GCSE BIOLOGY

Compiled by

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Classifying Living Things

- The term **classification** means putting things into groups according to their differences and similarities e.g. sex (male and female).

Differences Between Plants & Animals

a. **Method of Feeding**

- Plants make their own food from simple inorganic compounds such as **carbon dioxide** and **water**.
- Animals on the other hand animals take in already made food by eating plants or other animals.

b. Movement

- Most plants do not move unlike many animals.
- However, certain microscopic plants move just like microscopic animals.

c. Sensitivity

- Animals respond to changes in their environment more rapidly and more noticeably than plants.

d. Chlorophyll

- Most plants have a green pigment known as chlorophyll, which is absent in animals.
- Chlorophyll absorbs light energy, which is used for photosynthesis in green plants.

e. Presence of Cell wall

- Plant cells have a cell wall that is composed of a substance called **cellulose**, which is absent from animal cells.

- When classifying living things, it is important to use characteristics that are constant e.g. size would not be a good characteristic to distinguish plants from animals.

Using a dichotomous key to identify living things

The animals A, B, C and D can be identified by using a dichotomous key like this one:

1. Has legs …… see 2

   Has no legs …. snake

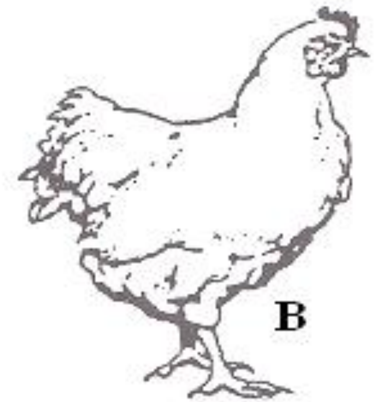
2. Has two legs …. chicken

   Has more than two legs …. see 3

3. Has six legs …. grasshopper

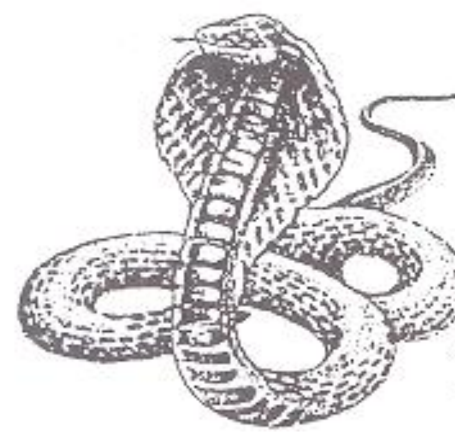
   Has eight legs …. spider

A



B

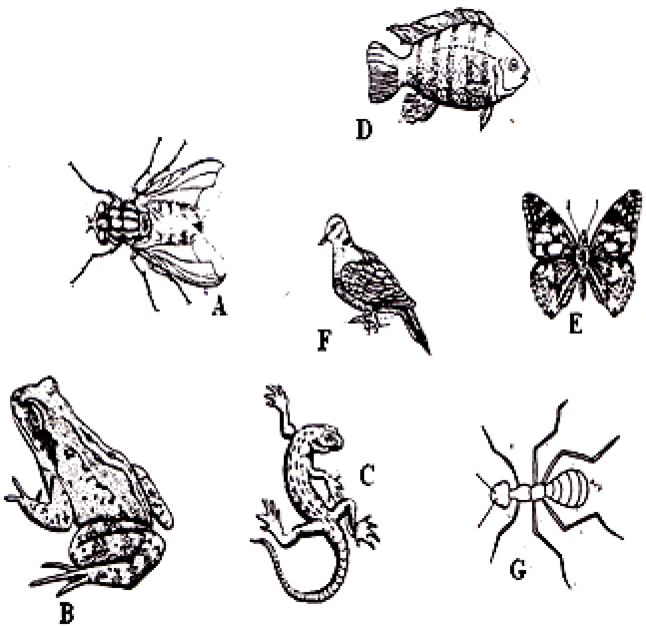
C



D

- A **dichotomous** key is arranged in steps, where each step has a pair of statements that describe the animals.
- Each pair of statements in the key divides the animals into two groups.
- For instance, step 1 of the key separates the animals with legs (A, B, C) from those without legs (D); step 2 separates the animals with 2 legs from those with more than two legs while as step 3 identifies an animal with 6 legs and that with 8 legs.

- At each step you have to compare the organism with a list of characteristics.
- The organism may have one of the characteristics, and then either you are told its name or you have to go on to another step for more comparison.
- This is repeated until finally you arrive at the name of the organism.



1. Has a backbone … see 2

Has no backbone … see 3

2. Has feathers … bird

Has no feathers …. see 4

3. Has 2 pairs of wings ….see 5

Has no wings … ant

4. Has 4 legs … see 6

Has fins …. fish

5. Has clubbed antennae .. butterfly

Has large compound eyes . housefly

6. Has a tail … lizard

Has no tail … frog

Classification of Plants

- Different types of plants that enrich our environment differ in a number of ways i.e. where they grow, how they reproduce, how they feed and their structures.
- These differences are used to classify plants firstly into two main groups i.e. non-flowering and flowering plants.

Non-flowering Plants

- Non-flowering plants are classified into **algae**, **liverworts**, **mosses**, **ferns** and **conifers** (pines).

Algae

- Algae live mainly in water.
- Some are multicellular plants e.g. the giant seaweed, while others are microscopic unicellular plants e.g. diatoms.
- The multicellular algae’s body is not clearly distinguishable into roots, stem or even leaves, therefore it is called a **thallus**.
- In some algae the thallus develops a base called a **holdfast** with projections for its attachment to surfaces for support.

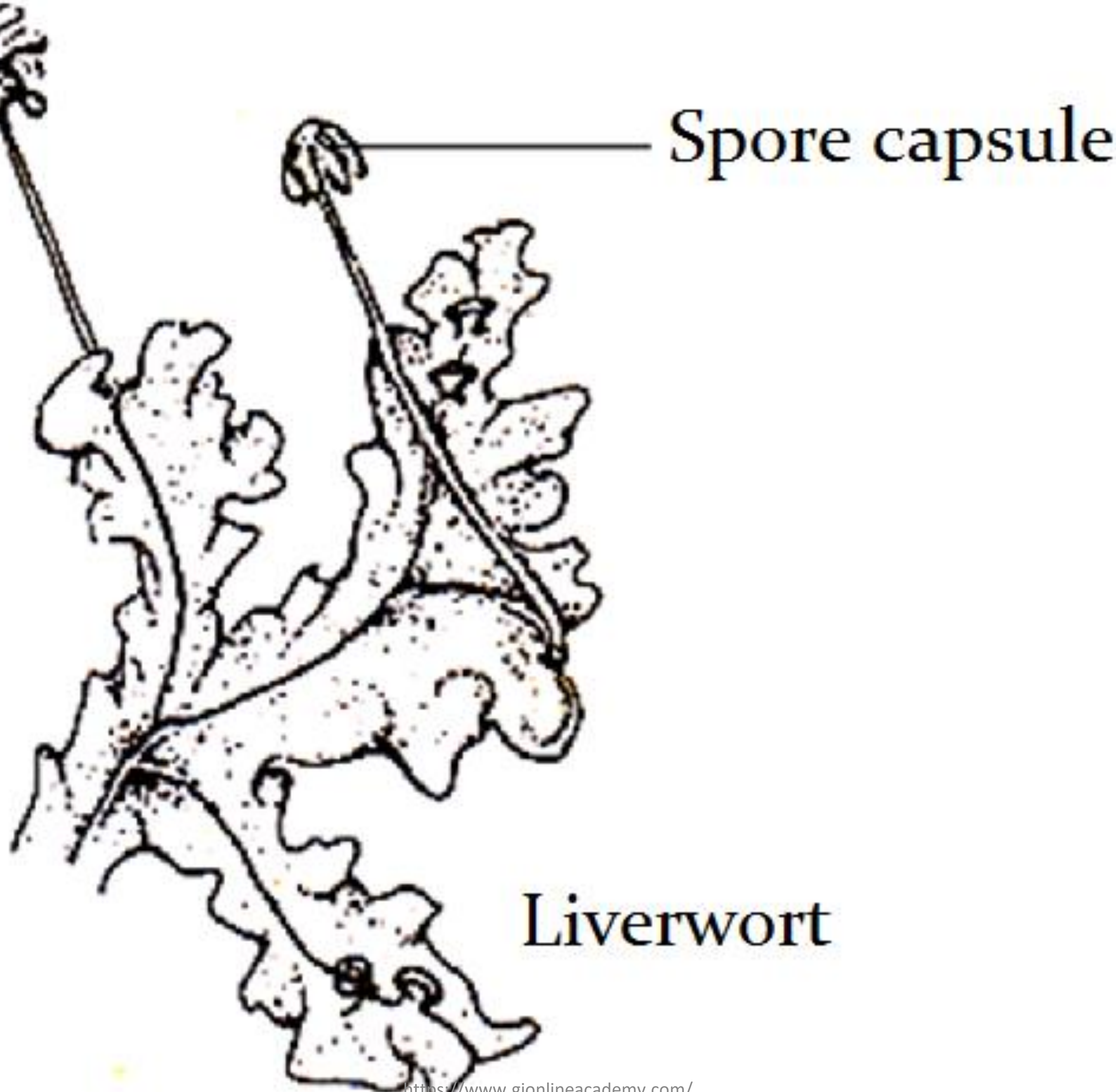
- All algae manufacture their own food because they contain chlorophyll.
- Some algae have green chlorophyll, while others have brown or blue chlorophyll.
- The cells of **spirogyra**, a multicellular green algae, are joined together into a string-like filament, which is covered in a slimy substance.
- This slimy coating makes spirogyra very slippery to the touch and also protects it from harmful bacteria.
- Spirogyra has no roots, no stem and no leaves.

- Spirogyra commonly reproduces by vegetative propagation, where part of a filament breaks off and continues to live as a separate plant.

Liverworts

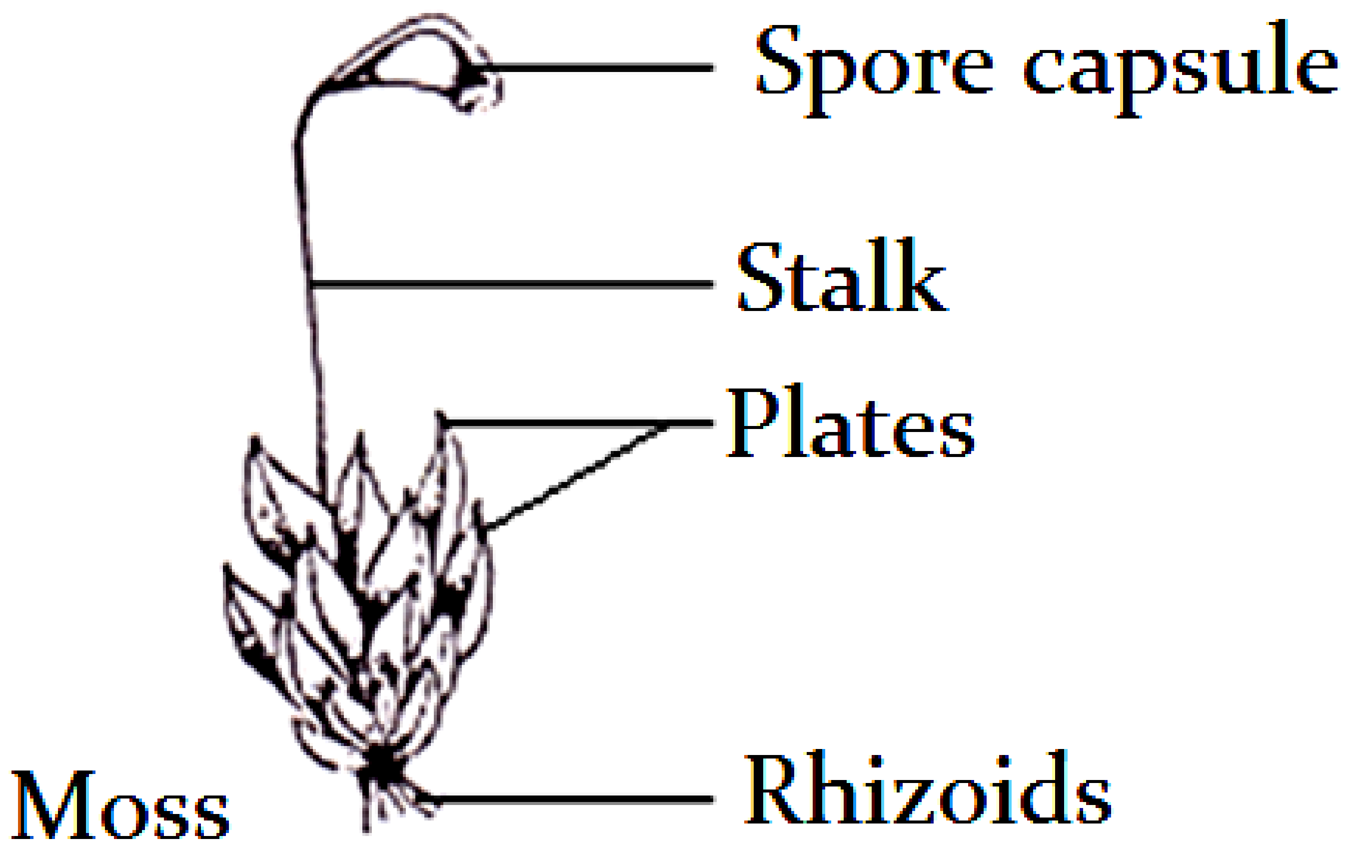
- Liverworts are simple green plants which mainly grow on damp surfaces in shade reached by some light.
- The simplest liverwort's body is a thallus, whose mass is not distinguished into a stem or leaves.
- However, most liverworts show something resembling a "stem" and a "leaf" as shown below.

- These stems and leaves are not true leaves since they do not have vascular bundles.
- Instead of roots, they have **rhizoids**.
- Rhizoids are unicellular root-like structures used for anchorage of the plant.
- Liverworts reproduce by spores, which are found in a capsule.
- They can also be propagated vegetatively by breaking off a piece of the thallus.


Spore capsule
Liverwort

Mosses

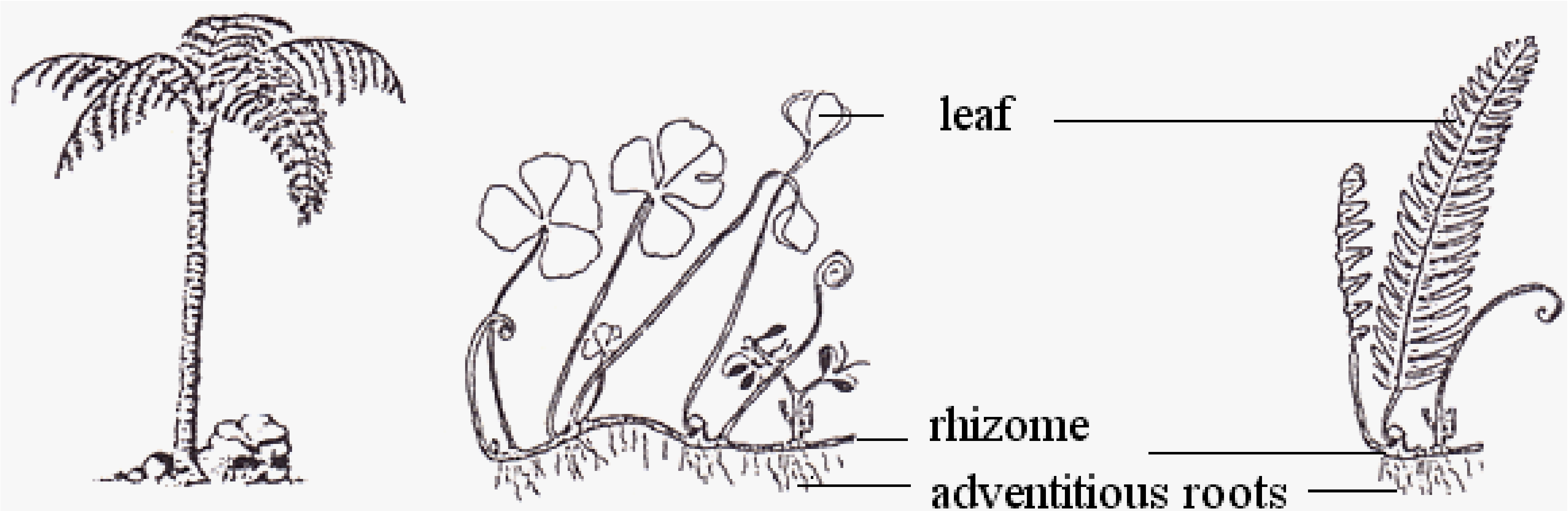
- Mosses do not have proper roots, stems or leaves.
- They have small brown rhizoids for anchoring the plant and absorbing water.



- Instead of a stem mosses have a stalk without vascular bundles that conduct water and mineral salts in true stems.
- The flat plates that look like leaves are just one cell thick.
- Mosses are found in damp shady places e.g. on logs, drainage systems, sides of walls and even on rocks.
- They reproduce by spores.
- When spores fall on a suitable surface, they germinate and grow into new plants.

Ferns

- Ferns can grow in different types of habitats, mostly underground but can also grow on surfaces of trees (as parasites), or in water.
- A fern has an underground stem called a **rhizome** from which adventitious roots emerge.
- Ferns have true roots and leaves with fully developed vascular bundles.



- Like mosses, ferns reproduce through spores, which are produced under mature leaves.
- When spores fall on suitable surface, they germinate and row into new plants.

Conifers (Pines)

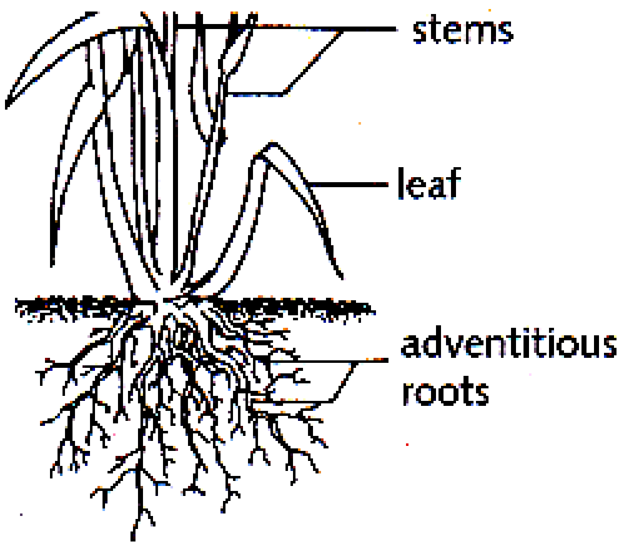
- Conifers are evergreen plants which are either trees or shrubs, and grow in high altitude places such as mountain slopes.
- They have true needle-like leaves that grow in pairs and are covered in a thick waxy cuticle.
- They also have proper roots and stems with well developed vascular bundles.

- Their vascular bundles conduct water, mineral salts and food.
- Their roots tend to spread rather than grow deep in the soil.
- A typical feature of conifers is the presence of **male** and **female cones**.
- Pollen from male cones is transported by wind and lands on the female cones where it fertilises the ovules inside them.

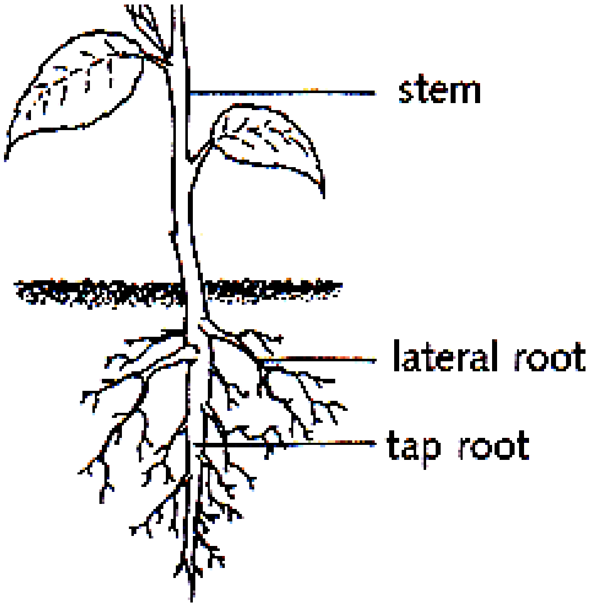
- The fertilised ovules then grow into winged seeds, which are eventually dispersed by wind.

Flowering Plants
Roots

Fibrous Root System



Tap Root System



Tap Root System

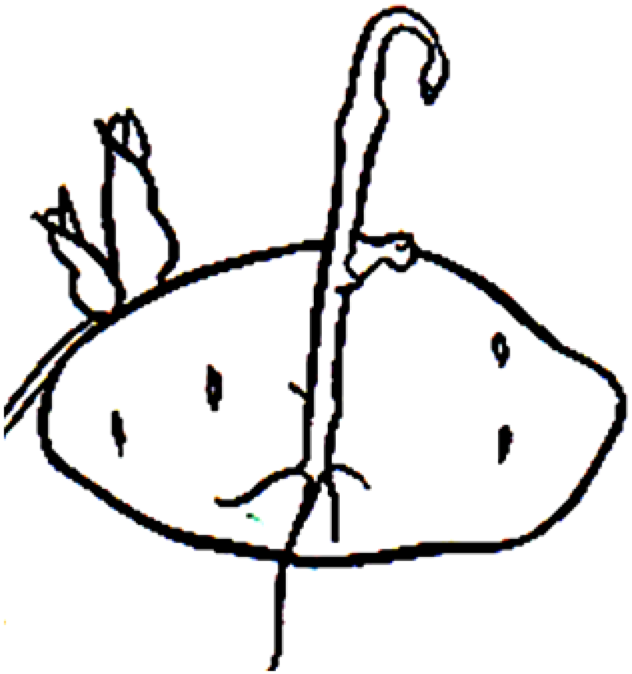
- This is where a single root (main root) grows vertically into the ground when a seed germinates e.g. a bean seed.
- Lateral roots then grow from it and other branches of roots arise from the lateral roots.

Fibrous Root System

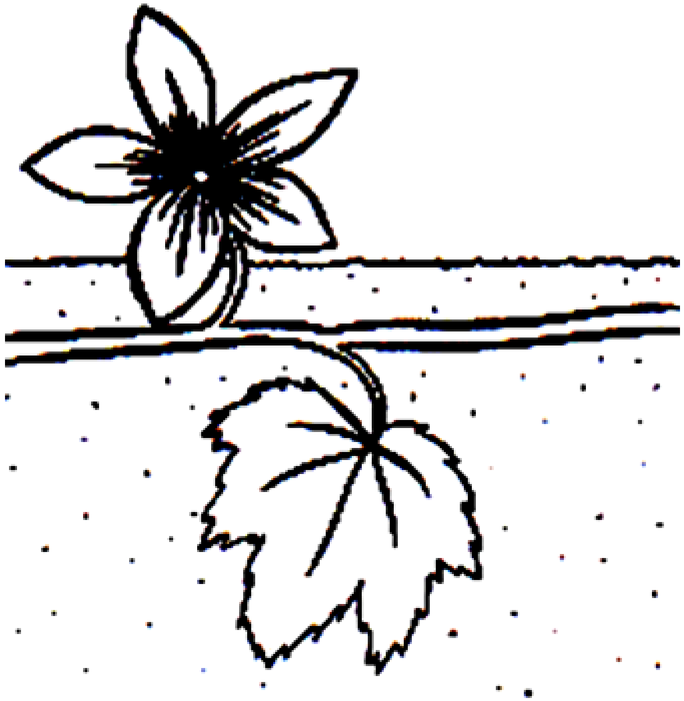
- This is where several roots grow at the same time and laterals arise from them when a seed germinates e.g. a maize seed.
- Sometimes roots (adventitious roots) grow directly from the stem e.g. onions, sugar cane and reeds.

- Adventitious roots are also called fibrous roots because there is no distinguishable main root.

Stems

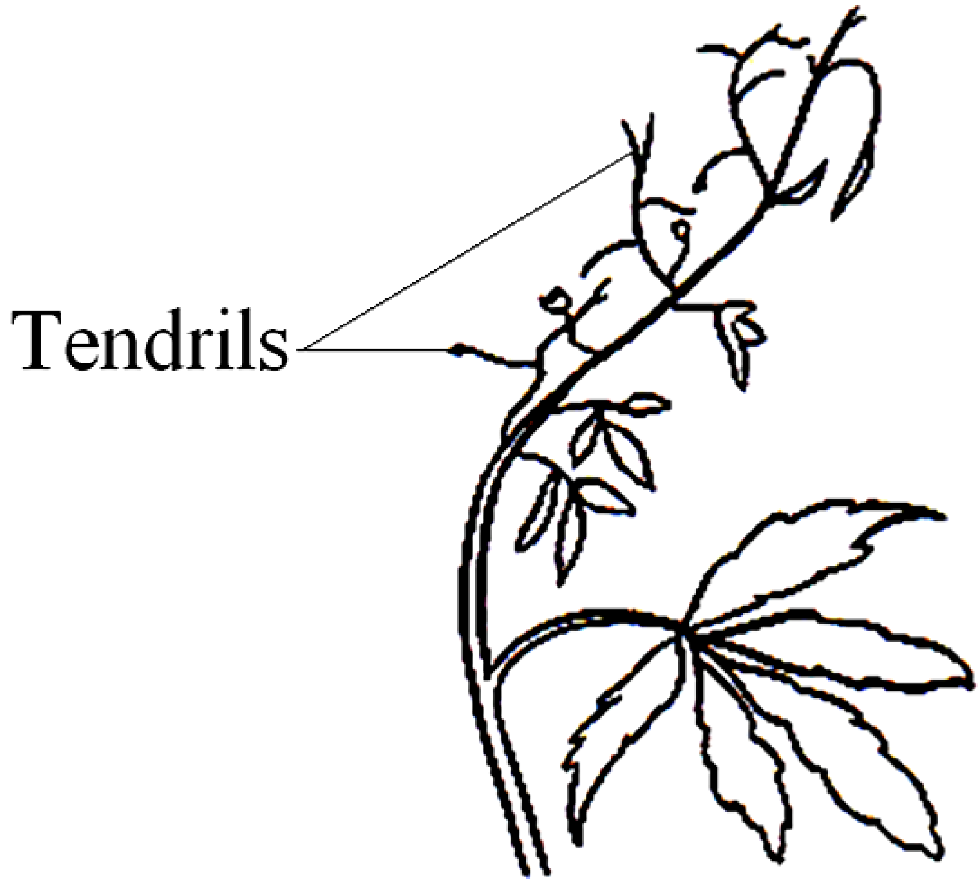


Underground Stem



Creeping Stem

Upright or Erect Stem

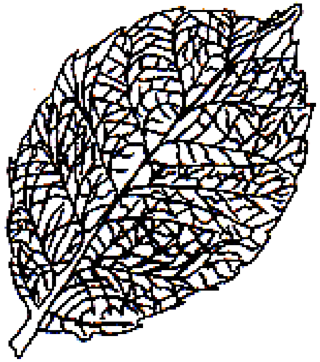


Climbing Stem

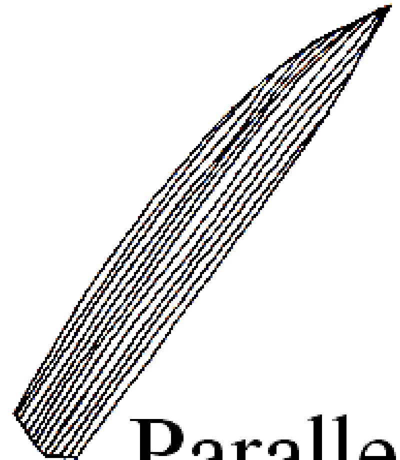
- There are several types of stems, which include underground stems (e.g. reeds, potato tubers), upright stems (e.g. maize), climbing stems (e.g. beans) and creeping stems (e.g. sweet potatoes).
- Many climbing stems have structures called **tendrils**, which are modified leaves for hooking the climbing plant to other plants or objects for support.
- Creeping stems grow along the ground.

Leaves

- Leaves differ in a number of ways e.g. **venation** and **form**.
- Venation is the arrangement of veins in a leaf, which consists of two main kinds i.e. **reticulate** and **parallel**.
- In reticulate venation, the veins are arranged in a network e.g. in tomato plant.
- In parallel venation, several main veins run parallel to one another e.g. in a maize plant.

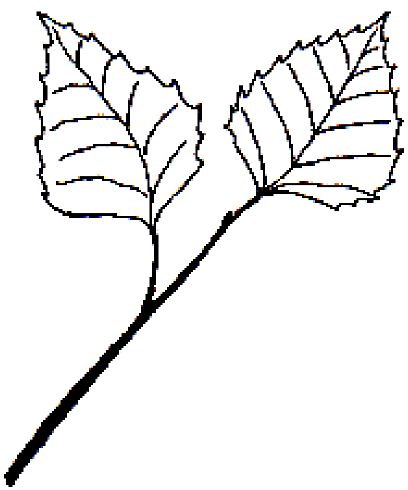


Reticulate Venation

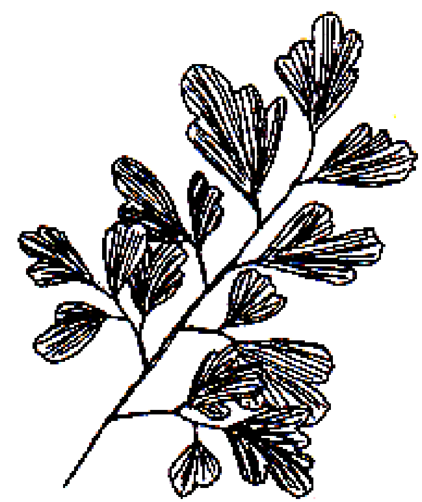


Parallel Venation

- The two main leaf forms include **simple** and **compound**.



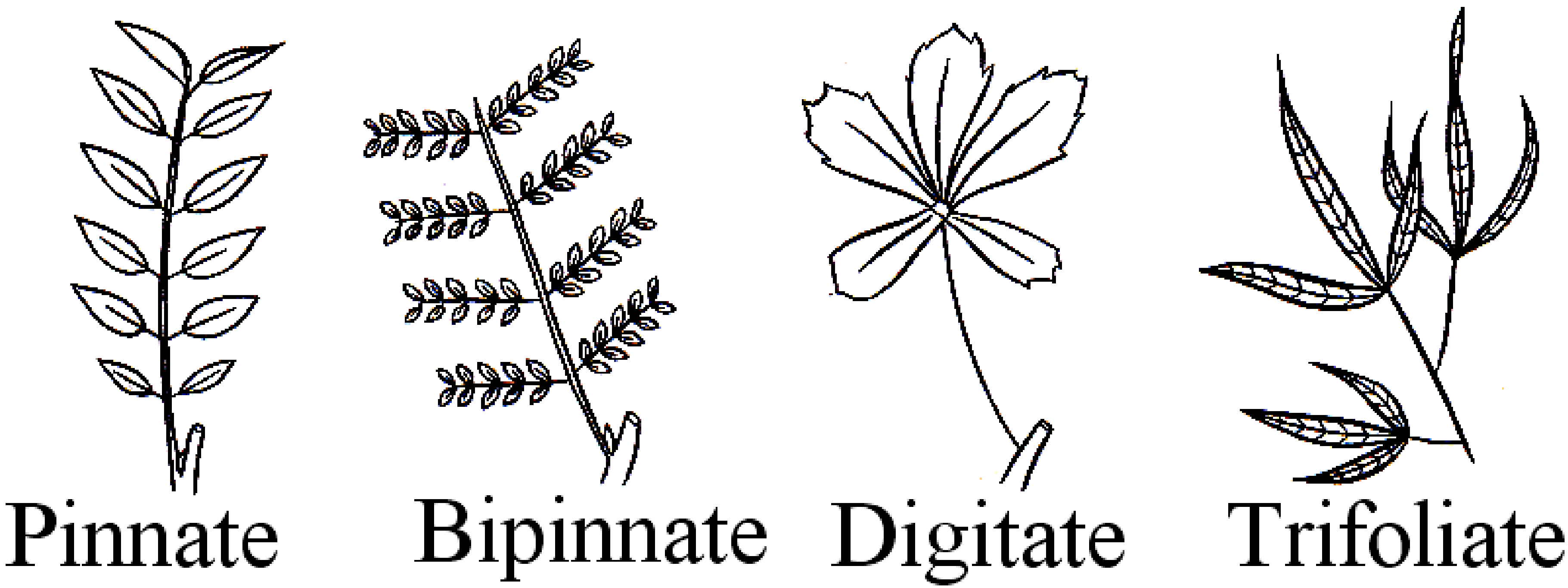
Simple Leaf



Compound Leaf

- A simple leaf has a single leaf stalk e.g. hibiscus.
- A compound leaf has the lamina divided into several leaflets , which might be arranged in many ways: **pinnate**, **bipinnate**, **digitate** and **trifoliate**.
- In pinnate arrangement the leaflets are arranged in pairs opposite one another along the main stalk e.g. Cassia.
- Bipinnate leaves are those where each pinnate leaflet is itself divided into pinnate leaflets such as in jacaranda.
- In digitate leaves, the leaflets radiate out from the end of the stalk like fingers of a hand e.g. cassava.

- In trifoliate leaves, each leaf consists of three leaflets e.g. beans.



Flowers

. Flowers may be classified according to their agent of pollination i.e. **wind** or **insects**.

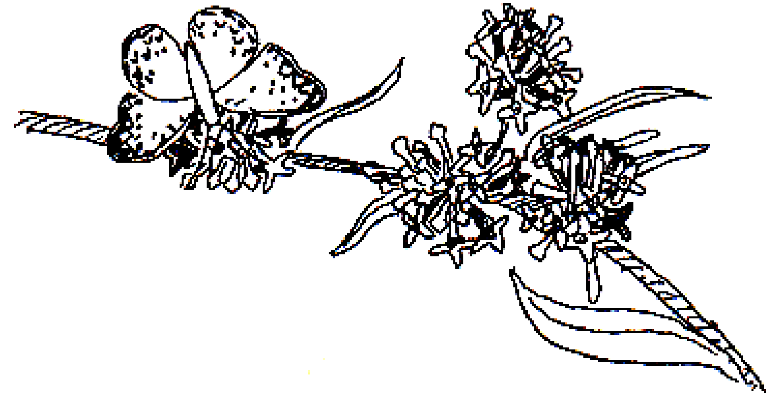
Wind-pollinated Flowers

- Are small, inconspicuous and have no scent or nectar.
- Produce large amounts of smooth light pollen.
- Have feathery stigmas that hang outside the flower.
- Have large anthers loosely attached to the filament.

