitrogen gas into ammonia which is then converted into nitrates for plant utilisation.
  2. **Nitrogen fixation by free living bacteria e.g. *Clostridium, Azotobacter,* and some algae such as *Anabaena, chlorella and Nostoc.***
- ☞ **Non-Biological nitrogen fixation.** This is done by lightning. During thunderstorms, lightning energy combines atmospheric nitrogen gas with oxygen to form nitrous and nitric acid. These are then converted into nitrates.
- ☞ Plants absorb nitrates and convert them into plant proteins. Animals feed on these plants and obtain the proteins. They are then digested into amino acids and become assimilated into animal proteins.
- ☞ When living organisms die, saprophytic bacteria and fungi break down the proteins in their bodies into ammonia. Nitrifying bacteria convert this ammonia into nitrates through a process called **nitrification**. *Nitrosomonas and Nitrococcus* convert ammonia into nitrites and *Nitrobacter* convert nitrites into Nitrates.
- ☞ Some soil micro organisms such as *Pseudomonas denitrificans & Thiobacillus denitrificans* utilise the oxygen in the nitrates reducing it to nitrites, ammonia and eventually into nitrogen gas. This is called **de-nitrification**.
- ☞ This reduces the amount of nitrogen available to plants but it frees the nitrogen so that it becomes available for the cycle to continue.

## Diagram

## Practical activity 2

### Study question 6

#### Energy Flow in an Ecosystem

The sun is the natural source of energy. This energy is transferred to the following feeding levels;

- Producers
- Primary consumers
- Secondary consumers
- Tertiary consumers
- Quaternary consumers
- These feeding levels are called **Trophic levels**

#### Decomposers

They break down organic materials into simple substances which are made available for re-use by other organisms. Decomposers are mainly fungi and bacteria.

#### Food Chains

This is the representation of energy flow from a producer to other organisms linearly. Green plants are eaten by herbivores which are eaten by carnivores.

Producers'      Primary consumers      Secondary consumers  
Tertiary consumers      Quaternary consumers

Some energy is lost as it is moved from one trophic level to the next. This is through respiration, defecation, excretion and in form of heat.

#### Fig. 2.7

#### Examples

When the decomposers are included in a food chain, they are placed at the end.

#### Study Question 7

#### Food Webs

These are several interconnected food chains. Simple food chains rarely exist since in any ecosystem, many populations interact.

#### Examples

#### Study Question 8

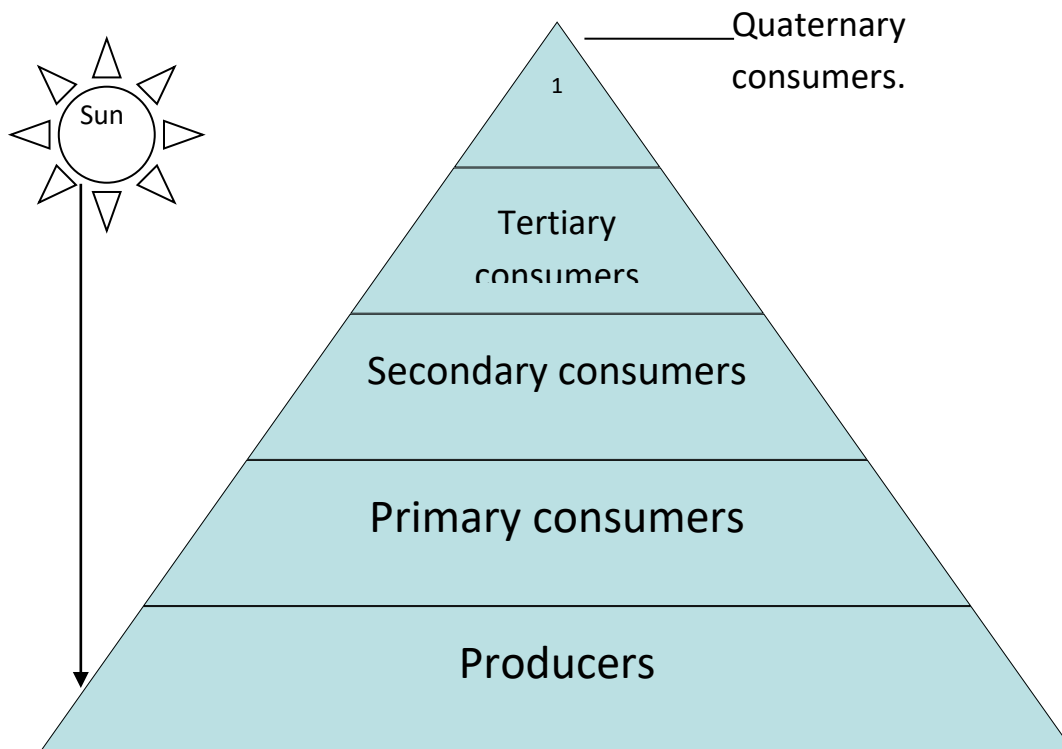
## Ecological Pyramids

These give a simplified representation of feeding relationships and energy flow in an ecosystem. They are of three types.

- **Pyramid of numbers**
- **Pyramid of biomass**
- **Pyramid of energy**

### Pyramid of Numbers

There is a progress decrease in the number of organisms as one move from the producers all the way to the quaternary consumers. Producers have the greatest number followed in a decreasing order by primary, secondary, tertiary and quaternary consumers.



### Construction of Pyramid of Numbers

- i.) Use data provided or collected.
- ii.) From the data, identify and draw the most suitable food chain.
- iii.) Indicate the numbers at each trophic level in the food chain.
- iv.) Choose a suitable scale for the data.
- v.) Using the chosen scale draw a horizontal rectangular bar to represent the number of the producers as the base of the pyramid.

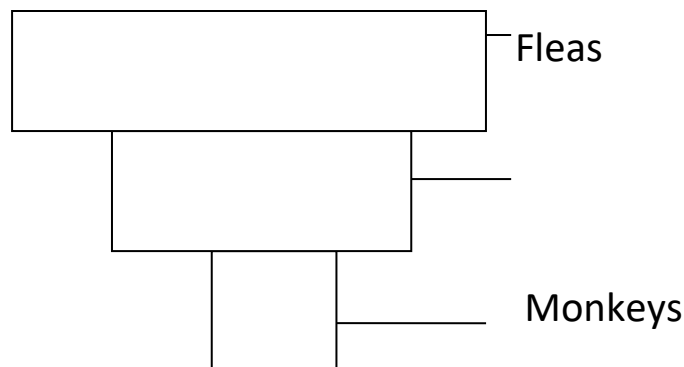
vi.) Progressively draw horizontal bars of the other trophic levels in their ascending order.

- *Ensure that the width of the bars is uniform.*

### Study Question 9

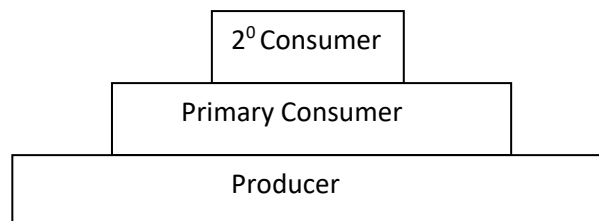
#### Interpretation of Pyramid of Numbers

- Generally the body size of organisms increases at each trophic level from the base to the apex of the pyramid as their number decreases.
- At each trophic level much energy is lost through respiration, excretion, sweating, defecation etc. therefore less energy is transmitted to the succeeding trophic level. Fewer organisms can therefore be supported.
- Inverted pyramid of numbers also exist. For example where one mango tree supports several monkeys each being fed on by several fleas.



#### Pyramid of Biomass

Biomass of an organism is its constant dry weight. In an ecosystem, the producers have the highest biomass followed in decreasing order by primary, secondary, tertiary and quaternary consumers.



### Study Question 10

#### Practical activity 3

## Study Question 11

### Population

Populations change in size, structure and organisation.

#### Characteristics of a population.

- **Density.** This is the number of individuals per unit area. E.g. 50 gazelles per Km<sup>2</sup>.
- **Dispersion.** This is the distribution or spread of organisms in a habitat.
- **Population growth.** This refers to the rate of increase in numbers.

#### Population Estimation Methods

Usually a representative sample is used to estimate the population of organism in a big habitat. A sample is a small number of individuals taken from the habitat that is a representative of the whole population. The following methods are used when sampling.

- Quadrat method.
- Line transect.
- Belt transect.
- Capture-recapture method.

#### Adaptations of plants to various Habitats

An adaptation is a **change to suit environment:** the development of physical, physiological or behavioural characteristics that allow organisms to survive and reproduce in their habitats. There are four main groups of plants namely;

- Xerophytes.
- Mesophytes.
- Hydrophytes.
- Halophytes.

#### Xerophytes

These are plants adapted to survive in the dry habitats. These habitats have the following characteristics.

- Unpredictable and poorly distributed rainfall between 250-350mm per year.
- Very high day temperatures and very low night temperatures hence high diurnal temperature range.

- iii.) They are very windy.
- iv.) Low humidity.

### **Adaptations of Xerophytes**

- i.) Shedding of leaves during the dry season to reduce the surface exposed to transpiration.
- ii.) Reduced leaves in size such as in pine or modified into spines as in cactus. This reduces the surface area over which transpiration occurs.
- iii.) Leaves have a thick waxy cuticle to reduce the rate of transpiration.
- iv.) Some store water in large parenchyma cells contained in succulent stems and leaves.
- v.) Some have reversed stomatal rhythm.
- vi.) Sunken stomata
- vii.) Folded leaves reduced the surface area.
- viii.) Reduced number of stomata
- ix.) Some have deep roots to absorb water from deep in the soil. Others have superficial roots growing horizontally close to the surface to absorb water after a light

### **Mesophytes**

These are plants growing in well watered areas. Such habitats have the following general characteristics.

- Adequate rainfall; 950-1800mm that is well distributed throughout the year.
- Relatively high humidity
- Thick clouds
- Moderate to high temperatures
- Shallow water table
- Less windy

### **Adaptations of Mesophytes**

They show various adaptations depending on where they grow. Some of these adaptations are for reduction of water loss, others for increased water, loss and some are also adapted to light conditions.

### ***Forest Ecosystem***

- i.) Vegetation grows fast to compete for light.

- ii.) Trees grow very tall to compete for light.
- iii.) Some develop buttress roots or prop roots for extra support such as the *Ficus natalensis*.
- iv.) Climbers such as lianas support themselves on stems of tall trees to reach light.
- v.) Epiphytes support themselves on the branches of tall trees.
- vi.) Others are adapted to carry out photosynthesis under low light intensity by having many chloroplasts that are sensitive to low light intensity.
- vii.) They show leaf mosaic pattern to minimise overlapping enhancing trapping of light for photosynthesis.
  - *Those in areas with a lot of water have broad leaves, thin cuticle and many stomata on both surfaces to encourage high rate of transpiration.*
  - *Those in dry areas have waxy and shiny cuticle to reflect light. Others are deep rooted to obtain water from deep in the soil.*

## Hydrophytes

These are plants growing in fresh water either partially or wholly. Such habitats have the following general characteristics.

- Low concentration of dissolved gases such as oxygen
- Presence of waves and currents
- Inadequate light in water

## Adaptations of hydrophytes

- i.) Broad leaves with maximum number of stomata on upper leaf surface providing a large surface area for transpiration.
- ii.) They have a large air filled tissue called *aerenchyma* tissue. The air reduces the density hence creating buoyancy to the plants and also aids in gaseous exchange.
- iii.) Submerged ones have dissected leaves to offer large surface area for light absorption required during photosynthesis.
- iv.) They have chloroplasts sensitive to low light intensity.
- v.) They have poorly developed leaves and lack the root hairs to reduce water absorption
- vi.) Flowers are raised above the water to allow for pollination.

## Diagrams

### Halophytes

These are plants which are able to tolerate very salty conditions in soil and marine water. Such habitats have the following general characteristics.

- High concentration of mineral salts
- Low concentration of dissolved gases
- Low light intensity in marine water
- Presence of waves and currents in marine water

### Adaptations of Halophytes

- i.) They root cells which concentrate a lot of salts to enable them to absorb water by osmosis.
- ii.) Some have salt glands that secrete excess salts.
- iii.) Many have water storage tissues.
- iv.) Some like the mangroves have breathing roots called *pneumatophores*. These rise above the water surface to obtain oxygen from the atmosphere.
- v.) Mangroves growing on mud flats have buttress roots for support
- vi.) Submerged halophytes are adapted to photosynthesise under low light intensity.
- vii.) Their fruits are adapted for dispersal by having *aerenchymatous* tissue for air storage to make them buoyant.

## CLASSIFICATION II

Classification, in biology is the identification, naming, and grouping of organisms into a formal system based on similarities such as internal and external anatomy, physiological functions, genetic makeup, or evolutionary history.

### Study Question 1

#### General Principles of Classification

Organisms that have similar and common features are grouped together while those that have different features are grouped separately.

**Taxonomy** is the study of grouping of organisms according to their relationship. There are seven major taxonomic units (taxa).



- Kingdom
- Phylum (phyla) or Division in plants
- Class
- Order
- Family
- Genus
- Species

As you move from the kingdom to the species the differences decrease as the similarities increases.

**Species** is a group of organisms that can freely interbreed to give rise to viable/fertile offsprings.

Sometime members of different species may interbreed to give an offspring which is *sterile*. E.g. a donkey and a horse can interbreed to give rise to a mule which is infertile.

### **Binomial Nomenclature**

This is the *double naming* system of organisms where organisms are assigned two names i.e. the *generic* name and the *specific* name.

### **Examples**

In binomial nomenclature the following rules are observed.

- v.) Generic name is written first followed by the specific name.
- vi.) First letter in the generic name is in capital and the rest are in small letters.
- vii.) Specific name is written in small letters.
- viii.) The two names are underlined separately when handwritten or italicised when printed.

### **Study Question 2**

#### **The Five Kingdoms of Classification**

*Carolus Linnaeus* initially introduced the two kingdom system of classification. However many new life forms have been discovered which are neither animals nor plants. This has led to a more accepted classification system that adopts five kingdoms. These are;

- Monera
- Protoctista
- Fungi
- Plantae

- Animalia.

## Fig. 1.2

### 1. Kingdom Monera

The kingdom is made up of mainly the bacteria e.g. *nitrobacter*, *azotobacter*. *Vibrio cholerae* etc.

#### General characteristics

- They are unicellular and microscopic. Some are single cells while others are in colonies. They have different body shapes.

#### Fig. 1.4

- Most are heterotrophic, feeding either saprophytically or parasitically. Some are autotrophic.
- They are prokaryotic i.e. their nuclear material is not enclosed by a nuclear membrane.
- They have few organelles which are not membrane bound. They don't have mitochondria.
- They have a cell wall though not made of cellulose.
- They reproduce asexually mainly through binary fission.
- Most of them respire an-aerobically but some respire aerobically.
- Most of them move by use of flagella.

#### Diagrams

### Study question 3

### 2. Kingdom Protocista

Examples include paramecium, amoeba, plasmodium, chlamydomonas, euglena, spirogyra, and trypanosome.

#### General characteristics

- They are eukaryotic whereby their nuclei is bound by a nuclear membrane.
- Some are heterotrophic while others are autotrophic.
- They have many organelles including mitochondria all of which are membrane bound.
- They have different body forms; some are unicellular or colonial while others are multicellular.
- Reproduction is mainly asexual by fission, fragmentation or sporulation. Some reproduce sexually by conjugation.

- vi.) They are mobile and move by means of cilia, flagella or pseudopodia.
- vii.) Some may have specialised structures that perform specific functions such as contractile vacuole for osmoregulation.

## Diagrams

## Practical Activities 1 and 2

### 3. Kingdom Fungi

#### Examples

Saprophytic ones include mushrooms, toadstools, bread moulds, penicilia, yeast etc.

Parasitic ones cause plant diseases such as wheat rust, potato and tomato blight and animal diseases such as athlete's foot and ringworm.

#### Practical Activities 3

#### General characteristics

- i.) They are eukaryotic.
- ii.) Most have cell walls made of chitin but a few have cellulose cell walls.
- iii.) They store food particles in their cytoplasm in the form of glycogen or oil droplets but not starch.
- iv.) The basic unit is the **hyphae**. Hyphae are thin filaments and many of them make up structures called **mycelium**.
- v.) Fungi have neither the chloroplasts nor the chlorophyll. They feed on already manufactured food. Hyphae act as the roots and are sent into the food material to obtain nutrients. In saprophytic fungi the hyphae are referred to as **rhizoids** and in parasitic ones as **haustoria**.
- vi.) They reproduce **sexually** (fusion of nuclei in hyphal branches) and **asexually** (spores and budding).

#### Examples

#### Study Question 4

## 4. Kingdom Plantae

### Study question 5

#### General Characteristics

- i.) They are eukaryotic and multicellular.
- ii.) In most their body is differentiated into leaves, stem and roots.
- iii.) They reproduce both sexually and asexually.
- iv.) Their cells have cellulose cell walls
- v.) They have photosynthetic pigment hence are autotrophic.
- vi.) Majority have a transport system
- vii.) They show alternation of generation.

The kingdom Plantae is divided into three main divisions.

- Bryophyta.
- Pteridophyta.
- Spermatophyta.

#### A. Division Bryophyta

These are the mosses and the liverworts.

#### General Characteristics

- i.) They lack the vascular system
- ii.) Contain chlorophyll and are therefore photosynthetic.
- iii.) They have rhizoids for anchorage and water and mineral salts absorption.
- iv.) They show alternation of generations.
- v.) Fertilisation depends of availability of water. Male gametes are produced by the *antheridia* and female gametes by the *archegonia*.
- vi.) They grow on damp substratum such as walls, rocks and marshes.
- vii.) They are *thalloid* as in liverworts or differentiated into simple leaf like and stem like structures as in mosses.

#### Diagrams.

#### B. Division Pteridophyta

This includes ferns and horsetails.

They are more advanced compared to the bryophytes.

## General Characteristics

- i.) They have leaves, stems and roots but no flowers.
- ii.) They are photosynthetic.
- iii.) They have a clearly defined vascular system made of xylem and phloem.
- iv.) They have compound leaves with leaflets called *pinna*.
- v.) On the lower side of mature leaves are the spores bearing structures (sporangia) which occur in groups called *sori* (*sorus-singular*). see diagram.
- vi.) They show alternation of generations where the sporophyte (fern plant) is the dominant one while the gametophyte is a heart shaped structure called *Prothallus*. See diagram.
- vii.) They have sexual reproduction which is dependent of water.

## Study Question 6

## Practical Activity 4

## Study Question 7

## Practical Activity 5

### C. Division Spermatophyta

This comprises of all the seed bearing plants.

#### General Characteristics

- i.) They contain chloroplasts hence are photosynthetic.
- ii.) The plant body is differentiated into roots, stems, leaves and seed bearing structures.
- iii.) Vascular system is highly developed with xylem tissue consisting of both xylem vessels and tracheids.
- iv.) Sexual reproduction is well defined.
- v.) Seeds are produced after fertilisation.
- vi.) They show alternation of generation.

The division Spermatophyta is made up of two main subdivisions i.e.

- **Gymnospermaphyta**
- **Angiospermaphyta**

### Gymnospermaphyta

#### General Characteristics

- They bear male and female cones.
- After fertilisation seeds are borne on the female cones and they are naked i.e. they are not enclosed in a fruit wall.
- They show xerophytic characteristics such as needle like leaves, rolled leaves, thick waxy cuticle and sunken stomata.
- Phloem doesn't contain companion cells and xylem mainly consists of tracheids.

This subdivision has three main classes.

- Coniferales
- Cycadales
- Ginkgoales

#### i) Class Coniferales

- These include all the common gymnosperms.
- They are found in areas of little water.
- They have small needle-shaped leaves with waxy cuticle.
- They have cones and most of them are ever green.
- **Male cones** are in form of clusters at the **base of the terminal bud**.
- **Female cones are on lateral buds** of young shoots and they contain naked seeds.

#### Diagrams.

#### ii) Class Cycadales

- They resemble the palm trees by appearance.
- They have long compound leaves which are clustered at the apex of a thick short un-branched stem.
- They bear cones at the apex of the trunk.

#### iii) Class Ginkgoales

- Members here are very rare.
- They include the **Ginkgo biloba** of China.
- They are deciduous with fan like leaves.

#### Angiospermaphyta

#### General characteristics

- Are usually bisexual and flower bearing.

- Seeds are enclosed in an ovary which develops into a fruit.
- Xylem has tracheids and vessels while the phloem has companion cells.
- They have double fertilisation.

This subdivision is divided into two classes.

- **Monocotyledonae. – examples**
- **Dicotyledonae. – examples**

| Class Monocotyledonae  | Class Dicotyledonae.  |
|--|---|
| <ul style="list-style-type: none"> <li>• They have seeds with one cotyledon.</li> </ul>  | <ul style="list-style-type: none"> <li>• Have two cotyledons.</li> </ul>  |
| <ul style="list-style-type: none"> <li>• They have narrow-long leaves with parallel venation.</li> </ul>                                   | <ul style="list-style-type: none"> <li>• Broad leaves with reticulate venation.</li> </ul>  |
| <ul style="list-style-type: none"> <li>• Most of their leaves have a modified petiole to form a leaf sheath.</li> </ul>                    | <ul style="list-style-type: none"> <li>• Leaves have distinct petioles.</li> </ul>  |
| <ul style="list-style-type: none"> <li>• Their stems have scattered vascular bundle.</li> </ul>  | <ul style="list-style-type: none"> <li>• Vascular bundles are arranged to form a concentric ring.</li> </ul>  |
| <ul style="list-style-type: none"> <li>• Pith is usually absent.</li> </ul>  | <ul style="list-style-type: none"> <li>• Pith is present.</li> </ul>  |
| <ul style="list-style-type: none"> <li>• Vascular cambium is usually absent hence no secondary growth.</li> </ul>                          | <ul style="list-style-type: none"> <li>• Vascular cambium is present hence there is secondary growth.</li> </ul>  |
| <ul style="list-style-type: none"> <li>• They have a fibrous root system</li> </ul>  | <ul style="list-style-type: none"> <li>• They have a tap root system</li> </ul>   |
| <ul style="list-style-type: none"> <li>• Floral parts are in threes or in multiples of three.</li> </ul>                                   | <ul style="list-style-type: none"> <li>• Floral parts are in fours, fives or their multiples.</li> </ul>  |
| <ul style="list-style-type: none"> <li>• In the root vascular bundles are arranged in a ring with phloem and xylem alternating.</li> </ul> | <ul style="list-style-type: none"> <li>• In roots, the xylem is centrally placed and star shaped with the phloem alternating with the arms of the xylem.</li> </ul> |

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### Study question 8

## Practical activity 6

### ix.) Kingdom Animalia

#### Study Question 9

#### General characteristics

- i.) Most show locomotion but a few are sessile
- ii.) Most reproduce sexually and a few asexually
- iii.) They are eukaryotic and multicellular
- iv.) All are heterotrophic
- v.) Their cells have no cell walls

Kingdom Animalia has nine phyla but only two will be discussed i.e. Arthropoda and chordata.

### Phylum Arthropoda

#### Practical Activity 7

#### General Characteristics

- i.) They are segmented.
- ii.) They are bilaterally symmetrical.
- iii.) They have open circulatory system where blood flows in open cavities called haemocoel.
- iv.) Head is well developed with eyes, sensory structures and a fairly developed brain.
- v.) Gaseous exchange is through the tracheal system which opens through the spiracles to the outside. Some aquatic ones use gills
- vi.) Reproduction is mostly sexual with internal fertilization. They have different sexes.
- vii.) They have jointed appendages hence the name arthropoda.
- viii.) They have a body covered with exoskeleton made of chitin. This provides a surface for muscle attachment. It is shed periodically to allow growth through a process called *moulting*.
- ix.) Most have their body divided into head, thorax and abdomen. In some, the head and the thorax are fused to form *Cephalothorax*. The thorax and the abdomen are all segmented.

The phylum arthropoda is divided into five classes.

- Crustacea
- Chilopoda
- Diplopoda



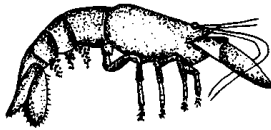
- Arachnida.
- Insecta.

Different members of the phylum are placed to their respective classes based on;

- Number of limbs
- Presence and number of antennae
- Number of body parts.

## 1. Class Crustacea

Examples. Daphnia, crayfish. Crab and prawn.



### General Characteristics

- i.) Head and thorax are fused to form cephalothorax.
- ii.) They have two pairs of antennae.
- iii.) They have between five and twenty pairs of limbs modified for different functions e.g. locomotion defence and feeding.
- iv.) They have a pair of compound eyes.
- v.) Gaseous exchange is through the gills.
- vi.) They have three pairs of mouth parts made of one pair of mandibles (lower) and two pairs of maxillae (upper).

## 2. Class Chilopoda

These are the centipedes.

### Diagram

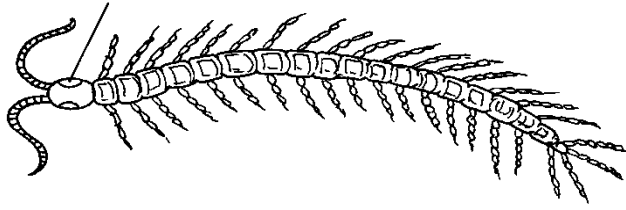
### General Characteristics

- i.) Body is divided into two parts, the head and the trunk.
- ii.) The body is dorso-ventrally flattened.
- iii.) Body is made up of 15 or more segments.
- iv.) Head has a pair of simple eyes.
- v.) Each segment has a pair of walking legs.
- vi.) Head has a pair of antennae.
- vii.) Have poison claws in the head and are therefore carnivorous.
- viii.) Have a tracheal system for gaseous exchange.
- ix.) Have separate sexes.

### 3. Class Diplopoda

These are the millipedes.

#### Diagram



#### General Characteristics

- i.) They have cylindrical body.
- ii.) Have three body parts, head, and thorax and body trunk.
- iii.) They have two clumps of many simple eyes.
- iv.) They have no poison claws and are therefore herbivorous.
- v.) Heads has a pair of short antennae and mandibles.
- vi.) Each body segment has a pair of spiracles for breathing.
- vii.) Body has between 9-100 segments.
- viii.) Each segment has two pairs of walking legs except the first thoracic segment.

### 4. Class Arachnida

These include the scorpions, spiders, ticks and mites.

#### Diagrams

#### General Characteristics

- i.) Body has two parts, cephalothorax and abdomen.
- ii.) Cephalothorax has two chelicerae which produce poison to paralyse the prey.
- iii.) Cephalothorax has four pairs of walking legs each having seven joints.
- iv.) At the end of each leg are two toothed claws.
- v.) Cephalothorax has eight simple eyes.
- vi.) Most have lung books for gaseous exchange, some use gill books or tracheal system.
- vii.) They have no antennae but have a pair of pedipalps which are sensitive to touch.

### 5. Class Insecta

They include grasshoppers, bees, houseflies, butterflies, termites, beetles etc.

Insects form half the population of animals on earth. They occupy all habitats i.e. air, water, and land. Their food is varied such as plant tissues, animal fluids, dead animals and excretions of animals making them to be found almost everywhere on earth.

### General Characteristics

- i.) Body is divided into three parts, head, thorax and abdomen.
- ii.) Thorax is made up of three segments with three pairs of legs. Some have one or two pairs of wings on the thorax.
- iii.) Head has one pair of antennae.
- iv.) They undergo complete or incomplete metamorphosis.
- v.) Excretion is through the malpighian tubules which remove uric acid.
- vi.) Gaseous exchange is through the tracheal system but they breathe through the spiracles.
- vii.) The head a pair of compound eyes and several simple eyes.
- viii.) Abdomen is made up of 11 or fewer segments. The terminal segments are modified for reproduction.
- ix.) Mouth parts consist of the mandibles, maxillae and labium. The mouth parts are modified according to their feeding habits such as sucking, biting, chewing etc.

### Assignment

**Discuss the economic importance of arthropods.**

### Study Question 10

### Practical Activity

### Phylum Chordata

Chordate, common name for animals of the phylum Chordata, which includes vertebrates as well as some invertebrates that possess, at least for some time in their lives, a stiff rod called a notochord lying above the gut. About 43,700 living species are known, making the chordates the third largest animal phylum.

In animals such as the *Amphioxus* the notochord persists but in others it is replaced at later stages of development by the vertebral column.

Members in this phylum inhabit both aquatic (marine and fresh water) and terrestrial (burrowers and arboreal) environments.

### General Characteristics

- i.) Members have a notochord at some stage of their development.
- ii.) They are bilaterally symmetrical.
- iii.) Heart is ventrally placed. Blood flows from the heart through the arteries and gets back to the heart through the veins.
- iv.) They have a post anal tail although it is greatly reduced in some.
- v.) They have an endoskeleton.
- vi.) They have a closed circulatory system.
- vii.) They have visceral clefts where in fish they become the gills in higher chordates they are only present in the embryo.
- viii.) They have a tubular dorsal nerve cord. It develops anteriorly into brain and posteriorly as the spinal cord. Spinal cord is enclosed by the vertebral column.
- ix.) They have segmented muscle blocks called *myotomes* on either side of the body.

The main classes of the phylum chordata are;

- Pisces
- Amphibia
- Reptilia.
- Aves.
- Mammalia

### Pisces

#### Diagram

These are the fishes. They include those with a skeleton made of cartilage e.g. shark and those with a bony skeleton such as the tilapia, Nile perch, lung fish, dog fish, and cat fish etc.

### General Characteristics

- i.) They move by fins
- ii.) Bodies are covered with scales
- iii.) Have gills for gaseous exchange in water.
- iv.) They don't have a middle or inner ear.
- v.) They have streamlined bodies.

- vi.) They have a lateral line for sensitivity.
- vii.) Their heart has two main chambers i.e. the auricle and the ventricle.
- viii.) They are poikilothermic/ectothermic.
- ix.) Eyes are covered by a nictating membrane.

- **Amphibia**

They include the toads, newts, salamanders and frogs.

The toad is the most advanced amphibian. Its skin is less moist and therefore uses the lungs more for gaseous exchange. They therefore stay mostly on land and only return to the ponds during reproduction.

### Diagrams

#### General Characteristics

- i.) They have a double circulatory system.
- ii.) They have a three chambered heart with two atria and one ventricle.
- iii.) Fertilisation is external and they breed in water.
- iv.) Gaseous exchange is through the skin, lungs and gills.
- v.) They have two eyes and an eardrum behind the eyes.
- vi.) They are ectothermic.
- vii.) They have 4 well developed limbs. The hind limbs are more muscular than the forelimbs.

- **Reptilia**

Examples include tortoise, turtles, snakes, crocodiles, lizards and chameleons.

#### General Characteristics

- i.) They are ectothermic.
- ii.) They have a well developed lung for gaseous exchange.
- iii.) They have double circulatory system with the heart having three chambers i.e. two atria and a partially divided ventricle. Crocodiles however have a four chambered heart.
- iv.) The body is covered with a dry scaly skin reducing desiccation.
- v.) Some have four limbs while others don't have any limbs such as the snakes.

vi.) Fertilisation is internal. They lay eggs with a leathery shell to avoid desiccation. Some species of chameleons give birth to young ones.

- **Aves**

Examples include doves, chicken, hawks, eagles and turkeys.

They are terrestrial and arboreal while some have been adapted for aquatic life.

### General Characteristics

- i.) Bodies are covered with feathers for in insulation.
- ii.) They have beaks.
- iii.) They internal auditory canal/ meatus
- iv.) Fertilisation is internal and they lay hard calcareous eggs.
- v.) They have lungs for gaseous exchange.
- vi.) They have air sacs which store air in them reducing their body density for flight.
- vii.) They are endothermic.
- viii.) They have hollow bones.
- ix.) They have scales on their hind limbs.
- x.) They have double circulatory system with a four chambered heart.
- xi.) The sternum is enlarged to form keel for attachment of flight muscles.

- **Mammalia**

### Study Question 11

- Some are arboreal such as the tree squirrels, and some monkeys.
- Some are terrestrial either on the surface of the earth or in tunnels.
- Some are aquatic such as the dolphins and whales.

### General Characteristics

- i.) They have double circulatory system
- ii.) They have mammary glands hence the name Mammalia.
- iii.) Their body is usually covered with fur or hair.
- iv.) They have two external ears (pinna)
- v.) They have sweat glands.
- vi.) They have lungs for gaseous exchange.

- vii.) They have four limbs.
- viii.) They have a diaphragm which separates the body cavity into thoracic and abdominal cavities..
- ix.) The brain is highly developed.
- x.) They have seven cervical vertebrae at their neck.
- xi.) They are endothermic.
- xii.) They have *heterodont* type of dentition where the teeth are differentiated into four types, incisors, canines, pre-molars and molars. The number varies in relation to feeding habits.
  - **Although most mammals give birth to live young ones, some are egg laying such as the duck billed platypus. After hatching, the young ones are fed on milk.**
  - **Practical Activity 9**
  - **Practical Activity 10.**

### The Dichotomous Key

The word dichotomous means separating into two. I.e. Separation of different or contradictory things: a separation into two divisions that differ widely from or contradict each other. As you move down the key you progress from general characteristics to more specific characteristics. The last single choice reveals the identity of the unknown organism.

### Rules Used in Constructing a Dichotomous Key

- i.) Use morphological features as far as possible.
- ii.) Start with the major characteristics and proceed to lesser variations that separate the organisms into smaller groups. E.g. in leaves start with type of leaf i.e. simple or compound.
- iii.) Select a single characteristic at a time and identify it by a number such as.
  - Type of leaf
  - Type of venation
- iv.) Use identical forms of words for the two contrasting statements e.g.
  1. a) leaf simple.
  - b) Leaf compound

2.
  - a) Leaf net veined.
  - b) Leaf parallel veined.
- v.) The statements should always be written in positive form. Where a negative statement cannot be avoided, the first statement must be in the positive form e.g.
  - a) Animal with wings
  - b) Animal without wings
- vi.) Avoid overlapping statements or generalisations such as
  - Short plants
  - Tall plants

Be very specific in your description such as

- Plant 1 metre tall and above.
- Plant 15cm to 60cm tall.

### Some common Features Used For Identification.

- **In animals**
  - i.) Locomotory structures (legs, wings and fins)
  - ii.) Antennae, presence and number
  - iii.) Presence and type of eyes
  - iv.) Number of body parts
  - v.) Body segmentation
  - vi.) Type of skeleton present
  - vii.) Feeding structures
  - viii.) Presence of hair, fur, scales or feathers on the body
- **In plants**

| Part of plant | Some characteristics.   |
|---------------|---|
| Leaf          | <ul style="list-style-type: none"> <li>• Phylotaxy</li> <li>• Leaf type</li> <li>• Leaf venation</li> <li>• Margin</li> <li>• Lamina</li> <li>• Colour</li> </ul> |
| Flower        | <ul style="list-style-type: none"> <li>• Inflorescence</li> <li>• Flower shape</li> </ul>   |



|       |  |
|-------|--|
|       | <ul style="list-style-type: none"> <li>• Number of floral</li> </ul>   |
| Stem  | <ul style="list-style-type: none"> <li>• Type of stem( woody, herbaceous or fleshy)</li> <li>• Shape (rectangular or cylindrical)</li> <li>• Texture of the stem (smooth or spiny/thorny)</li> </ul> |
| Roots | <ul style="list-style-type: none"> <li>• Root system (taproot or fibrous)</li> <li>• Storage roots.</li> </ul>   |
|       | <ul style="list-style-type: none"> <li>•</li> </ul>  |

## Summary of the Five Kingdoms.

## Practical Activities.

## Revision Questions.

## REPRODUCTION IN PLANTS AND ANIMALS

- This is the process by which mature individuals produce offsprings.
- There are two types of reproduction.

### 1) Sexual reproduction which involves male and female gametes

Diagram

### 2) Asexual reproduction where no gametes are involved.

Diagram

## Importance of Reproduction

### 1) Procreation

This ensures that a species does not become extinct.

### 2) Quality improvement

Reproduction allows for mixing of genetic materials bringing about variations.

These variations are important tools in the refinement of quality of offsprings.

## Cell Division

- Life in all living things start as a single cell as a spore or as a zygote.
- The cells have to divide further to give rise to make cells.
- Cell division starts with division of the nucleus (chromosome) and then the cytoplasm.

## Chromosomes

- These are microscopic thread like structure within cells that carries the molecule deoxyribonucleic acid (DNA)—the hereditary material that influences the development and characteristics of each organism.
- Each chromosome is made up of two parallel strands called **chromatids**.
- Chromatids are joined together at one point by the **centromere**.

## Diagram

- Each cell has a fixed number of chromosomes e.g. each human body cell has 46 chromosomes.
- Chromosomes occur in pairs in the nucleus. A member of each pair is called homologous chromosomes.
- Homologous chromosomes are similar in appearance, size, and shape but their genetic constitution may be different.
- Genes are found along the length of the chromosomes.
- Genes are very tiny and made up of a chemical substance called DNA (De oxy Ribonucleic Acid)
- DNA determines the characteristics of the offspring.
- **There are two types of cell division**
  - Mitosis**
  - Meiosis**

## Mitosis

- In this type of cell division, each cell divides into two daughter cells each having the same number of chromosomes as the parent cell.
- Mitosis occurs in series of stages i.e.
  - Interphase**

- ii) **Prophase**
- iii) **Metaphase.**
- iv) **Anaphase**
- v) **Telophase.**

### 1) **Interphase**

During this stage the following activities take place within the cell in preparation of the division.

- Synthesis of new cell organelles such as ribosome's, centrioles, mitochondria and Golgi apparatus.
- Multiplication of genetic material so that each daughter cell will have same number of chromosomes as the parent cell.
- Build up of enough energy stores in form of ATP (Adenosine Triphosphate) during respiration. This energy is important to see the cell through the process of division.
- At this stage the chromosomes are not clearly visible.

### **Diagrams**

#### 2) **Prophase**

The following events take place in this stage.

- Centrioles separate and move to opposite poles of the cells.
- Spindle fibres begin to form
- Nuclear membrane begins to break down and nucleolus disappears.
- Chromosomes thicken and shorten and they can be stained easily hence become visible.

### **Diagram**

#### 3) **Metaphase**

- Nuclear membrane disappears and chromosomes are free in the cytoplasm.
- Spindle fibres lengthen and attach to the centrioles at both poles.
- Chromosomes align themselves at the equator and are attached to the spindle fibres by their centromere.

### **Diagram**

#### 3) **Anaphase**

- Chromatids separate at the centromere and migrate to opposite poles. This is brought about by the shortening of the spindle fibres.
- Spindle fibres begin to disappear.
- In animal cells, cell membrane begins to constrict towards the end of anaphase.

## Diagram

### 4) Telophase

- Chromatids collect together at the two opposite poles of the spindle.
- Nuclear membrane forms around each set of chromatids and are now referred to as chromosomes.
- Cytoplasm divides into two hence the formation of two daughter cells.
- Chromosomes become less distinct.

*In animal cells, division of cytoplasm is by constriction of cell membrane.*

*In plant cells, a cell plate forms within the cytoplasm and grows to separate the cell into two.*

## Diagrams

### Significance of Mitosis

- Forms basis for asexual reproduction e.g. budding and spore formation.
- Causes cell growth when the cells formed increase in number and size.
- Ensures genetic constitution of the offspring is the same as the parents.
- Replaces damaged and dead cells in the body.

## Meiosis

- This involves two divisions of the parental cell resulting into four daughter cells.
- First meiotic cell division involves the separation of the homologous chromosomes. It is referred to as *Reduction division* because the numbers of chromosomes are reduced by half.

- In the second stage, the sister chromatids are separated and it is referred to as *Equatorial division*
- Each daughter cell has half the number of chromosomes (haploid  $n$ ) as the parent cell.
- This takes place in the reproductive organs of animals (testis and ovary) and plants (anthers and ovary).
- Meiosis is divided into same series of stages as in mitosis.
- The phases are given names as in mitosis but each is followed by I or II.

## First Meiotic Division

### Interphase I

The cell prepares for division by the following.

- Replication of chromosomes.
- Synthesis of new cell organelles.
- Build up of energy.

### Prophase I

- Nucleolus disappears.
- Centrioles move to opposite poles.
- Chromosomes shorten and thicken becoming more visible.
- Homologous chromosomes lie side by side in the process of *synapsis* forming pairs called *bivalents*.
- Homologous chromosomes may become coiled around each other with their chromatids remaining in contact at points called *chiasmata*.

NB/. During chiasma formation homologous chromosomes may exchange genetic material during crossing over. These genetic exchanges are important because they bring about variations in offsprings.

### Metaphase.I

- Nuclear membrane disappears.
- Homologous chromosomes as a bivalent move to the equator of the cell.
- Spindle fibres are fully formed and get attached to the chromosomes at the centromere.

- Homologous chromosomes orientate towards different poles.

### **Diagram**

#### **Anaphase I**

- Homologous chromosomes separate and migrate to the opposite poles with their centromeres leading. This is brought about by the shortening of the spindle fibres.

### **Diagram**

#### **Telophase I**

- Cell divides across the middle when the chromosomes reach the poles.
- At the end of meiosis I homologous chromosomes are separated.

### **Diagram**

#### **Second Meiotic Division.**

In this stage the sister chromatids are separated from each other.

#### **Interphase II**

- Cells go into a short interphase.

#### **Prophase II**

- Chromosomes become shorter and thicker.
- New spindle fibres are formed.

#### **Metaphase.II**

- Chromosomes align at the equator of the cell.
- Spindle fibres attach to their centromeres.
- Chromosomes orientate themselves towards the opposite poles.

#### **Anaphase II**

- Sister chromatids separate from each other.
- Spindle fibres shorten pulling them to the opposite poles.

#### **Telophase II**

- Spindle fibres disappears
- Nucleolus reappears and nuclear membrane forms around each set of chromatids.
- Chromatids uncoil and become threadlike.
- Cytoplasm divides.
- Four cells are formed (tetrad).
- Each cell has haploid (n) number of chromosomes.

## Significance of Meiosis

1. Gamete formation (sperms and ova) forming basis for sexual reproduction
2. Provides opportunities for genetic variations during crossing over

## Similarities between mitosis and meiosis

1. Both take place in plants and animals.
2. Both involve division (multiplication) of cells.

## Differences between meiosis and mitosis

| Meiosis   | Mitosis.  |
|---|---|
| 1. Homologous chromosomes associate with each other.                      | No association of homologous chromosomes                            |
| 2. Takes place in 2 nuclear divisions.                                    | Takes place in one nuclear division.                                |
| 3. 4 daughter cells are produced each haploid (n)                         | 2 daughter cells are produced each diploid (2n)                     |
| 4. Occurs in reproductive organs leading to gamete formation.             | Occurs in somatic (body) cells leading to growth.                   |
| 5. Chiasma formation takes place leading to crossing over hence variation | No chiasma formation therefore no crossing over hence no variation. |

## Asexual Reproduction

- This is the production of offsprings from a single organism without fusion of gametes.
- This type of reproduction involves mitosis.

## Types of Asexual Reproduction

1. Binary fission in amoeba, plasmodium and bacteria
2. Sporulation in rhizopus
3. Budding in yeasts

### 1. Binary fission in amoeba

- When there is enough food and favourable temperature and pH, a mature amoeba divides into two.

- During binary division, in amoeba, internal reorganization of molecules necessary for structural construction takes place.
- Nucleus first divides mitotically (Karyogamy) into two followed by the division of the cytoplasm (Cytogamy)

## Diagrams

### 2. Sporulation in Rhizopus

- This is the formation of spores in substrates like the bread to form bread moulds
- A spore is a microscopic reproductive unit which contains a nucleus and a small amount of cytoplasm.
- Spores are produced by bacteria, most fungi, mosses and ferns.
- Rhizopus has a vegetative body called the mycelium.
- Mycelium is made up of many branched threads called *hyphae*.
- Horizontal hyphae are called *stolons*.
- Vertically growing ones are called *sporangiophore*.
- Tips of sporangiophore swell up to form the *sporangia* (*sporangium*).
- Sporangia are the spore bearing structures. When fully mature, sporangium wall burst releasing the spores. If spores land on a suitable medium, they germinate and develop into other rhizopus.
- Rhizopus uses structures called *rhizoids* for anchorage and to obtain nutrients from the substrate.

## Diagrams

### Budding in Yeast

Under favourable conditions such as plenty of sugar, moisture, oxygen and optimum temperature, the yeast cell reproduces asexually by budding.

- A projection of bud forms on the parent cell.
- Nucleus divides into two.
- One nuclei moves into the new bud.
- Bud grows in size and forms new cell organelles. Later the bud separates off.

## Diagrams



## Sexual Reproduction in Plants

- In flowering plants the flower is the reproductive organ.

### Structure and Function of a Flower

- A flower is made up of a flower stalk (pedicel) and a receptacle.
- Attached to the receptacle are four groups of floral structures i.e.

i) Calyx (sepals)

ii) Corolla/petals

iii) Androecium – male parts

iv) Gynoecium – female parts

**i) Calyx (sepals)**

- Made up of the sepals which are usually green.
- If sepals are fused they form *gamosepalous* calyx.
- If they are free, they form *polysepalous* calyx.
- Calyx protects the inner parts of the flower especially during *bud* development.
- Some flowers have sepal like structures below the calyx called the *epicalyx*.

**ii) Corolla/petals**

- It's made up of the petals which are brightly coloured, large and conspicuous especially in insect pollinated flowers.
- If fused – gamopetalous.
- If free – polypetalous

**iii) Androecium – male parts**

- Made up of one or more stamens
- Satmen is made up of the filament and anthers.
- Another has four pollen sacs containing pollen grains.
- Pollen grains contain the male gametes.

### Diagrams

**iv) Gynoecium – female parts**

- It may contain one or more carpels
- A carpel consists of the ovary, the style and the stigma.
- Ovary contains the ovules.

- Ovaries are described as epigynous, hypogynous or perigynous depending on the place they occur in the flower.

### i) Epigynous (inferior) ovary

- Ovary is located within the receptacle.
- All other floral parts occur above it such as in the apple flowers.

#### Diagram

### ii) Hypogynous (superior) ovary

- Ovary is above the receptacle and other floral parts such as in hibiscus.

#### Diagram

### iii) Perigynous ovary

- The receptacle surrounds the carpel.
- All other floral parts arise around the ovary such as in roses.

#### Diagram

The gynoecia can also be grouped into different types depending on the number of carpels present i.e. monocarpous or syncarpous.

### Monocarpous Gynoecium

- It has only one carpel e.g. in beans.

#### Diagram

### Polycarpous Gynoecium

- It has two or more carpels. It is divided into two.

#### a) Apocarpous gynoecium

- The carpels are free e.g. in roses and bryophyllum.

#### Diagrams

#### b) Syncarpous gynoecium

- The carpels are fused together such as in hibiscus.

#### Diagrams

### Terms Used in Describing a Flower

i) *Complete flower* – has all the four floral parts; calyx, corolla, androecium and gynoecium.

ii) *Incomplete flower* – has one or two floral parts missing.

iii) *Unisexual flower* – a flower with only one of the reproductive parts either male or female flower.

iv) *Staminate flower* – male flower.

v) *Pistillate flower* – female flower.

- vi) *Monoecious plant* – bears both male and female parts of the flower.
- vii) *Dioecious plants* - the plant is either male or female e.g. in paw paw.
- viii) *Hermaphrodite or bisexual flower* – has both the male and female parts.
- ix) *Regular or actinomorphic flower* – a flower that can be divided into two similar halves by any vertical section passing through the center i.e. radial symmetry such as in morning glory.
- x) *Irregular or zygomorphic flower* – can be divided into two similar halves on one particular plane only i.e. bilateral symmetry e.g. in clotalaria.
- xi) *Pedicillate flower*- flower with a stalk.
- xii) *Solitary flower* – are flowers occurring singly.
- xiii) *Inflorescence* – flowers that grow in clusters.
- xiv) *Essential parts of the flower* – are the androecium and gynoecium.
- xv) *Non essential floral parts* – are the calyx and corolla.

## Pollination

This is the transfer of pollen grains from the anther to the stigma.

### Types of Pollination

- i) ***Self pollination.*** – Transfer of pollen grains from the anther to the stigma of the same flower.
- ii) ***Cross Pollination*** – transfer of pollen grains from the anther of one flower to the stigma of another flower but of the same species.

### Agents of Pollination

- Insect
- Wind

### Adaptations of Insect Pollinated Flowers (Entomophilous)

- i) Flowers are large, conspicuous with brightly coloured petals and inflorescence to attract insects.
- ii) Flowers are scented and produce nectar to attract insects.

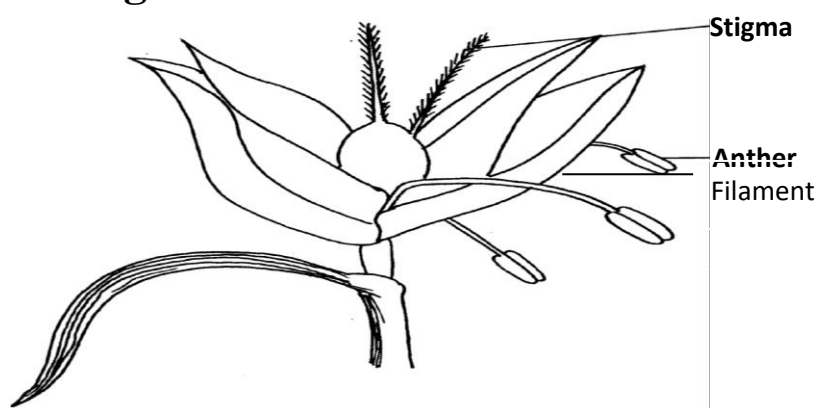
- iii) Pollen grains are relatively large, heavy, rough or sticky so as to stick on to the body of the sticks.
- iv) They have small and firmly attached anthers to a firm filament.
- v) Stigmas are small, sticky and contained within the flower. This ensures that pollen grains from the body of an insect stick onto it.
- vi) Flowers have a tubular or funnel shaped corolla, landing platforms and honey guides.

### **Adaptations of Wind Pollinated Flowers (Anemophilous)**

#### **e.g. maize and other grasses**

- i) Small flowers with inconspicuous petals, bracts or inflorescence.
- ii) Flower structure is simple and flowers have no particular shape.
- iii) Stigmas are long, feathery and hang outside the flower to trap pollen grains.
- iv) Pollen grains are small, smooth and light to be easily carried by the wind.
- v) Flowers are not scented and lack nectar.
- vi) Anthers are large and loosely attached to a flexible filament to be easily released when the wind blows.

#### **Diagram of a grass flower**



### **Features and Mechanisms Hindering Self Pollination and Self Fertilization**

- i) Heterostyly – condition where the stigma and style have different arrangements e.g. coconut flowers have shorter

stamens than pistils hence pollen grains from the anthers cannot reach the stigma.

**Diagram**

- ii) *Self sterility or incompatibility* – condition where pollen grains of a flower fail to germinate if they land on the stigma of the same flower.
- iii) *Protogyny and Protandry* – condition where either male parts of a flower mature before the female ones.  
*Protandry* – stamen mature before the stigma e.g.in sunflower.  
*Protogyny* – stigma matures before the anthers mature e.g. in maize.
- iv) *Dioecious plants and presence of features that promote cross pollination* such as brightly coloured petals which attract insects hence cross pollination.

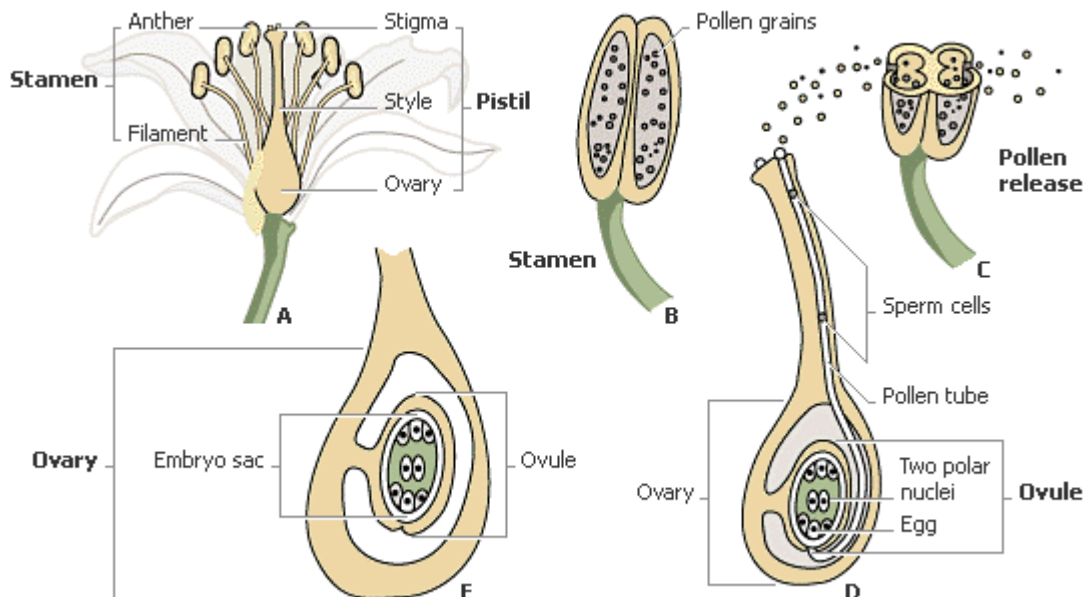
**Fertilization in Flowering Plants**

Fertilization in plants is the fusion of the male and female nuclei in the embryo sac.

- Male gamete is contained in the pollen grain produced in the anther.

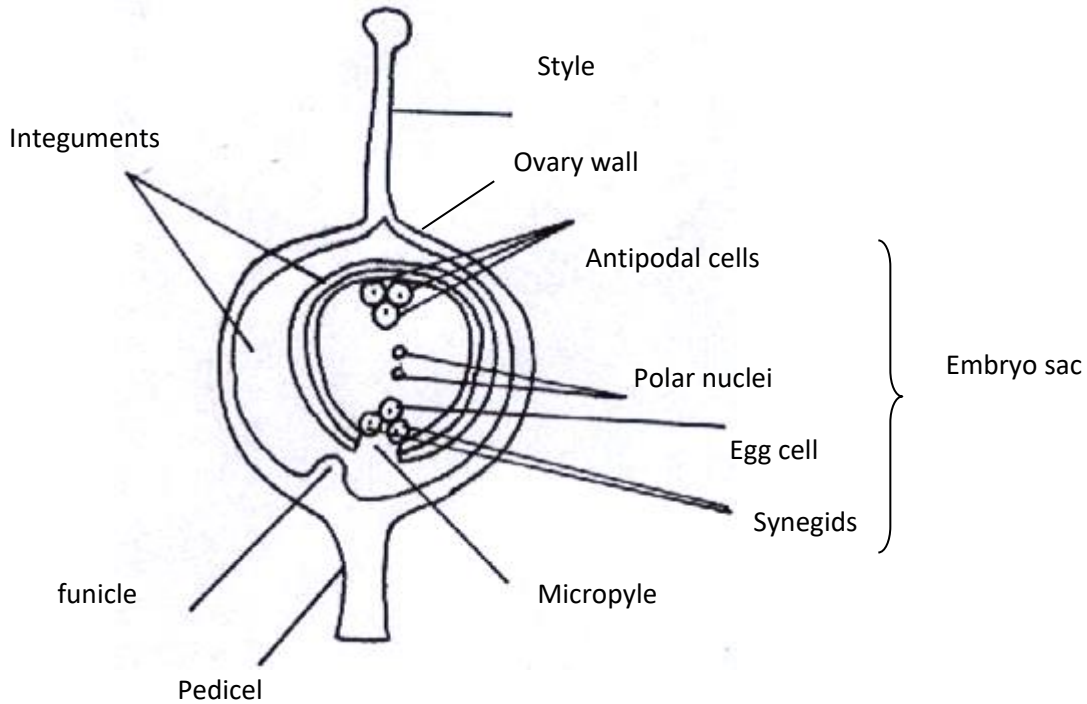
**Diagram**

Female gamete (egg cell) is found in ovules contained in the embryo sac.



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## Process of Fertilization



- Pollen grains land stick to the stigma and germinates to form pollen tube, which grows through the tissue of the style toward the ovary
- The generative nucleus undergoes mitosis, forming 2 male nuclei
- The pollen tube gets into the embryo sac through the micropyle, pollen tube nucleus disintegrates, creating a passage for the male nuclei.
- The egg cell fuses with one of the two male nuclei to form a diploid zygote. The zygote undergoes mitosis to form an embryo
- The two polar nuclei fuse with the second male nucleus to form a triploid nucleus.
- The triploid nucleus forms the endosperm. The two concurrent fertilization incidents are collectively referred to as double fertilization

## Seed and Fruit Development

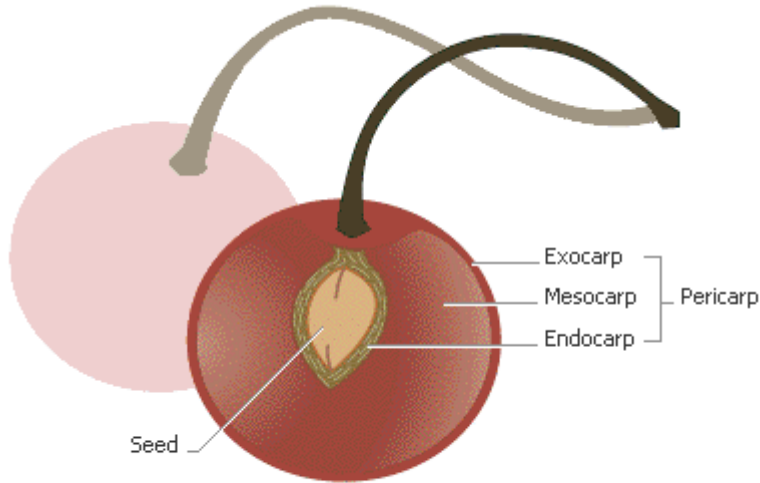
- Some changes occur to the ovary, ovule and the entire flower after fertilization.
- Calyx dries and falls off or may persist.
- Petals and stamens wither and fall off.

## Development of the Seed

- Zygote undergoes mitotic division to become the embryo (plumule and radicle) and one or two cotyledons.
- Primary endosperm nucleus develops into the endosperm.
- Ovule forms the seeds.
- Ovary develops into a fruit.
- Integuments become the seed coat (testa).
- Testa has got a scar (hilum) which is the attachment point to the placenta.
- A seed a tiny opening called the micropyle which allows water into the seed during germination.
- Water is withdrawn from the seed from about 80% to 15% by mass making the seed dry and hard.

## Development of Fruits

- A fruit is a fully grown fertilized ovary containing fully developed seeds.
- This is brought about by the hormones gibberellins and occurs after fertilization.
- As the ovules develop into seeds, the rest of the ovary develops into the fruit wall or the pericarp.
- Pericarp has two scars indicating the points of attachment to the style and to the receptacle.
- Pericarp has three layers; epicarp/exocarp (outer most), mesocarp (middle) and the endocarp (innermost).

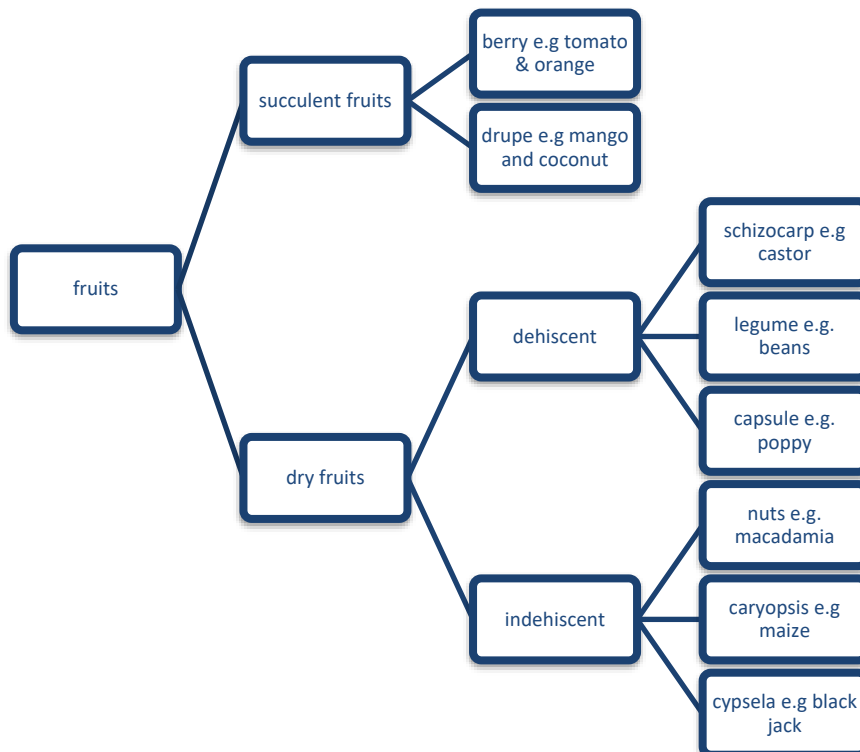


Cherry

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- In some fruits such as pineapples and bananas fruit formation takes place without fertilization. This is called **parthenocarpy**.
- False fruits are formed when other parts of the flower such as the receptacle enlarge and enclose the ovary e.g. in pineapples, apple, straw berry and cashew nut.

### Classification of Fruits



### Succulent fruits

They are divided into berry and drupe.



**Berry** – has a succulent pericarp divided into epicarp, mesocarp and endocarp e.g. orange, tomato, passion fruit, melon, paw paw etc.

**Diagram**

**Drupe** – they have a thin epicarp, fleshy or fibrous mesocarp and a very hard endocarp enclosing the seeds. In mango the fleshy edible part is the mesocarp while in coconut the mesocarp is a fibrous cover just before the hard endocarp.

**Diagram**

**Dry Fruits**

- They are divided into dehiscent and indehiscent.

**Dry Dehiscent fruit**

They dehisce to release their seeds. They are divided into;

1. Legume e.g beans

*Diagram*

2. Capsule e.g poppy

*Diagram*

3. Schizocarp e.g. castor.

*Diagram*

**Dry indehiscent fruits**

- These do not dehisce.
  - They include;
1. **Caryopsis** - pericarp and seed coat are fused together to form a thin covering round the seed e.g. maize.

**Diagram**

2. **Cypsela** - it's a one seeded e.g. the blackjack.

**Diagram**

3. **Nut** – the pericarp becomes hard and woody and it is separate from the seed coat e.g. macadamia.

**Diagram**

**Placentation**

- This is the arrangement of the ovules in an ovary. They include;

### 1. *Marginal Placentation.*

- Ovules are attached to the placenta in a row e.g. peas in a pod.

#### **Diagram**

### 2. *Basal placentation*

- Placenta is formed at the base of the ovary. Ovules are attached to it sunflower and sweet pepper.

#### **Diagram**

### 3. *Axile Placentation*

- The edges of the carpels fuse together to form a central placenta in the axile.
- Ovules are arranged on the placenta.
- The ovary is divided into a number of loculi by the walls of the carpel e.g. in orange

#### **Diagram**

### 4. *Parietal Placentation*

- Edges of the carpels fuse together and dividing walls disappear leaving a loculus.
- Placentas from each carpel appear as a ridge on the ovary wall and have numerous ovules on them e.g. in paw paw.

#### **Diagram**

### 5. *Free central placentation*

- Edges of carpels fuse together and the dividing walls disappear leaving one loculus.
- Placenta appears at the center and have numerous ovules on it e.g. in primrose

#### **Diagram**

## **Adaptations of Fruits to Various Agents of Dispersal**

### a) Water dispersal

- Such seeds and fruits enclose air in them to lower their density for buoyancy;
- They are fibrous/ spongy to lower the density for buoyancy;
- Have impermeable seed coat or epicarp to prevent water from entering during flotation so as to avoid rotting;

- The seeds can remain viable while in water and only germinate while on a suitable medium;

#### b) Wind dispersal

- They are light; and small; to be easily carried by wind currents due to lower density;
- Have developed extension (Parachute like structures and Wing like structures) which create a larger surface area; so as to be kept afloat in wind currents e.g. sonchus and jacaranda
- In some a Perforated capsule is usually loosely attached to a long stalk which is swayed away by wind scattering seeds;

#### c) Animal dispersal

- Brightly colored to attract animals
- Fleshy to attract animals; e.g. mangoes, passion fruits, oranges, tomatoes etc.
- aromatic /scented to attract animals;
- The seed coats are hard and resistant to digestive enzymes; the seeds are therefore dropped away in faeces/droppings e.g. passion fruit and tomatoes.
- Some have hook like structures to attach on animals fur e.g. blackjack

#### d) Self dispersal

- They have weak lines (sutures) on the fruit wall (pod), along which they burst open to release seeds, which get scattered away from the parent plant e.g. in legumes such as peas and beans.

## SEXUAL REPRODUCTION IN ANIMALS

- This involves gamete fusion.
- The male produces the male gamete (sperms) and the female produces the female gamete (ovum/ova).
- The gametes are produced in special organs called gonads i.e. the testes and ovaries.

- The sperm fuses with the ovum to form a zygote through a process called *fertilisation* the gametes are haploid and the zygote is diploid.
- Fertilisation may be internal or external.

### **External Fertilisation in Amphibians**

- The female lays eggs and the male sheds sperms on them (to fertilise them). This is only possible in water.
- Many eggs are released to increase the chances of survival since bacteria and other organisms can eat fertilised eggs.
- Eggs are also in long strands of slippery jelly like substance, which offer the eggs protection.
- This substance separates the eggs from each other allowing for good aeration.
- It also attaches the eggs to water plants and makes them buoyant.

### **Internal Fertilisation**

- This occurs in reptiles, birds and mammals where fertilisation occurs within the body of the female.
- Sperms are introduced into the female's body.
- Few eggs are produced because there are high chances of fertilisation and the gametes/zygote receive further protection.
- In most mammals, some chameleons and some snakes the fertilised eggs develop into young ones within the body of the female. They give birth to young ones.

### **Study Question 8**

#### **Reproduction in Mammals**

- Mammals have internal fertilization where eggs are laid or develop within the female's body in the uterus.
- The egg laying mammals (monotremes) they are said to be *oviparous such as the platypus*.



Photo Researchers, Inc./Tom McHugh

## Platypus

The duck-billed platypus, *Ornithorhynchus anatinus*, found only in eastern Australia, belongs to an unusual group of egg-laying mammals called monotremes. It lives in streams, rivers, and occasionally lakes. The duck-billed platypus feeds on bottom-dwelling aquatic insect larvae, which it finds by probing the streambed with its pliable, sensitive bill.

- In marsupials such as the kangaroo the zygote does not develop fully within the uterus but completes development in the pouch.



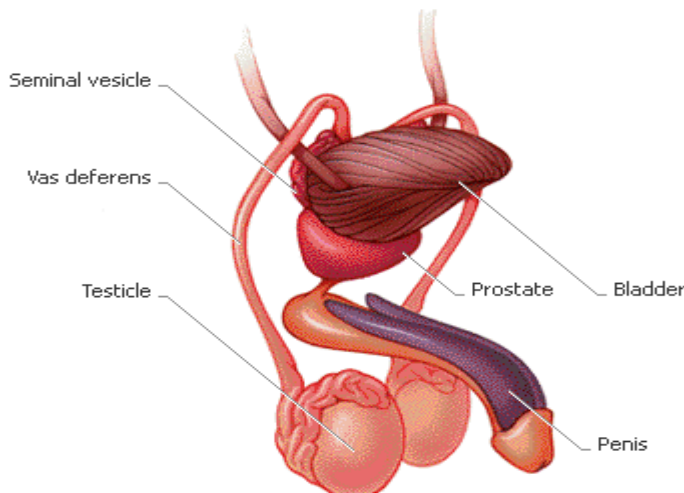
## Mother Kangaroo and Baby

Kangaroos are a type of mammal called a marsupial. Baby marsupials are unable to survive on their own when they are born, so they must live in a pouch on their mother's belly. A newborn kangaroo, called a joey, stays in its mother's pouch for about six months, where it feeds on her milk.

- The ability to give birth to young ones as in placental mammals is called viviparity.
- Mammals have mammary glands, which produce milk on which the young ones are fed. Parental care is highly developed in mammals.

# Reproduction in Human beings

## Structure and Function of The male Reproductive System

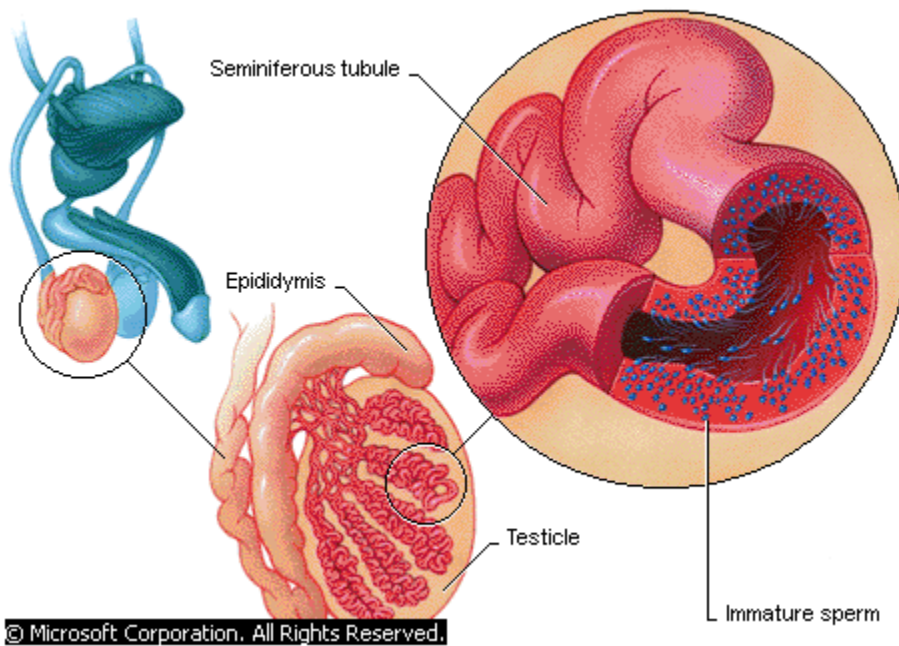


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### Male Reproductive System

The organs of the male reproductive system enable a man to have sexual intercourse and to fertilize female sex cells (eggs) with sperm. The gonads, called testicles, produce sperm. Sperm pass through a long duct called the vas deferens to the seminal vesicles, a pair of sacs that lies behind the bladder. These sacs produce seminal fluid, which mixes with sperm to produce semen. Semen leaves the seminal vesicles and travels through the prostate gland, which produces additional secretions that are added to semen. During male orgasm the penis ejaculates semen.

- Testes are found outside the abdominal cavity in the *scrotal sac*. This position provides a cooler environment for sperm production since sperms develop best at lower temperature than that of the body.
- Testis is made up of highly coiled tubes called **seminiferous tubules** whose inner lining has actively dividing cells which give rise to sperms.
- Between the seminiferous tubules are interstitial cells, which produce the male hormones (androgens).



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## Internal View of Male Reproductive System

The reproductive anatomy of the male human is largely external. Beginning at puberty, sperm are produced within seminiferous tubules of the testicles, a pair of glands that reside in a pouch called the scrotum. The external location of the scrotum keeps the temperature of sperm slightly below body temperature, which is necessary for their healthy development and survival. From each testicle, sperm migrate to a long, coiled tube known as the epididymis, where they are stored for one to three weeks until they mature. Also located outside the body is the penis, the erectile organ responsible for the excretion of urine and the transfer of sperm to the vagina of the female. Just before ejaculation during sexual arousal, mature sperm travel from the epididymis, a coiled tube behind each testicle, through a long duct called the vas deferens. Sperm leave the body in semen, a fluid produced by the seminal vesicles.

- Seminiferous tubules unite to form the **epididymis, which** is about 6m long and highly coiled. It stores the sperms.
- It's connected to the **sperm duct/vas deferens**. Sperm duct connects the epididymis to the urethra, which is the ejaculatory duct.
- **Seminal vesicles** provide an alkaline fluid, which contains nutrients for the sperms.

- **Prostate gland** secretes an alkaline substance to neutralise the vaginal fluids. It also activates the sperms.
- **Cowper's glands** secrete an alkaline fluid that neutralizes the acidity along the urethra.
- **All these fluids combine with the spermatozoa to form the semen.**
- Since the urethra serves both passage of urine and semen it is said to be urino-genital in function.
- The penis is erectile and made of spongy tissue, muscle and blood vessels.
- Once erect, the penis is able to penetrate the vagina in order to deposit sperms into the female's reproductive tract.

### Study question 9 and Practical.

### Structure and Function of The Female Reproductive System.

#### Diagram

- The internal sex organs of the female consist of the vagina, uterus, fallopian tubes (or oviducts), and ovaries.
- The *vagina* is a flexible tube-shaped organ that is the passageway between the uterus and the opening in the vulva. Because during birth the baby travels from the uterus through the vagina, the vagina is also known as the birth canal.
- The woman's menstrual flow comes out of the uterus and through the vagina.
- When a man and a woman engage in vaginal intercourse, the penis is inserted into the vagina.
- The *cervix* is located at the bottom of the uterus and includes the opening between the vagina and the uterus. It secretes a plug of mucus, which prevents entry of pathogens into the uterus during pregnancy.
- The *uterus* is a muscular organ that has an inner lining (endometrium) richly supplied with blood vessels and glands. During pregnancy, the uterus holds and nourishes the developing foetus.



- Although the uterus is normally about the size of a fist, during pregnancy it is capable of stretching to accommodate a fully developed foetus, which is typically about 50 cm (about 20 in) long and weighs about 3.5 kg (about 7.5 lbs).
- The uterine muscles also produce the strong contractions of labour.
- At the top of the uterus are the pair of *fallopian tubes (oviduct)* that lead to the ovaries.
- The two *ovaries* produce eggs, or ova (the female sex cells that can become fertilized), and female sex hormones, primarily oestrogen and progesterone.
- The fallopian tubes have finger like projections at the ends near the ovaries that sweep the egg into the fallopian tube after it is released from the ovaries.
- Movement of ovum is also aided by the smooth muscles of the oviduct.
- If sperm are present in the fallopian tube, fertilization (conception) may occur and the fertilized egg will be swept into the uterus by *cilia* (hair like projections inside the fallopian tube).

## Practical

### The Human Sperm

- Are formed in the seminiferous tubules of testes by meiosis.
- Final products of meiosis enter the sertoli cells where they are nourished and undergo maturation.
- Mature sperms leave for epididymis where they are stored.
- A mature sperm has an ovoid head, short neck, middle piece and a tail.

### Diagram

- Head has a large nucleus carrying the genetic material, which is haploid (n).

- At the tip of the head there is the acrosome containing lytic enzymes. These enzymes digest the wall of ova.
- The short neck contains centrioles.
- Middle piece has a large number of mitochondria, which provide with the energy required for propulsion of the sperm to reach the ova.
- The tail propels the sperm forward by its side-to-side lashing action.

## Formation of The Ova

- In females egg formation begins in the ovary of the foetus before birth unlike in males where production of sperms starts at puberty.
- At birth there are about **70,000 potential egg cells** in the ovaries of a baby girl.
- A layer of ovary cells called **primary follicles**, which provide them with nourishment, encloses them.
- Only about 500 of them develop into ova during puberty. During puberty the primary follicles grow to become **Graafian follicle**.
- At ovulation, the Graafian follicle bursts open to release a mature ovum surrounded by a layer of cells.

## Diagram

- A mature ovum is spherical in shape with a diameter of about 0.2 mm.
- It has a large haploid nucleus surrounded by a nuclear membrane.
- Nucleus is within the cytoplasm enclosed by the **plasma membrane**. **Vitelline** membrane surrounds the plasma membrane.

## Study Question 11

## Fertilisation

- Process where the nucleus of a male gamete fuses with the nucleus of a female gamete to form a zygote.
- This takes place in the upper part of the oviduct after copulation. Sperms are drawn up by suction through the cervix into the uterus. They swim up to the oviduct using their tails.
- Very many sperms are released but only one is required to fertilise the ovum.
- The ovum releases chemical substances, which are neutralised by those released by the acrosome.
- When the ovum comes into contact with the egg the acrosome bursts releasing lytic enzymes, which dissolve the egg membranes.
- The acrosome turns inside out forming a filament, which is used to penetrate the eggs.

## Diagrams

- The Vitelline membrane undergoes a change, which stops any other sperm from entering the ovum.
- Once inside the cytoplasm the head bursts to release the male nucleus, which then fuses with the female nucleus to form a diploid zygote.
- After ovulation the ovum can remain viable for 8-24 hours before it dies.
- The sperm can remain viable for 2-3 days in the female reproductive tract.

## Study Question 12

### Implantation

- This is the attachment of the blastocyst to the walls of the uterus by the villi.

- After fertilisation, the zygote undergoes various mitotic divisions as it moves down the oviduct. Its movement is aided by cilia in the oviduct and by the contractions of the smooth muscles lining the oviduct.
- By the time it reaches the uterus it has formed a hollow structure of cells called blastocyst.
- Movement of the zygote from the oviduct to the time it is implanted takes about 7 days.

## Diagrams

- Sometime the zygote may fail to move down to the uterus and gets implanted into the walls of the oviduct. This condition is referred to as **ectopic pregnancy**.

## Formation of Placenta

- During implantation the blastocyst differentiates into three layers, **chorion, amnion and allantois**.

## Diagram

- **Chorion** is the outermost and it has finger like projections called **chorionic villi**. These villi grow into the endometrium. During the early stages of embryo development, villi form the sites for material exchange between the embryo and maternal blood vessels.
- **Amnion** surrounds the embryo forming an amniotic cavity. Amniotic cavity contains the amniotic fluid, which suspends the foetus providing it with support. It also acts as a shock absorber hence protecting it against mechanical injury.
- **The chorionic villi, allantois and the endometrium form the placenta.**
- The embryo is attached to the placenta by a tube called the **umbilical cord**.
- When the placenta is fully formed, the embryo becomes the foetus at about three months of pregnancy.

## The Role of The Placenta

- This is a temporary organ found only in placental mammals. It is the only organ in animals composed of cells derived from two different organisms; the foetus and the mother.
- It facilitates the transfer of nutrients and metabolic waste products between the mother and the foetus. It selectively allows some materials to pass through and not others.

Refer to the table below

- Drugs, alcohol and some chemicals from cigarette smoke pass through the placenta. Pregnant mothers should therefore not take alcohol or smoke excessively.
- There is no direct connection between the foetal blood system and that of the mother.
- If the two systems were directly connected, the delicate blood vessels of the foetus would burst due the higher pressure in the maternal circulatory system.
- Exchange of materials occurs across the sinus in the uterine wall and the capillary system of foetus across intercellular space by diffusion.

### Diagram

### Study question 13

- During pregnancy, placenta takes over the role of producing hormones oestrogen and progesterone.

### *Major functions of oestrogen and progesterone during pregnancy*

| Oestrogen                         | Progesterone.                     |
|-----------------------------------|-----------------------------------|
| i.) Growth of mammary glands      | i.) Growth of mammary glands.     |
| ii.) Inhibits FSH release.        | ii.) Inhibits FSH release         |
| iii.) Inhibits prolactin release. | iii.) Inhibits prolactin release. |
| iv.) Prevent infection in         | iv.) Inhibits contraction of      |

|   |             |
|---|-------------|
| uterus<br>v.) Increase size of the uterine muscle cells.<br>vi.) Increase ATP and creatine phosphate formation.<br>vii.) Increases sensitivity of myometrium to oxytocin. | myometrium. |
|---|-------------|

| <b>What is allowed to pass through the placenta</b>  | <b>What is not allowed to pass through the placenta</b>   |
|--|---|
| <p><b>From the mother to the foetus.</b></p> <ul style="list-style-type: none"> <li>i.) Oxygen</li> <li>ii.) Vitamins</li> <li>iii.) Mineral salts</li> <li>iv.) Hormones</li> <li>v.) Water</li> <li>vi.) Antibodies and antigens.</li> <li>vii.) Glucose, amino acids, fatty acids and glycerol.</li> </ul> <p><b>From the foetus to the mother</b></p> <ul style="list-style-type: none"> <li>i.) Carbon (iv) oxide.</li> <li>ii.) Nitrogenous wastes.</li> </ul> | <ul style="list-style-type: none"> <li>i.) All blood cells.</li> <li>ii.) Plasma proteins.</li> <li>iii.) Most bacteria.</li> </ul> |

## Gestation Period

- This is the period between conception and birth. This varies in different animals.
- E.g. mice 22 days
- Rabbits, 30 days
- Man, 9 months
- Elephants, 18 month

- When the human embryo is **two weeks** old, allantois, chorion and amnion have already formed. Embryo then differentiates into tissues and organs.
- By the end of the **third month**, the heart and blood vessels are fully developed. Spinal cord and the head region, which includes the eyes and the nose, are also well developed. Limbs show early signs of development.
- By the end of **6 months** the alveoli and nose are well developed. Foetal movement can as well be felt.
- By the end of the **nine months**, the foetus head is directly above the cervix.
- By now all the organs and systems are fully developed.
- If birth occurs before completion of 6 months, this is called **miscarriage** and the baby cannot survive.
- If the foetal development is interfered with either physically or chemically such that the foetus is released, this is called **abortion**.
- If birth occurs after 7 months but before term, this is called **premature birth**. Such babies are raised in incubators and they do survive.
- Pregnant mothers must have a balanced diet. Calcium, proteins, phosphates and iron should be abundant in her diet.
- Calcium and phosphorous are needed for bone formation while iron is for haemoglobin formation.
- Pregnant mother should visit antenatal clinic.

## Birth/Parturition

- Maternal posterior pituitary gland releases hormone oxytocin. Progesterone level goes down. Oxytocin stimulates contraction of the myometrium.
- Oxytocin is released in waves during labour. This provides the force required to expel the foetus from the uterus.
- The cervix dilates, the amnion and chorion rupture releasing the amniotic fluid.
- The uterus starts contracting from the top downwards pushing the foetus downwards head first through the widened cervix and the birth canal.
- After birth, the umbilical cord is ligatured/cut to separate the baby from the placenta. Placenta is expelled later after birth.

- Then newborn baby takes in the first breath, lungs expand and become functional. The respiratory role of the placenta is taken over by the lungs.

## Diagrams



### Caesarean delivery

- This is the surgical incision of the abdominal and uterine walls for delivery to be achieved. This is done where there are complications such that the foetus cannot pass through the birth canal.

### Parental care

- The newborn baby is given food and protection. Placental mammals feed their young ones on milk. Milk is produced by the mammary glands under the influence of lactogenic hormones e.g. prolactin.
- Mother's milk is the best as it contains all the nutrients needed for the growth and development of the body.
- For the first 3 days, colostrum is produced which contain antibodies, which provide natural defence to the foetus against diseases.
- Milk is deficient of iron. The baby relies on iron stored in its liver during gestation.
- Milk let down is an example of a reflex action.
- The prevailing environment as shown below influences it either positively or negatively.

### Milk production in various environments

| <i>Positive Environment</i>  | <i>Negative Environment</i>  |
|--|--|
| <ul style="list-style-type: none"> <li>• Sucking at the breast, smell of the baby or crying of the baby trigger milk let down.</li> <li>• Hypothalamus relays impulses to pituitary gland which releases hormone oxytocin</li> <li>• Oxytocin reaches the breasts and causes alveoli to contract forcing milk into the ducts.</li> </ul> | <ul style="list-style-type: none"> <li>• Milk let down may be inhibited or blocked if the breastfeeding mother experiences embarrassment, fatigue or anxiety.</li> </ul> |



- |  |  |
|--|--|
| <ul style="list-style-type: none"> <li>• Ducts conduct milk into the reservoirs behind the areola</li> <li>• Baby sucks the milk from this reservoir.</li> </ul> |  |
|--|--|

## Assignment

### Child labour

### Role of Hormones in Human Reproduction

#### Secondary sexual characteristics

These are physiological, structural and mental changes associated with masculinity and femininity. They are controlled by oestrogen in females and androgens in males. They occur at puberty.

#### Secondary sexual characteristics in males

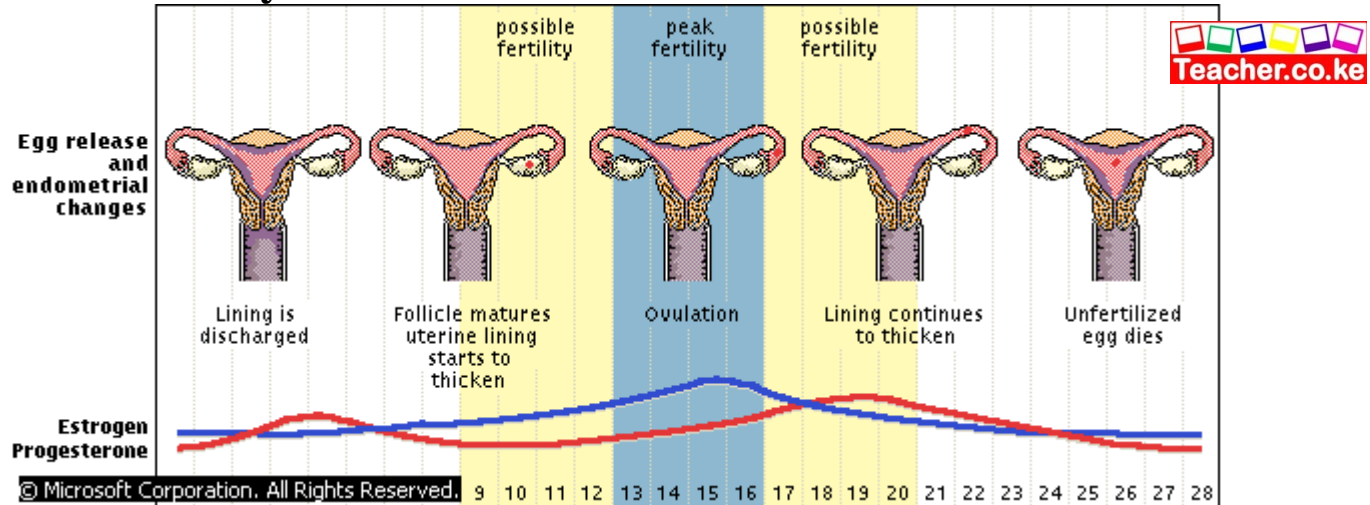
- Hypothalamus stimulates pituitary gland to release gonadotrophic hormones i.e. FSH and LH.
- FSH stimulates sperm synthesis.
- LH is also known as Interstitial Cell Stimulating Hormone (ICSH) and it stimulates interstitial cells to release Androgens mostly Testosterone. It stimulates the onset of secondary sexual characteristics mostly at the age of 14. These include;
  - i.) Deepening of voice
  - ii.) Growth of hair in pubic parts and armpit region
  - iii.) Appearance of beards
  - iv.) Body becomes masculine
  - v.) Testes enlarge and begin to produce sperms

#### Secondary sexual characteristics in females

- In females they start at early age 10-12 years. They include,
  - i.) Development of mammary glands
  - ii.) Growth of hair in pubic parts and armpit region
  - iii.) Enlargement of the pelvic girdle and widening of the hips
  - iv.) Body becomes feminine.
  - v.) Ovaries mature and start releasing eggs under the influence of FSH and LH hence ovulation and menses.

- Unlike in males, the production of gonadotrophic hormones is not continuous. It is produced periodically in cycles.

## Menstrual Cycle



## Menstruation

- An average menstrual cycle begins with three to five days of menstruation, the shedding of the uterine lining, during which hormone levels are low.
- At the end of menstruation, pituitary gland secretes FSH which has two functions. It stimulates new Graafian follicles to develop in the ovary and stimulates the ovary to secrete the hormone oestrogen.
- Oestrogen brings about repair and healing of the endometrium, which is destroyed during menstruation.
- Oestrogen accumulates to levels, which stimulate the release of LH. LH stimulates the maturity of Graafian follicle. The mature Graafian follicle releases the ovum into the fallopian tube. This is called Ovulation and occurs on the 14<sup>th</sup> day.
- The empty Graafian follicle forms the corpus luteum, an endocrine body that secretes progesterone.
- LH stimulates corpus luteum to secrete hormone progesterone. This hormone stimulates thickening and increased blood supply to the endometrium preparing the endometrium for implantation.
- If fertilization takes place, the level of progesterone increases and thus inhibits FSH from stimulating the maturation of another Graafian follicle.
- If fertilization does not take place, the corpus luteum dies and progesterone hormone levels fall.
- Without hormonal support, the uterine lining disintegrates and discharges, beginning a new menstrual period and cycle.
- This cycle lasts for 28 days in human beings.

## Assignment

### Sanitary Health

- Menopause
- STI

### Advantages of Asexual reproduction

- i.) Good qualities from the parents are retained since there is no variation.
- ii.) There is faster maturation.
- iii.) Its independent of processes such as pollination, fertilisation and fruit and seed dispersal
- iv.) New offspring's are able to obtain nourishment from their parents and are therefore able to survive under unsuitable conditions.
- v.) There is no wastage of a large number of offspring's.

### Disadvantages

- i.) Reduction in strength and vigour in offsprings.
- ii.) Undesired qualities are easily inherited.
- iii.) Due to faster maturation there are chances of overcrowding and competition.
- iv.) Offsprings may not withstand changing environmental conditions due to lack of variation.

### Advantages of sexual reproduction

- i.) There is hybrid vigour due to mixing of genetic material.
- ii.) There is high adaptability
- iii.) Variation form basis for evolutionary changes.

### Disadvantages

- i.) May produce individuals with undesirable qualities.
- ii.) Method is dependent of union of gametes and therefore may not take place if the two organisms are isolated

### Revision Questions

## BIOLOGY FORM FOUR NOTES

### THE EYE

The mammalian eye is spherical; fluid filled and has three layers;

- Outer layer or sclera
- Middle layer or choroid
- Inner layer or retina

### Adaptations of the eye

| Part | Properties | Functions |
|------|------------|-----------|
|------|------------|-----------|

|                          |  |   |
|--------------------------|--|---|
| 1. Sclera                | Tough, white opaque layer.                                       | <ul style="list-style-type: none"> <li>• Protects delicate inner parts of the eye.</li> <li>• Maintain shape of the eye.</li> </ul>                               |
| 2. Cornea                | Transparent and front layer of the sclera.                       | <ul style="list-style-type: none"> <li>• Allow light into the eye.</li> <li>• Refract light entering the eye</li> </ul>   |
| 3. Conjunctiva           | Thin and transparent layer before the cornea.                    | <ul style="list-style-type: none"> <li>• Allow light into the eye.</li> <li>• Protects the cornea.</li> </ul>   |
| 4. Choroid               | Have cells that have melanin, arteries & veins                   | <ul style="list-style-type: none"> <li>• Provide nourishment to the eye.</li> <li>• Pigment prevents reflection of light within the eyeball.</li> </ul>           |
| 5. Ciliary body          | Have thin rings of thickened tissue arising from choroids.       | <ul style="list-style-type: none"> <li>• Produce the aqueous humour</li> <li>•</li> </ul>   |
| 6. Ciliary muscle        | Have circular and radial muscles which are antagonistic.         | <ul style="list-style-type: none"> <li>• Muscles alter the tension of suspensory ligaments.</li> </ul>  |
| 7. Suspensory ligaments. | fibrous  | <ul style="list-style-type: none"> <li>• Alter the shape of the lens.</li> </ul>  |
| 8. Pupil                 | Hole at the center of iris.                                      | <ul style="list-style-type: none"> <li>• Regulates the amount of light entering the eye.</li> </ul>   |
| 9. Iris                  | Contain melanin, circular and radial muscles.                    | <ul style="list-style-type: none"> <li>• Give the eye its colour.</li> <li>• Regulates the amount of light entering the eye</li> </ul>                            |
| 10. Lens                 | Transparent, biconvex and elastic structure. Found behind pupil. | <ul style="list-style-type: none"> <li>• Refracts light onto retina.</li> <li>• Involved in accommodation of the eye.</li> <li>• Separates the aqueous</li> </ul> |



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|                                   |   |   |
|-----------------------------------|---|---|
|                                   |   | humor from vitreous humor.  |
| 11. Aqueous/<br>Vitreous<br>humor | Transparent<br>fluids                                     | <ul style="list-style-type: none"> <li>• allow light pass / refract light,</li> <li>• Hydrostatic pressure maintain shape of eyeball.</li> <li>• Contains sugars / proteins / salts – provide nutrients to eye.</li> </ul>  |
| 12. Retina                        | Contains photoreceptors (Cones & Rods) and blood vessels. | <ul style="list-style-type: none"> <li>• Rods are sensitive to low light intensity and detect black and white and more in nocturnal animals. Have photochemical pigment called <i>rhodopsin</i>.</li> <li>• Cones are sensitive to high light intensity, detect colour and present in large numbers in diurnal animals. Have photochemical pigment called <i>iodopsin</i>.</li> </ul> |
| 13. Fovea centralis               | Contain mainly the cones.                                 | <ul style="list-style-type: none"> <li>• It's the most sensitive part of the retina.</li> <li>• Image is formed here.</li> </ul>  |
| 14. Blind-spot                    | Has no photoreceptors                                     | <ul style="list-style-type: none"> <li>• Optic nerve leaves the retina.</li> <li>• Blood vessels emerge here to nourish the eye.</li> </ul>   |
| 15. Optic nerve                   | Made of nerve fibres                                      | <ul style="list-style-type: none"> <li>• Transmits nerve impulses to the brain for interpretation.</li> </ul>   |
| 16. Lachrymal gland               | Secrete tears   | <ul style="list-style-type: none"> <li>• Tears moisten the cornea and washout foreign particles.</li> <li>• Tears have antiseptic effect.</li> </ul>  |
| 17. Nictitatin                    | Transparent   | <ul style="list-style-type: none"> <li>• Draw across the eye</li> </ul>   |

|                          |                                       |   |
|--------------------------|---------------------------------------|---|
| g membrane               | membrane in birds, reptiles and fish. | cleaning and protecting it.   |
| 18. External eye muscles | Contractile                           | <ul style="list-style-type: none"> <li>• move eyeball within socket</li> </ul>  |
| 19. others - externally- |                                       | <ul style="list-style-type: none"> <li>• <b>orbit</b>- protective</li> <li>• <b>eye lids</b>-protect the eye by closing</li> <li>• <b>Eye lashes</b>-prevent entry of small foreign particles.</li> <li>• <b>Eye brows</b>-prevent dust &amp; sweat from entering eye.</li> </ul> |



### Image formation and interpretation

- Light from an object is refracted by cornea, aqueous humour, the lens, through the vitreous humour and focused on the yellow spot of the retina.
- Image formed is recorded as real, inverted and small.
- Photoreceptors are stimulated and generate a nerve impulse which is transmitted by the optic nerve to the cerebrum of the brain for interpretation.
- In the brain the image is interpreted as real, upright and normal.
- Images from the right eye are interpreted by the left hemisphere of cerebrum while those from the left eye by the right hemisphere.

### Diagram pages 100 KLB

#### Binocular vision or Stereoscopic Vision

- This is the ability of both eyes to look straight ahead but see the same scene from a slightly different angle.
- The eyes' visual fields overlap in the center, and the brain merges these images to create a sense of depth important for judging distance.
- Humans and other mammals have stereoscopic vision.
- Birds, fish, and snakes have monocular vision in which each eye sees a separate image covering a wide area on each side of the head.

#### Advantages

1. Larger field of view
2. Provide much accurate assessment of distance, height or depth of objects.

3. Damage to one eye is compensated by the other

4. Cancels the effect of blind spot

### **Accommodation of The Eye**

- This is the refraction of light in order to fall on the fovea centralis (yellow spot) for clear focus of image regardless of the distance of the object.



### **Accommodation of a close object**

- Ciliary muscles contract thereby relaxing the tension on suspensory ligaments.
- Curvature of the lens increases.
- The close objects are greatly refracted by the lens focusing them on the retina.

### **Diagram**

### **Accommodation of a distant object**

- Ciliary muscles relax increasing the tension on suspensory ligaments.
- The lens is stretched decreasing its curvature i.e. lens become thinner.
- Light rays from the object are less refracted and focused on the retina.

### **Diagram**

### **Control of Light Entering the Eye**

#### ***1. Bright Light***

- Circular muscles of iris contract and the radial muscles relax.
- Diameter of pupil decrease and less light enters.
- This protects retina from damage by too much light.

### **Diagram**

#### ***2. Dim Light.***

- Circular muscles relax and radial muscles contract.
- Diameter of pupil increase and more light enters the eye.
- This allows in enough light to stimulate photoreceptors on the retina.

### **Diagram**

### **Defects of the Eye**

#### ***1. Short sightedness(Myopia)***

- This is the ability to view near objects clearly but distant objects are blurred.

- This is due to a long eyeball and image is formed before the retina.

### Correction

- Wearing concave (Diverging lens)

### Diagram

#### 2. *Long sightedness (Hypermetropia)*

- This is the ability to view distant objects clearly but near objects are blurred.
- This is due to a short eyeball and image is formed behind the retina.

### Correction

- Wearing convex (converging lens)

### Diagram

#### 3. *Astigmatism*

- The curvature of the cornea is uneven hence the image is formed on different planes.
- It's corrected by wearing cylindrical lens.

#### 4. *Squintedness*

- Eyeballs face different directions due to defective muscles which move the eye left and right.
- Corrected surgically

#### 5. *Old sight (Presbyopia)*

#### 6. *Cataracts*

#### 7. *Colour blindness*

## THE EAR

### Functions of the ear

1. Hearing
2. Maintaining body balance and posture

### Diagram

### Adaptations of the ear to its Functions

The ear is divided into:

#### 1. Outer ear

- *Pinna.*
  - Pinna is funnel shaped to direct sound waves into auditory canal;
  - its large to offer large surface area for collection of sound waves;
- *Auditory meatus/canal*
  - Tube that directs sound waves to ear drum.
  - Lined with hairs to trap solid particles.
  - Lined with wax secreting cells to trap dust.



- Wax also maintains flexibility of the eardrum.

## 2. Middle ear. Its air filled

- *Tympanic membrane/ear drum.*
  - It's a thin tough membrane.
  - It transforms sound waves into vibrations.
- *Ossicles*
  - They are three bones; *malleus, incus and stapes.*
  - They receive vibrations from tympanic membrane and amplify them then transmit them to the oval window.
- *Eustachian tube*
  - Connects middle ear and pharynx.
  - Equalizes pressure between the middle ear and outer ear preventing distortion of the ear drum.
- *Oval window*
  - Picks vibrations from the ossicles and transmit them to inner ear.
- *Round window*
  - Bring back vibrations from the inner into the middle ear.

## 3. Inner ear. Its fluid filled

- *Cochlea*
  - It's responsible for hearing
  - It's filled with endolymph and perilymph
  - Highly coiled to occupy a small space ; and increase surface area ; for accommodation of many sensory cells
  - Vibrations from oval window are transmitted to perilymph which vibrates
  - Sensory cells are stimulated by these vibrations to generate nerve impulses which are transmitted to the brain for interpretation.

### Diagram

- *Semi circular canals*
  - Has semi circular canals which are at right angles to each other
  - Each canal has a swelling called *ampulla* at one end containing sensory cells.
  - Contains endolymph

- Movement of endolymph in canal helps to detect changes in position of the body and maintain body balance posture in relation to head movement.

### Diagram



- *Vestibule*
  - Has *utricle and saccule* that have sensory cells.
  - It maintains body balance posture in relation to gravity.

NB/ Auditory nerve – transmits nerve impulses to the brain for interpretations.

### Defects of the Ear

- Deafness
- Vertigo
- Tinnitus

## GENETICS

This is the study of *inheritance* and *variation*.

### Terms used in genetics

1. *Inheritance*; transmission of characteristics from the parents to the offsprings
2. *Variation*; possession of characteristics different from those of the parents and other offsprings.
3. *DNA*; De-oxyribonucleic acid
4. *RNA*; Ribonucleic acid
5. *Monohybrid inheritance*; inheritance of one characteristic controlled by one pair of hereditary factors e.g. Tallness
6. *Dihybrid inheritance*; inheritance of two characteristics at the same time e.g. colour and Texture/shape in the garden pea plant
7. *Dominance*; ability of a trait to only express itself
8. *Recessiveness*; a trait that only expresses itself when in homozygous state.
9. *Heterozygosity*; presence of two dissimilar members of an allele e.g. Rr, Tt etc.
10. *Homozygosity*; presence of two similar of an allele e.g. TT, RR, tt, rr etc.
11. *Allele*; one pair of genes which occupy corresponding loci/positions in homologous chromosomes

12. *Phenotype*- the physical appearance of an individual or organism. It's influenced by the genotype and environment.
13. *Genotype*- the genetic constitution of an organism. Its purely genetical.
14. *F1 generation (first filial generation)* - are the offsprings that represent the first generation of organisms or individuals under study.
15. *F2 generation (second filial generation)* - these are offsprings obtained after self crossing the F1 gen.
16. *Incomplete dominance/ co-dominance*- a condition where no allele is dominant over the other. The phenotype of the offspring is intermediate between that of the parents.
17. *Multiple allelism*- are characteristics determined by more than two variant forms of a single gene e.g. inheritance of the Blood groups in man (ABO)
18. *Test cross / back cross*- it's a crossing involving a homozygous recessive to determine the genotype of an organism.
19. *Mutation*- these are spontaneous changes in the individual's genetic makeup.



## Concepts of Variation

Variation refers to observable differences among living organisms.

### Types of variation

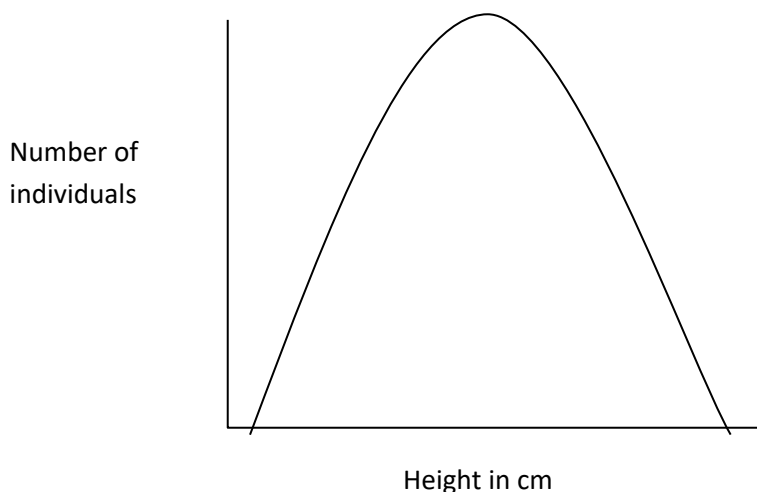
1. Discontinuous variation – in this type of variation, there are distinct and definite groups of individuals with no intermediate forms. E.g.
  - sex either male or female,
  - blood groups- one can only belong to one of the four blood groups A,B,AB,O
  - ability to roll the tongue
  - Presence of long hair in the nose and on the ear pinna.
  - Presence of a free or attached ear lobe.

*All these traits are controlled by one or two major genes. These traits are not influenced by the environment*

2. Continuous variation – this variation has a wide range of differences for the same characteristic from one extreme to the other e.g.
  - Height
  - Skin colour/pigmentation

- Weight
- Length of internodes
- Number of leaves, fruits on a tree etc
- Finger prints

When these traits are plotted on a graph a normal distribution curve is obtained.



### A normal distribution curve of heights

This type of variation is brought about by the interaction of both the genetic environmental factors.

E.g. a plant with genes for tallness may fail to grow tall due to climate and poor soils.

### Practical Activity 1

- Tongue rolling
- Finger prints
- Height

### Causes of variation

1. **Gamete formation** – during gamete formation two processes contribute to variation. These are
  - *Independent assortment*- during metaphase I of meiotic division, homologous chromosomes come together in pairs and segregate into daughter cells independently of each other. This independent assortment produces a variety of different gametes. The total number of combinations is given by  $2^n$  where 'n' is the haploid number of chromosomes. In man  $n = 23$  hence  $2^n = 2^{23}$  which is equal to 8,388,608.
  - *Crossing over* during the prophase I of meiotic cell division. I.e. when homologous chromosomes break and rejoin at certain points called *chiasmata*.

2. **Fertilization** – during fertilization parental genes come together in different combinations. Therefore desirable

and undesirable qualities of parents can be combined in the offsprings.

3. **Mutation**- these are spontaneous changes in the genetic makeup of an organism. Mutation brings about changes in the living organisms.



### ***The Chromosome***

Each chromosome is made up of two parallel strands called chromatids. Each pair of chromatids is connected at a point by the centromere. Chromosomes contain the hereditary material called the genes. All cells including the sperms and ova have chromosomes. Chromosomes are present in the nucleus and are only visible under the microscope during cell division – mitosis and meiosis. There is a definite number of chromosomes in each cell for every species of animal or plant.

E.g. in man somatic cells (body cells) have 46 chromosomes while the sex cells/gametes have 23 chromosomes. During fertilization fusion of the sperm- 23 chromosomes and the ova - 23 chromosomes restores the 46 chromosomes to form a diploid zygote.

### ***Chromosomal numbers in different organisms***

| Organism                                     | Number of chromosomes |             |
|--|-----------------------|-------------|
|  | Somatic cells –<br>2n | Gametes - n |
| Sheep ( <i>Ovis auries</i> )                 | 56                    | 28          |
| Cow ( <i>Bos Taurus</i> )                    | 60                    | 30          |
| Fruit-fly ( <i>Drosophila melanogaster</i> ) | 8                     | 4           |
| Maize ( <i>Zea mays</i> )                    | 20                    | 10          |
| Wheat( <i>Triticum vulgare</i> )             | 14                    | 7           |
| Tobacco ( <i>Nicotiana tabacum</i> )         | 12                    | 6           |
| Man ( <i>Homo sapiens</i> )                  | 46                    | 23          |

### **Practical Activity 2**

- Chromosomal behaviour during mitosis
- Chromosomal behaviour in meiosis

### **GENES AND DNA**

Genes occupy specific positions on the chromosomes called the *gene loci*( *gene locus*)

The gene is a chemical in nature. The genes are in the form of a nucleic acid molecule called De-oxyribonucleic acid (DNA). In

1953 two Biologists Francis Crick and James Watson worked out the structure of the DNA. DNA was found to be composed of three different components;

1. A five carbon sugar-pentose
2. phosphate molecule
3. nitrogenous base

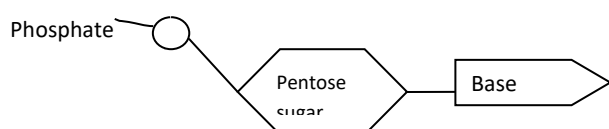


There are four types of the nitrogenous base;

- Adenine – N
- Guanine – G
- Thymine- G
- Cytosine – C

A combination the pentose sugar, a phosphate molecule and a nitrogenous base forms a **nucleotide**.

*I.e.*



DNA structure contains several nucleotides fused together to form long chains called DNA strands. Two parallel strands twist on one another forming a double helix structure. Adenine always combines with Thymine and Cytosine with Guanine.

## Diagram

### *Role of DNA*

- Stores genetic information in a coded form
- Enables transfer of genetic information unchanged to daughter cells through replication
- Translates the genetic information into the characteristics of an organism through protein synthesis

## DNA REPLICATION

- During cell division both daughter cells arising from mitotic division have the same genetic constitution as the parent cell. DNA in the parent cell must therefore duplicate accurately before the cell divides. The process through which a DNA molecule forms an exact *Replica* is called *DNA replication*.
- The two strands forming the double helix separates like a *zipper*. Each parallel strand becomes a *template* that specifies the base sequence of a new complimentary strand. Through the action of

replicating enzymes, free nucleotides take up positions along the template strands.

- The specificity of the base pairing ensures that only *complimentary* bases link together with those on the template strands. I.e. G-C and A-T.
- Covalent bonds are formed between the nucleotides resulting in the formation of a new DNA strand.
- The template and the new DNA strand the undergo coiling to form a double helix. In this way, two identical DNA molecules are formed from the original single molecule.
- Each of the new DNA molecules gets incorporated into one of the two nuclei formed just prior to the separation of the daughter cells.



## Diagram

### *Role of the DNA in protein synthesis*

The sequence of bases along the DNA strand acts as the alphabet and determines the sequence of amino acids when they join to form a polypeptide chain. Protein synthesis takes place in ribosome's found in the cytoplasm. Since the DNA molecules are confined in the nucleus, there has to be a way of communicating the DNA information to the ribosome's where actual protein synthesis occurs.

The cell therefore has a special molecule called the Ribonucleic acid (RNA). Its role is to carry genetic information from the DNA to the site of protein synthesis in the cytoplasm. It's referred to as messenger RNA (mRNA). RNA is formed from the DNA strands.

During formation of the mRNA a section of the DNA strands acts as the template strand. The double helix of the DNA unzips and free nucleotides align themselves opposite the template. The base sequence of the template strand is copied onto a new strand.

In RNA, Thymine is replaced by another base called *Uracil (U)*. The transfer of DNA sequence on the mRNA strand is referred to as *Transcription*.

## Diagram

After its formation the mRNA leaves the nucleus with instructions from the DNA about the kind of protein to be synthesised by the cell. This information is in the form of base

triplets known as Codons which code for a particular amino acid of a protein molecule e.g.

- AAA-phenylalanine
- TTT-lysine
- CAA- valine
- CTA- aspartic acid



### Differences between DNA and RNA

| DNA  | RNA  |
|--|--|
| 1. Has De-ox ribose sugar  | Has ribose sugar   |
| 2. Double stranded   | Single stranded  |
| 3. Confined in the nucleus                                       | Found in nucleus and cytoplasm                             |
| 4. Have organic bases as cytosine, guanine, adenine and thymine. | Has organic bases as cytosine, guanine, adenine and uracil |

## THE FIRST LAW OF HEREDITY MENDEL'S EXPERIMENTS

An Austrian monk known as Mendel is considered to be the father of genetics. He carried out various breeding experiments and observed variations in different characteristics of the garden pea. The characteristics include:

- Height of the stems- tall or dwarf
- Texture of the seed coat- smooth or wrinkled
- Colour of the seeds- yellow or green
- Texture of the pods
- Colour of the flowers- white or purple
- Position of the flower- axial or terminal

He selected a group of dwarf plants and self pollinated them by dusting mature pollen grains onto the stigmas of the same plant. He collected the resulting seeds and planted them. He noted that these seeds grew into dwarf plants only. He repeated the experiment for several generations and obtained the same results.

In another experiment, Mendel selected tall plants and self-pollinated them. He planted the resulting seeds and observed that they grew into a mixture of tall and dwarf plants. He took seeds from the tall offsprings only and repeated the experiment for many generations until he obtained only tall plants.

This way he was able to obtain a pure line of tall garden peas and a pure line of dwarf garden peas.



He then cross-pollinated pure bred tall garden peas with the pure bred dwarf variety. He planted the resulting seeds and he observed that all the offsprings were tall plants.

### Diagram

He further crossed two of these tall offsprings and planted the resulting seeds. Mendel observed that this second generation consisted of a mixture of tall and dwarf plants. After counting these plants he noted that the ratio of tall to dwarf plants was approximately 3:1 respectively. He observed that this ratio was always obtained when crosses were made between the non-pure breeds of tall plants.



### Diagrams

Mendel concluded that the traits of an organism are determined by hereditary factors which occur in pairs. Only one of pair of such factors can be represented in a single gamete. This later became *Mendel's First Law, The Law of Segregation*

At this time Mendel had no idea of genes and so he called them factors. He postulated that these factors are found on the chromosomes and are passed from the parents to the offsprings via gametes.

### *Reasons behind Mendel's success*

1. He used favourable materials i.e. the garden pea plant which is normally self pollinated. This made it easy for him to employ cross pollination at will.
2. the pea plant he used had several contrasting traits
3. His study was focused on particular traits while those before him had been attempting to determine wholesome heredity of each organism.
4. He kept accurate data on all his experiments and from the analysis of this data he was able to formulate definite hypothesis.

### *Mendel chose the garden pea plant because of the following reasons*

- Plant had many contrasting traits e.g. flower colours, seed coat texture, length of the stems etc.
- Plant is normally self pollinated but cross pollination can be employed at will.
- Plant matures relatively fast
- Plant produces many seeds that can be planted to produce many offsprings

## ***Monohybrid Inheritance***

This is the inheritance of one trait like height in the garden pea plant that is controlled by a single pair of hereditary factors (genes) contributed by both parents. Genes occur in pairs on chromosomes and such gene pairs are known as ***alleles***.

The genetic constitution of an organism is called the ***Genotype*** while the physical appearance is known as the ***Phenotype***.

The genotype of an organism is represented using paired letter symbols. Capital letters represents the dominant gene while small letters represent the recessive gene.



## ***Genetic Cross***

Components of a genetic cross

- Parental phenotypes
- The parental genotype –the crossing X should be shown here.
- The gametes and should be circled.
- The fusion process or fertilization.
- The filial generation genotypes

*NB. The conventional symbol for male is ♂ and that of female is ♀*

### ***Example 1***

During gamete formation in the dwarf plant, each gene in the pair segregates into different gametes. When the female and male fuse during fertilization, the offspring produced contain the same number of genes as in each parent. The inheritance of dwarfness in the pea plant can be illustrated diagrammatically by the following genetic cross

Diagram

### ***Example 2***

Similarly the pair of genes in the pure breed tall plants will segregate into different gametes during gametogenesis. When self fertilised the resulting seeds will have half the number of genes from each parent i.e.

Diagram

### ***Example 3***

When the purebred tall plant is crossed with dwarf plants, the resulting seeds grow into tall plants only. These offsprings represent the first generation (F1 gen)

## Diagram.

In the genetic cross above, the male plant is tall and the female plant is dwarf. If the cross is reversed so that the female is tall and the male a dwarf, this is referred to as a **reciprocal cross**. The F1 results will be the same for either cross.



## Diagram

### Example 4

When the F1 offsprings are self pollinated, they produce offsprings which that grow into a mixture of tall and dwarf plants. These offsprings are known as the F2 gen.

## Diagram

A *Punnet Square* can also be used to work out genetic crosses e.g.

Parental phenotype tall tall  
Parental genotype Tt X Tt  
Gametes T t T t

|   |   |    |    |
|---|---|----|----|
|   | ♀ | T  | t  |
| ♂ |   |    |    |
| T |   | TT | Tt |
| t |   | Tt | Tt |

When the allelic genes are identical, as in **TT** and **tt**, the condition is known as *homozygous*. An individual with such a condition is known as a *homozygote*.

When the allelic genes are not identical as in **Tt**, the condition is referred to as *heterozygous*. An individual with such a genotype is referred to as a *heterozygote*. An individual with genotype **Tt**, will be physically tall because the gene **T** is *dominant* over **t**. The allele **t** is *recessive*.

A dominant gene expresses itself in both the homozygous (**TT**) and heterozygous (**Tt**) states while a recessive gene only expresses itself I its homozygous state (**tt**). **TT** is therefore referred to as homozygous dominant and **tt** is homozygous recessive.

The ratio 3 tall: 1 dwarf, in the F2 gen is characteristic of monohybrid inheritance where one gene is completely dominant over the other. This is referred to as *complete dominance*.

The monohybrid crosses are based on Mendel's first law, The law of Segregation which states the characteristics of an organism are determined by internal factors which occurs in

pairs. Only one of a pair of such factors can be represented in a single gamete.

Diagram - the process of segregation

### **Ratios and Probability**

The 3:1 ratio in monohybrid inheritance can be represented in the form of probability. When a large number of heterozygous garden pea plants are selfed, the probability of getting tall plants is  $\frac{3}{4}$  or 75% and that of dwarf will be  $\frac{1}{4}$  or 25%.



### **Diagram**

**NB.** The inheritance of characteristics involves probability. The chance that a particular gamete will fuse with another is a random occurrence, in genetics this done by showing all possible fusions.

### **Practical Activity 3 and 4**

- Tossing a coin
- To demonstrate random fusion of gametes in monohybrid inheritance.

Similar monohybrid inheritance results as those of Mendel have been obtained by using the fruit fly (*Drosophila melanogaster*) the insect has many observable characteristics that are contrasting such as,

- Wing length – long wing dominant over vestigial wing
- Eye colour – red eyes dominant over white eyes
- Size of the abdomen – broad abdomen dominant over narrow abdomen
- Body colour – grey body colour dominant over black body colour.

### **Assignment**

Using appropriate letters work out the following crosses with respect to the fruit fly

- Cross between a purebred long winged and a vestigial winged
- Cross between two long winged heterozygotes
- Cross between a red eyed heterozygote and a white eyed fruit fly.

The fruit fly is suitable for genetic study because of the following reasons.

1. The female lays very many eggs hence increasing the sample size for study.

2. Have many observable characteristics that are distinct and contrasting.
3. It is easily bred in the laboratory with minimum requirements.
4. It has a short generation time 10-14 days. Therefore many generations can be studied in a short period of time.
5. Offsprings can be crossed with their parents at will (backcrossing)
6. Flies are safe to handle because they do not transmit any known human diseases.

### Study Question 10

### Practical Activity 5

- Breeding fruit flies.

### *Incomplete Dominance (Co-dominance)*

In Mendel's experiments with garden pea plants, the genes determining the various traits were clearly dominant or recessive. However in some species, alleles determining several contrasting traits do not have a clear cut dominant-recessive relationship. This implies that neither of the alleles is completely dominant over the other.

Heterozygous individuals are phenotypically different from either of the parents. Mostly the phenotype of the heterozygous offspring is intermediate between that of the parents. This phenomenon is called ***Incomplete Dominance***. Examples of incomplete dominance.

#### 1. *Inheritance of flower colour in the 4 o'clock plant*

(*Mirabilis Jalapa*). If a true breeding plant producing red flowers is crossed with a true breeding plant producing white flowers, all the F1 offsprings will have pink flowers. When the F1 plants are self pollinated, they yield ***red*** flowered, ***pink*** flowered and ***white*** flowered offspring at a ratio of 1:2:1 respectively.

### Diagrams

2. *Incomplete dominance in short horn cattle*. Mating red and white shorthorn cattle yields Roan (light Red) calves due to presence of both red and white hairs. A mating between two roan coloured shorthorns yields a mixture of red, roan and white coloured calves at a ratio of 1:2:1 respectively.

## Diagrams

### Study Question 12

#### Inheritance of the Blood groups (Multiple allelism)

In all the kinds of inheritance discussed so far, each phenotypic characteristic is determined by 2 variant forms of a single gene located at a specific locus on the homologous chromosome.

However some characteristics are determined by more than two variant forms of a single gene. This phenomenon is referred to as *multiple allelism* and the genes involved are called *multiple alleles*. E.g. in the ABO blood groups in humans, there are *three* genes involved and they are responsible for the presence of antigen types on the red blood cells.

These are gene **A** responsible for the presence of antigen **A**, gene **B** for antigen **B** and gene **O** responsible for absence of antigens on the red blood cells.

Genes A and B have equal degree of dominance i.e. are *co-dominant*. They both express themselves when present together as in the blood group AB.

Genes A and B are *dominant over* gene O. Gene **O** is *recessive* and only expresses itself in the *homozygous* condition. The genotypes for the four blood groups in the ABO system are therefore,

| Blood group (Phenotype) | Genotype | Antigens |
|-------------------------|----------|----------|
| A                       | AA, AO   | A        |
| B                       | BB,BO    | B        |
| AB                      | AB       | A and B  |
| O                       | OO       | O- Zero  |

i.e.

- AA or AO-Blood group A
- BB or BO – blood group B
- AB – blood group AB
- OO – blood group O

A marriage between a man of blood group A and a woman of blood group B will produce children of all the four blood groups if both parents are heterozygous.

#### Diagram

Marriage between a man of genotype AA (blood group A) and Woman of genotype BB (blood group B) results in all the offsprings having blood AB.

Diagram.

## Assignment

Work out the following crosses

- Both parents with blood group O
- Heterozygous blood group A and blood group O



## Study Question 13

### *Inheritance of the Rhesus factor*

In man the possession of Rhesus antigens makes one Rh<sup>+</sup> and this is dominant over Rh<sup>-ve</sup>. If blood from a Rhesus positive person is transfused into a rhesus negative person, this induces antibodies against the Rhesus factor of the donor. This causes agglutination of red blood cells of the recipient.

If a Rh<sup>-ve</sup> woman is married to a Rh<sup>+ve</sup>, when she becomes pregnant, the child will be Rh<sup>+ve</sup>. Rhesus antigens cross the placenta into the mother's blood stream. This stimulates the mother's immune system to produce Rhesus antibodies. When these antibodies get into the foetal circulation, an antigen-antibody reaction takes place and the red blood cells of the foetus are destroyed (Haemolysed).

During the second pregnancy, the amount of Rhesus antibodies are more and cause a lot of damage to the foetus's red blood cells resulting to death. This is called *Haemolytic Disease of the Newborn or Erythroblastosis foetalis*.

### *Determining Unknown Genotypes*

This can be done in two ways.

#### 1. Carrying out a Test Cross

A test cross is a cross between an individual of unknown genotype with an individual of a recessive genotype. A test cross where an offspring is crossed with one of its parents is called a **Back Cross**.

In garden pea plants the gene that determines red flowers is dominant over that which determines white flowers. A plant with red flowers may either be homozygous (RR) or heterozygous (Rr) for this characteristic. To establish its correct genotype it is crossed with a homozygous recessive plant i.e. a white flowered one (rr)

If all their offsprings bear red flowers then this indicates that the red flowered plant is homozygous or it's from a pure line.

## Diagram

If the offsprings bear a mixture of red and white flowers in the ratio of 1:1, this indicates that the red flowered plant was heterozygous.

## Diagram

### Selfing

Unknown genotypes can also be determined by carrying out selfing experiments. For example, a phenotypically tall plant is either homozygous (TT) or heterozygous (Tt) for this trait.

If selfed and all its offsprings are tall, the parental genotype is TT that is homozygous dominant.

## Diagram

But if after selfing both tall and dwarf offsprings are produced in the ratio 3:1 respectively, then the parental genotype is heterozygous (Tt).

## Diagram

### Sex Determination

The sex of an organism is a genetically determined characteristic. Cells of most organisms contain a pair of chromosomes called *sex chromosomes* in addition to the ordinary chromosomes. In man there are *46 chromosomes (23 pairs of homologous chromosomes in everybody cell)*. The genes determining whether a child becomes a female or a male are located on the *specific pair of sex chromosomes* called the **X** and the **Y** named after their shapes.

The remaining 22 pairs of chromosomes are called **Autosomes**. Autosomes are responsible for other inheritable traits.

A male human being carries the XY chromosome i.e. he is **Heterogametic**

The female carries the XX chromosomes i.e. **Homogametic**.

After meiosis in a male the spermatozoon can either carry the X or Y chromosome while the female ova contain only the X chromosome. The sex of a child is a matter of chance and depends only on whether a spermatozoon that fertilizes the ovum carries X or Y chromosome.

There is therefore a 50% chance that fertilization can result in either XY (Boy) or XX (Girl) i.e.

|                        |   |   |
|------------------------|---|---|
|                        | X | X |
| Female<br>(XX)<br>Male |   |   |



|      |    |    |
|------|----|----|
| (XY) |    |    |
| X    | XX | XX |
| Y    | XY | XY |

**I.e. 2 girls: 2 Boys**

In terms of probability, the chance that a boy or a girl is produced in a family is 1/2.

NB/ in birds the female is XY – *heterogametic* and the male is XX – *homogametic*.

In some insects, the female is XX and the male is XO with the Y chromosome absent.

In the fruit fly (*Drosophila melanogaster*) sex determination is as exactly as in man, i.e. male XY and Female XX.

**Linkage**

An organism has a large number of traits controlled by many different genes. Because the number of chromosomes is limited, each gene cannot be located on its own chromosome. Therefore chromosomes must accommodate many genes each controlling particular characteristics. Those genes located on the same chromosome are called linked Genes. All the linked genes constitute a linkage group. Linked gene are inherited together and do not segregate/separate during meiosis. They are therefore transmitted into the same gamete.

**Diagram**

If genes Q, R and T are linked, then all the three pairs of genes are accommodated on a homologous pair of chromosome.

In *Drosophila sp*, it has been found that the genes for wing length, abdomen size and body colour are located on the same chromosome. Therefore these characteristics are usually inherited together.

**Sex-linked Genes**

All the genes located on the sex chromosomes are said to be *sex-linked*. They are therefore transmitted together with those that determine the sex. In *Drosophila melanogaster*, the gene, which determine eye colour, is located on the X chromosome.

However the corresponding allele on the Y chromosome is absent. This is because most sex-lined genes are carried on the X chromosome whereas the Y chromosome carries very few genes and is almost empty.

In humans there are few genes located on the Y chromosome, which control traits that are exclusively found in males. These

are, *Premature baldness* and *tufts of hair in the in the inner pinna and in the nose*.

Diagrams.

The characteristics controlled by genes located on the X chromosome include *Colour blindness* and *Haemophilia*. These characteristics can arise in either male or females.



### Colour blindness

This is the inability to distinguish Red and Green colours by some people. This trait is linked to the X chromosome. The gene that determines normal colour vision is dominant over that for colour blindness. A marriage between a colour-blind man and a woman homozygous for normal colour vision results in their daughters being carriers but with normal colour vision. The daughters are said to be carriers because they are heterozygous and colour blindness is suppressed/masked by the dominant gene for colour vision.

All the sons are of the two parents are however normal. This is illustrated below. Let N represent the gene for normal colour vision and n represent gene for colour blindness. Since the gene is linked to X chromosome, its alleles are represented as  $X^N$  and  $X^n$ .

|   |          |        |
|---|----------|--------|
| Colour blind male<br>( $X^nY$ )<br>Normal Woman<br>( $X^NX^N$ ) | $X^n$    | Y      |
| $X^N$   | $X^NX^n$ | $X^NY$ |
| $X^N$   | $X^NX^n$ | $X^NY$ |

All the daughters are carriers-  $X^NX^n$

All the sons have normal colour vision- $X^NY$

If a carrier daughter from the above parents married a normal man, some of their sons will suffer from colour blindness while the daughters will either be carriers or homozygous for normal colour vision as shown below.

|                |       |       |
|----------------|-------|-------|
| Carrier female | $X^N$ | $X^n$ |
|----------------|-------|-------|

|   |           |           |
|---|-----------|-----------|
| $(X^N X^n)$<br>Normal male<br>$(X^N Y)$ |           |           |
| $X^N$                                   | $X^N X^N$ | $X^N X^n$ |
| Y                                       | $X^N Y$   | $X^n Y$   |

Offsprings are;  $X^N X^N$  - Daughter with normal colour vision

- $X^N X^n$  - Carrier Daughter
- $X^N Y$  - Son with normal colour vision
- $X^n Y$  - Colour blind son.

The above examples show that the gene for colour blindness is passed from mother to sons.

This is because the only X chromosome a man inherits is from the mother. If the X chromosome carries the gene for the trait, then this gene will be expressed since allele on the Y is absent. Therefore there are more male sufferers in a population compared to females.

Females only suffer when in homozygous condition of the recessive gene. Inheritance of colour blindness through several generations can be clearly illustrated using a pedigree. A pedigree is a record in table form showing the distribution of one or more traits in different generations of related individuals. *Fig. 1.24*

### Haemophilia

This is another sex-linked trait where the blood of the sufferer takes abnormally long time to clot. There is prolonged bleeding in the event of a cut hence the term **Bleeder's Disease**. A recessive gene on the X chromosome causes haemophilia.

If a normal man is married to a carrier woman for haemophilia, there is a probability of  $\frac{1}{2}$  that if their child is a boy will be a haemophiliac and if a daughter, she will be a carrier. None of the daughters of the couple will be haemophiliacs.

Let H represent the gene for normal blood clotting and h to represent gene for haemophilia i.e.

|                              |       |       |
|------------------------------|-------|-------|
| Carrier woman<br>$(X^H X^h)$ | $X^H$ | $X^h$ |
| Normal man                   |       |       |

|                    |                               |                               |
|--------------------|-------------------------------|-------------------------------|
| (X <sup>H</sup> Y) |                               |                               |
| X <sup>H</sup>     | X <sup>H</sup> X <sup>H</sup> | X <sup>H</sup> X <sup>h</sup> |
| Y                  | X <sup>H</sup> Y              | X <sup>h</sup> Y              |

**Their offsprings will be; -X<sup>H</sup>X<sup>H</sup> -Normal daughter**

X<sup>H</sup>X<sup>h</sup> -Carrier daughter

X<sup>H</sup>Y -Normal son

X<sup>h</sup>Y -Haemophiliac son.

### Study question 14

Apart from carrying the sex-linked traits, the X chromosome in the females and the Y in males bring about the development of both the primary and secondary sexual characteristics. At puberty, secondary sexual characteristics in females include breast enlargement, widening of the hips, and growth of pubic hair and onset of menstrual cycle. The X chromosome controls these.

In males, they include growth of pubic hair and beard, deepening of the voice, widening of the shoulders etc.

### Effects of Crossing Over on Linked Genes

Some of the linked genes separate and are transmitted on different chromosomes. This happens during crossing over (prophase I of meiosis) when sections of chromatids of a bivalent intertwine and may break off. Some of these sections get rejoined to different chromatids thus separating genes that were previously linked. The fusion of such gametes containing chromatids whose genes have changed places produces new combinations (recombinants). Crossing over results in chromosomal mutations, which in turn cause variations.

### Diagrams

#### Mutations

Mutation is brought about by *spontaneous changes in the individual's genetic makeup*. Mutations are normally due to recessive genes most of which are transmitted in the usual Mendelian fashion. Therefore they are quite rare. Individuals with mutations are referred to as *mutants*. Mutation can be induced by certain factors. Such factors are called *Mutagens*. They include,

- Exposure to Gamma rays
- Ultra violet light

- Colchicine
- Mustard gas

*NB: Mutations occurring in gametes are more important than those in somatic cells. Mutational changes are the basis of discontinuous variation in population.*



### ***Types of Mutations***

1. Chromosomal mutation
2. Gene mutation

#### **Chromosomal Mutations**

This involves the change in the structure or the number of chromosomes. During crossing over in meiosis homologous chromosomes intertwine at points called chiasmata. These points are later broken creating various opportunities for changes on the chromatids. There are five types of chromosome mutations (*chromosome aberrations*).

- Deletion
- Duplication
- Inversion
- Translocation
- Non-disjunction

#### ***Deletion***

This occurs when some sections of chromatids break off and fail to recombine. They are therefore completely lost and the genetic material they contain is said to be deleted out. Most deletions are lethal since the offspring may lose genes responsible for the synthesis of some vital protein molecules.

Diagrams

#### ***Duplication***

In this case a section of chromatids replicates and adds an extra length to itself. Duplication can produce serious effects depending on the chromosome sections involved.

Diagrams

#### ***Inversion***

In this case a chromatid breaks at two points. When rejoining, the middle piece rotates and joins in an inverted position. This reverses the gene sequence along the chromatid. This might bring together genes whose combined effects are advantageous or dis-advantageous.

**Diagrams**

## ***Translocation***

This occurs when a section of one chromatid breaks off and becomes attached to another chromatid but of a non-homologous pair.

Translocation therefore involves the movement of genes from one non-homologous chromosome to another.



### **Diagrams**

## ***Non-disjunction***

This leads to addition or loss of one or more whole chromosomes. If it occurs at anaphase of the first meiotic division, two homologous chromosomes fail to segregate and they move into the same gamete cell. If it happens at anaphase of the second meiotic division, sister chromatids fail to segregate. This results in half the gametes containing two of the same chromosome while the others have none.

### **Diagrams**

Non-Disjunction causes the following

1. ***Downs's Syndrome***: this is where there is an extra somatic chromosome number 21. such individuals have;

- Slit eye appearance
- Reduced resistance to infections
- Mentally deficient
- Thick tongue
- Cardiac malfunctions
- Short body with thick fingers

NB/ these conditions are common among children born of mothers above 40 years old.

2. ***Klinefelter's Syndrome***: in this case individuals have an ***extra sex*** chromosome. Such individuals have a total of 47 chromosomes in their cells i.e. XXY (male) and XXX (female). This occurs as a result of non-disjunction during spermatogenesis or oogenesis. The symptoms of Klinefelter's syndrome are

- Infertility in males due to lack of sperm production
- Under developed testes
- Reduced facial hair in males
- Very tall with signs of obesity

## Diagrams

3. **Turner's syndrome:** This is where an individual lacks one sex chromosome hence there are 45 chromosomes (XO or YO).
4. **Polyploidy:** sometimes during meiosis chromosomes might undergo non-disjunction. This results in half the number of gametes having two of each type of chromosome i.e. **diploid** the rest having none. If the resulting diploid gamete fuses with a normal haploid gamete a **triploid** zygote is formed. If two diploid gametes fuse, a **tetraploid** individual is obtained. This is what is called polyploidy.

Polyploidy is rare in animals but common in plants where it's considered to be advantageous. Polyploidy increases yields, early maturity and resistance to pests and diseases. It can be artificially induced using a chemical called **colchicine**, which prevents spindle formation during mitosis leading to a cell with double the number of chromosomes (4n).

## Gene Mutation

This involves a change in the structure of a gene. Gene mutations are also referred to as **point mutations**. A gene mutation arises as a result of a change in the chemical nature of the gene. The change may involve some alterations in the DNA molecule. A change in the DNA molecule is passed onto the m-RNA. This alters the sequence of amino acids during protein synthesis. This may result in unintended protein molecules being synthesised, which may be lethal. Types of gene mutations;

- Insertion
- Substitution
- Inversion
- Deletion

### Insertion

This is the addition of an extra base onto the existing DNA strand.

### Diagram

By this insertion no polypeptide chain is formed as it were intended.

### Deletion

This is the removal of a gene portion. If the base Thymine is deleted from its position as indicated below, the base sequence becomes altered at this point.

This results in the wrong proteins being synthesised.

## Diagrams

### *Substitution*

This is the replacement of a portion of the gene with a new portion. If Adenine is substituted by Guanine on a DNA strand, the base sequence is altered at this particular portion.

Diagrams

### *Inversion*

If a portion of the DNA strand is rotated through  $180^\circ$  that portion is said to be inverted as shown below. This alters the base sequence at this point.

Diagrams

## Study Questions

### Disorders Due to Gene Mutations

Such disorders include albinism, sickle cell anaemia, haemophilia, colour blindness and chondrodystrophic dwarfism.

#### 1. Albinism

This is a condition where the synthesis of skin pigment called *melanin* fails. The victim has a light skin, white hair and pink eyes. Such a person is referred to as an Albino. Melanin is derived from two amino acids – Phenylalanine and Tyrosine. Melanin is synthesised through a series of reactions controlled by a specific gene.

Gene '*A*' is responsible for presence of melanin and '*a*' is responsible for its absence. Gene '*aa*' in homozygous state blocks in one or two places in the synthesis of melanin hence no melanin is formed. This occurs as a result of one enzyme (Tyrosinase) failing to be formed in the presence of the recessive gene.

A person with genotype *AA* has normal skin pigmentation.

One with genotype *Aa* is a carrier and has normal skin pigmentation. In a family an albino can be born under three conditions only.

- If both parents are albinos
- If one of the parents is an albino and the other a carrier
- If both parents are carriers

### Assignment

- Work out crosses in each case.
- What is the probability of getting an albino child in each case?



## 2. Sickle Cell Anaemia

This is a gene mutation as a result of substitution. Normal haemoglobin Hb A consists of two polypeptide chains. In the sickle cell condition, one amino acid called *glutamic acid* is substituted by another amino acid called *valine* in each of the two-polypeptide chains of the haemoglobin molecule. The resulting haemoglobin is known as Haemoglobin S – Hb S and is different from the Hb A in several ways.



### Comparison between Hb A and Hb S

| Normal haemoglobin (Hb A)  | Defective Haemoglobin (Hb S)                                      |
|--|---|
| 1. A position in each polypeptide chain is occupied by glutamic acid | The same position is occupied by valine in each polypeptide chain |
| 2. Does not easily crystallise in low oxygen concentration           | Easily crystallises in low oxygen concentration                   |
| 3. The haemoglobin is efficient in oxygen loading and transportation | Not efficient in oxygen loading and transportation                |
| 4. The red blood cells are biconcave in shape                        | Red blood cells are sickle shaped (crescent shape)                |

Sickle cell anaemia is therefore the condition where the victim is *homozygous* for the defective gene that directs the synthesis of haemoglobin S. Most of the victims' red blood cells are sickle shaped and the person frequently experiences oxygen shortage to the body tissues. Such a person cannot carry out strenuous physical exercises.

Many sickle cell victims die young due to insufficient oxygen supply to body tissues.

In the heterozygous condition, less than half the number of the red blood cells is sickle shaped. The rest are normal and efficient in oxygen transport. *This is referred to as sickle cell trait.* An individual with the sickle cell trait experiences a mild case of anaemia but leads a normal life.

### Inheritance of Sickle Cell Anaemia

If a man with sickle cell trait marries a normal woman, the probability that any of the offspring will carry the sickle cell trait is  $\frac{1}{2}$ .

If both parents are carriers the probability of getting an offspring with sickle cell anaemia is  $\frac{1}{4}$ .

3. **Haemophilia:** This condition where the blood takes abnormally long time to clot. A haemophilic gene that prevents the production of the clotting factors causes the condition.

4. **Colour blindness:** There are different forms of colour blindness. The most common one is the red-green colour blindness. In this case an individual is unable to distinguish between red and green colours.

*NB. Most disadvantageous genes are recessive. Very few are dominant e.g. the gene for chondrodystrophic dwarfism*

## Study Question 16

### *Effect of Environment on Heredity*

The genotype and the environment influence the development of an individual. In animals genetically identical individuals reared under different environments will appear different than those reared under very different conditions. *Consider identical twins.*

### *Practical Applications of Genetics*

- Plants and animal breeding
- Blood transfusion
- Genetic counselling
- Genetic engineering

#### 1. Plants and Animal Breeding

Man chooses those plants and animals with the desirable qualities. This is referred to as *artificial selection*. Inbreeding or crossbreeding does this. Inbreeding however increases the chances of undesirable genes whereas crossbreeding increases heterozygosity with the offspring's having better performance than both parents. This is referred to as *hybrid vigour* e.g. a cross between Boran and Hereford.

Polyploidy has also been used in planting. The original wheat had a diploid number of 14 chromosomes but the commercial wheat has either 28 or 42 (tetraploid-4n or hexaploid-6n).

Examples of characteristics, which have been selected in agriculture.

1. Resistance to diseases e.g. cassava resistant to cassava mosaic, coffee variety resistant to CBD.
2. Early maturity in animals and plants.
3. Adaptations to various conditions e.g. rainfall, temperature etc.
4. Ease of harvesting e.g. in coffee and bananas where dwarf varieties have been developed
5. Increased productive season e.g. in chicken

6. Higher productivity
7. Production of flowers such as roses for their colour and aroma.

## 2) Blood Transfusion

Before blood is given to a recipient, blood typing is first done. This is done to ensure compatibility between the donor and the recipient.

Blood typing also can be used to solve disputed parentage. However the most recent technique in establishing parentage is the *DNA matching*.

## 3) Genetic Counselling

This is the provision of information and advice on genetically inherited disorders to individuals. The individual is given such advice to enable him or her make the best choice.

Examples of disorders for which genetic counselling may be done include

- Sickle cell anaemia
- Haemophilia
- Albinism
- Erythroblastosis foetalis
- Colour blindness
- Klinefelter's syndrome

In order to confirm the disorder the doctors can do the following

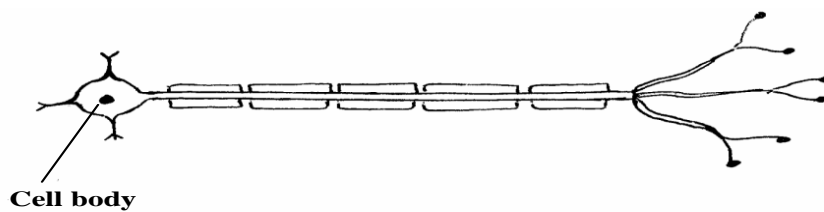
- Physical examination e.g. Lack of breasts in Turner's syndrome.
- Laboratory tests e.g. blood tests to confirm sickle cell anaemia
- Amniocentesis for chromosomal abnormalities in foetus
- Family history may be used to determine possible inheritance of the disorder e.g. haemophilia.
- Genetic screening of the defective gene in the population

## 4) Genetic Engineering

This deals with identification of a desirable gene, altering, isolating and transferring it from one living organism to another.

## STIMULUS AND RESPONSE REVISION QUESTIONS

1. The diagrams below represents a nerve cell



a) **Identify** the nerve cell.

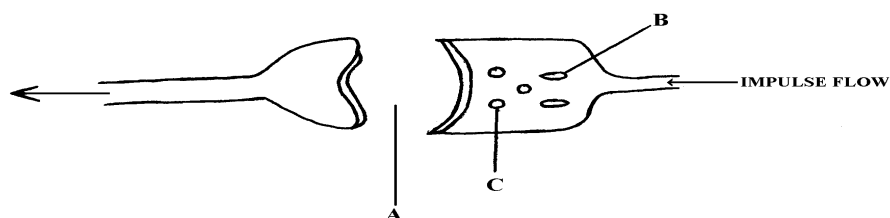
(1mark)

(b) (i) **Give** a reason for your answer in (a) above

(1mark)

(ii) **Show** by use of an arrow the direction of flow of the nerve impulses. (1mark)

2. Below is a diagram showing parts of a synapse observe and answer the questions that follow.



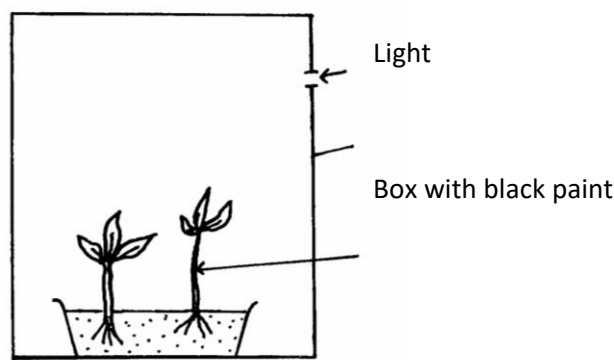
(a) **Name** the parts labeled: A, B.

(2mks)

(b) **What** is the role of part labeled C.

(1mk)

3. A student set up an experiment as shown in the diagram below.



The set up was left for 4 days.

a) What was the aim of the experiment.

(1mk)

b) i) State the expected results after 4 days.

(1mk)

ii) Account for the results you have stated in ( b) (i) above.

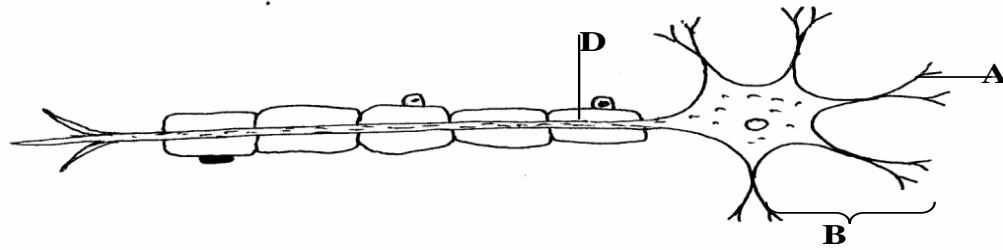
(4mks)

c) In another experiment, a student placed a seedling horizontally on moist cotton wool. Later the shoot grew upwards while the Radicle grew downwards. Explain why the radicle showed a downward curvature.

(2mks)

4. **Describe** how different types of tropisms adapt plants for survival in their habitats. (20mks)

5. **Diagram** below shows the structure of motor neuron.

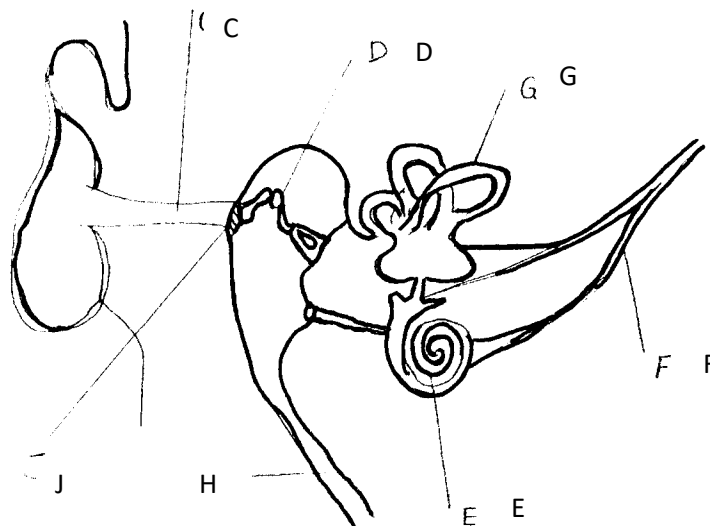


(a) **Name** the parts labelled. A, B  
(2mks)

(b) **State three** adaptations that enable the neurone to carry out its functions efficiently. (3mks)

(c) **State two** features that would distinguish sensory neurone from the above neurone. (2mks)

6. The diagram below shows the structure of its human ear.



a) State the functions of the ear.  
(2mks)

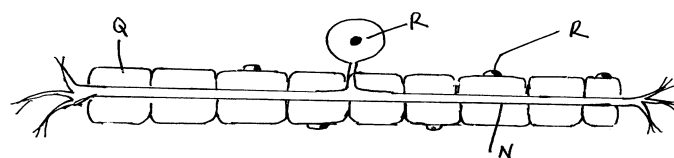
b) Give the names of the structure labelled C,G and F.  
(3mks)

c) (i) What is the function of the structure labeled H?  
(1mk)

(ii) Name the structure in the ear that detects sound waves.  
(1mk)

d) In which structure of the ear is the velocity of the sound waves fastest? (1mk)

7. The diagram below represents a **epithelial** cell. Study it and answer the questions that follow.



a) (i) Identify the cell  
(1mk)

(ii) Give a reason for your answer in a (i) above  
(1mk)

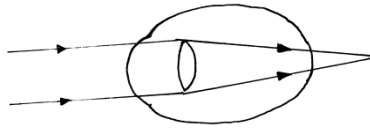
b) Name the parts labelled N, P, Q and R.

(4mks)

c) State the functions of the parts labelled N and Q.

(2mks)

8. Use the diagram below to answer the questions that follow



a) (i) Name the eye defect represented above

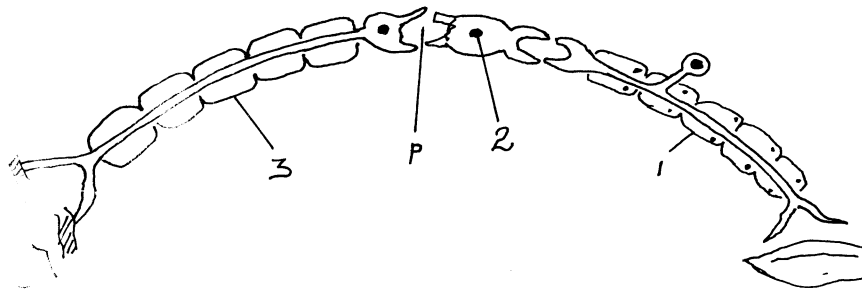
(1 mk)

(ii) What is the cause of this defect

(1 mk)

(iii) How can the defect you have named (a) (i) be corrected? (1 mk)

9 The diagram below shows three different types of neurones along a reflex arc



a) Identify the neuron labelled 1, 2 and 3

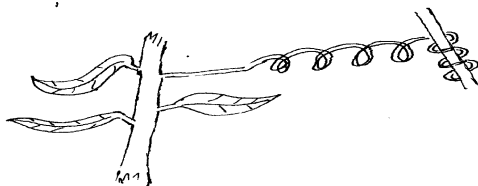
(3 mks)

b) Using arrows show the direction of impulse transmission on the diagram (1 mk)

c) Name the part of the spinal cord where the cell bodies of neurone 2 and 3 are located (1mk)

d) Describe the transmission impulse across the part labelled P (3 mks)

10 A response exhibited by a certain plant tendril is illustrated below



(i) Name the type of response

(1mk)

(ii) **Explain** how the response named in (i) above occurs. (3mks)

(iii) **What** is the importance of tactic responses to microscopic plants? (1mk)

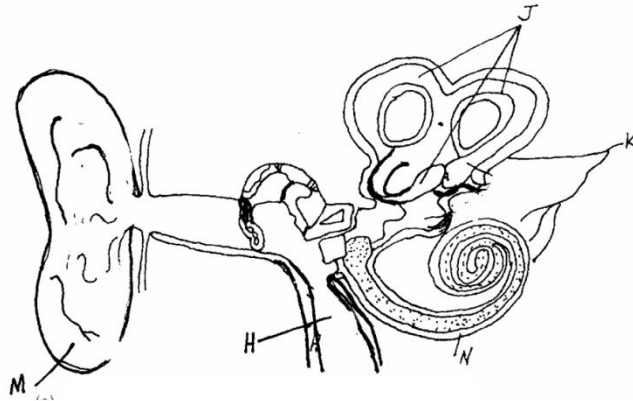
11 **Describe** how the mammalian ear is adapted to perform its functions. (20mks)

12. a) Describe how the structure of the eye is adapted to its function. (16mks)

b) Identify two defects of the eye and how they can be rectified. (4mks)

13 Differentiate between nervous and endocrine communication in animals (3mks)

14. The diagram below represents a section through the mammalian ear. Study it and answer the questions that follow.



(a) Name the structures labeled H and J (2mks)

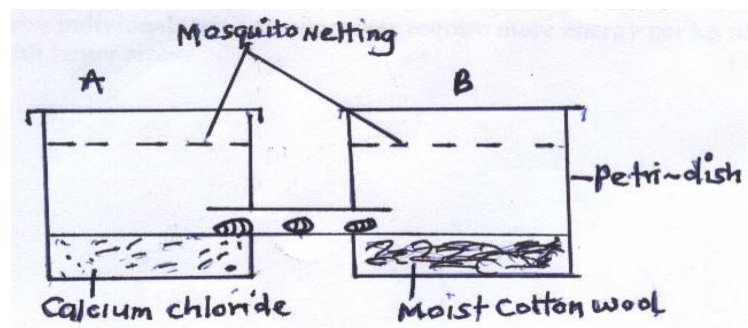
(b) State how the structures labeled H, M and N are adapted to their functions (3mks)

(c) State what would happen if the structure labeled K was completely damaged (1mk)

(d) Name the fluid contained in structure N (1mk)

(e) Apart from hearing, state the other role performed by the human ear (1mk)

15 The following experiment was set up in a chamber made from two connected Petri dishes. Housefly maggots were introduced at the centre of the chamber, so the maggots could move to either Petri dish A or B as shown below.



(a) Name the type of response being investigated in the set up. (1mk)

(b) State the survival value of the response named in (a) above. (1mk)

(c) **Give** the role of calcium chloride in the experiment above. (1mk)

16 (a) **What** is accommodation? (1mk)

(b) **Describe** the sequence of events that occur in the eye for one to be able to see clearly

(i) a distant object (4mks)

(ii) if one moved from a dim lit room to bright light. (3mks)



## MARKING SCHEME STIMULUS AND RESPONSE REVISION QUESTIONS

1 (a) Motor neuron/Motor nerve cell;

(b) (i) cell body is terminally situated/located at the end of the axon;

(ii) Arrow should point away from the cell body

2. (a) A-Synaptic cleft

B- Mitochondria

(b) Contains the transmitter substance/ Acetylcholine.

3. a) Show the effect of unilateral light on growth of seedling / plants; (1mk)

b) (i) Curvature of the tip of the shoot toward the source light;

(ii) Auxins / IAA/ Growth hormones; produced by the apical bud; move away from light / move to the dark side; causing faster elongation; hence curvature;

c) In the roots / radicle higher concentration of auxins / IAA inhibits growth; hence the upper side with less auxins grows faster than the lower side; (hence curvature downwards)

(2mks)

4. Phototropisms; -enables plant shoots to grow and get light for maximum photosynthesis; Allows for leaf mosaic;

Chemotropism; -Growth curvature in response to contact/ hard surface;

-Make plants with weak stems to get support on large plants /trees; this makes them to

reach and get light for maximum photosynthesis;

Geotropism; -Growth curvature in response to gravity; enables plant roots to grow deep into the soil



to Maximum support/ anchorage;

Hydrotropism; - Growth curvature in response to moisture / water;

- Enable plant roots to grow and find water in the soil; water is then used as a raw material
- During photolysis stage;

Chemotropism; -Growth curvature in response to chemical concentration gradient;

- Enables pollen tubes to grow down the style and into the ovary for fertilization to occur in plants flowers;

Thermo tropism; -Growth curvature in response to temperature changes;

- Enables some plants to grow to where they can acquire optimum temperature for effective plant processes; e.g. (Sunflower orientates towards the directions of the sun.

5 (a)

- A- Dendrites
- B-Cell body

(b)

- Has long axon to conduct impulses from CNs to effectors / muscles / glands;
- Axon enclosed with myelin sheath with nodes of ranvies to enhance speed of impulse conduction.
- Has dendrites which receive impulses from adjacent neurones.

(c)

| S.N                                       | M.N   |
|---|---|
| - Cell body has no dendrites              | -Cell body has dendrites                      |
| - Cell body at a point along nerve fibre; | -Cell body located at the top of nerve fiber; |

6 a) - Hearing / detection of sound;  
Body balance / posture;

(2marks.)

- b) (i) C- Ear canal / External auditory meetas;
- (ii) G- Semi – Circular canals;
- (iii) F- Auditory nerve;

(3marks)

c) (i) Equalise air pressure between middle ear and outer ear / prevent damage of ear drum;

(1mark)

- (ii) Cochlea/ E;  
(1mark)
- d) - Ear ossicles / D;  
(1mark)
7. a) i) Sensory neurons / afferent neurone  
ii) Cell body located off the axon  
b) N- Axon  
P- Cell body  
Q- Myelin Sheath  
R- Schwann cell  
c) N- Transmission of impulse  
Q- Insulation / speed up impulse transmission.
- 8 a) Long sightedness / Hypermetropia ;  
1 mk)
- b) Short eye ball;  
Weak lens (any one) ;1 mks
- c) Wearing of convex lens / conveying lenses; 1 mk  
rj if a(i) is wrong
- 9 a) 1- Sensory neurone / Afferent neurone  
2- Relay neurone / intermediate neurone  
3- Motor neurone/ efferent neurone  
3 mks
- b) Check on the diagram arrows show points towards neurone 3 from 2 and 1 : 1 mk
- c) Grey matter  
1 mks
- d) Impulse reaching the dendrites end of relay / Neurone 2 causes the synaptic vesicles, releases acetylcholine / transmitter substances✓; into the synaptic cleft✓;the acetylcholine / transmitter chemical diffuses across the cleft✓; and causes the depolarization of the motor neuron/ neurone

(i) Name the type of response (1mk)

**10 Thigmotropism/Haptotropism;**

(ii) Explain how the response named in (i) above occurs. (3mks)

**Contact with support; causes migration of auxins to the outside; causing faster growth on the side away from contact surface; (Causing dendrils to curl around the support);**

*NB (a) (ii) is tied to (i)*

(iii) What is the importance of tactic responses to microscopic plants? (1mk)

**Escape injurious stimuli/seek favourable habitat**

*Rej. Seek mate and obtain food*



11. Describe how the mammalian ear is adapted to perform its functions. (20mks)

- The pinna is flap made of skin and cartilage; for collection and concentration of sound waves;
- Auditory canal/meatus is a tube lined with hairs which trap solid particles like dust; It has wax secreting cells; that secrete wax for trapping solids and insects entering the ear;
- The eardrum/tympanic membrane is thin with double layer of epidermis; It vibrates translating sound waves into sound vibrations; Sound vibrations are transmitted to ear ossicles;
- Ear ossicles are malleus, incus and stapes; they amplify and transmit vibrations to the oval window;
- The oval window is a thin membrane which transmits sound vibrations to the fluid of the inner ear; perilymph and Endolymph;
- Eustachian tube connects middle ear with pharynx equalizing air pressure in the ear with atmospheric pressure; to prevent distortion of the eardrum;
- The cochlea is highly coiled tube with system of canals (and sensory cells) to occupy a small space/increase the surface area for accommodating many sensory cells to detect sounds vibrations; and generate impulses transmitted to the brain;
- Auditory nerve transmits nerve impulses to the brain for interpretation;
- Semicircular canals are tubular cavities containing fluid;
- The canals are arranged at right angles to each other in the three planes of spaces; to detect changes in position of the body; the canals have ampulla: utricle and saccule; to detect position of body in relation to gravity;
- Utricle has otoliths attached to sensory cells which generate impulses which are then transmitted to the brain through the auditory nerve;

- The perilymph and endolymph fluid in the inner ear absorb mechanical shock/transmit sound vibrations/protect delicate parts;

Total 25 max 20 marks

- 12 a) i) Conjunctiva transparent allow light to enter eye
- ii) Cornea transparent / curved allow light / refracts light entering eye;
- iii) Aqueous / vitreous humour – clear / allow light pass / refract light, hydrostatic pressure –  
Maintain shape of eyeball. Contains sugars / proteins / salts – provide nutrients to eye.
- iv) Iris – contractile – controls light intensity / amount of light entering eye;
- v) Ciliary body glandular – secretes humuor
- vi) Ciliary muscle contractile – controls curvature of lens;
- vii) Suspensory ligament – fibrous – holds lens in position
- viii) Lens transparent / Biconvex – allow light go through to retina / refract light / focus light.
- ix) Retina – rods - rhodopsin – for dim light vision;  
- Iodopsin – for bright light vision
- x) Fovea centralis – high concentration of cones – for accurate vision
- xi) Choroid layer – blood vessels pigmented – for nutrition  
- reduce light reflection / absorb stray light
- xii) Sclera – fibrous – protection / give eye shape;
- xiii) Optical nerves – sensory neurone – transmit impulse from retina to brain.
- xiv) External eye muscle – contractile – move eyeball within socket
- xv) Blind spot – cone and rods absent – no image is perceived

**Correction**

- b) i) Short sightedness;                      biconcave / diverging lens
- ii) Long sightedness;                      converging lens / convex lens
- iii) Astigmatism;                      use of cylindrical lens
- iv) Squinting;                      surgery                      (any 2)
- identify ✓ correction ✓ 4mks)

**13. Nervous communication communication**

**Endocrine**

- Nerve impulse to evoke a response  
substance/ hormone to evoke

- Chemical

Response

- High speed of transmission- Low speed of  
transmission;

- Rapid response

- Response delayed

- Impulse transmitted through neurone  
transmitted in blood

- Responses specific and localized to one

Responses affects several parts of the

Target organ

body;

Note: Comparison should come out clearly to award.