Insect-pollinated Flowers

- Are large, conspicuous with brightly coloured petals, scented and produce nectar.
- Produce small amounts of sticky pollen.
- Have flat or lobed sticky stigmas inside the flower.
- Have smaller anthers firmly attached to the filament.

Wind-pollinated Flower



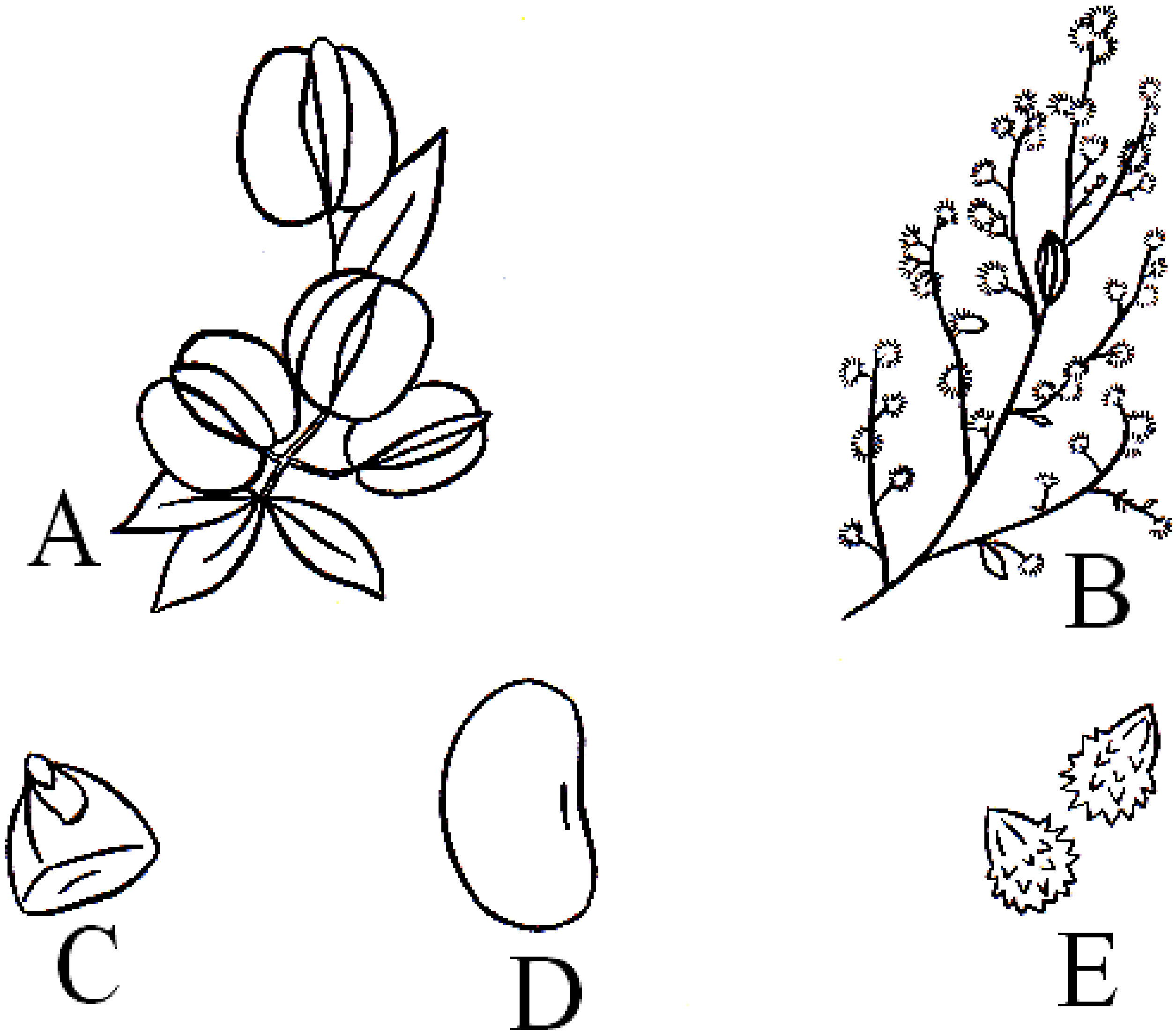
Insect-pollinated Flower

Seeds

- Flowering plants also produce different kinds of seeds that differ in their method of dispersal.
- For example, hairy seeds and those with wing-like structures are dispersed by wind.
- Seeds with spines such as *Bidens* (blackjack) are

dispersed animals or people since hooks on their spines help them to stick to animals' fur or people's clothes.

- Some types of seeds have two cotyledons and a plant whose seeds have two cotyledons is called a **dicotyledon** e.g. a bean plant.
- Other seeds have one cotyledon and a plant whose seeds have one cotyledon is a **monocotyledon** e.g. a maize plant.

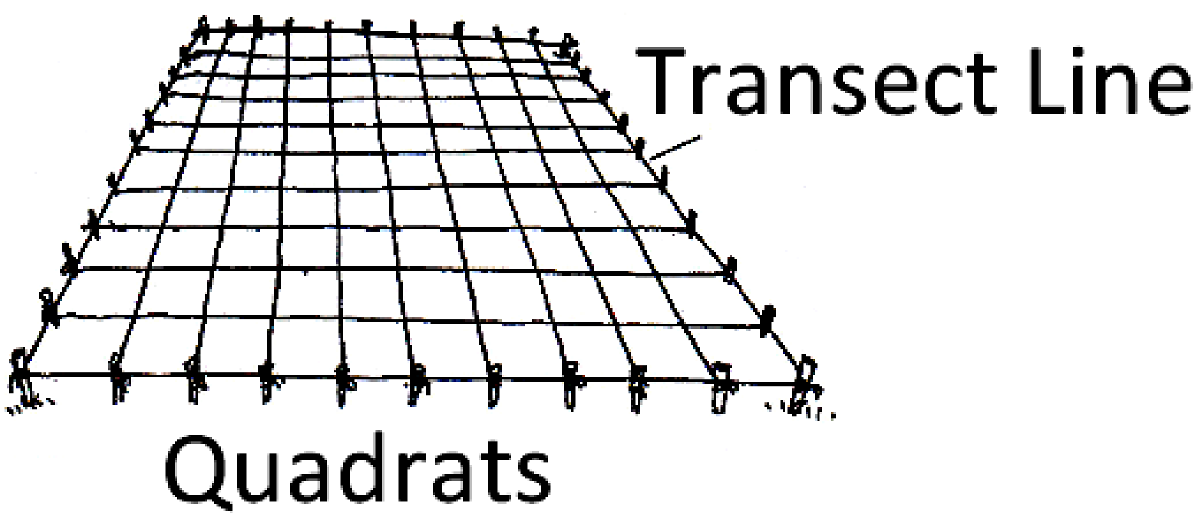


Types of Seeds

Estimating Plant Populations

- In biology, the term **population** refers to a group of individuals of any one kind of organism (i.e. of one species).
- For instance, if there are 1,000 *Bidens* in a garden, we can say that there is a population of 1,000 *Bidens*.
- Similarly, if there are 50 earthworms in a given area, we can say that the area has a population of 50 earthworms.
- To determine the population of a particular plant in a given piece of land one can count all the individual plants.

- If the plants are very numerous, this may not be possible, instead a **sample** is used to determine the population.
- A sample is a small proportion of the total population which is used to calculate the whole population.
- The sampling technique involves the use of quadrats as follows:



1. Select a 10m x 10m piece of land where a variety of plants e.g. *Bidens* are growing.
2. Lay a piece of string that will form a transect line across the area. (A transect is a line going across an area along which a study is conducted).
3. Within the $10m^2$ area, mark out $1m^2$ squares with string. This makes 100 quadrats.
4. Count the total number of *Bidens* in 10 of the 100 quadrats. Calculate the average number (mean) of *Bidens* in each of the 10 quadrats i.e. $1m^2$ of land.
5. Use the average number of *Bidens* in $1m^2$ to estimate the *Bidens* population in a $100m^2$ piece of land.

6. For example, if an average of five Bidens per quadrat was found, the total population of Bidens in $100m^2$ could be calculated as follows:

Number of *Bidens* in $1m^2$ of land = 5

Total area of land = $100m^2$

Total number of Bidens = 5 x 100 = **500**

- Thus using the sampling technique, the estimated population of Bidens in $100m^2$ of land is 500.

Classification of Animals

- As with plants, animals differ in many ways.
- One main difference is that some animals have a backbone while others do not.
- This separates the animals into two main groups: **vertebrates** and **invertebrates**.

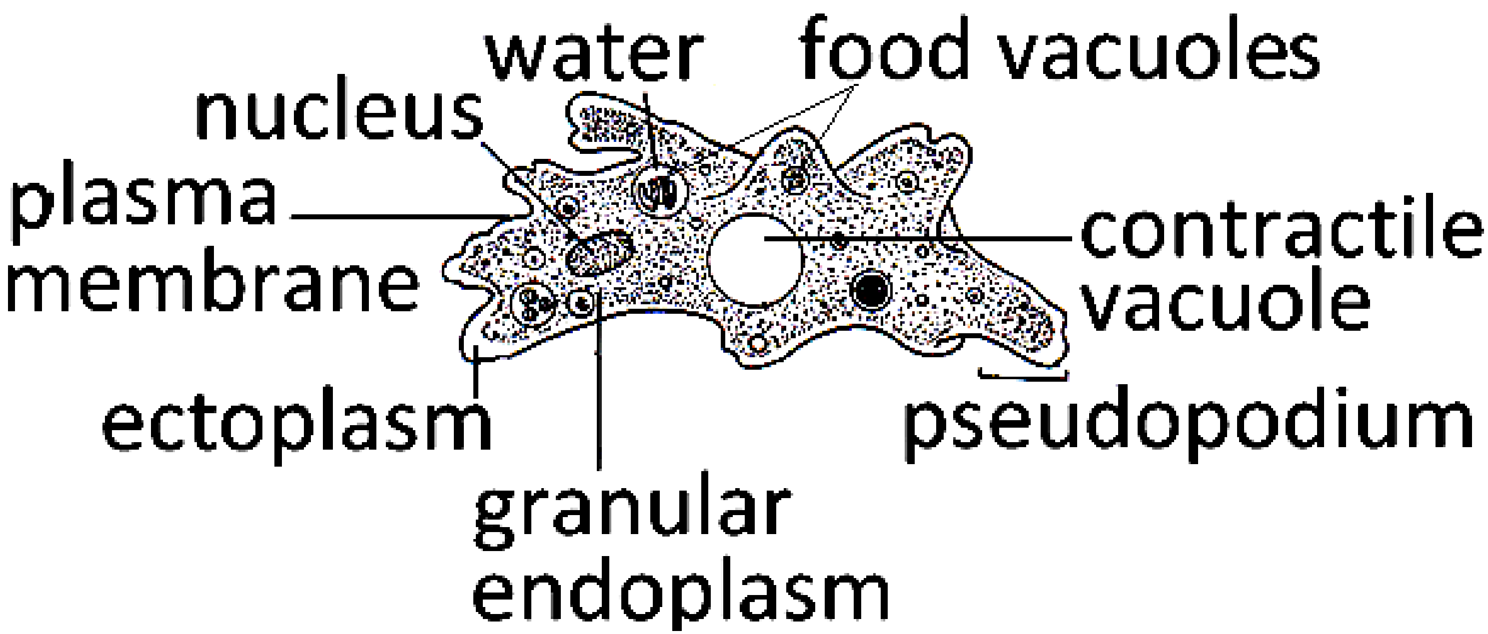
Invertebrates

- These are animals without a backbone.
- Invertebrates are basically grouped into five classes: **protozoans**, **coelenterates**, **worms**, **molluscs** and **arthropods**.

1. Protozoans (Protozoa)

- These are unicellular, microscopic animals.
- Some of them live in fresh or sea water while others live as parasites in bodies of other animals.
- Examples of protozoans are **amoeba**, **paramecium**, **plasmodium** and **trypanosoma**.

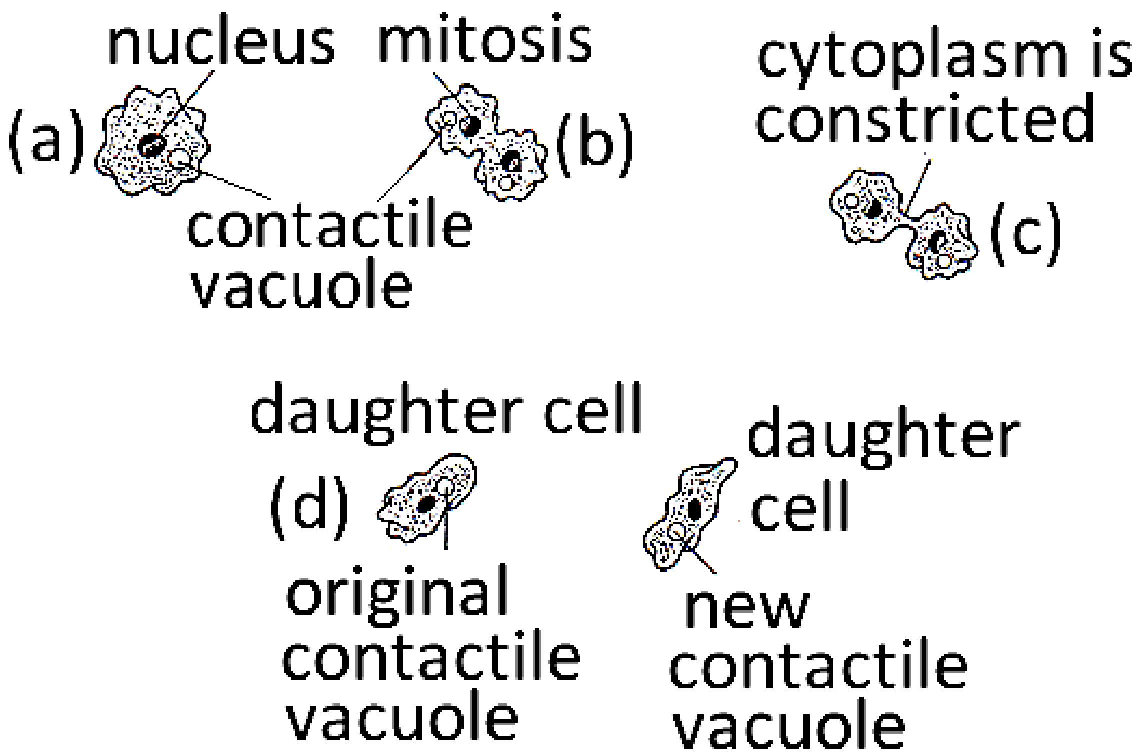
Amoeba



- The outer layer of an amoeba is the **ectoplasm** while the inner part is the **endoplasm**.
- The nucleus lies in the endoplasm and is enclosed by the nuclear membrane.
- A number of food vacuoles which contain tiny organisms on which the amoeba feeds occur in the endoplasm.
- The endoplasm also contains a bubble of liquid, called a **contractile vacuole**, which controls the amount of water in the amoeba.
- The amoeba’s endoplasm can flow in various directions resulting in the formation of finger-like projections called **pseudopodia**.

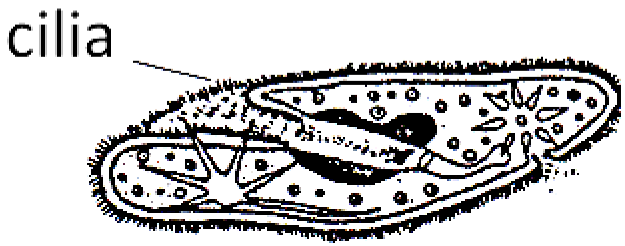
- This flow of the endoplasm helps the animal to move around.
- Amoeba reproduce asexually by **binary fission**.
- First the nucleus divides into two, which is followed by the division of the cytoplasm as shown below.

Reproduction in Amoeba



Paramecium

- The paramecium is commonly found in fresh water ponds.
- It does not have pseudopodia and moves by cilia, which are tiny hair-like projections found around the animal's body.

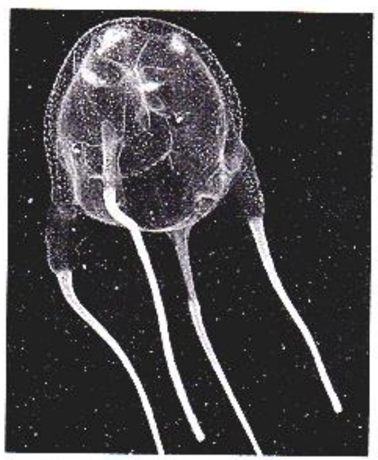


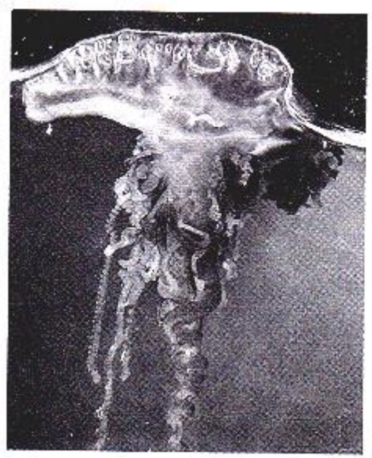
Paramecium

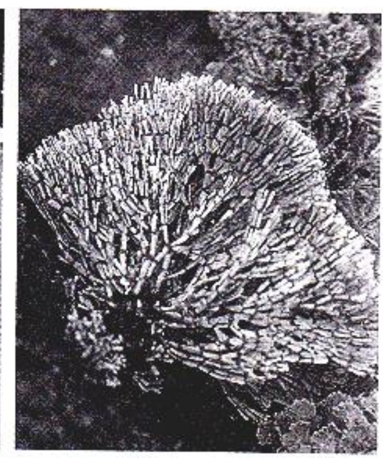
- Plasmodi a are parasites which live in the blood of other animals.
- Plasmodium causes malaria while trypanosoma cause sleeping sickness.

2. Coelenterates (Cnidarians)

- Coelenterates are multicellular; each consisting of many cells.
- Some live in the sea while others live in fresh water.
- Jellyfish, blue-bottles and corals are examples of coelenterates that live in the sea.


jellyfish

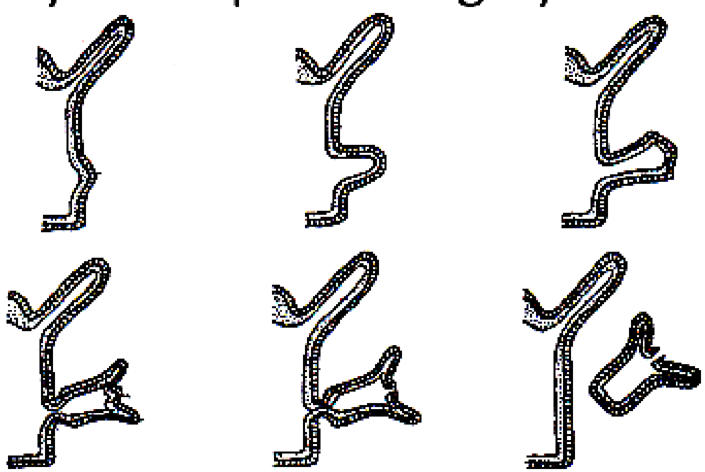

blue-bottle


coral

- Hydra, on the other hand is a coelenterate which lives in fresh water.

- It is a little animal about 15 mm long and attaches itself to the leaves and stems of water plants.
- Hydra can reproduce both sexually and asexually.
- Cells in one part of its body can multiply to form a bud that grows and develops into a new hydra.
- If the hydra is broken into several parts, each part can grow into a full individual hydra. This process is called **regeneration**.

Hydra Reproducing by Budding



3. Worms

- Worms are divided into three groups: **flatworms**, **roundworms** and **segmented worms**.
- Flatworms are subdivided into three sub-groups: **planarians**, **flukes** and **tapeworms**.

Flatworms

- Some of the planarians are free-living, while others are parasitic; on the other hand all tapeworms and flukes are parasitic.
- Examples of flukes include schistosoma (bilharzia worms) and liver flukes.

Roundworms

- Roundworms are also called nematodes.
- Some of them are free-living while others are parasitic.
- Examples of roundworms include **eelworm** (about 1cm long) found in soils, ***Ascaris***, **hookworm** and **filarial worm**.
- Examples of filarial worms are ***Wucheria bancroftii*** and ***Onchocera volvulus***.
- *Wucheria bancroftii* lives in the lymph vessels of the host and blocks them as it grows.
- The affected part swells, resulting in the disease called **elephantiasis**.

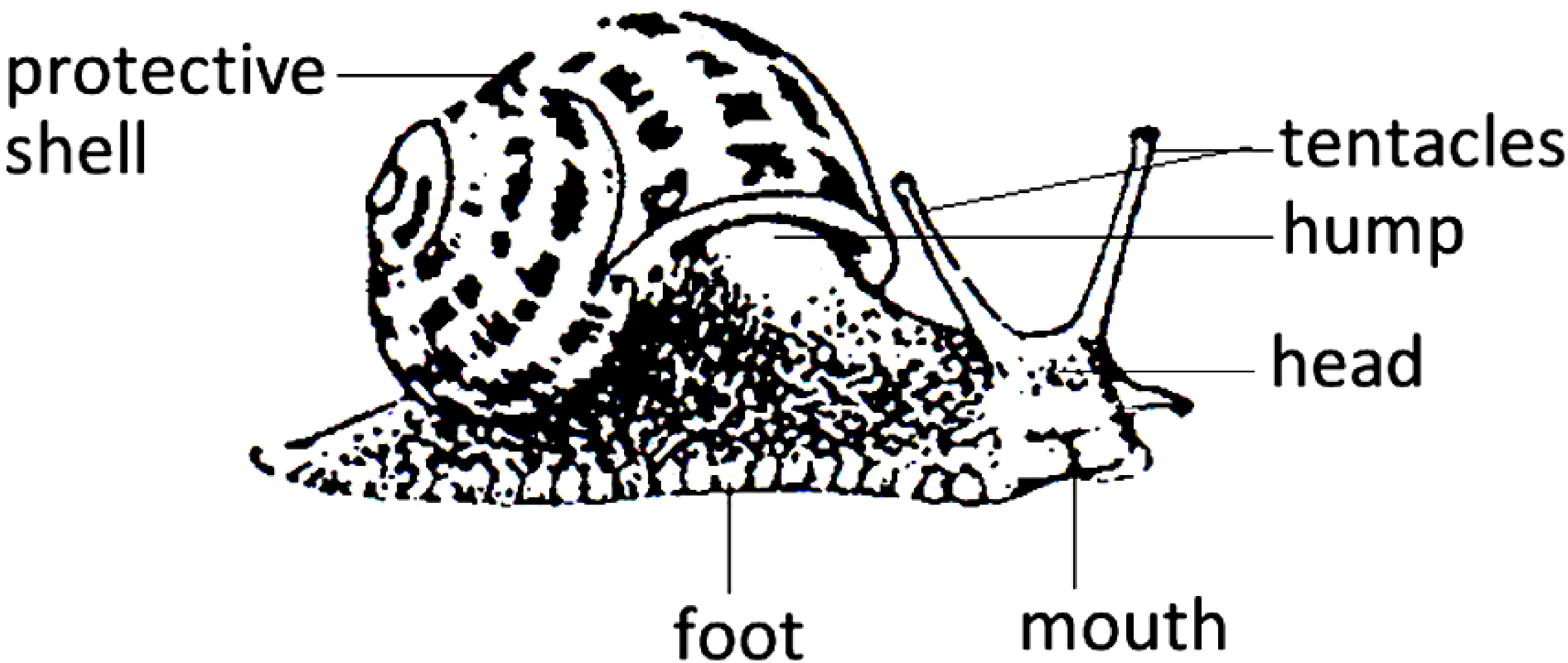
- The tiny larvae of the worms are transmitted from one person to another by mosquitoes.
- *Onchocera volvulus* causes river blindness because the worms block the lymphatic tissues of the eyes.
- *Onchocera volvulus* are transmitted from one person to another by a black blood sucking fly which breeds in rivers.

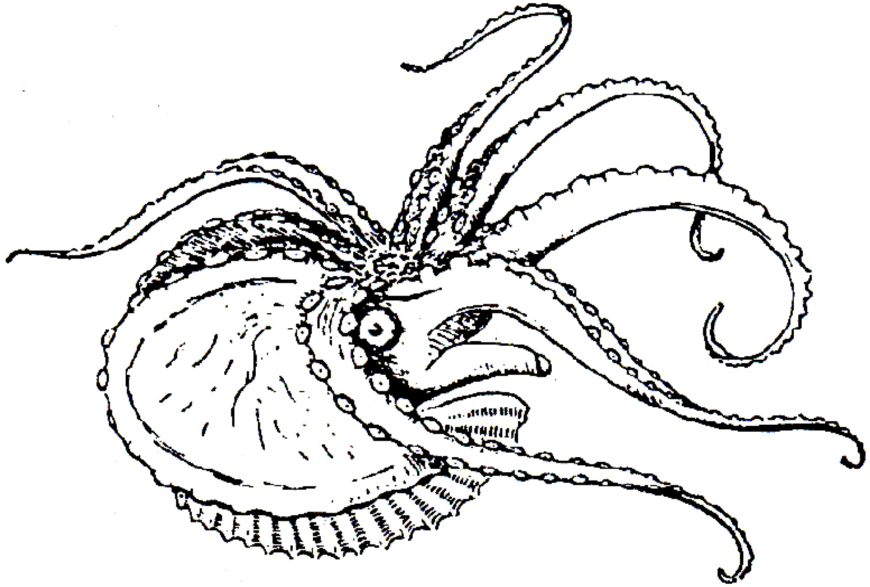
Segmented Worms

- Segmented worms are also called **annelids** and include **earthworms**, **marine worms** and **leeches**.
- Annelids' bodies are divided into several segments.
- Most annelids including earthworms, can regenerate if their bodies are broken into parts.

4. Molluscs

- Molluscs have soft, non-segmented bodies.
- They include snails, slugs, octopuses and oysters.
- Many molluscs are aquatic, while some of them live on land.





octopus

- The snail's body is soft and consists of a head, a foot and a hump which remains in a hard protective shell.
- The head has two pairs of tentacles which can be withdrawn if the snail is disturbed.
- Each of the two larger tentacles has an eye at the tip.

- The mouth is located under the head, while the rest of the body that is outside the shell is the foot.
- When the snail senses danger, the head and foot are drawn into the shell for protection.
- Snails are hermaphrodite i.e. each snail has both male and female reproductive organs.
- When two snails mate, they exchange sperms, which fertilise each other's eggs.
- The eggs are laid and hatch into young snails after a few days.

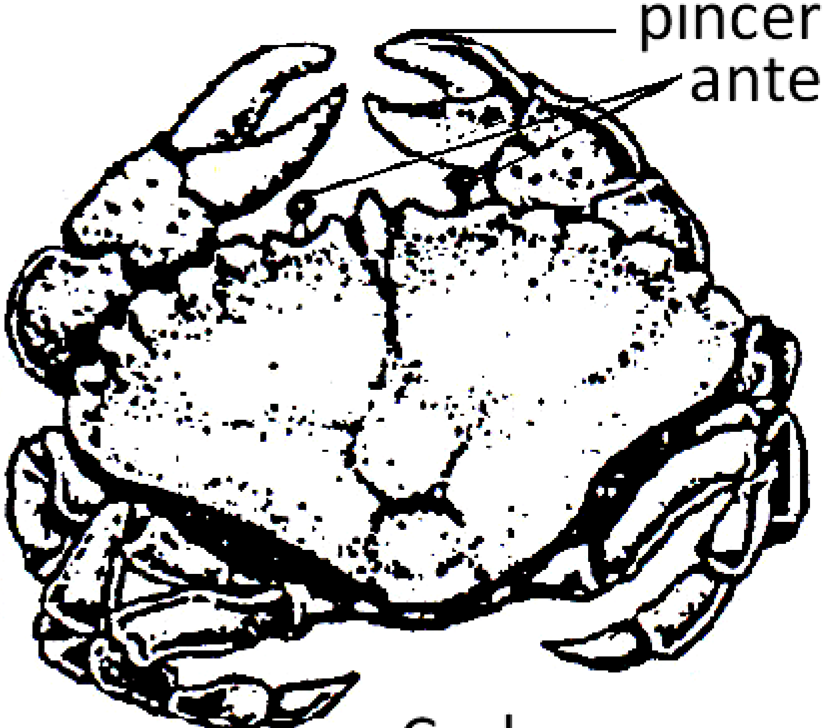
5. Arthropods

- This group includes **crustaceans**, **diplopods**, **chilopods**, **arachnids** and **insects**.
- Arthropods have three main characteristics in common:
  a. Their bodies are divided into **segments**. Sometimes some of the segments are fused or joined together.
  b. They have pairs of **jointed limbs**.
  c. Their bodies are covered by an **exoskeleton**, made of a hard substance called **chitin**.
     The exoskeleton:
  i. protects the animal and is used for muscle attachment.
  ii. restricts growth so they increase in size by moulting.

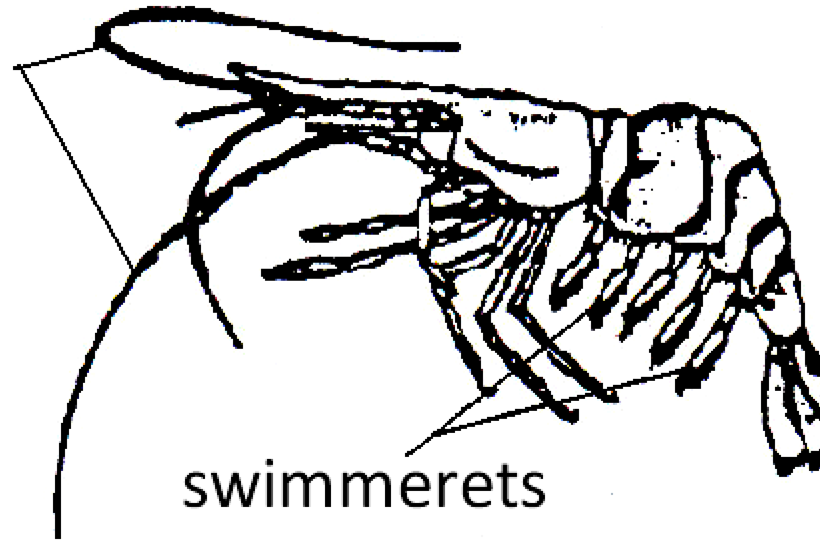
Crustaceans

- Almost all crustaceans are aquatic and breathe through gills.
- The head and thorax are fused thereby forming a **cephalothorax**.
- The first part of the cephalothorax has several pairs of mouthparts and compound eyes that are located at the ends of movable stalks,
- The cephalothorax has several pairs of legs,
- The first pair of legs end in pincers, which are used to seize and hold food.
- The abdomen has a number of flat plates called swimmerets, which are used for swimming.

- Examples of crustaceans include **crabs**, **prawns**, **wood lice** and **water fleas**.



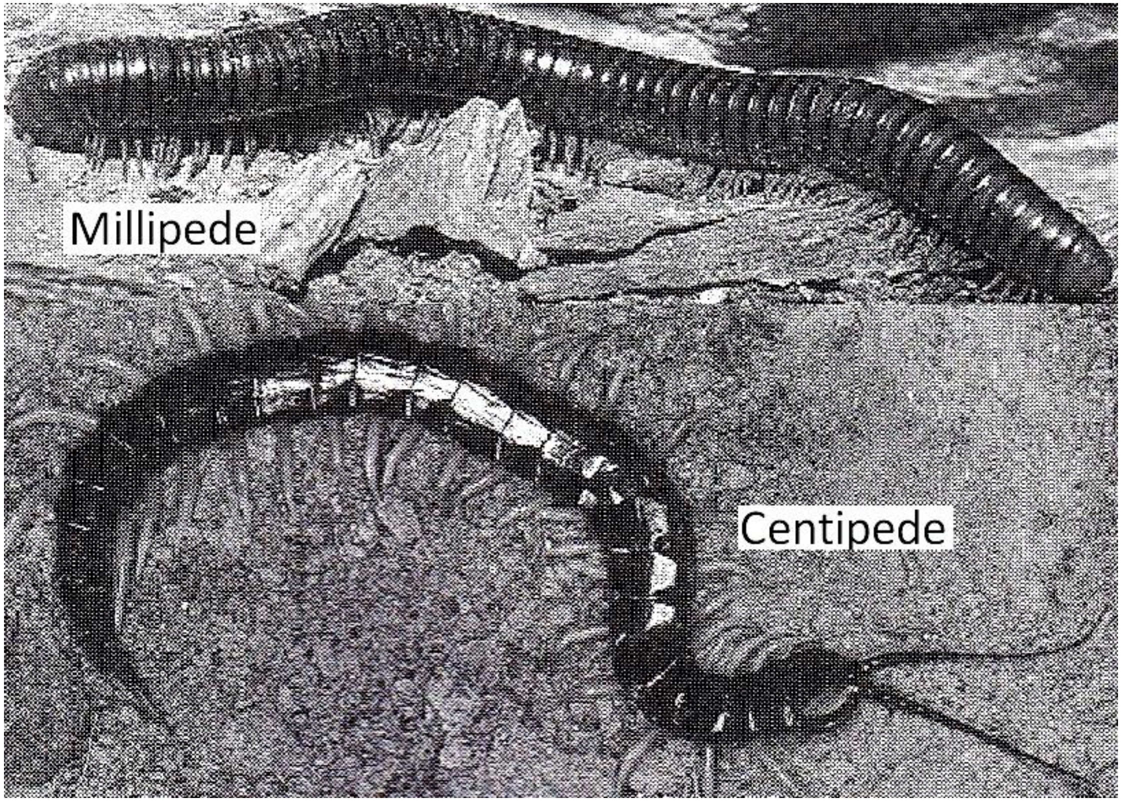
Crab



Prawn

Diplopods (Millipedes)

- All millipedes live on land.
- They have cylindrical bodies with several segments.
- Each segment has two pairs of walking legs.
- The head has a pair of antennae.
- Diplopods are herbivorous animals and live in litter or burrow into the soil.
- Like earthworms, millipedes help in aerating the soil.
- When touched, the millipede coils its whole body for protection.