14. a) H – Eustachian tube;

J – Semi-circular canals;

b) H – Tube open/ connection to the pharynx and to the  
middle ear/ opens during swallowing/ yawning and  
vomiting to equalize the air pressure in the middle ear  
with the atmospheric air pressure;

M – (pinna) curved/ funnel shaped to receive or  
collect and direct sound waves into the ear;

N – (cochlea) – long/highly coiled/ spiral in form to  
increase surface area for sound Perception;

- Has sensory hairs/ cells which convert sound  
vibrations to impulses/ generate impulses;

- Has endolymph to transmit vibrations;

**Mark one for each structure.**

**Rej. If the adaptation is not tied to function.**

c) Total deafness;

d) Endolymph;

e) Balance; acc body balance/ posture.

15 (a) Tactic response;

(b) Move away from a harsh environment/move to favorable  
environment;

(c) To absorb any moisture from Petri dish A/OWTTE

16.(a) A reflex mechanism/ability of the eye to adjust to bring  
an image from near or far object into sharp focus on the  
retina;

(b) Circular muscles of the iris contract; while the radial  
muscles relax; Ciliary muscles relax; increasing tension on  
suspensory ligaments; lens become thinner increasing the  
focal length; image focused onto the retina;

(ii) Circular muscles of the iris contract; pupil constrict/become smaller; and allows enough light for (sharp) image to be focused onto the retina;

## SUPPORT AND MOVEMENT IN PLANTS AND ANIMALS



- **Support** is the ability of organisms to bear their weight and maintain their body forms. It involves holding body parts in their position and allow for movement.
- **Movement** is the displacement of parts of the body of an organism e.g. growth movements in plants and limbs in animals.
- **Locomotion** is movement of the whole organisms.

### Support and Movement in Plants

- This can be at cell level e.g. gametes in bryophytes and Pteridophytes or at organ level in tropic and nastic responses.

### Importance of Movement in Plants

- Enable plants to obtain resources such as sunlight, water and nutrients due to tropic and nastic responses.
- Enhances fertilization in bryophytes and Pteridophytes
- Enhance fertilization in flowering plants by growth of pollen tube towards the embryo sac.
- Helps plants to escape harmful stimuli such as high temperature

### Importance of Support in Plants

- Hold flowers in position for pollination to occur.
- Help plants to withstand forces of the environment such as gravity and air currents.
- Fruits are held in appropriate position for dispersal to occur.
- Increase the efficiency of photosynthesis as the leaves are firm and arranged in mosaic pattern for maximum absorption of light and carbon (iv) oxide.

### Arrangement of Tissues in Plants

#### Diagrams

- **Parenchyma.** The cells are spherical or elongated. They are unspecialized cells forming the packing tissues. When turgid, they help in providing support in herbaceous plants.
- **Collenchyma.** It's underneath the epidermis. They are similar in appearance to parenchyma and they contain

living protoplasm. They have deposition of cellulose to provide mechanical support. They are mainly found in young leaves and stems.

- ***Sclerenchyma***. They appear as long fibres in stems. Cells are dead and they have lignin. Mainly found in stems and midrib of leaves. The walls are pitted to allow exchange of substances between cells.
- ***Xylem vessels and Tracheids***. Xylem vessels are long tube like structures with lignified walls used for transporting water and mineral salts and also give plant mechanical support. Tracheids are long cells with tapering ends whose walls are lignified to give the plant mechanical support. Both xylem vessels and tracheids are made of dead cells mainly present in woody stems.
- ***Tendrils and Climbing stems***. Some herbaceous plants support themselves by use of tendrils e.g. pumpkins, garden peas etc. Others obtain support by twinning round other hard objects such as stem of passion fruit, morning glory etc.
- ***Spines and Thorns***. Some plants use spines and thorns to attach to solid objects for support e.g. in rose.



### Practical Activity 3

#### To Observe Wilting in Plants

#### Support and Movement in Animals

- Animals have a firm and rigid framework for support called the skeleton.

#### Importance of Movement in Animals

1. Enable searching of food, mate and shelter.
2. Move to avoid predators.
3. To colonize new areas
4. Move from areas with unfavourable conditions such as fire, earthquakes, flood etc.

#### Types and Function of Skeletons

##### 1. *Hydrostatic skeleton*

- It is found in soft bodied animals such as the earthworm.

##### 2. *Exoskeleton*

- It is made of the external covering found in arthropods.
- It's made of waterproof cuticle which contains the protein Chitin secreted by the epidermal cells.

#### Functions of the Exoskeleton

- i. Reduces water loss

- ii. Protection against microbial infections and mechanical injury
- iii. Support body tissues and organs.
- iv. Provide point for attachment of muscles allowing locomotion to take place.
- v. Enhance flight in insects by means of wings which are the flattened parts of the exoskeleton.
- vi. Enhance walking in insects using jointed appendages.

*NB/. 1. Exoskeleton has a disadvantage as it limits growth. To overcome this limitation it is periodically shed through moulting (ecdysis).*

*2. Insects that jump or hop have powerful hind limbs. The femur of the hind limb has powerful antagonistic muscles.*

## Diagrams

### 3 Endoskeleton.

- It is found in all vertebrates.
- Muscles are external to the hard framework.
- It is made of living tissues either cartilage or bone which increase in size as the animal grows and therefore need not to be shed as in exoskeleton.

### Functions of the Endoskeleton

- i. Supports the animal's body
- ii. Gives the body its shape
- iii. Protects inner delicate organs such as the lungs, heart, liver etc from mechanical injury e.g. ribs.
- iv. Provide surface for muscle attachment facilitating movement.
- v. Production of blood cells i.e. the long and short bones
- vi. Acts as a reservoir of calcium and phosphate ions in the body

### Locomotion in Finned Fish (Tilapia)

#### Diagrams

#### *Practical Activity 5*

#### *Practical Activity 6*

### How a finned fish is adapted to locomotion in water

1. Streamlined body/ tapered anteriorly and posteriorly; to minimize water resistance;
2. Inflexible head; to maintain forward thrust;



3. Overlapping scales facing posterior end; to bring about less resistance; Overlapping of scales also prevents wetting of the skin;
4. Slimy/oily substance to moisten scales; hence reduce resistance between water and fish;
5. Swim bladder; air filled cavity which controls/ brings buoyancy; and depth at which it swims;
6. Flexible backbone /series of vertebrae with Myotomes/ muscles blocks; which contract and relax alternately bringing about thrust/force; which propels fish forwards;
7. Pectoral and pelvic fins (paired fins); which bring about balancing effect; braking; and changing direction; they also control pitching i.e. control upward and downward movement;
8. Dorsal fin, caudal fin and anal fin (unpaired fins); to increase vertical surface area; and therefore prevent rolling from side to side; and yawing;
9. Tail fins/caudal fins that are long and flexible; for steering/ more force/ thrust;
10. Lateral line has sensory cells; which enables to perceive vibrations; hence can locate objects so that it escapes / changes direction;

## **Support and Movement in Mammals**

### ***Diagram of a human and rabbit skeleton***

The skeleton is divided into:

- Axial (skull, sternum, ribcage and vertebral column.)
- Appendicular ( consists of girdles and the limbs attached to them)

### **Axial Skeleton**

#### **1. Skull**

- Made up of many bones fused together to form the cranium.
- The bones are joined together forming immovable joints called **Sutures**.
- Cranium encloses and protects the brain, olfactory organs, the eyes, middle and inner ear.
- Facial skeleton has a fixed upper jaw called maxilla and a movable lower jaw known as the mandible.
- At the posterior end, there are two smooth rounded projections called occipital condyles. These articulate with the first bone of the vertebral column (atlas) forming a hinge joint.

- This joint permits nodding of the head.
2. **Ribcage and sternum**
- Ribcage encloses the thoracic cavity protecting delicate organs such as the lungs and heart.
  - Cage is made up of ribs that articulate with vertebral column at the back and sternum to the front.
  - In birds, the sternum is modified to form the keel which gives a large surface area for attachment of flight muscles.
  - Ribcage and sternum help during breathing because they offer the surface for attachment of the intercostals muscles.

### 3. **Vertebral column**

- Consists of bones called vertebrae that are separated from each other by cartilage called inter-vertebral discs.
- The discs absorb shock and reduce friction. It also makes the vertebral column flexible.
- There are five types of vertebrae in the vertebral column;

#### 1. **Cervical vertebrae**

#### 2. **Thoracic vertebra**

#### 3. **Lumbar vertebrae**

#### 4. **Sacral vertebrae**

#### 5. **Caudal vertebrae**

All the vertebrae have a common basic plan.

### **Structure of a Vertebra**

Each vertebra is made up of the following parts.

- Centrum (body).** It supports the weight of the vertebra and the weight of the entire vertebral column..
- Neural arch.** It encloses the neural canal.
- Neural spine.** Provides surface for muscle and ligament attachment.
- Neural canal.** It protects the spinal cord which passes through it.
- Transverse processes.** Provides surface for muscle and ligament attachment.
- Zygapophysis (facets).** These are smooth patches for articulation with the other vertebrae. (The one in front and the other one behind). The front facets are called **Pre-Zygapophysis** while the back pair facets are called **Post-Zygapophysis**

### **Diagram**

#### 1) **Cervical vertebrae**

a) Atlas (First cervical vertebra)

- **Distinctive features.**

i.) No Centrum

- ii.) Broad and flat transverse processes.
- iii.) Has **vertebrarterial canal** in each transverse process for vertebral arteries to pass through.
- iv.) Front facets are large and grooved to articulate with condyles of the skull to allow nodding on the head.
- v.) Neural spine is very small.



### Diagram

- **Functions**

- i.) Protect the spinal cord.
- ii.) Provide surface for muscle attachment.
- iii.) Allows head to nod.

- b) Axis (second)

- **Distinctive features.**

- i.) Centrum prolonged to form the **odontoid** process.
- ii.) Has **vertebrarterial canal** in each transverse process for vertebral arteries to pass.
- iii.) Small wing like transverse processes.
- iv.) Wide neural canal.

- **Functions**

- i.) Protects the spinal cord.
- ii.) Allows the head to rotate. Odontoid process forms a peg which fits into the neural canal of the atlas.
- iii.) Provide surface for muscle attachment

### Diagram

- c) The other cervical vertebrae.

- **Distinctive features**

- i.) Short neural spine
- ii.) Transverse process divided and broad.
- iii.) Has **vertebrarterial canal** in each transverse process for vertebral arteries to pass through.
- iv.) Wide centrum

### Diagram

- **Functions**

- i.) Provide surface for attachment of neck muscle.
- ii.) Protect the spinal cord.
- iii.) Supports the weight of the head.

## 2) Thoracic vertebrae

- **Distinctive features**

- i.) Long neural spine pointing backwards.
- ii.) Large centrum.
- iii.) Short transverse processes.
- iv.) **Tubercular facets** on each transverse for articulation with **tuberculum** of the rib.

- v.) Two pairs of **capitular demi-facets** for articulation with **capitulum** of the rib.

### Diagram

- **Functions**

- i.) Helps to form the rib cage.
- ii.) Provides articulation for one end of each rib.
- iii.) Protects the spinal cord.
- iv.) Provides surface for muscle attachment.

### 3) Lumbar vertebrae

- **Distinctive features**

- i.) Large broad centrum to offer support.
- ii.) Broad neural spine.
- iii.) Broad and long transverse processes.
- iv.) Have extra processes like **metapophysis, anapophysis and hypapophysis**.

- **Functions**

- i.) Protects the spinal cord.
- ii.) Provides surface for muscle attachment.
- iii.) Protect and support the heavy organs in the abdominal cavity.
- iv.) Supports the heavy weight of the upper part of the body.

### 4) Sacral vertebrae

- **Distinctive features**

1. All sacral vertebrae fused to form sacrum
2. Transverse processes of first sacral vertebra large and wing like for articulation with pelvic girdle
3. Pairs of holes on the lower surface for the spinal nerves to pass through.
4. Sacrum is broader on the front side and narrow towards the tail.

### *Functions*

1. Protects alimentary canal on dorsal side.
2. Provides attachment to hip girdle
3. Protects the spinal cord
4. Provides attachment for the muscles

### Diagram

### 5. Caudal vertebrae

- **Distinctive features**

1. Very small in size
2. No neural canal

## Functions

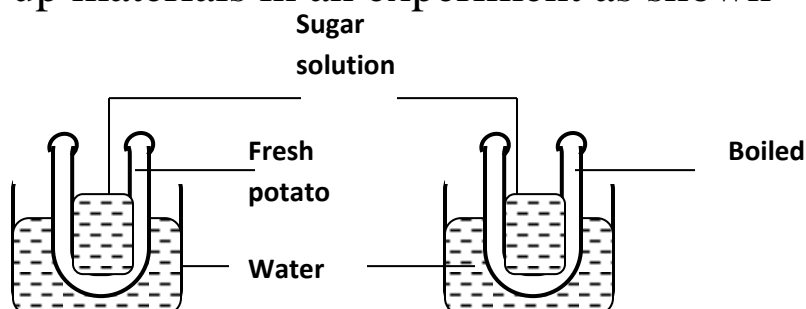
1. Provides attachment for tail muscles
2. Helps in the movement of the tail

## Diagram



## Biology Form 1-2 Work Revision

1. A student set up materials in an experiment as shown below.



- (a) State the physiological process being investigated. (1mk)

(b) If the experiment set up was left over-night, state observation in the set up A and B. (2mks)

(c) Account for the observations in each set up. (3mks)

(d) If another experiment C was set such that nothing is placed in the potato cup, state and explain the results that would have been obtained. (2mks)

2. An experiment was carried out to investigate, haemolysis of human cells. The red blood cells were placed in different concentration of sodium chloride solution. The percentage of haemolysed cells was determined. The results were shown in the table below.

|                                    |      |      |      |      |      |      |      |
|------------------------------------|------|------|------|------|------|------|------|
| Salt conc. (g/100cm <sup>3</sup> ) | 0.33 | 0.36 | 0.38 | 0.39 | 0.42 | 0.44 | 0.48 |
| Red blood cells haemolysed %       | 100  | 91   | 82   | 69   | 30   | 15   | 0    |

(a) (i) On the grid provided plot a graph of haemolysed red blood cells against salt concentration. (6mks)

(ii) At what concentration of salt solution was the proportion of haemolysed cells equal to non-haemolysed cells? (1mk)

(iii) State the percentage of red blood cells haemolysed at salt concentration of 0.45. (1mk)

(b) Account for the results obtained at:

(i) 0.33% salt concentration

(3mks)

(ii) 0.48% salt concentration

(3mks)

(c) What would happen to the red blood cells if they were placed in 0.50% salt solution. (3mks)

(d) Explain what would happen to onion cells if they were placed in distilled water. (3mks)

3. Explain how various environmental factors affect the rate of transpiration in plants. (20mks)

4. (a) State the meaning of the following terms.

(i) Digestion

(2mks)

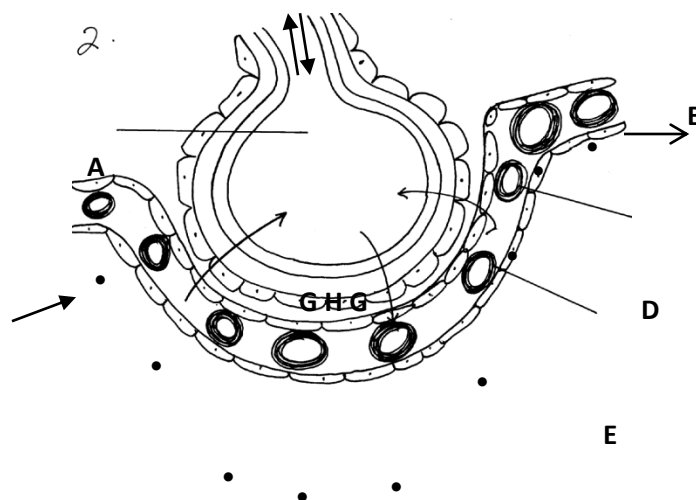
(ii) Ingestion

(2mks)

(b) Describe the process through which a piece of ugali undergoes in man from the time of ingestion up to the time of absorption.

(16mks)

6. The diagram below represents a unit of gaseous exchange in man. Study it carefully and answer the questions that follow.



a) Name the blood vessel that brings blood to the lungs and the vessel which takes blood away from the lungs.

(2mks)

b) Name the structure above.

(1mk)

c) Label A and E.

(2mks)

d) In what form is carbon (IV) oxide transported in structure labeled **E**. (1mk)

e) Name the gas **G**. (1mk)

6. Gastrin is a hormone produced by mammals.

(a) (i) Where is the hormone produced?

(1mk)

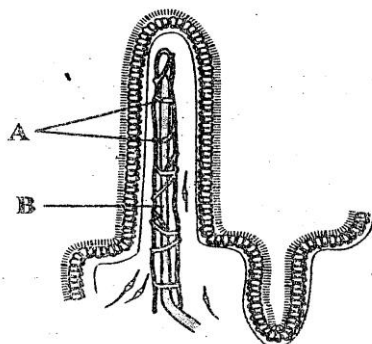
(ii) What is the function of gastrin?

(1mk)

(b) What stimulates the production of gastrin.

(1mk)

(c) The diagram below shows part of the human intestine.



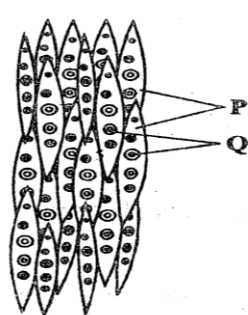
i) Identify the parts labeled **A** and **B**

(1mk)

(ii) To which circulatory system does the part labeled **B** belong. (1mk)

d) State any **two** adaptations of the human large intestine to its function. (2mks)

7. The diagram below represents part of a xylem tissue.



a) (i) Name the

parts labeled **P** and **Q**

(2mks)

(ii) Give the function of the part labeled **P**.

(1mks)

b) State the function of the phloem tissue.

(1mk)

c) (i) State how the functioning of the phloem tissue is affected if the companion cell is destroyed. (1mk)

(ii) Give a reason for your answer.

(1mk)

d) State any **two** structural differences between phloem and xylem tissues. (2mks)

8. In an experiment to determine the effect of exercise on the concentration of lactic acid in blood, the following data was obtained. Study the data and use it to answer the questions that follow.

The lactic acid concentration was measured before, during and after the exercise.



| Time minutes                        | 0   | 10  | 20 | 25 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
|-------------------------------------|-----|-----|----|----|----|----|----|----|----|----|----|-----|
| Lactic acid conc. (arbitrary units) | 0.5 | 0.5 | 5  | 13 | 12 | 8  | 6  | 4  | 3  | 2  | 1  | 0.9 |

a) Using a suitable scale, plot a graph of the concentration of lactic acid against time. (6mks)

b) From the graph you have drawn determine

(i) The period of exercise . Explain.

(2mks)

(ii) The time when oxygen debt occurred Explain.

(2mks)

(iii) The duration it took to pay back the oxygen debt.Explain

(2mks)

c) On the same set of axes plot a hypothetical curve for oxygen intake during the experiment period of 90 minutes.

(2mks)

d) Why does lactic acid level usually continue to rise in the blood after exercise ceases. (2mks)

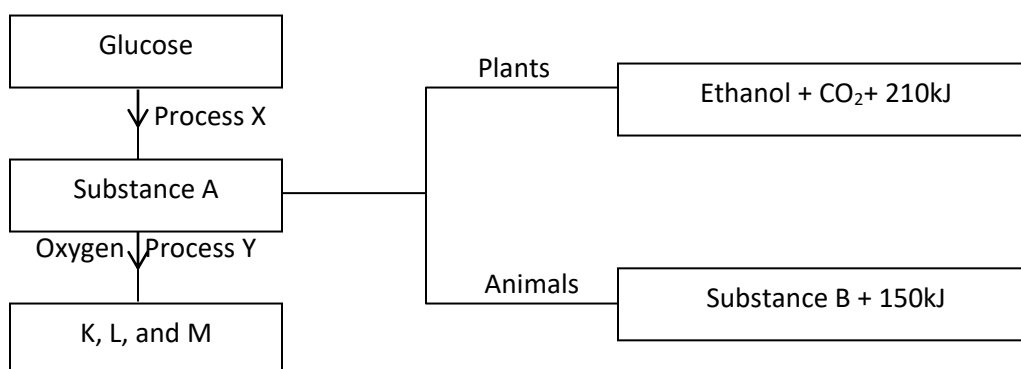
e) Suggest the **two** importance of anaerobic respiration to animals. (2mks)

d) What is oxygen debt?

(2mks)

9. What is the role of the liver in the maintenance of a constant level of materials in the body. (20mks)

10.The diagram below represents a simple respiratory pathway in cells





a) Name the process marked **X** and **Y**.

(2mks)

b) State **two** differences between process **X** and **Y**.

(2mks)

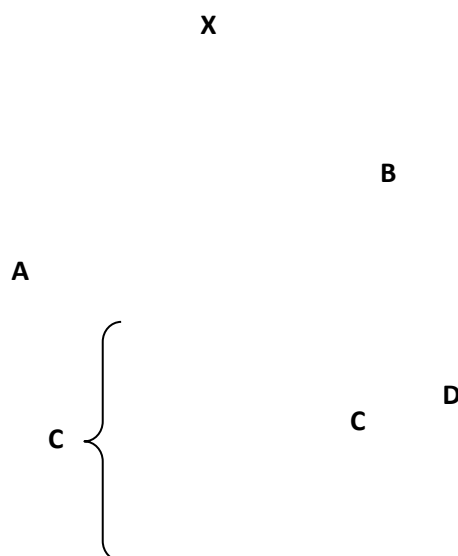
c) State the name of substance **B** and condition under which it is formed.

(2mks)

d) Explain how body size affects the rate of respiration in animals.

(2mks)

11. The diagram below represent the structure of a nephron. Study it and answer the questions that follow.



a) (i) State the physiological process by which solutes are selectively re-absorbed back into blood at the part labelled **B**.

(1mk)

(ii) How is the part labeled **B** adapted to carry out the physiological process named in 3 (a) (i) above.

(1mk)

b) In which part of the kidney is the part labelled **A** abundantly found.

(1mk)

c) On the diagram above, indicate the direction of flow of blood using arrows at the part labelled **C**.

(1mk)

e) State the functions carried out by the following hormones in the functioning of the nephron.

(i) Aldosterone.

(1mk)

(ii) Anti diuretic hormone.

(1mk)

12. The data below shows the rate of photosynthesis at different temperature in attached leaves of three East African plants. (Crotolaria, Gynandropsis and Amaranthus species) respectively which were grown outside with the same illustration while water and carbon (IV) oxide are not limiting factors in this experiment.

Rate of photosynthesis was expressed in terms of carbon (IV) oxide uptake in  $\text{mg/mm}^2/\text{hr}$  at various temperatures as tabulated below.

| Temperature<br>$^{\circ}\text{C}$ | Rate of photosynthesis ( $\text{mg/mm}^2/\text{hr}$ ) |                  |                  |
|-----------------------------------|---|------------------|------------------|
|                                   | Gynandropsis<br>sp                                    | Crotolaris<br>sp | Amaranthus<br>sp |
| 5                                 | -   | 20               | -                |
| 10                                | 22  | 40               | 10               |
| 15                                | 50  | 49               | 27               |
| 20                                | 60  | 64               | 42               |
| 25                                | 80  | 48               | 55               |
| 30                                | 85  | 45               | 54               |
| 35                                | 80  | 42               | 50               |
| 40                                | 73  | 31               | 45               |
| 45                                | 66  | 15               | 40               |
| 50                                | 2   | -                | 11               |

- a) Represent the results graphically (rate of photosynthesis against temperature)  
 b) Using the graph in (a) above indicate optimum temperature for the Gynandropsis and Amaranthus species.

(2mks)

Gynandropsis

.....

Amaranthus

.....

c) Give a reason why Gynandaropsis and Amaranthus could not function photosynthetically at  $5^{\circ}\text{C}$ . (1mk)

d) What are the possible ecological habitats for the following plants. (2mks)

(i) Amaranthus

(ii) Crotolaria

e) At what temperature was the amount of carbon (IV) oxide around the leaf of Gynandropsis highest?

(1mk)

f) What raw material is required in the light stage of photosynthesis. (1mk)

g) Name the parts of chloroplasts in which the following stages of photosynthesis take place. (2mks)

(i) Light stage

(ii) Dark stage

h) State **one** structural similarity and difference between chloroplast and mitochondria. (2mks)

Similarity

Difference

i) What is the compensation point of photosynthesis? (1mk)

13 (a) Explain why plants lack elaborate excretory organs like those found in animals. (3mks)

(b) Name **five** methods of excretion in plants. (5mks)

(c) State any **six** excretory products in plants and give economic uses. (12mks)

14. During a laboratory investigation, a scientist extracted gastric juice from the mammalian stomach. He used it to carry out tests on a food sample B which was suspected to contain proteins. He divided the food sample B into three portions and treated them as below.

I. On the 1<sup>st</sup> portion of B, he added Gastric juice and mixed them thoroughly before adding sodium hydroxide followed with copper (II) sulphate drop by drop.

II. On the 2<sup>nd</sup> portion of B, he added boiled gastric juice and mixed them thoroughly before adding sodium hydroxide followed with copper (II) sulphate drop by drop.

III. On the 3<sup>rd</sup> portion of B, he added Gastric juice, sodium bi-carbonate and mixed them thoroughly before adding sodium hydroxide followed with copper (II) sulphate drop by drop.

a) State the observations he made in each set up. (3mks)

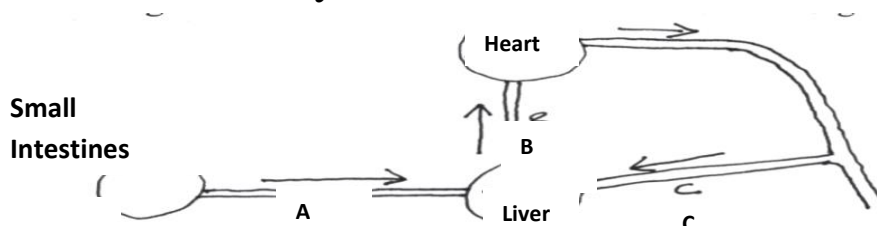
- 1<sup>st</sup> portion
- 2<sup>nd</sup> portion
- 3<sup>rd</sup> portion

b) Why was the experiment on the 1<sup>st</sup> portion included in the tests? (1mk)

c) Name the property of the chemical being investigated in these tests. (1mk)

d) Account for the observations made in 2 (a) above. (3mks)

15. The diagram below illustrates circulation in certain organs of the mammalian body.



a) Identify the blood vessels represented by A, B and C.  
(3mks)

b) Explain why blood from the small intestines goes to the liver before it goes to any other organ of the body.  
(2mks)

c) Compare the blood in vessels B and C.  
(1mk)

d) Outline how a glucose molecule in vessel A finally reaches the heart.  
(2mks)



16. The table below shows how the internal temperature two animals X and Y varied with the external temperature. The temperature was measured regularly and recorded for 12 hours in a day. Study the table and answer the questions that follow.

a) Using the same grid, draw graphs of external temperature, and internal temperature of animals X and Y  
(Y-axes) against time (X-axes).  
(7mks)

b) Account for the variation of internal and external temperatures for the animals X and Y. (2mks)

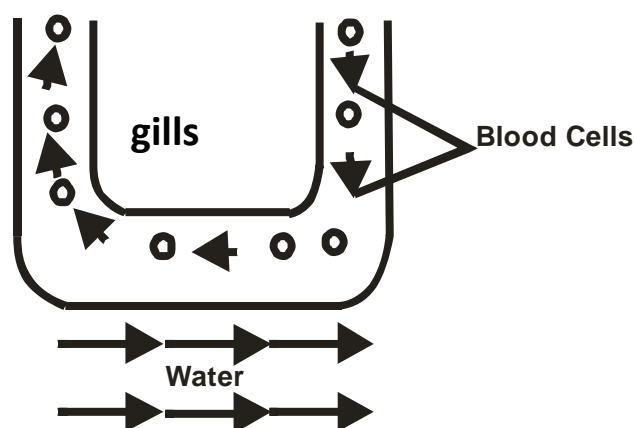
c) Identify the classification of organisms whose internal temperature varies as X and Y (2mks)

d) Explain **two** ways used by organism Y to make its internal temperature vary as shown despite of changes in external temperature.  
(4mks)

18 a) Give the functions of the skin in organisms.  
(6mks)

b) How is the mammalian skin modified to enable it perform its functions?  
(14mks)

19. The diagram below shows how gaseous exchange occurs across the gills in fish.



(a) According to the diagram water and blood flow in opposite direction across the gills.

- (i) Give the term used to describe this flow.  
(1 Mark)
- (ii) Explain the advantage of the above flow named in a(i) above. (2 Marks)
- (b) What difference would be observed if water and blood flows across the gills in the same direction?  
(2 Marks)
- (c) In which structures in the gills does gaseous exchange take place? (1 Mark)
- (d) Name **two** organs in man which display the flow system named in a(i). (2 Marks)

20. An experiment was carried out to investigate the effect of different concentrations of Sodium Chloride on human red blood cells. Equal volumes of blood were added to equal volumes of salt solutions of different concentrations. The results were as shown below:-

| Set up | Sodium Chloride concentration | Shape of red blood cells at the end of experiment | Number of red blood cells at the end of experiment |
|--------|-------------------------------|---|--|
| A      | 0.9%                          | Normal  | No change in number                                |
| B      | 0.3%                          | Swollen   | Fewer in number                                    |

- a) If the experiment was repeated with 1.4% Sodium Chloride solution, state the results you would expect with reference to:-
  - (i) Number of red blood cells.  
(1 Mark)
  - (ii) Appearance of red blood cells when viewed under the microscope. (1 Mark)
- Account for the fewer number of red blood cells in 0.3% Sodium Chloride salt solution. (3 Marks)
- c) Give the biological term which can be used to describe 0.9% Sodium chloride solution.(1 Mark)
- d) Define plasmolysis.  
(1 Mark)

**Marking Scheme**

- 1. i) Osmosis.
- ii) A – solution in potato cup increases. Level of water in the beaker decrease;

B- Remain the same;

iii) A – Surrounding the cube is a region with high concentration of water molecules while in the sugar crystals, there are very few water molecules;

The sugar crystals exert on Osmosis pressure by Osmosis water molecules move across the potato tissue, which acts as a semi-permeable membrane. The level rises;

B- No change since boiling denatures the membrane structure of potato cells;

iv) C- No water moves into the potato cup/remains the same; since there is no concentration gradient;

2(a) i) Graph.

ii)  $0.402 \pm 0.01$

iii)  $11\% \pm 1\%$ .

b) i) All cells have been haemolysed; cells contains one hypertonic to salt solution; water enters cells by osmosis; cells swell and eventually burst.

ii) No cells were haemolysed; cell contents were isotonic to salt solutions (amounts of water entering the cell was equal to that leaving the cell); no net movement of water into cells;

c) The cells would become crenated; the cell contents would be hypotonic to salt solutions; water would leave cells by osmosis; membranes would shrink.

d) Contents of Onion epidermal cells would be hypertonic to water; water would enter cells by Osmosis; cells would become turgid;

3. - **Temperature**;- High temperature faster rate of transpiration; high temperature increases the capacity of atmosphere to hold water and moisture; also heat increase internal temperature of the leaf hence water evaporation;  
*4 accept converse*

- **Atmospheric pressure**; Low atmospheric pressure, high rate of transpiration 2

- **Humidity**; Low humidity higher rate of transpiration; low humidity increases the saturation deficit; hence water moves form leaves to drier atmosphere; 4

- **Wind**; When it is windy the rate of transpiration is higher; wind sweeps away vapour that has accumulated at the surface of leaf; increasing saturation deficit; hence faster rate of transpiration 5

- **Light intensity**; High light intensity faster rate of transpiration high light intensity increase photosynthesis rate hence stomata opens; 4

- **Amount of water in soil;** More water in the soil increases the rate of transpiration; it wets the xylem (ensure xylem is wet throughout); 3

Max 20

4. a) **Define digestion and ingestion.**

- i) Digestion- It is break down of complex insoluble; ✓ food substance into simple soluble food substance; ✓
- ii) Ingestion- is introduction of food through the mouth into the digestive system;

b) **Describe the digestion of Ugali.**

- Digestion of ugali begins in the mouth; ✓ ugali is chewed by the teeth to increase large surface area ✓ for action of salivary amylase/ptyalin; ✓ The food mixes with saliva produced by salivary glands; ✓
- Saliva contains mucus and enzyme ptyalin. Mucus moistens, softens and lubricates the food; ✓ ptyalin speeds up the conversion of starch to maltose; ✓ ugali is made into bolus in the mouth; ✓
- The bolus moves along the oesophagus and peristalsis/by contraction and relaxation of circular and longitudinal muscles into the stomach; ✓
- The digestion continues until ugali become acidic since the stomach does not contain carbohydrase/carbohydrate digesting enzymes no digestion of ugali takes place here. ✓
- Ugali now moves into duodenum by peristalsis in form of acidic chime; ✓ where it mixes with the bile from the liver and pancreatic juice from the pancreases; ✓ bile being alkaline neutralizes the stomach acid; ✓ and provides a suitable alkaline medium for the enzymes to act on carbohydrates; ✓
- Pancreatic juice contains three enzymes out of the which enzyme amylase speeds conversion of starch to maltose; ✓
- When food reaches the ileum; it mixes with intestinal juice which contains several enzymes. Maltase – speeds up conversion of maltose to glucose; ✓
- Lactase which speeds up conversion of lactose to glucose ✓ and galactose; sucrase which speeds up conversion of sucrose into fructose and glucose;
- Absorption – glucose, the end product of all carbohydrates diffuses through the epithelium of villi



and capillary walls and enters into blood stream and is carried to the liver via hepatic portal veins;√

- Assimilation- in the liver excess glucose is converted into glycogen and stored;

- - The rest of the glucose is carried by the blood to tissues where it is oxidized during tissue respiration to release energy;√

(21 max 18

mks

Total 20mks)

5. (a) - Pulmonary artery  
- Pulmonary vein

(b) Alveolus

(c) **A**- cavity of alveolus

**E** – Red blood cell

(d) Hydrogen carbonate ions;  
Carbamino haemoglobin;

6. (a) (i) Walls of stomach;

(ii) Stimulates the secretion / production of gastric juice;

√

(b) Presence of food in the stomach;

(c) **A** – Blood capillaries; **B** – Lacteal;

(d) - Produces plenty of mucus to lubricate

coarse/indigestible material during peristalsis;

- Wide human accommodates /store indigestible food

- Elongate to increase surface area for absorption of

water.

- has muscles to facilitate peristalsis when they contract;

7. (a) (i) **P** – Tracheids **Q** – pits

(ii) **P**- water conducting elements of xylem

(b) Function of phloem – translocation/ transport of organic substances from the leaves to the rest of the plant;

(c) (i) Translocation of food will not occur acc. Slow translocation

(ii) Reason – it contains a lot of mitochondria which provide energy for translocation;

(d)

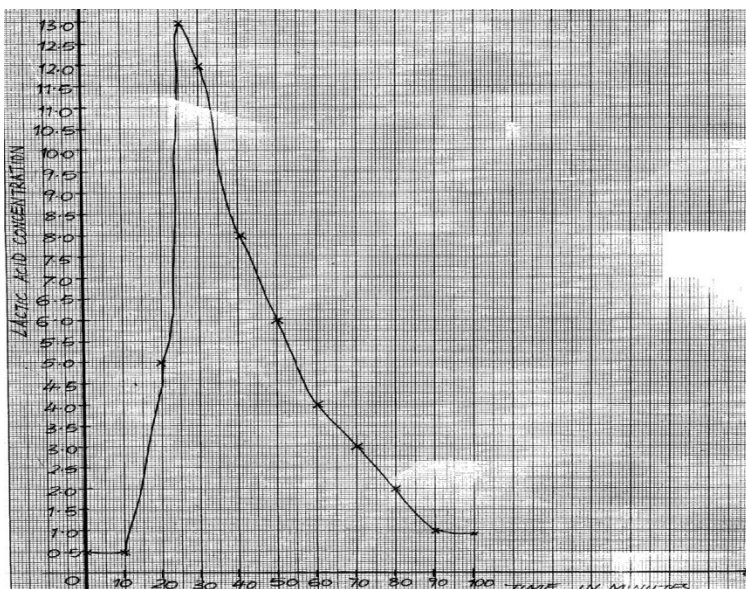
| Phloem                  | Xylem                      |
|-------------------------|----------------------------|
| 1) Made of living cells | - made of dead cells       |
| 2) Have companion cells | - lack companion cells     |
| 3) Have                 | - lack cytoplasmic strands |
|                         | - have lignin deposits;    |
|                         | (any 2x1=2mks)             |



|  |  |
|--|--|
| cytoplasmic strands<br>4) Lack lignin deposits |  |
|--|--|

8. (a) Photocopy – scale – 1m  
 Labeling axes – 1  
 Plotting – 2m  
 Curves – 2m (curves must be labeled) rej. Dotted line for curves

### A GRAPH OF LACTIC ACID CONCENTRATION AGAINST TIME



(b) (i) 10-15 minutes ; period of rapid increase in lactic acid concentration (2mks)

(ii) 10-20 seconds : period when lactic acid level starts to increase; (2mks)

(iii) 75minutes i.e. from 25<sup>th</sup> minutes to the 100minutes, this is the time lactic cid took to decrease from the highest level to normal; (2mks)

(c) It would have the same basic shape; but would peak slightly ahead of the lactic acid curve in time;

(e) Because it is still diffusing out of the muscles, where it was made a few minutes earlier;

(e) Allows for energy production even cases of oxygen deficiency; thus enables animals to survive active exercise and to inhabit even in areas with limited oxygen supply;

(f) Oxygen debt is the amount of oxygen to get rid of the lactic acid; that has accumulated due to anaerobic respiration; (2mks)



Tied (ii) Numerous Mitochondria in its wall to generate energy/microvilli/coiling increase surface area/thin epithelium for quick diffusion.

(b) Cortex

(c) on the diagram

(d) plasma proteins; Blood cells; accept specific examples e.g. albumins, red blood cells;

(e) (i) Regulate re-absorption of Sodium salts;

(ii) Regulate re-absorption of water

12. (a) Allocation of marks on graph

(b) Gynandropsis – opt  $T_o = 30^\circ\text{C}$

Amaranthus – opt.  $t_o = 25^\circ\text{C}$

(c) At  $5^\circ\text{C}$ , the enzymes that catalyse the process of photosynthesis are inactivated.

(d) Amaranthus – Terrestrial; Crotolaria – terrestrial;

(e)  $50^\circ\text{C}$ ;

(f) water;

(g)(i) Granum; (ii) Stroma

(h) Similarity: Both have double membrane; 1mk – Both have fluid filled matrix;

Difference : inner membrane of mitochondrion is folded to form cristae while inner membrane of chloroplast is smooth;

- chloroplast is biconcave shaped while mitochondria is oval/sausage shaped (any 1x1=1mk)

(i) Point at which the rate of photosynthesis equals to the rate of respiration.

13. (a) – plants wastes accumulate slowly;

- plants produce less toxic wastes;

- some excretory products are recycled by plants e.g.

$\text{CO}_2$ ,  $\text{SO}_2$ )

- plant tissues are tolerant to toxic wastes;

- plant wastes are stored in temporary structures

which fall off e.g. leaves (any 3x1=3mks)

(b) – Diffusion;

- Transpiration;

- Exudation;

- Deposition of wastes/ leaf fall/ flower fall/ storage in

bark;

- Recycling;

- Guttation ;

(any 5x1=5mks)

(c)

| Excretory products | Uses |
|--------------------|------|
|                    |      |

|                 |  |
|-----------------|--|
| 1. Caffeine;    | Body stimulant;                        |
| 2. Popain;      | Meat tenderizer;                       |
| 3. Tannin;      | Leather tanning;                       |
| 4. Nicotine;    | Stimulant; insecticide;                |
| 5. Latex;       | Manufacture of tyre/rubber products;   |
| 6. Quinine;     | Anti-malarial drugs;                   |
| 7. Atropine;    | Increase heart beat; dilate eye pupil; |
| 8. Morphine;    | Cancer treatment;                      |
| 9. Colchine;    | Used in genetics to induce polypoidy;  |
| 10. Cocaine;    | Anesthesia/painkiller/stimulant;       |
| 11. Cannabis;   | Pain killer;                           |
| 12. Khat/miraa; | Stimulant; (Any 6x2=12mks)             |

14. (a) 1<sup>st</sup> portion. - Blue; colour was observed  
 2<sup>nd</sup> portion – Purple; colour was observed  
 3<sup>rd</sup> portion – Purple; colour was observed
- (b) A control experiment;
- (c) Proteins are highly sensitive to temperature and pH changes; (*award if either temp of pH is stated singly*)
- (d) 1<sup>st</sup> portion – Enzyme pepsin broke down proteins into peptones;  
 2<sup>nd</sup> portion – Enzyme pepsin works in acidic medium; (*not in basic medium*)
15. (a) **A** – Hepatic portal vein;      **B** – Hepatic vein;  
**C** – Hepatic artery;
- (b) – So that any toxic substances absorbed together with food nutrients from the ileum be detoxified;  
 - So that food substances e.g. glucose, amino acids can be regulated. Only the required quantity of glucose is left in circulation as excess is either stored as glycogen, fat and excess may be respired.  
 Excess amino acids are deaminated;
- (c) **B** – Deoxygenated                                      **C** - Oxygenated
- (d) From the small intestines, it is transported to the liver through Hepatic portal vein; (It is then transported to the heart through the hepatic vein;
16. (a) **graph**

(b) **X** – Lacks internal mechanisms to regulate its internal temperature

**Y** – Has internal means to regulate its internal temperature. hence able to maintain it within narrow range

(c) **X** – Poikilotherm

**Y** – Endotherm

(d) – Blood vessels vasodilate when temperature is higher than norm to allow for heat loss from blood through radiation, evaporation, etc; when temperature is lower, blood vessels constrict to prevent loss of heat from blood through radiation, evaporation etc;

- When temperature is higher, lies flat to allow for heat loss from the body since insulation layer of air is removed; when temperature is lower, hair strands erect to hold air which insulates the body against heat loss through radiation, evaporation etc.

17. (a) Higher temperature; increases the kinetic energy; of water molecules which makes water turn into vapour on the leaf surfaces faster and hence increase rate of transpiration

- Higher light intensity; influences maximum opening of stomata which increases the surface area; over which transpiration occurs maximumly
- Wind; carries away moisture around the plant and create a higher saturation deficit; which then increases the rate of water loss/transpiration in plants.
- Higher relative humidity; reduces saturation deficit; which causes lowering of water loss/transpiration in plants.
- Higher amount of water in the soil; makes the plant to absorb excess water which increases the need for the plant to get rid of it through transpiration faster;
- If the leaf is broader and has numerous larger open stomata; the surface area over which water loss occurs is increased; causing increase in the rate of transpiration.

(award max. 12mks)

18. (a) – It **protects** the underlying tissues against mechanical injury, UV-light rays and entry of pathogens; (*Rej. germs*)

- As an **excretory organs**, it enables organisms to eliminate excess water, ions and traces of urea;
- As a **sensory organ**, it enables the organisms to be aware of deviations in pressure, touch and temperature from the external environment;
- It is a **thermoregulator** such that it enables the body to lose excess heat to lower its temperature back to norm or

may enable the organisms to store its heat if the temperature is lower and hence raise it back to the norm;

- It takes part in **osmoregulation** by enabling the body fluids to get rid of excess water or excess ions;
- It takes part in the regulation of the pH of body fluids by enabling the body to get rid of either Hydrogen ions or bicarbonate ions;



(b) – Presence of the cornified layer; which is tough and has keratin to enable it protect the underlying tissues from mechanical injury; It also has sebum; which is antiseptic and enables it to protect the body against entry of pathogens.

Presence of melanin; enables it to protect the underlying tissues against damage by the UV-light radiations.

- It has sweat glands with secretory cells; which absorb excess water, excess ions and traces of urea from blood and secrete them into the sweat duct;
- Has the sweat pores; which open on the skin surface to allow for elimination of sweat containing excess water, excess ions and traces of urea;
- It has nerve endings; which enables it to detect any deviations in temperature, pressure and contact/touch;
- It has hair follicles; which stand erect when temperature is lower than normal to reduce heat loss from the body or lie flat to enable the body lose excess heat and lower temperature back to the norm when the internal temperature is higher;
- Has blood vessels; which vasodilate when temperature is higher than norm to enable the organisms lose heat to the norm to reduce heat loss from the body;

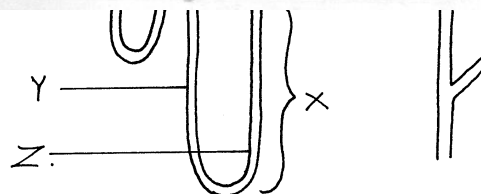
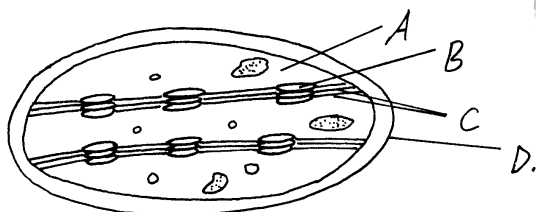
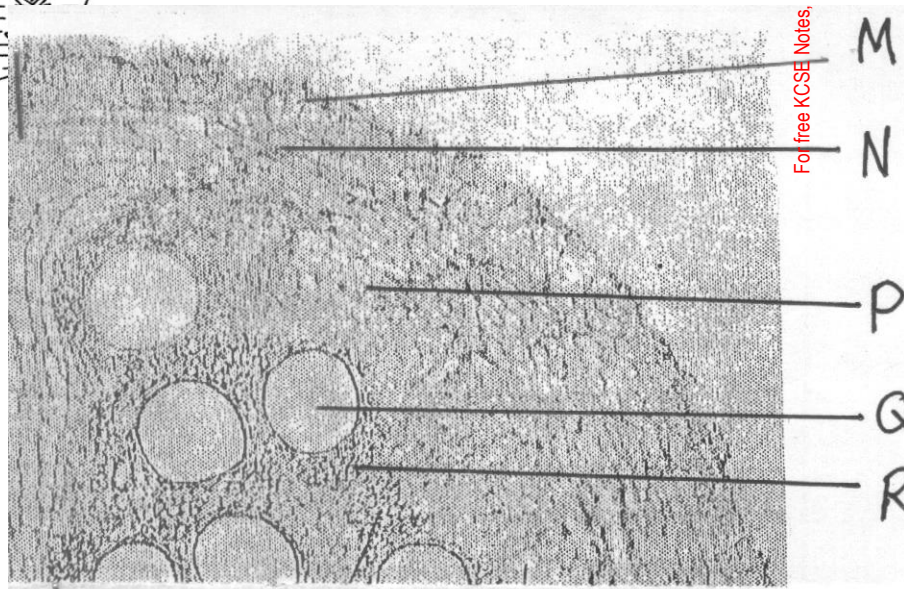
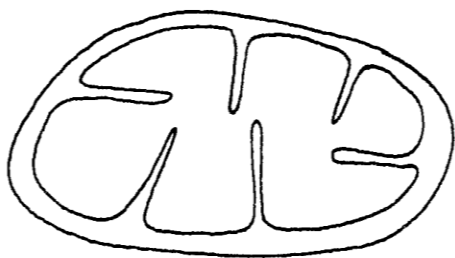
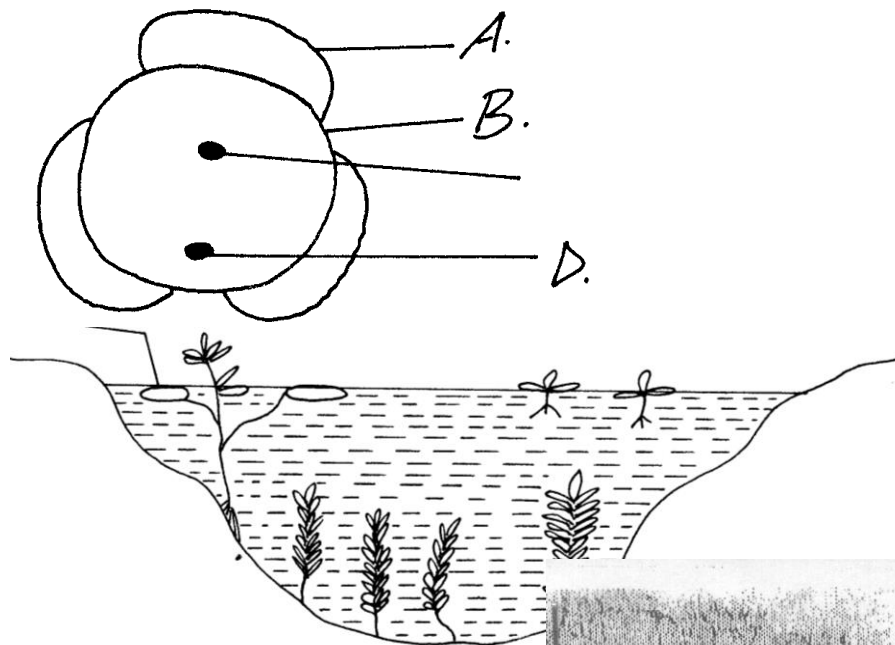
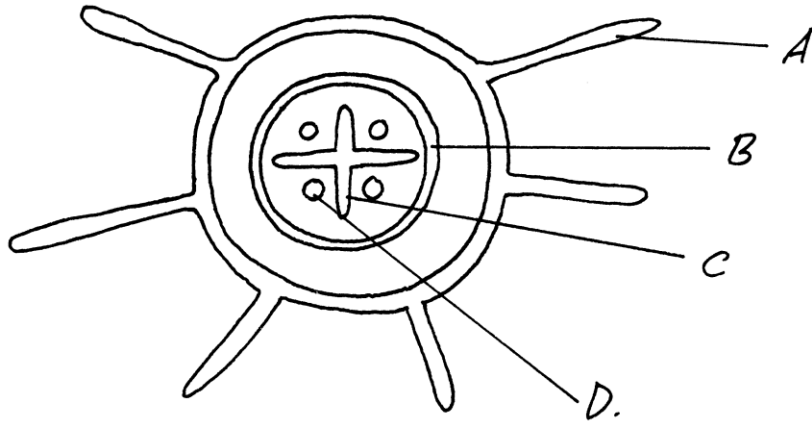
19. a) i) Counter current system;  
ii) Maintain a diffusion gradient so that there is maximum uptake of oxygen; continue diffusing into blood and Carbon (iv) oxide into water;  
b) Parallel flow lower diffusion gradient; so that less oxygen diffuse into blood/low rate of gaseous exchange  
c) Gill filaments  
d) Placenta

Kidney

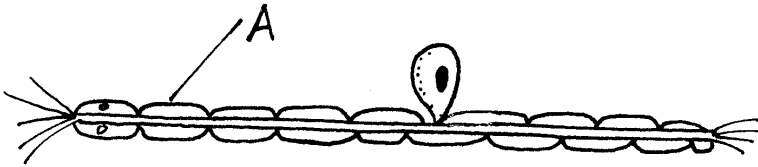
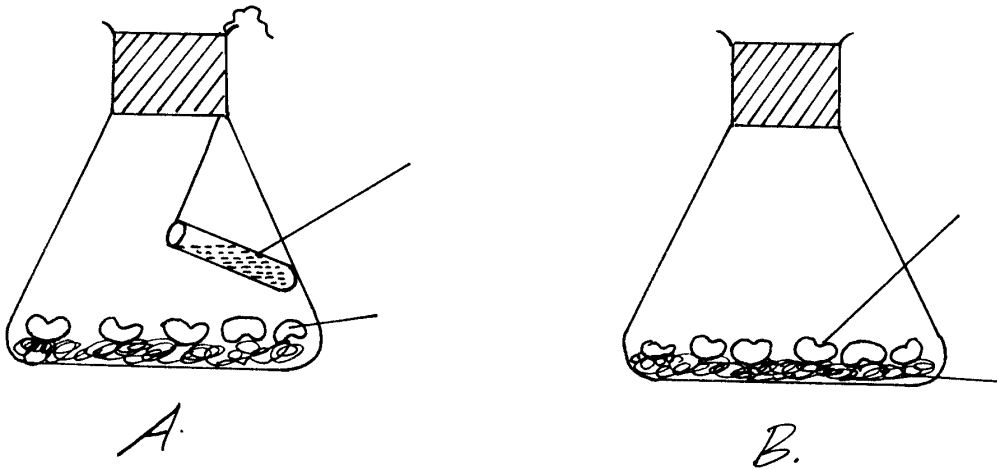
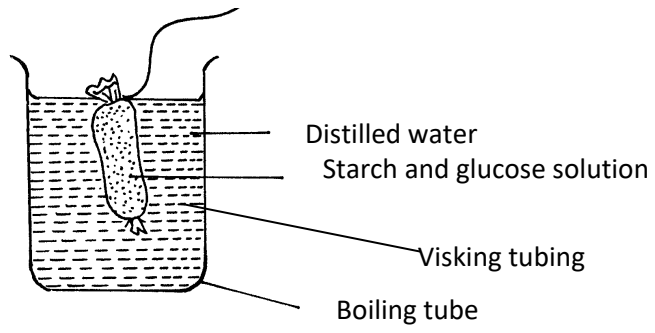
- 20 a) i) Remain the same  
ii) Crenated  
b) The solution is hypotonic to red blood cells hence the cells gain water; by osmosis; swelling until they burst.  
c) Isotonic solution

d) Plasmolysis – the process by which plant cells loss water by Osmosis shrink and become flaccid.

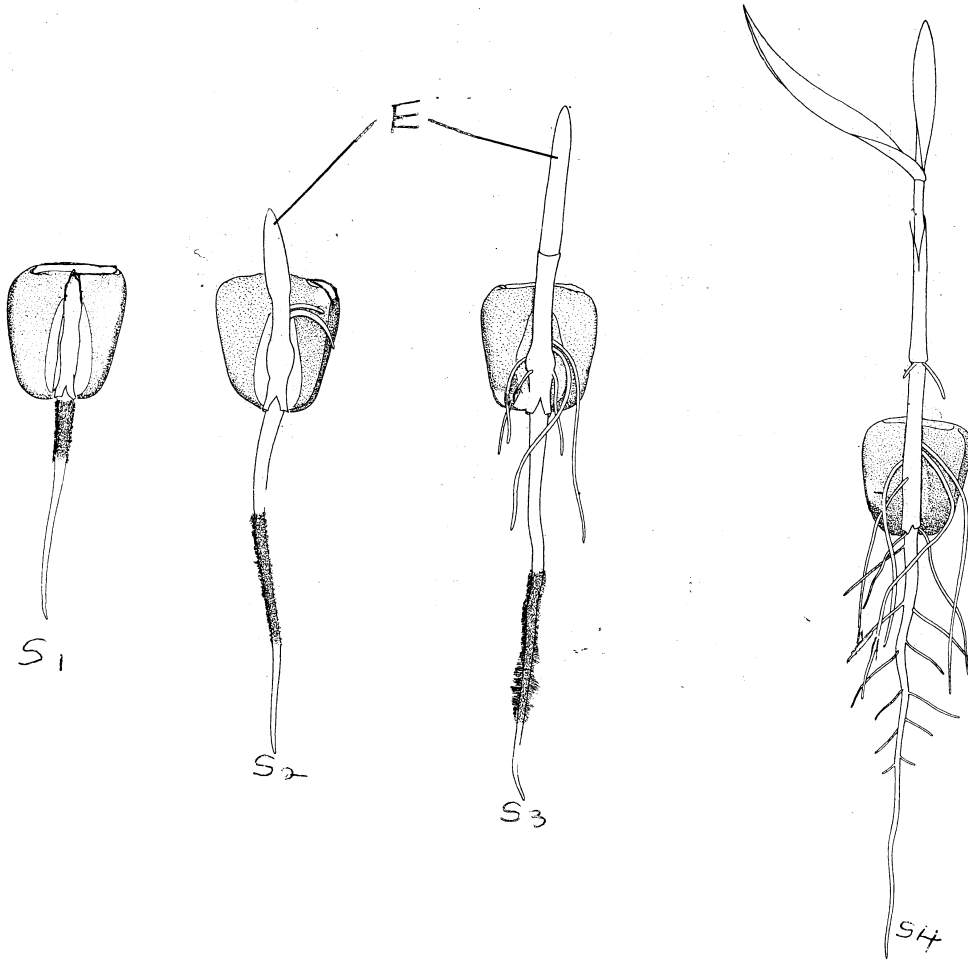
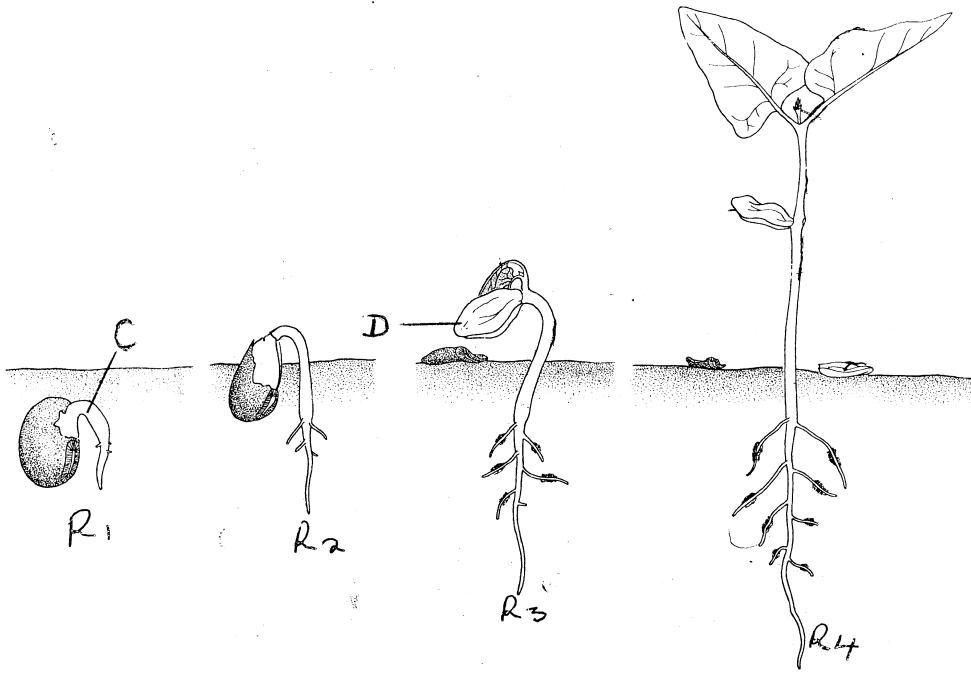
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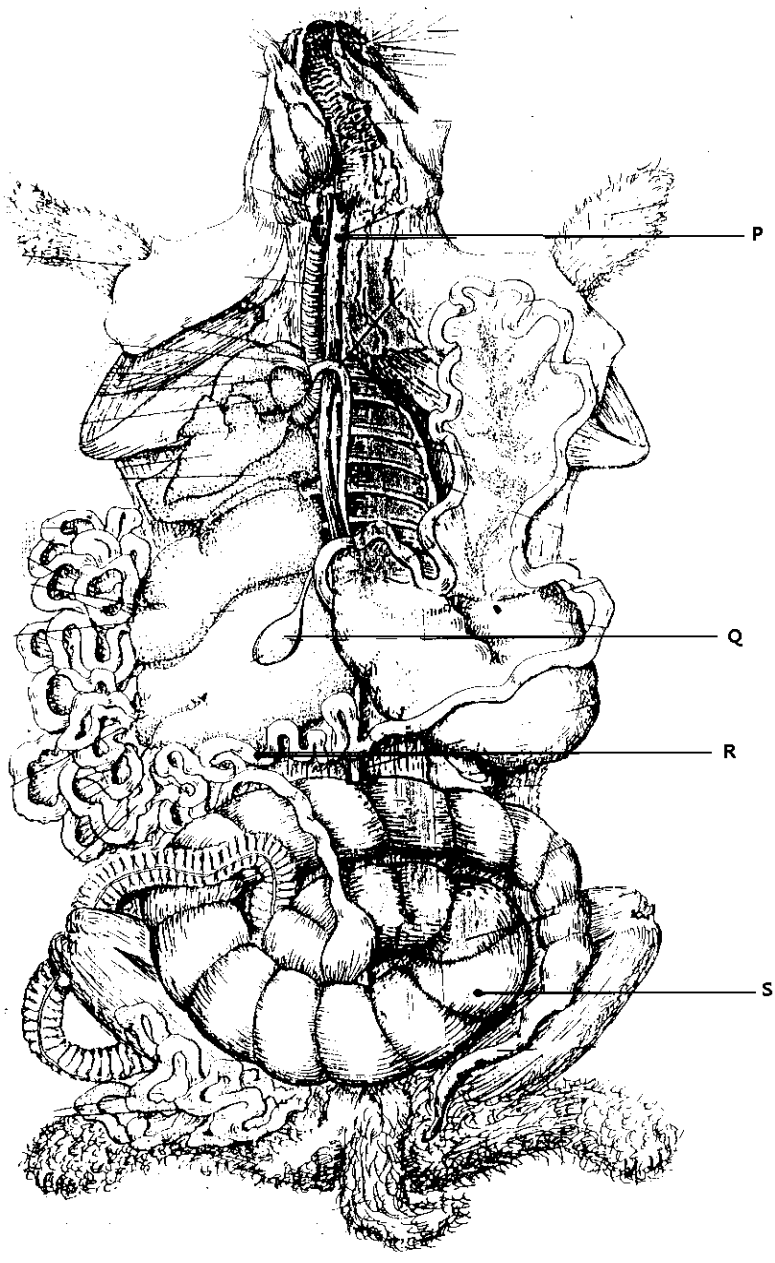
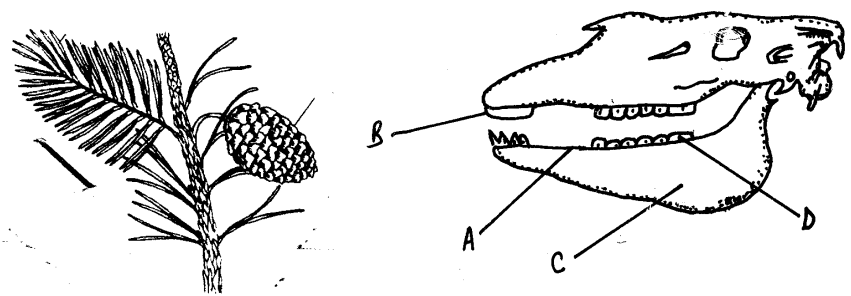
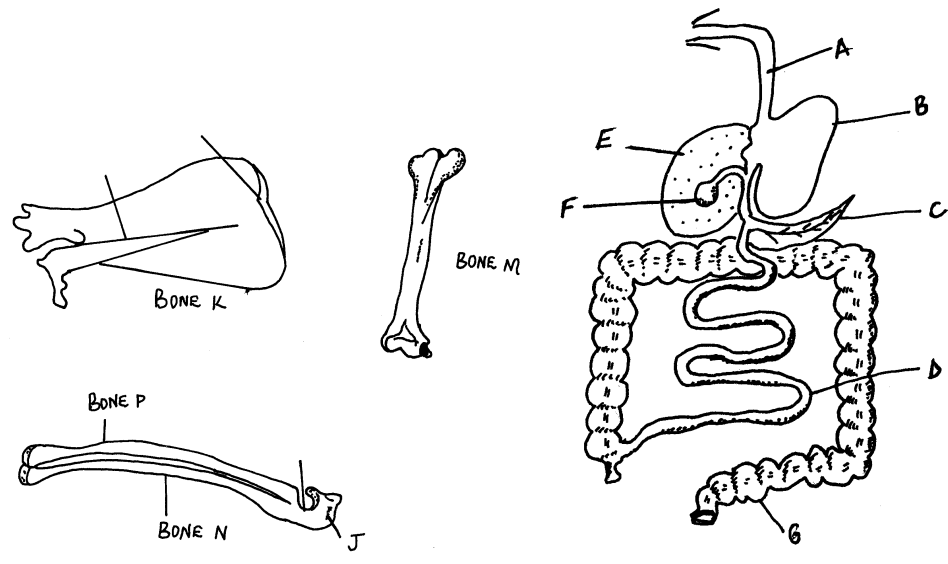


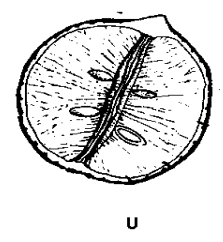
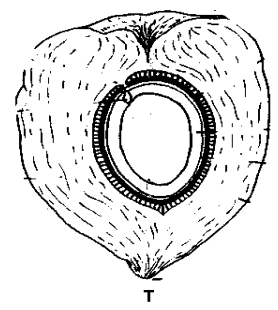
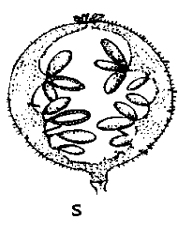
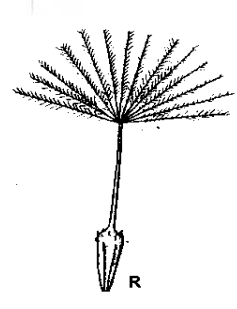
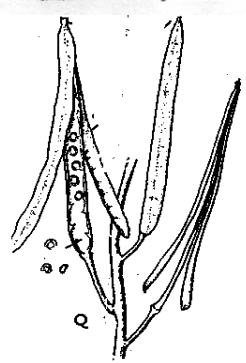
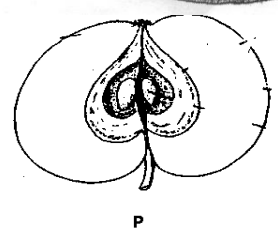
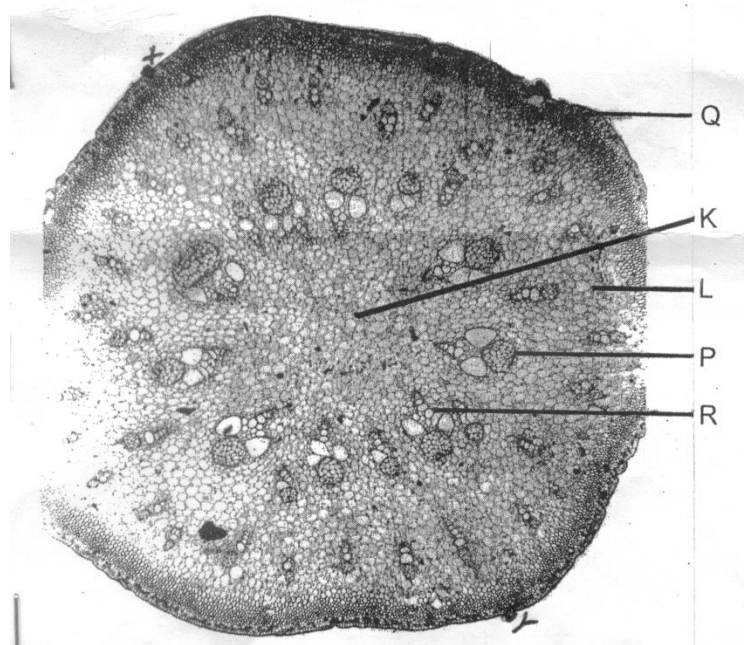
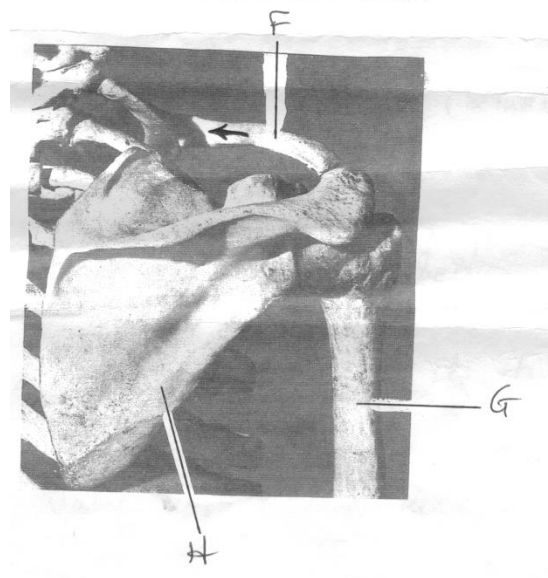
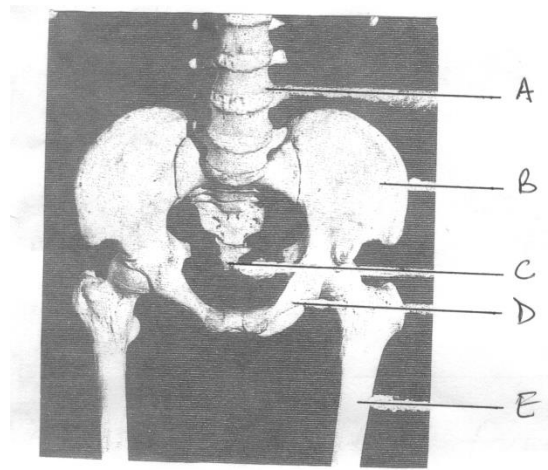
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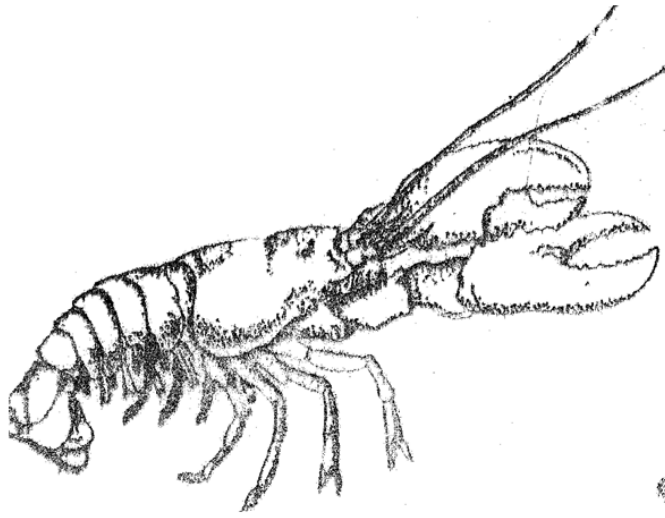




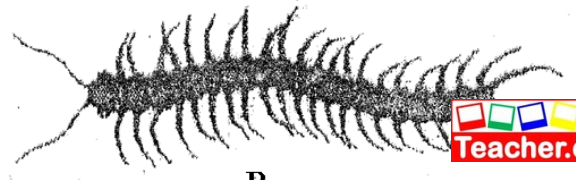








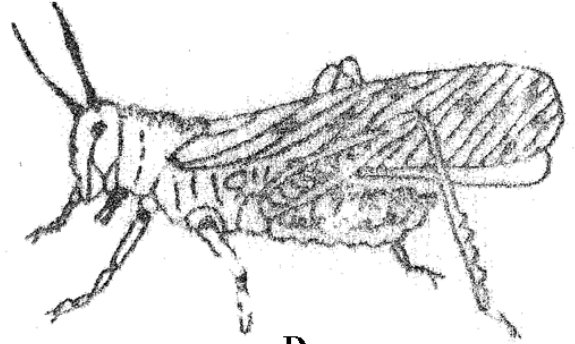
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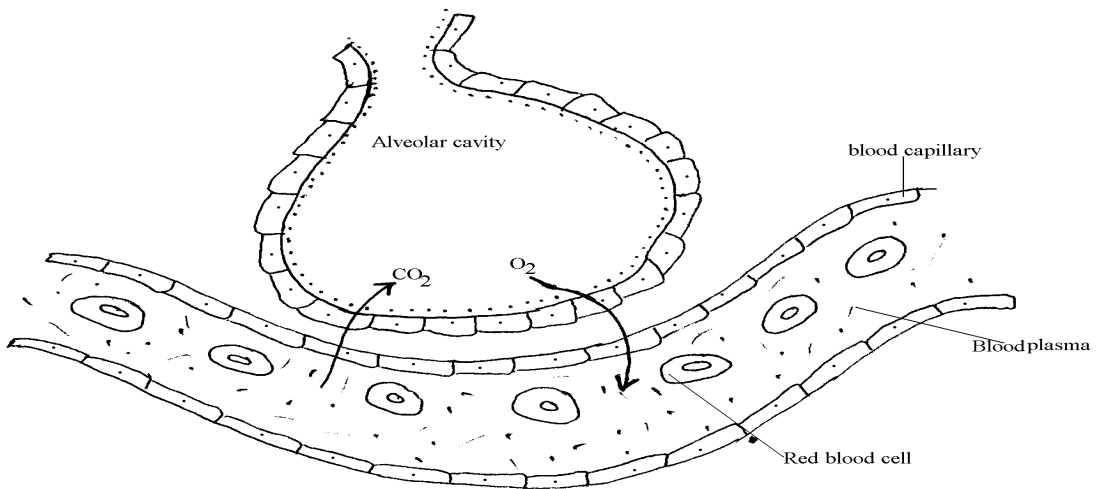
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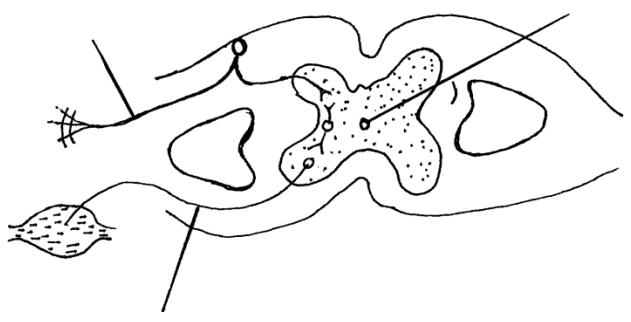
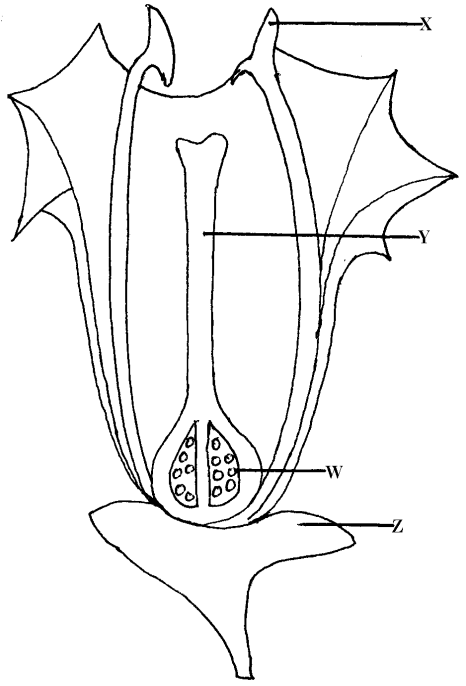
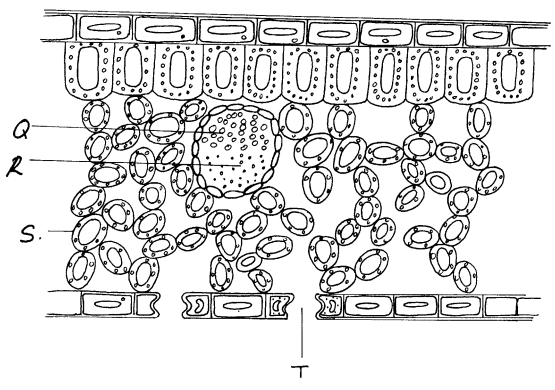


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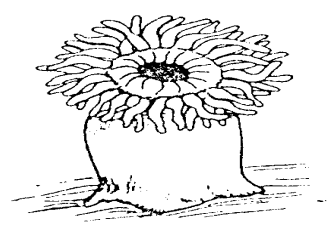


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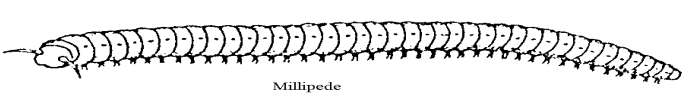