Chilopods (Centipedes)

- Chilopods live on land and have flat bodies with about 15 to 20 segments.
- Each segment has a pair of walking legs.
- The head has a pair of antennae.

- Centipedes are fast moving carnivores that feed on insects, spiders and worms.
- They paralyse their prey by grasping it with their poisonous claws.

Arachnids

- The body of an arachnid is divided into two parts: **cephalothorax** and **abdomen**.
- The cephalothorax has several simple eyes and mouthparts.
- The mouth parts are segmented and end in pincers.
- Arachnids have no antennae.

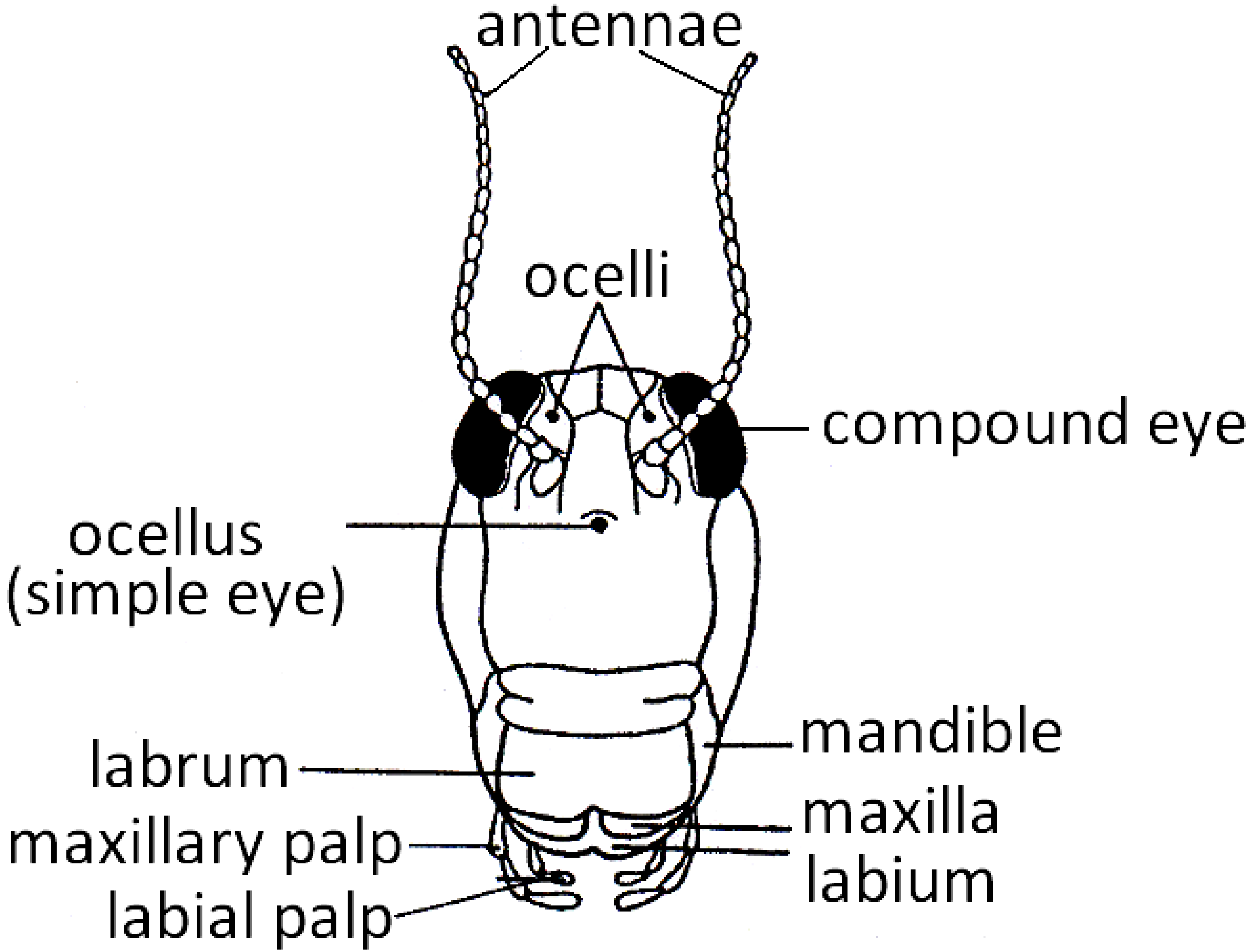
- The cephalothorax has four pairs of walking legs.
- The number of legs can be used to distinguish an arachnid from an insect.
- Examples of arachnids include **spiders**, **scorpions**, **mites** and **fleas**.
- Spiders have spinnerets on their abdomen which produce silk for web-making.
- Some spiders hunt their prey while others catch their prey using webs.
- Scorpions have a segmented abdomen which has a stinging spine at the last segment.
- Ticks are parasitic and feed on the blood of other animals, including domestic animals and humans.

- They transmit tick-borne diseases (e.g. **Tick-borne typhus** and **Relapsing fever**) as they feed on the blood of infected animals.

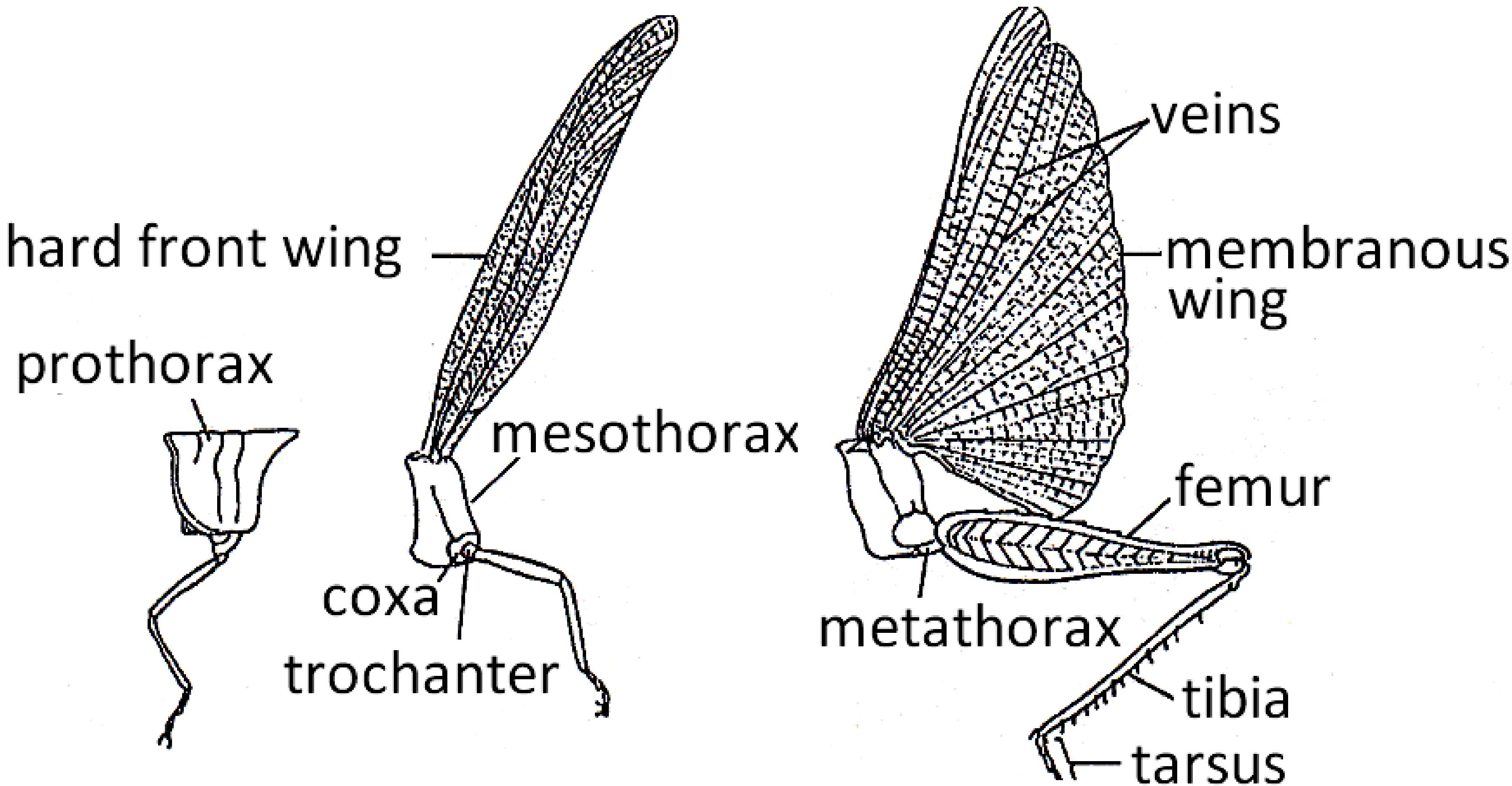
Insects

- Examples of insects are grasshoppers, bugs, beetles, butterflies, moths, flies, mosquitoes, termites, ants, bees, wasps etc.
- An insect’s body is divided into three parts: **head**, **thorax** and **abdomen**.
- The whole body is covered by an exoskeleton of chitin.
- The exoskeleton is more flexible at the joints to allow easy movement.

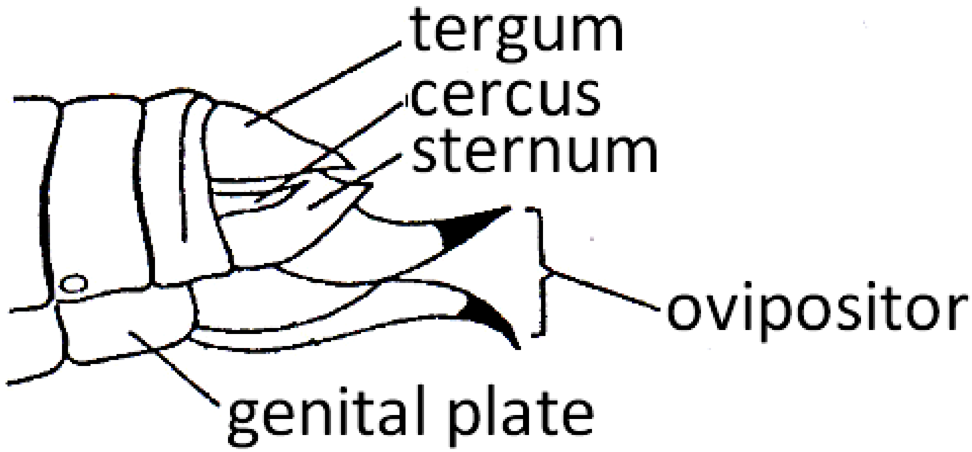
- The head has a pair of antennae, a pair of compound eyes and three pairs of jaws (mandibles and first and second maxillae).
- The thorax has three segments and each segment has a pair of jointed legs.
- The second and third segments may each bear a pair of wings for flying.



Grasshopper: Head and Mouthparts



Grasshopper: Thoracic Appendages



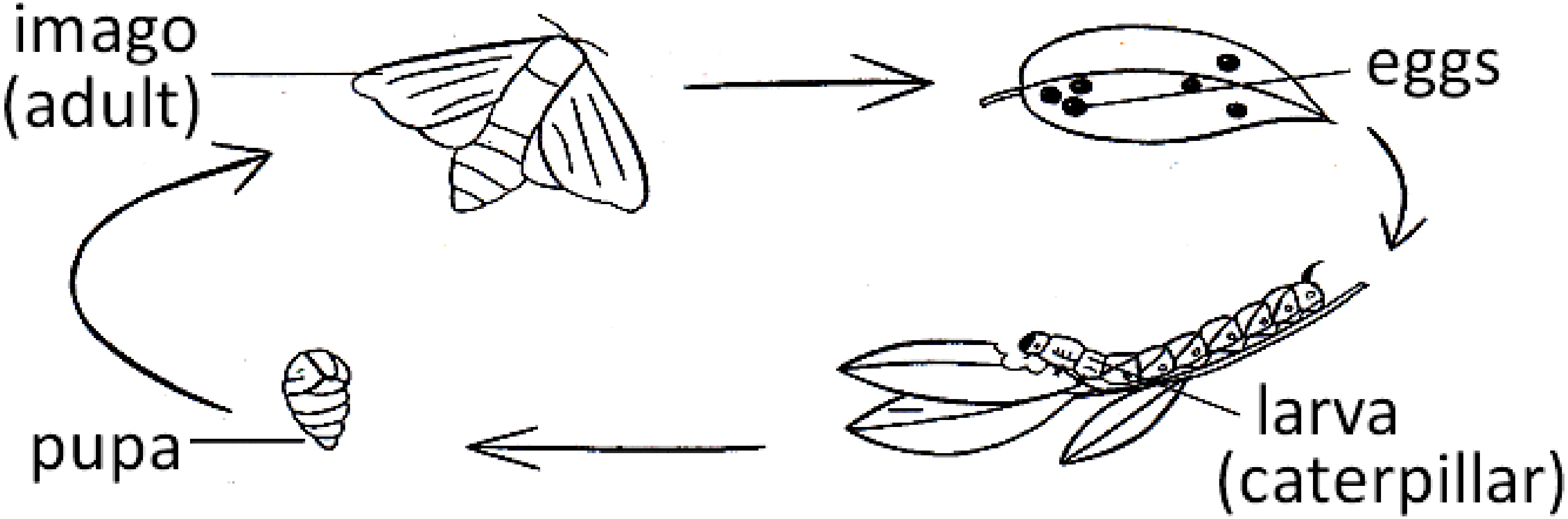
Grasshopper: Ovipositor of Female

Social Insects

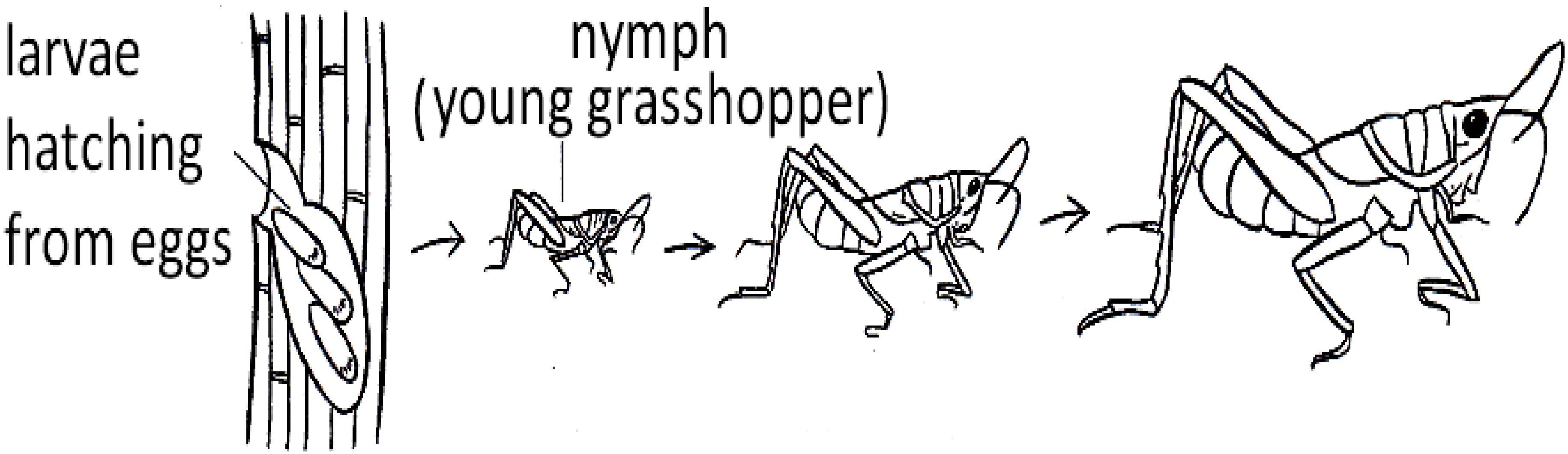
- Social insects are those that live in communities where there is division of labour and dependence on each other for existence e.g. termites, ants, bees and wasps.
- Within the community, some individuals provide food and shelter, some provide protection and others are concerned with reproduction.

Metamorphosis

- Metamorphosis refers to the development of an insect from the young to the adult stage.
- There are two types of metamorphosis: **complete** and **incomplete** metamorphosis.
- Complete metamorphosis is where an egg hatches into a larva, which changes to pupa, and this develops into an imago or adult.
- Insects such as flies, butterflies, ants, bees, wasps and beetles undergo complete metamorphosis.
- Incomplete metamorphosis has no pupa stage i.e. a larva hatches from the egg and this develops into the adult form.



- Insects such as grasshoppers, termites, bugs and cockroaches undergo incomplete metamorphosis.



Incomplete Metamorphosis

Vertebrates

- Vertebrates are animals with a backbone.
- The backbone is also called the **vertebral column** or **spine**.

Characteristics of Vertebrates

	Amphibians	**Fish**	**Reptiles**	**Birds**	**Mammals**
Body Covering	Naked, moist, soft skin	Scales	Scales	Feathers, scales on legs	Hair/fur
Breathing	Lungs, skin, mouth	Gills	Lungs	Lungs	Lungs
Body division	Head, trunk	Head, trunk, tail	Head, trunk, tail	Head, neck, trunk, tail	Head, neck, trunk, tail

	Amphibians	**Fish**	**Reptiles**	**Birds**	**Mammals**
Body shape	Short, flattened from top to bottom	Spindle-shaped	Long and thin, slightly flattened	Boat-shaped	Cylindrical, body carried horizontally
Locomotion	Four limbs	Fins	Four limbs (sometimes absent)	Two wings and two legs	Four limbs
Warm- or cold-blooded	Cold-blooded	Cold-blooded	Cold-blooded	Warm-blooded	Warm-blooded
Reproduction	External fertilisation, oviparous	External fertilisation, oviparous	Internal fertilisation, mostly oviparous, sometimes viviparous	Internal fertilisation, oviparous	Internal fertilisation, viviparous

- **Warm-blooded** animals are those which try to keep the inside of their bodies at a constant temperature.
- They do this by generating their own heat when they are in a cooler environment, and by cooling themselves when they are in a hotter environment.
- **Cold-blooded** animals are those which take on the temperature of their surroundings.
- They are unable to regulate internally their body temperatures; they are hot when their environment is hot and cold when their environment is cold.
- **Oviparous** animals are those which lay eggs that mature in their environment.

- They may fertilize their eggs either externally or internally.
- External fertilization involves the passage of the sperm to the ova through an ambient medium, usually water.
- For example, frogs achieve external fertilization of their eggs, when the male deposits sperm over the eggs as they are laid by the female.
- **Viviparous** animals give birth to live babies.
- These living young are usually nourished in close contact with their mothers' bodies before they are born.

GROWTH AND WATER UPTAKE IN PLANTS

- Growth can be defined as a permanent increase in size or volume produced by formation of new cells or other living material.

Measuring Plant Growth

- Plant growth can be determined by measuring over a long period of time:
  - the **length** of a part of the plant e.g. stem, root, internode, or leaf;
  - the **height** of the plant;
  - the **fresh mass** of the entire plant;
  - the **dry mass** of the entire plant and
  - the **surface area** of a leaf.

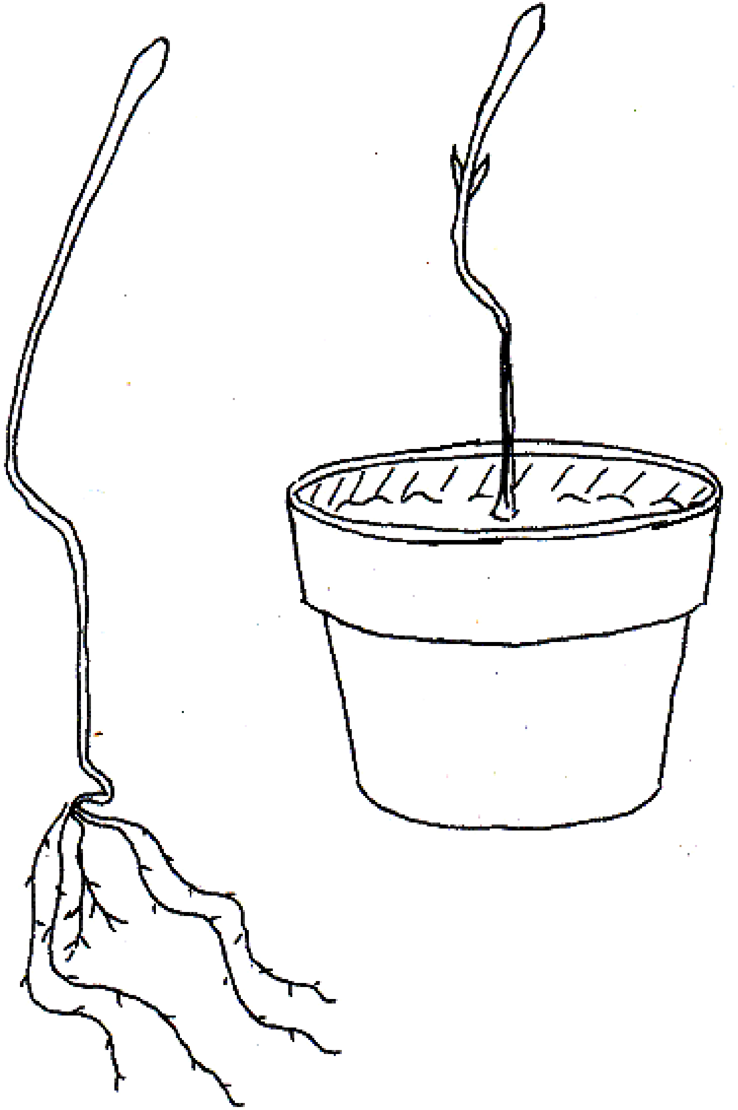
- Usually, the length and surface area are the best indicators of growth when looking at specific parts of a plant, such as stems and leaves.
- The mass of a plant can be measured by weighing it on a scale.
- A plant’s **fresh mass** changes depending on how much water the plant contains when you weigh it.
- It is therefore better to obtain the **dry mass** by repeated heating, cooling and weighing until a constant mass is obtained.
- Taking an average dry mass of several plant specimens gives a more accurate indication of growth.

Factors Affecting Plant Growth

- The growth of a plant can be affected by a number of factors such as **light**, **temperature**, **humidity**, **water**, **nutrients** and **gases** from the atmosphere.

The Effect of Light on Plant Growth

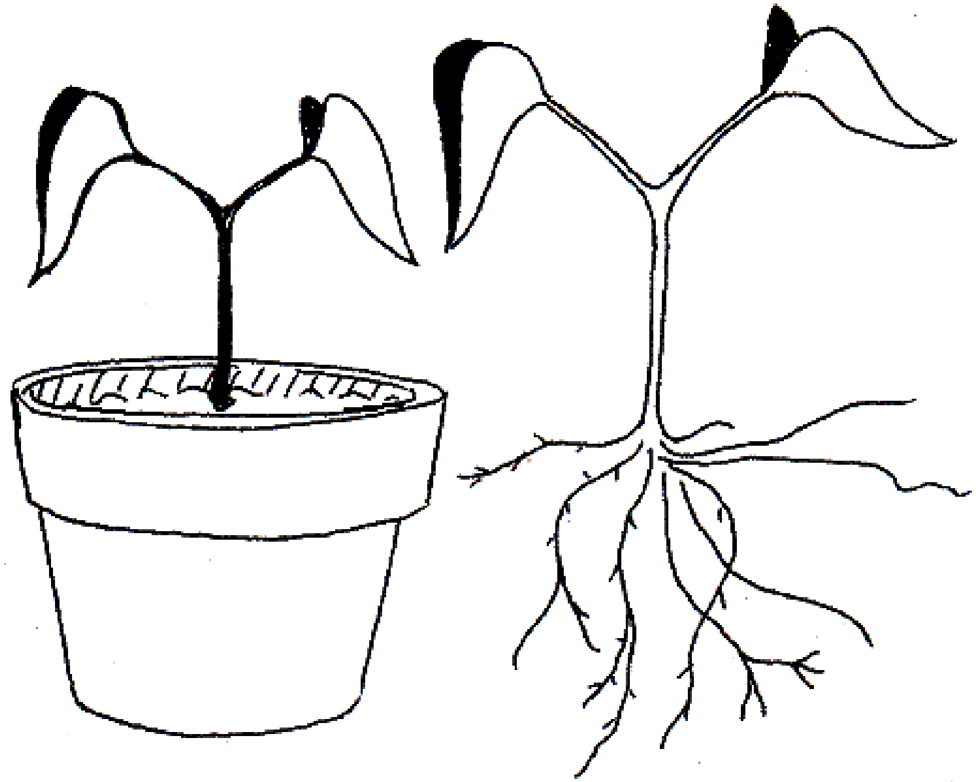
- Seedlings placed in the dark grow taller than those left in the light.
- Thus, plants grow faster when light is absent, which means light retards stem growth.
- The stems are however thin, elongated and very weak such that they fail to hold the seedlings upright.



Seedlings Grown in the Dark

- Often the leaves are **poorly developed**, **reduced in size**, and **fewer in number**.

- In addition, the stems and leaves are a pale colour.
- Seedlings in this condition are said to be **etiolated**.
- On the other hand seedlings grown in the light **have more leaves**, which are **broader**, **greener** and **well developed**.
- Their stems are shorter, but thicker and much stronger and are able to keep the plant upright.



Seedlings Grown in the Light

- The roots of plants grown in the light are **many** and **well developed**.
- Etiolated plants' roots, on the other hand, are **fewer** and **poorly developed**.

Effect of Plant Nutrients on Plant Growth

Element	Function	Effect on Plant When Deficient
Nitrogen (N)	• Formation of chlorophyll and proteins	• Stunted growth • Yellowing of leaves starting with older leaves
Phosphorus (P)	• Formation of high energy phosphate compounds e.g. ATP	• Poor and reduced growth • Leaves appear burnt

Element	Function	Effect on Plant When Deficient
Potassium (K)	• Improves resistance to disease • Formation of chlorophyll and proteins	• Leaves wither very early, before their time • Leaves turn yellow and acquire abnormal shapes
Calcium (Ca)	• Formation of cell wall cement in between cells	• Reduced plant growth • Poor root growth • Deformed leaves

- The elements listed in the table above plus others make up the nutrients that plants need in sufficient and balanced quantities for healthy growth.
- Nitrogen, calcium, phosphorus, potassium, magnesium, sulphur, hydrogen and oxygen are needed in large quantities and are called **macro-elements**.
- Manganese, boron, zinc, molybdenum, iron, copper and chloride are required in small quantities and are known as **micro-elements**.

- Except for carbon, all these elements occur as soluble salts in the soil.
- Carbon is absorbed by plants, through leaves as carbon dioxide gas.

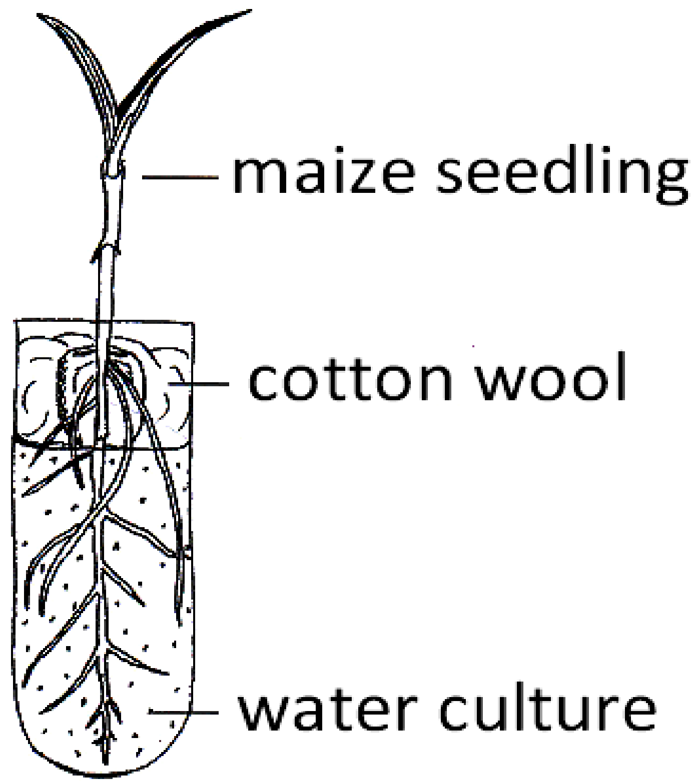
Element	**State in which they are Absorbed by Plants**
Nitrogen (N)	nitrate ions (NO_3^-); ammonium ions (NH_4^+)
Calcium (Ca)	calcium ions (Ca2+)
Phosphorus (P)	phosphate ions (PO_4^{3-})
Magnesium (Mg)	magnesium ions (Mg^{2+})
Potassium (K)	potassium ions (K^+)
Sulphur (S)	sulphate ions (SO_4^{2-})
Oxygen (O)	carbon dioxide (CO_2); sulphate ions (SO_4^{2-})
Hydrogen (H)	hydrogen ions (H^+); water (H_2O)

Crop Fertilisers

- Crop fertilisers supply these nutrients as soluble salts which dissolve in water and form a soil solution.
- Plants then absorb these nutrients as ions.
- Fertilisers commonly used in Malawi include CAN, (Calcium Ammonium Nitrate) DAP, UREA and 23:21:0 + 4S.
- Each type of fertiliser is manufactured in such a way that it provides the plant with certain nutrients e.g. CAN provides calcium and nitrogen (in form of ammonium ions).

Effect of Lack of Some Nutrients on the Growth of Maize

- A solution of water containing nutrients which a plant requires for its nutrition is called a **water culture**.



Maize Seedling in a Water Culture

- The maize plants grown in a water culture deficient of nitrogen do not grow as much and have fewer and smaller leaves.
- Their leaves show characteristic yellowing from the tip of the leaf backwards, especially in young leaves.
- The roots of maize plants grown in the calcium-deficient culture are poorly developed.

Bean Plants Growing in Culture Solutions, Showing Mineral Deficiency Symptoms

- These results show that for normal plant growth, a plant requires an adequate and balanced supply of mineral elements or nutrients.
- Thus a deficiency of even one mineral element or nutrient interferes with the normal plant growth.

The Effect of Water on Plant Growth

- A shortage of water greatly reduces plant growth.
- When there is a prolonged shortage of water, plant growth virtually stops and, when accompanied by cells drying up, the whole plant eventually dies.

Why Does Water Have Such an Impact on Plant Growth?

a. Water is an important raw material for the process of photosynthesis.
b. Water transports manufactured food from the leaves to the rest of the plant.

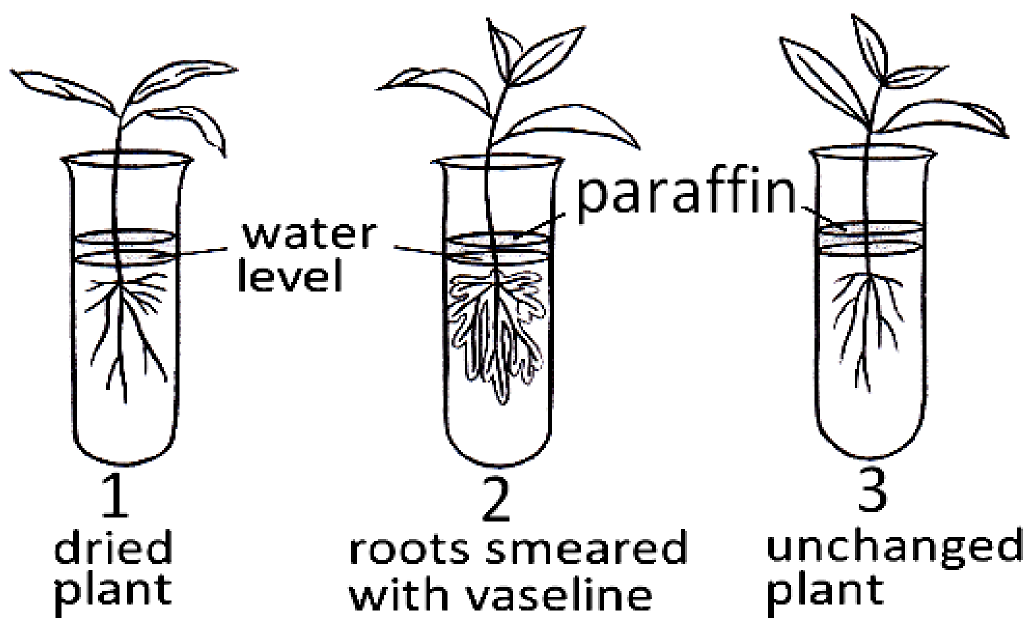
c. Water transports mineral salts absorbed from the soil by the roots to all parts of the plant.
d. Water helps to cool down the plant through a process called **transpiration**. As water evaporates through the stomata, the plant cools down just as the body is cooled by the evaporation of sweat from the skin.
e. Water provides an important medium in which many chemical reactions, such as respiration take place.

Water Uptake in Plants

How Roots Affect Water Uptake

1. Obtain two fresh young plants of about the same size and one young dried plant of the same species.
2. Pour enough water to cover the roots of the plants into three test tubes and label them 1, 2 and 3.
3. Put in the dried plant in the test tube labelled 1.
4. Smear the roots of one of the two fresh plants with Vaseline and put it into the test tube labelled 2.

5. Put the remaining fresh plant into the test tube labelled 3 without smearing its roots with Vaseline. Ensure that the water levels in all the three test tubes is the same.
6. Pour paraffin onto the water surface in all the three test tubes and mark the water level in each test tube. Record this as water level for day 1. Leave the set-up for 24 hours.



7. Measure the height of the water level after 24 hours and record your findings in a table.

	Water Level (mm)		
Test tube	Day 1	Day 2	Day 3
1			
2			
3			

- Water enters plants mainly through very tiny structures found on the plant roots called **root hairs**.

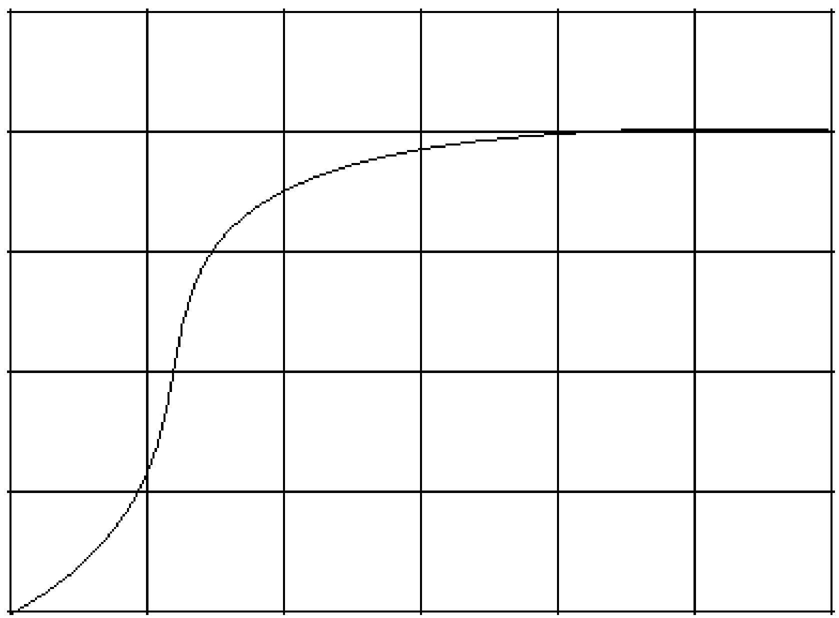
- Root hairs are tubes formed from the cells on the surface of the roots, with an average diameter of about 4 – 16µm and a length of about 80 – 150µm.
- They are very soft and break easily.
- Their thin walls allow water to enter them easily.
- They are found in large numbers on the roots, which increases the surface area for water absorption.
- From the experiment's results, it is apparent that water uptake is impossible when the plant is dead nor when the roots are covered.

- The small drop observed in the water level is probably due to the stems simply soaking up the water just like blotting paper would do when dipped in water.
- On the other hand, the effect of leaves on water uptake probably shows that the upward water movement in the stem is connected to the loss of water through the leaf stomata (transpiration).

The Growth Rate of Bean Leaves

- The growth rate of a plant is the increase in height or some other measurement per unit time e.g. 2 mm per day (2 mm/day).

- As a plants grow, they follow a growth pattern which forms an S-shaped curve.
- This is called a **growth curve**.
- This curve shows that at the beginning, growth is slow, then increases rapidly, and slows down and finally stops.



HUMAN NUTRITION

- Human nutrition deals with the food people eat and their eating habits.
- It also concerns how the food we choose to eat and our eating habits affect our health.

Food Nutrients

- Nutrients are chemical substances obtained from food.
- The body uses the nutrients for :
  - Growth and replacement of damaged tissues;
  - Provision of energy for daily activity;
  - Building up of its structure;

- The general maintenance of the body etc.

Classes of Nutrients

- There are six classes of nutrients
    a. Carbohydrates
    b. Lipids
    c. Proteins
    d. Vitamins
    e. Mineral salts and
    f. Water

Carbohydrates

- Carbohydrates are compounds with molecules consisting of carbon, hydrogen and oxygen, where the ratio of hydrogen to oxygen atoms is always 2:1.
- They are classified into **monosaccharides**, **disaccharides** and **polysaccharides**.

Monosaccharides

- These are simple sugar molecules e.g. **glucose** (grape sugar), **fructose** (fruit sugar) and **galactose** (milk sugar).

Disaccharides

- These are double sugar molecules which are made by combining two simple sugar molecules.
- Examples of disaccharides are **maltose**, **lactose** and **sucrose**.
- Maltose is made by combining two glucose units; lactose (milk sugar) is made by combining galactose and glucose while sucrose (cane sugar) is a combination of glucose and fructose.
- Sucrose is the sugar used in tea, coffee and other beverages and is very sweet.

Polysaccharides

- These are formed when thousands of simple sugar molecules join together to form long chains.
- Examples of polysaccharides include **starch**, **glycogen**, **chitin**, **pectin** and **cellulose**.

Functions of Carbohydrates

a. Provision of energy.
b. Improvement of bowel movement, which helps to prevent constipation as well as haemorrhoids (swelling of the rectal veins).

c. Provision of a feeling of being satisfied for a long time (satiety value).

d. Making food more acceptable since they are responsible for the food's sweetness.

e. Help to prevent heart disease, diabetes (sugar disease) and cancer.

Lipids

- The basic chemical elements of lipids are also carbon, hydrogen and oxygen however lipids contain much more carbon and hydrogen relative to oxygen.
- Lipids include **fats** and **oils**.

- Fats (e.g. butter or margarine) are solid at room temperature whereas oils (e.g. Vegetable cooking oil) are liquid at room temperature.

Sources of Lipids

- Common fat sources are margarine, butter and other dairy products, and lard from meat.
- Common vegetable oils include groundnut oils, sunflower oil and cotton seed oil.

Functions of Lipids

a. Provision of energy. Fats and oils provide much more energy per gram than carbohydrates.

b. For building of cell structures.
c. Protection of major organs such as kidneys where they act as shock absorbers.
d. Insulating the body thereby keeping it warm.
e. Production of vitamin D, some hormones and bile.
f. Transportation of fat-soluble vitamins.

Proteins

- Proteins differ from carbohydrates and lipids in their chemical composition.
- Besides carbon, hydrogen and oxygen, proteins also contain nitrogen.

- The simplest molecule formed when these elements join together is an **amino acid**.
- Amino acids join together in different ways to form thousands of different kinds of proteins.

Common Sources of Proteins

- Eggs, fish, meat, groundnuts, beans and milk

Functions of Proteins

a. Supply of the basic building material of the body.
b. Repair of damaged tissues e.g. broken bones and torn skin.

c. Growth.
d. Protection against diseases by forming antibodies. Antibodies are large protein which fight germs entering the body.
e. Transportation of small molecules e.g. haemoglobin transports oxygen in the blood.
f. Provision of energy when lipids and carbohydrates are in short supply.

Vitamins

- Vitamins are a collection of organic substances which are needed in very small quantities in the diet.
- They interact with other nutrients in processes such as metabolism, digestion and developing blood cells .
- They are commonly known by the letters of the alphabet, however they have chemical names.
- Vitamins function only when they are intact. They are easily destroyed by: **heat**, **light** and **chemical agents**.

- Overcooking food can therefore reduce the effectiveness of the vitamins it contains.
- Eating a variety of foods ensures that the dietary requirements for vitamins are met.
- For vitamins to do their job they must be in solution.
- Some vitamins dissolve in water and are called **water-soluble vitamins**, while others dissolve in fat and are called **fat-soluble vitamins**.
- Vitamins **B complex** and **C** are water-soluble whereas Vitamins **A**, **D**, **E** and **K** are fat-soluble.

Vitamin	Sources	Function	Deficiency Signs
Vitamin A (Retinol)	dark green and yellow vegetables and deep orange fruits e.g. carrots, spinach, squash, sweet potatoes, pumpkins, and animal sources e.g. liver, liver oils, milk, butter, cheese, and eggs.	• Promotes new cell growth. • Maintains health of the skin, hair, and tissues. • Helps vision in dim light. • Helps the immune system	• Night blindness • Drying of the eyes • Permanent blindness due to softening of the eyes • Reduced immunity • Painful joints • Skin with white lumps

Vitamin B_1 (Thiamine)	outer skin of cereals (e.g. rice), pork, mushrooms , milk, fortified bread, dried beans, sorghum, potatoes, spinach, nuts, peas, yeast	• Required in cell respiration • Normal functioning of heart and nervous system • Helps maintain appetite • Production of red blood cells	• Beri-beri (heart failure) • Nerve damage resulting in paralysis • Mental confusion (worry) • Difficulty in walking • Tiredness and fatigue, muscle weakness • Loss of appetite

Vitamin B_2 (Riboflavin)	Leafy green vegetables, bread, milk and milk products, meat	• Release of energy from food	• Pellagra • Digestive system disorders • Irritation due to light • Cracks at corners of the mouth • Skin rash
Vitamin B_3 (Niacin)	poultry, lean meat, pulses, peanuts, milk, eggs, liver, heart, kidney, avocados, tomatoes, sweet potatoes, whole grains,	• Maintains a healthy skin • Helps normal working of the digestive system	• Skin disorders • Fatigue • Depression • Diarrhoea

Vitamin C (Ascorbic acid)	Citrus fruits, melon, dark green leafy vegetables strawberries, green peppers, tomatoes, potatoes	• Increases resistance to infections • Strengthens blood vessels' walls • Promotes absorption of iron • Formation of scar tissue that helps in healing of wounds • Formation of collagen, a protein structure that acts like a rope	• Prone to infections • Rough skin leading to slower healing of wounds • scurvy (gum and dental problems) • Fatigue, loss of appetite • Weak bones and painful joints • Anaemia

Vitamin D (Calciferol)	milk, fat, cheese, whole eggs, liver, salmon; the skin can synthesise it if exposed to enough sunlight i.e. 15 minutes of exposure to the sunshine, three times a week will enable the body to manufacture all the vitamin D that it needs.	• Promotes the absorption and use of calcium and phosphorus from the gut • Helps in the calcification of bones and teeth	• Rickets • Reduced growth • Enlargement of the head due to delayed closure of fontanel • Easy decay of teeth

Vitamin E (Tocopherol)	vegetable oils (e.g. palm, sunflower, olive and soybean), nuts, seeds, wheat germ, spinach, green leafy vegetables, and cereals	• Helps prevent cancer • Helps prevent cardiovascular and heart disease. • It is often added to skin lotions, as it may delay the ageing process.	• are not very common but may include some nerve damage.
Vitamin K (Phylloquinone)	Liver, spinach, cauliflower, kale, green leafy vegetables, soya beans, and onions	• For blood clotting • Helps maintain strong bones • Could prevent osteoporosis	• Signs may include easy bruising and bleeding

Mineral Salts

- Mineral salts are required by the body in very small amounts.
- They provide the body with necessary mineral elements.
- The elements found in these mineral salts are in small amounts.
- A wide selection of food ensures that dietary requirements for most of these elements are satisfied.
- Common mineral salts obtained from food are sodium chloride, iron and calcium salts and fluorides.

Element	Source	Function	Deficiency Signs
Iodine (I)	iodised salt, fish and other sea foods, dairy products	• Formation of **thyroxin** in the thyroid gland, which : ▪ Controls respiration ▪ Regulates growth and development ▪ Regulates reproduction and metabolism	• Goitre (swelling of the thyroid gland) • Reduced growth • Weight gain • Mental retardation
Fluorides	Tea, water treated with fluorides, seafood	• Formation of strong teeth and bones • Resistance to tooth decay	• Tooth decay

Calcium (Ca)	Beans, dried onions, roots cereals, fish, green vegetables, and milk and milk products	• Maintenance of normal blood pressure • Formation of bones and teeth • Involved in blood clotting • Contraction and relaxation of muscles	• Rickets • Poorly formed teeth • Soft bones
Iron (Fe)	Liver, green vegetables, eggs, roots, yeast, cereals, caterpillars	• Formation of haemoglobin in red blood cells • For growth of the placenta and the foetus	• Anaemia

Water

- Water is a simple inorganic compound consisting of the elements hydrogen and oxygen.
- It is a special substance as it is a solvent for many nutrients and other substances, hence it is present in most of the body fluids.
- Thus it is a medium in which most substances dissolve and are transported.

Functions of Water

a. It transports nutrients from the gut to the tissue cells.

b. It transports metabolic wastes such as carbon dioxide and urea from tissue cells to excretory organs
c. It maintains blood volume thereby helping in the normal functioning of the heart.
d. It lubricates the joints of the skeleton.
e. It helps to maintain a constant body temperature.
f. It provides a cushioning effect for the foetus in the womb thereby preventing shock.

Macro- and Micro-nutrient Requirements

- **Macro-nutrients** are those which are required by the body in large amounts daily.
- Examples of macro-nutrients include lipids, carbohydrates, proteins and water.
- Nutrients which are required by the body in small amounts daily are known as **micro-nutrients**.
- Micro-nutrients include vitamins and mineral salts.
- Of all the micro-nutrients, calcium is needed by the body in large amounts.

Macro-nutrients	
Nutrient	**Recommended Daily Amounts**
Carbohydrate Starch and Fibre Sugars	 300g/day 50g/day
Lipids	65g/day or 2000kcal/day
Proteins Infants Children below 4yrs Children over 4yrs + adults Pregnant women Lactating women	 14g/day 16g/day 50g/day 60g/day 65g/day
Water Adults Infants	 1.0 – 1.5 ml/kcal used 4.2 - 6.3 ml/kcal used 1.5 ml/kcal used

Micro-nutrients

Nutrient	Recommended Daily Amounts (RDA)
Iron	
Men	10 mg/day
Women	
▪ 19 – 50 years	15 mg/day
▪ Over 51 years	10 mg/day
▪ Pregnant	30 mg/day
Calcium	
19 – 24 years	11 200 mg/day
25 years and over	800 mg/day
Fluoride	1.5 – 4.0 mg/day
Iodine	
Pregnant women	150 µg/day
Lactating women	200 µg/day

Nutrient	Recommended Daily Amounts (RDA)
Vitamin A	
Men	1 000 µg/day
Women	800 µg/day
Vitamin B_1	
Men 19 – 50 yrs	1.5 mg/day
Women 19 – 50 yrs	1.1 mg/day
Vitamin B_2	
Men 19 – 50 yrs	1.7 mg/day
Women 19 – 50 yrs	1.3 mg/day
Vitamin C	60 mg/day
Vitamin D	
19 – 24 years	10 µg/day
25 years and older	5 µg/day

- Protein is needed in fairly large amounts everyday because it makes up a major part of most of the body structures.
- The daily requirement for protein increases with increase in bodily activity.
- Hence as young people grow, more protein is required per day to satisfy the need for new tissues to be formed or to repair tissue damaged in the process.
- Higher protein intake is required in pregnant and lactating women for development and growth of the foetus.

- Of all the micro-nutrients, calcium is needed by the body in large amounts.
- This is so because calcium forms the major component of bone structures and teeth.
- Its constant supply is needed for maintenance, replacement and repair of bone structures.
- Children need the right amount of calcium to ensure normal bone formation, strong enough to support their body weight.
- It also ensures an adequate supply of calcium in adulthood when bones begin to weaken from natural bone loss (osteoporosis).

- Iron's requirements for men and women above 51 years are the same.
- However, girls or women who are menstruating need more iron to make up for the loss of blood during menstruation.
- More iron is also needed during pregnancy for the growth of the placenta and the foetus itself.
- Thus a pregnant woman needs more iron than she normally gets even from a balanced diet.
- Therefore, pregnant women should take iron supplements in order to meet their daily requirements.

Factors Influencing People's Choice of Food

- There are various reasons why people choose certain foods as follows:

a. **Tradition**

- People tend to eat certain foods because they have eaten that kind of food from childhood.
- For example some people may complain that hunger is not satisfied when rice is served instead of the usual dish, *nsima*.

b. **Religious Beliefs**

- Strong religious beliefs also influence what people choose to eat or not to eat e.g. Moslems do not eat pork due to religion.

c. Affordability and Convenience

People will often choose food which they can afford to buy and can easily obtain. Thus a low income family will try to satisfy their nutritional needs with foods that are cheap. On the other hand a rich family has greater choice of food to provide necessary nutrients.

d. Food Taboos and Superstitions

In the past, certain foods were thought to be bad, usually not based on a knowledge of nutrition. For instance children were not allowed to eat eggs because they were thought to make the epileptics.

e. **Health Status**

Special consideration should be made due to one's health condition as to which foods they are to be given. For instance people who develop rash after eating meat should not be given meat.

f. **Habit**

Habit is a strong influence in peoples choice of food e.g. for some people breakfast means tea and bread, while others consider breakfast to be maize porridge and tea.

g. **Food Availability**

People tend to choose foods that are available at a particular time of the year. Thus seasonal foods cannot be part of the regular diet.

A Balanced Diet

- A balanced diet is the one which is rich in all the nutrients required by the body in the right proportions.
- The nutrients needed by the body are found in the food an individual consumes.
- Some foods contain more of one nutrient than another.
- This being the case, it is necessary to carefully select one's food so that the body gets all the nutrients it requires in the right proportions.

- Since body needs differ from one person to another, a balanced diet for one person may not be suitable for another.
- For instance, though milk is nutritionally balanced for a baby, it may not be adequate for an adult because it falls short of some of the requirements.
- The locally available foods are rich in nutrients needed by the body.
- To achieve a balanced diet even with less of each kind of food, increase the variety of foods eaten.

- Ensure plenty of different types of food in small amounts in one meal rather than too much of one or two types of food.
- A balanced diet makes one healthy and ensures that different parts of their bodies do their jobs properly.

Deficiency Diseases

- These are illnesses caused by lack of food or particular nutrients in the body
- Many children suffer from and die of deficiency diseases in many parts of the world, including Malawi.

General Causes of Deficiency Diseases

a. Lack of nutrients in the diet.
b. The body's inability to absorb food from the gut.
c. Poverty.
d. Illiteracy
e. Poor methods of food preparation such as overcooking.
f. Worm infections e.g. tape worm infection.

Deficiency Disease	Cause	Signs and Symptoms	Treatment / Prevention
Goitre	• Lack of iodine in the diet.	a. Swelling of the thyroid gland in the throat.	a. Using iodised salt in meals. b. Surgical removal of the thyroid gland in severe cases.
Scurvy	• Lack of vitamin C in the diet.	a. Bleeding gums b. Painful joints c. Weakness d. Reduced resistance to infection	a. Including citrus fruits (oranges, tangerines and lemons), guava, papaya, potatoes and fresh green vegetables in the diet.

Kwashiorkor	• Lack of protein in the diet	a. Weight loss b. Oedema of the face and legs (swelling of tissues due to water retention) c. Diarrhoea d. Poor appetite e. Miserable-looking appearance f. Stunted growth g. Pale skin which peels easily h. Large and protruding abdomen i. Weak, sparse, pale and non-curled hair	a. Providing children with regular, well-balanced meals

Marasmus	• A general shortage of protein and carbohydrate	a. Looking alert but thin b. Monkey-like face like that of an old person c. Wrinkled skin d. Stunted growth e. Good appetite f. Weakness g. Good appetite h. Wasted muscles	a. Giving children with regular well-balanced meals
Pellagra	•Lack of niacin (vitamin B_3) in the diet	a. Cracking, crusting and scaling of the skin b. Diarrhoea c. Nervousness d. Dizziness	a. Including more good sources of niacin in diet e.g. milk, pulses, eggs etc

Rickets	• Lack of vitamin D in the diet	a. Curved legs b. Enlarged and tender joints c. A bony chest	a. Including eggs, butter, cheese, milk, liver etc in the diet
Night Blindness	• Lack of vitamin A in the diet	a. Dry eyes b. Loss of shine in the whites of the eyes	a. Including red and yellow fruits and vegetables in the diet
Anaemia	• Lack of iron in the diet	a. General body weakness b. Heart palpitations c. Paleness of mucous membranes, tongue and skin d. Oedema e. Breathlessness	a. Including sources of iron in the diet b. Giving iron tablets where necessary

Effects of Deficiency Diseases

a. Retarding the development of the community and nation because:
   i. Resources that could be used for development are diverted to the treatment of the deficiency diseases.
   ii. Parents/guardians spend more time caring for the sick than performing other activities that are necessary for the family's well-being.

b. Loss of human resources.

c. Pressure on health services.

d. Stress on the economy.

e. Deformity.

Obesity

- This is a condition which results when one's energy intake exceeds their energy output over a long period of time.
- This results in people becoming overweight and can cause heath problems such as high blood pressure.

Solving the Problem of Obesity

a. Balancing food energy intake with the rate at which it is used up.
b. Regular physical exercise

DIGESTION IN MAMMALS

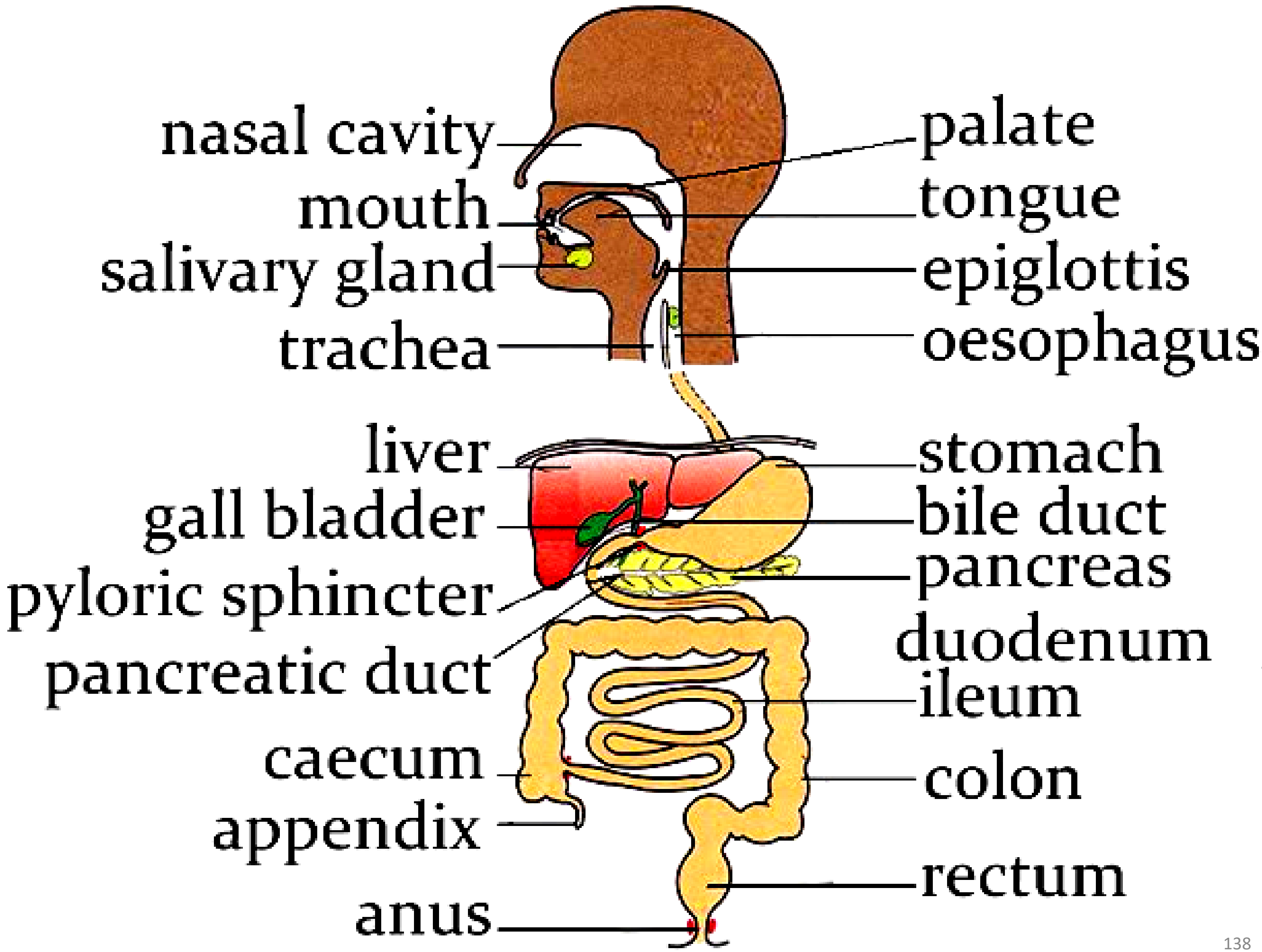
- The food for most animals is solid, before it is used by the animal it must be in solution form.
- The processes concerned with the use of food by animals include:
  a. **Ingestion** of food
  b. **Digestion** of foodstuffs
  c. **Absorption** of the products of digestion
  d. **Assimilation** of digestion products by the tissue cells
  e. **Egestion**
- **Ingestion** is the taking in of solid food into the mouth.

- Digestion is the process through which food is broken down into smaller molecules which can eventually dissolve in the bloodstream.
- There are two forms of digestion i.e. **physical** and **chemical** digestion.

The Human Digestive System

- Digestion in humans takes place in a special system called the **digestive tract** or **gut** or **alimentary canal**.
- The alimentary canal is a long tube which begins at the mouth and ends at the anus.

The Human Alimentary Canal



Physical Digestion

- In physical digestion food is mechanically broken down into smaller particles without forming new substances.
- Physical digestion occurs in:
  i. the mouth by the action of teeth and tongue
  ii. the duodenum by the action of bile.

Chemical Digestion

- This involves the breakdown of ingested food into smaller molecules by digestive **enzymes**.
- Enzymes are secreted by glands in different parts of the alimentary canal.

- The small soluble molecules are then absorbed into the bloodstream and transported to the tissue cells.

Digestion in Different Parts of the Alimentary Canal

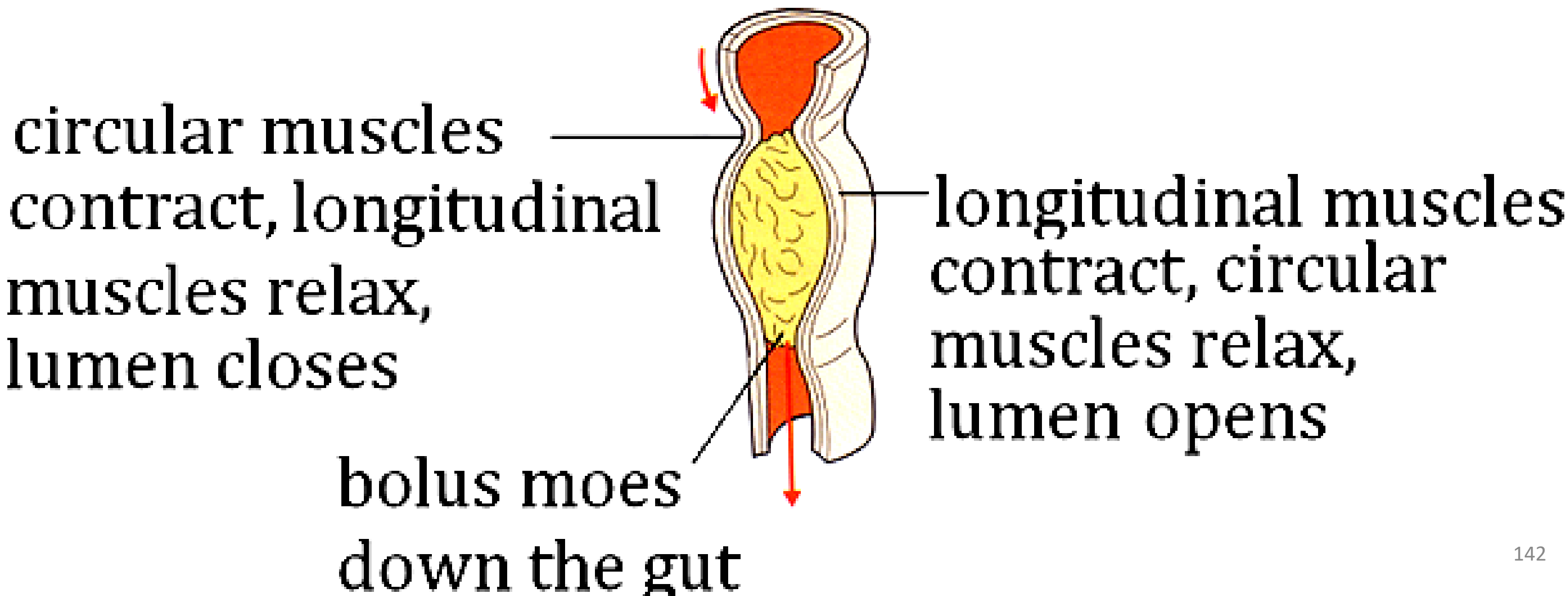
Mouth

- Ingested food is chewed by the teeth and mixed with saliva from the salivary glands.
- The teeth tear and grind the food into smaller particles and the tongue moves the food during chewing to form a spherical mass called **bolus** in readiness for swallowing.

- Saliva:
    i. acts as a lubricant to facilitate swallowing and
    ii. contains the enzyme **ptyalin** (salivary amylase) which breaks down **cooked starch** to **maltose**.
- Saliva is alkaline and ptyalin acts only in an alkaline medium.
- The food bolus is the pushed by the tongue to the back of the mouth and swallowed thereby entering the oesophagus.
- As food is swallowed, the **epiglottis**, a flap-like structure, closes the entrance to the trachea, thus preventing food from entering the lungs.

- The food bolus is forced into and down the oesophagus by **peristalsis** of the oesophagus walls.
- Peristalsis refers to a rhythmic series of contractions and relaxation of longitudinal and circular smooth muscle layers of the alimentary canal.

Peristalsis in the Oesophagus



Stomach

- Food enters the stomach from the oesophagus through the **cardiac sphincter**.
- The passage of food from the stomach is controlled by a powerful circular muscle called the **pyloric sphincter**.
- The gastric glands in the stomach walls secrete **gastric juice**.
- The muscular stomach walls keep the food in a constant peristaltic motion.
- This helps to mix the food completely with the gastric juice to form a creamy substance called **chyme**.

- Gastric juice consists of **hydrochloric acid**, **mucus**, and the enzymes **rennin** and **pepsin**.
- Dilute hydrochloric acid provides an acidic medium in the stomach, which stops the action of ptyalin but favours the action of rennin and pepsin.
- Rennin found in young mammals converts caseinogen found in milk into casein.
- Pepsin breaks down proteins into peptides.
- Small quantities of chyme are squirted through the pyloric sphincter at intervals into the duodenum.

Duodenum

- Two ducts enter the duodenum, the **bile duct** from the **liver** and **pancreatic duct** from the **pancreas**.
- **Bile**, a green alkaline liquid, produced by the liver and stored in the gall bladder enters the duodenum whenever necessary.
- Bile emulsifies fats in the chyme to form very small oil globules (separate oil droplets). This is physical digestion of fats.
- Emulsification increases the surface area for the efficient digestion of fats.

- **Pancreatic juice** from the pancreas also enters the duodenum.
- Pancreatic juice, an alkaline fluid, contains:
  a. **sodium hydrogen carbonate**, which neutralised the acidic chyme.
  b. **pancreatic amylase**, an enzyme which breaks down **starch** to **maltose**.
  c. **trypsin**, an enzyme that breaks down **proteins** to **peptides**.
  d. **lipase**, an enzyme which breaks down **fats** to **fatty acids** and **glycerol**.

Ileum

- From the duodenum the chyme enters the ileum where digestion is completed.
- Glands in the intestinal wall produce ***succus entericus*** (intestinal juice), which contains:
  - **a. maltase**, an enzyme which breaks down **maltose** to **glucose**.
  - **b. lactase**, an enzyme which breaks down **lactose** to **glucose** and **galactose**.
  - **c. sucrase**, an enzyme which breaks down **sucrose** to **glucose** and **fructose**.
  - **d. peptidase**, an enzyme that breaks down **proteins** to **amino acids**.

Absorption

- Absorption is the process by which the end products of digestion diffuse through the wall of the ileum into the bloodstream.

Adaptations of the Ileum for Absorption

a. It is very long (about 7 to 10 metres). This ensures that the food takes much longer to pass through.

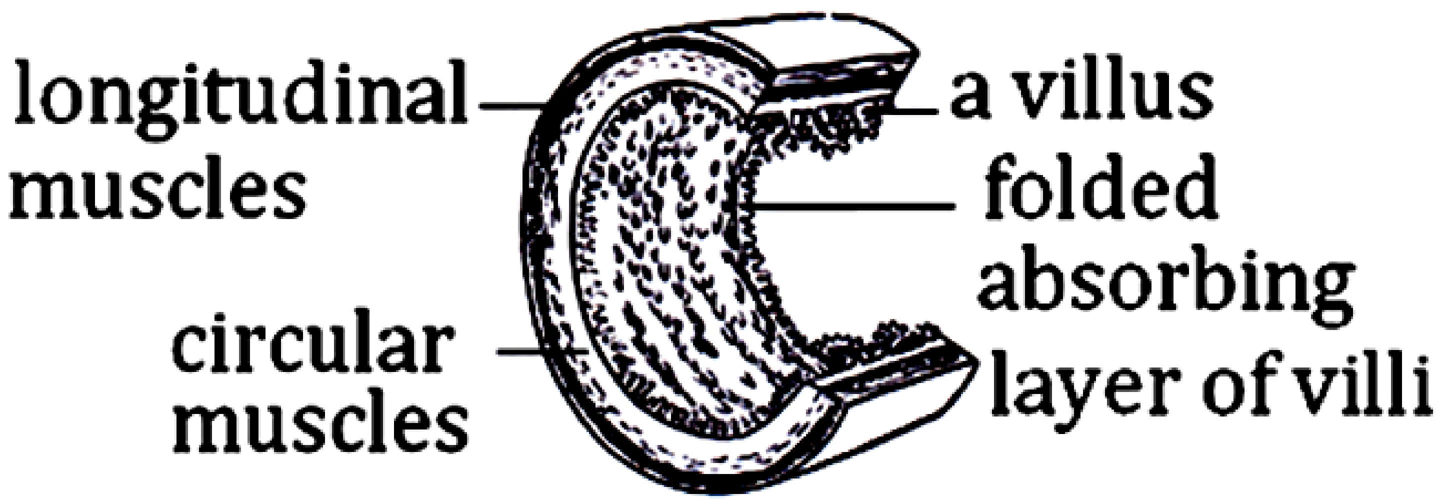
b. Its inner surface is folded into thousands of microscopic finger-like projections called **villi** (singular villus). The large number of the villi increases the surface area for absorption of digestion products.

c. The very thin epithelia (wall) of the villi speed up the movement of digested food into the bloodstream.