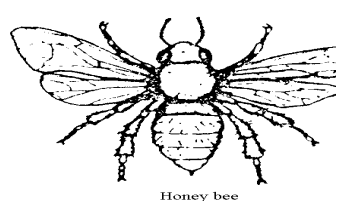
Earth worm



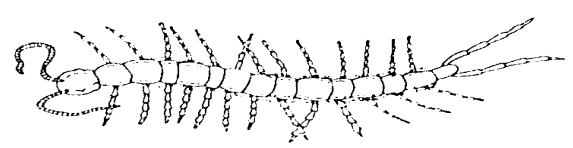
Sea anemone



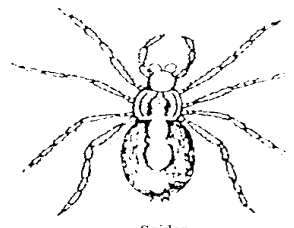
Millipede



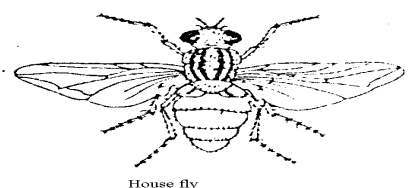
Honey bee



Centipede



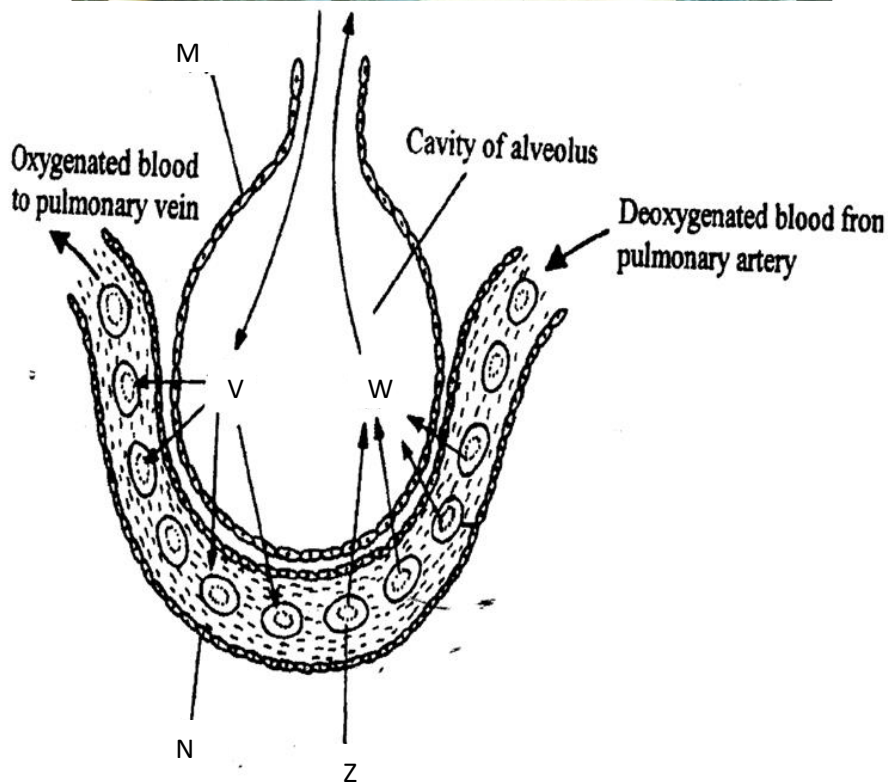
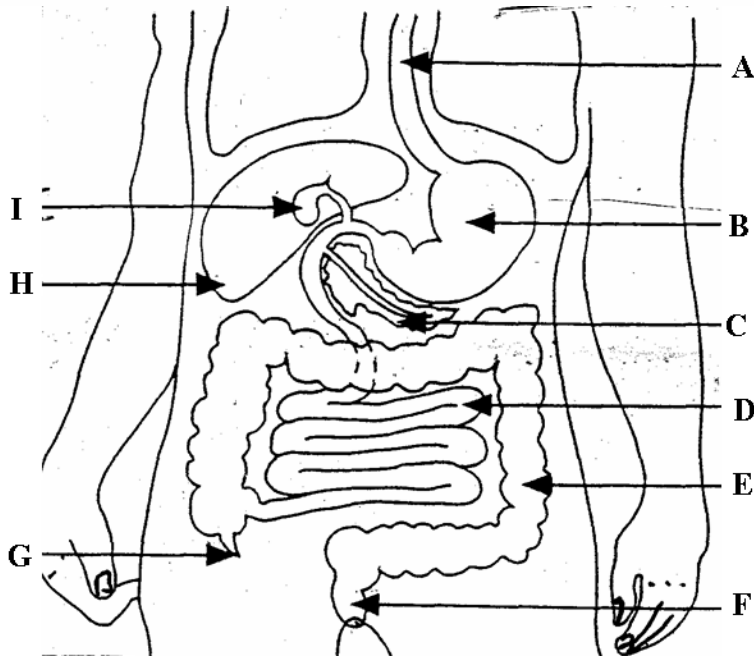
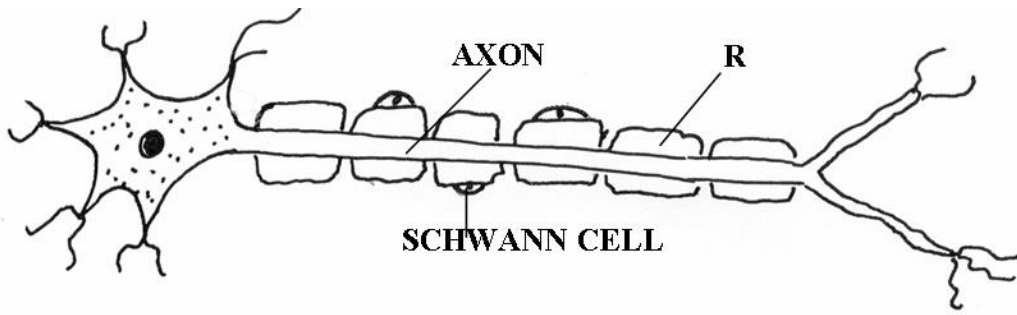
Spider

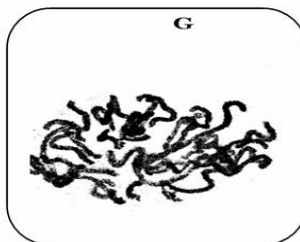
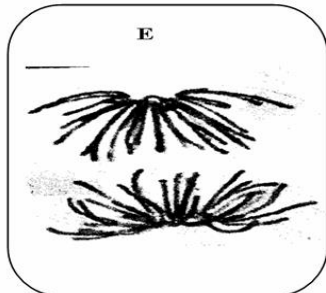
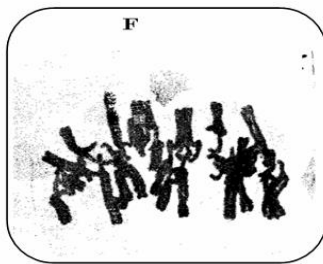
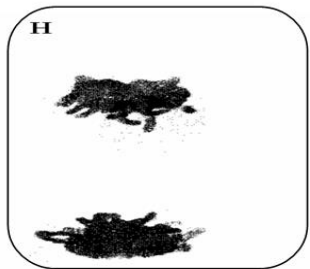
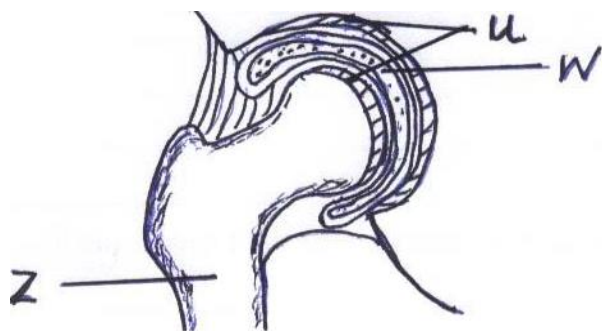


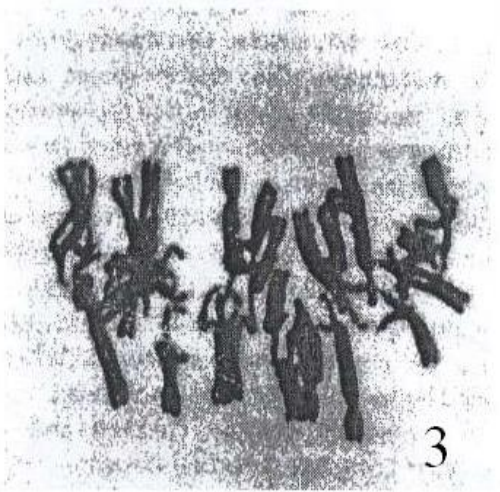
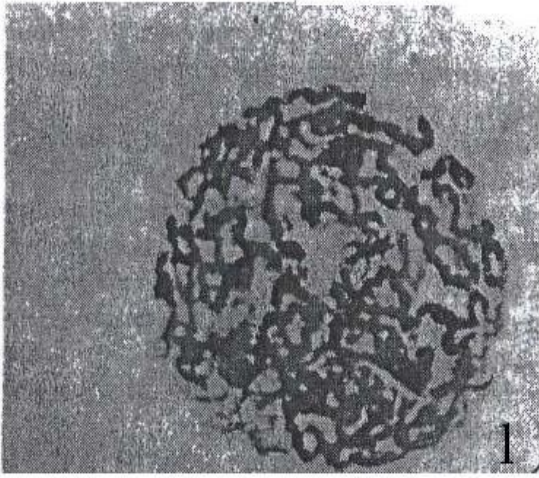
House fly



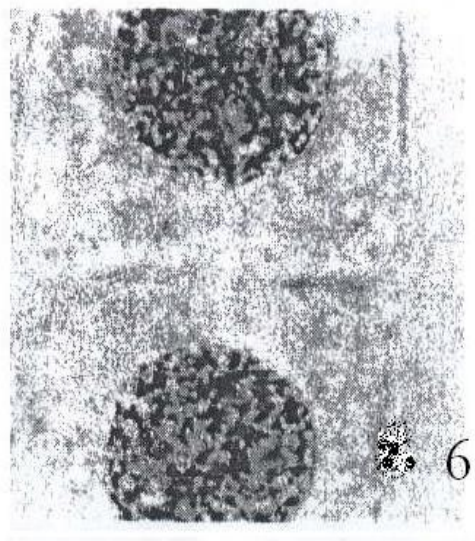
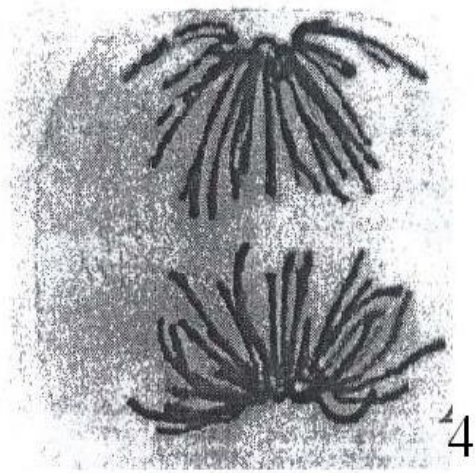
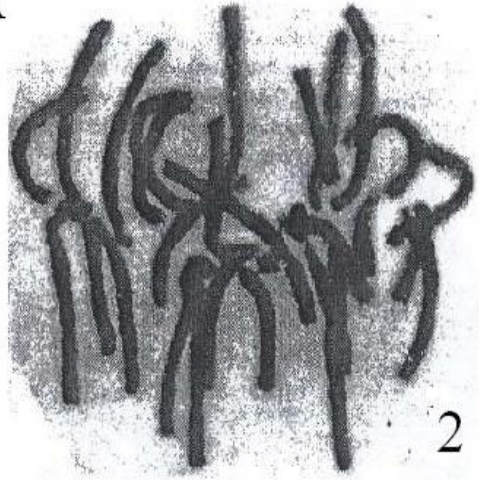
Round worm



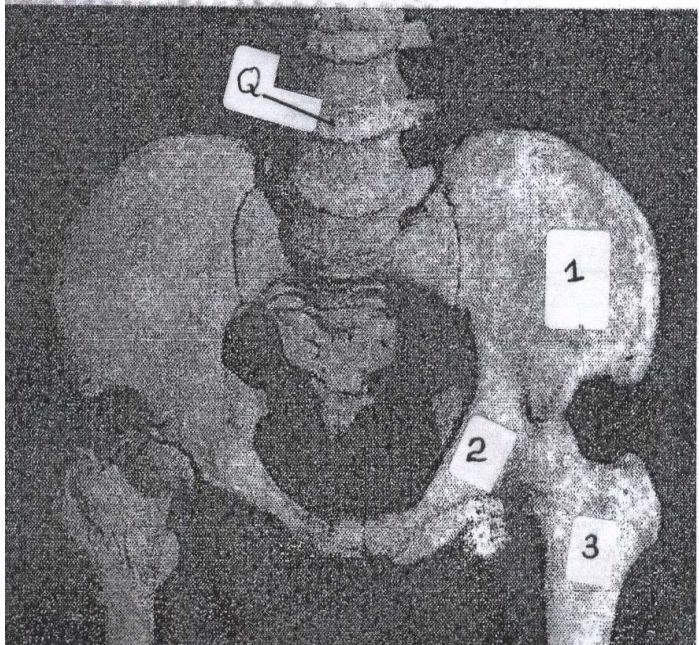
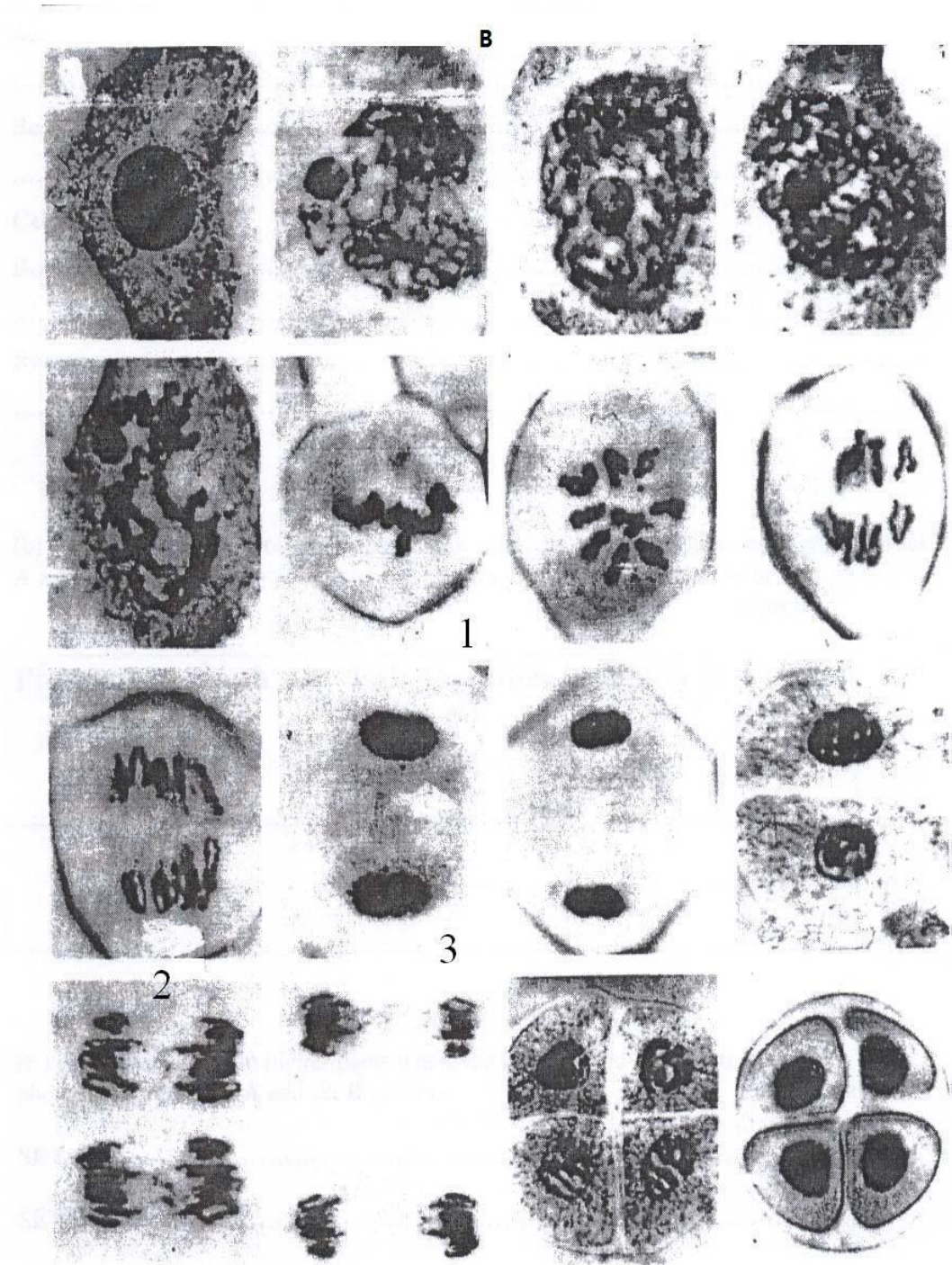


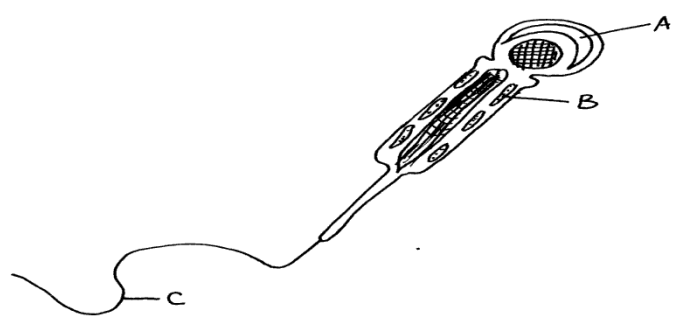
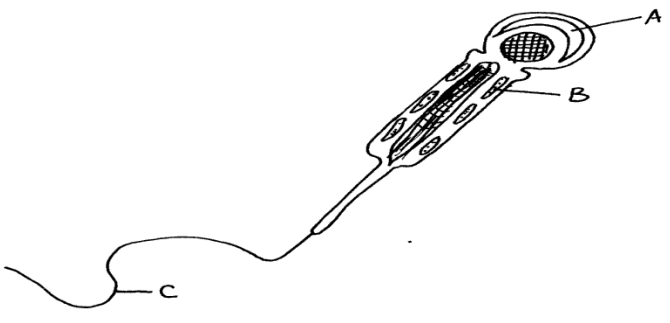
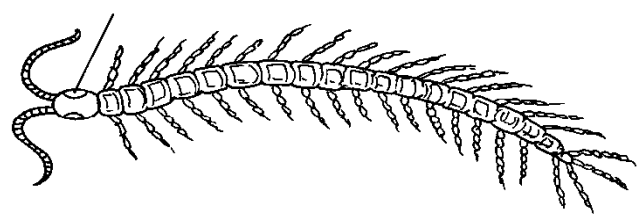
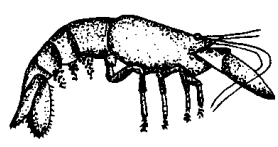
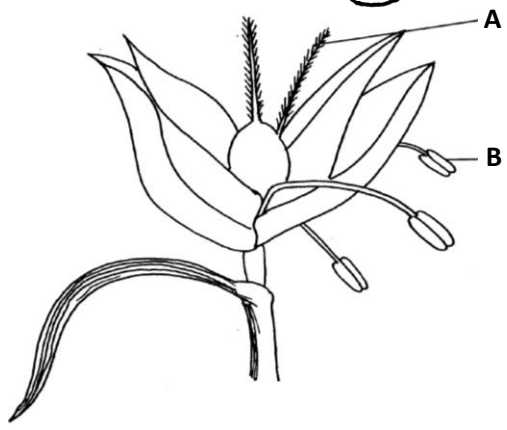
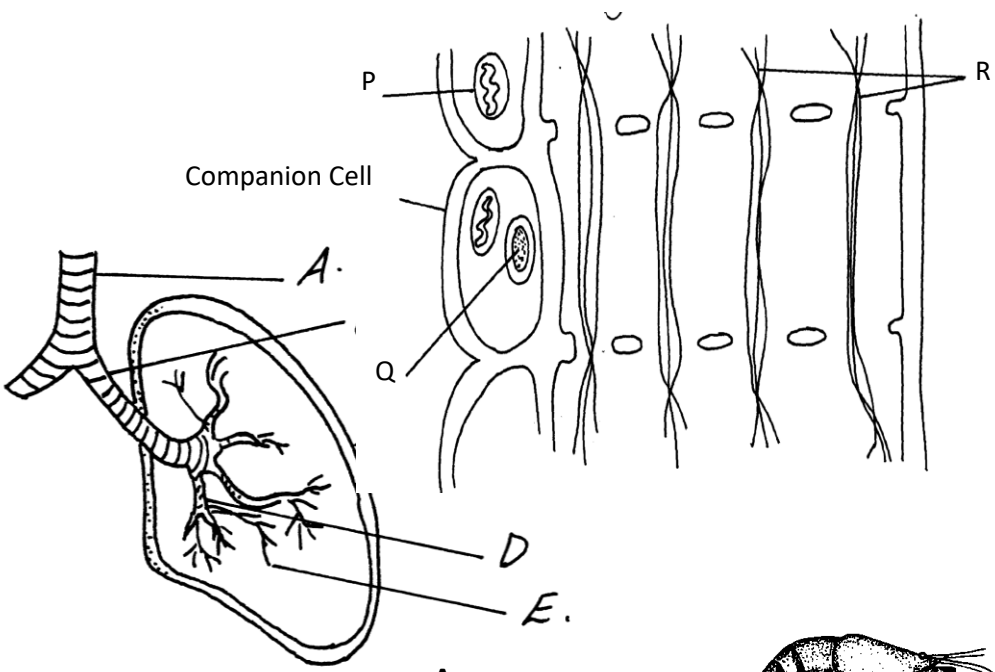


A









# TOPICAL QUESTIONS FOR BIOLOGY

## FORM I TOPICS

### 1. a) Define biology

-the study of life/living things

### b) List the branches of biology

- Zoology (study of animals)
- Botany (study of plants)
- Microbiology (study of microorganisms)

### c) Explain the importance of biology

- helps to solve environmental problems
- Helps to learn scientific skills
- For entry into other professions/careers
- To apply knowledge to everyday life situations
- To classify organisms into their right groups
- understanding living organisms

### d) State the characteristics of living organisms

- feeding/nutrition
- Growth and development
- respiration (to produce energy)
- sensitivity/irritation/response
- excretion (getting rid of metabolic waste material)
- movement/locomotion
- reproduction

### e) State the main differences between plants and animals

| Animals                                  | Plants                                 |
|--|--|
| Specialized excretory organs             | No specialized excretory organs        |
| Respond to stimulus quickly              | Slow respond to stimulus               |
| All body parts grow equally(intercalary) | Grow at shoot tip and root tip only    |
| Move around to look for food             | Stationery                             |
| Heterotrophic                            | Autotrophic                            |
| Cells have no cell walls                 | Cells have cell wall made of cellulose |
|  |  |

|                             |                                   |
|-----------------------------|-----------------------------------|
| No chlorophyll              | Contain chlorophyll               |
| Give parental care to young | Plants don't care for their young |

## 2. a) i) What is a hand lens?

- Convex lens mounted on a frame and used to magnify small objects for viewing.

## ii) How is a hand lens used?

- place the lens a short distance from the eye
- Bring the object to be viewed near the lens until an enlarged and clear image can be seen.

## ii) When is a hand lens used?

- For reasonably sized objects such as insect wing, leg, flower parts.
- Cannot be used for small objects such as cells, stomata.

## iv) Explain how to calculate drawing magnification

- drawing magnification equals to length of drawing divided by length of object or image length divided by actual length i.e.  

$$\frac{\text{length of drawing}}{\text{Length of object}} \text{ or } \frac{\text{image length}}{\text{actual length}}$$

## b) i) what is classification?

- Orderly arrangement of living organisms into various groups according to their similarities

## ii) List the external features used to classify plants

- rhizoids(e.g. mosses)
- frond (e.g. ferns)
- roots e.g. taproot, fibrous roots, modified roots
- flowers
- leaves
- buds
- seeds

## iii) List the external features used to classify animals

- horns e.g. cattle, goat, sheep, deer, gazelle etc
- hooves e.g. cattle, sheep, donkey
- mammary glands e.g. cattle, dog, sheep, cat
- hair e.g. human, cat
- Shell e.g. snail, Tortoise
- spines e.g. hedge hog, porcupine

## c) Give the reasons why classification is important

- Placing/grouping living organisms into correct groups called taxa
- Identification
- arrange information about living organisms into orderly and sequential manner i.e. it is easy to study organisms in groups

- helps in understanding evolutionary relationships
- monitoring disappearance and appearance of organisms i.e. predict characteristics of organisms

**d) i) Name the taxonomic units of classification in descending order**

- Kingdom (largest unit)
- Phylum (animals)/division (plants)
- Class
- Order
  - Family
  - Genus
  - Species(smallest unit)

**ii) What is a species?**

- all organisms which can interbreed and give rise to fertile (viable) offspring

**iii) Name the major kingdoms used in classification**

- monera
- protocista/protista
- fungi
- plantae
- animalia

**e) i) Define the term binomial nomenclature**

- a scientific system of naming organisms using the generic/genus and specific/species names
- e.g. for humans, Homo sapiens

**ii) State the principles followed during binomial nomenclature**

- the first (generic) name should begin with a capital letter while the rest are small letters
- the two names are printed in italics and if handwritten should be underlined each separately

**iii) Give the advantages of using binomial nomenclature**

- no confusion about which organism is referred to
- names are internationally accepted regardless of language
- shows evolutionary relationship hence easy to understand
- useful in naming many species unlike use of common names

**iv) Name the types of classification**

- traditional (using common names)
- scientific(using binomial nomenclature)

**3. a) i) Define the term cell**

- it is the basic unit of organization of an organism i.e. the basic functional and structural unit of an organism.

## ii) What is cell biology?

- study of structure and functioning of a cell
- also called cytology

## b)i) What is a microscope?

- an instrument used to magnify objects and make them appear bigger.



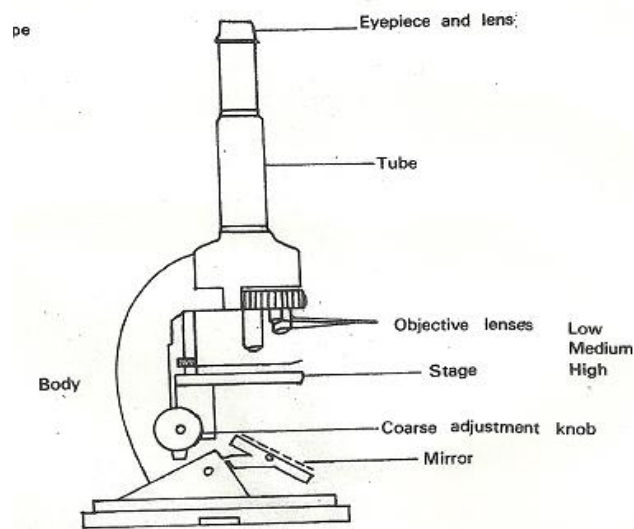
## ii) Name the types of microscope

- the light microscope
- the electron microscope

## iii) State the purpose of using a light microscope

- it magnifies and reveals the structure details of tiny objects such as the cell, that cannot be seen by the human eye directly

## iv) Draw a labeled sketch of a light microscope



## v) State the functions of the labeled parts

- Eyepiece** used to look through and to magnify the object
  - Course adjustment knob** raises or lowers body tube and focuses object roughly
  - Fine adjustment knob** raises or lowers body tube by small distances to bring image into fine focus
  - objective lens** brings image into focus and also magnifies object/image
- **stage** is a platform where object or specimen on slide is placed
  - **mirror** reflects light through condenser and directs it to objective lens
  - **clips** hold glass slide in position
  - **body tube** holds eyepiece and revolving nose piece which has objective lenses
  - **limb** or base support whole instrument
  - **arm** for holding when carrying instrument

- **revolving nose piece** holds objective lens in place enabling change from one objective lens to another

**e) i) Explain the procedure followed when using a microscope**

- put the microscope on the bench with the stage facing away from you (viewer)
- turn the lower power objective to click in line with the eyepiece
- Ensure that the diaphragm/iris is fully open
- Adjust the mirror until the stage is illuminated with enough light
- Place the slide containing the specimen on the stage for magnification
- Draw the image and indicate magnification of the drawing.



**ii) State the precautions that are necessary when handling a microscope**

- always use two hands when carrying it
- never place a microscope too close to the edge of the bench or table
- do not touch the mirror and lens with wet or dirty hands
- clean dirty lenses using a special lens cleaning cloth
- clean other parts using a soft cloth or tissue paper
- low power objective must click into position before and after use.
- Do not wet any part of the microscope
- Clean and store well after use

**d) i) What is magnification?**

- The power of making an image larger

**ii) Give the formula used to calculate magnification in a light microscope**

- eyepiece lens magnification x objective lens magnification

**iii) Give the reasons for each of the following steps when preparing a cross-section of a stem or leaf for examination under the microscope**

**cutting very thin sections**

- thin sections allow light to pass through making it easy to observe the tissue

**Using a sharp razor blade during the cutting**

- sharp blade does not damage, deform, destroy or distort the surface of cell or tissue
- it makes thin sections

## Placing sections in water

- to maintain turgidity hence maintain shape of cell
- it prevents drying of the section

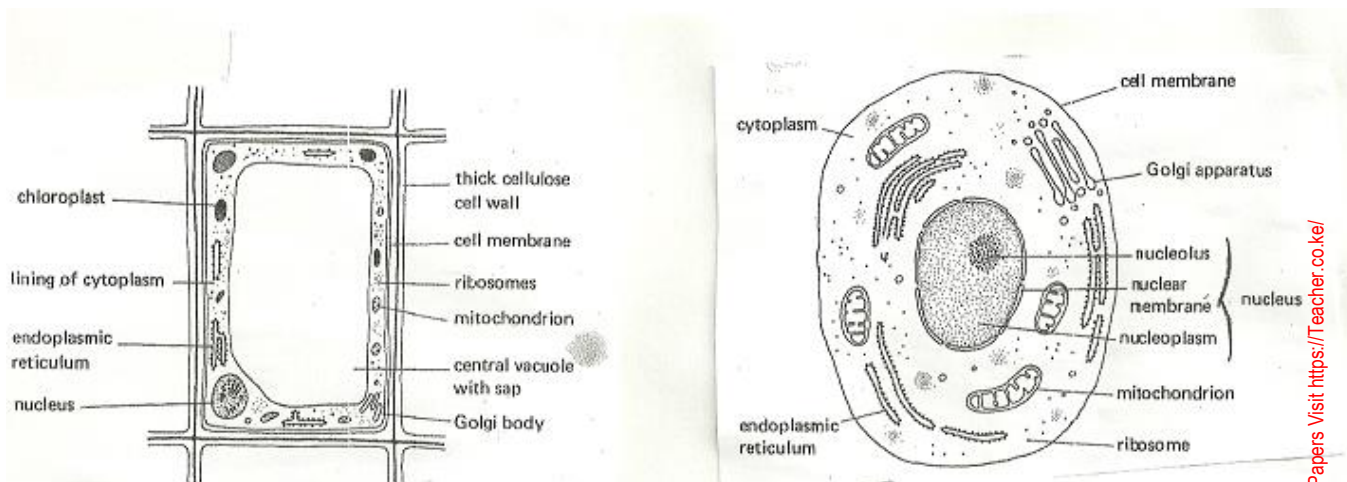
## Staining the sections with iodine before observing

- To make chloroplasts, starch containing structures, granules or plastids distinct.



## e) i) List the parts of a cell that can be seen under a light microscope

- a cell membrane
- b cytoplasm
- c cell wall
- e nucleus
- d vacuole



## ii) Draw the general structure of a plant and animal cell

## iii) List the parts of a cell that can be seen under an electronic microscope and state the functions of each part.

### Cell wall

- found in plant cells in addition to cell membrane
- made of cellulose which makes the plant tough
- allows gases, water and other substances to pass through

### Cell membrane

- permeable/selective to control movement of materials in and out of cells
- bound/encloses the cell contents
- also called plasma membrane or plasmallema

### Cytoplasm

- fluid medium where chemical reactions occur
- also where cell organelles are suspended

### Nucleus

- controls cell activities

### Nucleolus

- synthesizes DNA

### Vacuole



- sacs filled with fluid called cell sap
- large in plants but small in animals
- act as reservoirs for food and harmful wastes which would otherwise interfere with the metabolism in cytoplasm

### **Lysosomes**

- store hydrolytic enzymes
- destroy worn out cell organelles, cells, pathogens
- digestion of food in unicellular organisms
- autolysis

### **Golgi apparatus**

- processing/packaging of synthesized materials
- transporting/secretion of packaged materials/cell materials e.g. glycoproteins and mucus
- production of lysosomes

### **Ribosomes**

- where protein synthesis takes place

### **Mitochondrion**

- synthesis of ATP/energy

### **Chloroplasts**

- where photosynthesis takes place

### **Endoplasmic reticulum**

- transport of cell secretions
- can be rough or smooth

### **iv) State the functions of cell sap**

- stores chemical substances, sugar, salts
- maintains shape of the cell/provides mechanical strength
- plays a role in osmoregulation by creating an osmotic gradient that brings about movement of water

### **e) Compare plant and animal cells**

- plant cells have chloroplasts lacking in animals
- animal cells have many small vacuoles while plant cells have a large central vacuole
- plant cell have cellulose cell walls lacking in animal cells
- cytoplasm in plant cell is in the periphery but in animal cell it is centrally placed
- plants store starch, oil and protein while animals store fats and glycogen
- animal cells have centrioles which plant cells do not have

### **f) Explain the meaning of each of the following**

#### **i) Cell**

- Basic unit of organization in an organism
- Specialized animal cells include sperm, ovum muscle

Specialized plant cells include epidermal, guard cell and palisade cell

## ii) Tissue

- these are cells of a particular type grouped together to perform a certain function
- animal tissues include epithelium, blood, nerves, muscle, skeletal and connective tissues
- plant tissues include epidermal, photosynthetic, vascular, strengthening tissues

## iii) Organ

- tissues combine together to form organs
- an organ is a complex structure with a particular function
- animal examples include heart, liver, kidney, lungs, brain, blood vessels, muscles, skeleton
- Plant organs include leaves, roots, flowers, and stem.

## iv) Organ system

- organs are grouped together to form systems also called organ systems
- animal systems include excretory, digestive, respiratory, nervous, circulatory, endocrine(hormones/glands), skeletal systems
- plant systems include transport system

## g) i) Name the structures which are present in plant cells but absent in animal cells

- Chloroplast
- Cell wall

## ii) Name the structures which are present in animal cells but absent in plant cells

- Lysosomes
- Centrioles
- Pinocytic vesicles

## h) Explain how to estimate cell size

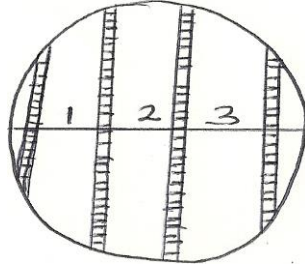
### i) Materials

- cell sizes are measured in units known as micrometers ( $\mu\text{m}$ )
- required is a transparent ruler marked in millimeters
- $1\text{m}\mu = \frac{1\text{mm}}{1000}$

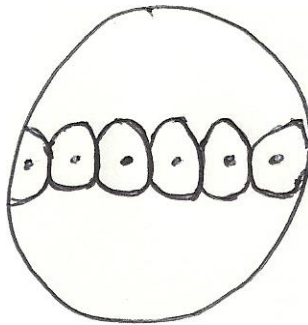
### ii) Procedure

- Click to low power
- place transparent ruler with its millimeter marks on the stage

- focus so that the millimeter marks can be seen as thick dark lines
- estimate the diameter of field of view by counting the one millimeter spaces between the first mark and the last one across the field of view as shown below



- the diameter of the field of view above is estimated as 3.2 mm
- convert the diameter of the field of view from millimeters to micrometers i.e.  $3.2/1000$
- Estimate the fraction of the field of view occupied by the cell. This is done by estimating the number of cells places end to end that would fill the diameter of the field of view as shown below



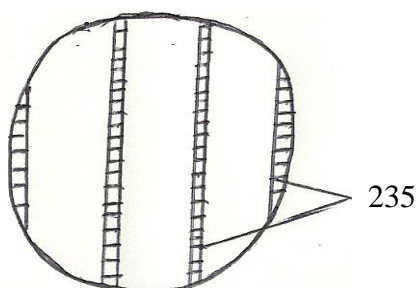
- in the figure above, it is estimated that approximately six cells will occupy the diameter of the field of view
- therefore, one cell will occupy  $1/6$  of the field of view
- its diameter is calculated as  $1/6$  times the diameter of the field of view

**i) In a drawing of a giraffe, the height of the head from the ground was recorded as 10cm. the drawing also showed a magnification of 0.02. calculate the actual height of the giraffe**

$$\text{Drawing height} = 10\text{cm} = 500\text{cm}$$

$$\text{Magnification} = 0.02$$

- i) **In a class experiment to estimate sizes of cells a student observed and obtained millimeter marks on the field of view of a microscope as shown in the diagram below.**



### Millimeter marks

- If the student counted 40 cells on the diameter of the field of view, what was the approximate size of the each cell in micrometers?

Diameter of field of view =  $3 \times 1000 = 75 \mu\text{m}$

Number of cells 40

**ii) Under which of the following light microscope magnifications would one see a larger part of the specimen? X40 or x400? Give a reason**

- x40
- Smaller magnification gives a wider field of view hence a larger part seen.

**e.) a) i) Define cell physiology**

- the study of the functions of a cell in relation to their structure

**ii) State the functions of the cell**

- exchange of materials between the cell and the external environment
- physiological reactions e.g. photosynthesis
- production of energy through mitochondria

**b) i) Describe the structure of cell membrane**

- made up of three layers
  - Lipid portion sandwiched between two protein layers
  - Lipid portion enhances penetration of oil soluble substances
- Pores present to facilitate inward and outward movement of water soluble substances

**iii) Give the properties of cell membrane**

- semi-permeable
- sensitive to changes in temperature and pH
- Possesses electric charges.

**c) i) What is diffusion?**

- movement of substances/molecules/particles/ions from a region of high concentration to a region of low concentration (until equilibrium is reached)

**iii) State the factors affecting diffusion**

- diffusion gradient/concentration gradient
- surface area to volume ratio
- temperature
- size of molecules
- state of the diffusing substance
- thickness of membrane and tissues

### iii) Explain the roles of diffusion in living organisms

- gaseous exchange
- absorption of digested food in intestines
- movement of salts in plants
- movement of materials between blood capillaries and tissues
- removal of waste materials from bodies of small organisms
- air movement in intercellular spaces in plants



### iv) Suggest an experiment to demonstrate diffusion

- to a beaker of water, drop crystals of potassium permanganate or copper sulphate
- leave to stand in a place without disturbing
- observe the spreading of molecules
- liquid is coloured uniformly due to diffusion

### d) i) What is osmosis?

- Movement of water or solvent molecules from a dilute/hypotonic solution to a more concentrated/hypertonic solution across a semi-permeable membrane.

OR

- movement of solvent molecules from a region of their higher concentration to a region of their lower concentration through a semi-permeable membrane

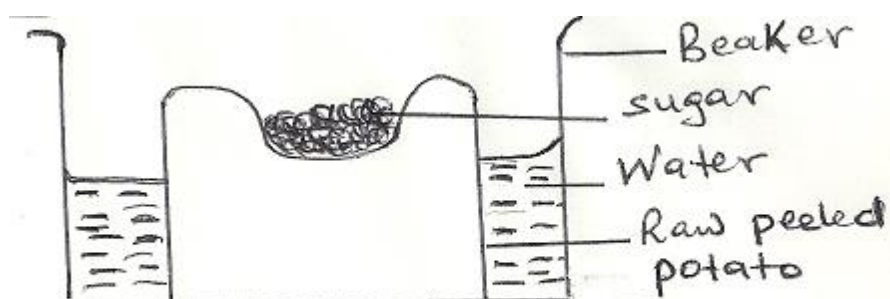
### ii) State the factors affecting osmosis

- concentration of the solution
- concentration gradient
- temperature

### iv) Explain the roles of osmosis in living organisms

- helps to draw water into roots of plants
- helps in the passage of water from one living cell to another in the plant
- helps to keep plant cells turgid increasing support
- Helps in opening and closing of stomata.
- Folding of leaves in *Mimosa pudica* when touched
- Feeding in insectivorous plants

### v) A group of students set up an experiment to investigate a certain physiological process. The set up is as shown in the diagram below.



After some time they observed that the level of sugar had risen.  
What was the physiological process under investigation?

- Osmosis

**Why was there a rise in the level of sugar solution?**

- sugar solution is more concentrated than cell sap osmosis
- those cells become more concentrated and therefore draw water from neighbouring cells
- this process continues until the cells in contact with the water in the container draw it up causing a rise in the level of the sugar solution

**Suggest the results that the students would obtain if they repeated the experiment using cooked potato**

- The level of sugar solution will not rise.

**What is the reason for your suggestion?**

- boiling kills/destroys cells making them osmotically inactive

**vi) Explain the following terms**

**Hypotonic**

- a solution whose concentration is lower than that of the cell

**Isotonic**

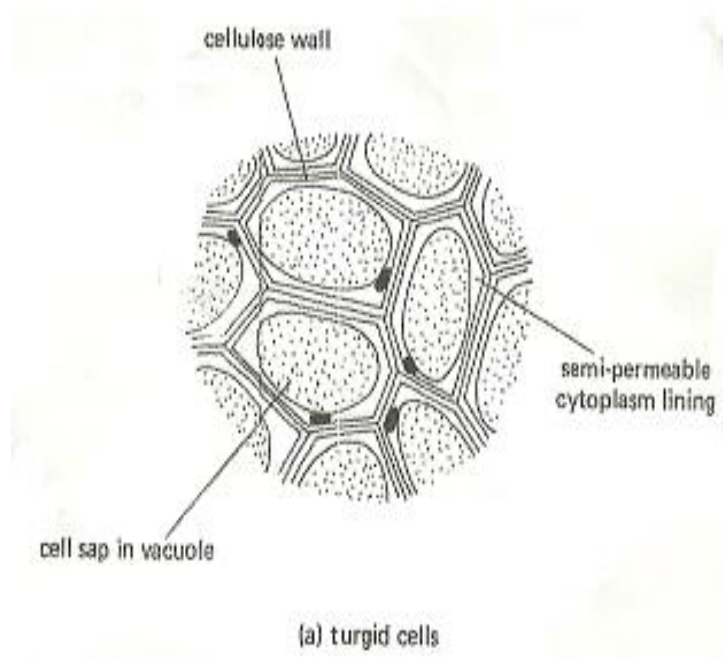
- a solution whose concentration is the same as that of the cell

**Hypertonic**

- a solution whose concentration is higher than that of the cell

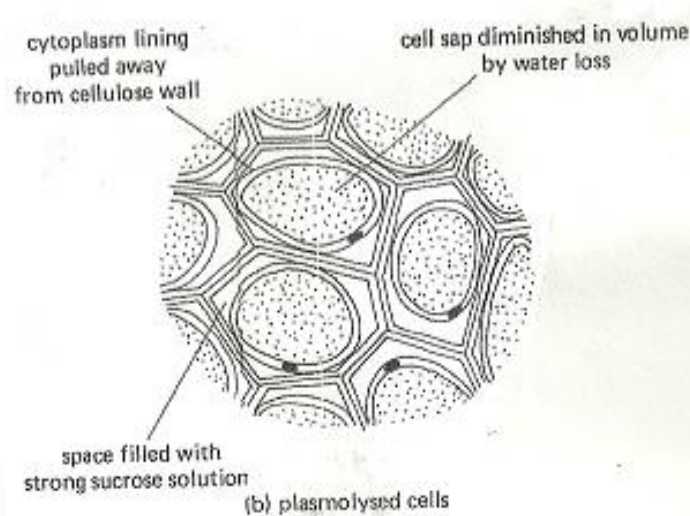
**Turgor pressure**

- As a cell gains water, its vacuole enlarges and exerts an outward pressure called turgor pressure.



## Plasmolysis

- if a plant is placed in a hypotonic solution it loses water
- the protoplasm shrinks to an extent that it pulls away from the cellulose cell wall



## Wilting

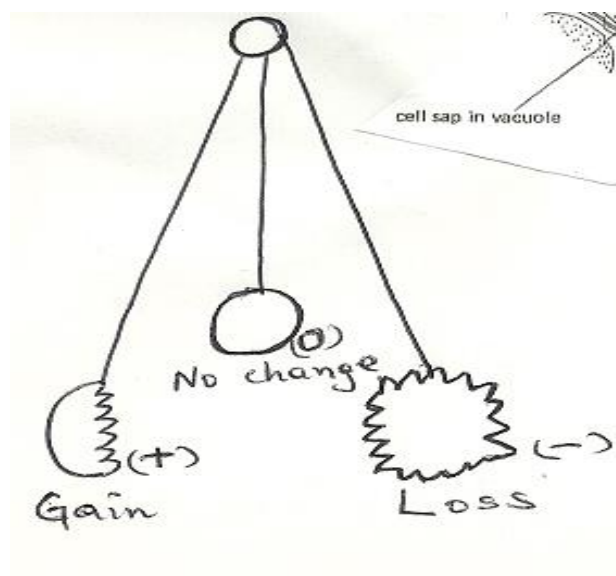
- when a plant is turgid it can stand upright
- however, if the cells lose a lot of water, turgidity is reduced
- the plant then droops because the cells are flaccid
- the plant is said to wilt

## Haemolysis

- if red blood cells are placed in distilled water, the cells take up water by osmosis, swell and burst
- this is because it does not have any mechanism like the cellulose cell wall to prevent overstretching nor any means of removing excess water
- this is called haemolysis

e) A form one student placed red blood cells in different salt concentrations and obtained the following results:-

There was a gain (+) no change (0 zero) and a loss (-) in the volume of the cells as show below:-



## Briefly explain the results of the experiment

- in the first solution, red blood cell absorbed water by osmosis, swell and burst (haemolysis) hence the solution is hypotonic
- in the second solution, there was no change in size or structure as it was isotonic hence no osmotic gradient
- in the third solution the red blood cell lost water to shrink hence became crenated as the solution was hypotonic to the cell cytoplasm.



### f) i) What is active transport?

- movement of molecules and ions against a concentration gradient
- the substances move from a lower to a higher concentration gradient by use of energy

### ii) State the factors affecting active transport

- oxygen concentration
- temperature
- change in pH
- glucose concentration
- enzyme inhibitors

### iii) Why is oxygen important in the process of active transport?

- Oxygen is required for respiration, which produces energy necessary for the process to occur.

## 2.0 ) the factors that affect the rates of the following process in living organisms.

### a.) DIFFUSION.

- **Diffusion gradient** which refers to the difference in concentration of molecules between the region of high concentration and the region of low concentration. Increasing the concentration gradient causes an increase in rate of diffusion and vice versa.

-**Surface area to volume ratio** .is the ratio of total surface area exposed by an organism compared to its body volume. Small sized living organisms have a large surface area to volume ratio. The larger the surface area to volume ratio ,the high the rate of diffusion and vice versa. Small organisms like amoeba and paramecium can hence rely on diffusion for transport of substances into and within its body and removal of waste products



**-thickness of membranes.** Molecules take longer to diffuse across thick membranes than across thin membranes hence the thinner the membrane the higher the rate of diffusion.

**-Temperature.** Increasing temperature increases the kinetic energy of diffusing molecules making them to spread faster. Increasing temperature increases the rate of diffusion and vice versa

**-size of molecules/molecular weight.** Small sized molecules/molecules of low molecular weight move/diffuse faster hence the rate of diffusion is high where the molecules involved are small or have low molecular weight and vice versa.

## **B.) OSMOSIS**

**-Temperature.** Increasing temperature increases the kinetic energy of water molecules making them to spread faster. Increasing temperature increases the rate of osmosis and vice versa

**-concentration gradient/diffusion pressure deficit.** Refers to the difference in concentration on either side of a semi-permeable membrane. The higher the osmotic pressure difference the higher the rate of osmosis.

## **C.) ACTIVE TRANSPORT**

**OXYGEN CONCENTRATION.** It is required for respiration/to oxidize respiratory substrates to release energy required for active transport. an increase in oxygen concentration causes a simultaneous increase to the rate of active transport upto a certain level.

**P<sup>H</sup>** Enzymes being protein in nature are P<sup>H</sup> specific. Extreme change in P<sup>H</sup> affect the rate of respiration which is controlled by enzymes and may denature the enzymes reducing the rate of active transport.

**-GLUCOSE CONCENTRATION.** is the main respiratory substrate for energy production. An increase in glucose concentration in cells increase the rate of respiration and hence the rate of active transport is increased upto a certain optimum level beyond which any additional increase in glucose concentration has no effect.

**TEMPERATURE.** The process of respiration by which energy for active transport is generated is controlled by enzymes.

Enzymes work best at temperatures of between 35<sup>0</sup>c-40<sup>0</sup>c, usually called optimum temperature ranges. At very low temperatures enzymes are inactive lowering the rate of respiration hence low rates of active transport . increase in temperature above optimum ( above 40<sup>0</sup>c)denatures enzymes

slowing down respiration and active transport until it finally stops.

**ENZYMES INHIBITORS.** They are substances which slow down (by competing with the enzyme for the active sites in the substrate) or stop (by blocking the active sites of the enzyme) the activity/functioning of enzymes. This slows down or stops respiration and so is active transport.

**CONCENTRATION OF CARRIER MOLECULES IN THE CELL MEMBRANE.** They are substances that bind to the ions being transported actively and carrying them across the membrane. Increase in concentration of carrier molecules increases the rate of active transport up to a certain level and vice versa.

4.) Explain briefly the role of osmosis in living tissues.

In plants:

Osmosis facilitates the absorption of water from the soil by plant roots, water is required for the process of photosynthesis.

Turgidity of cells contributes to support in herbaceous plants and helps plant to maintain shape.

Helps in closing and opening of stomata regulating the process of gaseous exchange and transpiration.

It facilitates feeding in insectivorous plants like Venus fly trap.

In animals:

Enables reabsorption of water from the kidney tubules back to blood stream facilitating the process of osmoregulation.

It enables organisms in fresh water bodies like amoeba to absorb water.

It is applied in food preservation.

5.) Explain what happens when plant and animal cells are put in hypotonic and hypertonic solutions.

**a. i) plant cells in hypotonic solution.**

The concentration of the plant cell sap is hypertonic to the solution/water medium. The cell draws in water by osmosis through the cell wall, cell membrane into the cell cytoplasm.

Water enters the cell vacuole by osmosis; it enlarges and exerts an outward pressure on the cell wall called turgor pressure.

Increased turgor pressure pushes the cell cytoplasm against the cell wall until the cell wall cannot stretch any further. The cell becomes firm or rigid and is said to be turgid. As the cell wall is being stretched outwards, it develops a resistant inwards pressure that is equal and opposite to the turgor pressure and this is called wall pressure.

**ii.) Plant cells in hypertonic solution.**

The plant cell sap is hypotonic to the solution medium. Water molecules are drawn out of the plant cells by osmosis into the hypertonic solution through the semi-permeable membrane of the plant cells. As a result the plant cell will start to shrink/less rigid and become flabby. The cell membrane/plasma membrane is pulled away from the cell wall and the cell is said to be flaccid. This process by which a plant cell loses water, shrinks and becomes flaccid is called plasmolysis. However, the shape of the plant cell is maintained by the tough rigid cellulose cell wall which prevents crenation in plant cells.

**b.i) Animal cells in hypotonic solution.**

The concentration of water in the cytoplasm of the plant cells is hypertonic to the solution medium in the test. Water molecules are then drawn into the animal cell cytoplasm from the surrounding medium by osmosis through the semipermeable membrane. The cell swells as water is drawn into them by osmosis. As water continues to enter into the cell, the weak animal cell membrane bursts, a process called lysis. In red blood cells, this process is called haemolysis. However, in unicellular organisms like amoeba and paramecium, bursting of their cells does not take place because they have specialized organelles called contractile vacuoles for removal of excess water out of their bodies/cells.

**ii.) Animal cells in hypertonic solution.**

The concentration of the animal cell cytoplasm is hypotonic to the solution medium in the test. The surrounding hypertonic solution will draw water out of the animal cells by osmosis through the semi-permeable membrane. Continued loss of water causes the cells to be smaller in size and their membranes become wrinkled. This process will continue until the concentration of the cell sap and the surrounding medium is equal, i.e. isotonic. The process by which animal cells lose water and shrink is called crenation.

**6.) Explain briefly the role of active transport in living organisms.**

It is involved in active reabsorption of glucose and mineral salts in kidney tubules during formation of urine. It enables the absorption of digested food from the alimentary canal/small intestines into the blood stream. Excretion of waste products from body cells for eventual removal. Involved in transmission

of nerve impulses within the nerve cells through the sodium pump which maintains a balance between sodium and potassium ions. It facilitates accumulation of substances in the body cells to offset osmotic pressure of organisms in dry and marine environment allowing them to absorb water by osmosis and avoid desiccation. In plants it enables plant roots to absorb water from the soil against the concentration gradient. It's involved in translocation of manufactured food in the phloem tissue within the plant body. It's involved in the opening and closing of the stomata through the sodium-potassium pump mechanism.



#### **iv) Outline the roles of active transport in living organisms**

- mineral salt intake by plants
- selective reabsorption of glucose and some salts by kidney tubules
- absorption of digested food by small intestines
- excretion of waste products from body cells
- reabsorption of useful materials in the blood stream or at the tissue fluid
- sodium pump mechanism in the nerve cells/neurons

#### **f.) a) i) Define nutrition**

- the process by which living organisms obtain and assimilate nutrients

#### **ii) State the importance of nutrition**

- for respiration to get energy
- for growth
- for development
- to repair and replace worn out and damaged parts and tissues

#### **b) Differentiate the various modes of feeding**

##### **i) Autotrophism**

- manufacturing food from simple organic substances
- types are photosynthesis and chemosynthesis

##### **ii) Heterotrophism**

- obtaining food from autotrophes and other organic substances
- types are holozoic, saprophytic and parasitic

#### **g.) a) i) Define photosynthesis**

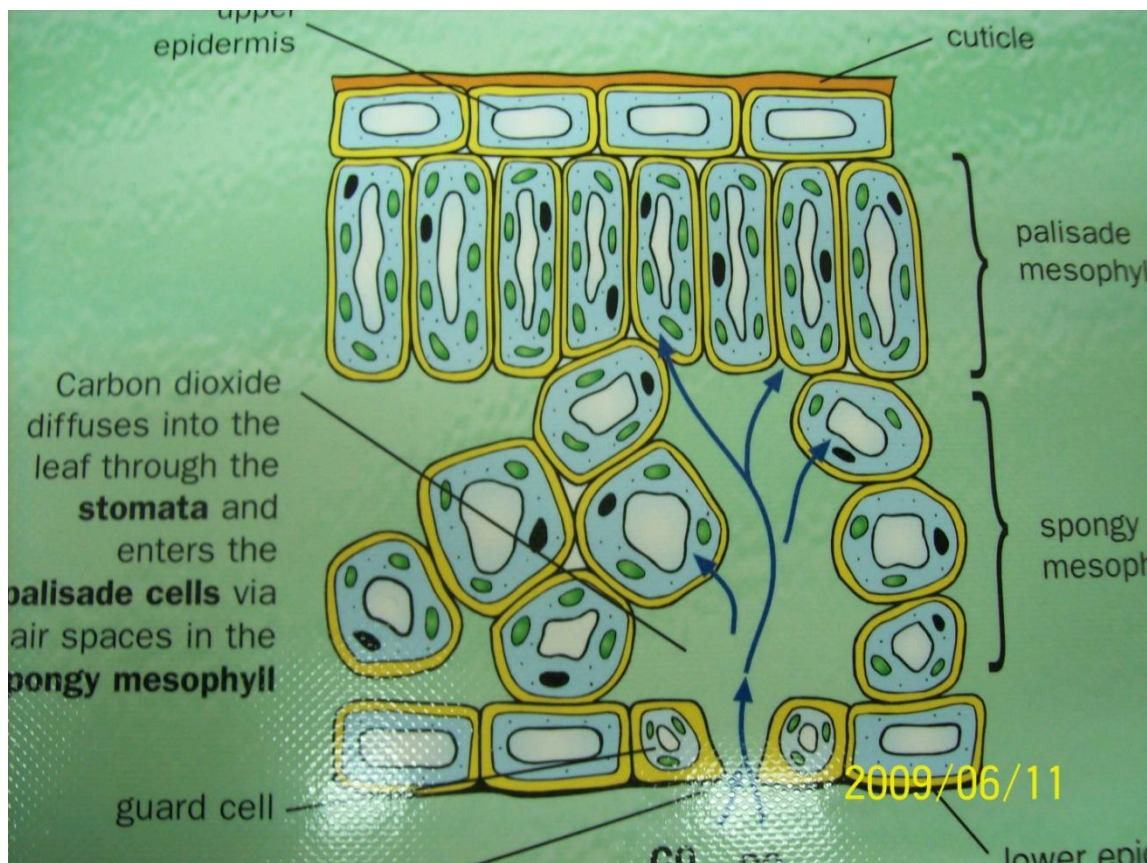
- the process by which green plants build up organic compounds from carbon IV oxide and water in the presence of sunlight

#### **ii. State the importance of photosynthesis**

- formation of sugars/glucose which is a source of energy

- purification of air(CO<sub>2</sub> is used, O<sub>2</sub> is released)
- storage of energy to be used later in respiration
- stores energy in wood, coal, oil to be used later to run industries

## Structural adaptation of the leaf to its function



The leaf has a broad and flattened lamina to provide a large surface area for trapping optimum light for photosynthesis and allow maximum gaseous exchange.

The leaf epidermis is thin ( one cell thick) to reduce the distance across which diffusion of carbon (iv) oxide gas to palisade cells and oxygen gas from palisade cells takes place.

The leaf has numerous stomata that allows easy diffusion of gases into and out of the palisade tissue.

The leaf cuticle and epidermis are transparent to allow easy penetration of light to the photosynthetic tissue.

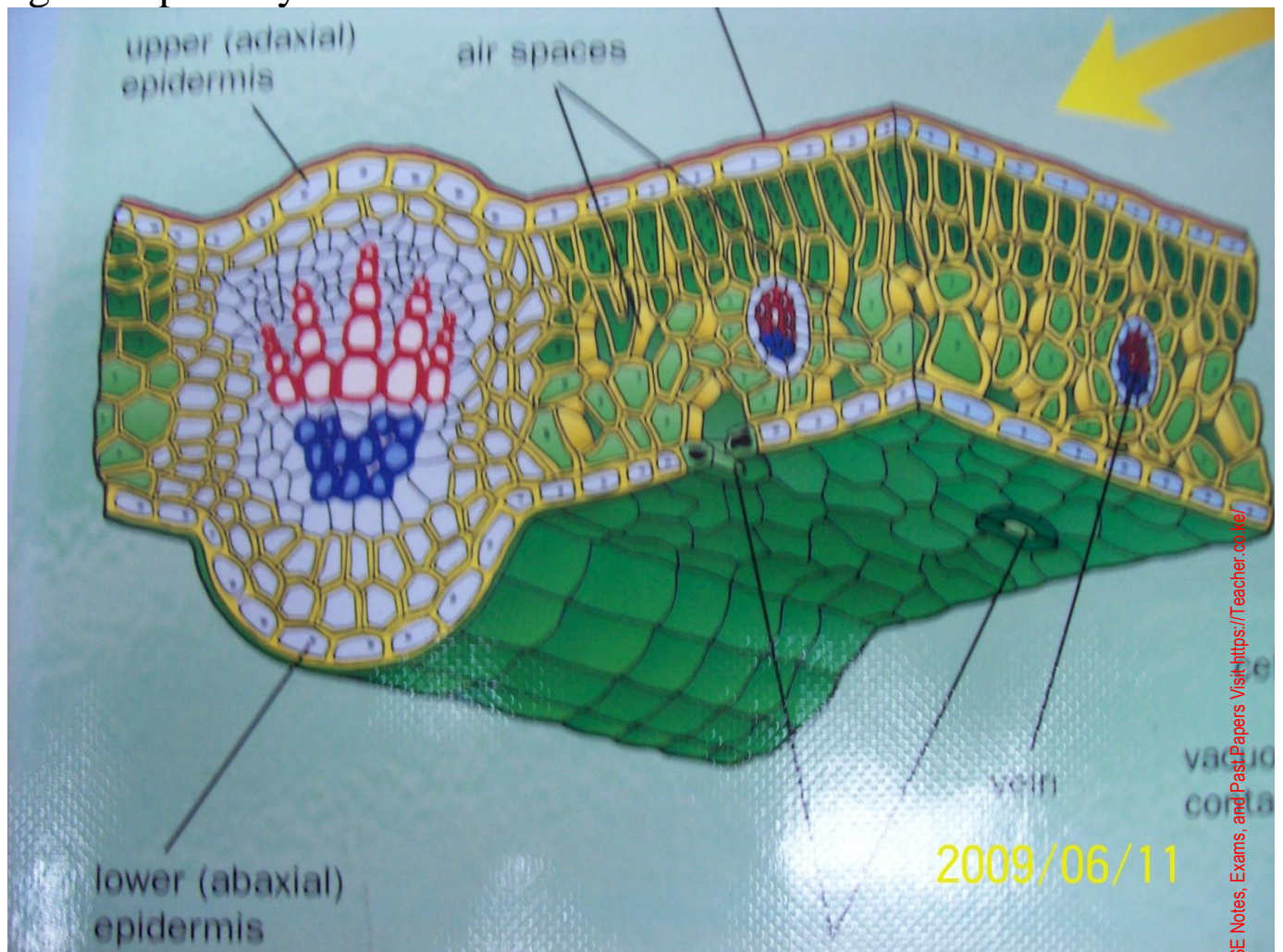
The palisade cells are numerous,elongated and contain numerous chloroplasts to trapping optimum light for photosynthesis.

The palisade tissue is just beneath the upper epidermis exposing them to trap optimum light for photosynthesis.

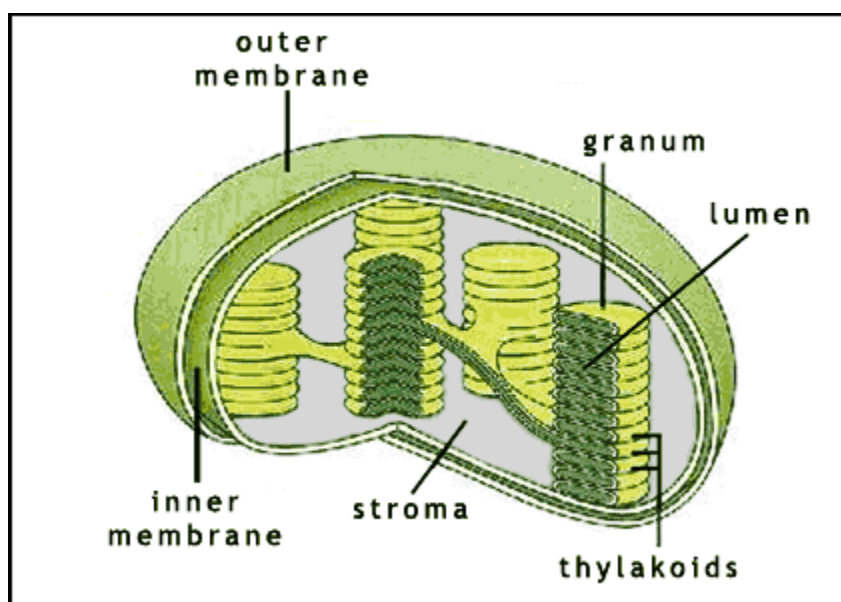
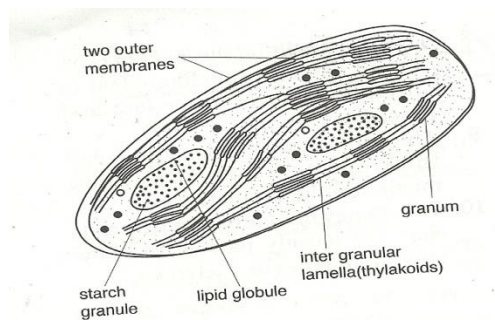
The leaf has numerous leaf veins consisting of a.) xylem vessels and tracheids for transporting water and dissolved mineral salts from the soil to the photosynthetic tissue

b.) phloem tissue for translocation of of manufactured food from the leaf to storage organs and other parts of the plant .

Numerous and large air spaces in the spongy mesophyll layer for optimum gaseous exchange with the photosynthetic tissue. Phyllotaxy which is regular arrangement of leaves on the stem minimizes overshadowing and overlapping exposing all leaves to light for photosynthesis. The prominent midrib and leaf veins reduces chances of rolling of leaves maintaining a large surface area for trapping optimum light for photosynthesis.



**C) Describe the structure and function of chloroplast**  
**i) Structure**



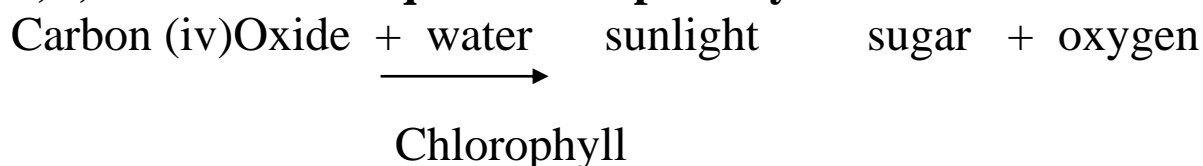
## ii) Function

- structure in which photosynthesis takes place

## iii) Adaptations

- has numerous/many grana to provide large surface area for packing many chlorophyll pigments
- have numerous chlorophyll pigments which trap sunlight/light for photosynthesis
- has stroma/third matrix which contain certain enzymes that catalyze photosynthetic reactions

## d) i) Give a word equation for photosynthesis

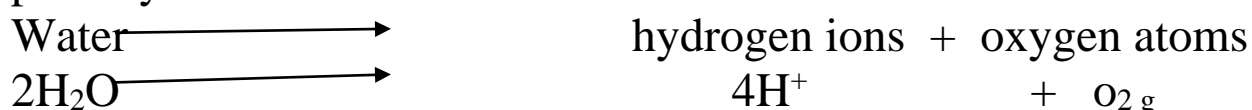


## .) Describe briefly the process of photosynthesis in plants.

The process of photosynthesis takes place in green plants allowing them to make their own food. The process is controlled by enzymes and involves a series of reactions that take place in chloroplasts. The raw materials required are water and carbon (iv) oxide. the process takes place in two consecutive stages i.e

### Light reaction stage

It's also called the light dependent stage as it requires light energy . the reactions take place in the granna of the chloroplast. light energy from the sun is trapped by chlorophyll in the chloroplast and converted into chemical energy. This energy splits water molecules into hydrogen ions and oxygen atoms a process is called photolysis. The oxygen atoms are released as aby product or used up in the process of respiration. The hydrogen ions formed are used in the dark stage of photosynthesis.



Some of the light enrgy is used to combine a molecule called adenosine diphosphate(ADP) with a phosphate group to form the rich energy molecules called adenosine Tri-Phosphate(ATP)

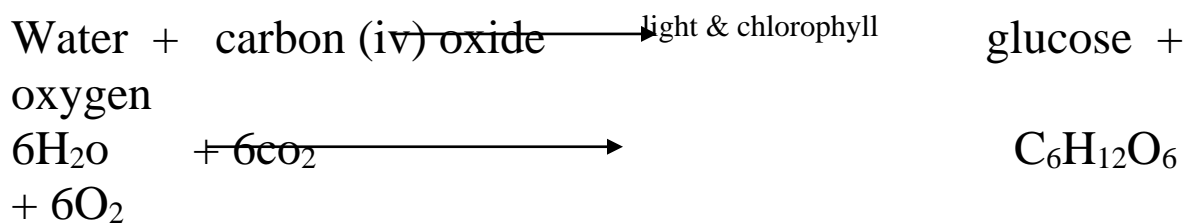


### Dark reaction stage

It's also called the light independent stage of photosynthesis since light is not required because it can take place both in presence and absence of light. the reactions are controlled by enzymes. the hydrogen atoms released in the light stage are

combined with carbon(iv)oxide to form simple sugars mainly glucose. The process uses energy from ATP. This is referred to as carbon (iv) oxide fixation. The reactions take place in the stroma of chloroplast. The excess glucose is converted into starch or lipids for storage.

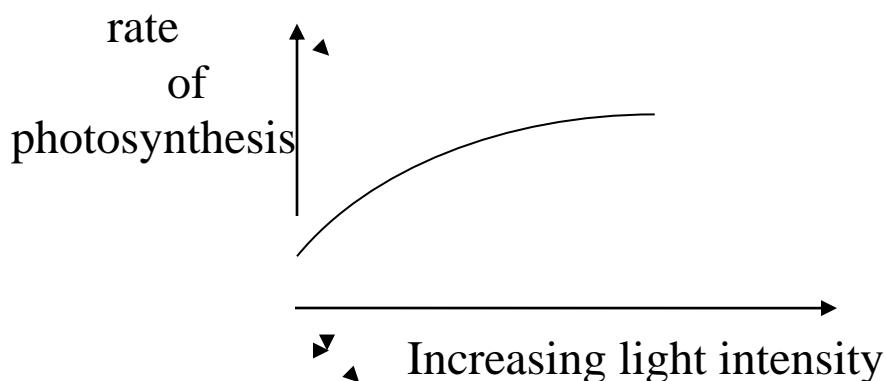
The general process of photosynthesis can be summarized by the following word and chemical equations.



### 9.) Factors that cause high rate of photosynthesis.

**High water availability in the soil.** Water a raw material for photosynthesis is split in presence of light to provide the hydrogen ions required in carbon (iv) fixation. When water is readily available more hydrogen ions are produced hence high rate of photosynthesis.

**High light intensity.** Light splits water molecules to hydrogen ions and oxygen atoms. Increasing light intensity increases the rate of photosynthesis up to a certain level beyond which other factors become limiting and rate of photosynthesis becomes constant.

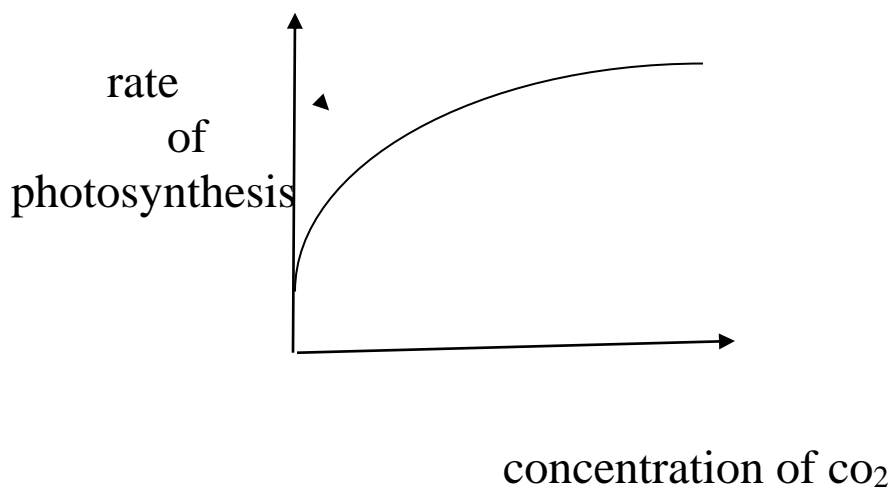


**Day length.** Long day length especially at high latitudes (temperate regions) provides more light for photosynthesis causing an increase in the rate of photosynthesis.

**Light quality.** The preferred wavelengths for photosynthesis range between 400nm-700nm. the rate of photosynthesis is higher in red and blue light and lower in all other types of light.

**Concentration of carbon (iv) oxide.** It's a raw material required to combine with hydrogen ions to form simple carbohydrate molecules. Increasing the concentration of carbon (iv) oxide increases the rate of photosynthesis up to an optimum level beyond which other factors limit the rate of photosynthesis.





**f) Give the differences between the light and dark reactions during photosynthesis**

| Light reactions   | Dark reactions   |
|---|--|
| <ul style="list-style-type: none"> <li>occurs in grana</li> </ul> | <ul style="list-style-type: none"> <li>occurs in stroma</li> </ul> |

**h.) a) i) What are chemicals of life?**

- substances which make up cells, tissues and organs of the living system
- they combine to form organic compounds

**ii) What are organic compounds?**

- compounds that contain the element carbon

**iii) List the organic compounds**

- proteins
- carbohydrates
- lipids(fats and oils)
- vitamins
- enzymes
- nucleic acids(DNA and RNA)

**b) i) What are carbohydrates?**

- Compounds of carbon, hydrogen and oxygen
- The elements are in the ratio of 1 carbon: 2 hydrogen: 1 oxygen

**ii) Name the groups of carbohydrates**

- monosaccharides (simple carbohydrates) e.g. glucose, fructose and galactose
- disaccharides (formed when two monosaccharides combine) e.g. maltose, sucrose, lactose
- polysaccharides (composed of many monosaccharides and disaccharides) e.g. starch, glycogen, cellulose

**iv) State the general functions of carbohydrates**

- production of chemical energy
- storage of starch(plants) and glycogen (animals)
- commercial uses e.g. manufacture of paper, textiles

### c) i) what are proteins?

- compounds of carbon, hydrogen and oxygen and in addition nitrogen, and sometimes sulphur and or phosphorus
- building blocks are called amino acids

### ii) Name the types of amino acids

- essential amino acids which must be supplied in food since they body cannot synthesize them
- Non-essential amino acids which body can synthesize.

### iv) State the classes of proteins

- first class proteins which supply all the essential amino acids
- second class proteins which lack at least one amino acid

### v) Give the functions of proteins

- structural compounds e.g. muscles, hair, hooves, and feathers
- as enzymes e.g. pepsin, trypsin
- hormones e.g. insulin and glucagons
- antibodies
- part of haemoglobin molecule
- actin and myosin in muscles
- collagen in bones and cartilage
- pigments in rods and cones for coordination
- components of blood i.e. plasma proteins

### d) i) What are lipids

- Fats and oils
- They contain carbon, hydrogen and oxygen
- However, they contain a higher proportion of carbon and hydrogen but less oxygen than in carbohydrates

### ii) Name the types of lipids

- oils(liquid under room temperature)
- fats (solid under room temperature)

### iii) What are the building blocks of lipids?

- fatty acids and glycerol

### v) State the functions of lipids

- production of energy
- source of metabolic water
- structural compound

### e) i) What are enzymes?

- a chemical compound, protein in nature, which acts as a biological catalyst

### ii) State the properties of enzymes

- are highly specific in nature
- they are not used up during chemical reactions
- work within specific range of temperature
- work within specific range of pH
- enzyme controlled reactions are reversible

### iii) State the factors that affect enzyme action

- temperature
- substrate concentration
- pH of the medium
- enzyme concentration
- presence of inhibitors and co-factors

### v) Name the types of enzyme inhibitors

- competitive inhibitors
- non- competitive inhibitors

### vi) What are the functions of enzymes?

- enable cellular reactions to take place at a reasonably faster rate
- Control cell reactions therefore no violent incidences occur in cells that might burn them.

### i.) a) Explain the various types of heterotrophic nutrition

#### i) Holozoic

- Mode of feeding by animals where solid complex food substances are ingested, digested and egested.

#### ii) Saprophytism

- feeding on dead organic matter

#### iii) Parasitism

- feeding from another organism but not killing it

#### iv) Symbiosis

- an association in which organisms of different species derive mutual benefit from one another

### b) Differentiate between omnivorous, carnivorous and herbivorous modes of nutrition

#### i) Herbivorous

- herbivores feed exclusively on vegetation

#### ii) Omnivorous

- omnivores are animals which feed partially on plant materials and partially on flesh e.g pigs

#### iii) Carnivorous

- Carnivores feed on flesh alone e.g. lion

### c) i) What is dentition?

- Refers to the number, arrangement and kind of teeth in an animal

## ii) Distinguish between the terms homodont and heterodont

- homodont have same kind , type, shape and size of teeth which perform similar function e.g. fish, reptiles and amphibians
- Heterodont have different kind, type, shape and size of teeth which perform different functions as those found in mammals.



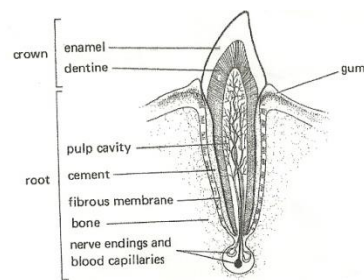
## iv) Name the types of teeth found in mammals

- Incisors
- Canines
- Pre-molars
- Molars

## d) Describe the adaptations and functions of various types of mammalian teeth

### Incisors

- chisel shaped/wedge shaped
- found in the front of the buccal cavity
- used for cutting

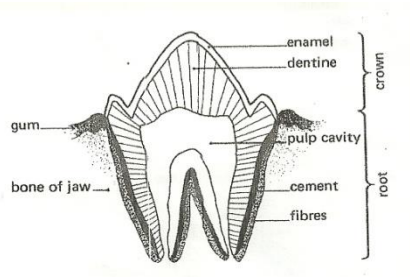


### i) Canines

- next to incisors
- very sharp and pointed
- located at the sides of jaws
- used for tearing food

### ii) Premolars

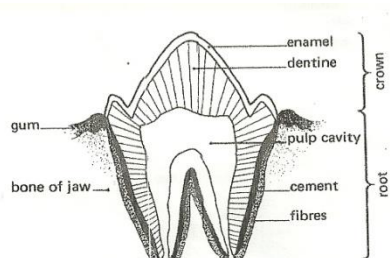
- next to canines but before molars
- have cusps and ridges on their surface
- used for crushing and grinding



### iii) Molars

- found at the back of the jaw
- have cusps and ridges on their surface
- absent in young mammals but appear later when permanent teeth grow
- used for grinding and crushing
- 

## e) i) Draw a labeled diagram to represent internal structure of a mammalian tooth.



## ii) State the functions of the labeled structures labeled

### Dentine

- main constituent of teeth
- like bone in structure but contains no cells

### Enamel

- protects tooth from mechanical/physical injury
- the hard covering of the exposed part of teeth

### Crown

- portion of tooth above the gum
- covered with dentine

### Root

- part imbedded in the jaw below the gum
- covered by substances called cement
- cement is hard and bone-like

### Cement

- bone-like substance covering root and enamel of mammalian tooth

### Neck

- region at the same level with the gum
- forms a junction between the crown and root
- covered by enamel

### Pulp cavity

- at centre of tooth within dentine
- has blood vessels for transporting nutrients/food and gases
- has nerves for sensitivity

### f) i) What is dental formula?

- formula indicating the number of each kind of teeth for a given species of mammal
- only half the jaw is included
- the number in the upper jaw of one side is written above that in the lower jaw of one side
- the categories of teeth are given in the order incisors, canines, pre-molars, molars

### ii) Give examples of dentition in named mammals

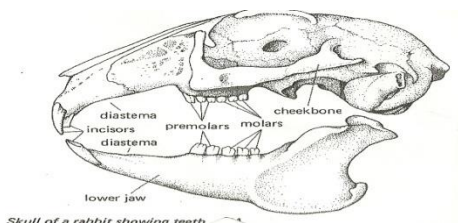
- carnivore e.g. dog  $i^{2/3}$ ,  $c^{1/1}$ ,  $pm^{2/3}$ ,  $m^{2/3} = 42$

- herbivore e.g. sheep  $I^{0/3}, c^{0/1}, pm^{2/3}, m^{3/3} = 30$
- Omnivore e.g. human  $I^{2/2}, c^{1/1}, pm^{2/2}, m^{3/3} = 32$

iii) How would one use dental formula to identify the following?