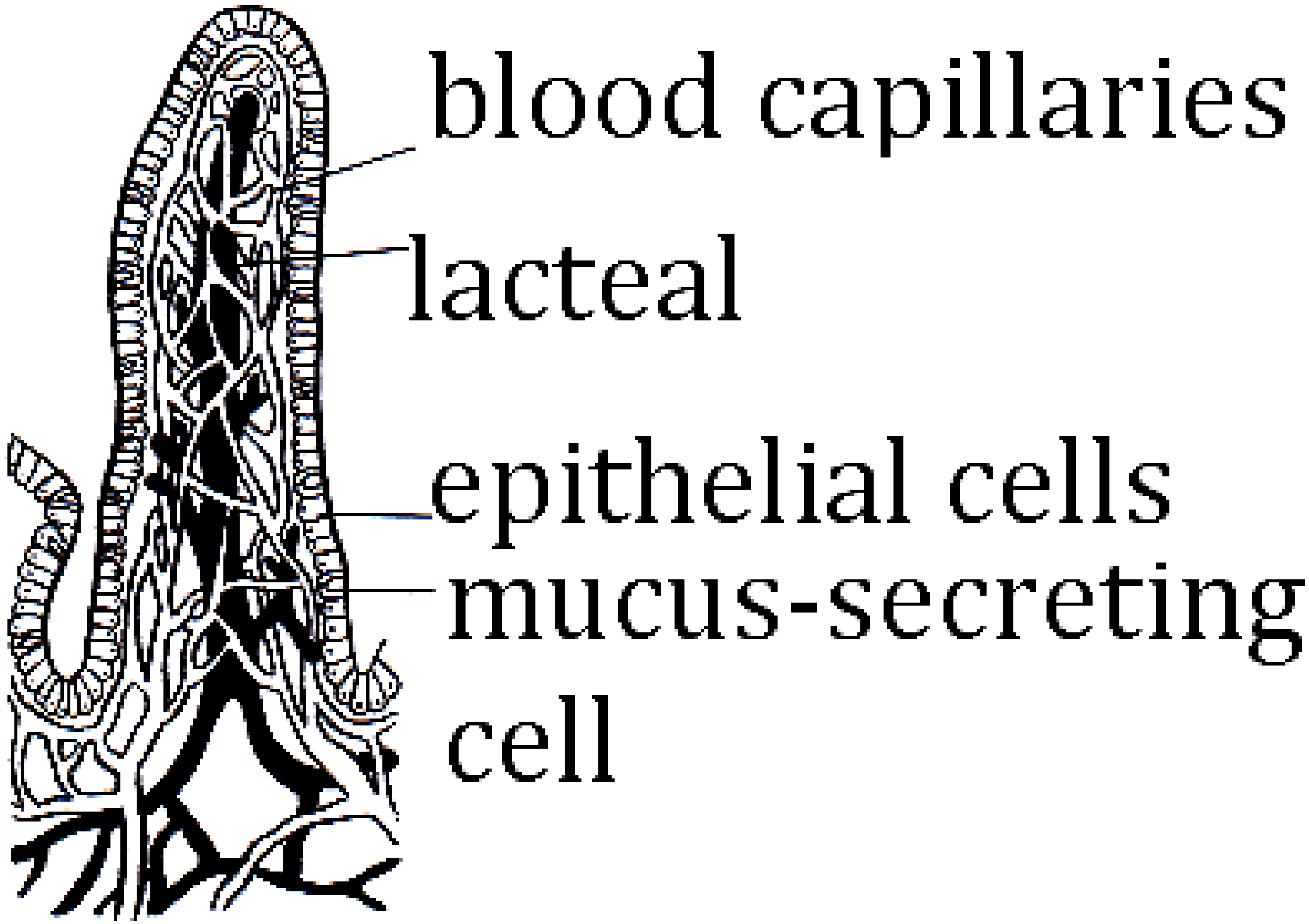
d. The inside of the villi has a dense network of blood capillaries. This enables a lot of soluble end products to enter the bloodstream.

e. The villi have lacteals into which fatty acids and glycerol are absorbed.

Villi on the Wall of the Intestine



Vertical Section Through a Villus



- Once in the bloodstream, the soluble food molecules are transported to the liver through the hepatic portal vein different parts of the body.

Assimilation of End Products of Digestion

- Assimilation is the process whereby absorbed nutrients are taken up and used by the body cells.
- **Glucose** is used in **respiration**, a chemical reaction which releases energy.
- This energy is used by the body for activities such as growth, talking, running, thinking and working.

- Surplus glucose is converted to glycogen (animal starch) by the liver, where it is stored.
- When there is insufficient glucose, the liver reconverts the stored glycogen to glucose, which is used in respiration.
- **Fatty acids** and **glycerol** are also used in **respiration** to release energy. They provide twice as much energy per gram as glucose.
- They can also be used in building up of cell membranes.
- Excess fatty acids and glycerol are stored as fat in the adipose tissue beneath the skin.

- **Amino acids** are used to build new proteins, which are needed by the body.
- Excess amino acids are deaminated by the liver.
- **Deamination** is the process by which excess amino acids are converted to **glycogen**, which is stored for future use, and **urea**, which is excreted in urine.

Colon

- The bulk of the undigested food which consists of roughage moves on to the colon.
- Together with other wastes such as bacteria and dead cells torn off from the intestinal wall linings, the roughage is called **faecal matter** (faeces).

- Faeces are in a semi-solid state.
- As they move along the colon, water is absorbed from faeces, thus making them more solid.
- However, mucus secreted by the large intestine lubricates the faeces, allowing them to be easily egested through the anus.
- **Egestion** is the process by which the faecal matter is expelled from the body through the anus.
- Egestion is aided by contractions of the muscles of the gut.

Problems of Digestion

Constipation

- Constipation is a condition where the faeces become hard and dry and difficult to expel.

Causes of Constipation

a. Low roughage diet resulting in weak bowel movement. This makes faeces to stay in the rectum much longer than normal so that more water is absorbed from them, making them more solid.
b. Stress and anxiety.
c. Sickness that affects the digestive system.

d. Not drinking enough water.

Water helps to keep the food in the intestines in a semi-solid state, and therefore easier to egest.

Prevention/Treatment of Constipation

a. Including more roughage in the diet.
b. Drinking enough water.
c. Physical exercises.
d. Taking laxatives (drugs) prescribed by doctors in severe cases.

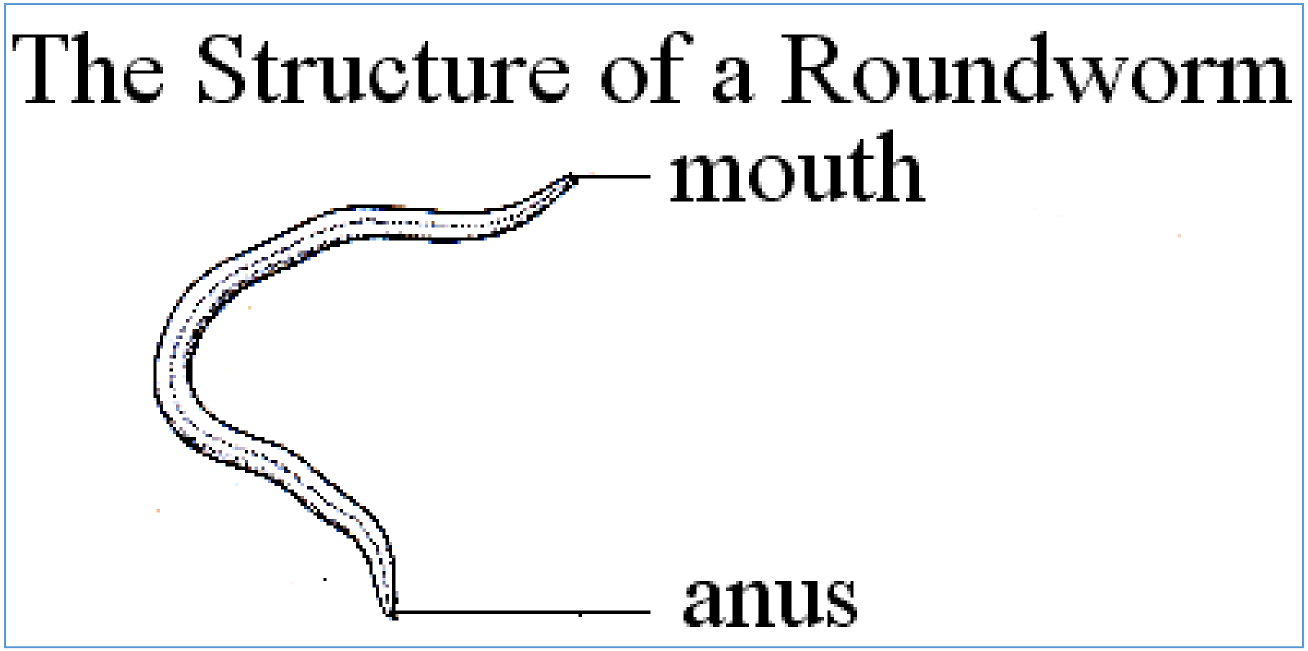
Note: For digestive systems of a **rabbit** and **ruminants**, refer to **Agriculture**.

Worm Infections

- Parasites are living organisms which live in or on other living organisms (hosts).
- They depend on their hosts for their nutrition, often at the expense of the hosts' health.
- Some parasite members of the worm family that commonly infest humans' intestines include **roundworms**, **tape worms**, **hookworms**, **threadworms** and **bilharzia worms**.
- Worm infections are very widespread in Africa, Malawi included, due to low hygiene standards.

Roundworm Infection

- Roundworm (***Ascaris lumbricoides***) infection is very common, especially among children.
- Roundworms infest humans and domestic animals such as pigs and are common in unhygienic conditions.
- They live in the small intestine where they feed on the hosts' digested food, but can also travel to other parts of the alimentary canal.
- A roundworm grows up to 30 cm in length and may sometimes pass out with faeces.



Signs and Symptoms of Roundworm Infection

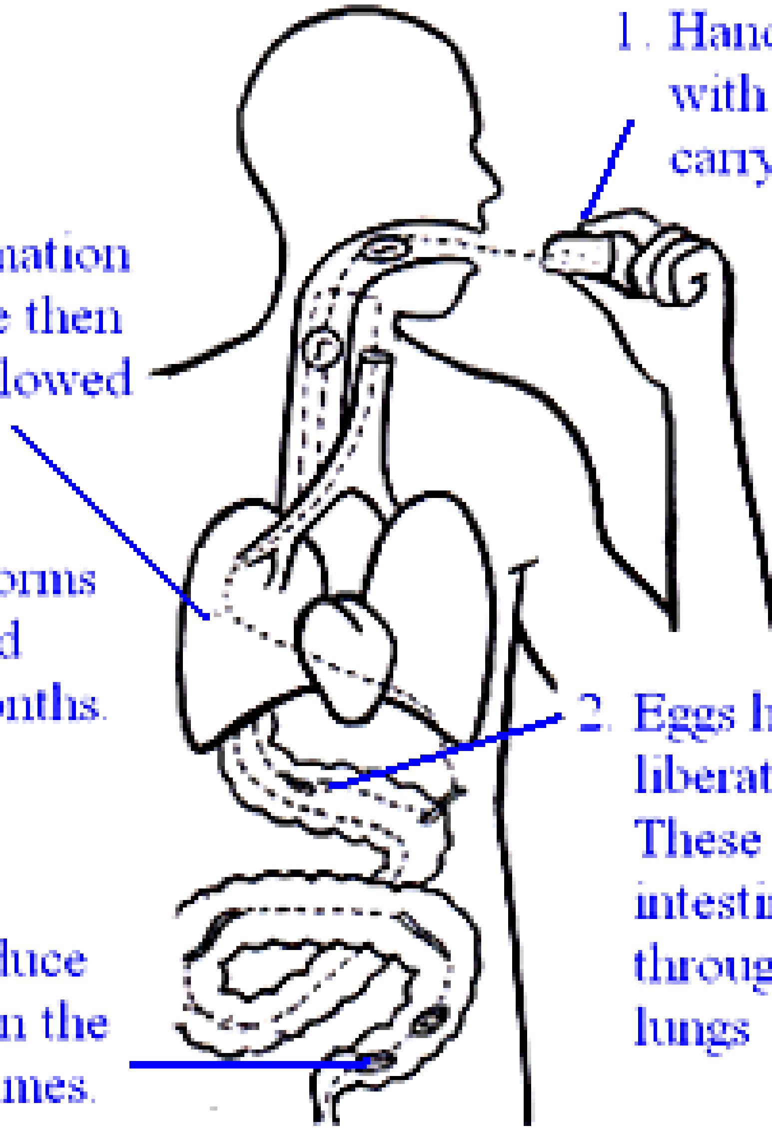
a. Loss of appetite.
b. General weakness.
c. Dullness.
d. Damage to the lungs by the worms' larvae.
e. Malnutrition

f. Stunted growth in children.
g. A disinclination to work.
h. Nausea.
i. Abdominal discomfort.
j. Obstruction of the intestine
k. Death when larvae move into the brain or other parts of the body

Life cycle and Transmission of Roundworm

- The roundworms' eggs are passed out with the faeces of an infected person.
- A female worm produces up to 200, 000 eggs daily, which can survive for up to 5 years in wet earth.

The Life Cycle and Transmission of Roundworms



- Hands contaminated with the roundworm eggs carry the infection through raw food e.g. fruits or vegetables into the mouth.
- The eggs are then swallowed and go to the stomach where they hatch and liberate tiny embryos (larvae).
- The larvae burrow through the intestinal walls, pass into the bloodstream and then travel to the lungs.
- The larvae grow for about 10 days in the lungs where they cause inflammation and are then coughed up and then swallowed into the intestine.

- The larvae mature into adults in the intestine and live for about 10 to 12 months.
- Mature adult roundworms produce eggs which are passed out in the faeces and then the cycle resumes.

Prevention/Control of Roundworm Infection

- At the egg stage, the roundworm’s life cycle can be broken by:

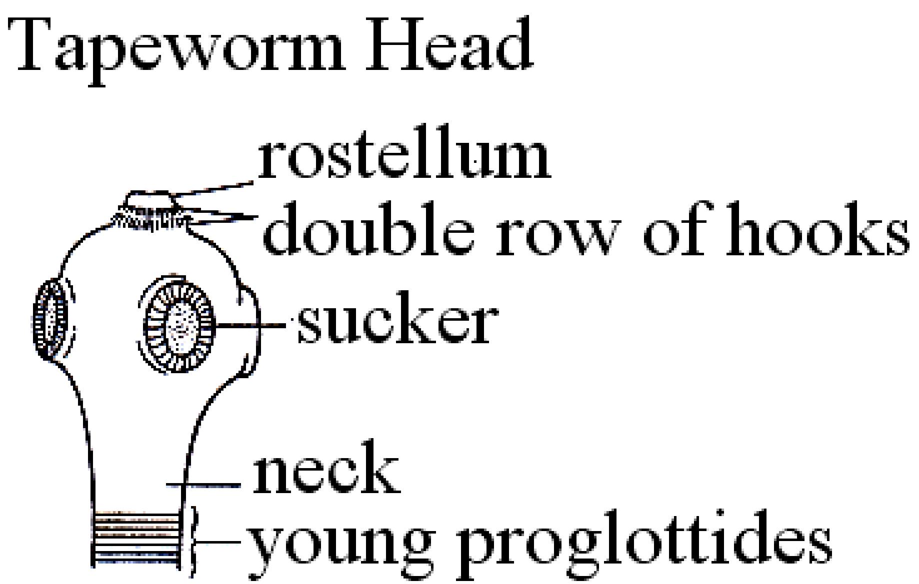
a. Washing vegetable and fruit before eating.
b. Cooking vegetables to destroy eggs
c. Washing hands before handling food.
d. Always using a proper toilet.

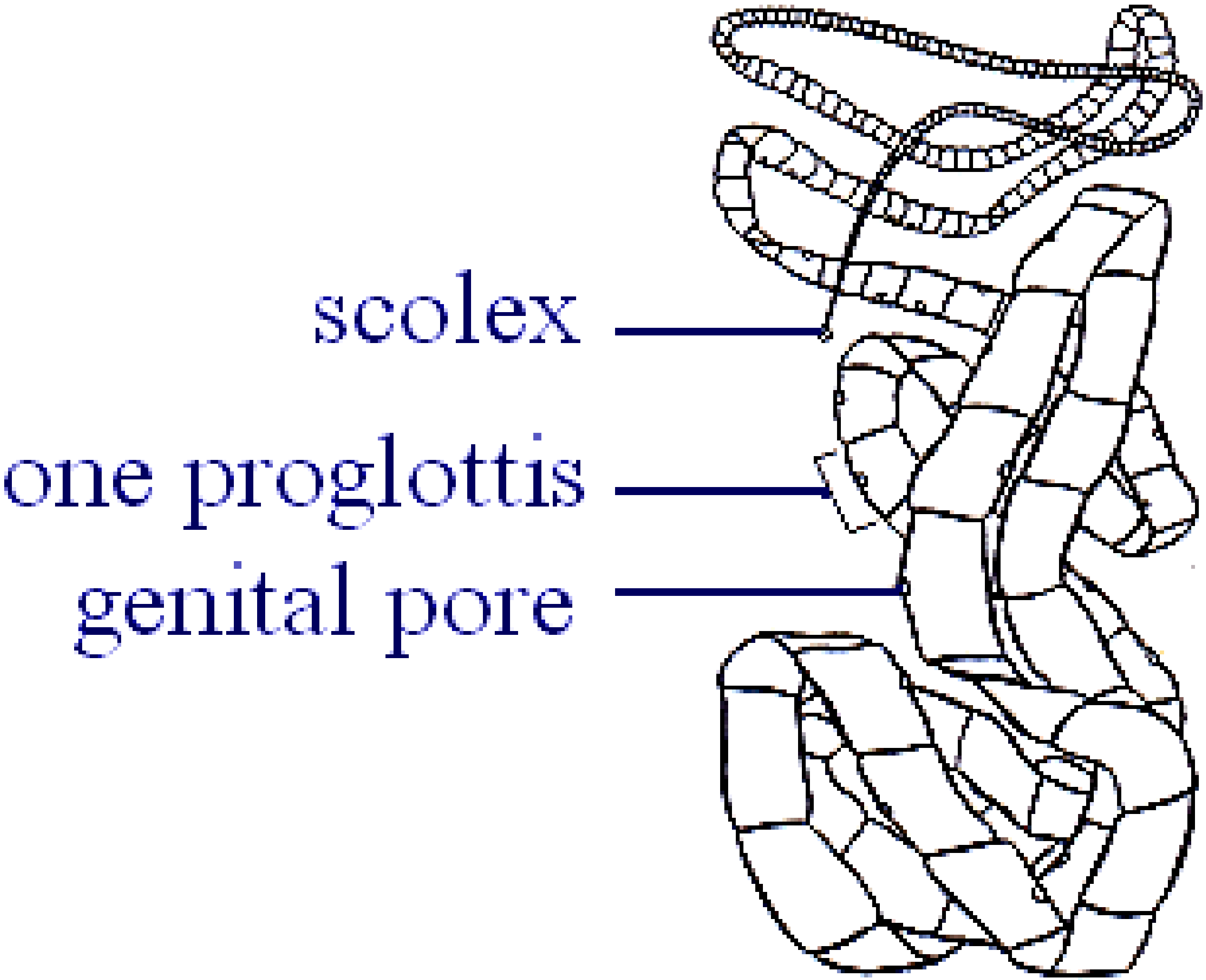
- At the larvae and adult stages the lifecycle can be broken by:

a. Taking appropriate drugs prescribed by doctors to kill larvae and adult roundworms in the body.

Tapeworm Infection

The Structure of a Tapeworm




scolex
one proglottis
genital pore

- The various types of tapeworms can all become parasites in humans and animals such as pigs, cattle and fish.
- Tapeworms have flat, tape-like bodies reaching a length of 3.5 metres.
- At one end of its long body is a small head called the **scolex**, which is about the size of a pin head.
- The body consists of numerous flat segments called **proglottides**, which bud off from the narrow region behind the scolex.
- Tapeworms have four evenly spaced suckers on the head and some of them have a ring of hooks.

- It uses these hooks and suckers to attach itself to the lining of its host’s intestine.
- Its ribbon-like shape allows it to fit easily into the hosts alimentary canal.
- It feeds by absorbing the hosts’ digested food through its whole body surface, which provides a large absorptive area.
- It is not digested by the hosts digestive juices since it secretes a substance which neutralises them.
- In addition, the parasite is not easily passed out because it’s firmly anchored by the scolex to the intestinal wall.

- A large tapeworm may completely block the host's intestine.
- It also produces waste substances which are absorbed by the hosts and make them ill over time.

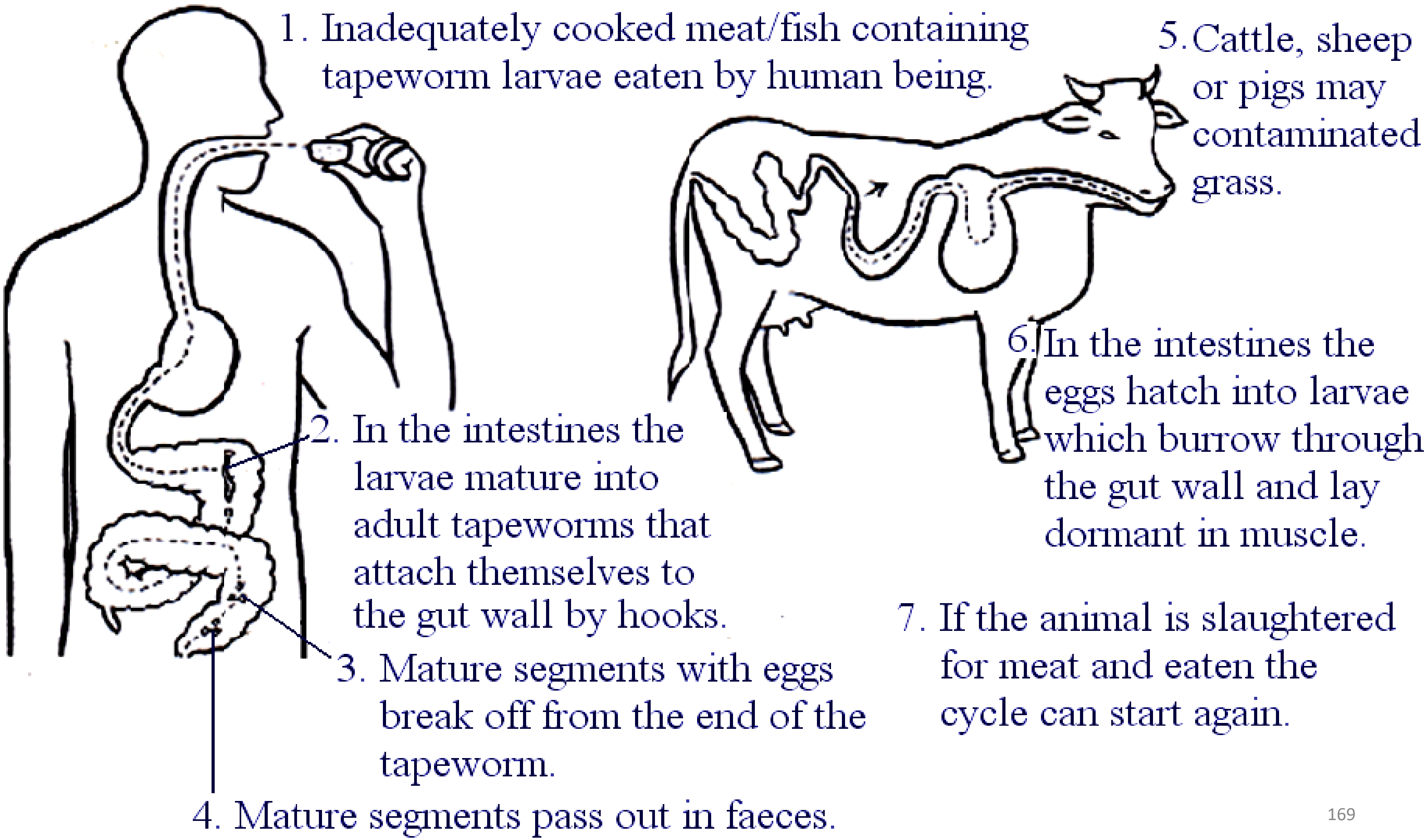
Signs and Symptoms of Tapeworm Infection

a. Anaemia.
b. Abdominal pains.
c. Segments containing eggs in faeces.
d. Worm segments emerging through the anus.
e. Diarrhoea.
f. Obstruction of the intestine by large worms.

g. Pale appearance

h. Sometimes there are no symptoms at all.

The Life cycle and Transmission of Tapeworms



- Tapeworm infection occurs most commonly in people who eat uncooked or poorly cooked infected meat or fish.

1. Inadequately cooked flesh of a cow, sheep or pig, which may contain tapeworm larvae, is eaten by humans.
2. The larvae develop into adult tapeworms in the human intestine and attach themselves to the gut's wall by the hooks.
3. Mature segments full of tapeworm eggs break off from the end of the tapeworm.
4. The mature segments pass out in the faeces.

5. Cattle, sheep or pigs may eat grass which is contaminated with human faeces.
6. In the animals' intestines the eggs hatch into larvae which burrow through the gut wall and lay dormant in the muscle.
7. If the animal is slaughtered for meat and eaten, the cycle can start again.

Prevention/Control of Tapeworm Infection

a. Cook meat and fish thoroughly.
b. Carrying proper meat inspection in abattoirs.
c. Proper disposal of faeces in toilets.
d. Seeking medical advice.

e. Following personal and household hygiene.
f. Regular administering of anti-worm drugs to livestock.

Hookworm Infection

- Hookworms resemble *Ascaris* except that they are only 1 cm long.
- Hookworm infection is far more serious.
- A patient suffering from hookworm infection is in fact suffering from an infestation of parasitic worms.
- The infection is widespread, but is most common in damp tropical climates, where over 90% of the population may be infected.

The Structure of Hookworms

- Hookworms live in the intestines where they attach themselves to the intestinal lining and suck blood.
- An adult hookworm is about 1 cm long and red in colour due to blood which they suck.

Signs/Symptoms of Hookworm Infection

a. Abdominal pains.
b. Weakness.
c. Fatigue.

d. Weight loss.
e. Anaemia.
f. Diarrhoea.
g. Flatulence or wind.
h. Itching of the skin at the sight of penetration.
i. Difficulty in breathing.
j. Coughing, sore throat and blood in sputum. This is due to the passage of the immature worms to the lungs.

The Life cycle and Transmission of Hookworms

- The worms' eggs come out with faeces and hatch into larvae which can live in water or damp soil.

i. Hookworms enter the body from the soil through the bare skin of the hands or feet.
ii. They burrow and bore through the skin and make their way via the bloodstream to the lungs.
iii. They cause inflammation of the lungs and crawl up the windpipe and then swallowed into the gut.
iv. In the small intestine they attach themselves with their hooked mouths and feed on blood by puncturing the blood vessels.

v. They lay eggs which pass out in the faeces and hatch out in the soil within 7 to 8 days. The cycle resumes when humans come into contact with the worms.

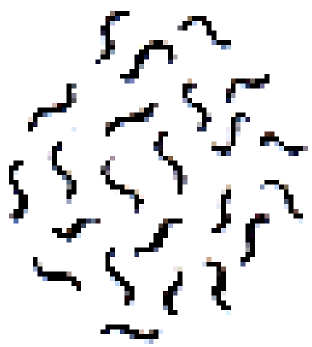
Prevention/Control of Hookworm Infection

a. Disinfection of latrine floors.
b. Wearing shoes.
c. Keeping bare hands and feet out of infected soil.
d. Proper disposal of faeces.
e. Taking appropriate medicines to get rid of adult worms in the intestine.

Threadworm Infection

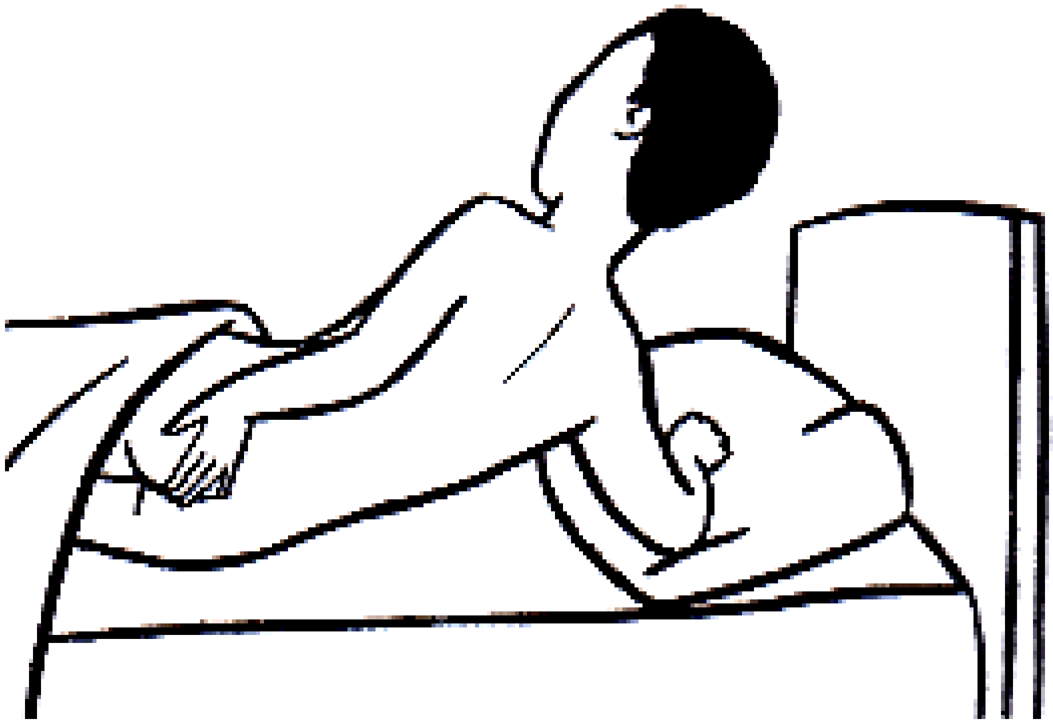
- Threadworms, also called pinworms, mainly infect young children, although adults do get infected occasionally.

The Structure of Threadworms



- Threadworms a[illegible] and about 1 cm long. The male is however much smaller than the female.
- They live in the large intestines.

A Child Infected with Threadworm



Signs/Symptoms of Threadworm Infection

a. Intense itching of the anus.
b. Development of very painful sores around the anus. This is due to excessive scratching.
c. Presence of worms in faeces.

The Life Cycle and Transmission of Threadworms

- At night female threadworms move from the colon and lay thousands of eggs in the folds of skin around the anus.
- This causes intense itchiness of the anus.
- The eggs pass onto the fingers, underwear and bedding during scratching of the anus.

- The eggs are swallowed when the fingers are put into the mouth.
- The eggs hatch into young worms in the stomach.
- The young worms grow into adult worms as they migrate from the stomach to the colon.
- At night mature female threadworms move to the anus where they lay eggs in the skin folds and the cycle starts all over again.

Prevention/Control of Threadworm Infection

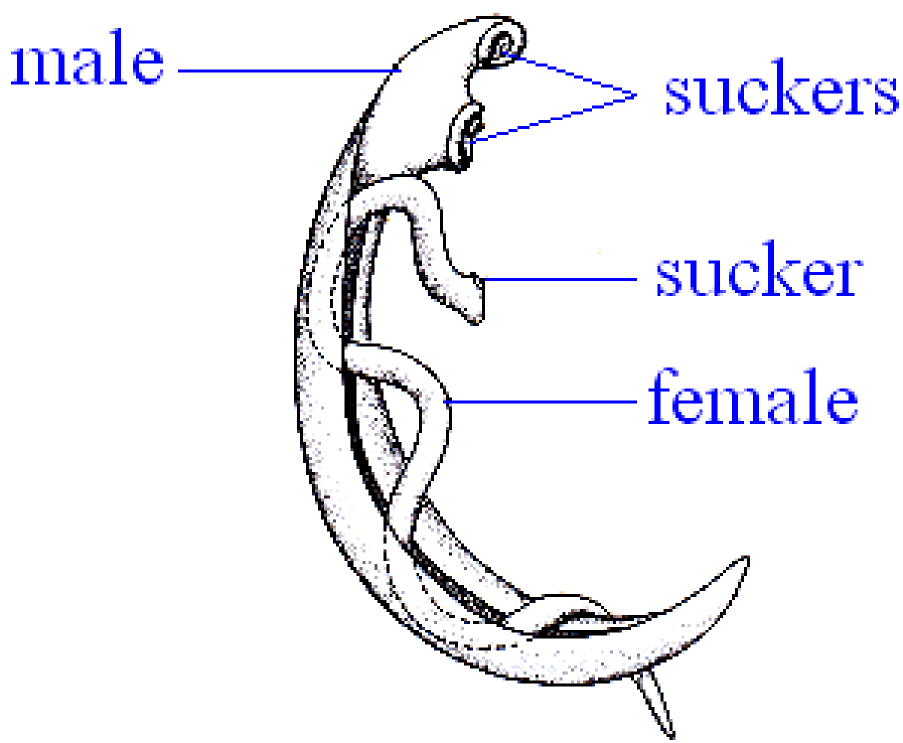
a. Raising standards of personal hygiene.

b. Discouraging children from developing the habit of putting fingers in their mouths.
c. Washing hands and scrubbing fingernails with soap and water after visiting the toilet, and before handling food.
d. Changing underwear everyday and washing bedding in hot water as often as possible.
e. Cleaning toilet seats using soap and water everyday.

Bilharzia

- Bilharzia is a disease resulting from an infection by parasitic flatworms called ***Schistosoma***.
- The disease is also called **Schistosomiasis**.
- Schistosoma (flukes) live in infected people.

The Structure of Bilharzia Worms / Schistosoma



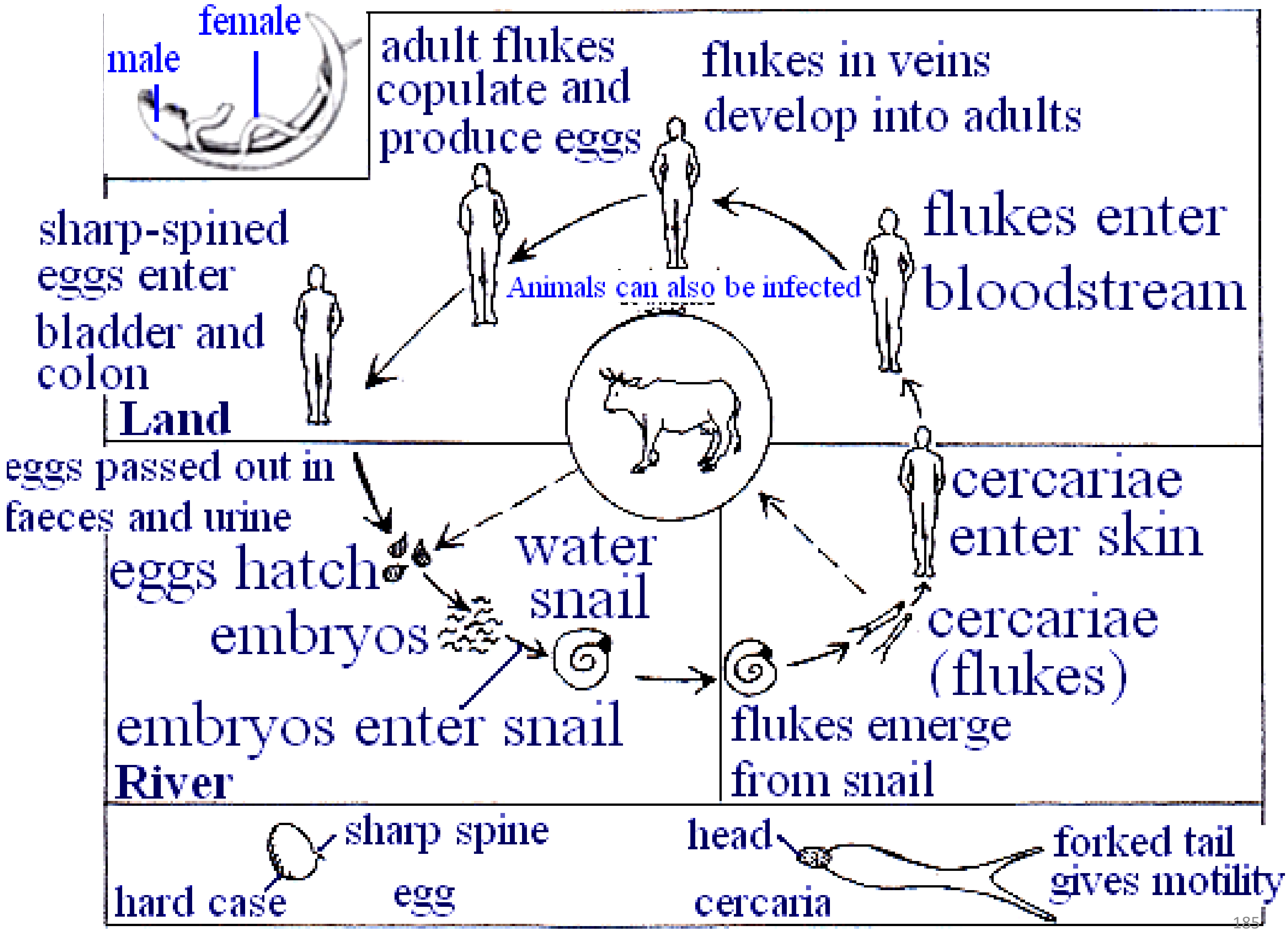
- The male and female flukes are flat and about 1-2 cm long.
- The male worm has got a groove in which the female fluke lives.
- In this position the eggs laid by the female can easily be fertilised by the male.
- Bilharzia worms live in the bladder and intestines where they feed on human blood.

Signs/Symptoms of Bilharzia

a. Abdominal pains. This is due to the presence of eggs with sharp spines in the intestines and other tissues.

b. Blood in urine.
c. Skin rash for a few days
d. Anaemia.
e. Pain when urinating.
f. Fever.
g. Blood in faeces.
h. Cough.
i. Cancer of the bladder or intestines over the years.
j. Reduced resistance to infections.

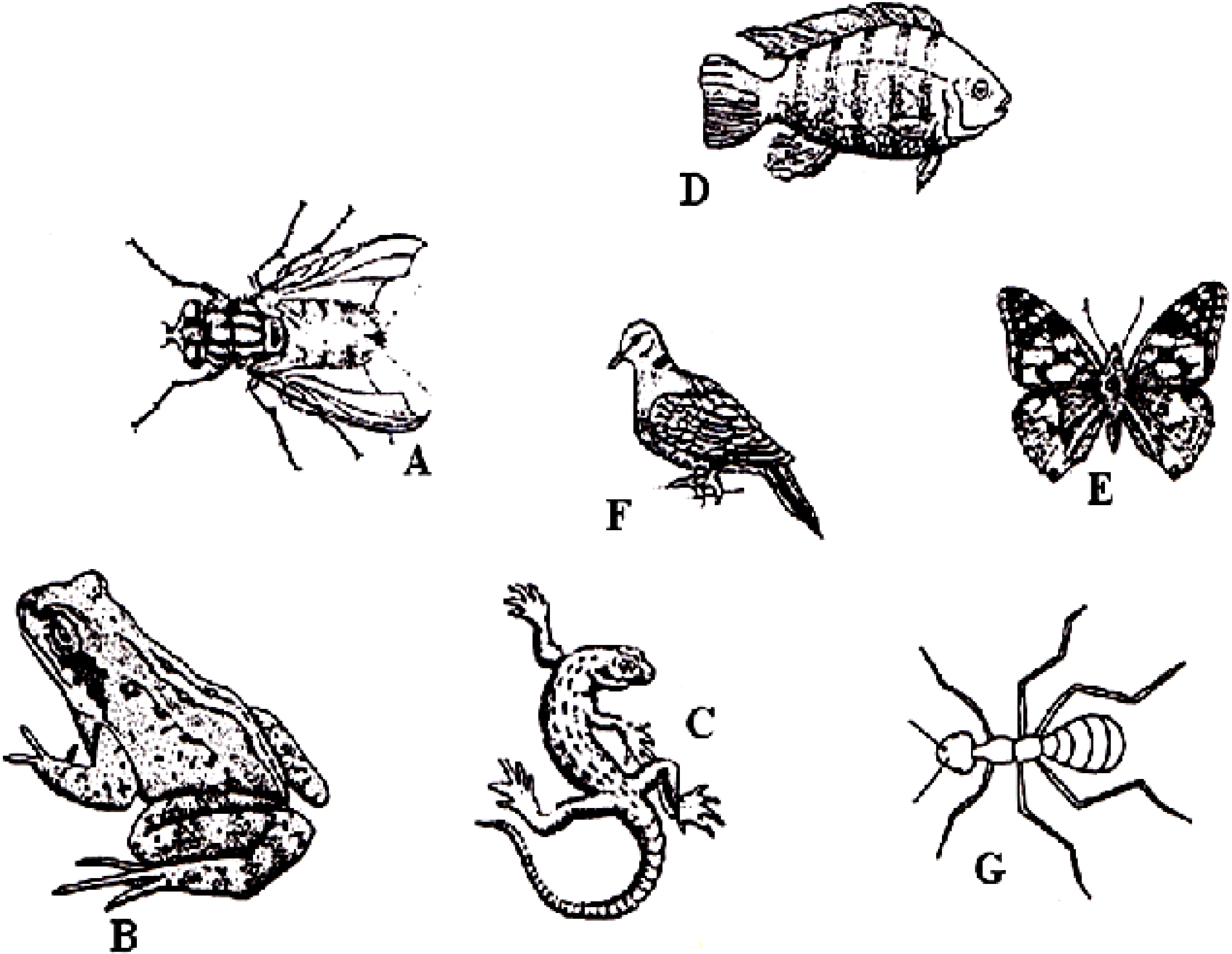
The Life Cycle and Transmission of Bilharzia



- The eggs in urine or faeces from an infected person may get into water in rivers.
- In the water the eggs hatch into embryos which enter the intermediate host, the water snails.
- In the snail, the embryo develop into fork-tailed larvae called cercariae (singular cercaria).
- The cercariae escape from the water snails and burrow through the human skin and loge in the blood vessels.
- The cercariae mature through stages into adult male and female flukes inside the blood vessels.
- The female flukes lay eggs in the surrounding tissues and the cycle resumes.

Prevention and Control of Bilharzia

a. Proper disposal of urine and human (or animal) excreta. This ensures that eggs do not enter the water.
b. Civic education programmes to ensure good health in the communities.
c. Eliminating water snails by using chemicals or ridding rivers of the weeds on which snails feed.
d. Avoiding getting into contact with contaminated water by not standing, washing, swimming or bathing in infected water.
e. Boiling drinking water.
f. Allowing all water for domestic use to stand for two days. This allows cercariae to die.


D
A
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HUMAN NUTRITION

A Balanced Diet

- A balanced diet is the one that contains all the food nutrients in the required amounts.
- Thus a balanced diet must include proteins, lipids, carbohydrates, vitamins and minerals.
- Sources of carbohydrates are plant seeds, roots, stems and fruits.
- Lipids are obtained from animal products and oil-containing seeds.

- Protein sources mainly include animal products such as meat, fish, eggs and milk, and leguminous plants' seeds and some fruits like avocado pear.
- The sources of vitamins are vegetables and fruits, as well as other animal and plant products.
- Fruits and vegetables are also a good source of dietary fibre.
- Mineral salts, on the other hand, are found in water and most of the foods that we eat.

Food Tests

- Food tests refer to experiments conducted in order to determine the nutrients contained in different foods.
- Most food tests use reagents to determine the presence of food nutrients.
- **Reagents** are chemicals which change their colour when they react with certain specific substances.
- Examples of reagents are Benedict's and iodine solutions.

Test	Procedure	Results	Remarks
Starch	Add two drops of iodine solution to a food sample	Maize flour: Rice : G/nut flour: Sugar :	
Protein (Biuret's Test)	Add 2ml sodium hydroxide solution to 2ml food solution. Then add 2ml copper sulphate solution to the mixture.	Maize flour: G/nut flour: Egg white:	
Lipid	Place two drops of food solution on a paper. Allow to dry.	Maize flour: G/nut flour:	
Reducing Sugars	Add 2ml Benedicts's solution to food solution Heat gently.	Sucrose solution:	
Non-reducing sugars	Add a few drops of dilute hydrochloric acid and 2ml Benedicts' solution to 2ml food solution.	Sucrose solution:	

Reducing and Non-reducing Sugars

- Benedict's solution is the chemical reagent used to test for the presence of reducing sugars.
- When boiled with glucose, an orange or brick-red precipitate is formed.
- Reducing sugars change the Benedict's solution colour from blue to orange because they reduce copper (II), a blue element in Benedict's solution to copper (I), which is an orange or brick-red precipitate.
- All monosaccharides and disaccharides (except sucrose) are reducing sugars.

- When Benedict's solution is boiled with sucrose solution, the blue colour is maintained.
- Boiling sucrose with dilute hydrochloric acid **hydrolyses** the sucrose to glucose and fructose, both of which are reducing sugars.
- These reducing sugars react with the Benedict's solution to form an orange or brick-red precipitate.
- Boiling is a requirement for the hydrolysis to occur.
- Heating Benedict's solution with the acid will prevent the possibility of the acid being the one reacting with Benedict’s solution.

Sources of Food in a Community

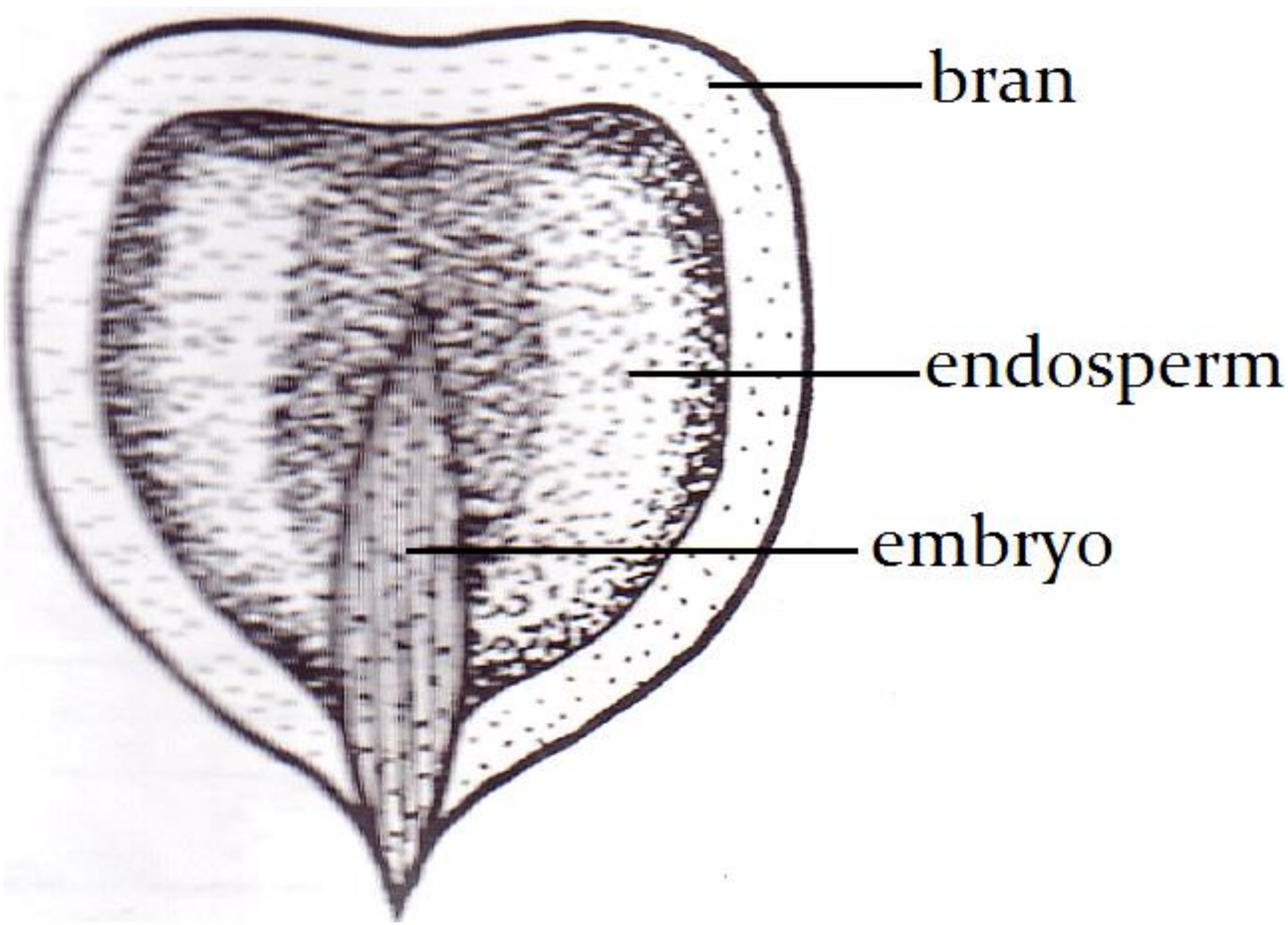
- Food is a source of nutrition in the community.
- The communities obtain their food through **buying** from the markets and shops or **producing** in cultivated plots of land.
- For instance, vegetables are grown and animals like chickens and cattle are kept for meat or milk in local areas.

Composition of Food in Malawi

- *Nsima* is the most common type of meal in Malawi.
- It is usually eaten with a relish of meat, beans, fish or vegetable stew.

- Green maize is very nutritious because it contains bran, endosperm and embryo.

Structure of a Maize Seed



- The bran contains lipids and vitamins, the endosperm contains carbohydrates, while the embryo proteins.
- *Mgaiwa*, maize ground into maize meal, contains carbohydrates, proteins, lipids and vitamins.
- *Ufa woyera* is made from *mphale* (samp), which is maize that has been refined by removing the bran and embryo.
- It contains less proteins and lipids and almost no vitamins.
- Samp is soaked in water for some days before it is ground into flour, which contains only starch.

- Other types of meals include, sweet potatoes, (*mbatata*), finger millet (*mawere*), banana fritters (*zitumbuwa*), peanut puffs (*mtedza*) and vegetables such as cabbage, carrots, green beans (*zitheba*) etc.
- Some foods can lose their nutritional value during preparation e.g. vegetables lose most of their vitamins when boiled for a long time.
- Other foods increase in nutritional value during preparation e.g. adding groundnut powder, which is rich in proteins to vegetables.

- On the other hand proteins are only obtained from soya beans when they are boiled or roasted.
- Food choice is determined by factors such as taste, tradition, availability and cost among others.
- However, there is need to consider the food values of the food substances in order to obtain a balanced diet. (*see Strides in Biology Book 2, page 57*)
- For one to obtain a balanced diet, a combination of various food substances is required.

BLOOD CIRCULATION

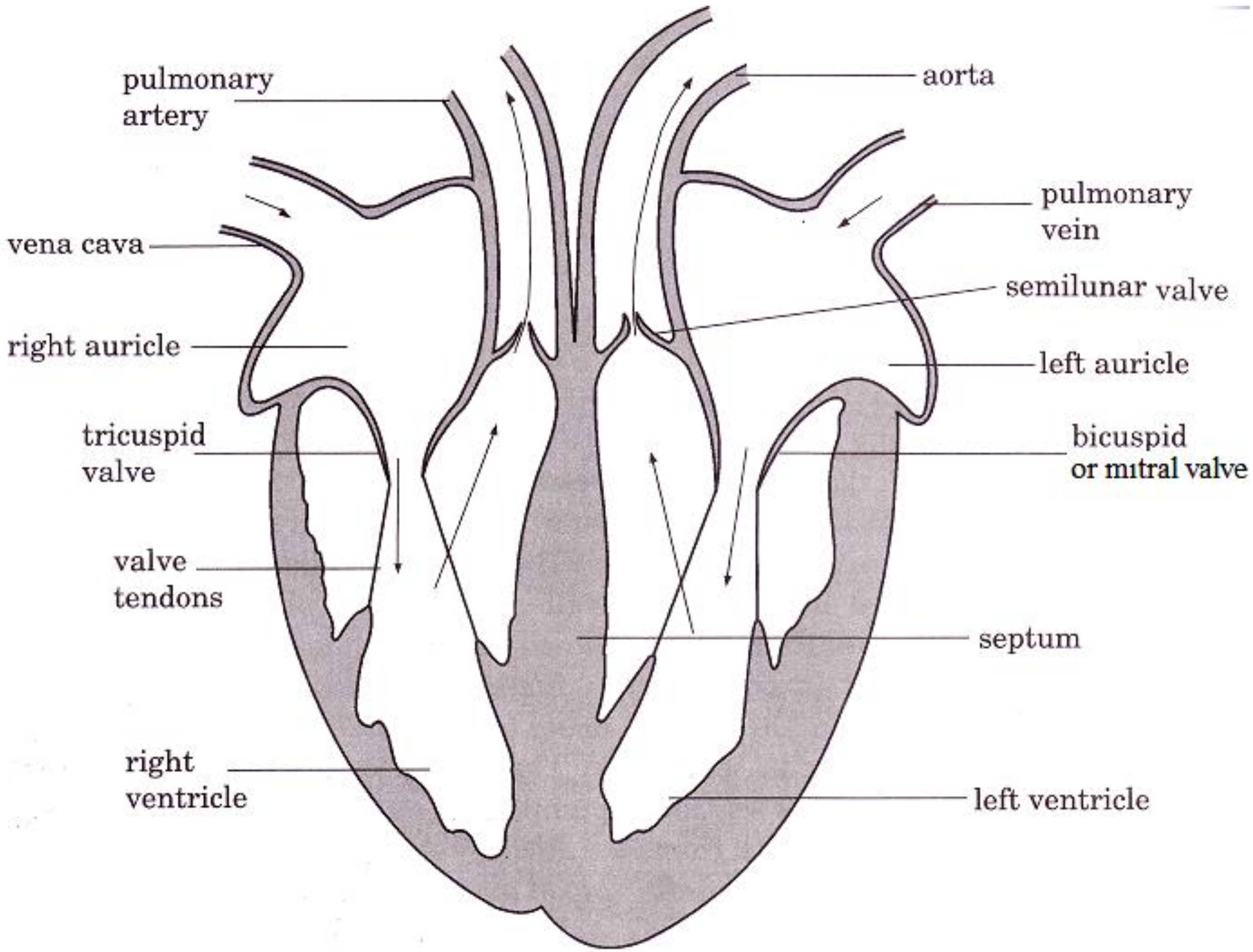
The Human Circulatory System

- The human circulatory system is a closed system consisting of the **heart** and **blood vessels**.
- The blood vessels include the **arteries**, **veins** and **capillaries**.

The Mammalian Heart

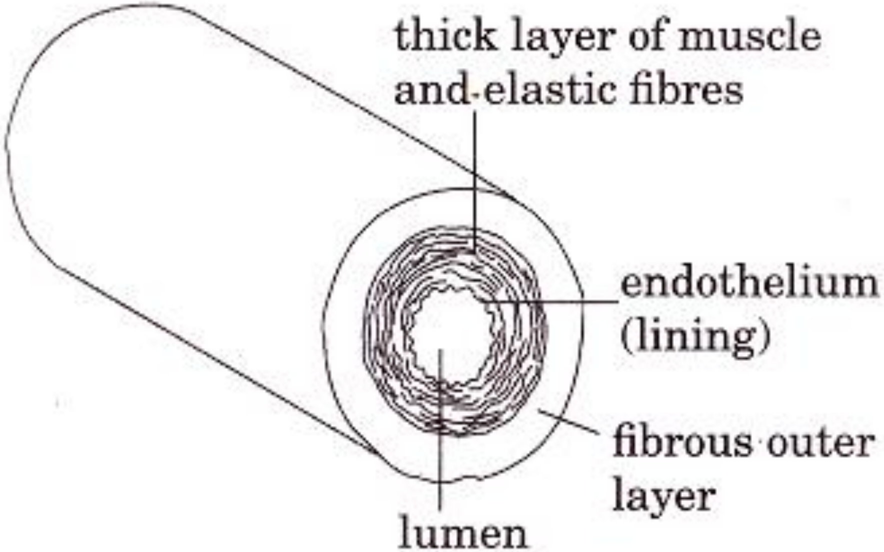
- The mammalian heart is made up of the upper two thin-walled chambers called **auricles** or **atria** and the lower two thick-walled chambers called **ventricles**.

- The atria receive blood whilst the ventricles pump blood out of the heart.

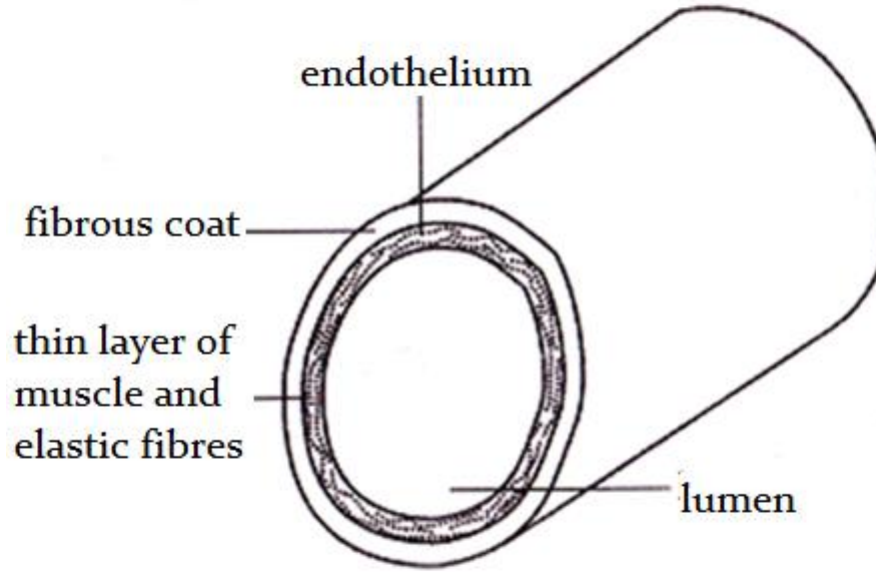


Blood Vessels

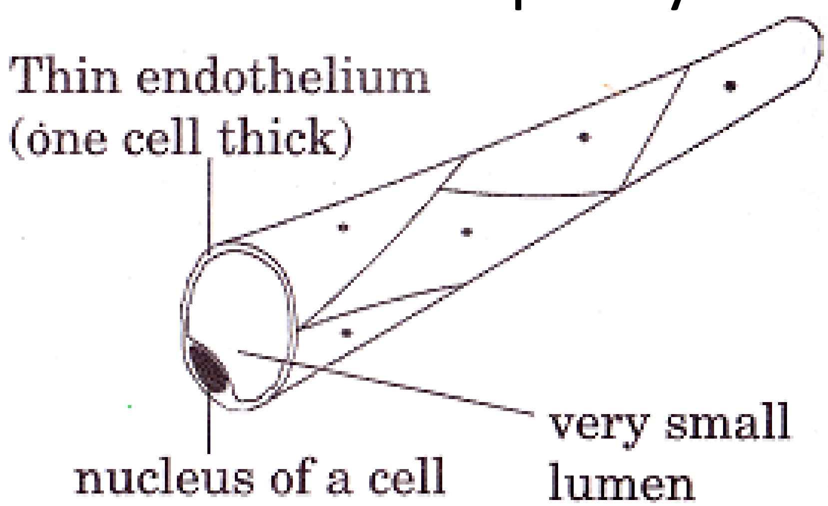
Structure of an Artery



Structure of a Vein



Structure of a Capillary



Characteristics of Arteries

a. Have thick muscular walls to withstand and maintain higher blood pressure.
b. Have an outer fibrous coat for strength and protection.
c. Have a thick middle layer of muscle and elastic fibres.
d. Have a narrow lumen to maintain the blood pressure inside them.

Characteristics of Capillaries

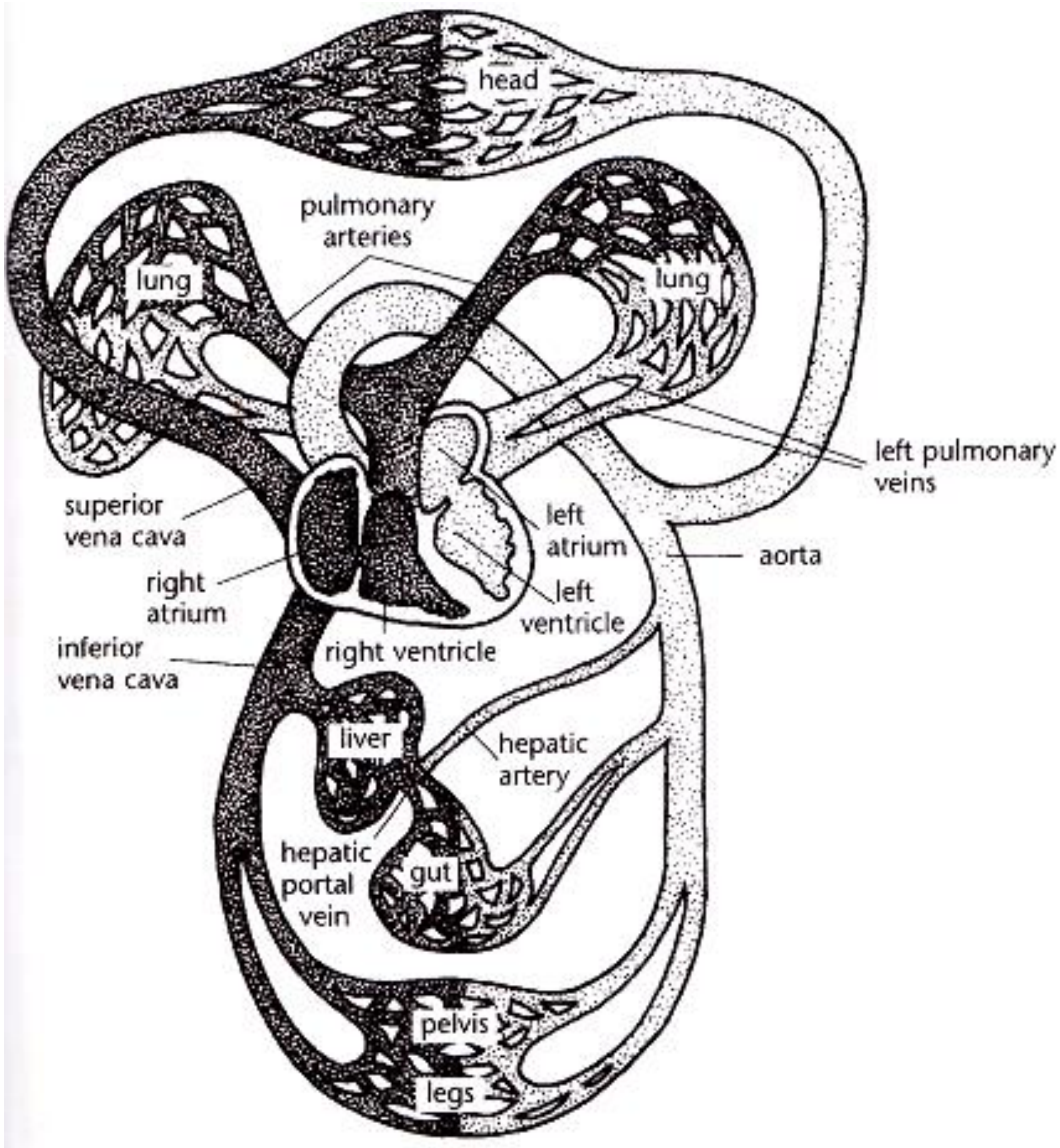
a. Are numerous and form a dense network in all body tissues.

b. Have very thin walls that are made up of only one cell layer.

Characteristics of Veins

a. Have thin walls composed of a thin outer fibrous coat.
b. Have a thin middle layer of muscle elastic fibres.
c. Have valves at intervals that prevent the back flow of blood
d. Carry **deoxygenated blood** except the pulmonary vein which carries oxygenated blood.
e. Have a wide lumen.

Blood Circulation in the Body



- Deoxygenated blood from the body enters the heart at the right auricle
- Contraction of the right auricle pushes blood into the right ventricle.
- Contraction of the right ventricle pumps blood through the **pulmonary artery** to the lungs where it is oxygenated.
- The pulmonary artery divides into smaller arteries called **arterioles**, which further divide into tiny **capillaries**.
- The thin capillary walls allow substances to pass through them easily.

- Oxygen from the lungs diffuses across the thin capillary walls into the blood.
- Oxygenated blood then flows back to the heart from the lungs returns through small **venules**, which join to form larger veins and eventually the **pulmonary vein**.
- Oxygenated blood enters the left auricle, and then moves into the left ventricle.
- As the left ventricle contracts, blood is pumped out of the heart to the rest of the body, so its walls are thicker than those of the right ventricle.

- Blood flows under great pressure through the **aorta**, which divides into arteries.
- The arteries divide into arterioles and eventually into capillaries in the tissues, where the pressure is gradually reduced.
- In the capillaries, the blood exchanges materials with the tissue fluid surrounding the cells.
- Blood provides oxygen, food nutrients and other substances to the body cells.
- The blood carries away carbon dioxide and other metabolic wastes and returns through the veins to the heart, where it enters the right auricle.

Why Blood Flows Back to the Heart

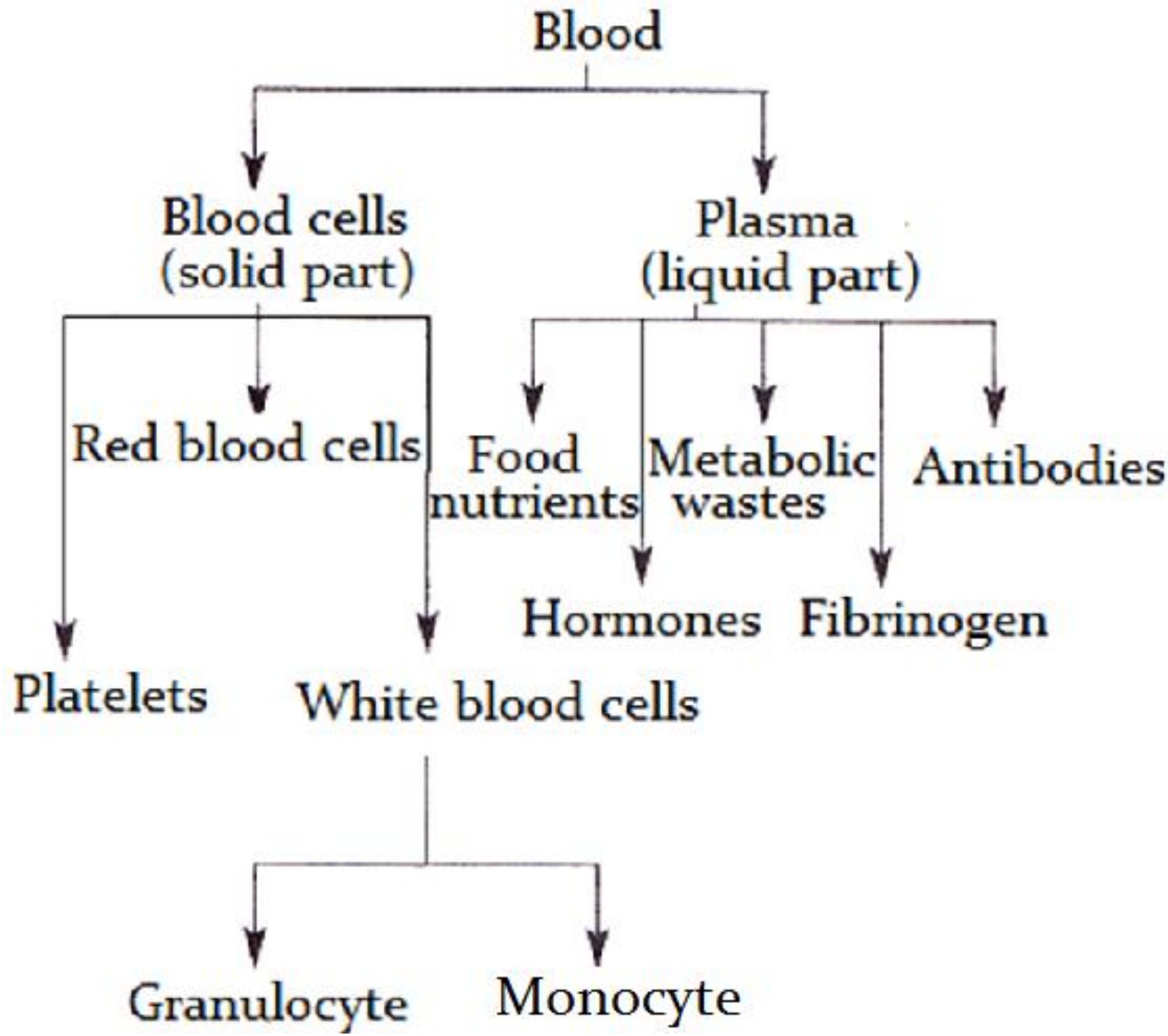
- Blood pressure is lowest in the right auricle, so the blood moves towards it.
- Less force is required to push the blood through the veins' wider lumen.
- Valves in the veins' lumen, prevent the blood from flowing backwards.
- Contraction of skeletal muscles lying close to the veins help to push blood back to the heart.