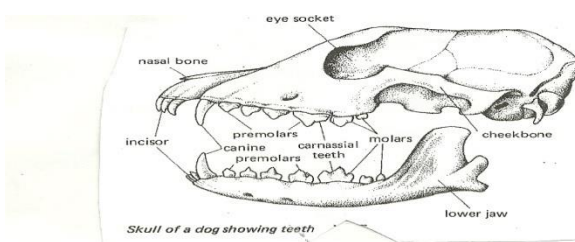
### Herbivores

- presence of diastema/gap between incisors and premolars
- free movement of tongue
- absence of incisors in upper jaw
- absence of canines
- presence of hard pad
- closely packed molars



### Carnivore

- presence of canines
- presence of carnassial teeth
- presence of incisors in upper jaw/absence of diastema/gap between incisor and premolar



iv) State the functions of the following structures in mammals

### Carnassials

- tearing flesh from bones

### Pad of gum

- provides grasping surface for lower incisors

g) Name the common dental diseases

- dental caries
- periodontal (pyorrhea and gingivitis)

j.) a) i) What is digestion?

- breakdown of complex food particles by enzymes to simple substances which can be absorbed

ii) Explain the types of digestion

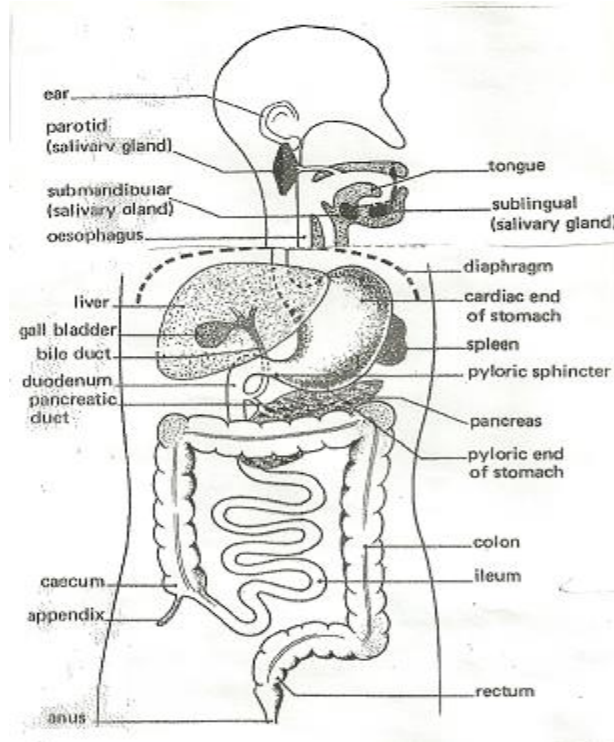
### Intercellular

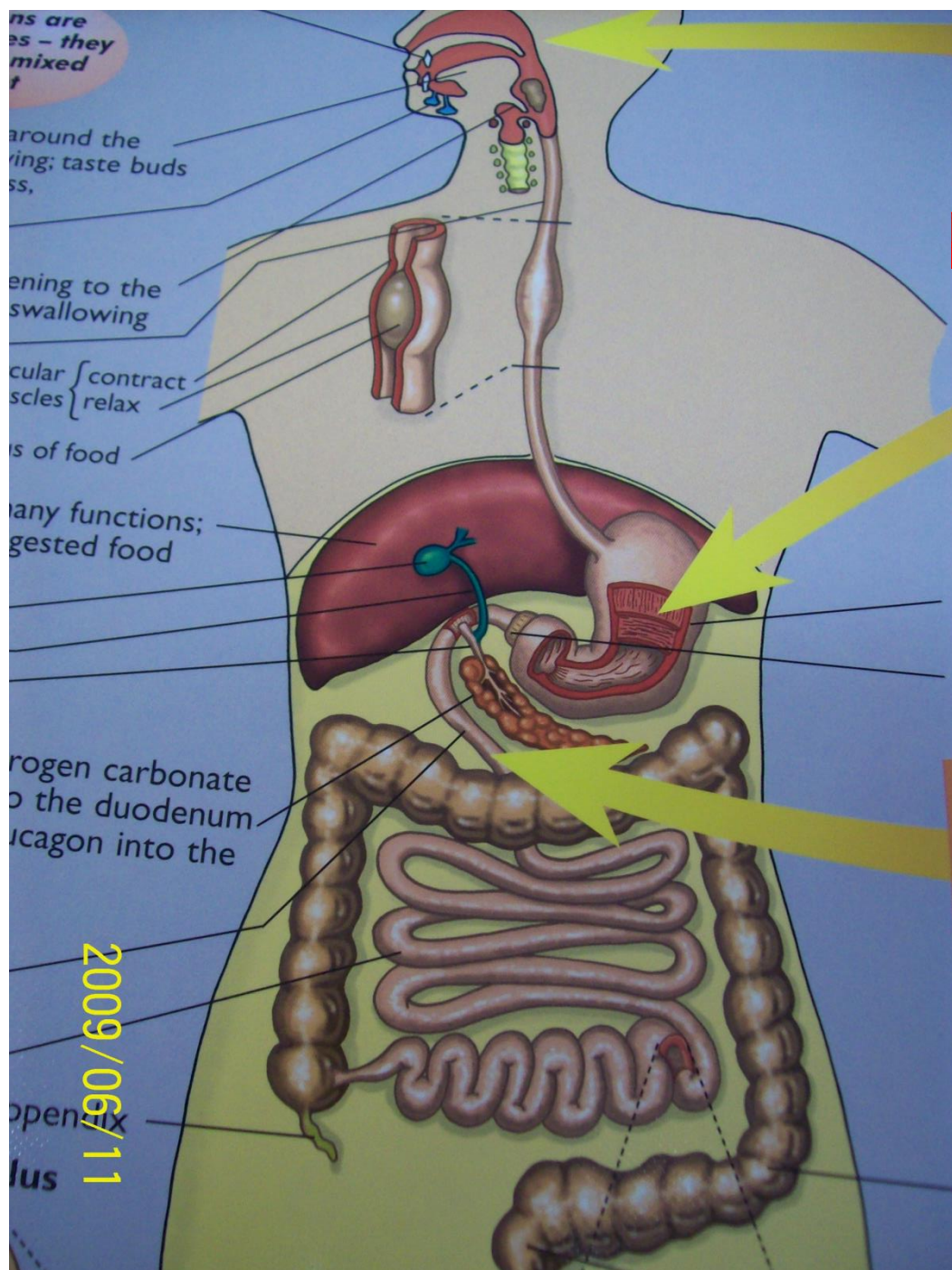
- Digestion that takes place in food vacuoles inside cells.

### Extra cellular

- digestion that takes place outside cells e.g. in the digestive tract

### b) i) Draw human digestive system





## ii) Describe the process of digestion in the various parts of the human digestive system

### Mouth

- contains teeth for chewing
- has tongue for mixing food with saliva
- has salivary glands for chemical digestion, secretion of enzymes and mucus secretion
- starch is acted on by salivary amylase enzymes to produce maltose
- the tongue rolls food into a bolus which is carried into the stomach by peristalsis
- peristalsis is movement of food along the gut by waves of contraction
- it facilitates rapid digestion due to its mixing action

### Oesophagus

- also called gullet



- forms a passage for food by peristalsis
- connects the mouth to the stomach

## **Stomach**

- has gastric glands which secrete gastric juices
- these juices contain hydrochloric acid(HCL), mucus, and the enzymes pepsin, rennin and lipase
- HCL produces an acidic medium for enzyme action
- Proteins are acted upon by pepsin to produce peptides
- Caseinogen is acted upon by rennin to produce casein
- Fats are acted upon by lipase to produce fatty acids and glycerol
- Mucus lubricates the stomach and prevents autolysis of stomach (mucus protects stomach)



## **Duodenum**

- the first u-shaped part of the small intestine
- food in the stomach is now in a semi-liquid form called chime
- chime leaves the stomach by peristalsis into the duodenum
- there, the liver produces bile pigments, bile salts and sodium hydrogen carbonate
- the stomach is usually alkaline to neutralize chime which is acidic
- bile salts emulsify fats
- bile comes from the gall bladder through the bile duct
- sodium hydrogen carbonate provides the correct pH/alkaline
- pancreatic juices are released by pancreas into the duodenum
- the juices contain trypsin, chemotrypsin, amylase, lipase and protease
- proteins are acted upon by trypsin to form polypeptides and amino acids
- starch is broken down to maltose by amylase

## **Ileum**

- produces intestinal juices
  - Intestinal juice contains maltase, sucrase, lactase, erepsin, lipase, and several other peptidases
  - Maltose is broken down to glucose and galactose by lactase
  - Sucrose is acted upon by sucrase to glucose
- Polypeptides are broken down into amino acids by erepsin
- Mucus secretion is to protect the ileum wall from digestion/autolysis

## Colon

- Commonly called the large intestine
- Wider than the ileum
- has several mucus-producing cells

Highly folded for water absorption

- Also prepares food for egestion
- egestion is the process by which the insoluble parts of food are discharged from the body in form of faeces.

## Rectum

- Muscular and enlarged
- it produces mucus
- used for storage and removal of faeces

## Anus

- found at the exterior end of the rectum

The rectum opens into the anus

- The anus has anal sphincter to control egestion
- Anus is used for egestion of faeces

### **c) Explain how mammalian intestines are adapted to perform their function**

- The mammalian intestines are relatively long and coiled. This allows food enough time and increases surface area for digestion and absorption of products of digestion
- The intestinal lumen (inner wall) has projections called villi to increase surface area for absorption
- The villi have projections called micro-villi which lead to further increase of surface area for absorption
- The walls have glands which secrete enzymes for digestion e.g. maltase, sucrase, lactase, peptidase and enterokinase.
- Goblet cells (mucus secreting cells or glands) produce mucus which protects the intestinal wall from being digested and reduces friction.
- Intestines have openings of ducts which allow bile, a pancreatic juice into the lumen
- The intestines have circular and longitudinal muscles whose contraction and relaxation (peristalsis) leads to mixing of food with enzymes (juices) helps push food along the gut.
- The intestines are well supplied with blood vessels that supply oxygen and remove digested food.
- Intestines have lacteal vessels for transport of lipids (fats and oils)
- Intestines have thin epithelium to facilitate fast/rapid absorption/diffusion

### **d) What is the function of hydrochloric acid in digestion?**

- kills bacteria
- activates trypsinogen to trypsin which digests proteins to peptones and peptones to soluble amino acids
- provides acidic medium for gastric enzymes

**e) i) What is assimilation?**

- The process by which digested food is taken up by cells and used in the body for various purposes.

**ii) State the uses of digested food in the bodies of animals**

- Protection
- Repair
- Growth
- Energy production

**f) Name the types of food substances in the food that do not undergo digestion in human digestive system**

- mineral salts
- water
- roughage
- vitamins

**k.) Explain the importance of the following food substances in human nutrition**

**Vitamins**

- are organic chemical compounds essential for a healthy body
- are obtained from fresh fruits and vegetables
- some are synthesized in the body e.g. vitamin K
- they are destroyed by overcooking food
- they protect the body against diseases, play regulatory mechanisms in the body and act as co-enzymes
- insufficient amounts lead to deficiency diseases e.g. rickets, scurvy, beriberi

**a) Mineral salts**

- are important in organic compounds containing elements which are essential for normal body metabolism
- those required in large quantities are called macro-nutrients while those required in small quantities are called micro-nutrients or trace elements
- They are used in bone and teeth formation. In osmotic balance and neurotransmission
- insufficient amounts lead to anaemia, rickets, goiter
- Excess amounts lead to high blood pressure, and dental disorders.

**b) Roughage**

- composed of cellulose and plant fibers
- digested by cellulose contained by gut microorganisms
- provides grip essential for peristalsis
- lack of roughage leads to slow movement of food leading to constipation
- roughage adds bulk to food for peristalsis to take place



### c) Water

- used in transport in the body, universal solvent, hydrolysis
- insufficient leads to dehydration

### l.) Explain the factors that determine energy requirements in humans

#### a) Basal Metabolic Rate (BMR)

- this is the energy required when the body is completely at rest
- used to carry out breathing, heartbeat, circulation of blood and other basic reactions
- also used in maintaining body temperature at constant
- all movements or physical work e.g. walking, eating required more energy.

#### b) Occupation

- means activity occurring everyday
- everyday activity determines energy requirement
- People doing heavy work like digging require more energy than office workers.

#### c) Age

- children carry out many activities and also have more cell division than adults
- their BMR is therefore higher than for adults
- as they grow older, they become less active and their energy requirements decrease

#### d) Body size

- small bodied people have a large surface area to volume ratio
- their bodies lose more heat energy to the surrounding
- they therefore require more energy-giving foods
- this is the opposite for big bodied people

#### e) Sex

- most males are more muscular than females
- they also do heavier work than females hence require more energy
- females do lighter work hence require less energy

#### f) Climate

- in warm climate the body requires less energy
- in low temperatures the body requires more energy to maintain body temperature

**m.) Explain various tests carried out on food**



| Test                      | Procedure   | Observation   | Conclusion |
|---------------------------|---|---|------------|
| Starch                    | - add iodine solution   | - colour changes to blue<br>black/dark blue                   | Present    |
| Reducing sugar            | Benedicts solution<br>heat/boil/warm in hot water bath                | - colour changes to Green to yellow to orange to brown to red | Present    |
| Non-reducing sugar        | Dilute HCL, NaHCO <sub>3</sub> ,<br>heat/boil, warm in hot water bath | - colour changes to Green to yellow to orange to brown to red | Present    |
| Proteins                  | 1% CuSO <sub>4</sub> ,<br>5% NaOH                                     | -- colour changes to purple/violet                            | Present    |
| Ascorbic acid (Vitamin C) | DCPIP drop wise   | DCPIP decolorized   | Present    |
| Fats/oils (lipids)        | - rub on filter paper<br>- ethanol                                    | - translucent mark<br>- white emulsions                       | present    |

## FORM TWO TOPICS

### 1. a) i) Define transport

- movement of substances from one part of the body to another

### ii) Explain the necessity of transport in plants and animals

- make nutrients move from one point to another
- movement of respiratory gases i.e. oxygen and carbon IV oxide
- elimination of metabolic wastes

- movement of hormones
- movement of water
- movement of salts
- movement of enzymes

### b) i) Describe the structure and function of root hair

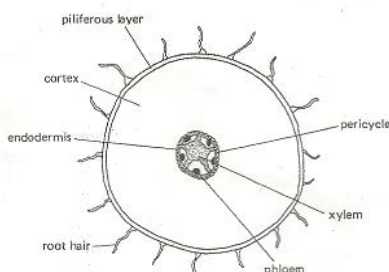
- root hairs are found near the root tip
- they are cells with elongated finger-like projections which are in contact with soil particles
- they are permeable to water and mineral salts hence are used to absorb water and mineral salts
- Their large number offers a large surface area for absorption of water and mineral salts.

### ii) State ways in which the root hairs are adapted to their functions

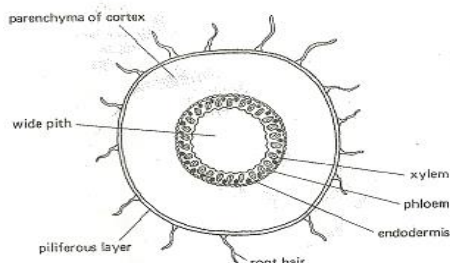
- the root hair is long/narrow/numerous to increase surface area for absorption of water and mineral salts
- many mitochondria in cytoplasm to supply energy for active transport of mineral salts
- are thin walled to speed up rate of absorption of water and mineral salts

### c) i) Compare the internal structure of a dicotyledonous root and a monocotyledonous root

#### Dicot root



#### Monocot root



### ii) State the similarities and differences between a dicotyledonous and monocotyledonous root

#### Similarities

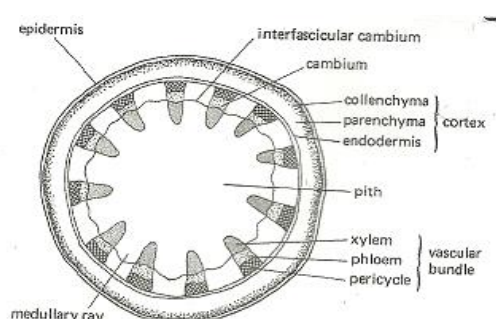
- both used for anchorage and absorption of water and mineral salts
- both have root hairs, epidermis, pericycle, cortex, endodermis and vascular bundles (xylem and phloem)
- both may be used to store food/storage organs

### Differences

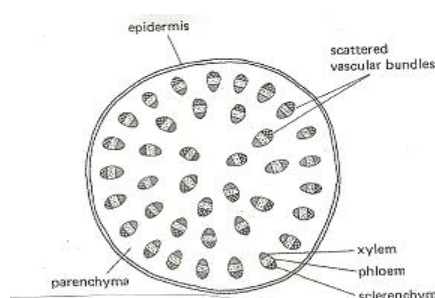
| Monocotyledonous   | Dicotyledonous  |
|--|---|
| <ul style="list-style-type: none"> <li>• phloem and xylem are arranged in ring form alternately</li> <li>• pith present</li> </ul> | <ul style="list-style-type: none"> <li>• phloem lies between radial rays of central xylem (star shaped)</li> <li>• pith absent</li> </ul> |

### iii) Compare the internal structure of a monocotyledonous and dicotyledonous stem

#### Monocotyledonous



#### Dicotyledonous



### v) Give the similarities and differences between a monocotyledonous and dicotyledonous stem

#### Similarities

- both are used for protection
- both conduct water, salts and food
- both have epidermis, cortex, pericycle and vascular bundles

#### Differences

| Monocotyledonous   | Dicotyledonous   |
|--|--|
| <ul style="list-style-type: none"> <li>• vascular bundles are many and scattered</li> <li>• some have hollow pith or pith is absent</li> <li>• no cambium layer therefore cannot undergo secondary growth</li> <li>• very little cortex</li> </ul> | <ul style="list-style-type: none"> <li>• vascular bundles are few and arranged in a concentric ring near the epidermis</li> <li>• pith large and well developed</li> <li>• presence of cambium therefore undergoes secondary growth</li> <li>• cortex has several layers of cells</li> </ul> |

v) **State the differences between the internal structure of a root and a stem.**

| Root  | Stem  |
|---|---|
| <ul style="list-style-type: none"> <li>• has root hairs</li> <li>• no cuticle</li> <li>• xylem and phloem arranged alternately</li> <li>• in xylem, the small vessels are towards the outside</li> <li>• cortex is the widest tissue</li> </ul> | <ul style="list-style-type: none"> <li>• no root hairs</li> <li>• cuticle present</li> <li>• xylem and phloem arranged on the same radii</li> <li>• in xylem, the smallest vessels are towards the inside</li> <li>• pith is the widest tissue</li> </ul> |



c) i) **Name the transport structures of a flowering plant**

- xylem vessels and tracheids transport water and mineral salts from the soil
- Phloem vessels translocate manufactured food from leaves to other parts of the body.

ii) **State the ways in which xylem vessels are adapted to their function**

- lignified/thickened to prevent collapsing
- narrow to facilitate capillary
- no cross walls for continuous flow/column of water
- have bordered pits for lateral movement of water

d) i) **Why do flowering plants need water?**

- photosynthesis
- transport
- turgidity which helps in plant support
- solvent i.e. medium for chemical reactions
- cooling effect during transpiration
- seed germination

ii) **Describe the movement of water from the soil to the leaves of a tall plant**

**Soil**

- water exists as a thin film in the soil, between soil particles
- the concentration of cell sap of root hair is greater than that of the surrounding solution in the soil, thus drawing the water molecules across the cell wall and cell membrane into the root hair by osmosis
- water drawn into the root hair cell dilutes the cell sap making it less concentrated than that in the adjacent cortex cells of the root



- due to osmotic gradient water moves from the root hair cells into the cortex by osmosis, from cell to cell by osmosis, across the endodermis by active transport into xylem vessels of the root that conduct water into xylem vessels of the stem into xylem vessels of the leaves

### Stem

- Once in the stem water moves up the plant aided by the narrowness of the xylem vessels (capillary), root pressure, attraction of water molecules to each other (cohesion). Attraction of water molecules to the walls (adhesion)
- from the stem water enters the xylem of leaves
- water moves in the xylem vessels of the stem in a continuous (uninterrupted) water column up to the tree leaves

### Leaves

- once in the leaves water moves into the mesophyll cells by osmosis
- as water vaporizes from the spongy mesophyll cells their sap becomes more concentrated than the adjacent cells
- as the result water flows into the cell from other surrounding cells which in turn takes in water from xylem vessels within the leaf veins
- this creates a pull (suction force) called transpiration pull that pulls a stream of water from xylem vessels in the stem and roots
- The transpiration pull maintains a continuous column of water from the roots to the leaves.

### **iii) Name the process by which mineral salts enter into a plant**

- active transport
- diffusion

### **vi) Explain the forces that make water and mineral salts move through a plant**

- mineral salts are taken up due to diffusion because of the concentration gradient between the mineral ions in sap and those in soil solution
- active transport involves energy in form of ATP due to respiration which forces mineral salts through a plant against a concentration gradient
- water moves by osmosis through a semi-permeable membrane of root hairs and between cells of stem

- in stem water moves by cohesion (attraction of water molecules to each other)
- it also moves by adhesion (attraction of water molecules to walls)
- capillarity is due to narrowness of xylem vessels
- transpiration pull occurs when water vapour evaporates from sub-stomatal chambers into the air
- root pressure is a force that pushes water up the stem from the roots and causes guttation / exudation

**vii) Explain the uptake of mineral salts by plants**

- plants require mineral salts for metabolism and proper functioning of their bodies
- mineral salts are taken up from the soil into the root hairs in form of solution by active transport which requires energy
- active transport involves substances called carriers taken up together with water and are then carried to the stems and leaves
- the main process involved in uptake and movement of mineral salts is active transport

**e) i) What is transpiration?**

- loss of water from plant to the atmosphere

**ii) Name the sites through which transpiration takes place in a plant**

- stomata (stomatal transpiration)
- lenticels (lenticular transpiration)
- cuticle (cuticular transpiration)

**iii) State the importance of transpiration to plants**

- cooling the plant
- transport of water
- transport of mineral salts
- excretion of excess water from plants
- excess transpiration causes wilting

**v) Explain the structural factors that affect the rate of transpiration in plants**

- number of stomata i.e. the more the stomata the higher the rate and vice versa
- turgidity of the guard cells which control the opening and closing of stomata when they are open transpiration rate is high
- size of leaves where the larger the surface area the higher the rate of transpiration

- leaf fall leads to lower rate of transpiration and also drying of leaves reduces rate of transpiration
- Thin cuticle reduces distance through which water vaporizes hence increase transpiration rate. Absence of cuticle also increase rate of transpiration

**vi) explain the environmental factors that affect rate of transpiration in plants**

- high temperature increases rate of transpiration and low temperature reduces the rate
- humidity when high increases rate and when low reduces the rate
- transpiration rate is higher in moving air (wind) than in still air
- high light intensity increases internal temperature hence higher rate of evaporation leading to higher rate of transpiration
- availability of water in the soil leads to more absorption hence more loss to the atmosphere
- atmospheric pressure when high leads to more evaporation and when low leads to low rate evaporation of water

**vii) State the structural differences between xylem vessels and sieve tubes**

- sieve tubes have cross wall while xylem vessels have none
- xylem vessels are lignified while sieve tubes are not
- Sieve tubes have cytoplasm elements while xylem vessels have none.

**viii) State the adaptations of plants which enable them to reduce water loss**

- thick waxy cuticle
- reduced leaf size/thorns/spines
- shedding of leaves
- Sunken stomata. Water vapour accumulates in the depression of stomata lowering the water vapour concentration gradient leading to lower rate of evaporation
- rolling of leaves

**ix) State the factors that cause increase in the rate of transpiration from leaves**

- increased light intensity
- low relative humidity
- temperature

**x) Explain how drooping of leaves on a hot sunny day is advantageous to a plant**

- reduces surface area exposed to sun reducing cuticular transpiration

**f) Explain how aquatic and terrestrial plants are adapted to deal with problems of transpiration**

a. Mesophytes

- they grow in soils with enough water
- water loss is perfectly balanced by absorption of more from the soil
- no special adaptations

b. Xerophytes

- they grow in dry conditions
- root grow very deep to absorb water
- succulent/fleshy leaves to store water
- few stomata which are sunken
- thickened waxy cuticle
- leaves are hairy and often folding
- some leaves are needle-like/spines or scales
- leaf surfaces are reduced i.e. small leaves
- all these adaptations are to reduce water loss

c. Hydrophytes

- plants that grow in water
- presence of sclereids
- leaves are broad
- leaves have many stomata on upper side only (none on the lower surface)
- some leaves float on water
- absence or reduced leaf cuticle
- large air spaces
- some leaves are submerged
- poorly developed or reduced vascular bundles

**g) i) What is translocation**

- transfer of manufactured food substances to the parts where they are required

**ii) Name the tissue which is responsible for translocation of manufactured food in flowering plants**

- phloem tissue

**iii) Name the processes that bring about the translocation of manufactured food**

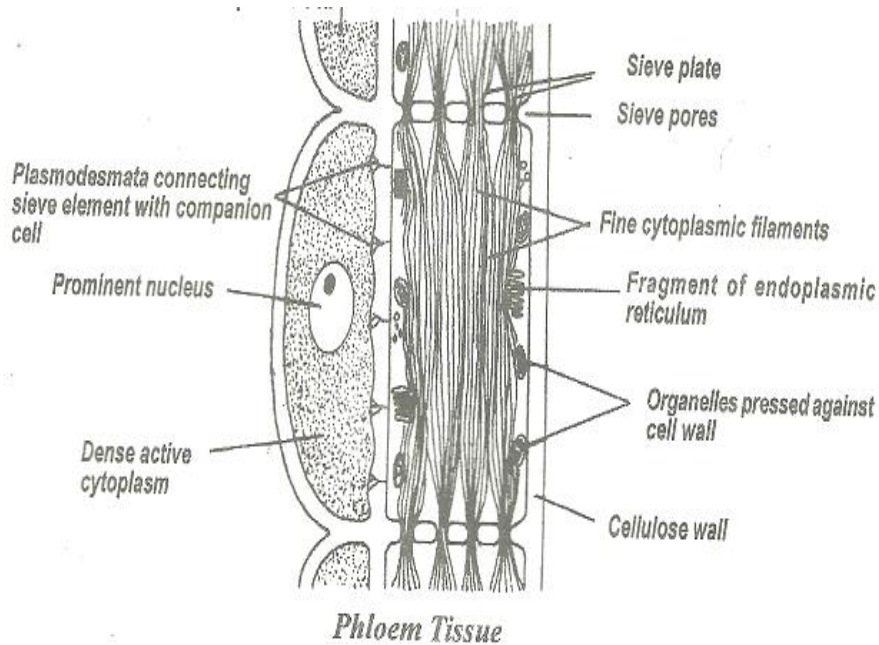
-active transport

Diffusion

Mass flow

Cytoplasmic streaming

iv) Draw a labeled diagram to represent phloem tissue



vi) State the functions of the labeled structures  
cytoplasmic strands

- translocation

**Companion cell**

- supply nutrients to sieve tube element
- supply energy for translocation
- regulates activities of tube cells/elements

**Sieve tubes element**

- conduct food down the stem

vii) name the compounds that are translocated in phloem

- sugars
- amino acids
- hormones e.g auxins
- oils/lipids
- resins
- vitamins

**Describe an experiment you would carry out in order to demonstrate that phloem transports manufactured food substances in a plant**

a. Ringing experiment

- cut a ring in the bark including the phloem from the stem of a woody plant
- phloem is found next to or just beneath the bark
- observe daily for some time (more than three weeks)
- a swelling of the bark appears above the ring
- this is due to accumulation of food from leaves

- the bark of a second similar plant is removed carefully leaving the phloem intact
- a swelling does not appear

## ii) Use the radioactive tracers

- plant is exposed to carbon containing radio-active carbon C14
- C14 is found in the end products of photosynthesis
- It is finally detected in phloem
- C14 is found to move in both directions



## iii) Collecting exudate from stylets of aphids

- aphids feed on certain plant phloem using their stylets
- aphid mouthparts are dissected using a sharp razor
- exudates from the mouthparts are collected and then analyzed
- sucrose is found to be a major component of the exudates
- this proves that phloem translocates manufactured food substances

## h) Describe an experiment you would carry out to demonstrate that xylem transports water

### i. Either

- cut a stem of a young plant or twig of a tree under water
- or else uproot a young herbaceous plant and wash the soil gently
- put some water in a beaker and add a dye i.e. eosin or red ink and place the cut stem or young plant in a beaker
- leave for time e.g. between 20 minutes and one hour
- cut a thin section of stem or leaf
- mount it on a slide and examine under a microscope
- observe and note the distribution of the dye or ink
- the dye appears only in the xylem vessels

### ii. OR

- use radio-active tracers, C14 in form of carbon
- ring a plant then put it in a container containing radio-active phosphorous solution
- The radio-active phosphorus is later detected in the leaves.

## 2. a) i) List the components of animal transport systems

- system of blood vessels in which materials are circulated round the body
- blood, a fluid medium which contains dissolved substances and cells

- the heart, a pumping mechanism which keeps blood in circulation

**ii) Distinguish between closed and open circulatory systems**

- closed system has blood vessels through which blood moves eg vertebrates
- open system has no blood vessels hence blood is in direct contact with tissues e.g arthropoda



**iii) What are the advantages of the closed circulatory system over open circulatory system?**

- Closed system has continuous vessels hence able to generate high pressure
- Circulates blood over longer distance
- Circulates blood at a faster rate
- Efficient transport of nutrients and waste products
- Animals are more active

**iv) Distinguish between single circulatory system and double circulatory system**

**Single circulatory**

- blood passes through the heart once in a complete circuit of the body

**Double circulation**

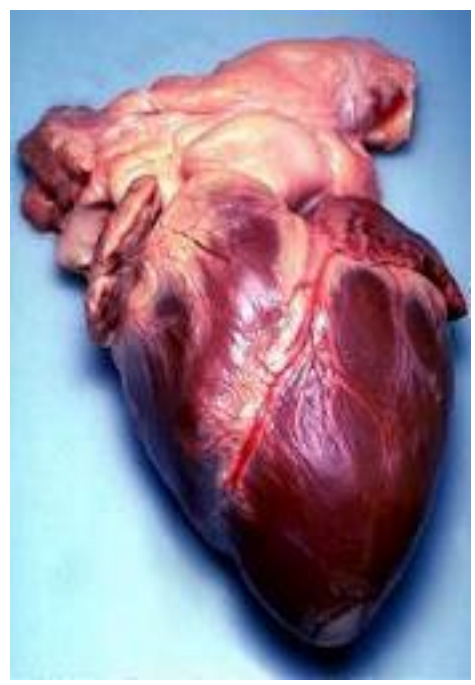
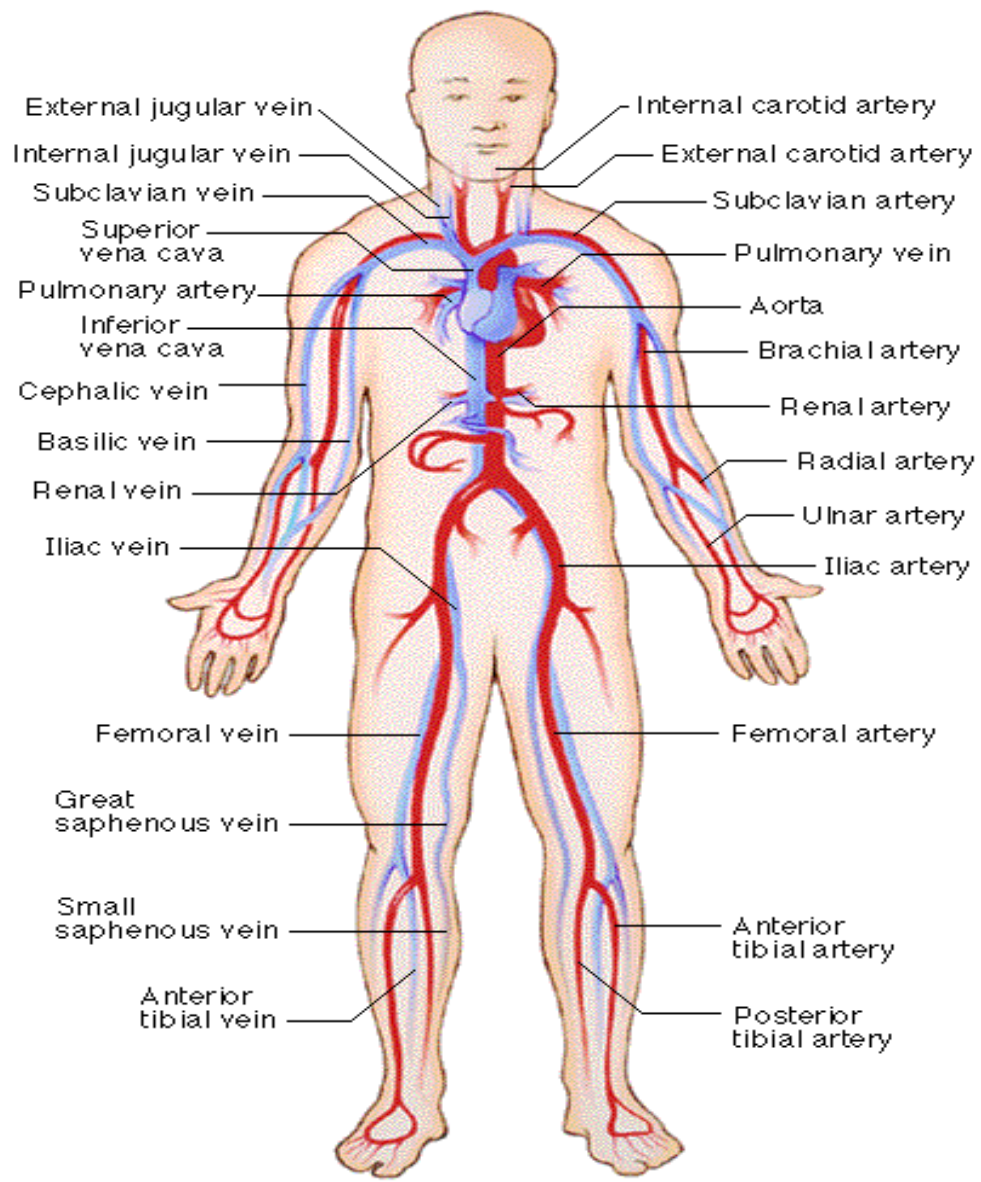
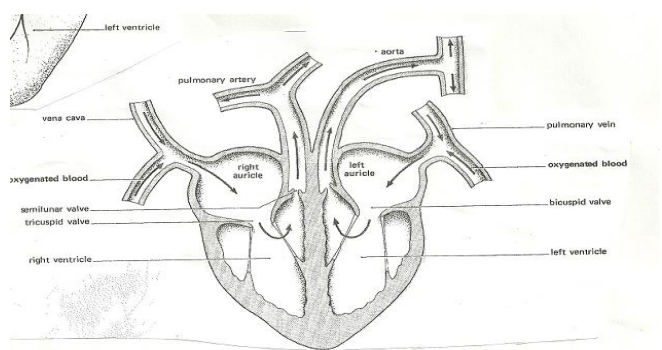
- blood enters the heart twice in a complete circulation
- Pulmonary circulation from the heart to lungs and back
- Systemic circulation from the heart to body systems and back

**b) i) describe the general layout of the transport system in mammals**

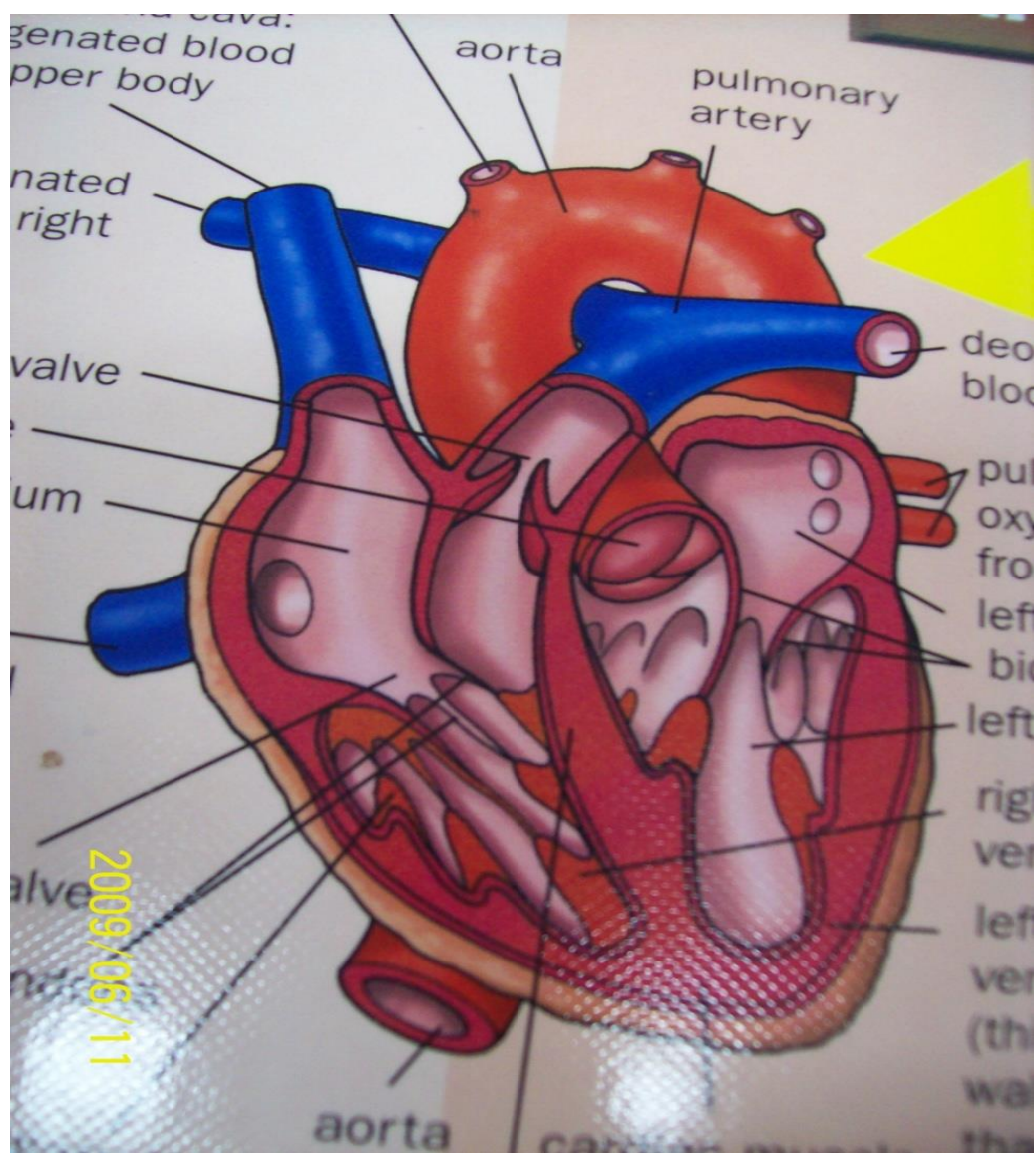
- blood which is a fluid tissue of the body carrying food substances, oxygen, carbon IV oxide and metabolic wastes
- arteries which are elastic tubes carrying blood from the heart to cells
- veins which are blood vessels carrying blood away from the cells to the heart
- capillaries which are extremely numerous and are microscopic channels connecting arteries to veins

**ii) Describe the structure and function of the mammalian heart**

- the heart is a four-chambered hollow muscle located in the thoracic cavity
- it consists of two small receiving chambers, the atria(auricles) and two larger pumping chambers, the auricles







- the left ventricle is the most powerful and has the thickest walls
- this is because it is the chamber which pumps blood throughout the body
- each time it contracts, blood is forced out into the elastic arteries(aorta)
- blood moves on to the capillaries
- from capillaries blood moves to veins and back to the heart through the vena cava

- from vena cava it enters into right auricle which contracts and pumps blood into the right ventricle
- right ventricle pumps blood into the lungs through the pulmonary artery
- blood releases carbon IV oxide to lungs and picks oxygen then returns to left auricle
- left auricle pumps blood into left ventricle
- left ventricle then pumps blood into the aorta and into arteries, starting the process all over again
- both auricles contract simultaneously while both



### **iii) Explain how the mammalian heart is adapted to performing its functions**

- the heart is made of muscles that contract and relax synchronously without requiring nervous stimulation
- nerve supply however, determine contraction strength and frequency
- the heart is divided into four chambers
- The right atrium is connected to the right auricle. It receives blood from the whole body.
- The blood is pumped from the left atrium to the right ventricle
- To avoid flow back into the right atrium, a valve is present between the two chambers – the tricuspid valve
- The right ventricle pumps blood to the lungs
- This is facilitated by the presence of pulmonary artery
- A valve is also present to avoid blood flowing back from the pulmonary artery to the right ventricle
- Blood from the lungs enters the heart through the pulmonary vein into the left atrium.
- When the left atrium contracts, blood flows into the left ventricle
- Blood will not flow back into the left atrium because of the presence of bicuspid valve(mitral)
- The left ventricle is connected with the aorta and when it contracts, blood flows into the aorta for distribution into the whole body
- The heart muscle surrounding the left ventricle is thicker than that surrounding the right ventricle to be able to generate enough pressure to push blood to the whole body
- A pace-maker is present in the heart muscle to initiate and synchronise contractions.

- For the heart muscle to be well nourished and be provided with enough oxygen and carbon IV oxide removal, it is supplied with blood by the coronary arteries and drained by the coronary veins

**iv) Explain why blood leaving the lungs may not be fully oxygenated**



- under ventilation of the lungs
- blockage of alveoli (air sacs)
- high cardiac frequency i.e. high rate of pumping of blood in the heart

**e) Describe the structure and functions of the blood vessels**

**i. Arteries**

- carry away blood from the heart
- carry oxygenated blood except pulmonary artery which takes blood from the heart to lungs for oxygen
- have thick, muscular walls
- are elastic
- have narrow lumen
- all these adaptations are required to withstand high pressure caused by heartbeat

**ii. Capillaries**

- link arterioles and venules to arteries and veins
- small in diameter to increase pressure resistance for materials to filter out
- thin walled as they consist of a single layer of cells to allow diffusion of substances e.g leucocytes to tissues
- thin walled to allow presence of intercellular spaces
- large number i.e. numerous to provide a large surface area for exchange of materials
- have sphincter muscles at the junction of the arterioles and capillaries to control movement of blood into them
- lie close to the body for easy exchange of materials

**iii. Veins**

- carry blood back to the heart
- all carry deoxygenated blood except pulmonary vein that carries blood from the heart to lungs
- have thinner walls than arteries
- have valves to prevent backflow of blood
- have wide lumen

**g) i) State the ways in which the composition of blood in the pulmonary arterioles differs from that in the pulmonary venules**

| Pulmonary arterioles   | Pulmonary venules  |
|--|--|
| <ul style="list-style-type: none"> <li>• deoxygenated</li> <li>• high carbon IV oxide</li> <li>• low oxygen</li> <li>• more nutrients</li> </ul> | <ul style="list-style-type: none"> <li>• oxygenated</li> <li>• low carbon IV oxide</li> <li>• high oxygen</li> <li>• less nutrients</li> </ul> |



**ii) Give the reasons why pressure of blood is greater in the arterioles than I the veins of mammals**

- blood is pumped to the arteries by the heart at high pressure
- blood pressure in veins is reduced by capillary resistance
- arteries have narrow lumen which maintains high pressure/veins have wide lumen which reduces pressure
- arteries have more/thicker muscular walls which generate pressure/veins have less/thinner muscular walls which reduce pressure

**iii) Name the common heart diseases in humans**

- thrombosis
- antheroma
- arteriosclerosis
- varicose veins
- cerebral vascular thrombosis

**h) i) State the functions of mammalian blood**

- transport of substances
- defense against diseases
- clotting
- temperature regulation

**ii) Describe how mammalian blood components carry out their functions**

**Plasma**

- transport dissolved food substances like glucose, amino acids, fatty acids and glycerol from small intestines to liver and other body tissues
- transports hormones, enzymes from secretory glands to tissues when required
- transports carbon IV oxide to lungs and urea from tissues to the kidneys
- distributes heat
- bathes the tissues allowing for exchange of materials
- contains protein fibrinogen and pro-thrombin which take part in blood clotting

**Red blood cells (Erythrocytes)**

- transports oxygen from the lungs to body tissues in form of haemoglobin

- transport carbon IV oxide from body tissues to the lungs in form of bicarbonates

### White blood cells (leucocytes)

- engulf foreign bodies
- produce antibodies for defense against disease
- produce antitoxins which neutralize bacterial toxins



### Blood platelets (thrombocytes)

- produce an enzyme called thrombokinas/thromboplastin necessary for blood clotting
- prevents loss of blood, water and mineral salts

### iii) State the ways in which the red blood cells are adapted to their functions

- many per unit volume hence carry more oxygen and carbon IV oxide
- biconcave in shape to provide large surface area for absorption of oxygen and carbon IV oxide
- absence of nucleolus hence more haemoglobin to carry sufficient oxygen and carbon IV oxide
- alter shape to be able to pass through the narrow lumen of capillaries to deliver or supply oxygen and carry away carbon IV oxide
- have haemoglobin with high affinity for uptake of oxygen and carbon IV oxide

### iv) State the structural differences between a red blood cell and a white blood cell.

| Red blood cells  | white blood cells   |
|--|---|
| <ul style="list-style-type: none"> <li>• has haemoglobin</li> <li>• smaller size</li> <li>• lacks nucleus</li> </ul> | <ul style="list-style-type: none"> <li>- not pigmented</li> <li>- larger size</li> <li>- nucleated</li> </ul> |

### v) State the functional differences between a red blood cell and a white blood cell

| Red blood cell  | White blood cell |
|---|------------------|
| - Transports oxygen and carbon IV oxide against harmful pathogens | - protects body  |

### vi) How does the heart increase blood flow to some parts of the body during exercise

- stronger contractions
- faster contractions/heartbeat

## Explain how oxygen and carbon IV oxide are transported in the blood

### Oxygen

- oxygen concentration is higher in lungs(alveoli) than in blood
- oxygen in the alveoli dissolves in the film of moisture and diffuses through thin epithelial and capillary walls into plasma and red blood cells
- the oxygen combines with haemoglobin to form oxyhaemoglobin
- blood then becomes oxygenated
- blood from lungs then travels to all body tissues where the oxyhaemoglobin breaks down to form oxygen and haemoglobin
- haemoglobin is transported back to the lungs to collect more oxygen while the oxygen in capillaries diffuses into body cells for respiration
- respiration produces carbon IV oxide

### Carbon IV oxide

- carbon IV oxide produced during respiration diffuses out of cells into blood plasma and red blood cells due to concentration gradient
- carbon IV oxide and water form carbonic acid carbamino compounds with haemoglobin
- in the presence of carboxyl anhydrase enzyme, hydrogen carbonate is carried in blood to the lungs
- in the lungs the hydrogen carbonate dissociates to liberate carbon IV oxide which diffuses into alveolar cavity due to concentration gradient
- from alveolar space carbon IV oxide is expelled during expiration

**Most carbon IV oxide is transported from tissues to lungs within the red blood cells and not in the blood plasma. Give the advantages of this mode of transport.**

- PH of blood is not altered/homeostasis is maintained
- Within the red blood cell is an enzyme, carbonic anhydrase which helps in fast loading(combining) and offloading of carbon IV oxide

#### **i) i) what is blood clotting?**

- process in which blood components clump together to prevent loss of blood from an injured/cut vessel

**ii) Name a protein, vitamin, an enzyme and a mineral element involved in blood clotting**

Protein – fibrinogen/prothrombin

Vitamin - k/quinine

Enzyme – thrombokinase/thromboplastin/thrombin

Mineral element – calcium

**iii) Describe the blood clotting process**

- enzyme thromboplastin produced in the platelets of damaged tissues converts plasma protein prothrombin into thrombin in the presence of calcium ions
- thrombin converts another plasma protein fibrogen into fibrin in the presence of vitamin K
- fibrin is insoluble
- fibrin forms fibres which form a meshwork that forms a clot
- prothrombin thromboplastin thrombin  
calcium ion

Fibrinogen thrombin fibrin clot

vitamin K

**iv) State the role of blood clotting on wounds**

- prevents blood/body fluids from being lost
- conserves water and salts
- prevents entry of microorganisms/pathogens
- regulates body temperature
- enables wound to heal faster

**v) Explain why blood flowing in blood vessels does not normally clot**

- Presence of anticoagulant in blood

**j) i. list the major types of human blood groups**

- O, with neither B nor A antigen
- AB, with both A and B antigens
- A, with type A antigen
- B, with type B antigen

**iii. explain the meaning of :**

**Universal donor**

- a person who can donate blood to any other blood group without agglutination/clumping
- this is usually blood group O
- however this person cannot receive blood from other blood groups except group O

**Universal recipient**

- can receive blood from all blood groups without agglutination
- this is usually blood group AB
- however, can only donate blood to group AB

**iii) What is the difference between rhesus positive and Rhesus negative blood samples?**

- rhesus positive blood has the Rhesus (Rh) antigen
- rhesus negative lacks the Rhesus antigen

**vi) What is blood transfusion?**

- Introduction of blood from one person to another

**v) Under what conditions would blood transfusion be necessary in people?**

- during accidents
- during surgery in hospitals
- bleeding mothers when giving birth

**vi) How can low blood volume be brought back to normal?**

- transfusion
- taking fluids
- eating iron rich food/taking iron tablets

**How may excessive bleeding result in death?**

- Anaemia/low blood volume/loss of iron/low red blood cells count/low haemoglobin leading to low oxygen, loss of nutrients and dehydration.

**State the precautions that must be taken before blood transfusion**

- blood must be disease free
- sterilized equipment must be used
- blood of the recipient and that of the donor must be compatible to both ABO and rhesus factor
- Fresh blood must be used.

**j) i) What is immunity?**

- Resistance to disease by organisms

**ii) Distinguish between natural and acquired immunity**

- natural immunity is inherited/transmitted from parent to offspring/inborn/innate
- Acquired immunity is developed after suffering from a disease or through vaccination.

**iii) What are allergic reactions?**

- Excessive sensitivity and reaction of an individual to certain substances in environment e.g. dust, pollen, perfumes, smoke etc.



**vi) How does an allergic reaction occur?**

- the substances act as antigens
- an antigen-antibody reaction occurs on surface of cells
- the cells release a substance called histamine
- the histamine causes irritation, itching and may stimulate nasal discharge



**vii) State the role of vaccination against certain diseases**

- protect body against infectious diseases
- prevent spread/transmission of certain diseases
- diseases for which vaccination is given include tuberculosis, poliomyelitis, measles, whooping cough, diphtheria

**3. a) i) What is gaseous exchange?**

- The continuous exchange of oxygen and carbon IV oxide between the organism and environment.

**ii) Why is gaseous exchange important to organisms?**

- to supply oxygen necessary for energy production
- to remove carbon IV oxide produced during respiration
- To remove water vapour.

**b) i) name the structure used for gaseous exchange by plants**

- stomatal pores/stomata
- lenticels
- cuticle
- pneumatophores

**ii) Briefly describe the structure of stomata**

- are minute pores found in leaf epidermis
- each consists of a slit-like opening
- Each is bordered by two large, bean-shaped guard cells.
- Guard cells contain chloroplasts, unlike the other epidermal cells which enable photosynthesis to occur
- Inner walls of guard cells are thicker than the outer cells

**iii) State the factors which affect stomatal opening**

- water which when low stomata close and when high stomata keeps open
- light as stomata open in bright light and close in darkness
- temperature

**iv) Name the theories suggesting the mechanism of opening and closing of stomata**

- interconversion of starch and sugar
- pH theory
- mineral ion concentration

**v) Describe the mechanism of opening and closing of stomata**

- stomata close at night and open during daytime
- This comes about due to changes in turgidity as a result of pH changes in guard cells.
- In the dark carbon IV oxide accumulates in the intercellular spaces
- This raises concentration of carbonic acid
- The pH drops (pH lowered)
- Enzymes convert sugar into starch in guard cells
- Osmotic pressure in guard cells is lowered
- Water moves out of guard cells by osmosis making cells lose turgidity hence become flaccid
- The stomata close
- During day time there is photosynthesis hence the production of sugar, carbon IV oxide concentration is lowered, pH increases, guard cells become turgid causing stomata to open.
- During the day potassium ions concentrate in guard cells, raising their osmotic pressure and causes them to open
- In the night the concentration of potassium ions decreases increasing osmotic pressure in guard cells therefore causes stomata to open.

**vii) What is the advantage of having stomata open during daytime and having them closed at night?**

- opening in the daytime allows diffusion of carbon IV into the leaf for photosynthesis to take place and allows diffusion of oxygen out of the leaf
- transpiration also takes place, thus cooling the leaf and facilitating uptake of water and mineral salts
- Closing in the night is to conserve water in the plant especially when there is not enough water available in the soil.

**c) i) State the ways in which leaves of plants are adapted to gaseous exchange**

- presence of stomata for faster gaseous exchange
- intercellular spaces/air spaces in the leaf for movement/circulation of air
- film of moisture around the surface of cells for easy diffusion
- broad/flattened shape to increase surface area
- thin lamina to reduce distance of diffusion

- exposed to air for easy diffusion

## ii) Describe how gaseous exchange takes place in terrestrial plants

- Gaseous exchange takes place in spongy mesophyll
- During the day air diffuses into large air spaces of spongy mesophyll through stomata
- The carbon iv oxide in the air diffuses into the photosynthesis oxygen is produced
- Some of the oxygen diffuses out of the leaf through stomata
- During the night air diffuses out of air spaces of spongy mesophyll
- The air dissolves into film of moisture
- The oxygen in the air diffuses into cells and is used in respiration during which carbon iv oxide is produced
- The carbon iv oxide diffuses out of the leaf through stomata due to diffusion/concentration gradient
- At night carbon iv oxide accumulates in the leaf since photosynthesis does not take place
- Some gaseous exchange also takes place through cuticle
- Gaseous exchange occurs through epidermis of young leaves and stems
- The cork cells at lenticels are loosely packed
- Gaseous exchange takes place between cork and atmosphere within the loosely packed cells

## iii) State the ways in which floating leaves of aquatic plants are adapted to gaseous exchange

- stomata found only on upper dermis to allow efficient gaseous exchange
- presence to aerenchyma tissues/large air spaces to enable it float/buoyancy/storage of air
- absence of cuticle to enhance gaseous exchange

## iv) How is aerenchyma tissue adapted to its function?

- has large airspaces which store gases/for gaseous exchange/buoyancy

## v) Explain stomatal distribution in plants of different habitats

- land plants have their stomata mainly on the lower side to reduce water loss but if on both sides then upper side has very few
- water plants, floaters, have stomata on upper side to enhance water loss

- in dry areas, plants have leaves with sunken stomata to reduce water loss by transpiration
- Plants in wet areas have stomata equally distributed on both sides.

**d) i) List the types of respiratory surfaces of animals**

- cell membrane in unicellular organisms e.g. amoeba
- gills in fish
- tracheal system
- skin, buccal cavity and lungs in amphibians
- lungs in mammals

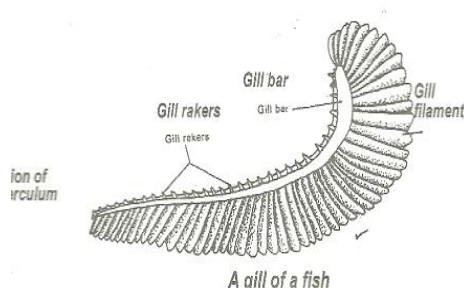
**ii) State the characteristics of respiratory surfaces in animals**

- moist
- thin walled/thin membrane/thin surface
- Highly/richly vascularised/numerous blood vessels/well supplied with blood vessels.
- Large surface area

**iii) Describe gaseous exchange in protozoa**

- example is amoeba
- small and have large surface area
- oxygen diffuses into the organism and carbon IV oxide diffuses out into water
- simple diffusion of gases is enough to meet its respiratory requirements

**e) i) Make a labeled drawing of a fish gill**



**ii) How is a fish gill adapted to its function?**

- large surface area due to many filaments
- extensive vascularisation due to capillaries, for gaseous exchange
- thin filaments to facilitate diffusion of gases
- presence of rakers to filter solid particles
- gill bar is bony, hard and firm to support the filaments and rakers and for attachment of filaments and rakers

**iii) Discuss gaseous exchange in bony fish**

- example is tilapia

- the mouth opens and the floor of the mouth is lowered so that the volume in the mouth is increased and pressure is lowered
- water then enters into the mouth cavity
- the mouth is closed and the floor of the mouth raised so that the volume is reduced
- this raises the pressure, forcing water over gills and out through the operculum
- As water passes over the gills oxygen diffuses due to concentration gradient (partial pressure) into the blood stream.
- In the body tissues, carbon IV oxide diffuses into the blood (due to concentration gradient, and is transported to the gills and diffuses out into the water.

#### iv) What is counter-flow system?

- Where water in which the fish lives flows in opposite direction across the gill.

#### vi) What is the advantage of counter-flow system?

- maintains a diffusion gradient so that there is maximum uptake of oxygen
- oxygen continues diffusing into blood and carbon iv oxide into water

#### f) i) Describe the mechanism of gaseous exchange in terrestrial insects

- example is cockroach
- air in the atmosphere contains oxygen
- air is drawn into the body of the insect through the spiracles due to movement of abdominal muscles
- these movements cause the opening of spiracles
- air moves through the trachea to tracheoles
- oxygen moves from the tracheoles into body cells by diffusion due to concentration gradient
- carbon iv oxide in the tissues diffuses into tracheoles due to concentration gradient
- From tracheoles carbon IV oxide moves into trachea and out through the spiracles into the air.

#### ii) State how traceholes are adapted to gaseous exchange

- thin walls of tracheoles
- moist surface
- large surface area due to numerous tracheoles

#### g) i) What is breathing?

- Any process which speeds up the rate of gaseous exchange between an animal and its surrounding.

**ii) Name the structures in humans that are used in gaseous exchange**

- nose
- larynx
- epiglottis
- trachea
- lungs
- pleural membrane
- pleural cavity
- diaphragm muscles

**iii) Describe the mechanism of gaseous exchange in a mammal**

**Breathing in**

- external intercostals muscles contract while internal intercostals muscles relax, raising the ribcage upwards and outwards
- muscles of the diaphragm contract hence it flattens
- the volume of the thoracic cavity increases while pressure decreases
- higher air pressure in the atmosphere forces air into lungs through the nose

**Breathing out**

- external intercostals muscles relax while internal intercostals muscles contract, moving the ribcage downwards and inwards
- muscles of the diaphragm relax hence the diaphragm assumes dome shape
- the volume of the thoracic cavity decreases while pressure increases
- the higher pressure forces air out of the lungs through the nose

**iv) Explain how mammalian lungs are adapted to gaseous exchange**

- large number of alveoli that increase surface area
- moist inner surface of alveoli for dissolving oxygen/gases to facilitate exchange of gases through alveolar cavities and blood
- thin walls of alveoli to allow efficient/faster diffusion of gases

- rich capillary/blood supply on alveolar surface to transport oxygen away from the lungs and carbon IV oxide to the lungs

**v) Name the features of alveoli that adapt them to their function**

- have large surface area/spherical shaped
- numerous/many to increase surface area
- one cell thick
- moist surface for air to diffuse
- highly vascularised/numerous capillaries

**vii) How is the trachea of a mammal suited to its function?**

- has a ring of cartilage which keeps it open at all times
- cilia that move mucus/particles to the top of the trachea i.e. into larynx for removal
- mucus to trap dust, solid particles and microorganisms
- hollow for passage of air

**viii) State the advantages of breathing through the nose rather than through the mouth**

- nose has hairs to filter solid particles
- it has mucus lining to trap dust particles
- the nose has cells sensitive to smell for survival
- it warms the air before it reaches the lungs

**ix) Give the conditions under which the carbon iv oxide level rises above normal in mammalian blood**

- vigorous exercise
- emotions/stress
- disease infection

**x) Explain the physiological changes that occur in the body to lower the carbon iv oxide level back to normal when it rises**

- heartbeat/cardiac frequency increases to pump blood faster carbon iv oxide from the tissues and supply more oxygen
- ventilation rate/rate and depth of breathing increases to take more oxygen and remove carbon iv oxide from the lungs
- arterioles to take in more oxygen and remove carbon iv oxide from the lungs
- arterioles dilate leading to faster flow of blood to and from body tissues

**h) i) Describe the factors which control the rate of breathing in humans**



- breathing movements usually occur unconsciously
- it is controlled by the medulla oblongata part of the brain situated at the breathing centre
- medulla oblongata is in the brain
- respiratory centre transmits impulses to the diaphragm through phrenic nerves
- carbon iv oxide concentration in the blood determines the breathing rate
- if carbon iv oxide is less, the brain is triggered to decrease breathing rate
- cardiac frequency decreases and the arterioles constrict
- therefore carbon iv oxide level is raised
- this brings back to normal level of breathing and carbon iv oxide level increases/is more the brain is triggered to increase breathing rate
- cardiac frequency is increased
- there is vasodilation of arterioles
- carbon iv oxide level falls
- therefore the normal level is attained and carbon iv oxide is removed faster

#### ii) Name the respirator diseases

- asthma
- bronchitis
- whooping cough
- pneumonia
- tuberculosis

#### 4. a) i) Define respiration

- the oxidation/breakdown of food within cells to release energy

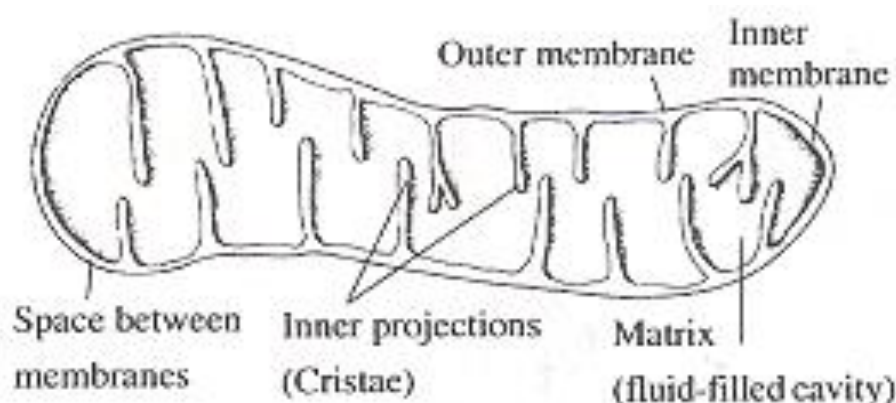
#### ii) Explain the significance of respiration in living organisms

- it yields energy (ATP)
- this energy enables organisms to move, grow, excrete and reproduce

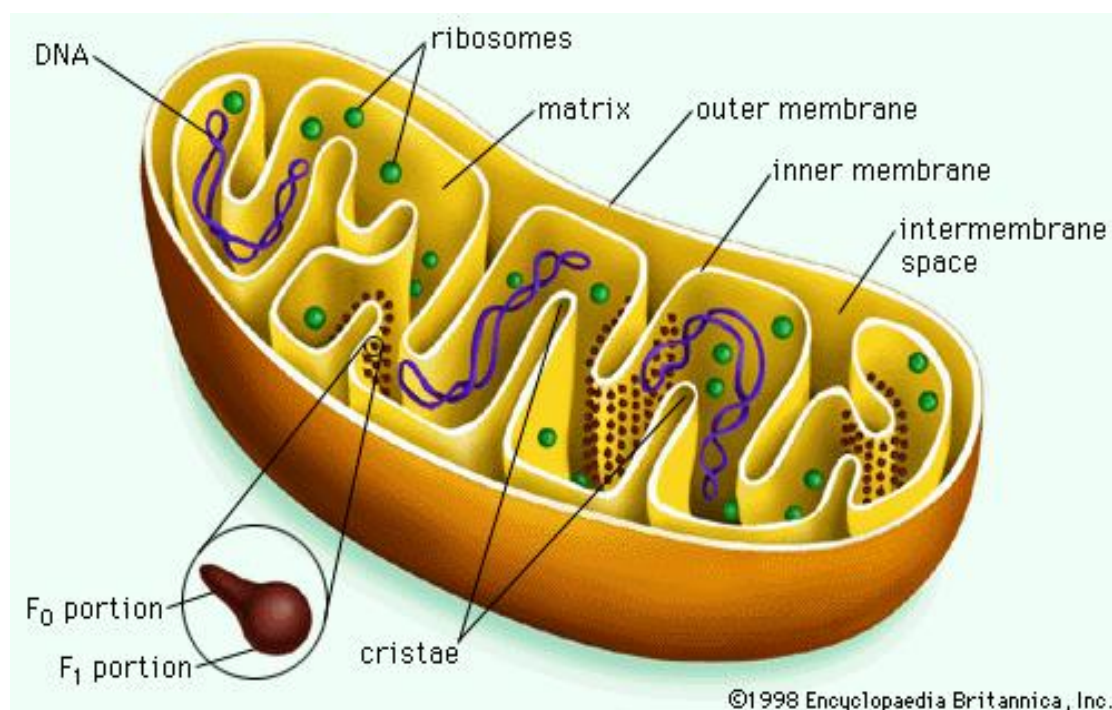
#### iii) Where does respiration take place?

- in the mitochondria

#### b) i) Draw and label a mitochondrion







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**ii) State the most important function of mitochondria**

- to produce Adenosine triphosphate (ATP) which is the energy source of the whole cell

**iii) Give the functions of the labeled parts**

**Outer membrane**

- controls what enters and what leaves mitochondrion

**Cristae**

- also called inner membrane
- increase surface area for attachment of enzymes
- this is where cellular oxidation reactions occur

**Matrix**

- enzymes are located here
- other reactions occur here

**c) Explain the roles of enzymes in respiration**

- they catalyse reactions i.e. speed up respiration

**d) i) What is aerobic respiration**

- respiration in the presence of oxygen

**ii) Give a word equation for aerobic respiration**

- glucose + oxygen - water + carbon iv oxide + energy

**iii) What are the end products of aerobic respiration?**

- energy
- carbon iv oxide
- water

**e) i) What is anaerobic respiration**

- occurs in the absence of oxygen

- e.g. yeast and certain bacteria release energy in the absence of oxygen

**ii) What are obligate anaerobes?**

- are completely independent of oxygen

**iii) What are facultative anaerobes?**

- can survive both in the presence and absence of oxygen
- also called partial anaerobes

**iv) State the word equation representing anaerobic respiration in plants**

- Glucose → ethanol + carbon iv oxide + energy

**v) Name the end products of anaerobic respiration in plants**

- alcohol/ethanol
- carbon iv oxide
- energy

**g) i) Give a word equation of anaerobic respiration in animals**

- Glucose → lactic acid + energy

**ii) Name the end products of respiration in animals when there is insufficient oxygen supply**

- lactic acid
- energy

**iii) Why is there a high rate of lactic acid production during exercise?**

- the demand for oxygen is more than supply leading to anaerobic respiration

**iv) Why does lactic acid level reduce after exercise?**

- lactic acid is oxidized to form carbon iv oxide and water
- some is converted to glucose
- some is converted into glycogen

**v) State why accumulation of lactic acid during vigorous exercise lead to an increase in heartbeat**

- lactic acid is poisonous to tissues and must be removed
- to increase supply of oxygen to tissues

**State the economic importance of anaerobic respiration**

- brewing of alcohol
- biogas production
- compost manure formation
- silage formation
- baking bread
- production of dairy products
- fermentation of milk
- sewage treatment

- Fermentation of tea in industries

### **What is oxygen debt?**

- amount of oxygen required to convert accumulated lactic acid to water, carbon IV oxide and energy



### **h) i) What is respiratory quotient(RQ)?**

- ration of carbon IV oxide produced to oxygen consumed

$$RQ = \frac{\text{volume of CO}_2 \text{ produced}}{\text{Volume of oxygen consumed}}$$

### **ii) Why are respiratory quotient important**

- their calculation assists in identifying the kind of substrate being used in respiration

### **iii) Name the respiratory substrates**

- carbohydrates
- fats
- proteins

### **iv) Why does anaerobic respiration of a given substrate yield a smaller amount of energy than aerobic respiration?**

- Some energy locked up in intermediate products like ethanol in plants and lactic acid in animals

- substrate is completely oxidized in aerobic respiration

### **iv) Explain the disadvantages of anaerobic respiration**

- Less energy produced in anaerobic respiration since food is partially oxidized while in aerobic respiration food is completely oxidized.
- Some metabolic wastes accumulate in cells affecting cellular functions
- Ethanol produced in plants poisons the tissues while lactic acid produced in animals causes muscle fatigue/muscle cramp and may stop muscle contraction
- Such intermediate wastes are not produced in aerobic respiration

### **v) Mention the types of experiments carried out for respiration**

- germinating seeds which yield energy in form of heat
- animals produced heat when they respire
- yeast cells respire to produce heat

## **5. a) i) Define the following terms**

### **Excretion**

- the process by which organisms get rid of waste products which result from chemical process which occur in living cells

## Secretion

- the process by which organisms produce substances which are useful to the body, by glands

## Egestion

- removal of indigestive materials from the body

## Homeostasis

- maintenance of constant internal environment

### ii) Explain why excretion is necessary in plants and animals

- products of excretion are usually harmful while some are toxic
- if allowed to accumulate in the cells they would destroy tissues and interfere with normal metabolism
- They are therefore removed through excretion

### b) i) Describe how excretion takes place in green plants

- carbon IV oxide, oxygen and water diffuse through the stomata, lenticels and hydathodes
- some toxic wastes are converted into non-toxic substances
- these are deposited in certain tissues of the plant or stored in aging structures
- resins and tannins are exuded through the bark of stem or lost during leaf fall

### ii) Why do plants lack complex excretory structures like those of animals?

- plants have lower rates of metabolism
- plants excrete non-poisonous products derived from carbohydrate metabolism unlike animals which produce toxic wastes derived from protein metabolism
- plants re-use some of their wastes like nitrogenous wastes used in protein synthesis
- plants store waste products in roots, fruits and leaves

### ii) State the excretory products of plants and some of their uses to humans

- **caffeine** from tea and coffee is used in medicine and as a stimulant which is harmful to humans
- **quinine** used for treating malaria
- **cocaine** derived from leaves of cocoa plant used as a stimulant by addicts or as a local anesthesia, also causes damage to the brain, may cause addiction if not well used and is an illegal drug
- **Tannins** derived from barks of acacia (wattle bark) trees are used to make ink and tanning (softening) of leather.

- **Nicotine** got from leaves of tobacco plant stimulates the central nervous, may cause addiction if much is used or consumed. It is used to make cigarettes, cigars and is poisonous. It is a precursor of lung cancer
- **Cannabis sativa**(bhang) is used to make drugs
- **Gum** derived from glues is used for sticking substances and making certain jellies
- **Rubber**, a product of latex, got from rubber plant is used to make tyres and synthetic fibres
- **Morphine** from opium poppy plant is a narcotic and illegal drug as it causes addiction
- **Khat and miraa** are used as stimulants
- **Colchicines** used in inducing polyploidy, cancer therapy, treatment of gout in small quantities
- **Papain** used as meat tenderizer

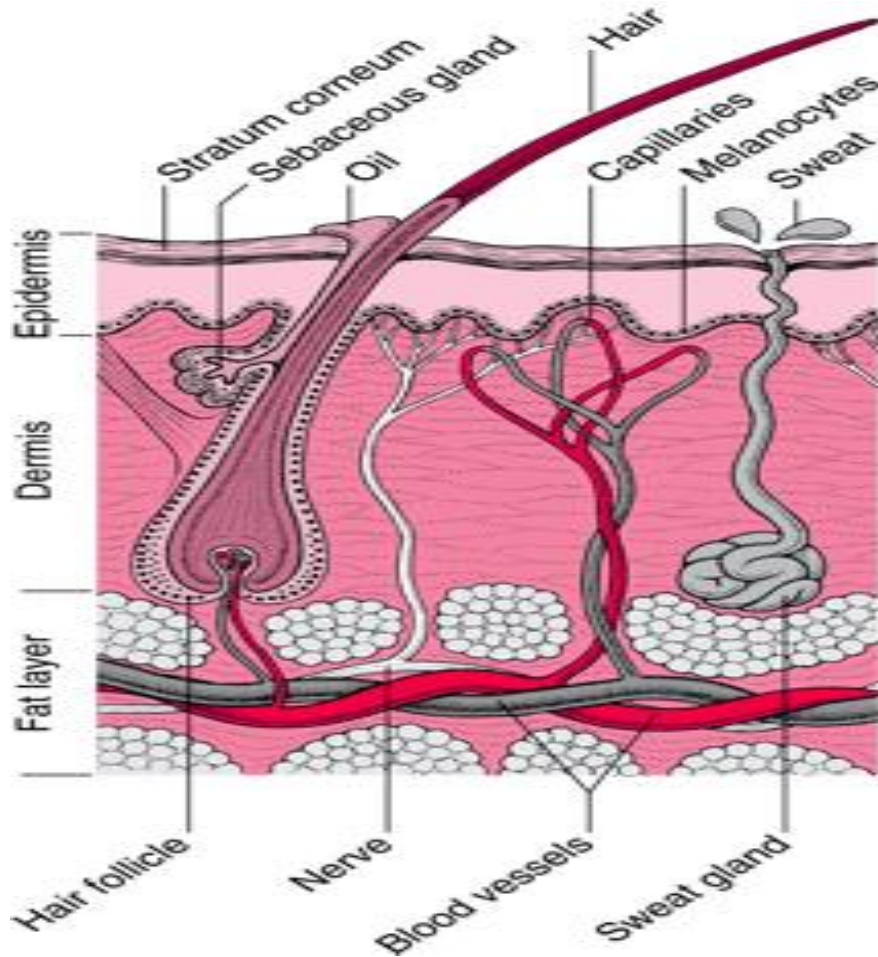
**c) i) Describe excretion in unicellular organisms**

- examples are amoeba and paramecium
- They have to remove waste products such as carbon IV oxide and nitrogenous substances e.g urea and ammonia
- These diffuse from the body surface into the surrounding water
- Diffusion is due to large surface area

**ii) List excretory organs and products of mammals**

- kidney excretes urea, water and salts
- skin excretes water, salts and urea
- lungs excrete carbon IV oxide and water
- liver excretes bile salts

## d)i) Draw and label a mammalian skin



## ii) Explain how the mammalian skin is adapted to its functions

- the skin is made up of dermis and epidermis

### Epidermis

- it is made up of three layers
- the outermost layer, cornified layer is made up of dead cells that prevent entry of microorganisms, prevent physical damage and desiccation
- granular layer made of living cells gives rise to cornified layer
- malpighian layer is made up of actively dividing cells that give rise to new epidermal cells/granular layer it contains melanin that protects the body against ultra violet rays(radiations)

### Dermis

- has several components
- Has sweat gland which produce sweat through sweat pores on the skin and the sweat evaporates cooling the body by lowering body temperature. When it is cold, no sweat is produced, conserving water
- sweat contains water, sodium chloride, uric acid and urea hence the skin acts as an excretory organ
- Has hair. The hair stands erect to trap air when temperature is low to reduce loss/insulation. It lies flat to allow heat loss when temperature is high.

- Has nerve endings which are sensitive to stimuli such as heat, cold, pain, pressure and touch
- Has subcutaneous fat/adipose fat that insulates the body against heat loss
- Has arteries and capillaries (blood vessels) that supply food and oxygen and remove excretory products. Arterioles vasodilate when temperatures are high to lose heat by radiation, and convection. Arterioles constrict when temperatures are low to conserve heat i.e. reduce heat loss
- Has sebaceous glands which secrete sebum, and antiseptic and water repellent that prevents drying and cracking the skin by making the skin supple

**e) What is the role of lungs in excretion?**

- during respiration oxygen is used up in the body cells to produce energy
- carbon IV oxide is produced as a by-product
- the carbon IV oxide must be eliminated from the body
- elimination is through the lungs
- also, water vapour is formed and must be removed
- this removal is through the lungs
- the lung is therefore considered as an excretory organ as it removes carbon IV oxide and water vapour which are by-products of respiration

**f) State the functions of the liver**

**i. Excretion**

- in this function the liver is aided by the kidney
- deamination i.e. excess amino acids converted into urea and uric acid which is transported to skin and kidney for removal
- detoxification where harmful substances are converted into harmless ones in the liver and transported to kidneys for removal
- breakdown of worn out blood cells and haemoglobin and the residue excreted through the kidney to give urine a yellow tinge
- Breakdown of sex hormones after they have performed their function and the wasted are released through the kidney and bile.