The Heart Beat

- When the heart contracts, both auricles contract at the same time.

- This is followed 0.1 seconds later by both ventricles contracting at the same time.
- The cardiac muscles then relax for a brief moment, which allows both the auricles and ventricles to fill up with blood in readines for the next contraction.
- This process is known as the **heart beat**.
- The number of heart beats per minute is known as the pulse rate.
- An adult human at rest has a pulse rate of 70 times per minute, which can more than double during physical exercise.

Composition of Blood

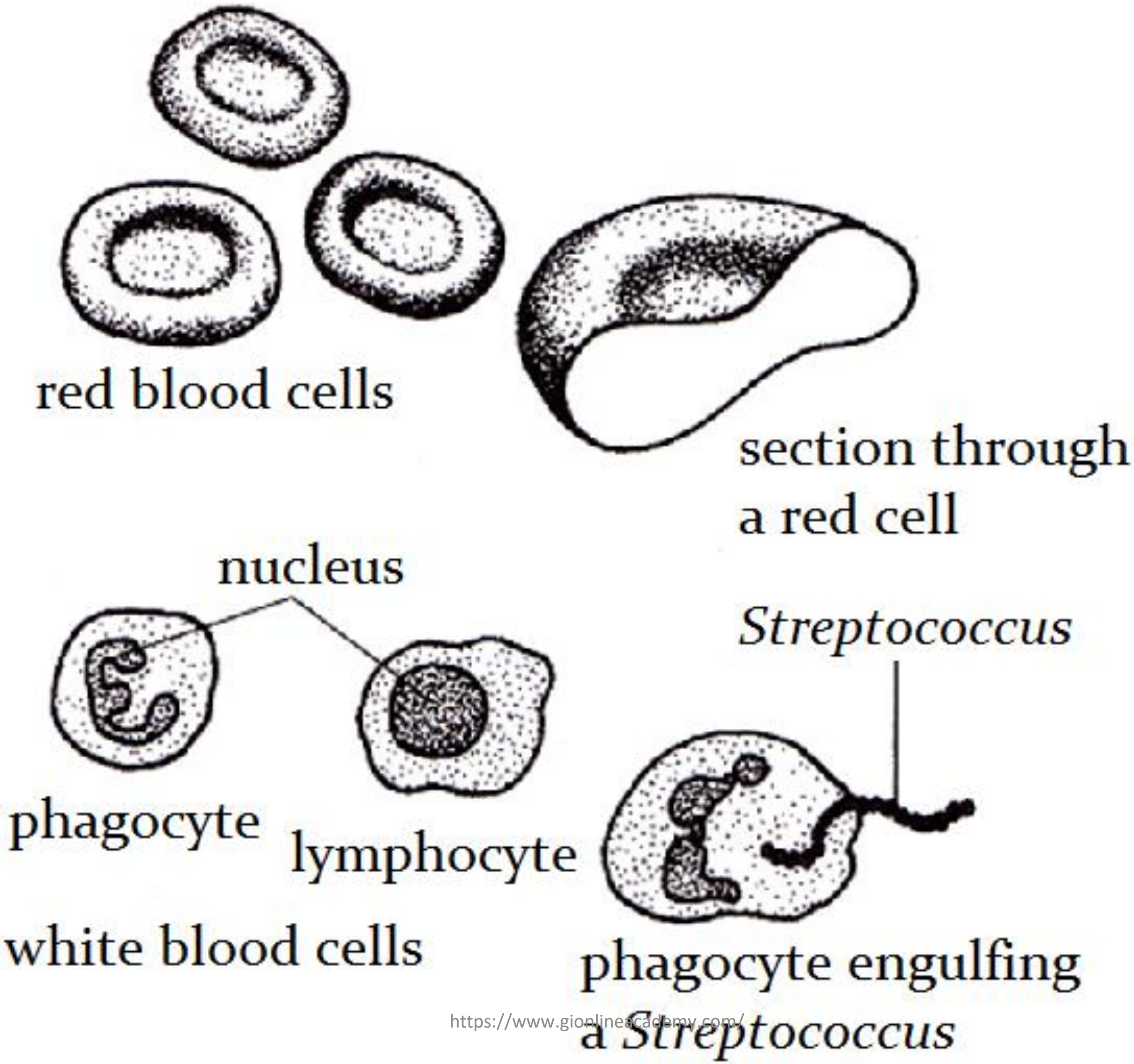


- Blood is a special living tissue consisting of a suspension of cells in a fluid.
- The fluid part of blood is called **plasma** while its cellular part includes **red blood cells**, **white blood cells** and **platelets**.

Plasma

- Plasma is a colourless watery fluid that carries many substances in solution including urea, nutrients, antibodies, hormones, carbon dioxide, and salts such as sodium chloride.

Blood Cells


red blood cells
section through
a red cell
nucleus
Streptococcus
phagocyte
lymphocyte
white blood cells
phagocyte engulfing
a Streptococcus

Red Blood Cells

- Red blood cells are **biconcave** (disc-shaped) cells with no nucleus.
- Their cytoplasm contains an iron-protein pigment called **haemoglobin**.
- Haemoglobin binds itself to oxygen to form a compound called **oxyhaemoglobin**.
- There are about five million red blood cells in every cubic millimetre (mm^3) of human blood.
- They are manufactured in the bone marrow of the sternum and ribs.
- They live for about four months and then they are destroyed in the liver and spleen.

White Blood Cells

- White blood cells are irregular-shaped cells with at least a nucleus.
- There are **two** main types of white blood cells:
  - Those with a single round or kidney-shaped nucleus called **monocytes** e.g. lymphocytes.
  - Those with many or lobbed nuclei called **granulocytes** e.g. phagocytes.
- They are much bigger than red blood cells and are fewer in number i.e. about 7, 000 in every mm^3 of human blood.

Blood Platelets

- Platelets are cell fragments that look like tiny plates.
- They play a key role in blood clotting.

Functions of Blood

- Blood has two main functions i.e. **transport** and **defence**.

Transport

a. Blood transports oxygen as oxyhaemoglobin from the lungs to the body tissues, where it is required.

b. Blood transports carbon dioxide from the tissue cells as **carboxyhaemoglobin** to the lungs, where it is exhaled.
c. Blood transports nutrients such as glucose, amino acids, vitamins etc from the ileum to the tisue cells, where they are needed.
d. Blood transports hormones from ductless glands e.g. pancreas to their target organs.
e. Blood transports heat from where it is generated e.g. liver and muscles to the rest of the body.

f. Blood transports metabolic wastes e.g. urea from the liver and other body tissues to the excretory organs.

Defence

a. Blood prevents germs from entering the body through cuts or wounds by clotting. Platelets form clots that stop entry of germs and further bleeding.
b. **Phagocytes** engulf and eat the germs that have entered the body through **phagocytosis**.

c. Lymphocytes produce complex proteins called **antibodies**, which destroy germs. Antibodies also attach themselves to germs and interfere with their activity, which makes it easier for the phagocytes to eat the germs.

- When the body fails to fight germs, they quickly multiply and cause sickness.
- The sickness is partly due to the poisonous substances produced by germs.
- Some viruses e.g. HIV, destroy the white blood cells.
- This makes HIV infected people to develop AIDS and die.

Bleeding

- Bleeding occurs when a blood vessel has been cut i.e. there is **arterial**, **venous** and **capillary** bleeding.
- Arterial bleeding is the most dangerous of all because oxygenated blood comes out in powerful spurts pumped by the beating heart.
- In arterial bleeding large quantities of blood can be lost in a very short time.
- In venous bleeding, blood flows out slowly and smoothly and not in spurts due to low pressure in the veins.

- A typical example of capillary bleeding is nose bleeding.
- This may be caused by increased blood pressure or a head injury that disrupts the capillaries surrounding the nasal passages.
- If a large quantity of blood is lost during bleeding the victim may go into **shock** and may develop **anaemia**.

Anaemia

- Anaemia is a blood condition caused by a deficiency of red blood cells or haemoglobin inside them.

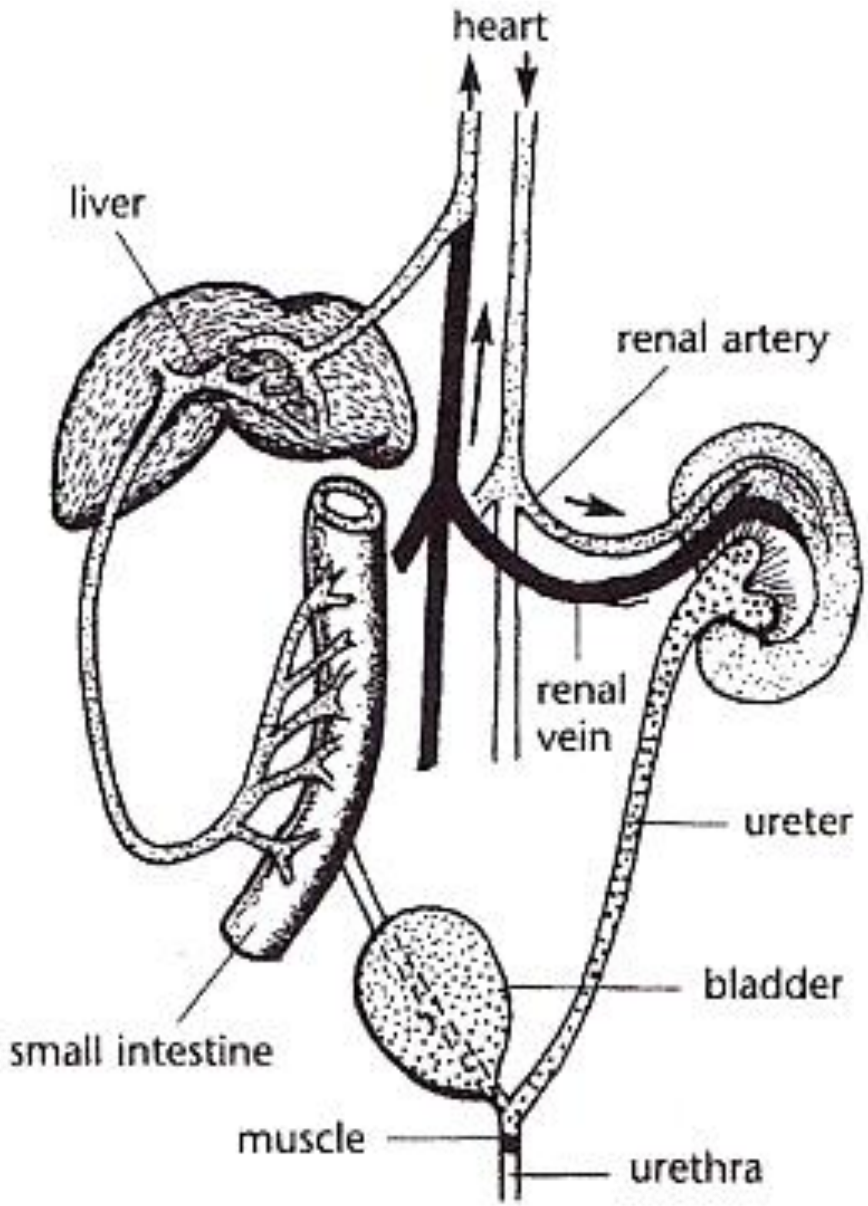
Causes of Anaemia

a. Bleeding.
b. Menstruation in adolescent girls.
c. Malnutrition
   i. A deficiency of vitamin C in the diet.
   ii. A deficiency of iron in the diet.
   iii. Increased demand for iron in one's blood e.g. during pregnancy.
d. Disease
   i. Malaria. Malaria parasites destroy large numbers of red blood cells.
   ii. Hookworm infection
   iii. Bilharzia worm infection

Prevention of Anaemia

a. Eating a balanced diet e.g. foods rich in iron, vitamin C and proteins.
b. Taking iron tablet supplements.
c. Bandaging open wounds.
d. Treating stomach ulcers.
e. Having a blood transfusion to restore the number of red blood cells.
f. Taking medication to cure malaria or other blood parasites.
g. Encouraging visitors to malaria areas to take preventive or prophylactic medication.

EXCRETION
Excretion in Mammals



- Excretion is the process through which the body gets rid of metabolic wastes.
- Metabolic wastes include hormones, drugs, excess water and salts and nitrogenous wastes such as urea and ammonia.
- When metabolic wastes accumulate in the body they become harmful/toxic/poisonous.
- The liver, kidneys, lungs and skin play an important role in excreting metabolic wastes.

Excretion and the Liver

- Dissolved food substances such as amino acids, glucose, vitamins, fatty acids, iron etc from the ileum travel to the liver through the hepatic portal vein.

- The liver works on them before releasing them into the general circulation.

Functions of the Liver

a. **Detoxification**

- Detoxification is the process through which the liver changes/breaks down toxic substances like alcohol and drugs into a harmless form.
- The harmless form is carried by the blood to the kidneys where it is expelled from the body as urine.
- However some drugs and toxic substances are excreted without undergoing any change. This is why certain drugs can be smelt in urine.
- Some drugs or toxic substances kill the liver cells which makes the liver unable to perform the task of detoxification.

- For instance, taking too much alcohol over a long period of time kills the liver cells, which results in **liver fibrosis**.

b. Deamination

- Deamination is the process through which the liver breaks down excess amino acids to form a less toxic substance called **urea**, which is later excreted by the kidneys as urine.

c. Storage of Nutrients

- The liver stores vitamins A, D and B_{12}, and minerals such as iron, potassium and copper.
- Iron stored in the liver comes from old red blood cells that are broken down in the spleen.

d. Production of Bile

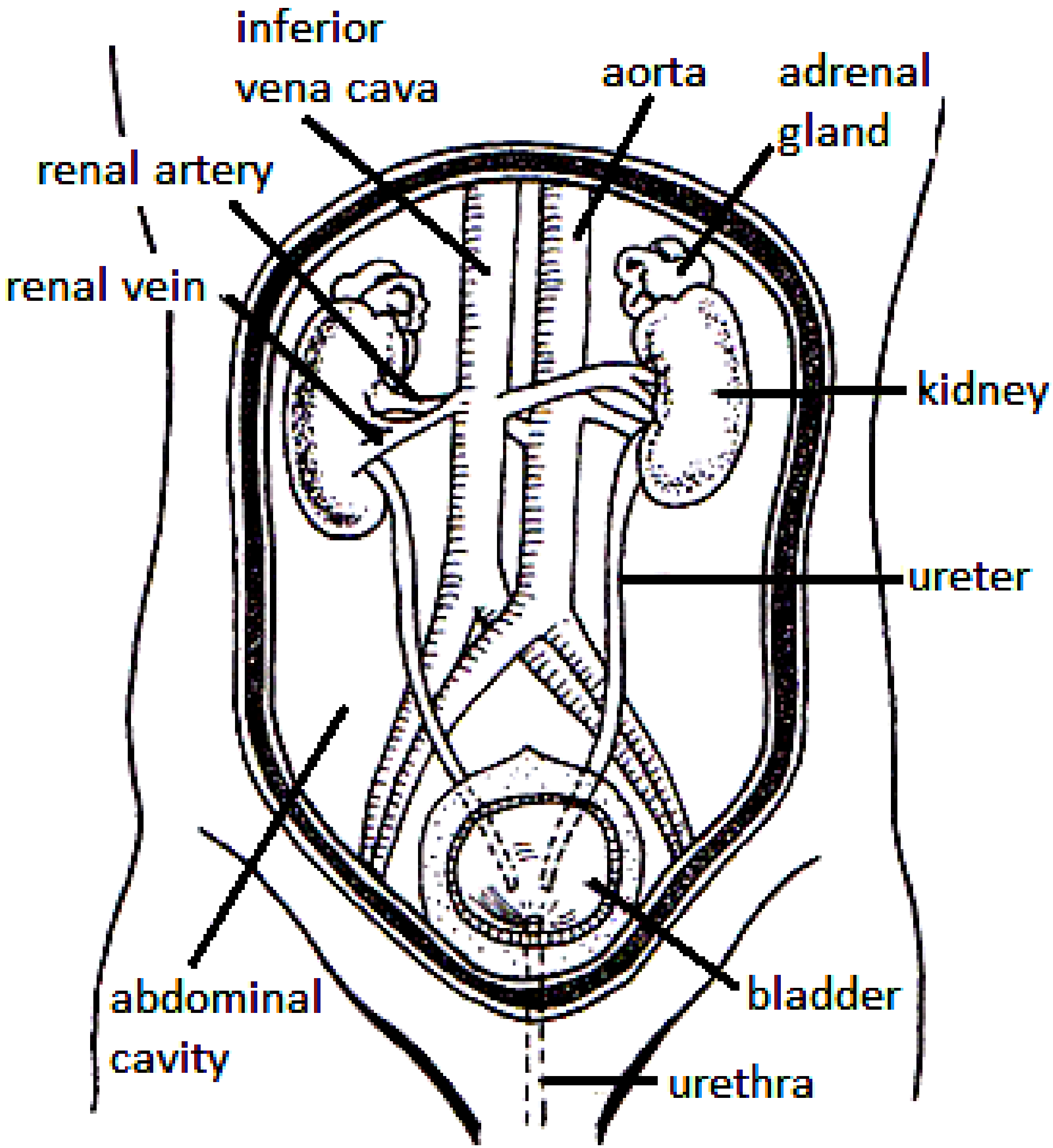
- The liver breaks down haemoglobin from old red blood cells to produce **bile**.
- Bile, a yellow-green liquid waste product which is stored in the gall bladder, plays an important role in the digestion and absorption of food.
- It neutralises the acidic chyme and emulsifies lipids/fats in the duodenum.
- Bile mixes with undigested food to give faeces their brown colour.

e. Regulation of Blood Glucose Levels

- Regulation of blood glucose concentration involves interaction between the liver and cells in the **Islets of Langerhans** in the pancreas.

- When blood glucose levels start to rise above the set point, the pancreas produces a hormone called **insulin**.
- Insulin stimulates the liver to remove excess glucose and convert it to **glycogen** for storage.
- A fall in the level of blood glucose below the set point influences the pancreas to produce a hormone called **glucagon**.
- Glucagon stimulates the liver to break down glycogen to glucose.
- Glucose is then released into the bloodstream until the blood glucose level returns to the set point.
- If the blood glucose level cannot be properly controlled, a disease called **diabetes** results.

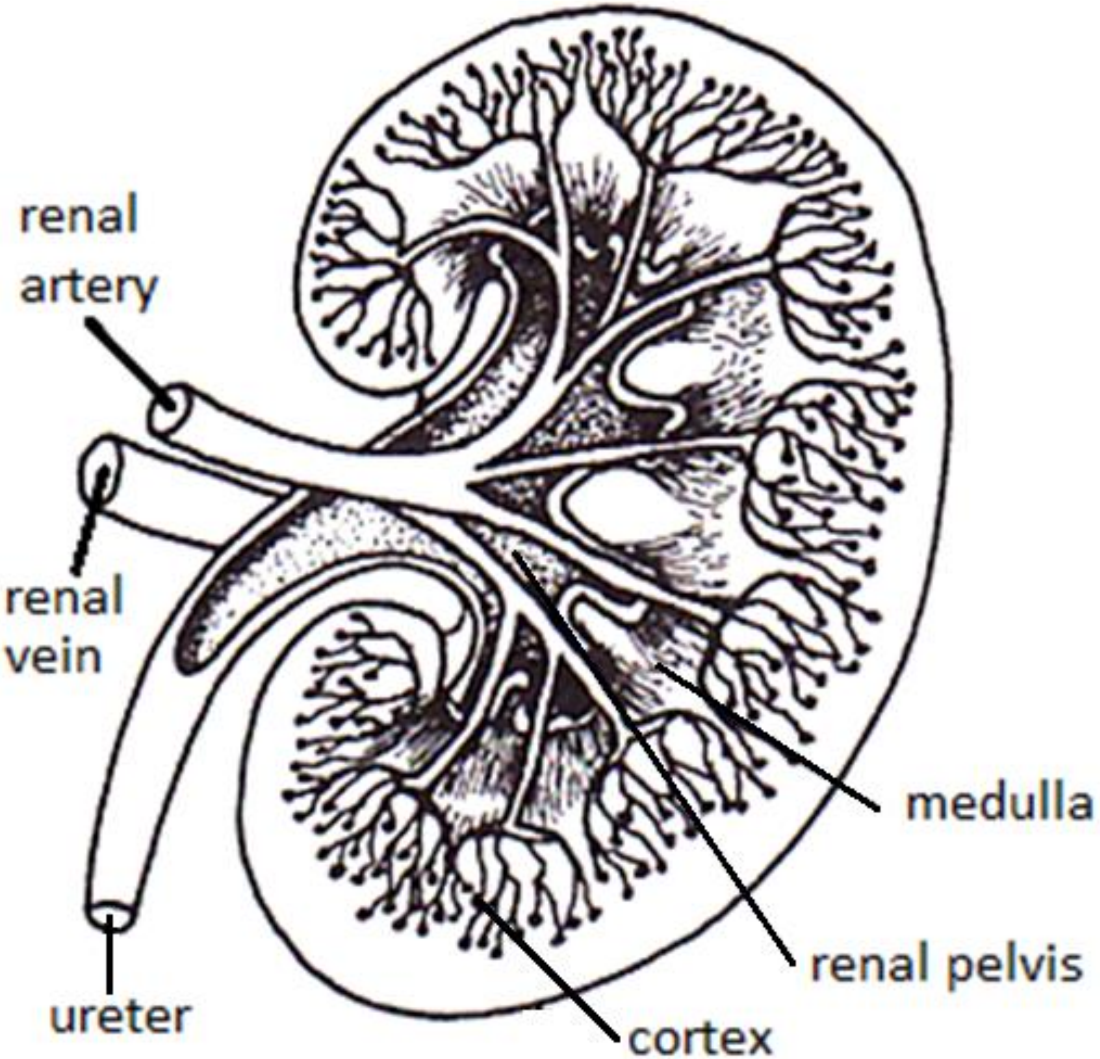
The Human Excretory System



- The human excretory system consists of a pair of **kidneys**, the **ureters**, the **bladder**, and the **urethra**.
- The **renal artery**, a blood vessel, carries oxygenated blood to each kidney.
- Inside the kidney, substances are exchanged between the excretory system and the blood.
- All valuable substances which the body needs are filtered out, reabsorbed and retained in the body.
- The remaining fluid, **urine**, is conducted by the ureters to the bladder, where it is temporarily stored before it is expelled through the urethra.

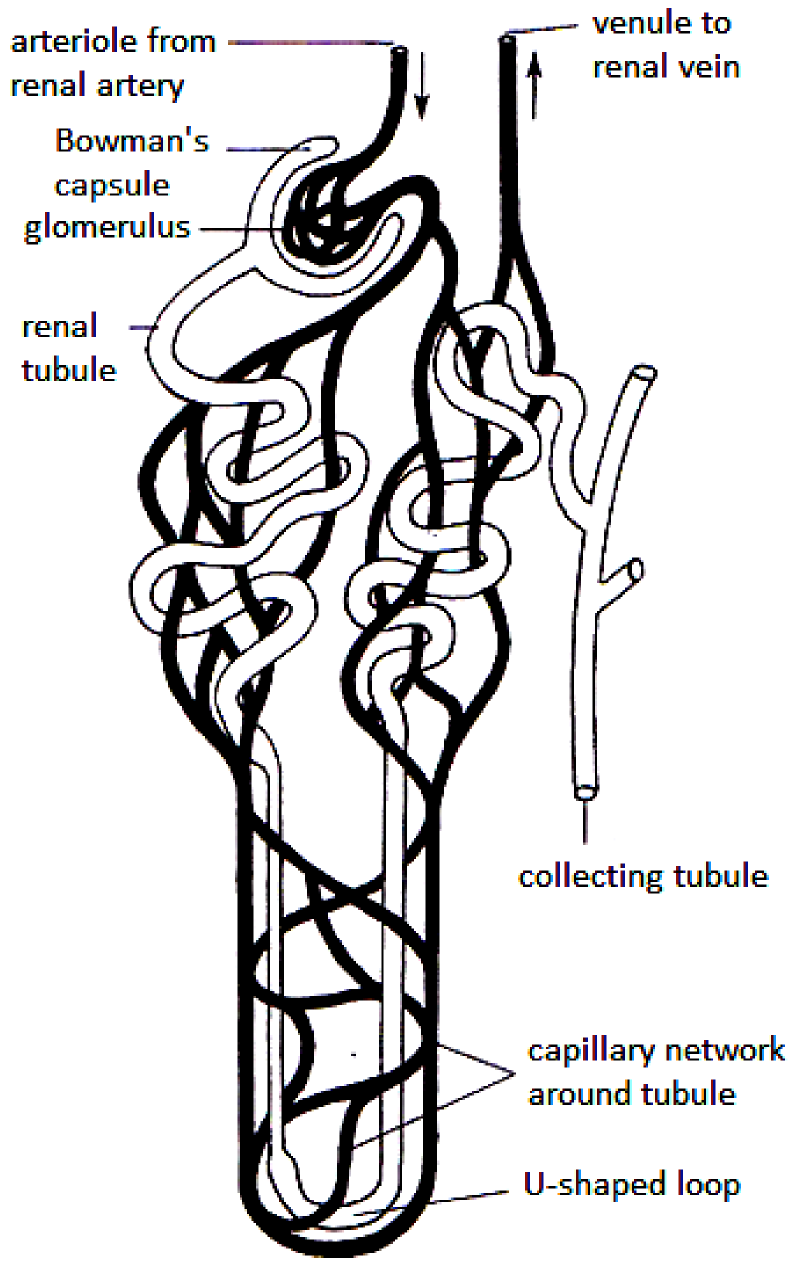
- The **renal vein**, a blood vessel, carries deoxygenated blood away from each kidney.

The Kidney



- The kidneys are a pair of bean-shaped organs situated near the back of the abdominal cavity.
- They are usually surrounded by fat, which helps to keep them in position.
- Inside each kidney the ureter opens into a cavity called the **renal pelvis**.
- Next to the renal pelvis is a tissue called the **medulla**, which is lighter in colour.
- The darker outer part of the kidney is called the **cortex**.
- The cortex is made up of millions of tiny structures called **nephrons**.

The Nephron



arteriole from
renal artery
venule to
renal vein
Bowman's
capsule
glomerulus
renal
tubule
collecting tubule
capillary network
around tubule
U-shaped loop

- Each nephron consists of a narrow tube called the **renal tubule**.
- The renal tubule ends in a tiny cap called the **Bowman's capsule**.
- The Bowman's capsule surrounds a tiny ball of blood capillaries called the **glomerulus**.

Urine Formation in the Nephron

- Blood entering the kidney through the renal artery reaches the glomerulus capillaries with high pressure.
- This forces fluid to be filtered into the Bowman's capsule in a process called **filtration**.

- The filtered fluid then flows into the renal tubule, which loops down into the medulla and back into the cortex again.
- The dense network of blood capillaries that surrounds the renal tubule allows exchange of substances.
- As the fluid passes through the renal tubule, most of the water and other useful substances move back into the blood in the capillaries.
- This is called **reabsorption**.
- Other substances pass from the capillaries into the renal tubule in a process called **secretion**.

- The remaining fluid called **urine**, which flows into the **collecting tubule** contains urea, excess salts and water.
- All collecting tubules empty the urine into the renal pelvis.
- From the renal pelvis the urine moves along the ureter to the bladder for temporary storage.
- At the lower end of the bladder is a ring of muscle called the **sphincter muscle**, which prevents the involuntary release of urine.
- When the sphincter muscle relaxes under one's voluntary control urine passes out of the body through the **urethra**.

Effects of Eating and Drinking on the Kidneys

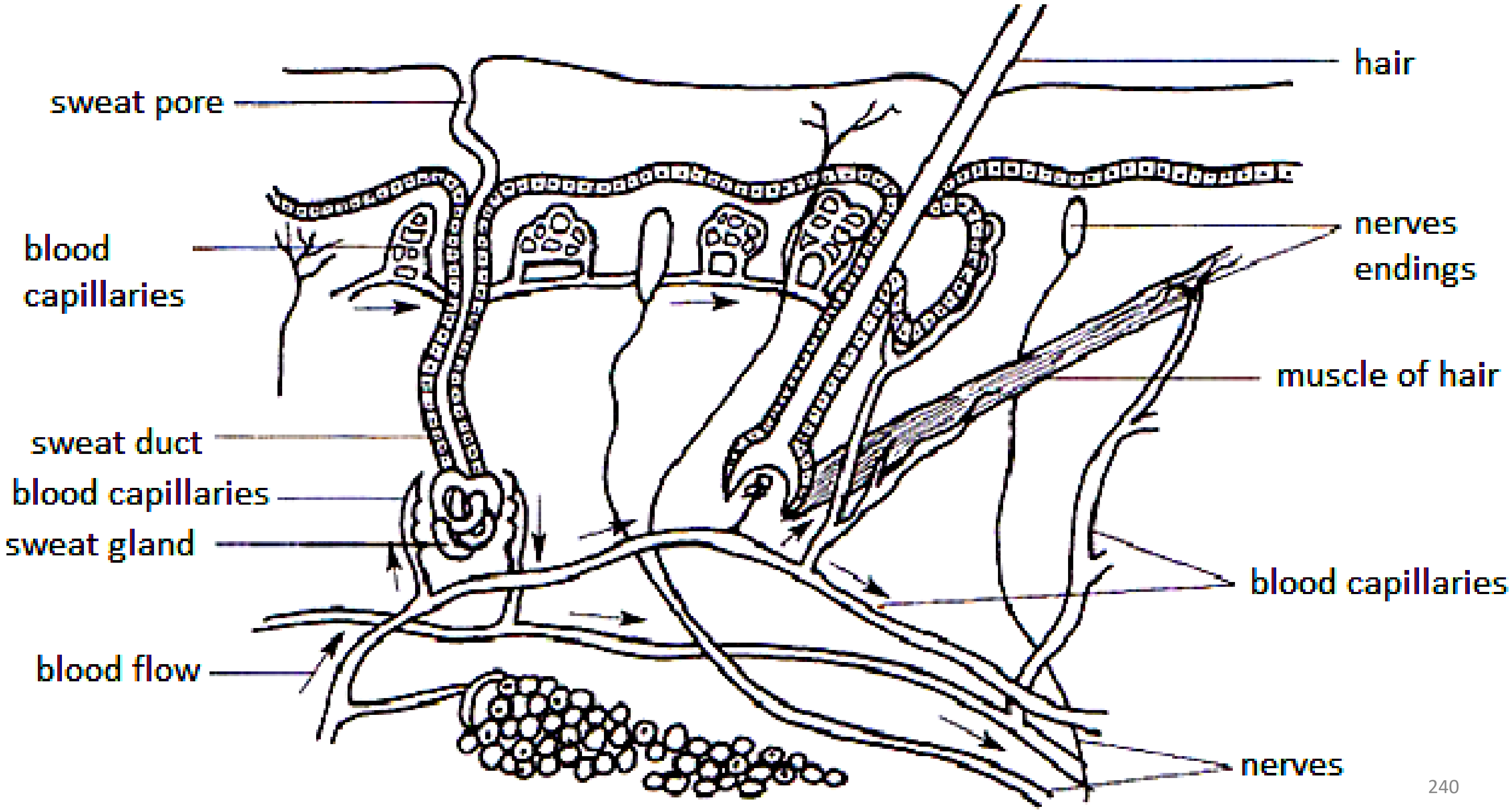
- The kidneys regulate the amount of salt and water lost from the body through urine by keeping the blood concentration constant.
- Blood concentration depends on the amount of salt dissolved in the blood.
- If the blood contains too much water or is too dilute, less water is reabsorbed from the renal tubules.
- This leaves more water to enter the bladder thus increasing urine output e.g. when one drinks a lot of water, which lowers the concentration of the blood.

- On the other hand if the blood is too concentrated, more water is reabsorbed into the blood from the renal tubules so that less passes to the bladder.
- For instance, when one drinks salt solution, the kidneys ensure that very little water is lost from the body as urine.
- In addition, more salt than usual is allowed to leave the body in urine, which will be very concentrated and dark yellow in colour.
- Drinking at least eight glasses of water daily ensures that the kidneys effectively remove metabolic wastes and maintain the correct blood concentration.

Excretion and the Lungs and Skin

- The lungs excrete carbon dioxide and water vapour, the products of respiration, through breathing.

The Generalised Structure of the Skin



- The body also loses water through sweating.
- Sweat has a salty taste because it is produced by the skin's sweat glands, which are surrounded by blood capillaries.
- Metabolic wastes in the blood e.g. water, urea and salts, diffuse out of the capillaries into the sweat glands.
- Water with dissolved salts and urea moves up the sweat duct to the skin surface.
- Sweating also helps to maintain the normal body temperature because as the water evaporates from the skin surface, the body cools down.