**ii) Homeostasis**

- regulation of blood glucose
- the normal amount of glucose in blood is about 90mg/100

- increase in blood sugar is detected by cells of the pancreas which secrete insulin
- insulin stimulates the liver to convert excess glucose to glycogen
- further excess glucose is converted to fats until the normal blood sugar level is attained
- Excess glucose is oxidized to carbon IV oxide, water and energy. Excess glucose is also used in respiration
- decrease in blood sugar level below normal level is detected by the pancreas, which secretes glucagon which stimulates the liver to convert glycogen to glucose until the normal sugar level is attained
- fats, amino acids are converted to glucose
- it also leads to reduced oxidation of glucose

### Deamination

- excess amino acids are deaminated by the removal of amino group
- the amino group is converted to ammonia
- ammonia combines with carbon IV oxide to form urea
- urea is excreted in urine through the kidney

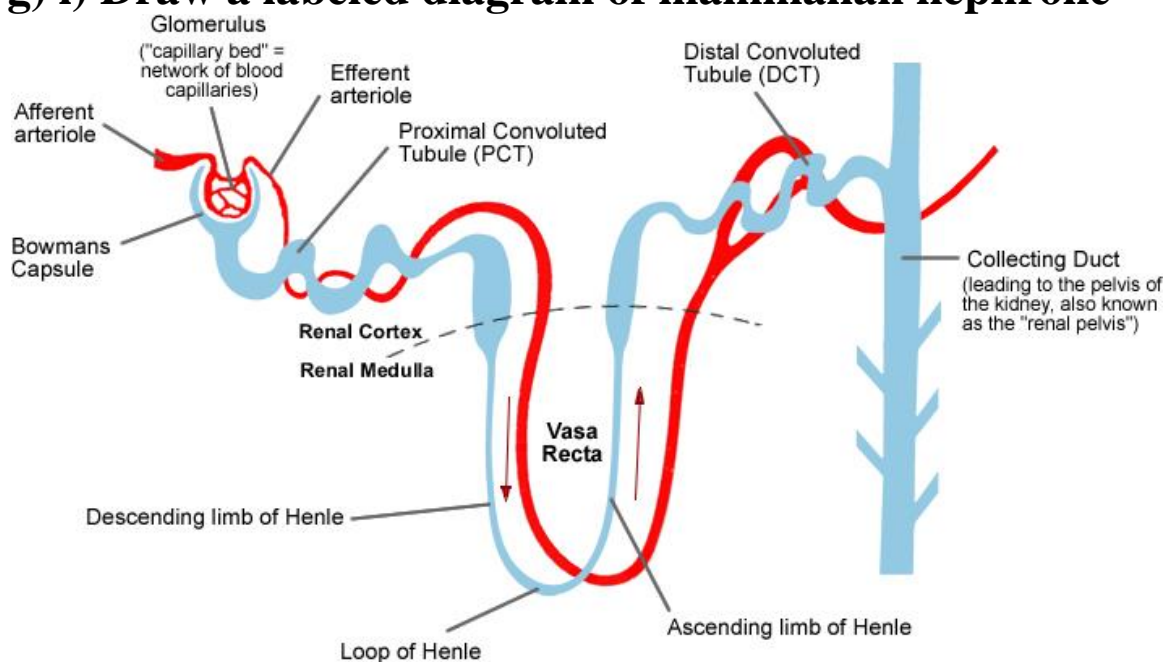
### Detoxification

- poisonous substances are converted to less harmful compounds

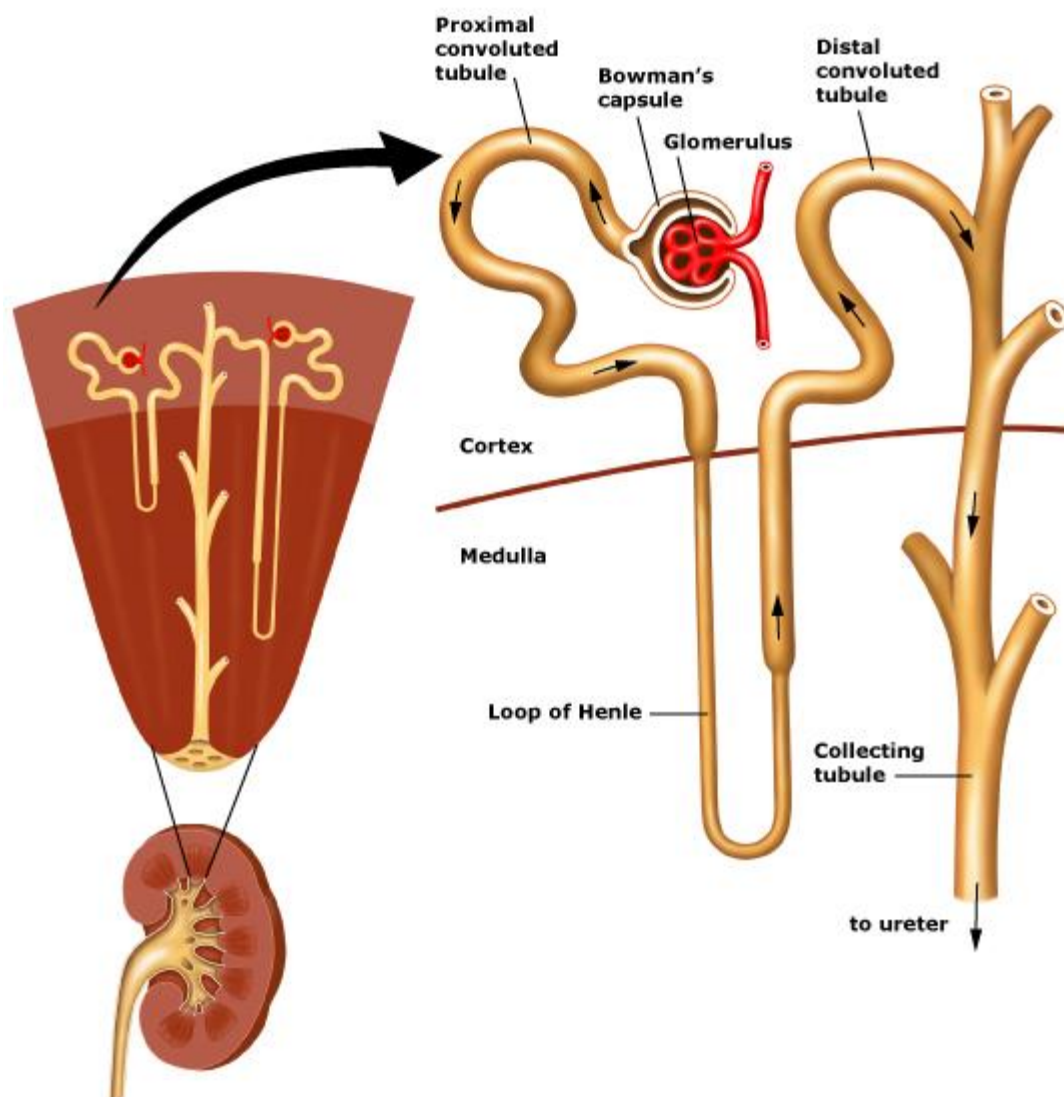
### Thermal regulation

- maintenance of body temperature
- heat is generated in the liver by chemical activities
- the heat is distributed

### g) i) Draw a labeled diagram of mammalian nephrone







## ii) Describe how the human kidney functions

- the afferent arterioles, which is a branch of the renal artery, supplies blood to the glomerulus
- the afferent arteriole has a wider diameter than the efferent arteriole
- this difference in diameter of afferent and efferent vessels causes high pressure leading to ultra filtration
- the walls of the blood capillaries are one cell thick hence glucose, amino acids, vitamins, hormones, salts, creatinine, urea and water filter into Bowman's capsule to form glomerular filtrate
- white blood cells, red blood cells, plasma proteins (such as globulin) and platelets are too large to pass through the capillary walls hence remain in blood capillary
- the filtrate flows into proximal convoluted tubule where amino acids, vitamins and all glucose are selectively reabsorbed back into the blood stream
- many mitochondria provide energy for reabsorption of these substances against a concentration gradient by active transport
- the glomerular filtrate flows into the loop of Henle

- water in the descending loop moves by osmosis into the blood capillaries
- sodium chloride is actively pumped from the ascending arm of the loop of Henle into the blood capillaries
- the glomerular filtrate flows into the distal convoluted tubule
- water and salts are reabsorbed from distal convoluted tubule into blood capillaries
- the glomerular filtrate flows into collecting tubule (duct) from where more water is reabsorbed into blood stream
- antidiuretic hormone influences the amount of water reabsorbed depending on osmotic pressure of blood
- the glomerular filtrate from collecting duct, now referred to as urine, is emptied into pelvis and ureter into bladder and out of body through urethra
- urine consists of excess water, salts and nitrogenous wastes

### iii) State the adaptations of proximal convoluted tubule to its function

- folded to increase surface area for absorption
- thin epithelium to reduce distance of diffusion
- micro-villi on inner lining to increase surface area for absorption
- folded to reduce speed of flow for efficient absorption
- numerous mitochondria to provide energy for reabsorption
- dense capillary network to transport reabsorbed products

### iv) Name the common kidney diseases

- nephritis
- kidney stones(renal calculi)
- cystitis
- oedema
- kidney failure

### 6. a) i) Why is homeostatic control necessary?

- this provides a constant internal environment so that the cells of the body have the optimum (best) condition for their survival

### ii) What is internal environment?

- immediate surrounding of body cells
- refers to tissue fluid within an organism

### b) i) Why is constant body temperature maintained by mammals?

- most enzymes in the body function within a narrow range of temperature

- high temperature denatures enzymes
- low temperature inactivates and inhibits enzymes

**ii) Explain the advantage gained by possessing a constant body temperature**

- animals remain active despite fluctuations in environmental temperature
- higher chances of survival in various environments ie they colonize various environments
- chemical processes in their body continues at an optimum rate



**iii) How do mammals regulate body temperature?**

- the body temperature of a mammal is kept constant
- to maintain this temperature the mammal must be able to balance its heat loss against the heat gain
- body temperature is controlled by the hypothalamus, a specialized part of the brain
- changes in the temperature within the body and the surrounding are detected by the hypothalamus
- it transmits impulses to the skin and the blood stream in response to temperature changes
- hypothalamus acts as a thermostat for the body
- a mammal loses heat by breathing out, urine, faeces, skin by radiation and by evaporation of sweat.
- A mammal generates heat by the activity of its muscles, by general metabolism in respiration, or chemical activities
- In hot conditions the hypothalamus stimulates responses that increase heat loss from the body hence lowering the body temperature
- Such responses include sweating, vasodilation, keeping its hair flat on the surface of skin and reduction of metabolic rate
- In cold conditions the hypothalamus stimulates responses that generate heat gain in the body and reduce heat loss to the environment
- Such responses include shivering, vasoconstriction, raising its hair to trap a layer of air around the skin because still air is a good insulator of heat and by generation of heat by increasing metabolic rate.

**iv) Why does body temperature of a healthy person rise up to 37°C on a hot humid day?**

- sweat evaporation is reduced hence cooling is less therefore more heat is retained in the body causing temperature to rise

**v) Name the structures in the human body that detect external temperature changes**

- temperature receptors (end bulb corpuscles e.g. bulb of Krause (warmth) and organ of Ruffini (cold))
- heat (thermal) receptors

**vi) State the advantages that organisms with small surface area to volume ratio experience over those with larger**

- heat loss slow hence their body temperature can increase to intolerable levels
- Heat gain from surrounding slower hence may remain inactive for a long time.
- Need specialized and complex transport system and also gaseous exchange system

**Explain why individuals with smaller sizes require more energy per unit body weight than those with larger sizes.**

- surface area to volume ratio is higher in smaller individuals than larger ones, therefore smaller heat is lost faster by smaller ones than larger ones
- they therefore require more energy per unit body weight to maintain body temperature

**c) i) What is the meaning of osmoregulation?**

- mechanism which regulates osmotic pressure of internal environment of an organism
- the regulation/maintenance of salt/solute-water balance of an internal environment

**ii) State the importance of osmoregulation**

- Maintenance of constant level of water and salts (osmotic pressure) for optimum/suitable conditions for metabolism suitable for cellular functions

**iii) State the ways by which desert mammals conserve water**

- fewer glomeruli
- longer loop of Henle
- excretion of dry faeces or concentrated urine
- hump for fat to be metabolized to give metabolic water for use
- nocturnal, burrowing, aestivate or hibernate
- sweat glands few or absent
- more ADH (vasopressin)

**iv) Explain why some desert animals excrete uric acid rather than water**

- uric acid is less toxic than ammonia, hence elimination of uric acid requires less water than ammonia therefore more water conserved
- uric acid being less toxic is safer to excrete where there is less water/desert



**v) Explain why eating a meal with too much salt leads to production of a small volume of concentrated urine**

- the concentration of salts in the blood rises leading to production of more ADH hence higher rate of water reabsorption by kidney tubules

**vi) Explain how marine fish regulate their osmotic pressure**

- swallow plenty of sea water to increase amount of water in the body
- have chloride excretory cells in their gills to remove excess salts
- eliminate nitrogenous wastes in form of trimethylamine oxide which requires little water for elimination
- few/small glomeruli thus slow filtration rate in the kidneys
- retain nitrogenous wastes in form of urea to raise osmotic pressure of body fluids

**d) i) What is the biological significance of maintaining a relatively constant sugar level in a human body?**

- body cells are surrounded by tissue fluids that are isotonic/same osmotic pressure as cytoplasm
- if sugar level is high/hypertonic, cell will lose water by osmosis to the surrounding, thus increasing the concentration of the contents
- this changes the physiology of the cell
- if the blood sugar is lower than the normal, the cytoplasm gains water by osmosis, diluting the cell contents, thus altering the physiology of the cell

**ii) Discuss the role of the following hormones in blood sugar control**

**Insulin**

- insulin is produced when there is increase in blood sugar concentration
- it converts glucose to glycogen which is in the liver or muscle thus lowering sugar level

**Glucagon**

- when glucose level decreases glucagon is produced, which causes the breakdown of glycogen to glucose thus raising blood sugar level

**e) Explain the part played by antidiuretic hormone in homeostasis**

- Produced when there is less water (high osmotic pressure above normal level of salt concentration) in the blood.
- It acts on kidney tubules (nephron) thus increasing water reabsorption from tubules to the blood stream, thus restoring osmotic pressure
- When there is more water (lower osmotic pressure) or decreased salt concentration in blood, little or no ADH is produced, less water reabsorbed hence water loss in urine (more dilute urine) hence raising the osmotic pressure in body fluids/blood

**f) What is the role of blood clotting in homeostasis?**

- when a blood vessel is cut, there is exposure of blood platelets to the air
- this triggers fibrinogen to be converted to fibrin
- the fibrin forms a clot that prevents body fluids e.g. blood from being lost
- therefore the clot conserves water and salts in the body

**g) Describe the role of the following hormones in homeostasis**

**i. Aldosterone**

- concerned with regulation of ionic balance
- secreted by the cortex of adrenal glands
- it increases sodium ion uptake by the gut and promotes the reabsorption of sodium ions (and therefore water) in the kidneys)
- this is accompanied by elimination of potassium ions
- this raises the overall level of sodium and lowers the overall level of potassium in the blood
- as sodium ions are absorbed in the blood, chlorine ions follow so as to neutralize the effect of sodium ions
- the production of aldosterone is regulated by the concentration of sodium ions which has an inhibiting effect, and a fall in sodium ions has a stimulating effect on the adrenal cortex
- the flow of aldosterone is stimulated by the adreno-cortic-tropic hormone (ACTH) produced in the anterior of the pituitary gland

- however, the main method of control is dependent on the fact that adrenal cortex itself is somehow sensitive to the relative concentration of potassium and sodium in the blood

## ii. Adrenaline

- produced by adrenal glands
- in high concentrations, it increases hydrolysis of glycogen and increases blood sugar
- it is usually released in emergency cases to increase glucose level for respiration
- this releases energy for the emergency



### h) i) Distinguish between diabetes mellitus and diabetes insipidus

- diabetes mellitus is a condition resulting from insufficient production of insulin causing hyperglucaemia and presence of glucose in urine
- diabetes insipidus is a condition whereby less or no antidiuretic hormone is secreted hence a high volume of water is passed out in urine in a condition called diuresis

### ii) How can high blood sugar level in a person be controlled?

- administer insulin

### iii) Why does glucose not normally appear in urine even though it is filtered in the mammalian Bowman's capsule?

- glucose molecules are actively reabsorbed in the proximal convoluted tubules

### iv) When is glycogen which is stored in the liver converted into glucose and released into the blood?

- after activity/when blood sugar (glucose) falls below normal
- when glucagon
- stimulates the liver/when glucagon is produced
- after strenuous/vigorous activity
- during starvation

### v) How would one find out from a sample of urine whether a person is suffering from diabetes mellitus?

- test or react urine in Benedict's solution
- positive result i.e. orange or red precipitate
- Positive result is an indication of diabetes mellitus.

## FORM III TOPICS

### 1. a) i) What is meant by the term binomial nomenclature?

- scientific system of naming organisms using the generic(genus) and specific (species) names



### ii) State briefly the general principles of classification of living organisms

- scientific names must be in Latin or should be latinised
- family names are formed by adding the suffix “idea” to the stem of the genus e.g. the genus Rana become Ranaidea
- generic names should be a single unique name

### b) State the main characteristics of the five kingdoms of organisms

#### i. Monera

- e.g. bacteria
- unicellular (single celled)
- prokaryotic (genetic material not surrounded by membrane)
- cell wall without cellulose
- lack most organelles
- small in size (microscopic)

#### ii. Protista(protoctista)

- single celled(unicellular)
- eukaryotic (most cell organelles present)
- when cell walls are present have no cellulose
- e.g. protozoa and algae
- usually microscopic

#### iii. Fungi

- have hyphae (which form mycelia)
- absence of chlorophyll
- have rhizoids (lack roots, leaves, stem)
- have spore forming structures (sporangia)
- e.g. mucor, rhizopus

#### iv. Plantae

- most are green/contain chlorophyll
- autotrophic/feed by photosynthesis
- cells have cellulose cell walls
- respond slowly to stimuli (tropism)
- lack locomotion (are stationary)
- indefinite growth (at meristems)
- lack specialized excretory structures

#### v. Animalia



- cells do not have cell walls
- most carry out locomotion
- heterotrophic
- fast response to stimuli (tactic)
- have specialized excretory structures

**c) Describe the economic importance of:**

**i. Fungi**

- some cause decay to our food
- some cause diseases to humans and animals e.g. ringworms
- may be used as food e.g. mushrooms, yeast
- some are used in production of antibiotics e.g. penicillin, chloromycin, streptomycin
- yeast is used in brewing industry, baking and source of vitamin B
- many cause diseases to our crops e.g. late blight
- important in recycling nutrients in soil since they cause decay of organic matter
- mycorrhizal association in forest development may help in water intake/absorption
- help in nitrogen fixation

**Bacteria**

- are useful in the manufacture of antibiotics
- silage formation,
- fermentation of cheese, butter, milk yoghurt
- curing of tea, tobacco and retting flax
- formation of vitamin B12 and K
- enzymes such as amylase and invertase
- hormones such as insulin
- vinegar, acetic acid, lactic acid, citric acid
- in septic tanks and modern sewage works make use of bacteria
- biogas production
- saprophytic bacteria are used in compost decomposition or cause decay
- symbiotic bacteria are used in compost decomposition or cause decay
- symbiotic bacteria in herbivores/ruminants help in digestion
- some diseases in animals/humans and plants are caused by bacteria
- many bacteria cause food spoilage/decay

- nitrifying and nitrogen fixing bacteria increase soil fertility/make nitrates available
- denitrifying bacteria reduce soil fertility/convert nitrates into nitrogen/reduce nitrates

**d) State the main characteristics of the following division of kingdom plantae**



**i. Bryophyte**

- e.g. mosses and liverworts
- presence of rhizoids
- lack of vascular tissues (lack phloem and xylem)
- body parts not differentiated into root, stem, leaves
- capsule or seta
- gametophyte generation dominant.

**ii. Pteridophyta**

- e.g. ferns
- has true roots, stems and leaves
- fond with sori on under-surface
- vascular tissues present
- sporophyte generation is dominant

**iii. Spermatophyte**

- photosynthetic
- well differentiated into roots, stems and leaves
- well developed vascular system
- seed bearing plants

**e) Name sub-divisions of spermatophyte and state the characteristics of each class**

**i. Gymnospermae (cornifers)**

- naked seeds (exposed)
- are all woody trees
- reproduce by means of cones
- show xerophytic characteristics
- xylem have tracheids but lack vessels
- phloem lacks companion cells
- single fertilization
- pollen lands directly on ovules

**ii. Angiospermae (flowering plants)**

- reproduce by flowers
- seeds enclosed (in fruits)
- flowers bisexual hence double fertilization
- herbaceous
- pollen grains land on stigma of pistil

- xylem contains vessels
- phloem contains companion cells
- ovules contained in ovary

**iii. Name the classes and state characteristics of angiospermae**

**Dicotyledonae**

- two seed leaves
- network venation of leaves
- regularly arranged vascular bundles
- tap root system
- broad leaves
- secondary growth occurs

**Monocotyledonae**

- one seed leaf
- parallel venation of leaves
- irregularly arranged vascular bundles
- fibrous root system
- narrow leaves
- sheath like leaf stalk (petiole)
- no secondary growth

**iv) State the importance of plants**

- balancing carbon IV oxide and oxygen in the atmosphere during photosynthesis and respiration
- influence water cycle
- reduce soil erosion by bind soil particles together
- useful products e.g. food, medicine, timber, paper and clothing
- habitat ( e.g. forests and grassland) for animals which may also be tourist attraction
- earn money from sales of products
- aesthetic value/beauty e.g. flowers, shade/shelter, live fences, windbreaks
- Some are harmful e.g. poisons, weeds, injurious (stinging nettles, thorns), water hyacinth.

**f) i) Give the general characteristics of phylum arthropoda**

- jointed appendages
- presence of exoskeleton
- triploblastic and coelomate
- segmented body
- bilateral symmetry (similar halves)

**ii. State the characteristics of the following classes of arthropoda**

## **Diplopoda**

- the millipedes
- two pairs of legs per segment
- many segments
- terrestrial habitat
- body cylindrical and long
- herbivorous
- one pair of antennae

## **Chilopoda**

- the centipedes
- one pair of legs per segment
- many segments
- terrestrial habitat
- body long and ventro-dorsally flattened
- carnivorous
- last pair of legs pointing backwards with poison claws called maxillipedes
- one pair of antennae

## **Insecta**

- three body parts i.e. head thorax, abdomen
- six legs/three pairs of legs
- a pair of compound eyes
- presence of wings
- a pair of antennae

## **Crustacean**

- two body parts
- segmented body
- have pincers (modified legs) to catch prey
- have hard exoskeleton
- a pair of compound eyes

## **Arachnida**

- body divided into two parts( abdomen and cephalothorax)
- simple eyes
- eight legs (four pairs of legs)

### **iii) State the economic importance of insects**

#### **Beneficial effects**

- food supply
- important in food chains
- pollinators
- biological control of pests and other organisms
- aesthetic value

- contribute to decomposition e.g. litter feeders like beetles

### **Harmful effects**

- pests
- vectors
- dirt and disease carriers
- injurious e.g. stings and bites

### **g) i) State the general characteristics of chordate**

- notochord
- dorsal slits (pharyngeal cleft during development)
- bilateral symmetry
- triploblastic (three layer body-ectoderm, mesoderm and endoderm)
- clear cut head formation
- multilayered epidermis
- post anal tail
- closed circulatory system
- segmented muscle blocks(myotomes)
- single pair of gonads

### **Give the characteristics of the following classes of chordate**

#### **Pisces**

- presence of fins for locomotion
- two chambered heart
- presence of overlapping scales
- presence of gills or operculum for gaseous exchange
- presence of lateral line for protection
- streamlined body
- poikilothermic (body temperature varies with that of environment)

#### **Amphibian**

- partially live in fresh water and partially on land
- poikilothermic
- pentadactylous with two pairs of limbs
- webbed feet for locomotion in water
- body streamlined
- heart is three chambered
- moist skin for gaseous exchange

#### **Reptilia**

- scales on body
- poikilothermic
- homodont teeth except tortoise and turtle
- all have limbs except snakes

- skin is dry
- oviparous (lay eggs)
- no pinna (external ear)
- three chambered heart (crocodile has four chambers)
- skin not glandular
- no mammary glands

### Aves

- the birds
- homoeothermic (constant body temperature)
- four chambered heart
- streamlined body for locomotion in air
- skin dry and covered by feathers
- scales on legs
- hollow bones
- oviparous (lay eggs)
- mouths modified into beaks

### Mammalian

- hair on the body
- homoeothermic
- viviparous (give birth to live young) except a few
- have mammary glands
- glandular skin e.g. sweat glands, sebaceous glands
- four chambered heart
- pinna (external ear)
- two pairs of pentadactyl limbs
- presence of diaphragm
- have salivary glands

#### i) i) What is a dichotomous key?

- A biological device (tool) which enables one to identify an organism by progressively opting between two alternative observable characteristics

#### ii. State the necessity of using a dichotomous key

- used to identify organisms quickly and accurately
- by following the statements in the key we are able to identify each organism on the basis of a characteristic which is not to be found in other specimens

#### iii. List the rules followed in constructing a dichotomous key

- use observable characteristics only
- start with major characteristics, placing organisms into two groups at each stage

- use a single characteristics at a time
- use contrasting characteristics at each stage e.g 1(a) short, 1(b) tall
- avoid repeating the same characteristics

**iv) Describe the procedure of using a dichotomous key. Make a list of major features of the characteristics to be identified**

- look at the features of similarities
- look at the features of differences between the organisms
- we can then be able to identify the organisms by distinguishing one from another
- the key uses a method of elimination by following statements that are correct only for the organism

**iv You are provided with a specimen kale leaf. Use the dichotomous key below to identify the taxonomic group to which the specimen belongs. Show the steps (number and letter) in the key that you followed to arrive at the identify of the specimen**

- |   |              |
|---|--------------|
| 1 a) leaf broad                             | go to 2      |
| b) leaf narrow                              | Araicaria    |
| 2 a) leaf parallel veined                   | Cynodon      |
| b) leaf net-veined                          | go to 3      |
| 3 a) leaf with one lobe (simple)            | go to 4      |
| b) leaf with many lobes (compound)          | Grevellea    |
| 4 a) leaf fleshy                            | Kalanchoa    |
| b) leaf not fleshy                          | go to 5      |
| 5 a) leaf petiole modified to form sheath   | go to 6      |
| b) leaf petiole not modified to form sheath | Brassica     |
| 6 a) leaf purple                            | Tradescantia |
| b) leaf green                               | Commelina    |

steps – 1a, 2b, 3a, 4b, 5b

Identify – Brassica

**v) You have been provided with four animals labeled K (mature adult housefly), L (mature adult grasshopper), M (maize flour beetle) and N (worker termite) use the dichotomous key below to identify the specimens. Write down in the correct order, the steps (number and letter) in the key that you followed to arrive at your answer.**

Dichotomous key

- |                              |         |
|------------------------------|---------|
| 1 a) animal with wings       | go to 2 |
| b) animal without wings      | go to 7 |
| 2 a) with two pairs of wings | go to 3 |

- b) with one pair of wings Diptera
- 3 a) with membranous wings go to 4
- b) hind pair of membranous wings go to 6
- 4 a) with long abdomen Odontata
- b) medium sized abdomen go to 5
- 5 a) wings with coloured scales Lepidoptera
- b) wings without scales hymenoptera
- 6 a) forewings hard and shell-like coleopteran
- b) forewings hard but not shell-like Orthoptera
- 7 a) body horizontally flattened Isoptera
- b) body laterally flattened Symphonoptera

**Identify the orders o the various specimens as per the table below**

| Specimen       | Order      | Steps followed |
|----------------|------------|----------------|
| K-housefly     | Diptera    | 1a,2b          |
| L- grasshopper | Orthoptera | 1a, 2a, 3b, 6b |
| M- beetle      | Coleoptera | 1a, 2a, 3b, 6a |
| M-termite      | Isoptera   | 1b, 7a         |

**2 a) Define the following ecological terms**

- i. Ecology**
  - study of the interrelationships between organisms and their environment
- ii. Environment**
  - surrounding of the organism i.e. biotic or a biotic factors
- iii. Habitat**
  - A specific locality (home) of a living organism with a set of factors (conditions) in which an organism lives.
- iv. Ecological niche**
  - Role of an organism in its habitat e.g. feeding relationship
- v. Population**
  - Number (group) of organisms of a species occupying a given habitat
- vi. Community**
  - Refers to different species of (plants and animals) organisms in a given habitat (area) co-existing or interacting (living) with each other and the environment in which they live
- vii. Ecosystem**
  - A community of organisms interacting with one another and the environment in which they live
- viii. Biosphere**



- The earth and its atmosphere where living organisms are found

#### **ix. Autecology**

- Study of a single (individual) species of plants or animals within a community, ecosystem, habitat or environment.

#### **x. Synecology**

- Study of natural communities (plants and animals) or populations interacting within an ecosystem.

#### **xi. Carrying capacity**

- maximum number of organisms an area can support without being depleted

#### **xii. Biome**

- geographical area with particular climatic conditions and flora and fauna
- it constitutes many ecosystems

#### **xiii. Biomass**

- dry weight (mass) of a living organism in a given area
- units of measurement are kg/m<sup>2</sup>/year

### **b) i) What are abiotic factors?**

- non-living components of the ecosystem

### **ii) Explain how abiotic factors affect living organisms**

#### **Wind**

- this influences rate of water evaporation from organisms
- therefore it affects distribution of organisms e.g. wind increases rate of transpiration and evaporation of water from the soil
- wind is an agent of soil erosion, may break and uproot trees
- may aid in the formation of sand dunes which can form habitats for some desert plants
- wind disperses fruits, seeds, spores
- wind forms waves in lakes and oceans which enhances aeration of water which replenishes oxygen concentration necessary for life
- wind is an agent of pollination

#### **Temperature**

- influences rate of enzyme action in photosynthesis and other metabolic reactions in plants and animals
- organisms function within a narrow range of temperature
- it affects distribution of organisms
- changes in temperature affect rate of photosynthesis and biochemical reactions e.g. metabolism and enzyme reaction
- temperature increases rate of transpiration

## Light

- needed by green plants and photosynthetic bacteria which are primary producers
- animals depend on plants directly or indirectly for food
- main source of light is the sun
- light is necessary for synthesis of vitamin D in certain animals
- some plants need light for flowering
- seeds like lettuce need light for germination



## Humidity

- amount of water vapour held by the air
- affects the rate at which water is lost from organisms body by evaporation and stomatal transpiration
- when humidity is low the rate of transpiration increases
- humidity influences distribution of organisms

## PH

- each plant requires a specific PH in which to grow (acidic, neutral or alkaline)
- pH affects enzyme reaction in metabolism

## Salinity

- some ions are needed for plant and animal nutrition
- osmoregulation in plants and animals is affected by salinity

## Topography

- altitude affects light, atmospheric pressure and light
- Slope influences surface runoff, wind erosion, etc.
- mountains affect distribution of organisms which differs in leeward side and windward side
- mountains affect distribution of organisms which differ on lowlands and on highlands
- mountains also form physical barriers to migration of organism and may cause isolation of species
- background may offer camouflage to some organisms hence protection from enemies

## Rainfall (water) or precipitation

- amount and distribution of rainfall affect vegetation type
- this consequently affects distribution of animals e.g. polar region water frozen hence only well adapted organisms survive
- fewer organisms found in deserts where rainfall is less
- Water is required for seed germination, raw material for photosynthesis, solvent for mineral salts. Provides turgidity

for plant support, medium for transport, disperses fruits, seeds and spores

## Pressure

- the weight atmosphere exerts upon the earth
- varies with altitude (the higher the altitude the less the pressure)
- this variation implies change in density which directly means less oxygen for respiration and less carbon iv oxide for photosynthesis and this affects distribution of organisms



## Mineral salts (trace elements)

- these affect distribution of plants in the soil
- plants thrive best where elements are available
- Plants living in soil deficient in a particular element must have special methods of obtaining it.
- They harbor nitrogen fixing bacteria and others have carnivorous habit
- Plant distribution influences animal distribution

### c) i) What are biotic factors?

- refers to living organisms in an area
- biotic environment of an organism constitutes all organisms around it, which it relates or interacts with in various ways

### ii) Give examples of biotic factors affecting ecosystems

- feeding relationships
- predation
- competition
- diseases and pests
- human activities

### d) Discuss how the various biotic factors affect living organisms

#### i. Competition

- organisms compete with one another for food, light, water, mates and shelter
- organisms must live together for competition for available resources
- those which cannot cope either structurally or behaviorally will migrate or die
- those remaining, due to better adaptations will increase in population
- competition between members of the same species is called intra-specific competition e.g. for mates
- Competition between members of different species is inter specific competition e.g. for food and space.

## ii. Predation

- this is predator-prey relationship
- predator feeds on prey hence both control the other's population
- Distribution of predator and prey is important as predator cannot survive without prey
- If there is no predator the prey will increase in population beyond carrying capacity hence die due to environment depletion



## iii. Parasitism

- an association where an organism lives in or on another living organism obtaining food (and other benefits) from it, causing harm to it (without necessarily killing it)
- parasites may kill host
- they deprive host of food
- make host weak by introducing diseases
- make reproductive ability of host low hence host becomes susceptible to predation

## iv. Diseases and parasites

- make organisms weak and susceptible to predation
- kill organisms and reduce their population

## v. Symbiotic

- an association of organisms of different species where both benefit from the association i.e. there is mutual benefit

## vi. Human activities

- these are human factors which have an influence on the biosphere
- examples are road construction, industrialization, deforestation, agriculture, pollution, poaching, fishing conservation, population control
- affect ecosystem and balance of nature

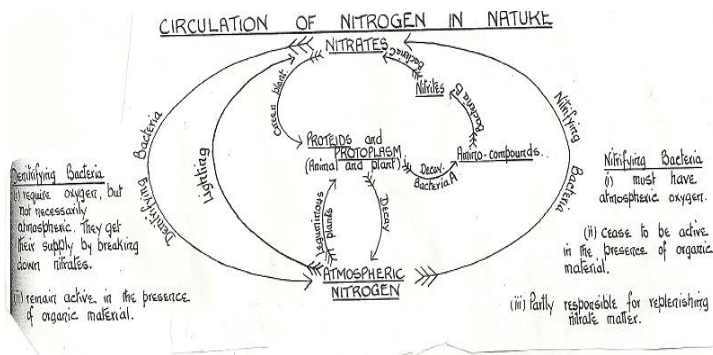
## Saprophytism

- saprophytes are organisms which obtain organic matter in solution from dead and decaying tissues of plants and animals
- they include saprophytic bacteria and fungi
- they make available carbon, nitrogen and other elements from dead to living organisms
- they are useful in recycling nutrients in nature

## e) i) What is nitrogen cycle?

- The process by which nitrogen in the air is made available to plants and animals and eventually returns to the air.

## ii) Draw a simplified diagram representing the nitrogen cycle



## iii) Describe the nitrogen cycle

- during thunderstorms/lightning nitrogen gas combines with oxygen to form nitrogen oxides
- nitrogen oxides dissolve in water to form nitric acid
- acid is deposited in the soil by rain
- nitric acid combines with chemical substances to form nitrates or nitric acid dissociates to form nitrates which are absorbed by plants
- symbiotic bacteria (Rhizobium) which are found in root nodules of leguminous plants fix free nitrogen to nitrates
- free living bacteria (clostridium and Azotobacter) fix nitrogen to nitrates
- nostoc algae (Anabaema chlorella) fix nitrogen to nitrates
- plants use nitrates to form plant proteins
- animals feed on plants and convert plant proteins into animal proteins
- plants and animals die and are decomposed by putrefying bacteria, fungi(saprophytes)
- decomposing plants, animals and nitrogenous wastes release ammonia which is converted to nitrites by Nitrosomonas and nitrococcus bacteria
- nitrites are converted to nitrates by nitrobacter bacteria
- nitrates in the soil can be converted to free nitrogen (denitrification) by some fungi, pseudomonas and theobacillus bacteria generally called denitrifying bacteria

### iii. Nitrogen in the atmosphere cannot be directly utilized by plants. State two ways by which this nitrogen is made available for plant use

- fixation by microorganisms (Rhixobium, Axotobacter)
- fixation by electrical discharge in atmosphere i.e. conversion by thunderstorm or lightning

## f) i) Describe how energy flows from the sun through the various trophic levels in an ecosystem

- energy from the sun is trapped by green plants during photosynthesis, producing chemical energy (food or carbohydrates)
- green plants are producers and occupy the first trophic level
- green plants are eaten by herbivores called primary consumers as they occupy the second trophic level
- herbivores are eaten by carnivores, secondary consumers, which occupy the third trophic level
- when organisms (plant and animals) die, fungi and bacteria which are saprophytic organisms feed on them thus causing them to decompose into simple substances e.g. mineral salts
- these organisms are called decomposers and detritivores
- decomposers feed on dead organic matter hence cause decomposition and decay which releases nutrients for plants, linking biotic and abiotic components
- at all levels energy is lost through respiration

### Give the reasons for loss of energy from one trophic level to another in a food chain

- insufficient utilization of food resources (wastage) e.g. by defecation
- through respiration
- through excretion e.g. urination and sweating

### Why are green plants referred to as primary producers in an ecosystem?

- They utilize the energy from the sun to manufacture food for themselves and for subsequent trophic level (consumers) and other organisms

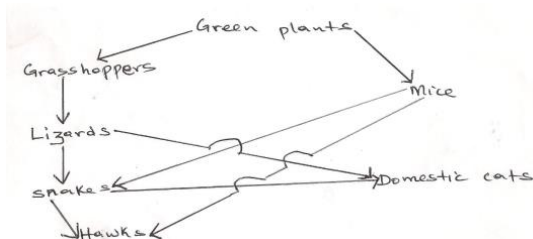
### vi. Explain the following terms giving suitable examples Food chain

- a nutritional sequence between producers and consumers through which energy flows in a straight line i.e. linear representation of feeding relationship between different organisms in an ecosystem
- if one consumer or the producer is removed the food chain is broken
- arrow points to the direction of energy flow e.g. green plant herbivore carnivore decomposer

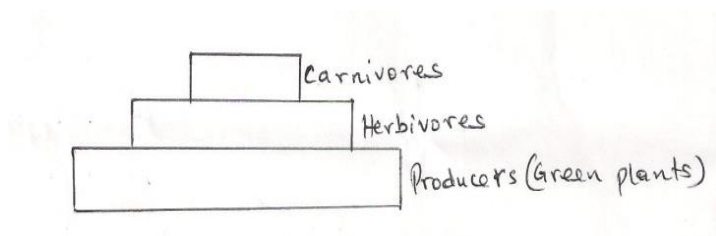
Green plants → herbivores → Carnivores

### Food web

- complex feeding relationship where a consumer feeds on more than one type of food while several herbivores feed on one type of plant
- it is an interrelationship of many food chains
- consumers are usually fewer than producers to ensure survival of both

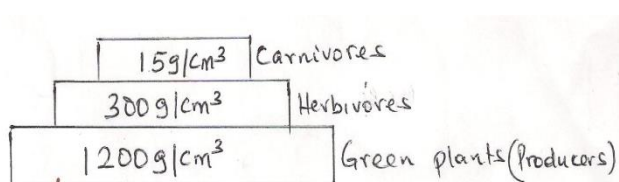


## Pyramid of numbers



- this is a diagrammatic representation of numbers of organisms at each trophic level in a food chain
- usually there are more producers than consumers
- hence producers herbivores carnivore
- the reason for the pyramid is because herbivores feed on many plants (producers) as carnivores feed on many herbivores
- sometimes this may not be true e.g. when many caterpillars feed on one tree or parasites on a herbivore
- this gives an inverted pyramid of numbers

## Pyramid of biomass



- refers to diagrammatic representation total dry weight of organisms at different trophic levels in a food chain
- producers have greater biomass than any level of consumers progressively
- size of organisms in successive e trophic levels increases
- amount of individuals decreases in successive levels

## Account for the decrease of biomass in the successive trophic levels

- fixed energy which supports living matter decreases at each successive trophic level since energy is lost by respiration and indigested (unconverted) materials hence less biomass supported at each level

## **h) i) Describe the three characteristics of a population growth**

- increase in numbers
- decrease in numbers/growth rate
- change in numbers

### **Dispersion**

- spread or distribution of organisms in a habitat

### **Density**

- the number of individuals per unit area

## **ii) Explain how the following methods are used to estimate population of organisms**

### **quadrat method**

- identify the study area
- throw or mark out the quadrat in the area of study at random
- identify or label the various species of plants in the quadrat
- count plants of each species
- record the numbers
- repeat the process
- work out the average per quadrat for each species
- calculate the total number of different species in the area or calculate the population for the total area of habitat

### **Line transect**

- a string is stretched along an identified area
- all plants touching the string are counted

### **Belt transect**

- preliminary study of the study area to estimate size or make a sketch map
- two parallel lines (strings or ropes) running for a determined distance and width
- count the number of organisms in the transect
- calculate the area covered by the transect
- calculate the number of organisms being investigated per unit area
- repeat this process at least three times in other parts of the study area
- find the mean number of organisms per unit area from all the belt transects



- from this figure calculate the total population of the desired organisms in the study area.

### **Capture-recapture method**

- e.g. grasshoppers or fish
- capture the grasshoppers
- count and mark using permanent ink
- record
- release and allow time
- recapture and count the marked and unmarked
- total population is equal to the number of marked and unmarked grasshoppers in the second sample multiplied by the number of marked grasshoppers in the first sample divided by number of grasshoppers marked in the second sample that were recaptured



## **2. a) Describe the adaptations of plants to various habitats**

### **i. Xerophytes**

- grow in areas with scarcity of water
- roots grow deeply and extensively (widely spread) to ensure access to water
- thick succulent stems, roots and leaves for water storage
- photosynthetic stems take place of leaves which would lose a lot of water
- Leaves are needle-like (reduced to spines), scaly, have sunken stomata. Some have curled (rolled) leaves. Some have thick waxy cuticle, reduced number of stomata to reduce water loss by transpiration
- some shed leaves during dry season to reduce water loss
- presence of thorns for protection
- short life cycle to ensure survival
- reversed stomatal rhythm

### **ii. Hyrophytes**

- grow in places with plenty of water (waterlogged)
- aerenchyma a tissue (airspaces) and large intercellular spaces and long fibrous roots for buoyancy (floating in water)
- poorly developed support tissues (sclerenchyma) because water provides the necessary support
- upper epidermis of leaves have more stomata than lower epidermis for gaseous exchange or for increased rate of transpiration

- poorly developed conducting tissues (xylem and phloem) because plants obtain water by diffusion

### iii. Mesophytes

- grow in well watered soils (common plants)
- no special adaptations, but depending on particular habitat may have some adaptations
- in forests they grow fast, tall to capture light. Have climbers while some are adapted to carry out photosynthesis in low light intensities (those that form undergrowth)
- in places with adequate water they form broad leaves, thin cuticle and many stomata on both leaf surfaces
- in drier regions they possess more stomata on the lower leaf surface and are deep rooted
- some are shallow rooted and develop buttress and prop roots for support
- some have waxy or glossy surface to reflect sun rays and drip off rain water

### iv. Halophytes

- plants that grow in very salty soil where the salt concentration is higher than that in the plant
- have root cells which concentrate a lot of salts in them and enable them to take in water by osmosis
- succulent roots to store water
- have pneumatophores (breathing roots) to take in oxygen
- some have buttress roots for support
- secrete excess salt by use of salt glands
- have large airspaces in leaves and stems for buoyancy and to store air
- capable of photosynthesis at low light intensities
- e.g. mangrove

### b) i) What is pollution?

- any process which leads to adverse or harmful changes in the environment

### ii) Explain the various human activities that have caused pollution

#### Causes and effects of air pollution

- sulphur iv oxide, hydrogen sulphide, chlorine, oxides of nitrogen produced by industries, sewage, decomposing organic matter and fumes affect gaseous exchange, makes acid rain and damage plant leaves

- aerosols, herbicides, insecticides (agrochemicals), paint spays, acaricides and CFC's sprayed to control diseases, pests and weeds affect respiratory organs of animals. The chemicals are residual and persistent (not easily broken down) and bring depletion of the ozone layer
- smoke and fumes produced in areas with heavy industries, motor vehicles, fires which burn fuel, oil, wood and coal cause carbon ii oxide, poisoning affect respiratory systems and affect visibility
- particles in smoke and fumes settle on leaves and stop photosynthesis
- carbon iv oxide causes green house effect which causes temperature inversion as a result of heating the lower layers of atmosphere
- sound and noise produced incessantly by machines, aeroplanes and heavy vehicles affect hearing in animals
- dust from cement factories, quarries, dust roads settles on leaves limiting photosynthesis
- removal of vegetation interferes with carbon cycle
- radio-active emissions from nuclear reactors, mines and bombs cause cancer, mutations and death.

### **Control of air pollution**

- use of lead free petrol in motor vehicles, air craft, aeroplanes and petroleum engines
- uses of smokeless fuels and electricity
- filtration, dissolution and use of chemicals to remove harmful gases
- factories should be erected far away from residential areas
- use of tall chimneys
- reduce volume or intensity of sound e.g. by use of ear muffs
- concords should fly at higher altitudes and aeroplanes to fly high up

### **State the causes, effects and methods of controlling and prop roots for support water pollution**

#### **Causes and effects**

- agrochemicals e.g. fertilizers cause eutrophication leading to increase in animal population
- Silting makes water surfaces shallow and silt clogs stomata and gills of fish reducing rates of photosynthesis and

gaseous exchange. It also leads to reduction of algae which causes reduction of consumers i.e. animal population

- industrial and domestic wastes contain toxic materials which kill producers and other organism while oily substances in wastes may clog gills of fish and may change pH of water oxygen solubility is also reduced by oily surfaces
- Untreated sewage and effluents where decomposition of organic matter in sewage reduces oxygen supply and sewage provides food for bacteria increasing their population and demand for oxygen thus depriving fish of oxygen.
- Human faeces causes eutrophication, carbon IV oxide produced by decomposition of faecal matter changes pH of water interferes with photosynthesis and may clog fish gills or block light penetration which interferes with producers thereby decreasing productivity.
- Dumping of chemicals from industries with toxic pollutants which kill organisms
- Spillage of oil and chemicals block oxygen and kill organisms
- Discharge of water from industries into water body where high temperatures reduce amount of oxygen in the water causing organism to suffocate and die
- Untreated sewage may lead to outbreak of epidemics

### **Control of water pollution**

-pollution caused by domestic effluents may be controlled by treating domestic waste, using biotechnology, banning the use of phosphate-based detergents, using plastic pipes instead of those made from lead, recycling garbage, using biodegradable detergents.

Pollution caused by industrial waste may be controlled by treating/cooling industrial waste, carrying out environmental impact assessment before establishing industries

Oil spillage may be controlled by cleaning spilled oil biotechnology and penalizing the industry individual or companies which cause oil spills/water pollution

Pollution caused by agrochemicals may be controlled by using mechanical control of weeds, biological control of weeds and pests, biodegradable organic fertilizer herbicides, insecticides pesticides, organic farming educate farmers on the use of correct amount of agrochemicals

- silting may be controlled by appropriate farming practices, contour farming, reforestation, building gabions and terracing

#### iv) State the causes /effects and control methods of soil pollution

##### Causes and effects

- Air pollutants e.g. sulphur IV oxide fumes from sulphuric acid with rain water. The acid rain alters soil pH therefore affecting plants that cannot tolerate acidic soil
- most aerosols sprayed to control pests and diseases precipitate in the soil and are taken up by plants which make its concentration many times higher, increasing the toxicity in the plants which absorb them
- petroleum products due to spillage by oil tankers making it impossible for plant roots to obtain oxygen in oil saturated soils, therefore plants are killed
- agrochemicals and inorganic fertilizers contain heavy metals that are not used up by plants and eventually soil microorganisms cannot inhabit the soils
- organic matter slows down, life ceases and soil becomes exhausted
- community, household wastes and industrial wastes disposal is a major problem in big towns and cities. commodities packaged in metal tins, rubber, plastic containers, scrap metal, glass bottles, different types of paper are nuisance to the environment, rendering it useless for agricultural purposes

##### Control of soil pollution

- use of organic farming techniques
- biological control of pests, diseases, parasites
- recycling of non-degradable containers or burying them safely after use
- controlled burning of garbage
- treatment of human and industrial waste for safe disposal
- avoid spilling chemicals and oil when used

#### v) Define biological control give suitable examples

- using a living organism to regulate, control or reduce the population of another organism e.g beetles to feed on water hyacinth, fish to feed on mosquito larvae.

#### vi) What is eutrophication?

- enrichment of water bodies with nutrients due to discharge of sewage leading to rapid growth of surface plants

**viii) What are the effects of eutrophication?**

- enrichment of water bodies with nutrients due to discharge of sewage leading to rapid growth of surface plants

**vii) What are the effects of eutrophication?**

- The plants block light from reaching plants underneath hence no photosynthesis

The plants die and decompose leading to lack of oxygen hence animals also die

**c) Describe the symptoms, mode of transmission and control of cholera, typhoid malaria and amoebic dysentery in humans**



| Disease | Causative agent              | Transmission  | Symptoms  | Control  |
|---------|------------------------------|---|---|--|
| Cholera | Vibrio cholerae (bacterium)  | Contaminate food or water<br>Spread by flies from faeces  | Intestinal pain<br>Diarrhea<br>Vomiting<br>Dehydration  | Proper hygiene e.g. boiling drinking water<br>Vaccination  |
| Typhoid | Salmonella typhi (bacterium) | <ul style="list-style-type: none"> <li>• contaminated food or water</li> <li>• spread by flies from faeces</li> </ul> | <ul style="list-style-type: none"> <li>• fever</li> <li>• rashes</li> <li>• diarrhea + blood from bowels</li> </ul> | <ul style="list-style-type: none"> <li>• proper sanitation</li> <li>• vaccination</li> </ul>   |
| Malaria | Plasmodium (protozoa)        | - bite by infected female anopheles mosquito  | - fever<br>Joint pains<br>Vomiting<br>Headache<br>Anaemia   | <ul style="list-style-type: none"> <li>• killing mosquito</li> <li>• killing the mosquito larvae</li> <li>• draining stagnant water</li> <li>• clearing</li> </ul> |

|                                |                                   |   |  |   |
|--------------------------------|-----------------------------------|---|--|---|
|                                |                                   |   |  | <ul style="list-style-type: none"> <li>g bushes</li> <li>• treatment</li> <li>• sleep under mosquito net</li> </ul>                                   |
| Amoebic dysentery (amoebiasis) | Entamoeba histolytica (bacterium) | - contaminated food or water due to improper disposal of faeces | - intestinal pain<br>Diarrhea<br>Vomiting<br>Dehydration | <ul style="list-style-type: none"> <li>• sanitation</li> <li>• personal hygiene</li> <li>• cook food well</li> <li>• treatment using drugs</li> </ul> |

**d) Discuss Ascaris lumbricoides under the following sub-headings**

**i. Mode of transmission**

- through ingestion of contaminated food
- live in intestines

**ii. Effects of parasite on the host**

- inflammation of lungs
- pneumonia
- produce toxic substances
- intestinal obstruction

**iii. Adaptations**

- thick cuticle which protects it against digestion
- lays many eggs to ensure survival
- mouthparts for sucking partly digested food
- lack of elaborate alimentary canal
- tolerant to low oxygen concentration
- two hosts to ensure survival
- eggs have protective cover to ensure survival in adverse environments

**iv. Control and prevention**

- proper sanitation

- wash hand after defaecation and before eating

**e) Discuss schistosoma under the following sub-headings**

**i. Mode of transmission**

- through contaminated water in swamps, etc

**ii. Effects on host**

- bleeding in lungs
- blood stained urine
- unthriftiness

**iii. Adaptations**

- has two hosts to increase chances of survival
- eggs have a hook like structure which ruptures the walls of intestine or bladder
- lay large number of eggs to ensure survival
- larvae have a sucker for attachment on human skin which it digests
- larva has a tail which it swims with in search of host in water
- prolonged association between male and female to ensure that fertilization takes place
- adults can tolerate low oxygen concentration (in the animal tissues)
- adult worm secretes chemicals against antibodies
- larvae and eggs (have glands that) secrete lytic enzymes to soften the tissues that ease penetration
- larvae are encysted so as to survive adverse conditions

**iv) Control and prevention**

- proper use of toilet facilities
- boiling water before use
- avoid bathing/washing in infected water
- Use of molluscicides (chemicals that kill snails/biological control/clearing water weeds on which snails feed.
- Drainage of stagnant water

**3. Wearing gum/rubber boots**

**a) i) What is reproduction?**

- process by which living organisms give rise to new members of their own species which resemble the parents

**ii) Why is reproduction important?**

- for continuity of species/ to ensure survival of species
- maintaining life of species
- replace dead individuals

**iii) Name the types of reproduction**



- sexual which involves fusion of male and female gametes
- asexual in which no gametes are involved but parts of a mature organism develops into new individuals

### b) i) What is cell division?

- process by which cells are formed from pre-existing cells



### ii) What are chromosomes?

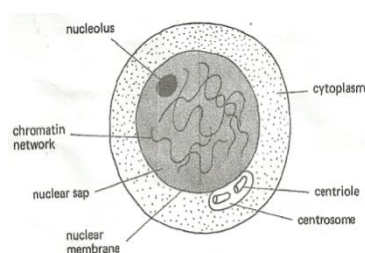
- Threadlike structures found in nucleus of a cell.
- The units called genes
- Genes are factors that cause inheritance or determine characteristics of offspring

### c) i) What is mitosis?

- A type of cell division that occurs during growth leading to increase in number of cells
- all cells maintain the same chromosome constitution i.e. the diploid state

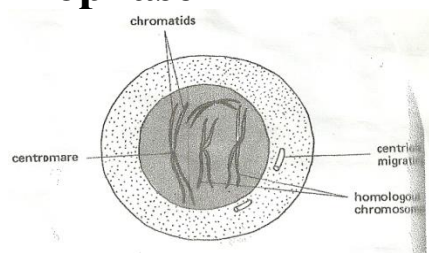
### ii) Describe the five stages of mitosis

#### Interphase



- replication of organelles
- duplication of DNA
- production of energy (ATP) for cell division

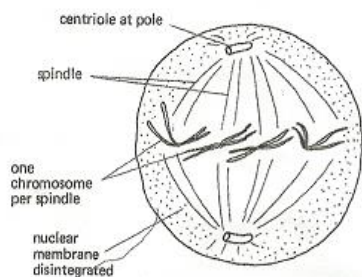
#### Prophase



- stage of dehydration
- chromosomes shorten and thicken
- chromosome replicates into two chromatids
- chromatids joined at centromere
- formation of spindle fibers

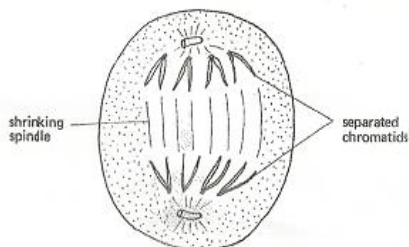
#### Metaphase

- chromosomes move to equator (early metaphase)
- chromosomes line up at the equator
- homologous chromosomes do not associate

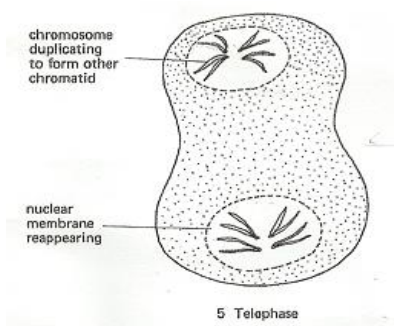


## Anaphase

- chromatids separate
- move to opposite ends (poles) of the cell



## Telophase



- chromatids reach the poles
- formation of two daughter cells occurs i.e. cytoplasmic division

### ii) State the significance of mitosis

- ensures each daughter cell has same number and kinds of chromosomes as daughter cells
- gives rise to new cells (responsible for growth)

### d) i) What is meiosis?

- division of diploid cells to form gametes which are haploid

### ii) State the significance of meiosis

- gives rise to gametes
- source of variation

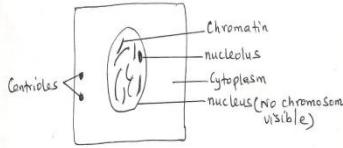
### iii) Give a summary of the stages of meiosis

#### First meiotic division

##### Interphase

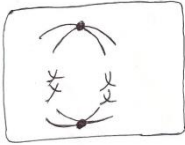
- cell is in non-dividing condition

- chromosomes appear threadlike



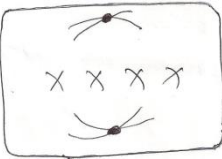
## Prophase I

- chromatic material shorten and thicken
- double stranded chromosomes appear (bivalent)
- double stranded chromosomes pair and twist round each other (synapsis)
- point of contact of chromosomes is called chiasma



## Metaphase I

- paired homologous chromosomes line up at the equator



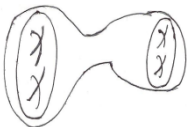
## Anaphase I

- paired homologous chromosomes move to the poles



## Telophase I

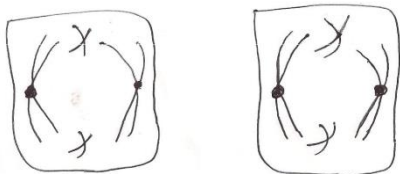
- paired homologous chromosomes reach the poles
- two new nuclei are formed



## Second meiotic division

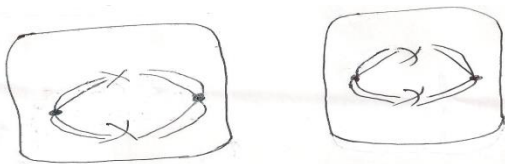
### Prophase II

- chromosomes shorten, thicken and become visible,
- stage of dehydration



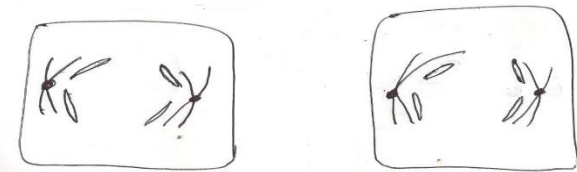
### Metaphase II

- movement of chromosomes to equator



## Anaphase II

-chromatids of each chromosome separate to the poles



## Telophase II

- reach the poles
- four haploid daughter cells are formed



### iv) Give the similarities between mitosis and meiosis

- both take part in cells
- both involve division (cell multiplication)

### v) What are the differences between mitosis and meiosis?

| Mitosis  | Meiosis   |
|--|---|
| <ul style="list-style-type: none"> <li>• maintenance of chromosome number (diploid)</li> <li>• takes place in somatic cells/growth</li> <li>• no crossing over/no variations</li> <li>• results into 2 daughter cells</li> <li>• no pairing/no synapsis/no bivalent formed</li> <li>• a one division process of four stages</li> </ul> | <ul style="list-style-type: none"> <li>• reduction/halving of chromosomes (haploid)</li> <li>• occurs in reproductive cells/gonads/produces gametes</li> <li>• crossing over takes place/variation occurs</li> <li>• results into 4 daughter cells</li> <li>• there is pairing/synapsis/bivalent</li> <li>• a two division process of four stages each</li> </ul> |

### d) i) What is asexual reproduction

- formation of new individuals as a result of the fusion of two gametes
- fusion is called fertilization

**ii) What is the significance of sexual reproduction in living organisms?**

- leads to genetic variation e.g. cross breeding which gives rise to hybrids

**iii) State the advantages of sexual reproduction**

- genetic variation
- greater adaptability to environment by offspring
- few bad or good traits inherited/retained
- greater amount of dispersal is possible
- may result in stronger offspring

**iv) Give the disadvantages of sexual reproduction**

- less certainty in egg and sperm meeting
- low rate of survival
- sex-linked diseases easily transmitted

**e) i) What is asexual reproduction?**

- formation of new organisms without fusion of gametes
- occurs with only one parent
- parts of organism develop into new individual

**ii) State the advantages of asexual reproduction**

- retention of useful characteristics/genes/traits
- offspring establish faster/shorter life cycle
- better chances of survival because of suitable environment

**iii) Give the disadvantages of asexual reproduction**

- lack of genetic variation
- lowered resistance to disease
- loss of hybrid vigor
- competition for resources due to overcrowding

**iv) Explain how reproduction occurs by the following methods of asexual reproduction**

**Sporulation**

- formation of spores
- spores are small haploid cells produced by plants
- spores give rise to new haploid organisms
- includes moulds, ferns, bryophytes, pteridophytes

**Budding**

- where an outgrowth arises from a parent and drops off to develop into a new organisms
- hereditary material in the daughter cell and parent are exactly the same
- occurs in organisms such as hydra, jelly fish, sea anemones, yeast and some fungi

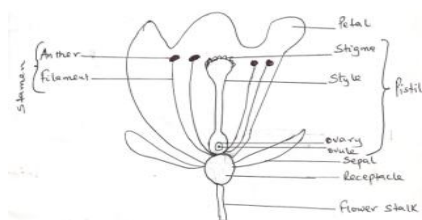
**Binary fission**

- a cell splits into two new cells of equal size
- each daughter cell grows into a new organism
- Occurs in organisms such as amoeba, euglena, paramecium, some fungi and bacteria.

### f) i) What is a flower?

- this is the reproductive structure which bears the reproductive parts of a plant
- it produces seeds and fruits

### ii) Draw a longitudinal section of a labeled diagram of a flower



### iii) Give the functions of the parts of a flower

#### Receptacle

- expanded end of stalk which bears floral parts

#### Calyx

- consists of sepals
- usually green
- protect flower in bud

#### Corolla

- consist of petals
- often colored or scented to attract insects

#### Androecium

- male part of flower
- consist of stamens
- each stamen consists of an anther containing pollen sacs
- another produces pollen grains which contain male gametes

#### Gynaecium

- female part of flower
- consists of one or more carpels
- each carpel contains one or more ovules in an ovary
- style bearing a stigma extends from ovary
- ovary contains female gametes which when fertilized become seeds

### iv) What is inflorescence?

- a group of flowers borne on the same branch (main stalk)

### v) Explain the meaning of the following terms which describe flowers

#### Hermaphrodite

- one with both stamen and carpel
- most flowers are hermaphrodite/bisexual

### **Unisexual**

- have only one of carpel or stamen i.e. either male or female

### **Carpelate**

- also called pistilate
- contains only carpels hence a female flower

### **Staminate**

- also called male flower
- contains only stamens

### **Dioecious plants**

- have pistilate and staminate flowers on different plants e.g. pawpaw

### **Monoecious plants**

- have pistilate and staminate on one plant
- however, pistilate and staminate occur at different plants e.g. maize

### **Complete flower**

- Has all four parts i.e. Calyx, corolla, androecium and gynoecium

### **Incomplete flower**

- does not have all four parts
- at least one is missing

### **vi) Explain the meaning of the following types of ovary**

#### **Superior**

- ovary occurs above other floral parts on the receptacle

#### **Inferior (epigynous)**

- other floral parts arise above ovary on the receptacle

### **g) i) What is pollination?**

- transfer of pollen grains from anther of a stamen to stigma of a flower

### **ii) Explain the types of pollination**

- self pollination takes place when mature pollen grains of a flower fall on the stigma of the same flower
- cross pollination takes place when pollen grains of a flower fall on the stigma of another flower of the same species

### **iii) State the advantages of pollination**

- healthy offspring
- leads to variation
- greater chances of dispersal

### **iv) List the agents of pollination**

- wind
- water
- insects

**v) How are flowers adapted to wind and insect pollination?**

**Insect pollinated flowers (entomophilus)**

- are scented to attract insects
- have stick stigma for pollen grains to stick on
- are brightly coloured to attract insects
- presence of nectar to attract insects
- have nectar guides to guide insects to the nectarines
- have nectarines to secrete nectar
- stigma/ anthers located inside the flower/tubal/funnel shaped corolla to increase chances of contact by insects
- sticky/spiny/spiky pollen grains which stick on the body of insects and on stigma
- large/conspicuous flowers easily seen by/attract insects
- anthers firmly attached to the filament for insects to brush against them
- landing platform to ensure contact with anthers and stigma
- mimicry to attract (male) insects

**Wind pollinated flower (anemophilus)**

- anthers/stigma hang outside the flower to increase chances of pollination
- the style/filament is long to expose stigma/anthers
- stigma is hairy/feathery/branched to increase surface area over which pollen grains land/to trap pollen grains
- pollen grains are smooth/dry/light/small to be easily carried by wind
- large amount of pollen grains to increase chances of pollination
- anthers loosely attached to filaments to enable them to sway to release pollen grains
- pollen grains may have structures which contain air to increase buoyancy
- flowers have long stalks holding them out in the wind

**vi) State the ways in which plants prevent self-pollination**

- protandry (anthers/stamens mature first)
- protagyny (pistils mature first)
- monoecism (where male and female parts are on same plant but different parts)



- dioecism (where male and female parts are on different plants)
- incompatibility (self sterility)
- heterostyly (styles at different heights)

**vii) Give the characteristics that ensure cross pollination takes place in flowering plants**

- presence of special structures that attract agents of pollination
- protandry/dichogamy
- protogyny/dichogamy
- monoecism
- self sterility
- heterostyly

**viii) State the advantages of cross pollination**

- hybrid vigour
- less prone to diseases
- promotes genetic variation
- greater evolutionary potential

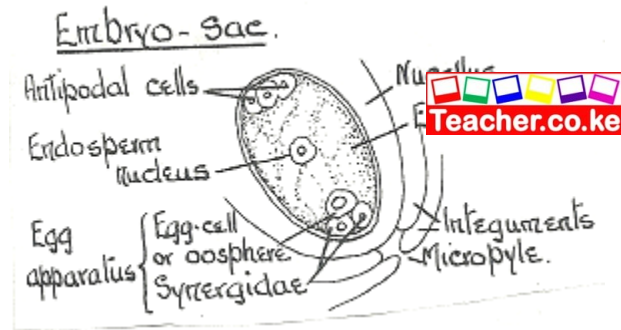
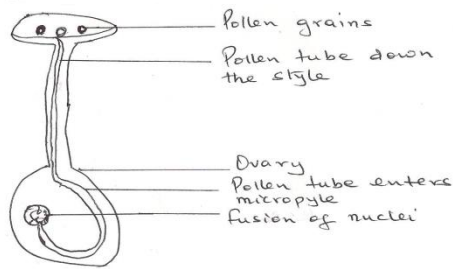
**h) i) What is fertilization?**

- Fusion of male and female gametes to form a zygote

**ii) Describe how fertilization takes place in a flower**

- this follows pollination
- pollen grain is deposited on the stigma
- pollen grain sticks to the surface of the stigma
- the surface of the stigma produces a chemical substance which stimulates the pollen grain to produce a pollen tube/to germinate
- the pollen tube grows through the style tissues on which it feeds until it enters the ovary
- the generative nucleus divides into two giving two male nuclei
- embryo sac contains eight nuclei i.e. two synergids, egg cell, two polar nuclei and three antipodal cells
- the pollen tube enters the embryo sac through the micropyle and one of the male nucleus fuses with the egg cell/ovum to form a zygote
- the other male nucleus fuses with the two polar nuclei to form the triploid nuclei (endosperm) food storage used by developing embryo)
- the pollen tube nucleus in the pollen tube disintegrates soon afterwards
- this process is referred to as double fertilization

- zygote grows into an embryo containing plumule, radicle and cotyledons



### iii) What is double fertilization?

- there are two male nuclei entering embryo sac
- one fuses with the ovum to form a zygote, while the other fuses with the polar nuclei to form a triploid primary endosperm nucleus
- therefore there are two fusions at fertilization

### iv) Name the changes that Occur in a flower after fertilization

- petals, stamen, calyx and style wither
- ovary wall changes into pericarp
- intergument changes into seed coat/testa
- zygote changes into embryo (by mitosis)
- primary endosperm nucleus changes into endosperm
- whole ovule changes into seed
- ovary develops and grows into fruit (under the influence of gibberellic hormone)

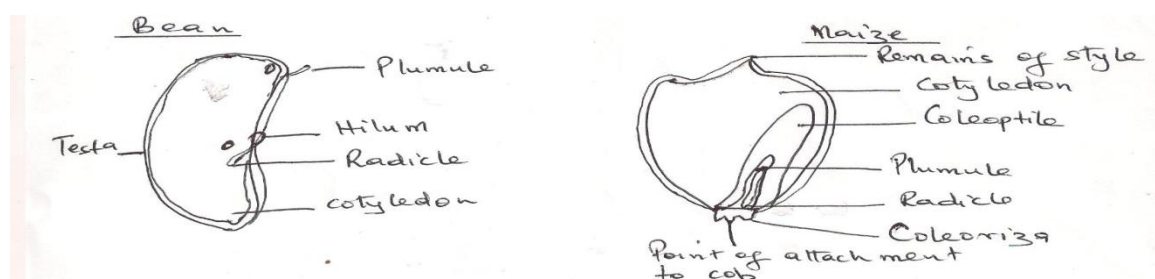
### j) i) Distinguish between a fruit and a seed

- a fruit is a fertilized ovary and has two scars
- a seed is a fertilized ovule and has one scar

### ii) How is a seed formed?

- after fertilization, zygote grows into an embryo, primary endosperm nucleus developed into endosperm, interguments harden to form testa, hence the whole ovule becomes the seed
- the seed loses water to become drier
- the seed has plumule, radicle, seed leaves called cotyledons, a micropyle and a scar

### iii) Draw a labeled diagram of a seed



#### iv) Describe the main parts of a seed

##### Testa

- also called seed coat
- a tough outer covering which protects the seed from insects, bacteria etc
- segment is the membrane inside the testa

##### Hilum

- a scar
- spot where the seed was attached to the fruit or pod

##### Micropyle

- small hole through which water and air enter the seed

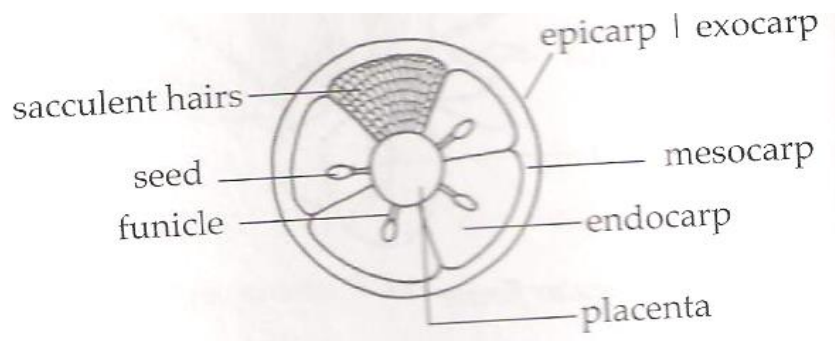
##### Radicle

- embryonic root
- grows into the shoot system

##### Cotyledons

- embryonic leaves
- store food for the germinating seed i.e. for plumule and radicle
- when plumule and radicle grow, they use food stored in the cotyledon
- in some seeds food is stored in the endosperm

#### v) Draw a labeled diagram of a fruit



#### vi) How is a fruit formed?

- one of the organs that remains on the plant after pollination and fertilization is the ovary
- within the ovary, the developing embryo produces special chemical substances that stimulate the young ovary
- these substances also signal the start of the formation of the fruit, which is a mature ovary
- the fruit may contain one or more seeds
- during fruit formation the ovary increases in size while ripening or maturing
- a true fruit is formed from the ovary of a flower after fertilization

- it has two scars(style scar and stalk scar) and contains seeds
- some seeds are not formed from the ovary of a flower
- some other parts of a flower develop to form a fruit
- such fruits are called false fruits

**vii) Explain the importance of fruits in the survival of plant.**



- protect the seed against desiccation, predators and adverse conditions
- aid in seed dispersal by attracting agents of dispersal
- stores food for the plant

**vii. Distinguish between parthenogenesis and parthenocarpy**

- parthenogenesis is development of new animals from unfertilized eggs
- parthenocarpy is development of a fruit without fertilization

**iv) State the differences between a seed and fruit**

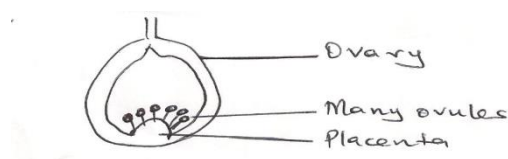
| Seed   | Fruit  |
|--|--|
| <ul style="list-style-type: none"> <li>• fertilized ovule</li> <li>• attached to placenta through funicle</li> <li>• one scar called hilum</li> <li>• has seed coat/testa</li> <li>• seed wall undifferentiated</li> </ul> | <ul style="list-style-type: none"> <li>• fertilized ovary</li> <li>• attached to branch through a stalk</li> <li>• two scars (style scar and stalk scar)</li> <li>• has fruit wall/pericarp</li> <li>• fruit wall is differentiated</li> </ul> |

**j. i) What is placentation?**

- arrangement of ovules within the plant ovary

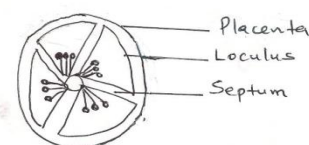
**ii) Explain the following types of placentation**

**Marginal**



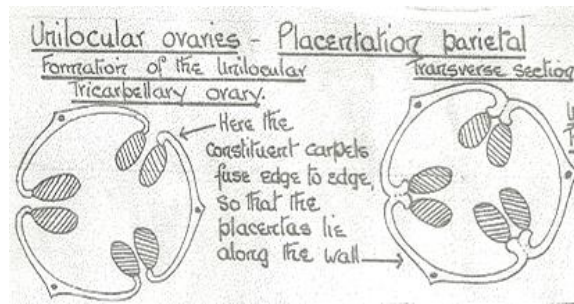
- placenta appears as one ridge on ovary wall
- ovules are attached to placenta in rows e.g. peas in a pod

**Basal**



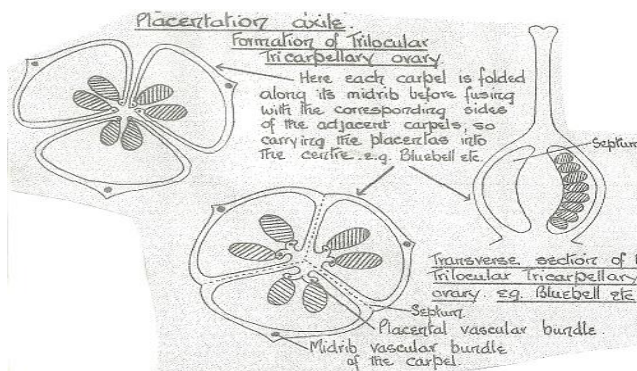
- placenta formed at the base of the ovary with numerous ovules attached to it

## Parietal



- edges of carpels fuse together
- dividing walls disappear, leaving one loculus
- have numerous seeds e.g. passion fruit
- placenta of each carpel appears as ridges on ovary wall

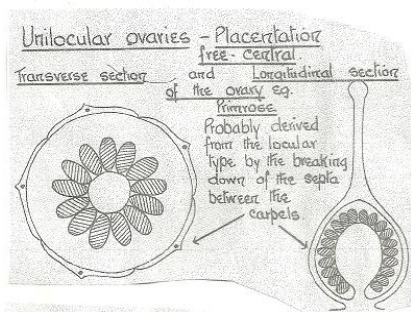
## Axile



- edges of carpels fuse together to form a single central placenta

- numerous ovules arranged on placenta
- ovary divided into a number of loculi by walls of the carpel e.g.

## Free central placentation



- edges of carpels fuse together
- dividing walls disappear leaving one loculus
- placenta appears at base of ovary
- has numerous ovules

## k) i) How are fruits grouped?

### Simple fruits

- formed from a single flower or one ovary e.g. mango

### Aggregate fruits

- consists a group of ovaries that appear on a common receptacle e.g. strawberry

### Multiple (compound) fruits

- formed from several flowers whose ovaries fuse together after fertilization

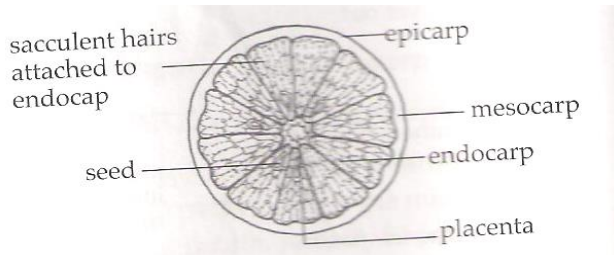
- form a bunch e.g. pineapple, figs
- are always false fruits

## ii) What are succulent fruits?

- also called fleshy fruits
- all or part of pericarp (fruit wall) becomes juicy

## iii) Give types of juicy fruits

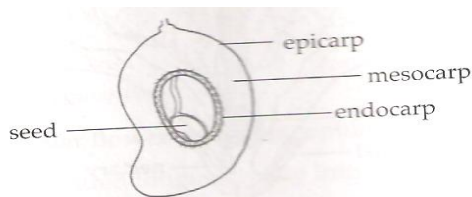
### -Berry



- has many seeds
- whole pericarp is succulent e.g. orange, tomato, pawpaw

### Drupe

- only one seed
- pericarp divided into three layers i.e. epicarp, mesocarp(juicy) and endocarp(hard)
- e.g. mango and coconut



### Pome

- juicy part is swollen receptacle
- is usually a false fruit
- example is a pear

## iv) What are dry fruits?

- have a pericarp that is dry, hard and woody
- either dehiscent or indehiscent
- called dry because they are not succulent

## v) What are dehiscent fruits?

- split open when ripe to release seeds
- contain many seeds

## vi) Give types of dehiscent fruits

### Legumes

- split along two edges
- are usually pods e.g. beans, peas, crotonaria

### Follicle

- split on one side only e.g. Sodom apple

## Capsule

- has several lines of weakness/sutures
- open in many places e.g. castor oil, cotton

### vii) What are indehiscent fruits?

- non-splitting fruits
- usually one seeded only

### ix) Give main types of indehiscent fruits

## Nut

- pericarp woody, hard and thick e.g. cashew

## Achene

- has thin, tough pericarp e.g. sunflower

### l) i) What is seed and fruit dispersal?

- spreading of seeds and fruits away from parents so as to settle where conditions are suitable for their germination

### ii) Why is dispersal of seeds and fruits necessary?

- prevent overcrowding
- reduces competition for space, nutrients and light
- colonization of new areas is made possible
- to increase chances of survival
- to prevent inbreeding
- to avoid extinction due to over competition for the necessities

### iii) Explain how seeds and fruits are adapted to various methods of dispersal

#### Adaptations for wind dispersal

- they have wings, feathers or hair-like structures to increase surface area for wind to carry them easily/buoyancy
- seeds/fruits are loosely attached on the stalks so that they can easily be released and carried away by wind
- seeds/fruits are generally light and small sized to be easily carried by wind
- some seeds/fruits have parachute-like structures to be easily carried by wind
- some have censor mechanism where seeds and fruits are borne on long stalks that are loosely attached which allows swaying so that movements of capsule by wind releases the seeds

#### Water dispersal seeds

- seed/ mesocarp has air spaces thus light/buoyant to float hence carried by water
- they have waterproof cover and tough pericarp protects seeds from getting soaked

- fibrous and spongy mesocarp to easily float

### **Animal dispersal seeds**

- presence of hooks for attachment to animals thus carried to other parts
- fruits are brightly coloured, succulent and scented to attract animals
- seed coats are hard and resistant to digestive enzymes hence seeds are dropped away from mother plant
- large in size or borne on clusters to be easily seen



### **Self dispersal/explosive**

- self opening seeds
- they have lines of weakness called sutures for violent opening thus scattering seeds away from parent plant

### **5. a) i) Distinguish between external and internal fertilization in animals**

- in external fertilization fusion of the male and female gametes takes place outside the body of the female e.g. amphibians and fish
- in internal fertilization union of gametes occurs inside the body of the female

### **ii) State the advantages and disadvantages of external fertilization**

#### **Advantages**

- large numbers produced therefore many offspring per breeding season
- female does not suffer gestation stress
- mother does not need to care for the young except in a few species
- the surviving individuals are highly selected for better survival

#### **Disadvantages**

- many predators surround the eggs before and after fertilization
- fewer chances of fertilization/a lot of gametes wasted
- embryo development at mercy of environment
- large numbers of female gametes are required therefore female gets much exhausted

### **iii) State the advantages and disadvantages of internal fertilization**

#### **Disadvantages**

- number of gametes fewer hence less number of offspring
- less adapted for sudden change of environment after birth



- in mammals females suffer gestation stress

### Advantages

- more chances of fertilization
- fewer predators of oval/fertilized egg protected in females body
- stable internal environment
- fewer gametes required

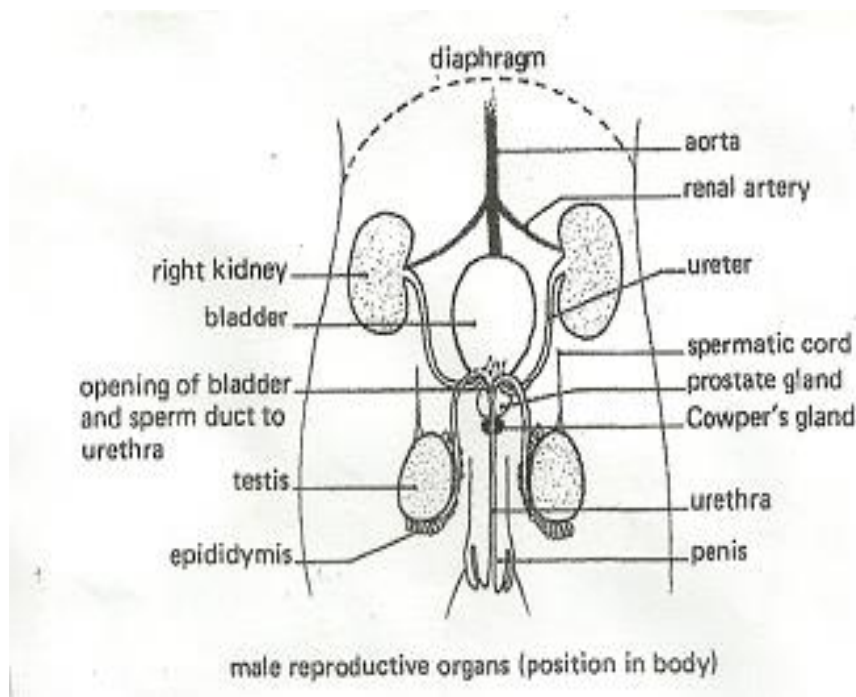
iii) Give a reason why it is necessary for frogs to lay many eggs

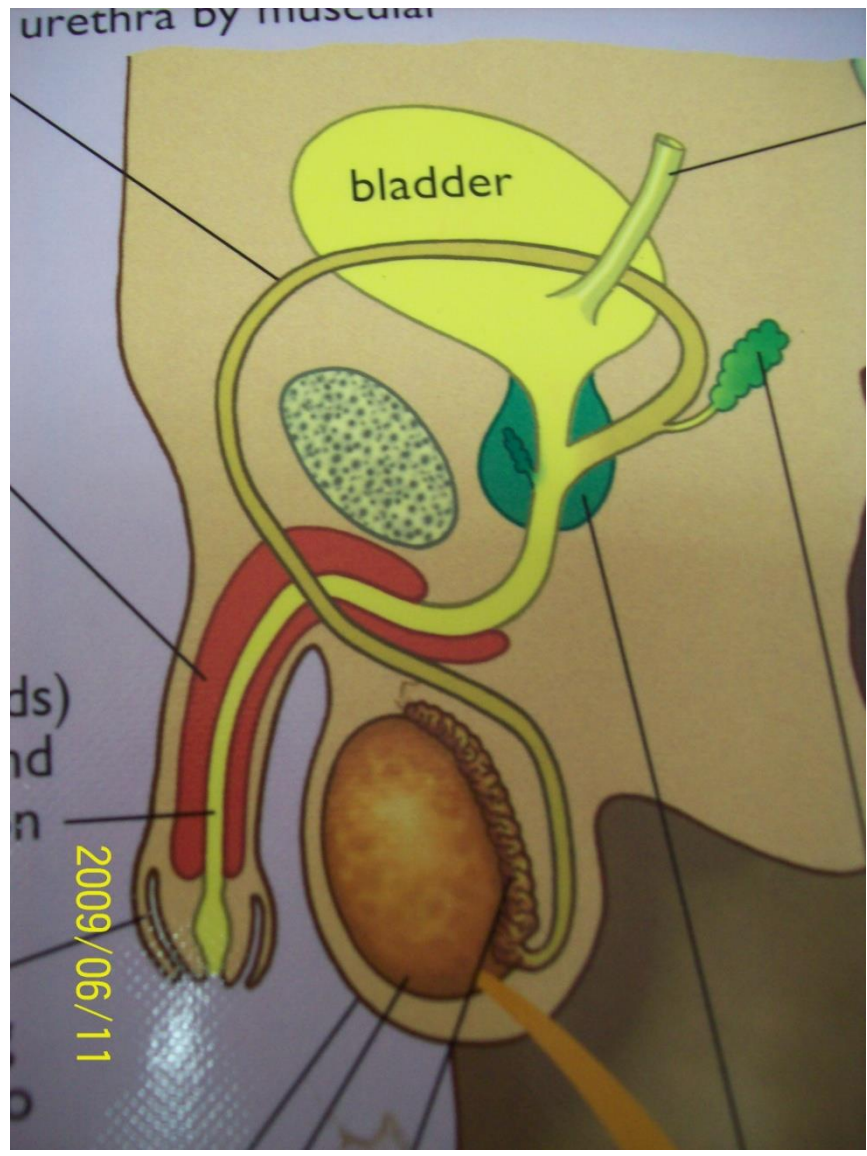
- to increase chances of survival/fertilization

iv) Compare external and internal fertilization

| External  | Internal   |
|---|--|
| <ul style="list-style-type: none"> <li>• occurs in water outside the bodies of animals</li> <li>• many eggs are laid</li> <li>• usually less contact between male and female</li> <li>• both fertilized eggs exposed to danger</li> </ul> | <ul style="list-style-type: none"> <li>• occurs inside the body of the female animal</li> <li>• fewer eggs released from ovary</li> <li>• very close contact in form of copulation between male and female</li> <li>• Fertilized eggs are enclosed hence highly protected inside females' body.</li> </ul> |

b) i) Draw and label the human male reproductive system





**ii) Describe how the mammalian male reproductive system is adapted to perform its functions**

**Penis**

- is highly vascularised/spongy
- has a sensitive glands
- becomes erect to allow entry into the vagina

**Scrotum**

- contains the testes outside the body on whose walls the process of spermatogenesis takes place
- the process is favored by lower temperature
- it contains sertoli cells which nourish sperms until they are mature

**Epididymis**

- long and coiled for the purpose of sperm storage

**Vas deferens**

- muscular
- upon contraction pushes sperms out and allows ejaculation

**Gametes**

- produced in large numbers to increase chances of fertilization
- the sperms have a tail for swimming/large number of mitochondria to provide energy/allow swimming to reach the egg



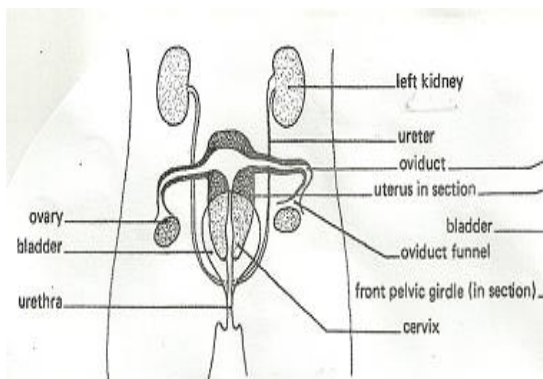
### Accessory glands

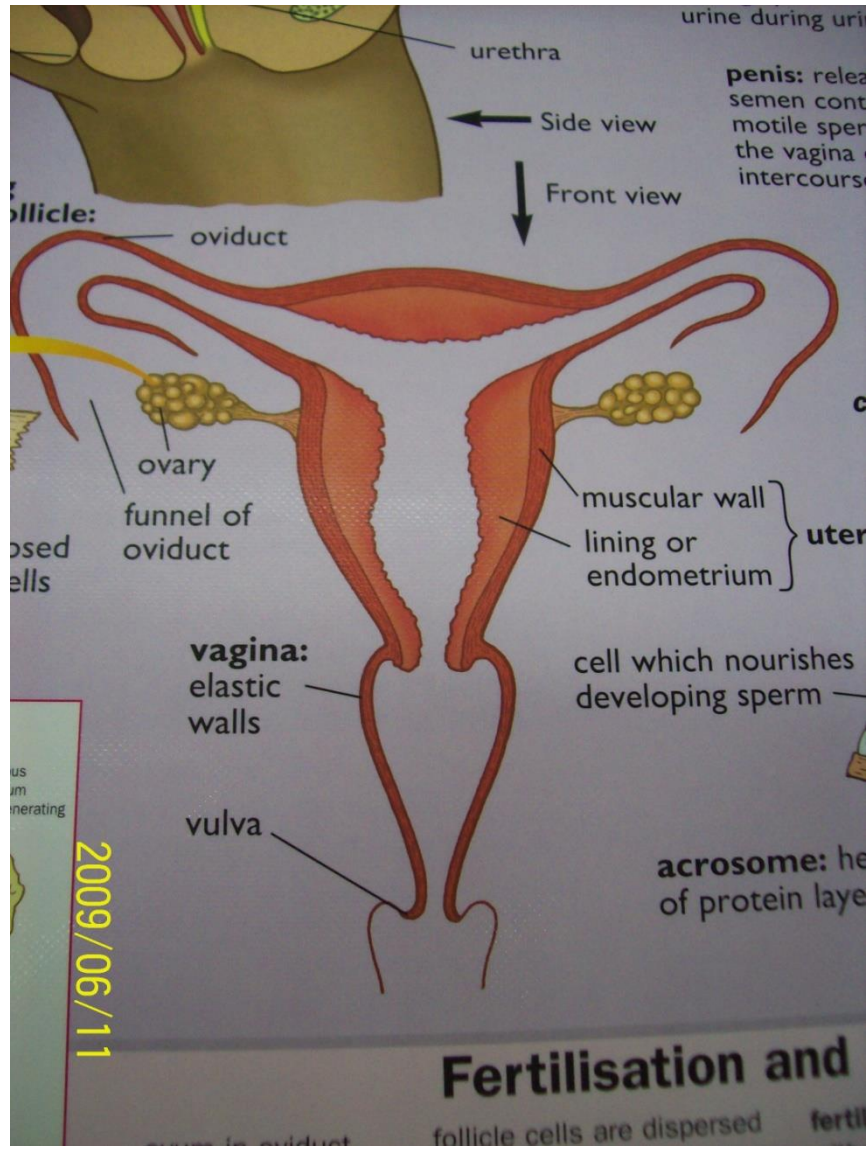
- are seminal vesicle, Cowper's gland and prostate gland
- they produce seminal fluid to provide a medium/ nutrients for sperms to swim

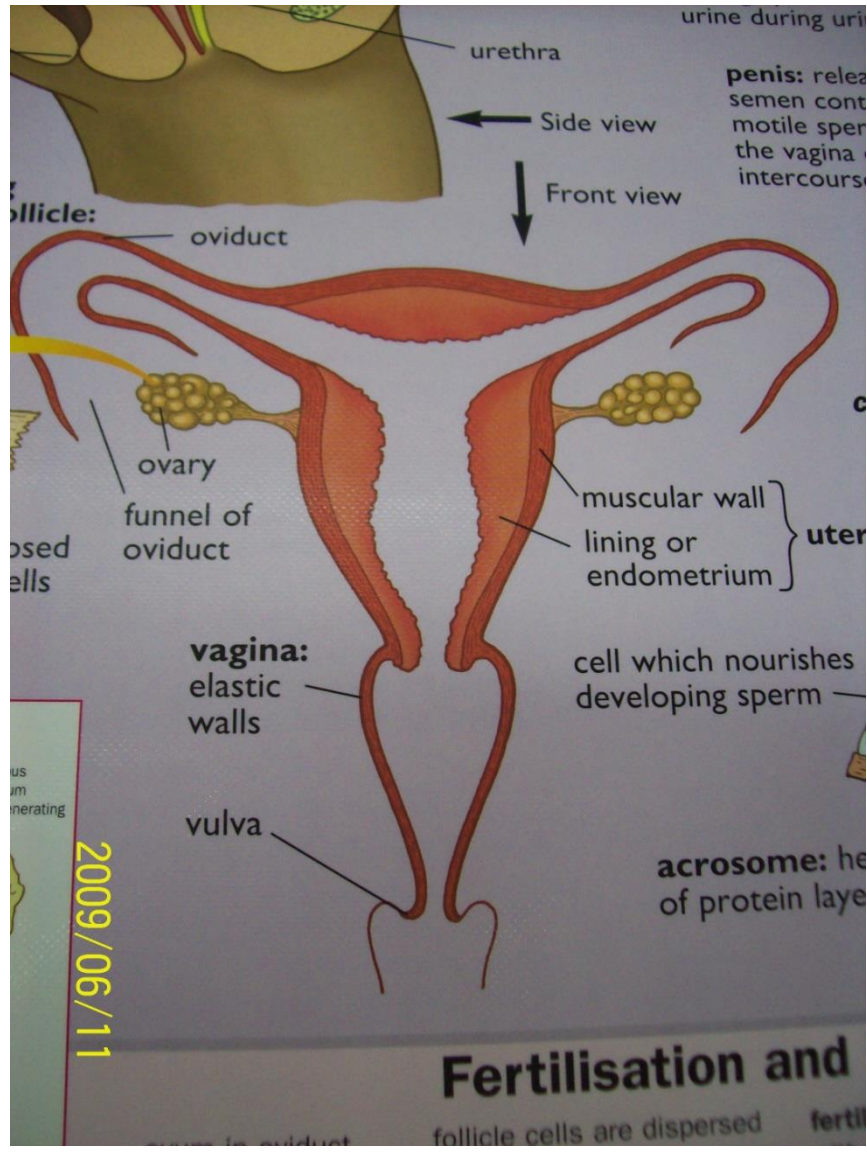
### iii) How is the sperm adapted to perform its function?

- acrosomes contain enzymes to digest egg membrane
- nucleus contains genetic material
- mitochondria produce energy to move the tail back and forth
- the lashing movement of the tail enables the sperm to move/propulsion in fluid medium towards the egg
- it is streamlined for faster/easier movement/swimming to meet the egg

### c) i) Draw and label the human female reproductive system

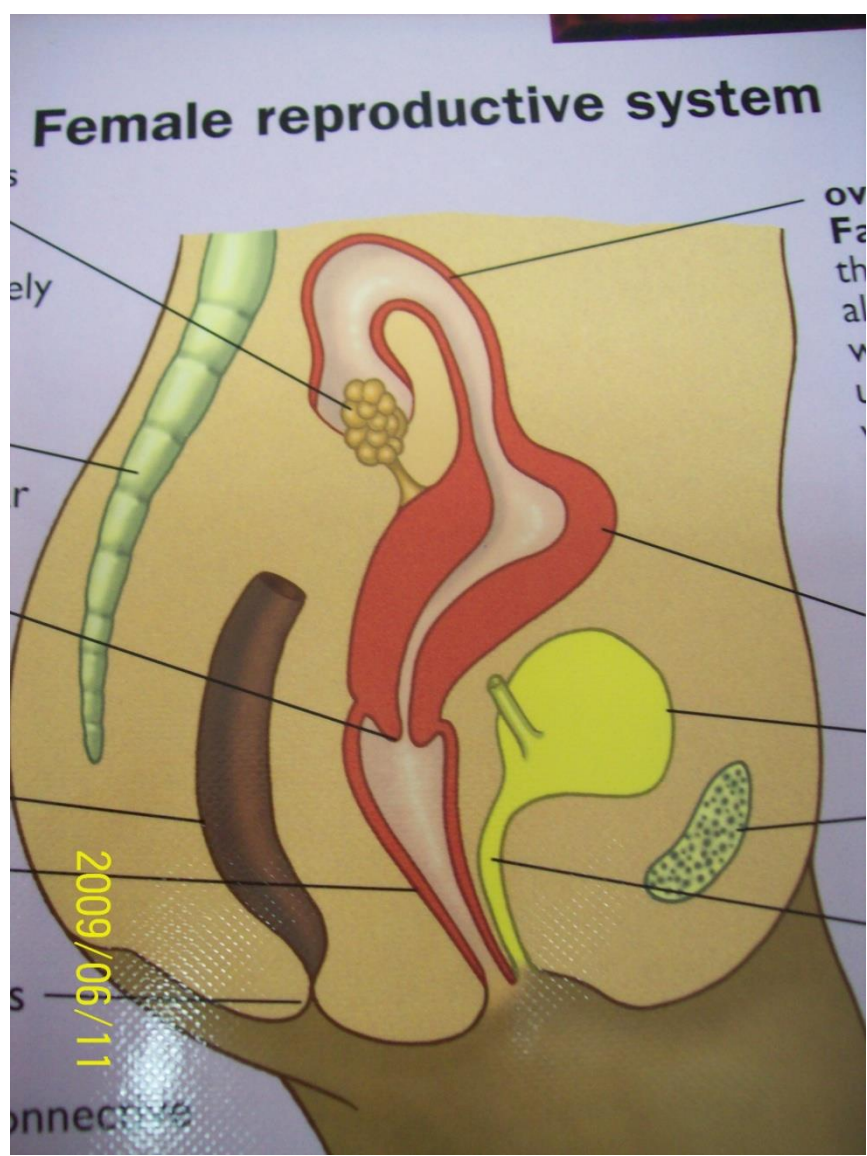






2009/06/11

### Fertilisation and



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## ii) Describe how the various structures of the human female reproductive system are adapted to their function

### Ovaries

- have several graafian follicles that develop and burst open to release/produce mature ova
- secretes sex hormones (oestrogen) which initiate/control development of secondary sexual characteristics
- produce hormones oestrogen and progesterone which prepare the uterus for implantation and subsequent nourishment of the embryo



### Oviducts (fallopian tube)

- are thin narrow and tubular to increase flowing speed of semen containing sperms
- are funnel shaped on the end next to ovary which enables them to receive the ovum
- their lining contains cilia which propel the ovum towards the uterus
- has peristaltic muscles that enable movement of zygote/ovum to the uterus for implantation
- is fairly long to increase surface area for fertilization

### Uterus

- is muscular for protection of developing embryo
- has elastic wall that allows growth and development of foetus/embryo
- has a highly vascularised endometrium that provides nutrients/gaseous exchange to developing embryo

### Cervix

- has valves that close the lower end of the uterus to ensure continued pregnancy during gestation period
- is capable of dilating
- has narrow entrance/neck-like entrance to uterus that enables quick swimming of sperms to uterus
- has suction mechanism that draws up/pulls sperms into uterus
- has a “W” shape that fits well with the glands of the penis to ensure sperms are deposited at the right point

### Vagina

- is elastic and muscular to enable good accommodation or penetration of the penis thus proper deposition of sperms and for easy parturition
- allows menstrual flow

- has sensitive labial walls which secrete/produce lubricating substances that ensure/enable/facilitate good coition
- capable of considerable enlargement, due to elastic muscles, to accommodate baby during parturition

### Clitoris

- has sensitive cells for orgasm

### iii) Explain how the ovum is adapted to its function

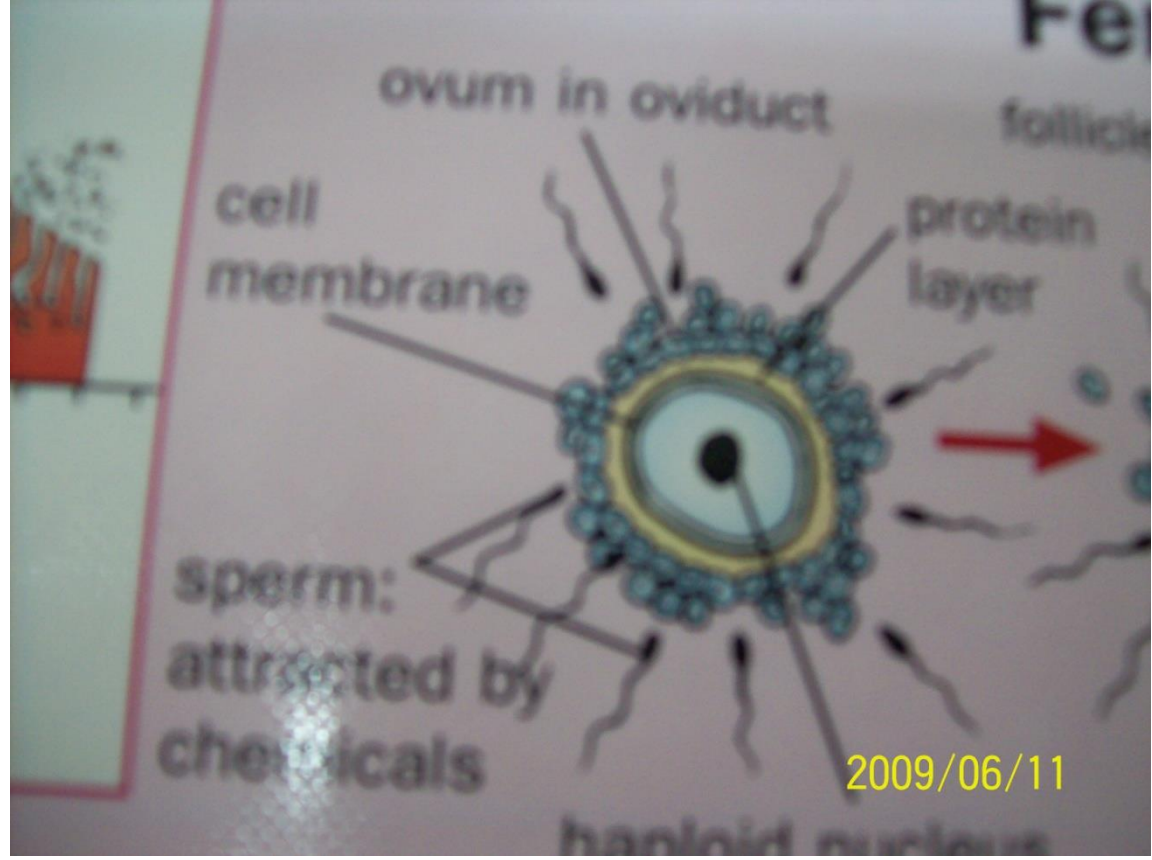
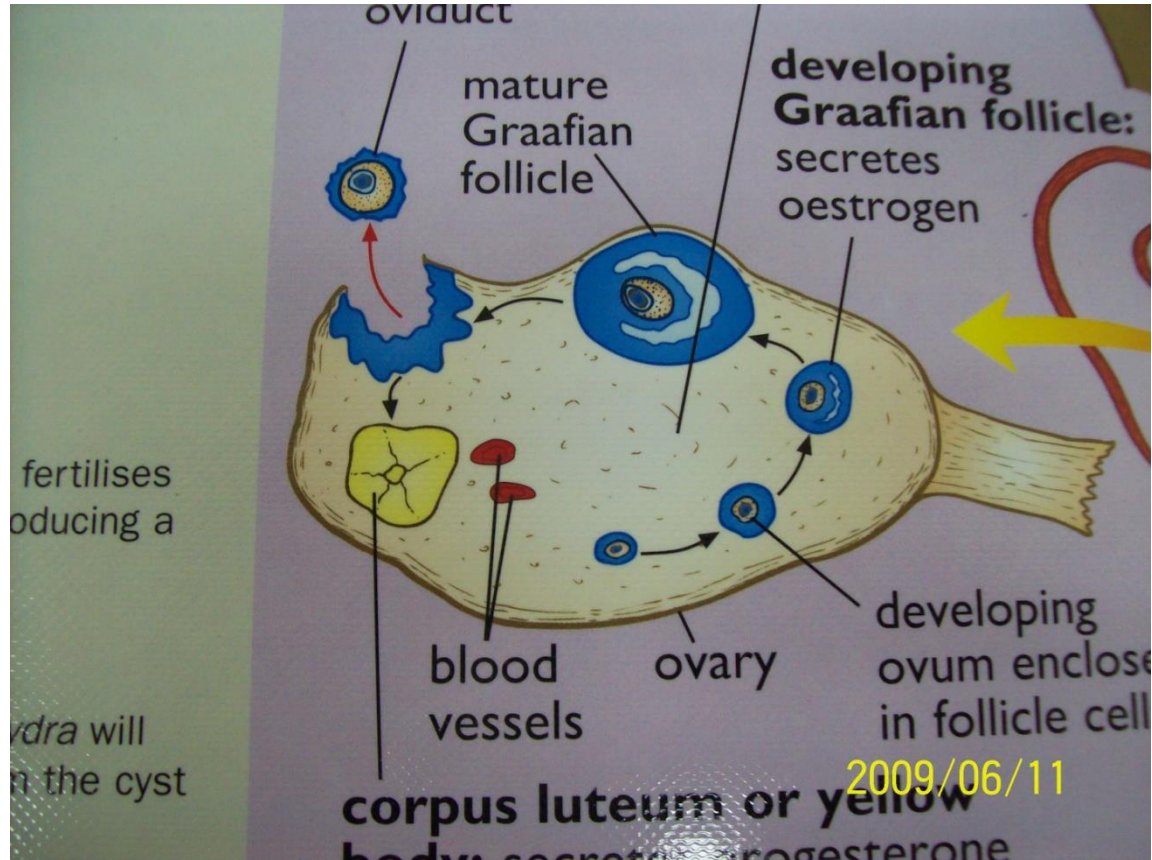
- nucleus contains genetic material
- ventelline membrane encloses plasma membrane which encloses yolky cytoplasm
- yolky cytoplasm provides nourishment
- jelly coat protects ovum against dehydration

### iv) Explain the differences between sperm and ovum

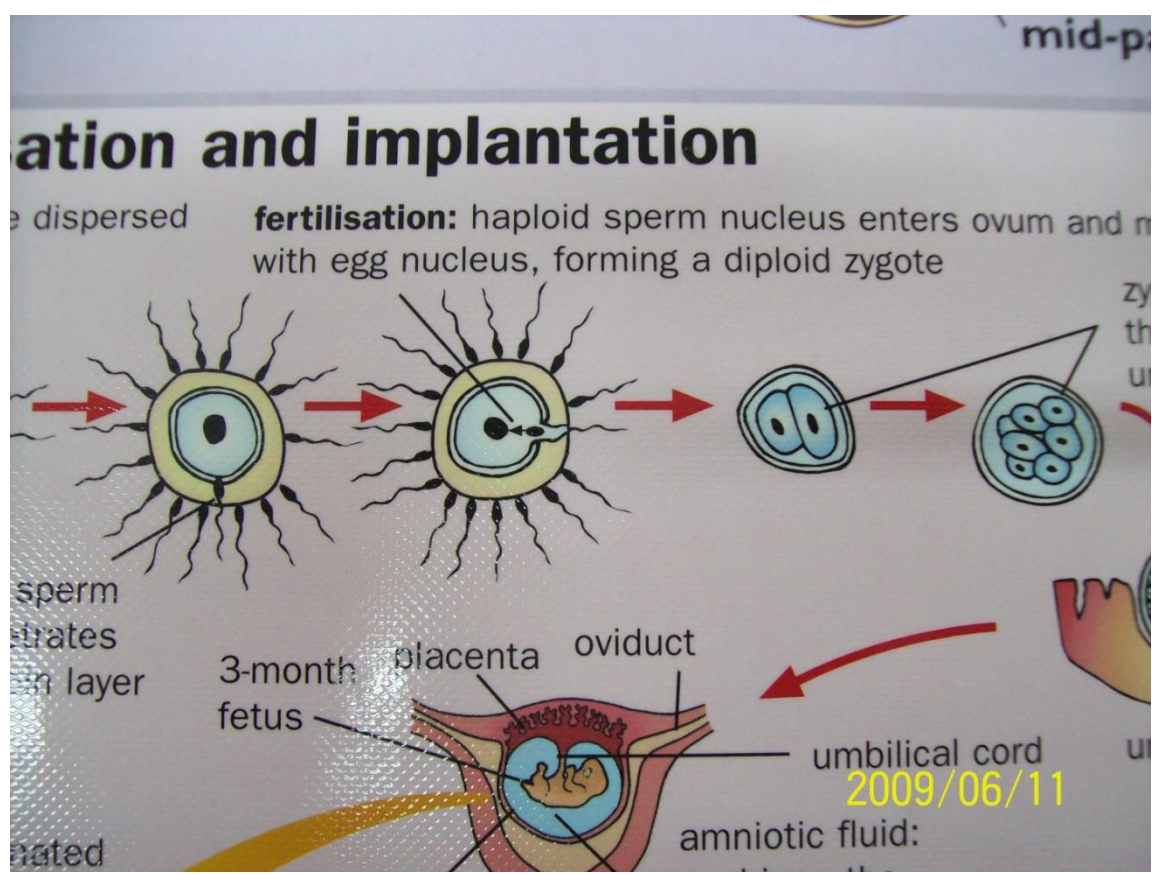
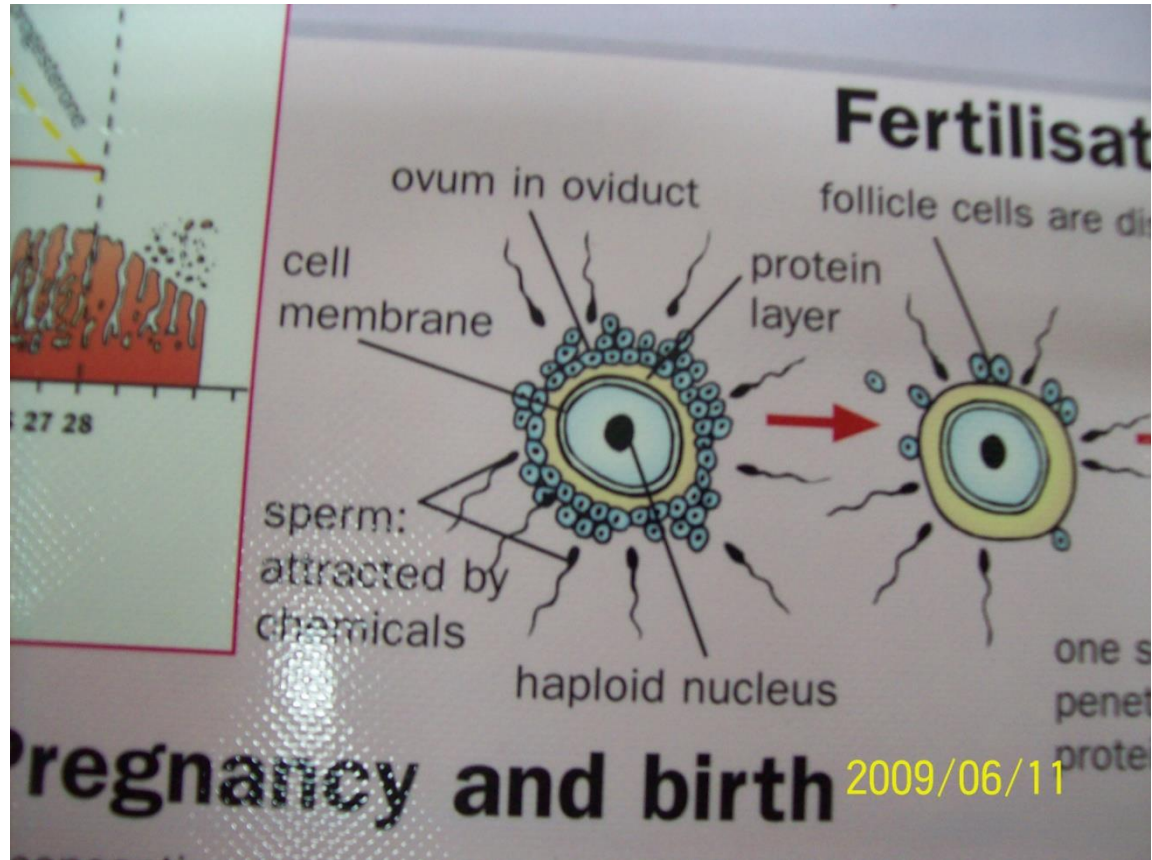
| Sperm   | Ovum  |
|---|---|
| <ul style="list-style-type: none"> <li>• long with a tail and head</li> <li>• small</li> <li>• locomotory</li> <li>• stores little food</li> <li>• has acrosome (tip with lytic enzymes)</li> <li>• nucleus prominent but cytoplasm negligible</li> </ul> | <ul style="list-style-type: none"> <li>• spherical</li> <li>• large</li> <li>• stationary</li> <li>• a lot of food stored in yolky cytoplasm</li> <li>• lacks acrosome</li> <li>• a lot of cytoplasm</li> </ul> |

### d) i) Explain the process of fertilization

- a process whereby the egg and sperm are brought together and fuse to form a zygote
- occurs in the fallopian tube after copulation
- sperm head penetrates the outer coat of the ovum while the tail remains outside
- penetration is due to reaction of acrosome
- acrosome digests the vitelline membrane
- thereafter a zygote is formed
- zygote which is diploid undergoes rapid cell division to form a mass of cells called blastocyst
- after fertilization a membrane forms around the ovum to prevent further entry of sperms
- blastocyst eventually develops into an embryo





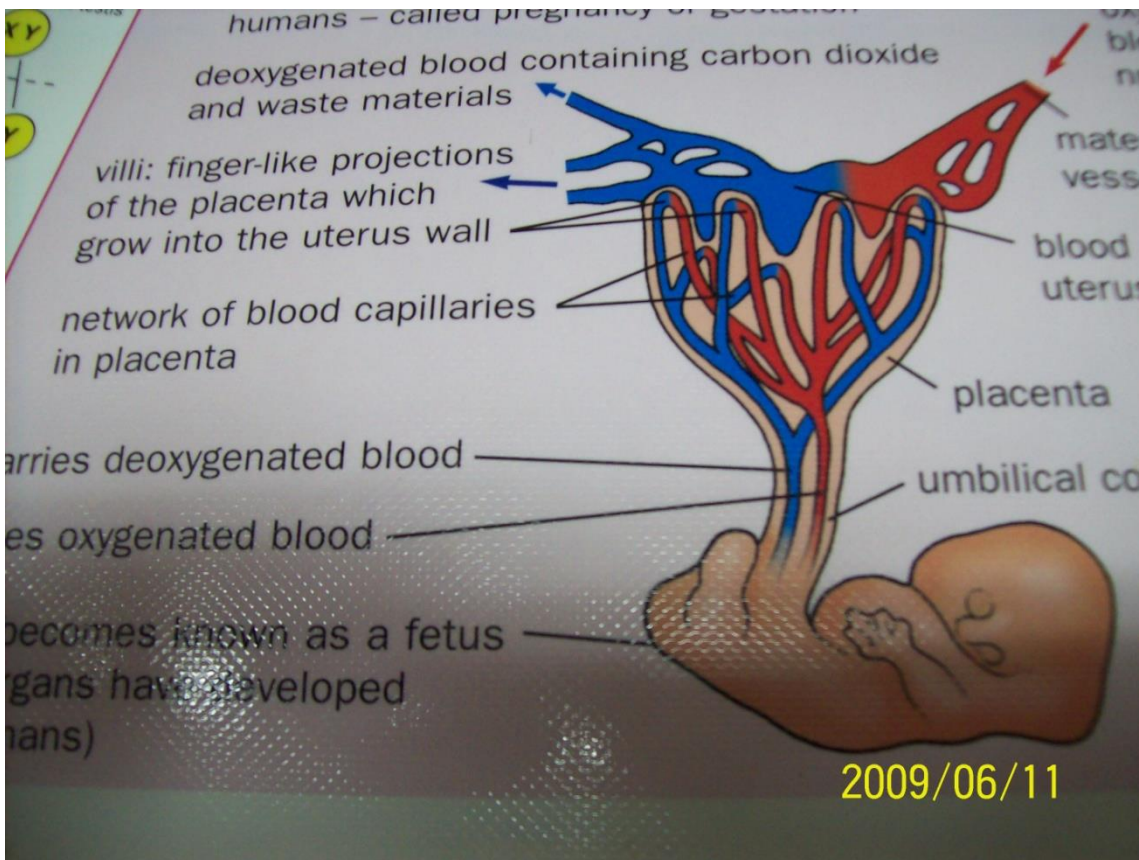
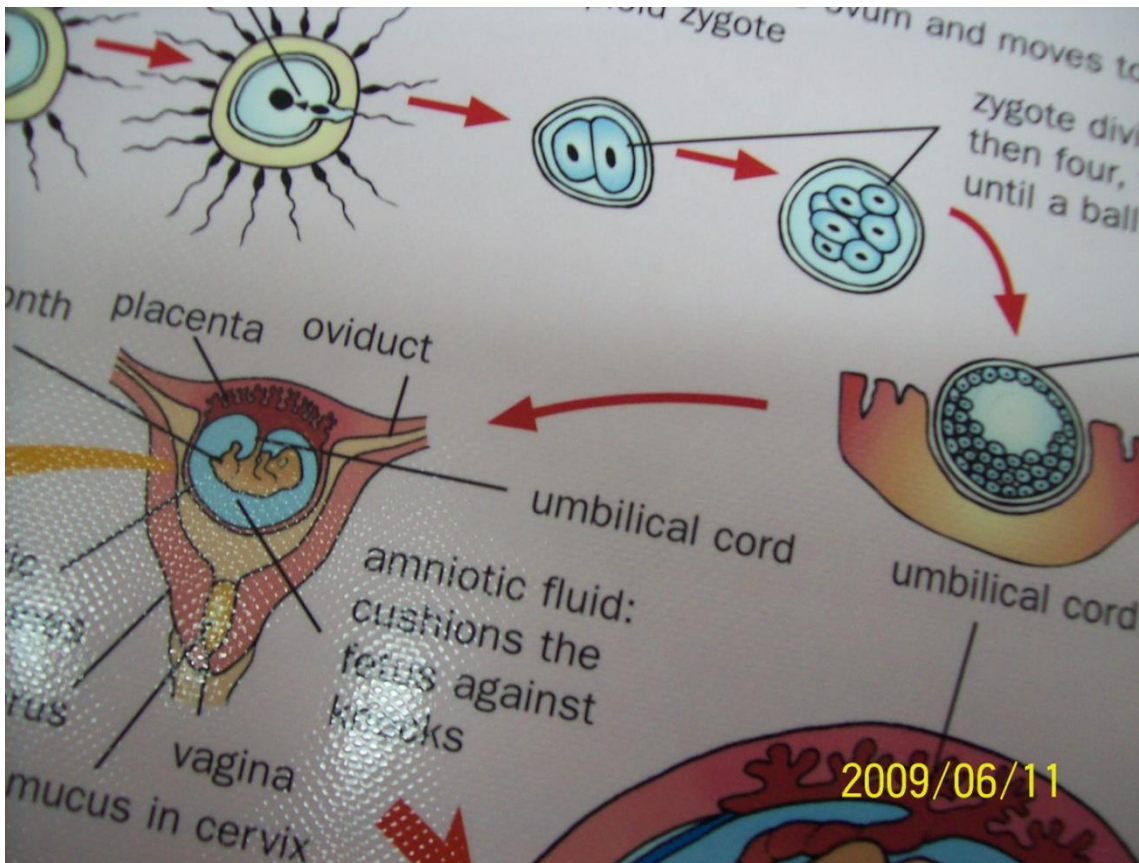


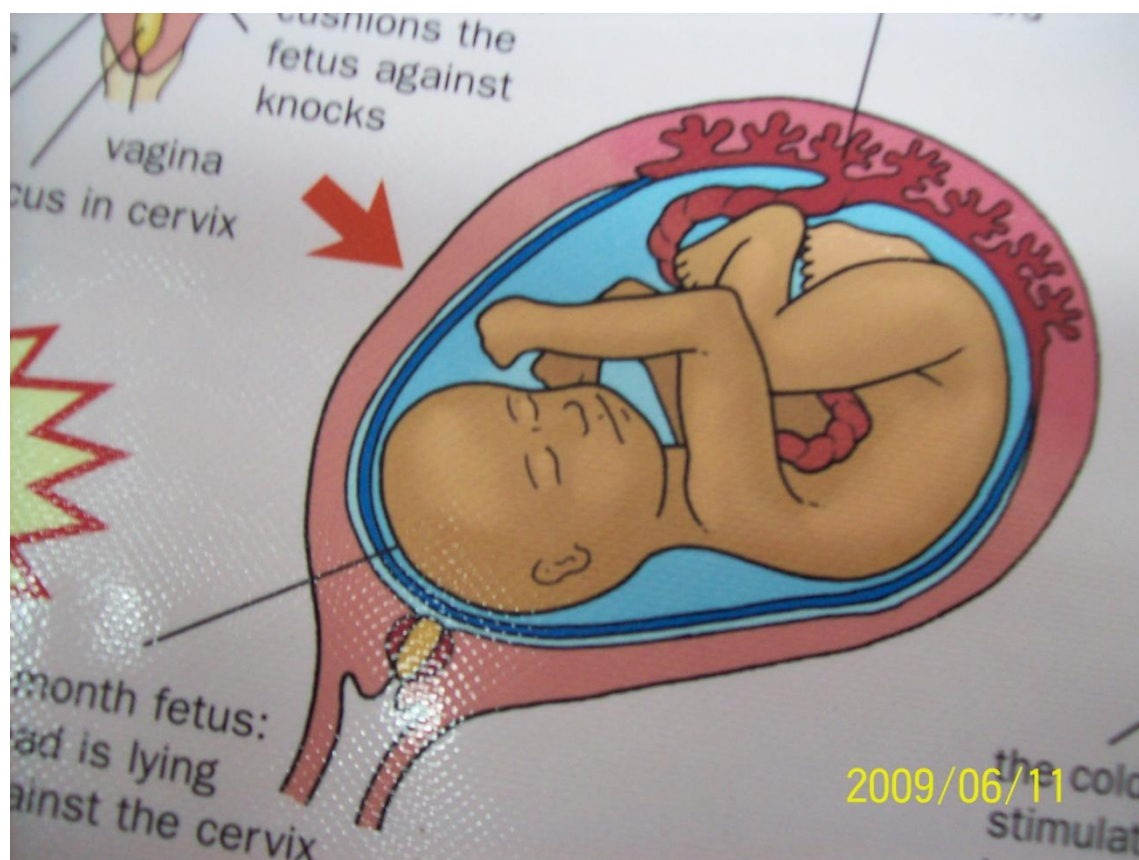
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**i) Explain the process of implantation**

- this is the embedding and attaching of the embryo in the uterine wall/endometrium
- implantation marks the beginning of pregnancy
- sometimes implantation occurs in the oviduct wall which is abnormal and results in ectopic pregnancy which is fatal
- the outer wall of the blastocyst develops fingerlike projections which project into the uterine wall for attachment
- the projections are called villi

- the villi and endometrium develop into an organ that is called the placenta
- the embryo is attached to the placenta through a cord called the umbilical cord





### State the functions of umbilical cord

- it contains blood vessels (umbilical artery, two umbilical veins)
- it joins the placenta to the embryo
- passage for nutrients from the mother
- passage of excretory substances from foetus to mother for final discharge
- gaseous exchange
- passage of antibodies from mother to foetus, for protection of foetus against diseases

### iv) State the role of placenta

- exchange of gases between mother and foetus
- exchange of nutrients and nitrogenous wastes
- anchorage/attachment of foetus
- produces hormones (oestrogen and progesterone)

### e) i) What is gestation period?

- time taken from fertilization to birth/pregnancy

### ii) Explain the functions of the membranes associated with placenta

#### Chorion

- surrounds the embryo
- has fingerlike projections that attach embryo to the uterus

#### Amnion

- contains amniotic fluid
- fluid surrounds embryo

- protects embryo from mechanical injury by acting as shock absorbers
- fluid also protects embryo from dehydration
- distributes pressure equally over embryo

### **Yolk sac**

- surround the yolk
- produces blood cells for embryo until its own liver is able to perform the task

### **Allantois**

- present only for a short time
- removes and store waste material
- it eventually becomes the umbilical cord

### **iii) Explain the events that take place to facilitate parturition**

- near birth the placenta produces less progesterone
- oxytocin hormone is produced by posterior lobe of pituitary gland
- because progesterone level has decreased the uterus becomes sensitive to oxytocin
- oxytocin causes the contraction of the uterus (myometrium)
- these contractions are called labour pains
- just before parturition the head turns downwards
- the contractions eventually push the baby through the vagina
- amnion breaks and amniotic fluid is released
- oxytocin dilates the cervix
- foetus is expelled through cervix with head coming out first
- finally the whole infant comes out
- the umbilical cord is cut and the placenta is expelled as afterbirth

### **iv) State the reasons why later in pregnancy the ovary will be removed without disturbing the pregnancy**

- corpus luteum in the ovary secretes progesterone which maintains pregnancy and development of foetus after conception
- after four months pregnancy is maintained by progesterone from the placenta

### **f) i) What are secondary sexual characteristics**

- Characteristics (physiological and anatomical) that start developing at puberty due to the influence of male and female hormones

### **ii) State the main secondary changes in Boys**

- deepening of the voice

- growth of hair on face, pubic part, chest, legs
- penis and testes become bigger
- muscular development
- sperm production begins at puberty and may continue throughout life

### Girls

- growth of hair on pubic part and armpits
- widening/enlargement of hips
- development of breasts
- menstrual cycle starts as ovaries mature
- body acquires extra fat

### iii) Describe the role of hormones in secondary sexual characteristics in Boys

#### Follicle stimulation hormone (FSH)

- from pituitary
- stimulates production of androgens (male hormones) mainly testosterone by testis

#### Testosterone

- secondary sexual characteristics

### Girls

#### FHS

- from pituitary
- development of follicles
- stimulates oestrogen production by ovary

#### LH

- from pituitary
- ovulation
- stimulates release of progesterone by ovary

#### Oestrogen

- stimulates release of LH
- secondary sexual characteristics

#### Progesterone

- also from placenta
- sustains pregnancy as it inhibits prolactin and oxytocin during pregnancy

#### Prolactin

- milk formation

#### Oxytocin

- parturition
- milk ejection

### g) i) What is menstruation?

- vaginal discharge due to disintegration of endometrium

## ii) Describe the role of hormones in the human menstrual cycle

- it is controlled by sex hormones which are responsible for the onset of secondary sexual characteristics and also control of the menstrual cycle
- the onset is signaled by discharge of blood/menses 14 days following the start of menstruation
- anterior lobe of pituitary gland secretes follicle stimulating hormone(FSH)
- Follicle stimulating hormone causes graafian follicle to develop in the ovary. It also stimulates tissues of the ovary/wall (theca) to secrete oestrogen
- oestrogen causes repair/healing of uterine wall
- oestrogen stimulates anterior lobe of pituitary to produce luteinising hormone (LH)
- LH causes ovulation. It also causes graafian follicle to change into corpus luteum. LH stimulates corpus luteum to secrete progesterone
- Progesterone causes proliferation/thickening of uterine wall
- Oestrogen/progesterone inhibits the production of FSH by anterior lobe of pituitary, thus no more follicles develop and oestrogen production reduces
- In the next two weeks progesterone level rises and inhibits production of LH from anterior lobe of pituitary
- The corpus luteum stops secreting progesterone and menstruation occurs when the level of progesterone drops
- Anterior lobe of pituitary starts secreting FSH again.

## iii) What is menopause?

- end of ovulation in women
- occurs after age of 45 years
- does not occur in males

## h) Explain the symptoms, methods of transmitting and prevention (control) of the following sexually transmitted diseases

### i) Gonorrhoea

- caused by a bacterium called *Neisseria gonorrhoea*
- transmitted through sexual intercourse,
- infects urethra and vaginal tract (epithelia)
- Symptoms include pain, discharge of mucus and bad smell (females)
- Effects include sterility, heart diseases, blindness of foetus and arthritis

- Treatment by antibiotics
- Control and prevention by proper sexual conduct

## ii) Herpes

- notably *Herpes simplex* and *H. genitalis*
- caused by virus which attacks genitalia
- symptoms are painful sores in genitalia, skin lesions
- transmitted in saliva, sexual intercourse and injection by drug addicts
- no treatment

## iii) Syphilis

- caused by bacterium called *Treponema palladium*
- symptoms are painless wounds in genitalia
- attack genitalia, nervous system, lips
- treated by antibiotics

## iv) Trichomoniasis

- caused by plasmodium called *Trichomonas*
- attacks reproductive tract
- symptoms are itching and discharge of pus from the genitals
- treated by antibiotics

## v) Hepatitis

- Viral disease

Affects the liver

Transmitted through sexual intercourse

No known treatment

## vi) Candidiasis

- caused by fungus called *Candida albicans*
- transmitted through sexual intercourse
- symptoms include itching urethra, and vaginal discharge (odourless)
- controlled by personal hygiene, early treatment and responsible sexual behavior

## vii) HIV/AIDS

- caused by HIV virus
- transmitted by sexual intercourse, blood transfusion, sharing piercing instruments from infected mother to foetus, infant and baby
- symptoms include fever, swollen lymph nodes, night sweating, cough, weight loss, fatigue, loss of appetite, diarrhea, headache, a opportunistic infections and tumors

- Control by responsible sexual behaviour, education, screening blood for transfusion and using sterile piercing instruments.

### 6. a) Define the terms

#### i) Growth

- an irreversible change in size of a cell, organ or whole organism
- growth is due to synthesis of protoplasm or extracellular substances

#### ii) Development

- refers to a series of changes which an organism goes through in its life cycle
- during development both qualitative and quantitative changes take place (involves differentiation)

#### iii) Differentiation

- refers to changes in which the cells of the body undergo and become specialised to perform specific functions

### b) i) Differentiate growth in plants and animals

| Plants   | Animals  |
|--|--|
| <ul style="list-style-type: none"> <li>• confined to shoots/root tips (apical)</li> <li>• have definite growth regions (meristems)</li> <li>• often indefinite/continuous</li> <li>• growth results in branching</li> <li>• affected by light, auxins, hormones and temperature</li> </ul> | <ul style="list-style-type: none"> <li>• occurs all over the body (intercalary)</li> <li>• different parts grow at different rates (allometric)</li> <li>• maximum growth on maturity (definite)</li> <li>• no branching</li> <li>• affected by nutrients</li> </ul> |

#### ii) List the processes involved in growth

- assimilation
- cell enlargement
- cell division (by mitosis)

#### iv) List the parameters used to measure growth

- height/length
- dry weight
- number of individuals
- volume
- leaf area of plant

#### iv) Name the patterns of growth in organisms

- allometric and isometric



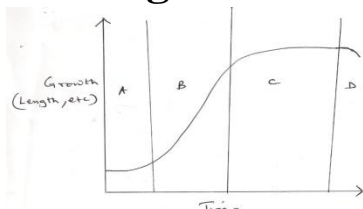
- limited and unlimited
- discontinuous growth

**c) i) Name the different types of growth curves**

- sigmoid curve(normal growth curve)
- intermittent growth curve



**ii) Draw a sigmoid growth curve and explain its different phases/stages**



**A-lag phase**

- Slow growth rate at first

Organism adapting to the environment

**B-exponential phase**

- organisms already adapted
- first growth due to birth rate that is higher than death rate

**C- Stationery phase (plateau)**

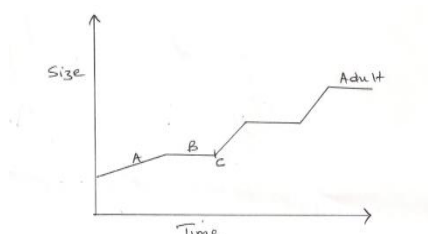
- Birth rate equals death rate (equilibrium)

Lack of nutrients, accumulation of toxic waste products

**D-phase of decline**

- due to depletion of nutrients, accumulation of toxic wastes, lack of space
- some individuals old hence not reproducing
- death rate higher than birth rate

**iii) Draw an intermittent curve and explain the various stages**



**A-growth**

**B-no growth**

**C- moulting/ecdysis**

- seen in arthropods
- growth in in arthropods is intermittent(takes place during some time only because their hard cuticles (exoskeleton) does not expand to cause growth
- the cuticle must be shed off first to allow further growth
- the shedding is called ecdysis or moulting

- when moulting has taken place animal grows but growth stops when the exoskeleton hardens again

**d) i) What is seed dormancy?**

- A state where a viable seed is incapable of germinating when all conditions are favourable.

**ii) State the biological importance of seed dormancy**

- gives embryo time to reach maturity
- gives time for dispersal
- allows plant to survive adverse conditions

**iii) State the factors which cause seed dormancy**

**Internal factors**

- presence of abscisic acid/ABA/ presence of germination inhibitors
- embryo not fully developed
- absence of hormones/enzymes/inactivity of hormones/enzymes/gibberellins/cytokinins
- impermeability of seed coat

**External factors**

- unsuitable temperature
- absence of light
- lack of oxygen
- lack of oxygen
- lack of water

**iv) Give the conditions necessary to break seed dormancy**

- scarification/scratching to make seed coat impermeable
- vernalisation/cold treatment in some seeds like wheat
- burning/nicking/expose to heat e.g. wattle seeds
- destruction of germination inhibitors

**e) i) What is seed germination?**

- process by which a seed develops in a seedling

**ii) What is viability**

- ability of a seed to germinate

**iii) Discuss the various conditions necessary for the germination of seeds**

**Water**

- medium for enzymatic activity
- hydrolysis of food into simpler substances
- medium of transport
- softens the seed
- acts as a solvent

**Air**

- in form of oxygen

- oxygen is used for respiration/oxidation of food to release energy

### Suitable (optimum) temperature

- activates enzymes involved in mobilization of food reserves

### Enzymes

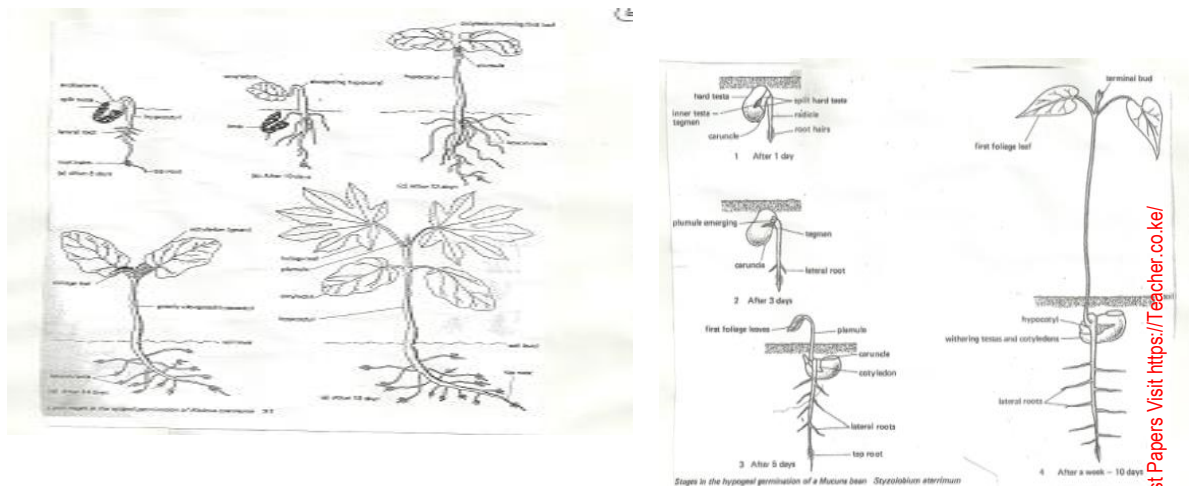
- breakdown and subsequent oxidation of food
- conservation of hydrolyzed food products into new plant tissues

### Viability

- only viable seed are able to germinate and grow

### iv) Name and describe the types of germination

#### Epigeal



cotyledons are brought above the ground level during germination due to elongation of hypocotyls

#### Hypogeal

- the cotyledons remain below the surface during germination due to elongation of epicotyl e.g. maize

### v) Name the part of the bean seed that elongates to bring about epigeal germination

hypocotyl

### vi) Account for the loss in dry weight of cotyledons in a germinating bean seed

- food stored is mobilized/used up for respiration and growth

### vii) Describe the physiological changes that occur in a seed during germination

- in presence of oxygen, optimum temperature and water, food reserves in the seed are hydrolysed or broken down into soluble diffusible form by enzymes
- soluble food diffuses to the growing embryo
- oils and carbohydrates provide energy
- simple sugars converted to cellulose to form cell wall

- amino acids make protoplasm
- seed develops plumule and radicle hence germinates

**viii) Explain the biological significance of cotyledons being brought above the ground in epigeal germination**

- cotyledons have inadequate food
- they are brought above the ground to acquire chloroplasts to carry out photosynthesis before the formation of foliage leaves to supplement food supply required for growth during germination



**f) i) Distinguish between primary and secondary growth**  
**Primary growth**

- occurs at the apical (shoot and tip) apices regions where meristematic cells occur
- causes plant elongation since cells divide by mitosis

**Secondary growth**

-occurs at the cambium meristems  
 Increases width (girth) of the stem

**ii) What are meristems**

- dividing cells
- meristem means they are dividing

**iii) State the characteristics of meristematic cells**

- dense cytoplasm
- thin cell walls
- absence of vacuoles/cell sap

**iv) State the location and function of the following meristematic tissues**

**Apical meristem**

- located at tips of roots and shoots
- increase length of stem and roots/primary growth

**Intercalary meristem**

- found at bases of internodes
- responsible for elongation of internodes and increase in leaf sheath in grasses

**Lateral meristems**

- found near the periphery of stem and root
- responsible for secondary growth/growth in girth of stem and root/lateral growth
- called cambium and constitute vascular and cork cambium

**v) Describe primary growth**

- occurs at tips of shoots and roots in the meristematic tissues of apical meristem
- at the apex there is a zone of cell division/mitosis
- cells elongate at elongation zone

- the elongated cells differentiate at the region of differentiation resulting in increase in size
- in the stems meristems give rise to leaf primordia which envelop the apex to form a bud
- the bud protects the delicate inner cells
- in roots the meristem is protected by root cap
- after cells differentiate they form permanent tissues

#### vi) Describe secondary growth in plants

- also called secondary thickening
- only occurs in dicotyledonous plants that have cambium
- monocotyledonous plants do not undergo secondary growth because they lack intervacular cambium
- cambium cells divide to produce more cells on either side of the cambium
- cells produced to the inside become secondary cambium
- cells produced to the outside become secondary phloem
- division of cambium cells occurs yearly producing new rings of secondary phloem and secondary xylem each year
- intervacular cambium (cambium between vascular bundles) divide to form secondary parenchyma, thereby increasing growth of medullary rays
- much more xylem is formed than phloem, thus pushing phloem and cambium ring outward
- the rate of secondary growth is dependent on seasons (rains) resulting in annual rings
- cork cambium is located beneath epidermis and is responsible for secondary thickening of the bark of perennial plants
- cork cambium divides to form new cork (bark) tissues to accommodate increased growth on outside and secondary cortex on the inside
- Cork cells (cells of the bark) are loosely packed at some points to form lenticels for gaseous exchange.

#### vii) State the significance of secondary growth

- increase girth or circumference of trees
- annual rings which show seasonal growth can be used to tell the age of trees

#### g) i) Describe one method which can be used to measure the average growth rate of a single leaf of a plant

##### **EITHER**

- choose/identify a young leaf (just unfolded)
- use the same leaf throughout
- measure (total) length of (whole) leaf

- record
- repeat at regular intervals until no more change occurs/constant length
- average rate of growth is equal to total increase in length divided by the period taken to achieve full length



Average rate of growth =  $\frac{\text{total increase in length}}{\text{period taken to achieve full length}}$

**OR**

- choose/identify a young leaf(just unfolded)
- use the same leaf throughout
- trace the outline on a graph paper and work out the area
- record
- repeat at regular intervals until regular area
- average rate of growth equals to total increase in area divided by the period of time taken to achieve full area

Average rate of growth =  $\frac{\text{total increase in area}}{\text{period of time taken to achieve final area}}$

**i) Describe how the growth of a root can be determined**

**Materials**

- fine thread, marking ink, germinating bean seedlings, blotting paper, ruler marked in millimeters, pins, cork, a boiling tube and moist cotton wool

**Procedure**

- dry seedlings using blotting paper
- place inside against the ruler marked in mm
- dip the fine thread in waterproof ink
- mark the radicle at equal intervals
- pin the seedling to the cork
- suspend the seedling into the boiling tube containing moist cotton wool
- allow the seedling to grow for two days/some time observe the intervals with the marks
- record your observations the widest intervals are found in the region just behind the tip indicating/showing region of greatest growth

**iii) A boy hammered a nail in the bark of a tree at a height of 1.5metres above the ground.**

**Four years later, the nail was found at the same height although the tree had grown 3 meters taller. Explain the above observation**

The nail was hammered at a point where vertical growth had stopped/further growth was confined to increase in width/diameter.

Vertical growth is confined to tips/apex/vertical apical meristem

## **h) i) Describe the role of hormones in growth and development of plants**

indole acetic acid/IAA/ auxins

Cell division/increase in cell division

Tropic responses

Cell elongation/increases in cell elongation

Development of abscission layer

Growth of ovaries into fruits/parthenocarpy/initiates flowers

Inhibits growth of lateral buds/produces apical dominance

Stimulates adventitious/lateral roots

Gibberellins (Gibberellic acid/GA<sub>3</sub>)

Promote cell elongation/rapid cell division/increase in length of the internodes

Promote fruit formation without fertilization/parthenocarpy

Reduces root growth

Breaks seed dormancy/promotes germination

### **Cytokinnins (Kinnins/Kinnetin/Zeatin)**

- breaks dormancy
- promotes flowering
- promotes cell division
- stabilizes protein and chlorophyll
- promotes root formation on a shoot
- low concentration encourages leaf senescence
- normal concentration increases cell enlargement in leaves
- stimulates lateral bud development

### **Ethylene (ethyne/C<sub>2</sub>H<sub>4</sub>)**

- accelerates ripening in fruits
- encourages fruit fall/leaf fall
- induces thickening in stem/inhibits stem elongation
- promotes flowering (in pineapples)
- promotes germination in certain seeds

### **Abscisic acid (ABA) abscisic hormone/dormin)**

- causes bud dormancy
- encourages fruit/leaf fall
- high concentration causes closing of stomata
- causes seed dormancy
- inhibits cell elongation

### **Traumatin**

- heals wounds by callous formation

### **Florigen**

- promotes flowering

## **ii) State the applications of plant hormones in agriculture**

- induce root growth in stem cuttings
- selective weed killers
- encourage sprouting of lateral buds
- breaking seed dormancy
- induce parthenocarpy
- accelerate ripening of fruits
- promote flowering
- cause dormancy

### iii) Explain apical dominance

- a phenomenon whereby production of auxins by a growing apical bud of a shoot inhibits growth of lateral buds
- this inhibition is due to high concentration of auxins (indoleacetic acid/IAA) in apical bud
- removal of terminal/apical bud causes development and sprouting of several buds which later develop into branches
- applied in pruning coffee, tea and hedges
- this leads to more yield

### iv) Describe the role of hormones in the growth and development of animal somatotrophin (growth hormones)

- from anterior pituitary
- promotes cell division
- overproduction causes gigantism
- underproduction causes dwarfism

### Thyroxine

- promotes growth and metamorphosis
- underproduction leads to a child becoming a cretin (mentally retarded)

### Androgens

- in males
- growth of male reproductive organs

### Oestrogen

- in females
- growth of female reproductive organs

### Ecdysone

- in arthropods
- moulting (ecdysis)

### t) i) What is metamorphosis?

- change in form during which there are changes in structure and function in body of organism
- prepares organism for life in a different habitat

### ii) Explain complete metamorphosis

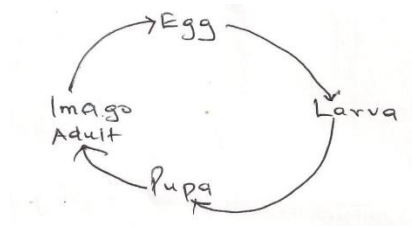


radical changes in the body during the life cycle of an organism

called holometabolous development

example is egg larva pupa adult (imago)

occurs in animals such as butterfly and bee



### iii) What is the significance of each of the four stages in complete metamorphosis?

#### Larval stage

- feeding takes place
- larva is quite different from adult
- larva sheds its cuticle (exoskeleton) several times to emerge as pupa
- dispersal stage avoids overcrowding

#### Pupa

- enclosed in a case called puparium (cocoon)
- no feeding
- organ formation takes place

#### Adult

- emerges from puparium
- reproductive stage of the life cycle

### iv) Describe incomplete metamorphosis

- called hemimetabolous development
- changes are gradual
- eggs develop into nymphs which develop into adults
- nymph resembles adult but are sexually immature
- a nymph moults several times as some parts develop before it becomes an adult
- stage of development between one moult and another is called instar
- occurs in insects such as locust and cockroach

Egg → Nymph → Adult

### v) Name the hormones that control metamorphosis in insects

- brain hormone responsible for moulting because it stimulates production of ecdyson (moulting hormone)
- ecdysone(moulting hormone) causes moulting
- juvenile hormone causes moulting in larvae

## vi) State the advantages of metamorphosis in the life of insects

- the adult and larvae exploit different niches
- do not compete for food
- pupa can survive adverse pupa can survive adverse conditions eg-feeding stage
- dispersal prevents overcrowding



## FORM IV TOPICS

### 1. a) i) Define the term genetics

- the study of heredity (inheritance) and variation or study of mechanisms by which characteristics are passed from parents to offspring

### iii) List some characteristics which are inherited

- size
- height/length
- colour/type
- shape
- yield

### iii) State the importance of genetics

- helps to explain differences between organisms of the same species
- helps to explain the transmission of characters from generation to generation
- improvement in livestock
- improvement in crops
- can be used to treat some difficult diseases

### b) i) Explain the meaning of the following terms

#### Heredity

- the resemblance among individuals related by descent
- transmission of traits from parents to offspring

#### Trait

- also called character
- A character of the organism e.g. type of ear, colour of eyes, height, yield etc.

#### Gene

- unit of inheritance
- it is the heredity factor which transmits traits from parents to offspring
- genes are located at fixed points on chromosomes
- each point is called a locus (loci)

## Allele

- genes can exist in a series of alternative forms at a particular locus
- allele refers to alternative forms of genes controlling a particular characteristic



## Chromosomes

- threadlike structures found in nuclei of all plants and animals
- they carry genes which are hereditary materials
- they consist of substances called DNA and proteins called histones

## DNA

- deoxyribonucleic acid
- substances that make up chromosomes
- double helix(strand) molecule that contains genes
- DNA consists of nucleotides
- A nucleotide consists of an inorganic phosphate, ribose sugar and a base
- There are four bases in a DNA molecule i.e. Adenine(A), guanine(G), thymine(T) and cystosine (C)
- Ribose sugar has four bases attached to it i.e. adenine, cystosine, guanine and thymine
- Adenine pairs with thymine while guanine pairs with cystosine
- Nucleotide initiates and controls protein synthesis

### ii) List the types of chromosomes

- somatic (body) chromosomes also called autosomes
- sex chromosomes (related to reproduction)

### c) i) What is variation?

- sequence of differences occurring among individuals of the same species

### ii) State the causes of variation in organisms

- random assortment of genes during meiosis
- crossing over
- fertilization
- doubling of chromosome numbers(mutation)
- environmental conditions

### iii) Name the types of variation

- Continuous variation (differences not clear cut) e.g. height, length, weight, skin colour, intelligence etc. They are quantitative and show intermediates

- discontinuous variation(differences are clear cut) e.g. ability to roll tongue, ABO blood grouping system, RH factor, patterns of fingerprints, and ability to taste PTC. They are qualitative and have no intermediates

#### iv) Explain the following terms

##### Acquired characteristics

- they are as a result of adaptations due to the environment and are not inherited

##### Inherited characteristics

- are passed down to offspring during sexual reproduction

##### Genotype

- genetic constitution of an individual/genetic makeup

##### Phenotype

- characteristics of an individual observed or discernible by other means i.e. observable character

##### Dominant gene (character)

- expressed in the phenotype when homozygous or heterozygous

##### Recessive gene

- only expressed in homozygous state

##### Homozygous

- when two alleles are identical e.g. LL,ll

##### Heterozygous

- when two alleles are different at a particular locus e.g. Ll

##### F1 and F2

- F1 means first filial generation i.e. the first generation produced when two varieties can be crossed
- F2 means second generation i.e. product of offspring or from F1 generation

#### d) i) Explain Mendel's first law of inheritance

- also called law of segregation
- it states that genes are responsible for the development of individual characters
- these characters are transmitted individually without any alterations
- Only one character from a contrasting pair can be carried in a gamete, hence only one character can be inherited.

#### ii) Give an example of this law

- In an experiment, *Drosophila* (fruit fly) with long wings were crossed with those having short wings. Assume letter L denotes gene for wing size. The gene for long wings is dominant to that for short wings

- the genes for dominant are LL and for recessive ll.
- State the expected results for the first cross

### iii) What is monohybrid inheritance?

- when inheritance of one character is studied one at a time e.g. wing size only
- the F<sub>2</sub> generation (when selfed) always gives a phenotypic ratio of 3:1 and a genotypic ratio of 1:2:1 in a complete dominance



### v) What is complete dominance?

- refers to where only one dominant character is expressed while the other character which is recessive is not expressed in the heterozygous state e.g. the case of wing size above

### e) i) What is meant by co dominance?

- When genes produce independent effects when heterozygous/none of the genes is dominant over the other/where two or more alleles does not show complete dominance/recessiveness due to the failure of any allele to be dominate in a heterozygous condition.

### ii) Give an example of co dominance

In a certain plant species, some individual plants may have only white, red or pink flowers. In an experiment a plant with white flowers was crossed with a parent with red flowers. Show results of F<sub>1</sub> generation. Use letter R for red gene and W for white gene.

**If the plants form F<sub>1</sub> were selfed, work out the phenotype ratio for the F<sub>2</sub> generation**

Phenotypic ratio 1red:2pink:1white

Genotypic ratio 1:2:1

### f) i) What is a test cross?

- A cross between an individual showing a character for a dominant gene(that is homozygous or heterozygous) with a homozygous recessive individual

**OR**

- a cross between individual(organism) of unknown genotype with a homozygous recessive individual

### ii) State the importance of a test cross in genetics

- helps in determining the genetic constitution/genotype of an organism

### iii) What are multiple alleles?

- a set of more than two alleles that may determine a character

- example is blood group which can be determined by any two of three alleles i.e. A,B and O

**iv) Explain the inheritance of ABO blood groups**

- in humans blood groups are determined by three alleles i.e. A,B and O
- it is only possible to have two genes at a time
- genes A and B are co-dominant while gene O is recessive to genes A and B



**Give a worked example using parents with heterozygous blood groups AO and BO**

**vi) Explain the inheritance of Rhesus factor (Rh) in human beings**

- in humans blood is either Rh positive or Rh negative
- people who have Rh antigen are Rh(+ve) while those without Rh antigen in their blood are Rh(-ve)
- Rh(+ve) is due to a dominant gene while the recessive gene causes lack of Rh factor. When a person who is homozygous dominant marries a person who is homozygous recessive the result is as shown below

Let the gene for dominant Rh factor be R while gene for recessive be r

**vii) How is sex determined in human beings?**

- there are two sex chromosomes in humans, x and y
- males are xy and females are xx
- in females all ova have x chromosome
- in males 50% of sperms contain x chromosomes while 50% of sperms contain y chromosome
- when a sperm containing x chromosome fuses with an ovum this results into a girl
- when a sperm containing y chromosome fuses with an ovum the result is a boy
- an example is given below

**g) i) What does the term linkage mean?**

- These are genes which occur together on a chromosome and are passed to offspring without being separated

**ii) Define the term sex-linked genes**

- genes carried in the sex chromosome that are transmitted along with genes that determine sex

**iii) What is meant by the term sex linkage?**

- genes are located on the sex chromosome
- they are transmitted along with those that determine sex

**iv) Name the sex-linked traits in humans**

- colour blindness
- haemophilia
- Hairy ears. pinna, nose
- Baldness
- Duchene muscular dystrophy (DMD) muscular wasting

v) **Give an example of a sex linked trait in humans on:**

**Y Chromosome**

- tuft of hair sprouting from pinna/baldness

**X Chromosome**

- colour blindness/haemophilia

vi) **In humans red-green colour blindness is caused by a recessive gene C, which is sex-linked. A normal man married to a carrier woman transmits the trait to his children. Show the possible genotypes of the children.**

Let C represent the gene for normal colour vision (dominant)

Let c represent the gene for colour blindness

Parental phenotype Norman man x carrier woman

viii) **State the importance of sex linkage**

- possible to determine sex of day old chicks

ix) **Haemophilia is due to a recessive gene. The gene is sex-linked and located on the x chromosome. The figure below shows sworn offspring from phenotypically normal parents**

What are the parental genotypes?

- XY and X<sup>h</sup>X

Work out the genotypes of the offspring

h) i) **What is mutation?**

- sudden change in the structure of DNA at a particular locus/chromosome/gen

ii) **Describe how mutations arise**

- mutations arise due to alterations in normal number of chromosomes
- change in a portion of a chromosome affecting one or more genes
- by chromosomal aberration e.g. deletion/duplication/substitution/inversion/translocation/crossing over
- caused by mutagenic agents e.g. radiation (x-rays, ultra violet light, gamma rays) and chemicals e.g. mustard gas/colchicines

iii) **State the factors that may cause mutation**

- these are chemicals and radiations

## **Radiations**

X-rays

Ultra violet rays

## **Chemicals**

- colchicines

Cyclamate

Mustard gas

Nitrous acid

behaves like guanine

Acridone orange

DNA

Formaldehyde

## **Effects**

gene/chromosome alteration

structural distortion of DNA

## **Effect**

prevents spindle formation

chromosome aberrations

chromosomes aberrations

adenine in DNA is deaminated so

addition and removal of bases of



## **iv) State the characteristics of mutations**

- arise suddenly
- are unpredictable
- random
- generally rare
- may breed true
- some are desirable while others are lethal

## **v) Explain chromosomal mutation**

- Change in nature, structure or number of chromosomes

## **vi) Explain how the following types of chromosomal mutations occur**

### **Duplication**

- a section of a chromosome is repeated/replicates
- therefore genes are repeated

### **Inversion**

- occurs when chromatids break at 2 places and when rejoining the middle piece rotates and joins in an inverted position

### **Deletion**

- portion of a chromosome is left out after it breaks off
- alters number and sequence of genes

### **Translocation**

- occurs when a section of a chromatid breaks off and becomes attached to another chromatid of another chromosome

### **Non-disjunction**

Failure of homologous chromosomes/sister chromatids to separate/segregate during meiosis

### **Polyploidy**

- where number of chromosomes double or triple
- beneficial in plants due to the following



- increased yields/hybrid vigour//heterosis
- resistance to pests
- early maturity
- resistance to drought
- resistance to diseases



**vii) What are gene mutations?**

- an alteration in the structure of a gene

**vii) Explain how the following occur during gene mutation**

**Deletion**

- some bases/nucleotides of a gene are removed

**Inversion**

- the order of some bases/nucleotides of a gene is reversed

**Insertion**

- addition of a base between two existing bases

**Substitution**

- a portion of a gene is replaced by a new portion

**viii) Name the disorders in humans caused by gene mutation**

- albinism
- sickle cell anaemia
- achondroplasia/chondrodystrophic dwarfism
- haemophilia
- colour blindness
- phenylketonuria

**I. State the practical applications of genetics**

**i. Breeding programmes (research)**

- high yielding/hybrid vigour/heterosis
- resistance to diseases
- resistance to drought/salinity
- early maturing

**ii. Genetic engineering**

- genetic manipulation to produce desired characteristics

**iii. Law**

- legal questions of paternity knowledge of blood groups or blood transfusion

**iv) Genetic counseling**

- aimed at reducing harmful traits e.g. albinism, congenital idiots, colour blindness e.t.c

**v) Others**

- Pre-sex determination

Understanding human evolution and origin of other species.

## 2. a) i) Explain the meaning of evolution

- a gradual change in living organisms from simple life forms to more complex forms over a long period of time.

## ii) Differentiate organic evolution from chemical evolution as theories of origin of life



- organic evolution refers to the emergence of present forms of organisms gradually from pre-existing forms (some of which no longer exist)
- chemical evolution explains the origin of life as having occurred when simple chemical compounds reacted to form the simplest life forms

## iii) What is special creation?

- maintains that the whole universe and all living organisms came into being due to the act of a supernatural being

## b) Discuss the various kinds of evidence for evolution

### i) Fossils

- fossils are remains of organisms preserved in naturally occurring materials for many years
- they give evidence of types of plants/animals that existed at certain geological age/long ago/millions of years ago
- gives evidence of morphological/anatomical/structural changes that have taken place over a long period of time e.g. human skull, leg of horse

### ii) Comparative anatomy

- gives evidence of relationship among organisms/gives evidence of a common ancestry of a group of organisms
- organisms have similar structures/organs performing the same function e.g. digestive system/ urinary system/nervous system/vestigial structures and vertebrate heart
- **Divergence** where the basic structural form is modified to serve different functions e.g. vertebrate forelimb/beak structure in birds/birds feet/parts of a flower. These are called homologous structures
- **homologous structures** have a common embryonic origin but are modified to perform different functions e.g. the pentadactyl limb
- **adaptive radiation** is a situation where organism have a homologous structure with common embryonic origin which is modified to perform different functions to adapt organisms to different ecological niches/habitats e.g. beaks of Darwinian finches(birds)

- **Convergence** is where different structures are modified to perform a similar function e.g. wings of birds and insects/eyes of humans and octopuses. These are called analogous structures
- **Vestigial structures** are greatly reduced in size and have ceased to function e.g. human appendix/caecium/coccyx in humans, wings of kiwi (flightless bird), presence of hind limb pad in python, halteres in insects, human hair nictitating membrane in human eye, human ear muscle, pelvic girdle in whale and third digit of wing of bird.

### iii) Comparative embryology

- some embryos of different animals appear very similar thus showing relationship and possibility of a common ancestry
- e.g. different classes of vertebrates larvae of annelida and mollusca are similar (trocophore)

### iv) Comparative serology/physiology

- these show biochemical and immunological comparisons of blood groups/components to show immunological similarities of tissues therefore showing relatedness of different organisms
- e.g. antigen antibody reactions, human blood groups/Rh factor reveal some phylogenetic relationship among organisms/common ancestry

### v) Geographical distribution

- organisms differ in various geographical regions
- present continents are thought to have been a large land mass joined together/pangea/Eurasia/Gondwanaland
- present continents drifted apart from one land mass/continental drift
- as a result of continental drift isolation of organisms occurred bring about different patterns of evolution
- organisms in each continent evolved along different lines hence emergence of new species/divergence/convergence

### Examples

- marsupials in Australia
- llama, jaguar, panther in S. America
- lion, camel in Africa
- tiger in Asia

### vi) Cell biology (cytology)

- structures and functioning of cells are similar
- occurrence of organelles e.g. mitochondria in all cells/both plant and animal cells

- these point at a common ancestry

**c) i) State the evolutionary characteristics that adapt human beings to the environment**

- Brain
- Eyes
- Upright posture/bipedal locomotion
- prehensile arm/hand
- Speech

**ii) State the ways in which Homo sapiens differs from Homo habilis**

- standing upright/erect posture
- intellectual capacity/higher thinking capacity/bigger brain/higher brain capacity
- communication through language/speech

**d) i) Explain Lamarck's theory of evolution**

- Inheritance of acquired characteristics/environment induces production of a favorable trait which is then inherited

**ii) Explain why Lamarck's theory of evolution is not accepted by biologists today**

- evidence does not support Lamarck's theory
- acquired characteristics are not inherited/inherited characteristics are found in reproductive cells only

**iii) Explain Darwin's theory of evolution**

- inheritance of genetically acquired characteristics
- a character happens to appear spontaneously which gives advantage to an organism therefore adapted then inherited through natural selection

**e) i) What is natural selection?**

- Organisms with certain characteristics are favoured by the environment

Such organisms tend to survive and produce viable offspring

Others not favored are eliminated from subsequent generations

**ii) With examples, explain how natural selection takes place**

- organism with certain characteristics are favored by their environment
- such organisms tend to survive and produce viable offspring
- others not favored are eliminated from subsequent generations
- as the environmental conditions change the survival value of a character may alter with time so that characteristics which were favored may no longer have advantage and other characters may then become favorable

- if a favorable character is inherited, then offspring produce generations which are better adapted to survive in a population
- more offspring are produced than can survive which results in struggle for survival
- the fittest survive

### **iii) State the advantages of natural selection to organisms**

- assist to eliminate disadvantageous characteristics/perpetuates advantageous characteristics
- allows better adapted organisms to survive adverse changes in the environment/less adapted organisms are eliminated

### **iv) State the ways in which sexual reproduction is important in the evolution of plants and animals**

- brings about useful variations/desirable characters
- variations make offspring better adapted for survival/more resistant to diseases
- may lead to origin of new species

### **v) Explain the significance of mutation in evolution**

- Mutation bring about variation which can be inherited
- Some of these variations are advantageous to the organism
- Others are disadvantageous
- The advantageous variations favour the organism to compete better in the struggle for survival
- This results into a more adapted organism to its environment or new species/varieties
- Those with disadvantageous characters will be discriminated against therefore eliminated from the population/death/perish

### **vi) Plain why it is only mutations in genes of gametes that influence evolution**

- gametes form the new offspring

### **vii) How would you prove that evolution is still taking place?**

- resistance of organism to antibiotics, pesticides and drugs
- new varieties of bacteria are resistant to certain antibiotics such as penicillin
- houseflies and mosquitoes are resistant to DDT

### **viii) Explain why some bacteria develop resistance to a drug after they have been subjected to it for some time**

- bacteria mutates/develops a new strain/chemical composition is altered hence is able to produce enzymes/chemicals which degrade the drug rendering it non-susceptible to the drug
- the new strain is favoured by selection pressure/ natural selection

**f) How has industrial melaninism i.e. peppered moth contributed towards the mechanism of evolution**

- This is an example of natural selection
- The peppered moth exists in two distinct forms, the speckled white form (normal form) and a melanic form (the black/dark)
- They usually rest on leaves and barks of trees that offer camouflage for protection
- Originally the “speckled white” form predominated the unpolluted area of England
- This colouration offered protection against predatory birds
- Due to industrial pollution tree barks have blackened with soot
- The white form underwent mutation
- A black variety/mutant emerged suddenly by mutation
- It had selective advantage over the white forms that were predated upon in the industrial areas
- The speckled white form is abundant in areas without soot/smoke

**3. a) i) Define irritability, stimulus and response irritability**

- also called sensitivity
- Responsiveness to change in environment

**Stimulus**

A change in the environment of organism which causes change in organism’s activity

**Response**

- change in activity of an organism caused by a stimulus

**ii) State importance of irritability to living organisms**

- Adjusting to environmental conditions.  
Sensitive/defect/responding

**iii) List the examples of external stimuli to organisms**

- air/oxygen (aero)
- light(photo)
- osmotic pressure (osmo)
- current (Rheo)
- chemical concentration (chemo)
- \water/moisture (hydro)
- Touch/contact (hapto/thigmo)
- Gravity/soil (geo)
- Temperature (thermo)

**b) i) What are tactic responses?**

- response in which whole organism or its motile parts move  
e.g. gamete

**ii) What causes tactic responses?**

- caused by unidirectional stimulus

- usually doesn't involve growth
- response is either positive or negative
- named according to source of stimulus
- e.g phototaxis, aerotaxis, chemotaxis

### iii) State the importance of tactic response to:

#### Members of kingdom protista

- move towards favorable environment/move away from unfavorable environment
- move towards their prey/food

#### Microscopic plants

- escape injurious stimuli/seek favorable habitats

#### iv) Name the type of response exhibited by:

Euglena when they swim towards the source of light

- phototaxis
- sperms when they swim towards the ovum
- chemotaxis

#### v) State the advantages of tactic responses to organisms

- to avoid unfavorable environment/injurious stimuli
- escape from predators
- to seek favorable environment
- to seek for food/prey

#### c) i) Define the term tropism

- growth movement of plants in response to external unilateral/unidirectional stimuli

#### ii) Explain the various types of tropism in plants

##### Phototropism

- growth movements of plant shoots in response to unilateral sources of light
- the tip of the shoots produce auxins down the shoot
- light causes auxins to migrate to outer side/darker side causing growth on the side away from light hence growth curvature towards source of light roots are negatively phototropic

##### Geotropism

- response of roots/parts of a plant to the direction of force of gravity
- auxins grow towards the direction of force of gravity causing positive geotropism in roots while shoot grows away from force of gravity (negatively geotropic)

##### Thimotropism/Haptotropism

- growth response of plant when in contact with an object

- contact with support causes migration of auxins to outer side causing faster growth on the side away from contact surface
- this causes tendrils/stem to twin around a support

### Hydrotropism

- growth movement of roots in response to unilateral source of water/moisture
- the root grows towards the source of water/ positively hydrotropic while leaves are negatively hydrotropic

### chemotropism

- growth movement of parts of plant to unilateral source of chemicals
- the chemicals form a gradient between two regions e.g. pollen tube growing towards the ovary through the style

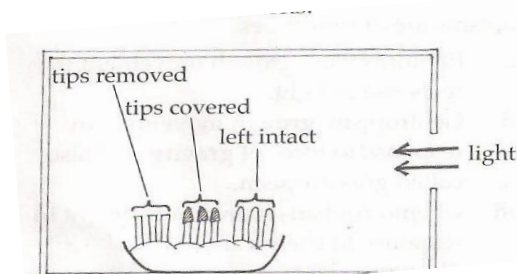
### iii) State the ways in which tropisms are important to plants

- expose leaves/shoots in positions for maximum absorption of sunlight for photosynthesis
- enables roots of plants to seek/look/search for water
- enables plant stems/tendrils to obtain mechanical support especially those that lack woody stems
- enables roots to grow deep into the soil for anchorage
- enables pollen tube grow to embryo sac to facilitate fertilization

### iv) Explain the differences between tropic and tactic responses

| Tropisms   | Taxes   |
|--|---|
| <ul style="list-style-type: none"> <li>- growth curvature in response</li> <li>- slow</li> <li>- influenced by hormones</li> </ul> | <ul style="list-style-type: none"> <li>- locomotory response</li> <li>- fast</li> <li>- external influence</li> </ul> |

### d) The diagram below represents growing seedlings which were subjected to unilateral light at the beginning of an experiment



R

- State the results of P, Q and R after 5 days
  - P will bend/grow towards light



- Q will remain straight/have little or no growth
- R will remain/grow straight/grow upwards

**ii) Account for your results in (i) above**

P- Growth substance/growth hormone/IAA/auxin are produced by the stem tip

- they move (downwards and get distributed) to the side away from light where they cause rapid/more growth/cell division/elongation that results in bending

Q- Source of auxin has been removed

R- The auxins cannot be affected by light because the tip has been covered

**iii) If the tin foil were removed from the tip of seedling R, what results would be observed after two days**

- it will bend/grow towards light

**iv) State the expected results after 3 day is if the box were removed**

- all seedlings will grow straight/upwards

**e) In an experiment to investigate a certain aspect of plant response, a seedling was placed horizontally as shown in diagram I below. After seven days the appearance of the seedling was as shown in diagram 2**

**Account for the curvature of the shoot and root after the seven days**

**i) Shoot**

- auxins accumulate on the lower side of the seedling due to gravity
- high concentration of auxins in shoot stimulates faster growth causing more elongation on the lower side than the upper side hence curvature occurs upwards

**ii) Root**

- the high concentration of auxins inhibits growth hence the upper side with less auxins grows faster than the lower side therefore the curvature occurs downwards

**f) What is etiolation?**

- phenomenon exhibited by plants when grown in darkness
- such plants are pale yellow due to absence of chlorophyll, have small leaves, long stems/hypocotyle and slender stems
- plants exhibit etiolation to reach light/obtain light
- this is a survival response

**3. a) i) What is coordination in animals**

4. - The linking together of all physiological activities that occur in the body so that they take place at the right time and in the correct place

**ii) Name the main systems for coordination in animals**

- Nervous system/sensory system
- Endocrine (hormonal system)

**iii) List the components of the mammalian sensory system**

- Central nervous system (CNS), brain & spinal cord
- Peripheral nervous system (PNS) cranial and spinal nerves
- Sense organs
- Autonomic nervous system (ANS) nerve fibers and ganglia

**iv). Explain the terms receptors, conductors and effectors**

- Receptors are structures that detect stimuli i.e. sense organs
- Conductors transmit impulses from receptors to effectors e.g. neurons
- Effectors are the responding parts e.g. muscles, glands

**v) What are the functions of the central nervous system?**

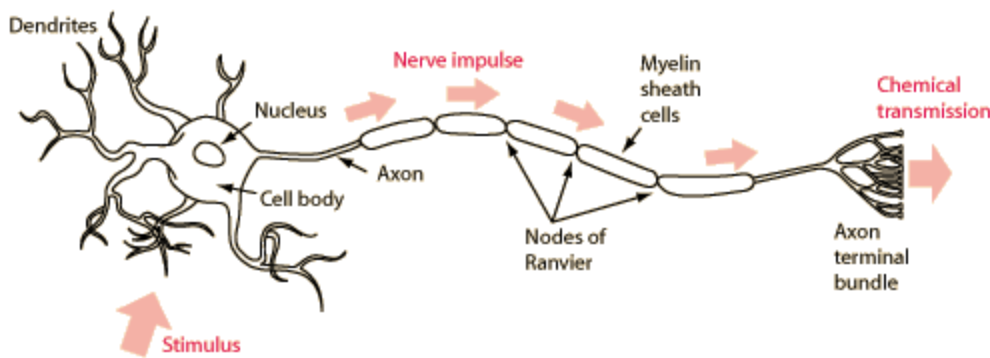
- provides a fast means of communication between receptors and effectors
- coordinates the activities of the body

**vi) State the differences between somatic and autonomic systems of peripheral nervous system**

- Somatic is concerned with controlling the conscious or voluntary actions of the body i.e. skin, bones, joints and skeletal muscles
- the autonomic (automatic) nervous system controls involuntary actions of internal organs, digestive system, blood vessels, cardiac muscles and glandular products.

**b) i) What is a neurone?**

- the basic unit of the nervous system
- also called nerve cell
- conducts impulses
- include monitor sensory and relay neurons

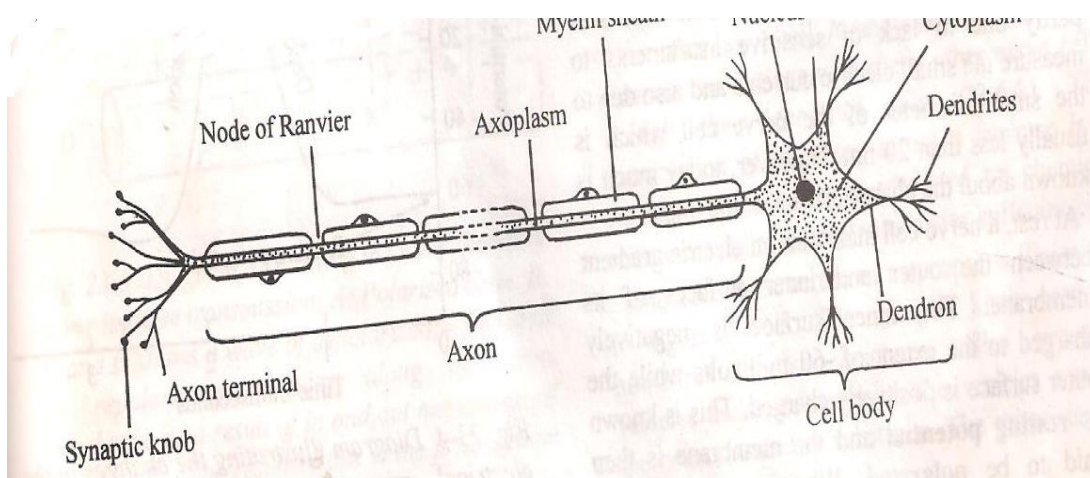


**ii) Name the parts of a typical neurone and state the functions of each part**

- cell body/centron contains nucleus and cytoplasm
- axon transmits impulses away from cell body
- dendrites relays impulses across adjacent neurons
- myelin sheath insulates axon and speeds up transmission of impulses
- schwan cells forms myelin sheath and aid in nutrition and regeneration of axon
- node of ranvier occur between schwan cells, where axon is not covered, speeds up impulse transmission
- nissils granules contain mitochondria that provide cell body with energy for metabolic process

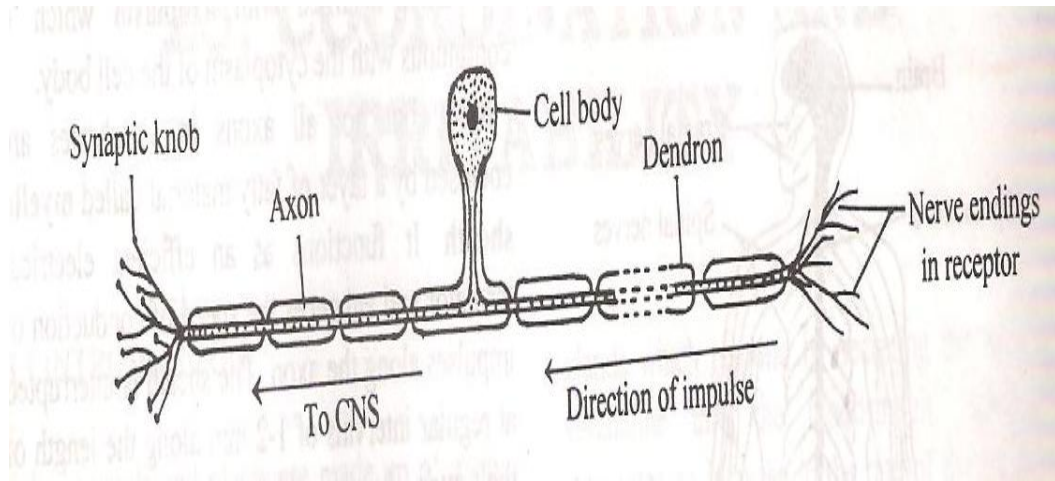
**i) Describe the structure and function of a motor neurone**

- motor neurone relays impulses from CNS (brain/spinal cord) to effectors ( muscles/glands)



**ii) Describe the structure and function of sensory neurone**

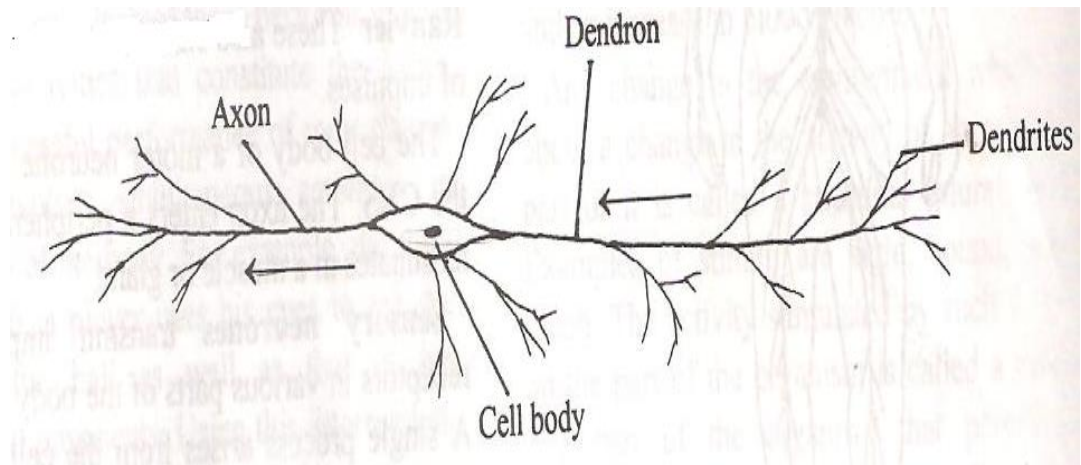
- sensory neurone relays impulses from receptors (sense organs) to CNS



**iii) State structural differences between motor and sensory neurons**

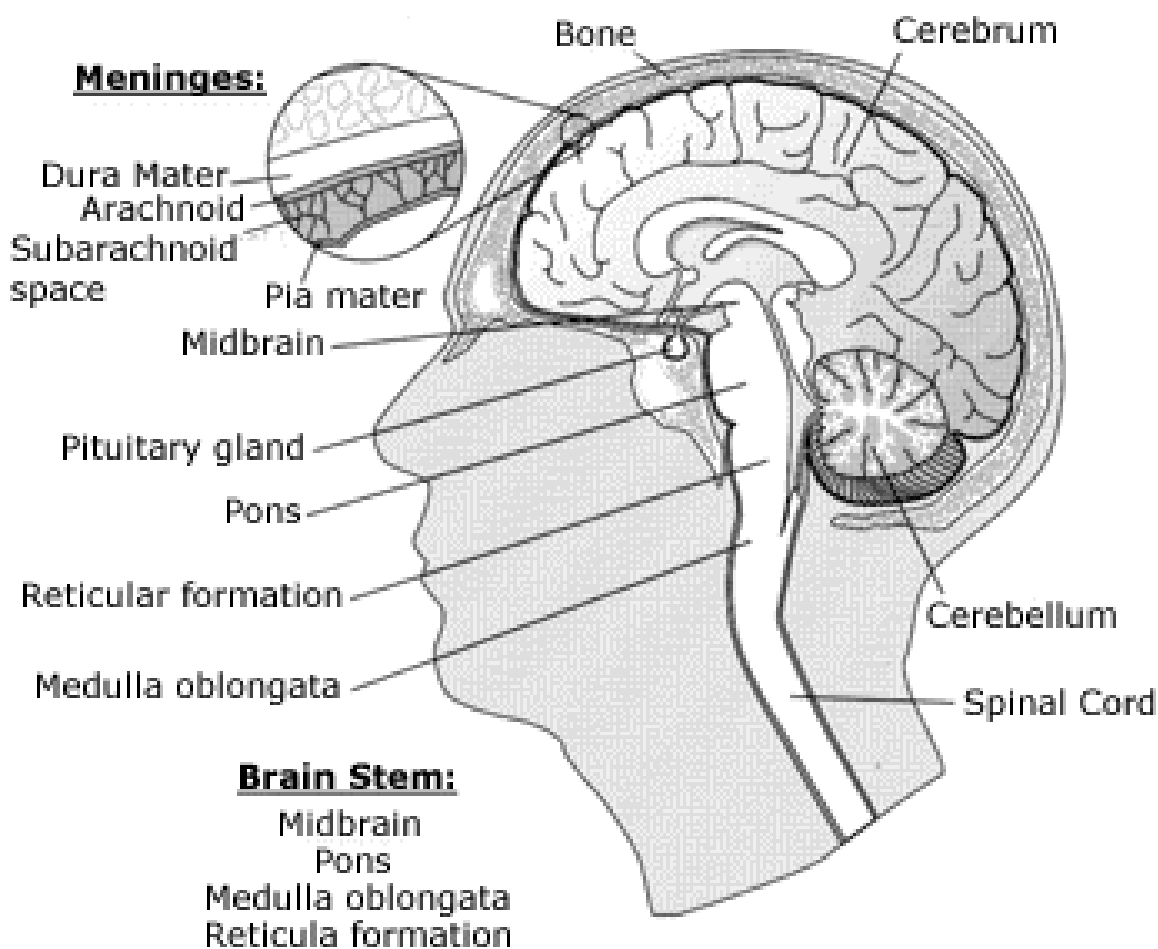
- Cell body in motor neurone is terminal (at the end) and inside central nervous system.
- Cell body in sensory neurone is terminal but has axon at both ends (bipolar)

**iv) Describe the structure and function of a relay neurone**



- also called intermediate/internuncial/associate/connector/interneurone
- locate inside central nervous system and spinal cord
- usually lack myelin sheath

**c) State the functions of the major parts of the human brain**



### i) Cerebrum

- called forebrain
- occupies most of the brain
- consists of four lobes each with specific function
- temporal lobe controls taste smell hearing learning and memory
- parietal lobe controls sensory output and touch
- occipital lobe controls vision, motor output and speech
- frontal lobe controls personality, learning thought and speech
- also has parts called thalamus and hypothalamus
- thalamus helps to sort sensory information
- hypothalamus controls hunger, heartbeat body temperature and aggression

### ii) Mid brain

- quite small in humans
- relay centre for audio and visual information
- also involves in some sight, hearing and orientation responses

#### i) Hind brain

- consists of cerebellum and medulla oblongata
- cerebellum is responsible for coordinating impulses, posture and balance, motor coordination and muscle tone

- medulla oblongata controls heartbeat, blood pressure breathing rate, coughing and sneezing

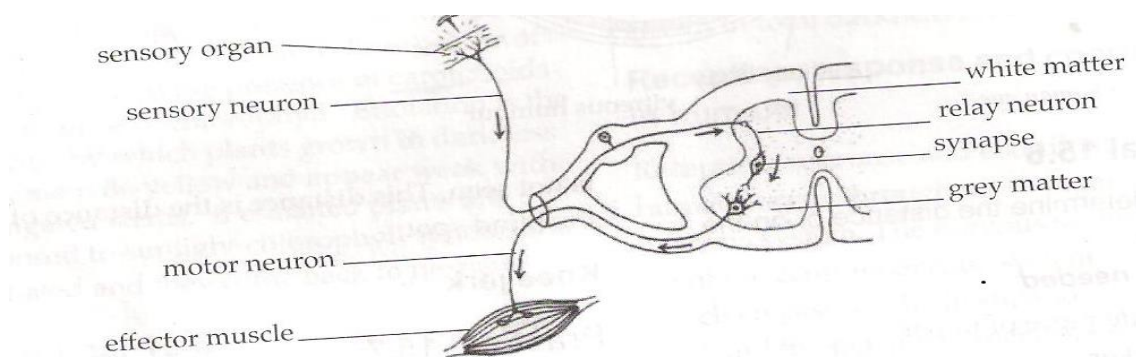
**a) i) What is reflex action?**

- an automatic response to an external stimulus e.g. sneezing or withdrawing hand from a hot object



**ii) Describe a reflex action that will lead to the withdrawal of a hand from a hot object**

- Receptors in the skin respond to stimuli. Are stimulated
- an impulse is transmitted through the sensory neurone, across a synapse to the central nervous system (white matter), through the relay neurone into grey matter, then to the motor neurone and finally to the effect muscle which contracts
- the hand is then withdrawn



**iii) Explain how an impulse is transmitted across the synapse (gap)**

- impulse initiates release of transmitter substance acetylcholine at the end of the sensory neurone
- acetylcholine diffuses across the synapse and generates an impulse in the next neurone

**ii) Briefly describe the transmission of a nervous impulse across a neuro-muscular junction**

- impulse arrives at synoptic knob and causes vesicle to move to the pre-synaptic membrane
- vesicle discharges transmitter substance into synaptic cleft
- transmitter substance/acetylcholine diffuses across the cleft and attaches to post-synaptic membrane
- the membrane is depolarized, generating the action potential

**iii) What are the functions of a synapse?**

- allows transmission of nerve impulses from neurone to neurone
- ensures nerve impulses travel in only one direction

- in the brain they store information/memory

**b) i) What is a conditioned reflex?**

- A response caused by a unilateral stimulus (associated stimulus) which substitutes the normal stimulus

**ii) Explain a conditioned reflex**

- it is automatic
- it involves the spinal cord
- it is usually learned e.g. writing, cycling, dancing
- it involves the interaction of highly specialized centers of the brain with a large number of neurone necessary to bring about conditioning
- example is experiments carried out by Pavlov using dogs

**iii) Compare a simple reflex action with a conditioned reflex**

| Simple reflex  | Conditioned reflex  |
|--|---|
| <ul style="list-style-type: none"> <li>• independent of experience</li> <li>• one stimulus to evoke response</li> <li>• some sensory and motor neurons used</li> <li>• reflex is simple</li> </ul> | <ul style="list-style-type: none"> <li>• dependent on experience</li> <li>• both substitute and original reflex evoke response</li> <li>• sensory component replaced but motor remains unchanged</li> <li>• reflex is modified</li> </ul> |

**c) i) What are endocrine glands?**

- ductless glands that produce hormones in animals
- hormones are chemical substances which help to coordinate the functions of the body

**ii) State the functions of hormones in animals**

- regulate growth and development
- control behavior during breeding
- proper functioning of cells
- regulate metabolic activities

**iii) Name the main endocrine glands, their secretions and functions in the human body**

| Gland       | Hormone             | Functions                              |
|-------------|---------------------|--|
| Thyroid     | Thyroxine           | Increases rate of metabolism           |
| Parathyroid | Parathyroid hormone | Regulates calcium and phosphate levels |
| Pituitary   | Hormone growth      | Regulate growth of                     |

|         |   |   |
|---------|---|---|
|         |   | body  |
|         | Gonadotrophic hormone                     | Stimulates the development of male and female sex organs  |
|         | Lactogenic hormone (prolactin)            | Stimulates secretion of milk after child birth  |
|         | Thyrotropic hormone(TSH)                  | - proper functioning of thyroid gland/thyroxine production  |
|         | Adrenocorticotropic hormone (ACTH)        | - stimulates release of adrenal cortex hormone  |
|         | Oxytocin                                  | <ul style="list-style-type: none"> <li>• regulates blood pressure</li> <li>• stimulates smooth muscles</li> <li>• stimulates contraction of uterus during childbirth</li> <li>• aids in flow of milk from mammary glands</li> </ul> |
|         | Follicle stimulating hormone(FSH)         | <ul style="list-style-type: none"> <li>• causes maturation of egg in females</li> <li>• stimulates sperm production in males</li> </ul>   |
|         | Vasopressin (ADH)<br>Antidiuretic hormone | - regulates water balance by kidneys  |
| Adrenal | Adrenaline (epinephrine)                  | <ul style="list-style-type: none"> <li>• for emergency</li> <li>• prepares body to cope up with stress</li> </ul>   |
|         | Aldosterone                               | - maintains balance   |



|           |              |   |
|-----------|--------------|---|
|           |              | of salt and water in blood  |
|           | Cortisone    | <ul style="list-style-type: none"> <li>• breaks down stored proteins to amino acid</li> <li>• aids in breakdown of adipose tissue</li> <li>• regulates sugar level in blood</li> <li>• prevents inflammation</li> </ul> |
|           | Sex hormones | <ul style="list-style-type: none"> <li>• supplements sex hormones produced by gonads</li> <li>• promotes development of sexual characteristics</li> </ul>   |
| Pancrease | Insulin      | <ul style="list-style-type: none"> <li>• regulates level of sugar in blood</li> <li>• enables liver to store sugar</li> </ul>   |
|           | Glucagons    | <ul style="list-style-type: none"> <li>• regulates level of sugar in blood</li> </ul>   |
| Ovaries   | Oestrogen    | <ul style="list-style-type: none"> <li>• causes sexual secondary characteristics in females</li> <li>• prepares uterus for pregnancy</li> </ul>   |
|           | Progesterone | <ul style="list-style-type: none"> <li>• growth of mucus lining of uterus</li> </ul>  |

|                  |                         |  |
|------------------|-------------------------|--|
|                  |                         | <ul style="list-style-type: none"> <li>• maintains uterus during pregnancy</li> </ul>                |
| Testes           | Androgens(testosterone) | <ul style="list-style-type: none"> <li>• causes secondary sexual characteristics in males</li> </ul> |
| Stomach cells    | Gastrin                 | <ul style="list-style-type: none"> <li>• stimulates release of gastric juice</li> </ul>              |
| Intestinal cells | Secretin                | <ul style="list-style-type: none"> <li>• stimulate release of pancreatic juice</li> </ul>            |

**iv) Give the differences between nervous and endocrine (hormonal) communication**

| Nervous  | Hormonal (endocrine)                       |
|--|--|
| Response confined to effector organs (localized targets) | Response more widespread (various targets) |
| Speed of response is rapid                               | Response less rapid                        |
| Nervous impulse through nerves/nerve cell/neurons        | Hormones transferred through blood         |
| Duration of response is short                            | Persist for long                           |
| Speed of transmission is rapid                           | Speed of transmission is slower            |
| Transmission is electrical                               | Transmission is chemical                   |
|  |  |

**v) State the effects of over secretion and under secretion of adrenaline and thyroxine in humans**

| Hormone    | Over secretion   | Under secretion  |
|------------|--|--|
| Adrenaline | <ul style="list-style-type: none"> <li>• thin toneless muscles</li> <li>• high blood pressure</li> <li>• weak bones</li> <li>• obesity</li> <li>• early onset of sexual development</li> </ul> | <ul style="list-style-type: none"> <li>• low blood pressure</li> <li>• inability to withstand stress</li> <li>• fatigue</li> <li>• muscular weakness</li> <li>• muscle wasting</li> <li>• increased dark pigmentation of skin</li> </ul> |
| Thyroxine  | <ul style="list-style-type: none"> <li>• increased</li> </ul>  | <ul style="list-style-type: none"> <li>• cretinism(retarded)</li> </ul>  |

|  |   |   |
|--|---|---|
|  | metabolism <ul style="list-style-type: none"> <li>• increased heartbeat</li> <li>• physical restlessness</li> <li>• mental restlessness</li> <li>• protruding eyeballs</li> <li>• enlarged thyroid gland</li> </ul> | growth and low mental development <ul style="list-style-type: none"> <li>• lowered metabolism</li> <li>• low ventilation rate of lungs</li> <li>• low body temperature</li> <li>• lowered mental activity</li> <li>• coarse hair</li> <li>• puffy eyes</li> <li>• enlarged thyroid gland</li> </ul> |
|--|---|---|

### g) i) Define the following terms

#### Drug

- a substance that causes a change in body function

#### Drug abuse

- indiscriminate use of drugs without minding their side effects
- misuse or wrong use of drugs

### ii) State the types of drugs, examples and side effects

#### Sedatives

- also called depressant
- a drug that decreases the action of the central nervous system
- reduce anxiety, and tension, induce sleep and act as muscle relaxants
- when abused they cause withdrawal effects such as anxiety, delirium and death
- includes barbiturates, other sedatives, tranquilizers and alcohol

#### Pain-killers

- suppress centers of pain in the brain

#### Hallucinogens

- given to people with hallucination or mentally ill patients to calm them down
- when abused they lead to a feeling of confusion, agitation, depression and violent behavior that can lead to murder or suicide
- examples include valium, LSD, bhang, narcotics and cannabis

## Stimulants

- drugs that temporarily increase the action of the central nervous system
- they create a feeling of alertness, wakefulness, a sense of self confidence and well being
- used to decrease fatigue and mild depression
- when abused they cause feelings of persecution, hallucination and addiction
- include amphetamines, cocaine, caffeine, miraa and nicotine



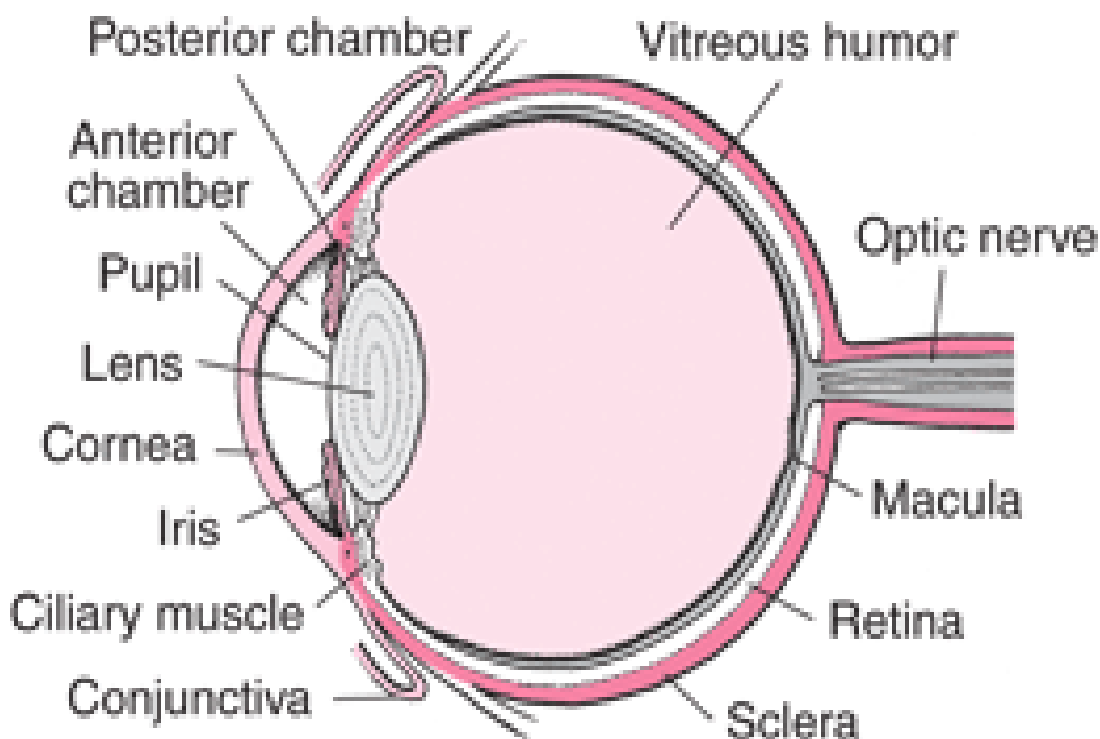
### iii) State the general effects of drug abuse on human health

- damage to body organs e.g. liver cirrhosis
- drug addiction
- impaired judgment resulting in clumsiness
- socio-economic problems e.g. crime, loss of jobs, divorce, prostitution, HIV/AIDS
- may cause poor health

### h) i) List the special sense organs in mammals and the major function of each

- Eye for sight
- Ear for hearing and balance
- Nose for smell
- Skin for touch, temperature detection, pain detection

### iii) How is the human eye adapted to its function?



- conjunctiva is thin/transparent/tough to allow light to pass through/to protect the eye

- Sclerotic layer is made up of (collagen) fibers/fibrous. It maintains shape of the eyeball/protects the eye
- cornea is transparent/curved thus refracts light rays/allows light to pass through
- Choroid is a layer of tissue with black pigment/dark pigment. Prevents internal reflection of light in the eye/contains blood vessels that supply oxygen/nutrients/remove (metabolic) wastes from the eye
- retina has cones/rods for bright colour vision/low light vision
- yellow spot has a high concentration of cones for accurate vision/visual acuity
- Blind spot has no cones and rods. Place where optic nerve leaves/enters the eye
- optic nerve has (sensory) nerve fibers for transmission of impulses to the brain (for interpretation)
- Lens is biconvex/made up of elastic material/transparent. Adjust focus on far or near objects allow light to pass through/for refraction of light rays
- ciliary body is made up of muscle fibers/glandular which contract/relax to change shape
- suspensory ligaments are inelastic to hold lens in position/attach it to ciliary body
- iris(is the coloured part of the eye it) has radial and circular muscles which control size of pupil
- pupil is the small hole at the centre of iris through which light passes into the eye
- aqueous humor is a fluid through which oxygen/nutrients pass to the cornea/lens/maintains shape of the eyeball/refracts light rays
- vitreous humor is a fluid which maintains shape of eye/refracts light rays

### iii) What is accommodation of the eye?

- ability of the eye to adjust to bring an image from a near or far object into sharp focus on the retina

### iv) Explain how an eye viewing a near object adjusts to viewing a far object

- ciliary muscles relax
- suspensory ligaments become taut/tight
- lens decreases curvature/becomes thinner
- radial muscles relax
- circular muscles contract

- size of pupil decreases to reduce amount of light
- v) **What changes occur in the eye if it changes from observing an object at a distance to one at a closer range?**
- ciliary muscles contract
  - Tension in suspensory ligaments reduces/relax/ slackens
  - Lens bulges/thickens/increases curvature
  - Radial muscles contract
  - Circular muscles relax
  - Size of pupil becomes large to allow in more light.

viii) **State the changes which would take place in the eye if a person in a dark room had lights switched on**

- circular muscles contract and radial muscles relax
- pupil becomes small to allow less light into the eye

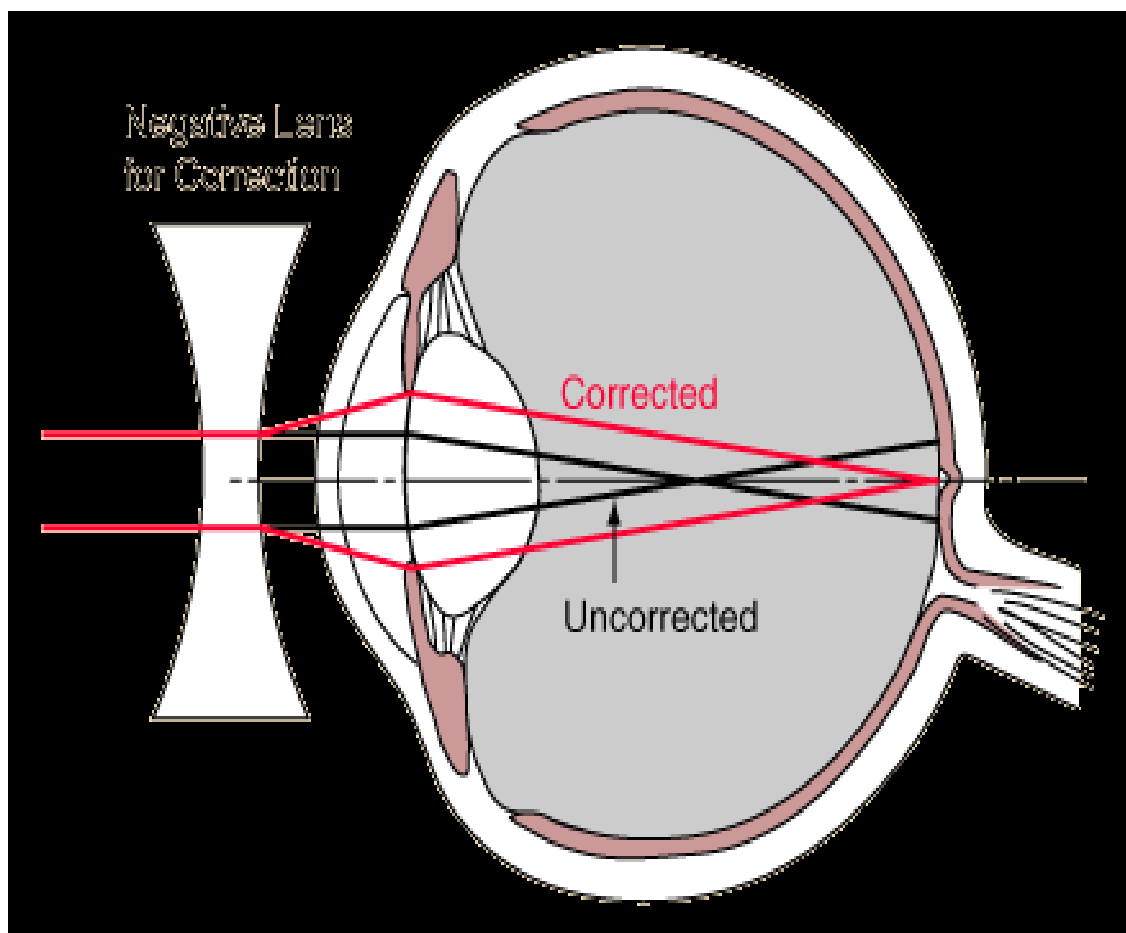
ix) **Explain how the eye forms an image**

- the mammalian eye works like a camera
- light rays enter the cornea pass through the pupil, aqueous humor, lens and vitreous humor
- light rays are refracted by the aqueous and humor and lenses
- finally light falls on the retina to form an image
- the image is real and inverted and smaller than object, back to front/reversed
- Retina forms a fine image when light rays reach it.

x) **Name the defects of the eye and state how they can be corrected**

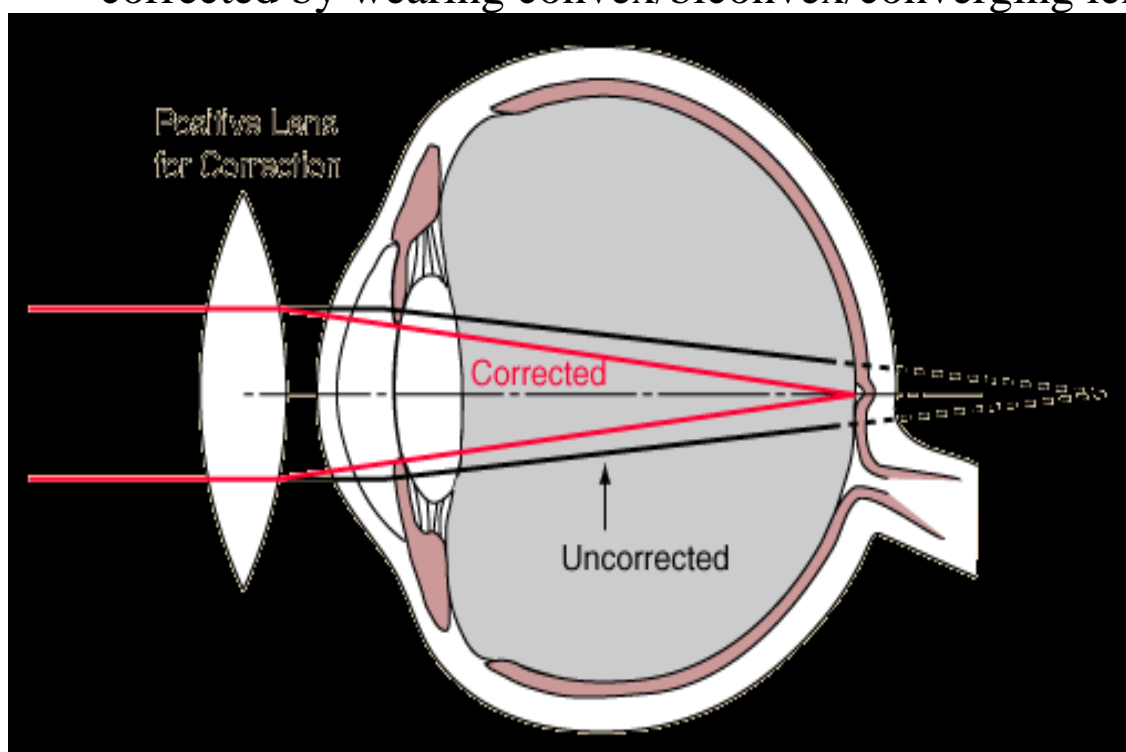
**Short sight (Myopia)**

- eye cannot focus on far objects
- image is formed in front of the retina because light rays converge in front of retina
- the lens is too thick, curve and eyeball too long
- corrected by wearing concave/biconcave/lenses
- these lenses diverge light rays onto retina



### Long sight (Hypermetropia)

- eye lenses are unable to focus because they are flat, thin and weak hence unable to focus image on the retina
- they are unable to accommodate/change the focal length
- near image is formed behind the retina but a distant one is correctly focused on the retina
- corrected by wearing convex/biconvex/converging lenses



### Presbyopia

- occurs in old age hence called old sight
- caused due to loss of elasticity of lenses, weakness of ciliary muscles hence lack of focus of light rays

- this causes long sight
- corrected by wearing biconvex/convex/converging lenses

### Squinting

- eyeballs are uncoordinated/do not turn at the same time
- eye muscles move in different directions
- this makes accommodation and focusing difficult
- corrected through surgery

### Astigmatism

- surface of cornea is uneven
- leads to weak focus of light raise on retina
- corrected by using cylindrical lenses/lenses with combined curvature

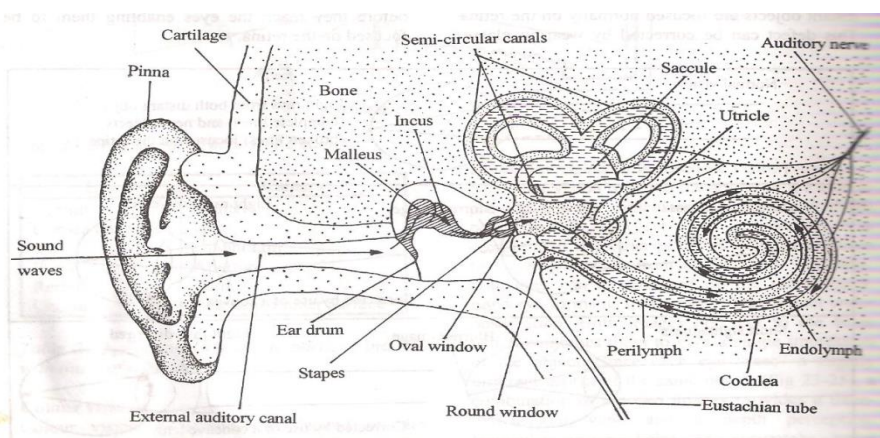
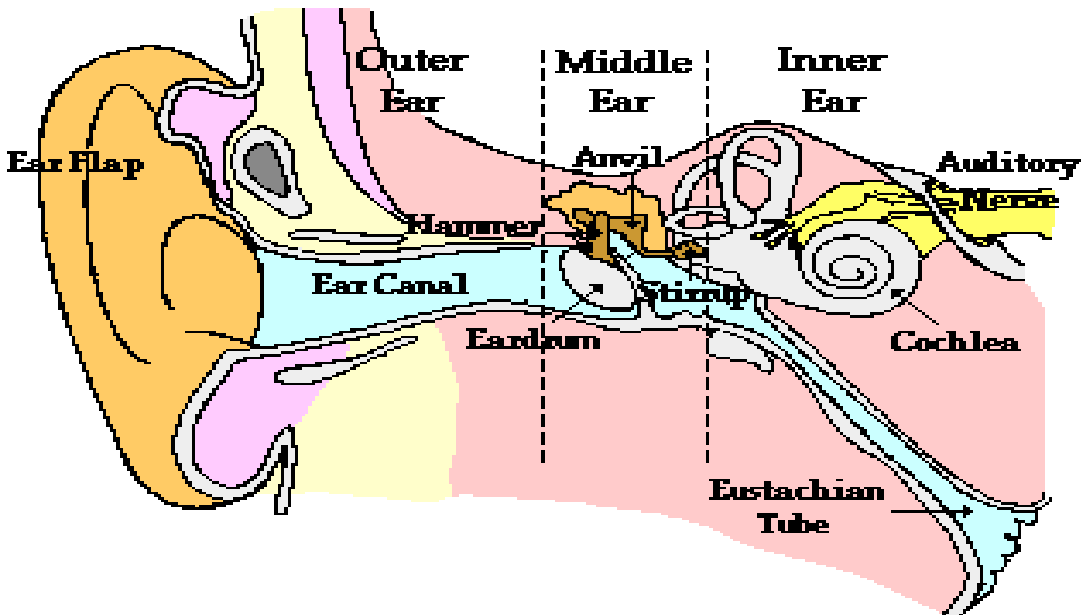
### xi) State the advantages of having two eyes in human beings

- stereoscopic vision
- gives a wider angle of binocular vision
- if one is damaged human is not blinded

### I i) What are the functions of the human ear?

- hearing
- balancing

### iv) How are the structures of the human ear suited to perform the function of hearing?





- shape of the external ear/pinna allows collection of sound waves and channels them down the auditory canal/auditory meatus
- auditory canal is a tube that concentrates and directs sound waves to tympanic membrane/ tympanum/eardrum
- Eardrum is thin and tight. It sets into vibration/vibrates/converts sound waves into vibrations
- the vibrations are transmitted to the ear ossicles/malleus, incus and stapes that amplify the sound vibrations
- the vibrations are then transmitted to the fenestra ovalis/oval window
- Oval window is a membrane which amplifies/transmits vibrations to the fluids (perilymph and endolymph) then to cochlea.
- The cochlea is coiled to occupy a small space and accommodate a large number of sensory cells
- The sensory cells/hairs (in the cochlea) are set into vibrations/stimulated producing nerve impulses in the auditory nerve
- Impulses in the auditory nerve are transmitted to the brain for interpretation for hearing
- Eustachian tube connects the inner ear to the throat. It equalizes air pressure in the middle ear with the atmospheric air pressure (in outer ear)
- Fenestra rotundus/round window dissipates/discharges/discards vibrations from inner ear to middle ear

### **iii) Explain how the structure of the human ear performs the function of balancing**

- there are three semi-circular canals/utricle/sacculus/vestibular apparatus arranged in planes at right angles to each other
- at the end of each canal is a swelling called ampulla which contains receptors
- the movement of the head causes movement of the fluid/endolymph in at least one canal
- the fluid movement causes stimulation of the receptors/sensory hairs
- sensory impulses are generated
- the auditory nerve transmits the impulses to the brain for interpretation for the position of body/posture/balance

**iv) State what would happen if the auditory nerve was completely damaged**

- deafness
- loss of body balance
- impulse not transmitted to the brain

**7. a) i) What is support?**

- to support is to carry part of the weight/mass of an organism

**ii) What is locomotion?**

- progressive change in the position of an organism

**iii) State the importance of support systems in living organisms**

- they provide a framework for the body of organisms and help to determine their shape
- provide land animals with means for support to their weights against gravity
- organs are attached to the skeleton for support and stability to avoid entanglement and crushing each other
- they protect very important and delicate organs whether inside or outside the body e.g. eyes, heart
- in large plants the rigid trunks of trees support the greater mass of leaves and fruits

**iv) State the importance of locomotion in animals**

- in search of food
- search for mates
- escaping predators

**b) i) Name the tissues in higher plants that provide mechanical support**

- sclerenchyma
- collenchyma (not lignified)
- xylem/tracheids and vessels

**ii) State the importance of support in plants**

- exposing the surface area of leaf to sunlight for photosynthesis
- ensure flowers are exposed to pollination agents
- expose fruits and seeds to agents of dispersal
- to resist breakages due to their own weight and that of other organisms
- for proper transport and translocation of materials

**iii) Name the types of plant stems**

- herbaceous e.g. shrubs
- woody e.g. trees

- weak stems in creepers, twining plants and plants bearing tendrils

**iv) Name the tissues in plants that are strengthened with lignin**

- sclerenchyma
- xylem vessels/tracheids/xylem

**v) What makes young herbaceous plants remain upright?**

- turgidity
- presence of collenchyma

**vi) State the ways by which plants compensate for lack of ability to move from one place to another**

- ability to pollinate
- response to nastic and tropic movement
- ability to exploit localized nutrients
- ability to disperse seed or fruit propagation

**c) i) Explain the ways in which erect posture is maintained in a weak herbaceous stem**

- This is the function of turgidity and presence of collenchyma  
Cells take in water and become turgid

**ii) Explain how support in plants is achieved**

- Turgor pressure due to absorption of water keeps cells firm hence hold herbaceous plants upright
- collenchyma and sclerenchyma tissues are closely packed in stem and roots to provide support
- inelastic cuticle on epidermis is covered by a waxy layer hence keeping shape of plant and setting inward pressure against turgid cells and this causes a force to hold plant upright
- xylem vessels and tracheids are lignified to provide support to stems, roots and leaves
- climbing plants obtain mechanical support from other plants and objects
- they have climbing structures like tendrils which hold on to other objects

**d) i) Give the reasons why support is necessary in animals**

- for attachment of muscles
- For attachment of other body organs
- to protect delicate body organs
- to maintain body shape/form
- to enable movement/locomotion

**ii) Why is movement necessary in animals?**

- enables animals to search for food

- enables animals to search for shelter
- enables animals to escape predators/harmful conditions
- enables animals to search for water
- enables animals to search for mates
- enables animals to search for breeding sites

**e) i) Name the organ used for support by animals**

- Skeleton

**ii) Name the different types of skeletons in animals, giving an example of an animal for each type of skeleton named**

- exoskeleton e.g. arthropoda (crab, insect)
- endoskeleton e.g. chordata (cat, fish)

**iii) State the difference between exoskeleton and endoskeleton**

- endoskeleton is a rigid framework covered by body tissues of an animal
- exoskeleton is a rigid framework found on the surface of an animal

**iv) State the advantages of having an exoskeleton**

- supports/protects delicate inner parts
- water proof/prevents drying up of body
- provided surface for muscle attachment

**v) Explain the importance of having an endoskeleton**

- support the body
- give body its shape
- protect delicate organs e.g. skull, brain, ribs
- used in locomotion e.g. bones serve as levers
- red blood cells are formed in bone marrow
- minerals are stored in bones e.g. calcium and phosphorus

**f) i) Explain how a fish is adapted to living in water**

- streamlined body for easy movement in water
- swim bladder controls depth of swimming
- fins for movement, balance, direction and stability
- gills for gaseous exchange in water
- presence of lateral line to sense vibrations
- scales provide protection
- colour which offers camouflage against predators

**ii) Explain how a finned fish is adapted to locomotion in water**

- streamlined body to reduce resistance/friction (to swim smoothly)
- the vertebral column consists of a series of vertebrae held together loosely so that it is flexible

- myotomes/muscles associated with vertebral column produce movement
- the sideways and backwards thrust of the tail and body against water results in resistance of water pushing the fish sideways and forwards in a direction opposed to thrust
- heat not flexible so as to maintain forward thrust
- presence of fins help in propulsion/balance/paired fins (pectoral and pelvic) for controlling pitch and slow down movement/unpaired fins (dorsal, ventral, anal) for yawing and rolling (caudal) for swimming/propulsion and steering/change of direction
- presence of swim bladder to make fish buoyant
- scales tip towards the back to provide smooth surface
- body covered with mucus to reduce friction
- flattened surface for easy floating

**g) i) Name the main parts of the vertebral column giving the types of bones found in each part**

#### **Axial skeleton**

- forms the main axis of the body
- formed by the skull, sternum, ribs and vertebrae

#### **Appendicular skeleton**

- composed of limbs and girdles
- the forelimbs are connected to the trunk by the pectoral girdles (shoulder bones)
- hind limbs are connected to the pelvic girdle (hips)
- bones are scapular, clavicle, humerus, ulna, femur, tibia, fibula, metacarpals, carpals, tarsals, metatarsals, phalanges, ilium, ischium and pubis

**ii) What are the vertebrae?**

- bones of the vertebral column

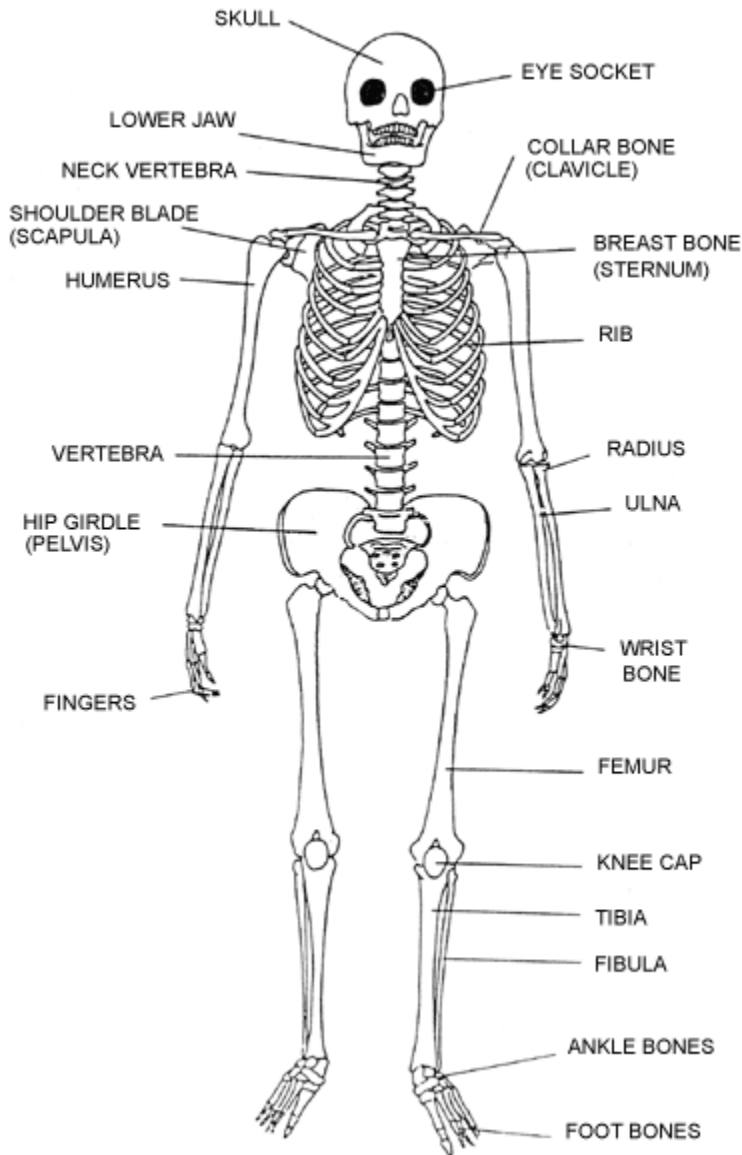
**iii) State the functions of the vertebral column**

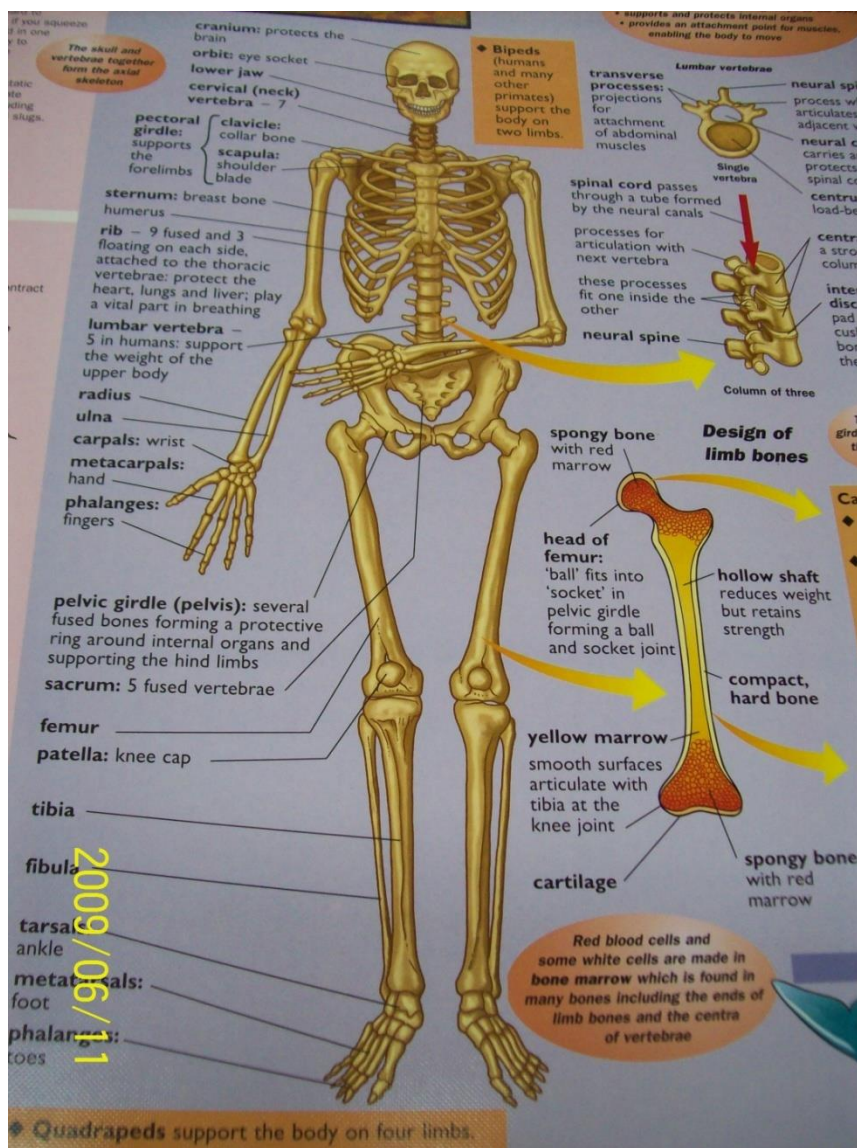
- gives flexibility
- absorbs shock
- protects spinal cord
- supports weight of body
- provide surface for muscle attachment
- between the vertebrae are soft discs which offer cushioning called intervertebral discs

**iv) State the general characteristics of vertebrae**

- have solid structure called centrum to support weight of body

- has transverse process lateral to centrum for muscle attachment
- neural spine is dorsal to centrum and provides surface area for muscle attachment
- neural canal a passage for spinal cord and offers protection to it
- has facets for articulation with other vertebrae
- neural arch encloses neural canal





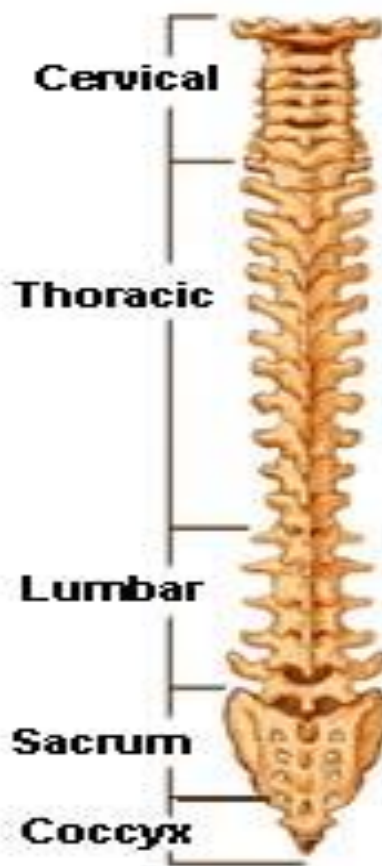
v) Name the bones of the vertebral column

- Cervical vertebra
- Thoracic vertebra
- Lumbar vertebra
- Sacral vertebra
- Caudal vertebra

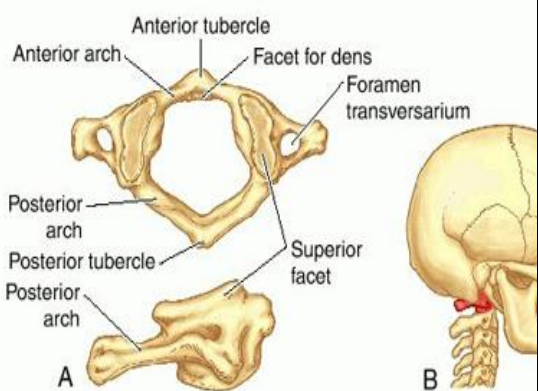
**Lateral (Side) Spinal Column**



**Posterior (Back) Spinal Column**



vi) Describe how the various vertebrae are adapted to their functions

| Bone   | Structure  | Function   |
|--|--|--|
| <p>Skull</p>  | <ul style="list-style-type: none"> <li>• cranium and jaw bones</li> <li>• made of several bones joined together</li> <li>• large box called cranium and smaller paired boxes for eyes, ears, nose, jaws</li> <li>• has large hole called foramen magnum for the passage of spinal</li> </ul> | <ul style="list-style-type: none"> <li>• attachment of jaws</li> <li>• protect brain and other delicate parts</li> </ul> |





|   | cord  |   |
|---|---|---|
| Cervical region<br>Atlas (first cervical) | <ul style="list-style-type: none"> <li>• ring shaped</li> <li>• no Centrum</li> <li>• broad, flat transverse processes</li> <li>• vertebrarterial canal for passage of vertebral artery</li> <li>• facet for articulation of condyles of skull</li> </ul> | <ul style="list-style-type: none"> <li>• protect spinal cord</li> <li>• attachment of muscles</li> <li>• allow nodding of head</li> </ul>                   |
| Axis (second cervical)                    | <ul style="list-style-type: none"> <li>• odontoid peg projects from Centrum</li> <li>• large flattened neural spine</li> <li>• vertebrarterial canal</li> <li>• small transverse process</li> </ul>   | <ul style="list-style-type: none"> <li>• allows head to rotate</li> <li>• protects spinal cord</li> <li>• provides surface for muscle attachment</li> </ul> |
| Cervical (others)                         | <ul style="list-style-type: none"> <li>• short neural spine</li> <li>• branched transverse process for neck muscles</li> <li>• vertebrarterial canals</li> <li>• wide neural canal</li> </ul>   | <ul style="list-style-type: none"> <li>• support weight of head</li> <li>• protect spinal cord</li> <li>• neck muscle attachment</li> </ul>                 |
| Thoracic                                  | <ul style="list-style-type: none"> <li>• long backward pointing neural spine</li> </ul>   | <ul style="list-style-type: none"> <li>• forms rib cage</li> <li>• articulation with one</li> </ul>   |

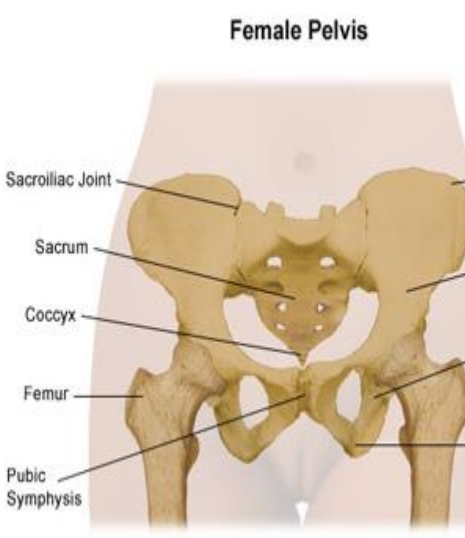
|        |  |   |
|--------|--|---|
|        | <ul style="list-style-type: none"> <li>• transverse process that points sideways</li> <li>• facets for articulation of ribs</li> <li>• notch for spinal nerves to pass through</li> </ul>  | <ul style="list-style-type: none"> <li>• end of a rib</li> <li>• protects, spinal cord</li> <li>• muscle attachment</li> </ul>  |
| Lumbar | <ul style="list-style-type: none"> <li>• short neural spine</li> <li>• long transverse process pointing towards abdomen</li> <li>• large Centrum</li> <li>• extra processes e.g. prezygapophysis, hypapophysis, anapophysis, metapophysis</li> </ul> | <ul style="list-style-type: none"> <li>• protect organs of abdomen</li> <li>• support upper part of body</li> <li>• protect spinal cord</li> <li>• muscle attachment</li> </ul> |
| Sacral | <ul style="list-style-type: none"> <li>• fused bones to form sacrum</li> <li>• well developed transverse process of first vertebra</li> <li>• vertebral canals</li> <li>• short neural spine</li> </ul>  | <ul style="list-style-type: none"> <li>• protects alimentary canal</li> <li>• attachment of hip girdles</li> <li>• protect spinal cord</li> <li>• muscle attachment</li> </ul>  |

|     |   |  |
|-----|---|--|
| Rib | <ul style="list-style-type: none"> <li>• long</li> <li>• flattened</li> <li>• attached to sternum from front</li> </ul> | <ul style="list-style-type: none"> <li>• protect internal organs</li> <li>• muscle attachment</li> </ul> |
|-----|---|--|



**vii) Describe the bones that form the appendicular skeleton**

| Bone                                     | Structure   | Function  |
|--|---|---|
| Pectoral girdle scapular (shoulder bone) | <ul style="list-style-type: none"> <li>• Broad i.e. Flattened blade</li> <li>• glenoid cavity to articulate with humerus</li> <li>• metacromion/acromion for muscle attachment</li> <li>• hard to provide support</li> <li>• socket with cartilage/smooth surface to reduce friction</li> </ul> | Support<br>Muscle attachment<br>Articulates with humerus                                  |
| Humerus                                  | <ul style="list-style-type: none"> <li>• long shaft for muscle attachment</li> <li>• round head to articulate with glenoid cavity</li> <li>• trochlea for articulation with ulna</li> <li>• olecranon fossa to prevent arm bending the other way</li> </ul>                                     | <ul style="list-style-type: none"> <li>• movement</li> <li>• muscle attachment</li> </ul> |

|  |  |  |
|--|--|--|
| <p>Ulna and radius</p>   | <ul style="list-style-type: none"> <li>• ulna longer and on side of little finger</li> <li>• has sigmoid notch and olecranon process to form hinge joint with humerus</li> <li>• radius is smaller and lies along thumb side and does not join ulna</li> <li>• allows articulation with wrist bones</li> </ul> | <ul style="list-style-type: none"> <li>• movement</li> <li>• muscle attachments</li> </ul>   |
| <p>Pelvic girdle(hip bone)</p>  <p>The diagram, titled 'Female Pelvis', shows a frontal view of the pelvic girdle. Labels with leader lines point to the following structures: Sacroiliac Joint (between the ilium and sacrum), Sacrum (the central triangular bone), Coccyx (the small tailbone), Femur (the thigh bone), and Pubic Symphysis (the joint between the pubic bones).</p> | <ul style="list-style-type: none"> <li>• composed of three fused bones (ilium, ischium, pubis)</li> <li>• upper end fused to sacrum</li> <li>• lower end has acetabulum for articulation with femur</li> <li>• has abturator foramen for passage of nerves and blood vessels</li> </ul>                        | <ul style="list-style-type: none"> <li>• movement</li> <li>• muscle attachment</li> <li>• support</li> <li>• absorbs pressure exerted by ground when animal moves</li> </ul> |



|                  |   |   |
|------------------|---|---|
| Femur            | <ul style="list-style-type: none"> <li>• rounded head to fit in acetabulum of pelvis</li> <li>• projections called trochanter for attachment of thigh muscles</li> <li>• condyles at lower end for articulation with tibia</li> <li>• patella that covers knee and prevents leg from bending backwards</li> </ul> | <ul style="list-style-type: none"> <li>• movement</li> <li>• muscle attachment</li> </ul> |
| Tibia and fibula | <ul style="list-style-type: none"> <li>• tibia is longer than fibula</li> <li>• tibia is outer bone and fibula is inner bone</li> <li>• tibia lies on side of large toe</li> <li>• fibula is fused to tibia (on outer side)</li> </ul>  | <ul style="list-style-type: none"> <li>• movement</li> <li>• muscle attachment</li> </ul> |

### 8. a) What is a joint?

- the point where bones meet

#### ii) State the functions of joints

- provide a point of articulation between bones

#### iii) Name the main types of joints

- immovable joints e.g. skull, pelvic girdles and sacrum
- slightly movable joints e.g. between vertebrae
- Freely movable joints e.g. knee, elbow

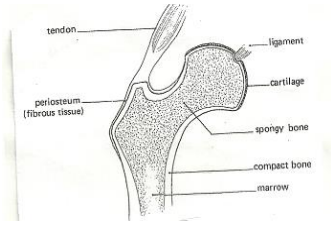
#### iv) Give the features of movable joints

- ends of bones covered with articular cartilage
- ends bound by capsules of ligaments
- have joint cavity filled with lubricating fluid called synovial fluid secreted by synovial membrane
- they are called synovial joints

#### b) Describe the synovial joints

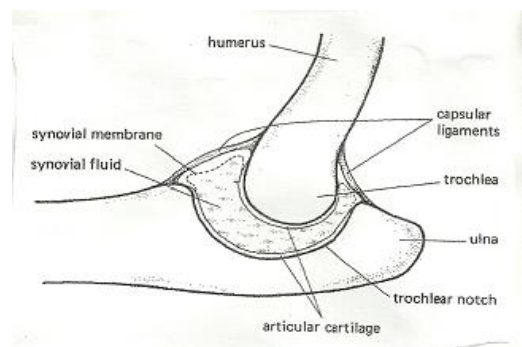
##### iv) Ball and socket

- allow movement in all planes /directions i.e. 360°
- rounded end of bone fits into a rounded cavity in another bone
- e.g. shoulder joint and hip joint



### v) Hinge joint

- convex surface of one bone fits into the concave surface of another bone
- this allows movement in only one plane/direction 180°
- e.g. elbow joint and knee joint



### vi) Pivot joint

- allows rotation e.g. where atlas pivots on olecranon process of axis

### c) i) What is synovial fluid?

- lubricating fluid produced by synovial membrane at movable joints

### ii) State the functions of synovial fluid

- absorbs shock
- reduces friction/gives lubrication
- nourishment
- distributes pressure

### d) Explain the following terms

#### v) Ligament

- connective tissue joining one bone to another

#### vi) Cartilage

- supporting soft tissue found at joints
- they cushion the bones and absorb shock

#### vii) Tendon

- tissue that connects muscle to bones

## 9. Muscles

**e) i) What is a muscle?**

- fleshy part of body
- composed of long cells enclosed in a sheath
- specialized cells capable of contracting

**ii) State the functions of muscles**

- cover the skeleton
- provide shape
- contract and relax to enable body to move

**f) Describe the structure and function of various types of muscles**

**i) skeletal muscles**

- also called voluntary/striated/stripped muscles
- they are attached to skeleton
- they consist of striated, multinucleated, long fibers and are cylindrical shaped
- found on legs, arms, eyes, neck where they cause movement

**ii) Involuntary muscles**

- also called smooth/visceral/unstriated/unstripped
- their movement is not controlled by the will
- they are unstriated, nucleated, short fibred and spindle shaped
- are found in alimentary canal, blood vessels, secretory glands, other tubular visceral organs, bladder, uterus, urinary tract, reproductive system, respiratory tract, ciliary body, iris

**iii) Cardiac muscles**

- also called myocardium
- found in the walls of the heart
- are not under control of the will
- composed of long cylindrical cells with special junctions
- myogenic i.e. generate their own contraction
- they are not fatigued
- their function is contraction of the heart to pump blood

**g) Explain how muscles cause movement of the human arm**

- the muscles which bring about these movements are called biceps and triceps
- biceps are attached to scapula and radius for bending
- triceps are attached to scapula, humerus and ulna for stretching



- when the biceps contracts, it pulls the radius (forearm) and the hand bends
- the triceps relaxes at the same time
- when the triceps contracts and biceps relaxes (extends) the arm is stretched
- biceps flexes the arm (flexor) and triceps extend (extensor muscle) the arm



**h) i) State the structural differences between skeletal muscles e.g. biceps and smooth muscles e.g. gut muscle**

| <b>Skeletal (biceps)</b>   | <b>Smooth (gut) muscle</b>  |
|--|---|
| <ul style="list-style-type: none"> <li>• multinucleated</li> <li>• striated/stripped</li> <li>• long muscle fibers</li> <li>• block/cylindrical</li> </ul> | <ul style="list-style-type: none"> <li>• uninucleated</li> <li>• unstriated</li> <li>• short muscle fibers</li> <li>• spindle shaped</li> </ul> |

**ii) Name the cartilage found between the bones of the vertebral column**

- intervertebral disc

**iv) What are the functions of the cartilage named in (d) ii) above**

- acts as a cushion/absorbs shock
- reduces friction
- flexibility of vertebral column

**END**