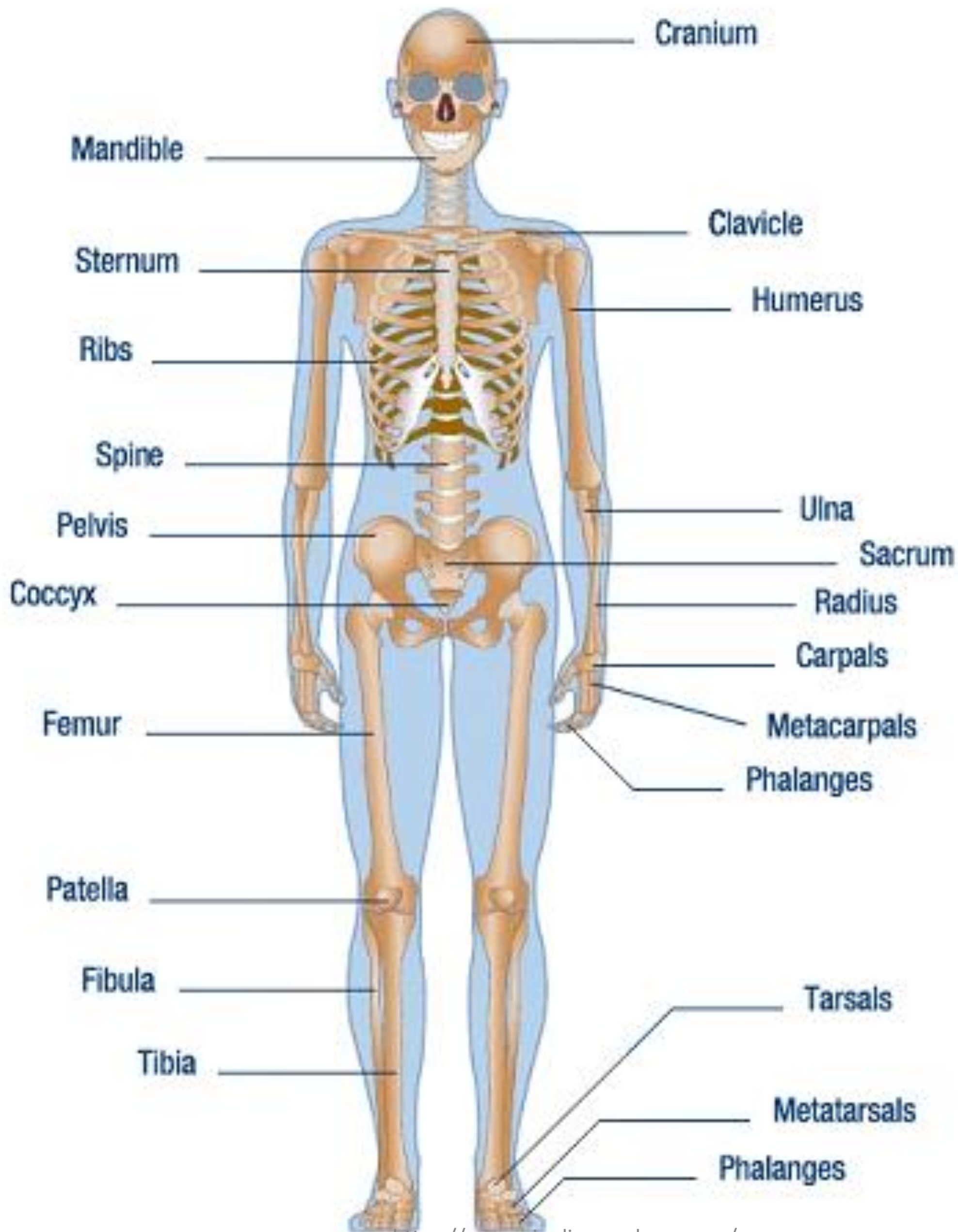
LOCOMOTION

- Locomotion refers to movement from one place to another by the whole organism.
- In humans, locomotion is made possible by the combined action of the **skeleton**, **joints** and **muscles**.

The Human Skeleton

- The human skeleton consists of 206 bones that are joined together to form a rigid framework.

The Human Skeleton



Parts of the Human Skeleton

- The human skeleton can be divided into two major parts namely the **axial skeleton** and the **appendicular skeleton**.
- The axial skeleton consists of the **skull** and the **vertebral column**.
- The vertebral column is made up of bones called the **vertebrae**.
- The vertebrae, which differ in shape, are joined to each other to form a very strong s-shaped vertebral column.
- The strength of the vertebral column ensures support for the trunk and flexibility to allow movement of the back.

- This allows one to bend and twist and carry relatively heavy loads on their back or head.
- The appendicular skeleton consists of the four limbs and their respective girdles i.e. the **pelvic** and the **pectoral** girdles.
- The two legs are attached to the pelvic or hip girdle, and the two arms are attached to the pectoral or shoulder girdle.
- The girdles connect the axial skeleton to the legs and arms.
- In humans the pelvic girdle is much more rigid than the pectoral girdle.

- This is because
    a. the pelvic girdle supports the trunk's weight
    b. the legs do a lot of work during movement.

Functions of the Human Skeleton

a. Formation of blood cells in the bone marrow.
b. Protection of delicate body parts. For instance, the skull protects the brain, the vertebral column protects the spinal cord and its nerves while the rib cage protects the heart and the lungs.
c. Provision of a rigid framework onto which internal organs are attached.

d. To allow body movement in conjunction with the muscles and joints.
e. Giving the body its shape and form.
f. Storage of fat and minerals e.g. Ca & phosphorus.

Types of Joints in the Human Skeleton

- A joint is a place where two or more bones are attached to one another.
- There are **two** main categories of joints, namely the movable or **synovial joints** and the immovable or **fixed joints**.
- Movable joints allow some movement of the bones while immovable joints do not.

- A summary of the types of joints is shown in the flow diagram below.

Joints

immovable (fixed)

movable (synovial)

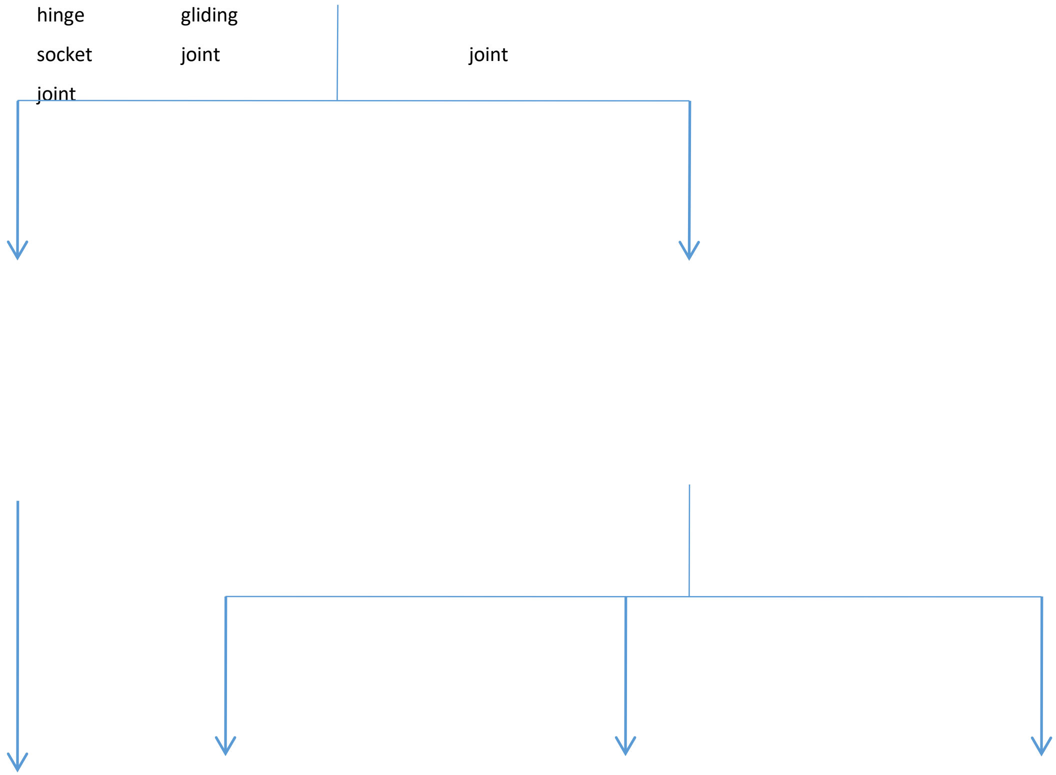
sutures

ball and socket joint

hinge joint

gliding joint

joint

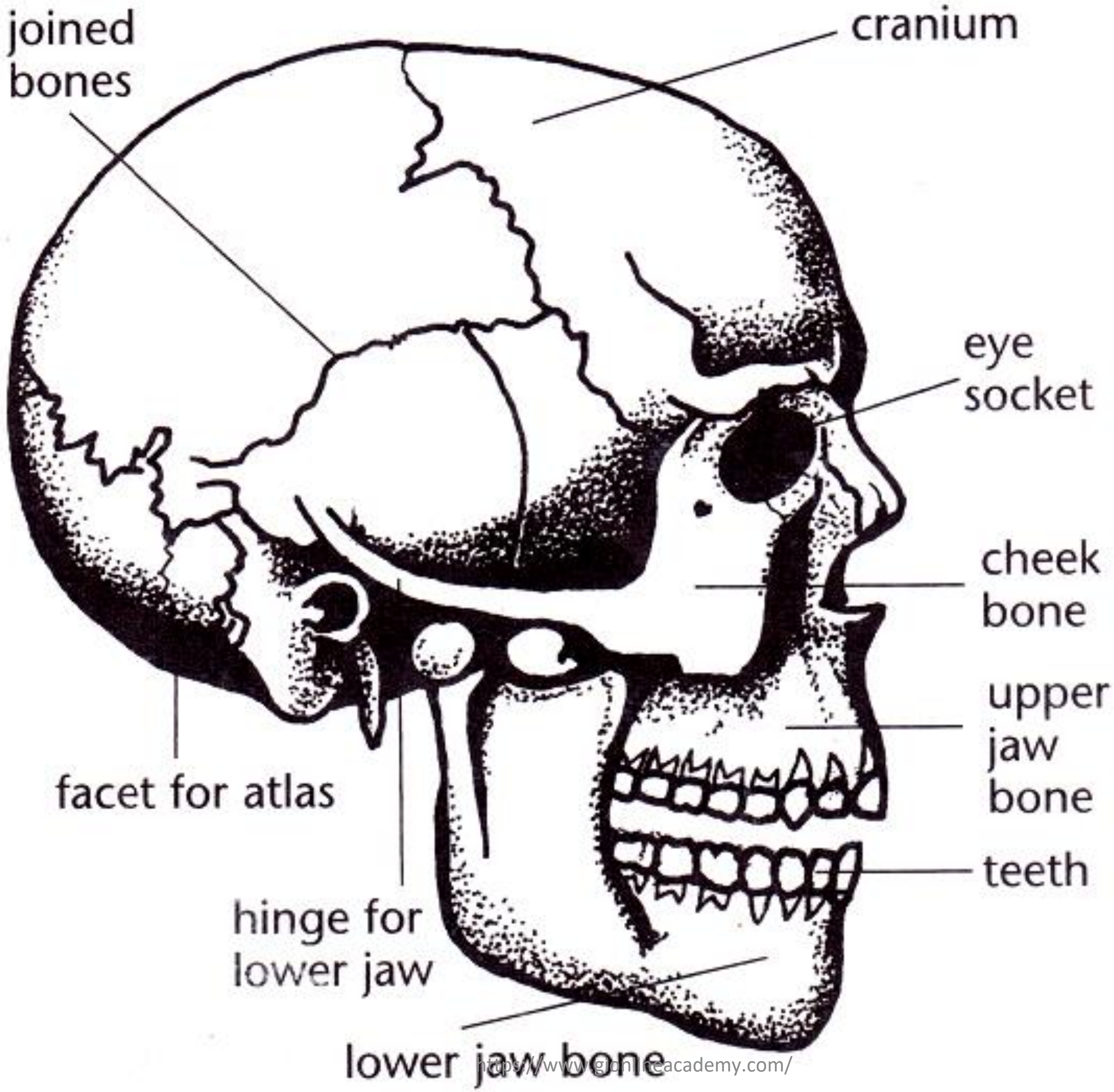


Types of Joints and the movement they Allow

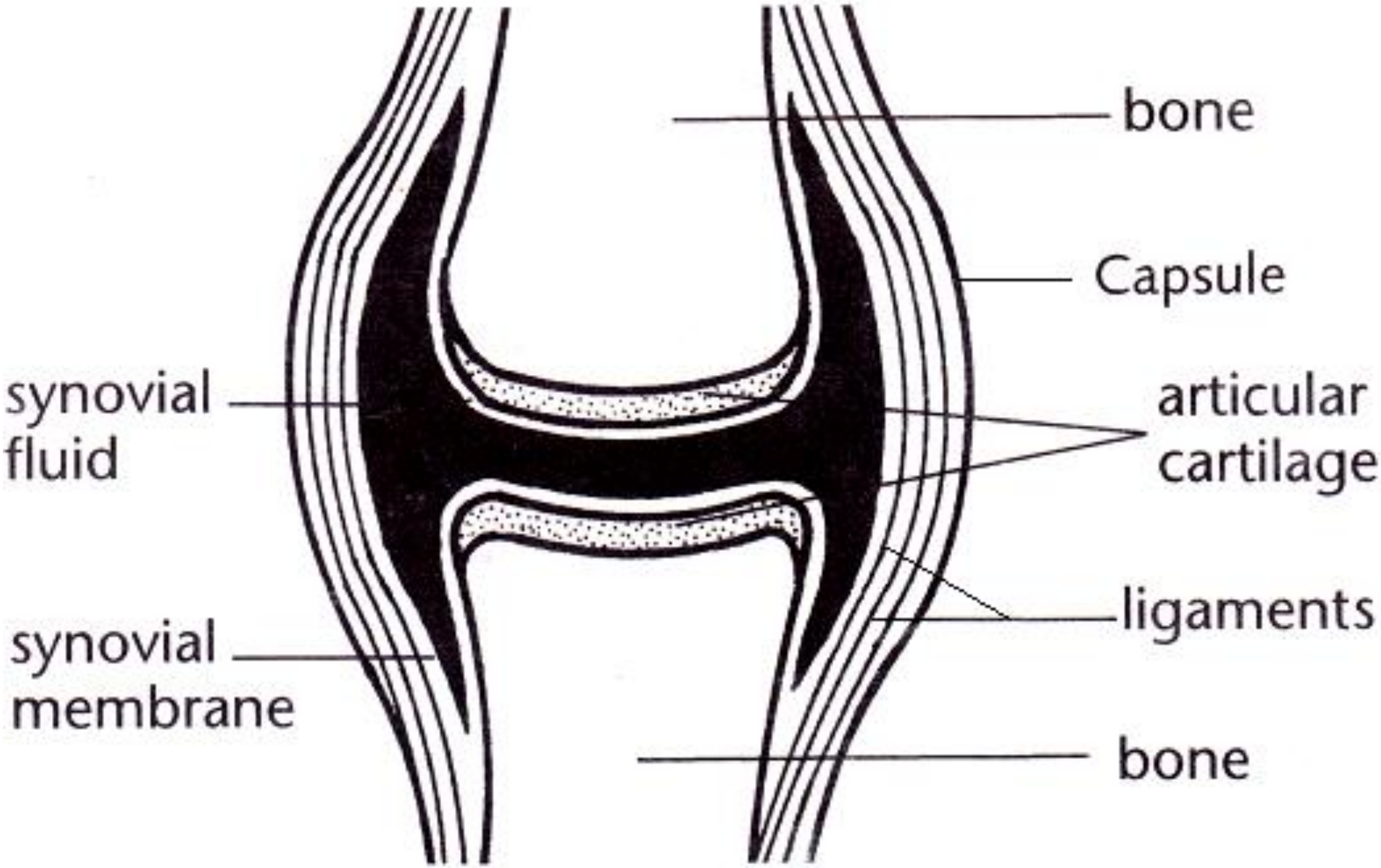
Type of Joint	Example	Movement Allowed
Gliding (sliding)	finger, wrist, tarsals	Sliding over each other.
Hinge	knee, elbow	Movement in one plane only.
Ball and socket	hip, shoulder	Movement in all planes.

- Immovable joints are found in the skull and in the pelvic girdle.
- In a baby the sutures in the skull allow a small degree of movement.
- This is very important as it allows expansion of the brain as it grows.
- However, once brain growth is complete, the sutures fuse to form fixed joints.
- The pelvic girdle, on the other hand, is made up of three bones that are fused together at sutures.
- This ensures that the pelvic girdle is very strong and can support the weight of the trunk.

The Joints of the Human Skull



A Typical Movable Joint



Functions of Parts of a Movable Joint

Part of Joint	Function
Capsule	Binds the whole joint and keeps it intact.
Ligaments	Hold the bones at a joint firmly together.
Synovial membrane	Secretes the synovial fluid.
Synovial fluid	Lubricates the joint.
Cartilage	Reduces friction between the ends of bones.

Muscles

- Muscles consist of bundles of very strong fibres that are the width of human hair.
- When the muscle fibres contract, the whole muscle contracts and shortens.
- When the muscle contracts, it exerts a pulling force on the bones or other muscles with which it is in close contact.
- However, when the muscle fibres relax, the muscle returns to its original length.
- Muscles can only pull; the cannot push.

- Regular exercise prevents muscles from becoming weak and flabby.
- It also helps them to grow larger so that they exert greater force during contractions.
- Doing light exercise before heavy work is very important because it warms up the muscles and makes them less likely to be injured.

Types of Muscles

- There are **three** types of muscles in the human body, namely **skeletal**, **cardiac** and **smooth** muscles.

Characteristics of Muscles

Skeletal or Voluntary Muscles

a. Are striated or striped muscles.
b. Are associated with the skeleton.
c. Need an impulse from the nervous system to contract.
d. Can contract and relax rapidly e.g. during running.
e. Can remain contracted for a long time e.g. during sitting.
f. Are under the control of the mind (will power) i.e. one is aware of their contraction and relaxation.

Cardiac or Heart Muscles

a. Are striated or striped muscles.
b. Are not associated with the skeleton.
c. Do not need an impulse from the nervous system to contract.
d. Are not under the control of the mind (will power) i.e. can contract and relax without one's knowledge.
e. Contract and relax continuously without tiring.
f. Can continue to contract even when the heart has been removed from the body.

Smooth or Involuntary Muscles

a. Are not striated.
b. Occur mostly in walls of hollow intestinal organs e.g. the stomach and bladder.
c. Can contract and relax without one's knowledge.
d. Can produce rapid contractions.
e. Are not associated with the skeleton.

Muscles and their Functions

Muscle	Function
Sphincter muscle	a. Dilation and constriction of the tube endings as in the anus and bladder.

Muscles and their Functions

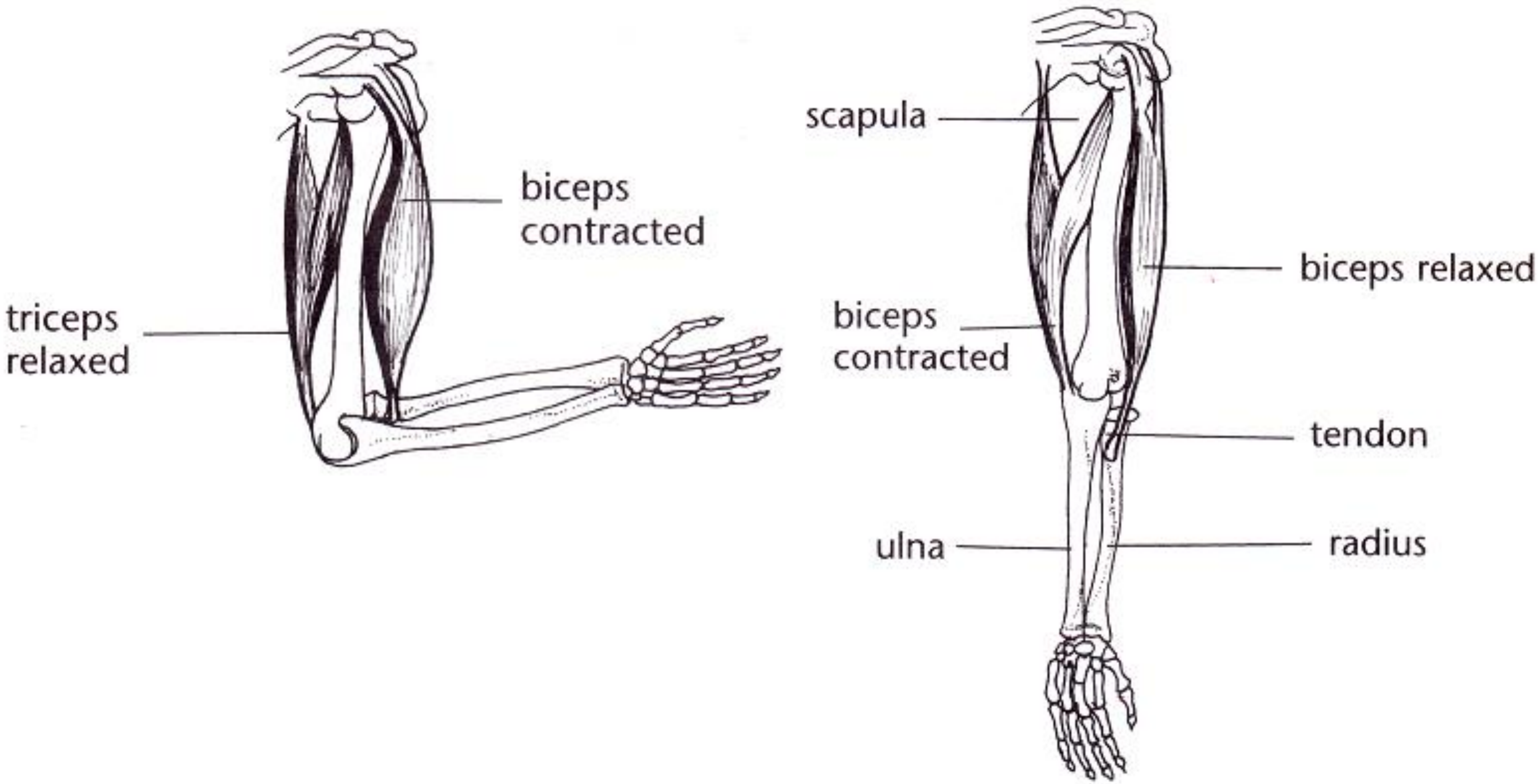
Muscle	Function
Intestinal muscles	a. Peristalsis of the intestines.
Stomach muscles	a. Churning food in the stomach during digestion.
Heart muscles	a. Beating of the heart for blood circulation. b. Beating of the heart throughout one's life.
Skeletal muscles	a. Stretching and folding of limbs. b. Movement of eyeballs. c. Movement of jaw bones when chewing and talking. d. Movement of backbone. e. Movement of whole body.

Antagonistic Muscles

- These are pairs of skeletal muscles that work in opposition to each other.
- Typical examples of antagonistic muscles are the **biceps** and **triceps** of the upper arm and leg.
- Muscles are attached to the bones by tough inelastic fibres called **tendons**.
- When the biceps muscle contracts, it pulls the bones of the lower arm upwards.
- During this process, the triceps muscle remains contracted.

- When the triceps muscle contracts, it pulls the bones of the lower arm downwards.
- The triceps is therefore working in opposition to the biceps.
- During contraction, the biceps and triceps shorten and form a lump which flattens out again as the muscles relax.
- When you move your leg forward, it is the muscles in the front of the thigh and hip that contract, while those at the back relax.
- As you move your leg back, the muscles at the back of the thigh and hip contract while those on the front relax.

Antagonistic Muscles of the Upper Arm



Fractures

- A fracture is a broken bone.
- Bones have a wonderful design that makes them very strong.
- Their inside is hollow and is often filled with bone marrow.
- The outside consists of a very hard and dense substance.
- This design ensures the bones’ resistance to stress and that they do not weigh too much.
- However, when subjected to a very large force, a bone can fracture.

- Old people's bones are weak and brittle such that they fracture easily.

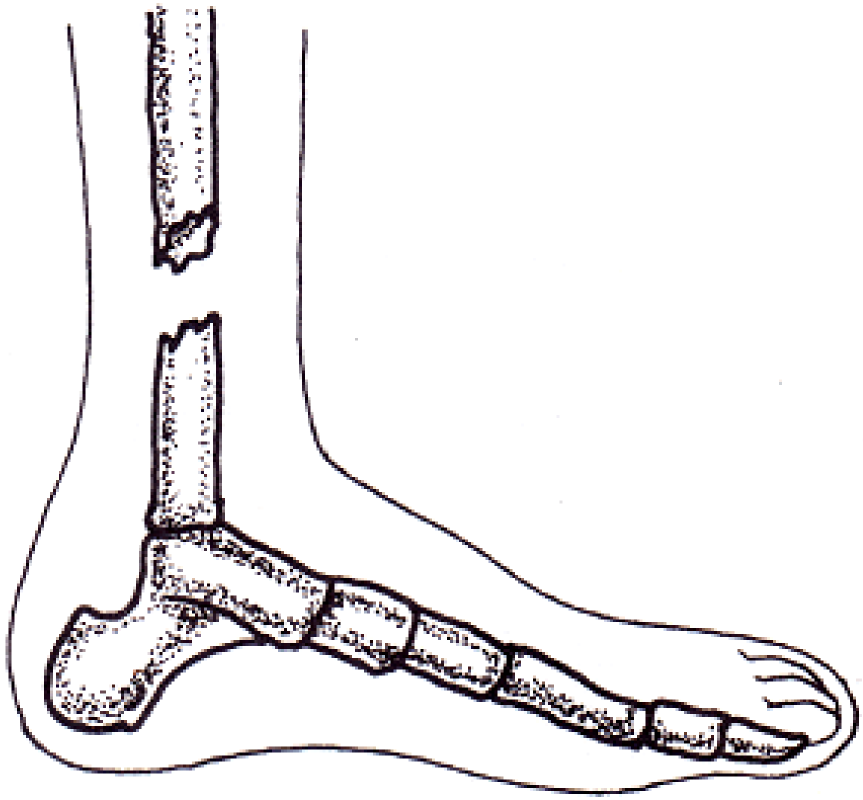
Types of Fractures

- There are **two** types of fractures, namely **simple** or closed and **compound** or open fractures.

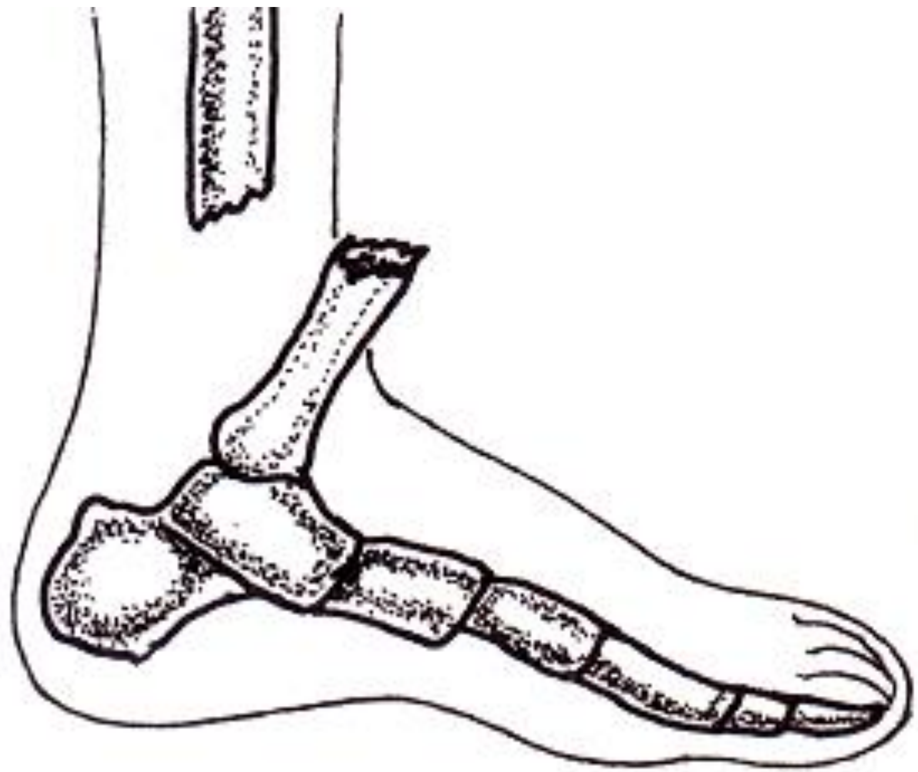
Characteristics of Fractures

Type of Fracture	**Characteristics**
Simple fracture	• Bruises and swelling around the fracture. • Skin around fracture is intact.
Compound fracture	• Open wound around fracture • Bone may protrude through skin.

A Simple Fracture



A Compound Fracture



Signs / Symptoms of a Fracture

a. Bruising and swelling at the site of a fracture.
b. Tenderness at the site of the fracture even when touched very gently.
c. The limb appears shorter, bent or twisted.
d. Sharp pain at or close to the fracture.
e. Inability to move the affected limb, possibly accompanied by pain.
f. Ends of bones appear to grate against each other.
g. A snapping sound heard as the bone fractures.

h. Shock if the pelvis, ribs or thigh bones are fractured, due to loss of blood.

First Aid for a Simple or Closed Fracture

a. Do not move the person unless he/she is in danger.
b. Quickly secure and support the fractured bone.
c. Ask the person to remain still and calm.
d. Tie the broken arm to the chest using a sling or the broken leg to the other leg using bandages.
e. If signs of shock are present, treat for shock.

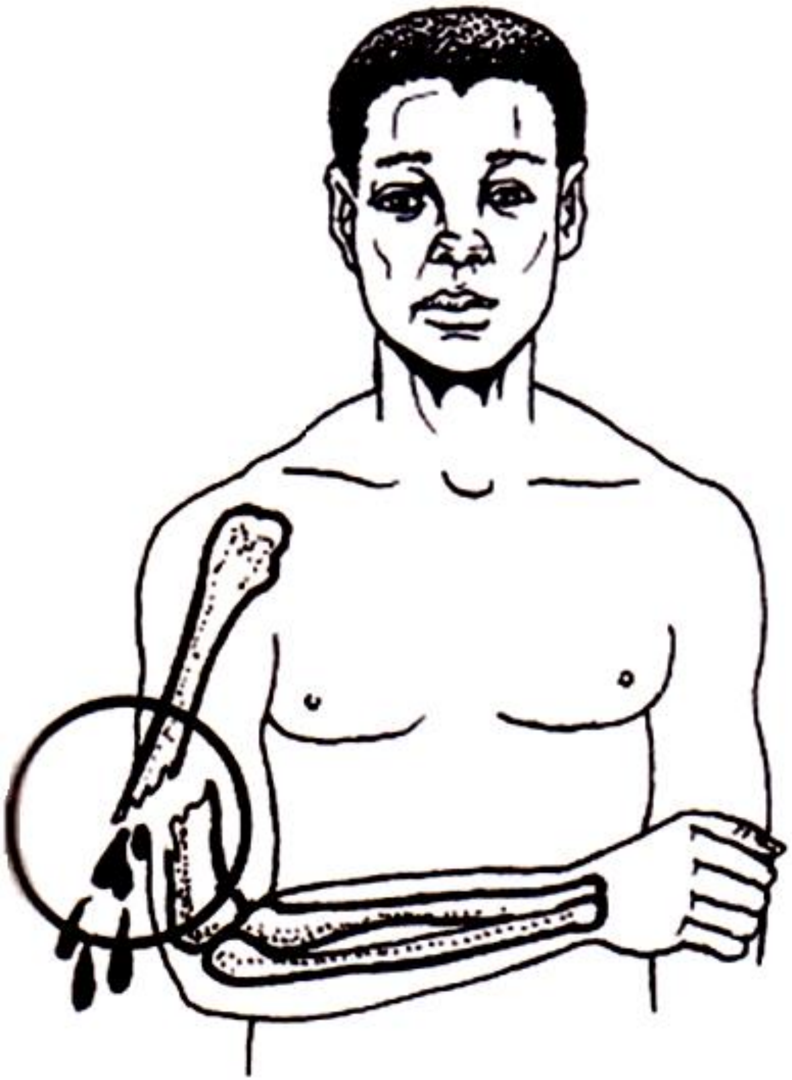
f. Do not try to replace the broken bone in the socket if it has been dislocated.
g. Take the person to the nearest hospital or call for an ambulance.

First Aid for a Compound or Open Fracture

a. Do not touch or push down on any bone protruding through the skin.
b. Stop or control bleeding by applying pressure around the wound. This can be done by making a *Nkhata* using soft materials such as cotton and newspapers.

c. Cover the wound using soft materials, which should be placed over the *Nkhata* to avoid touching the wound. Ensure that it is held firmly in place.
d. Tie the broken arm to the chest using a sling or the broken leg to the other leg using bandages. Elevate the leg if possible.
e. Treat the person for shock if necessary.

First Aid for an Open Fracture of the Arm



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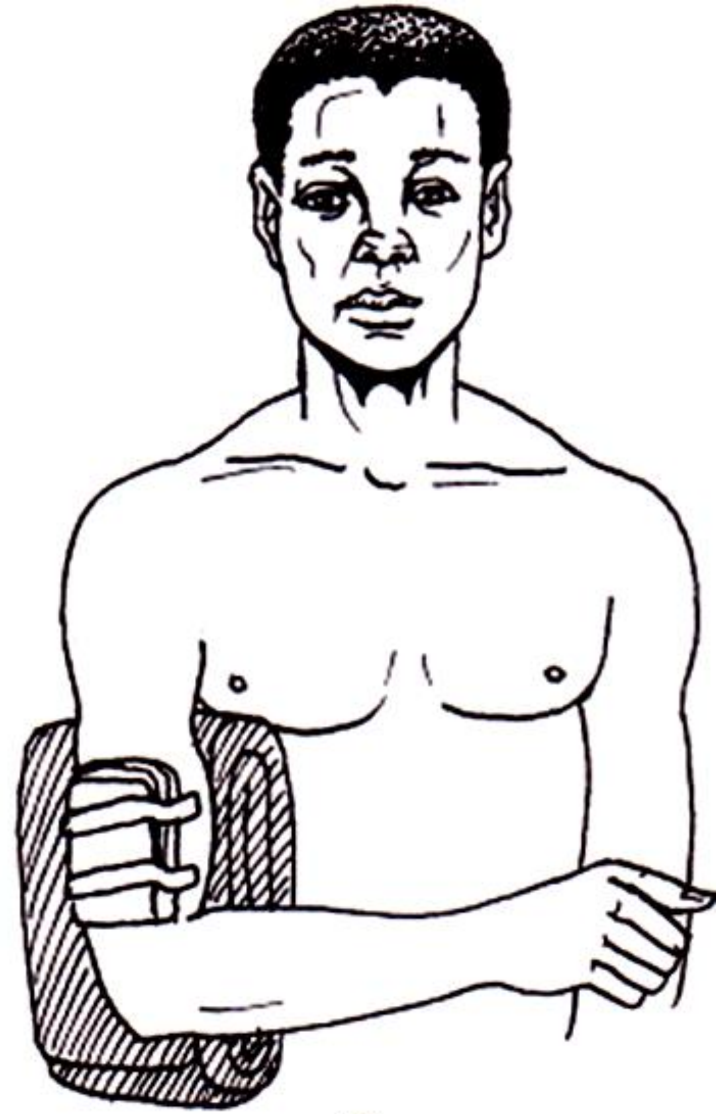

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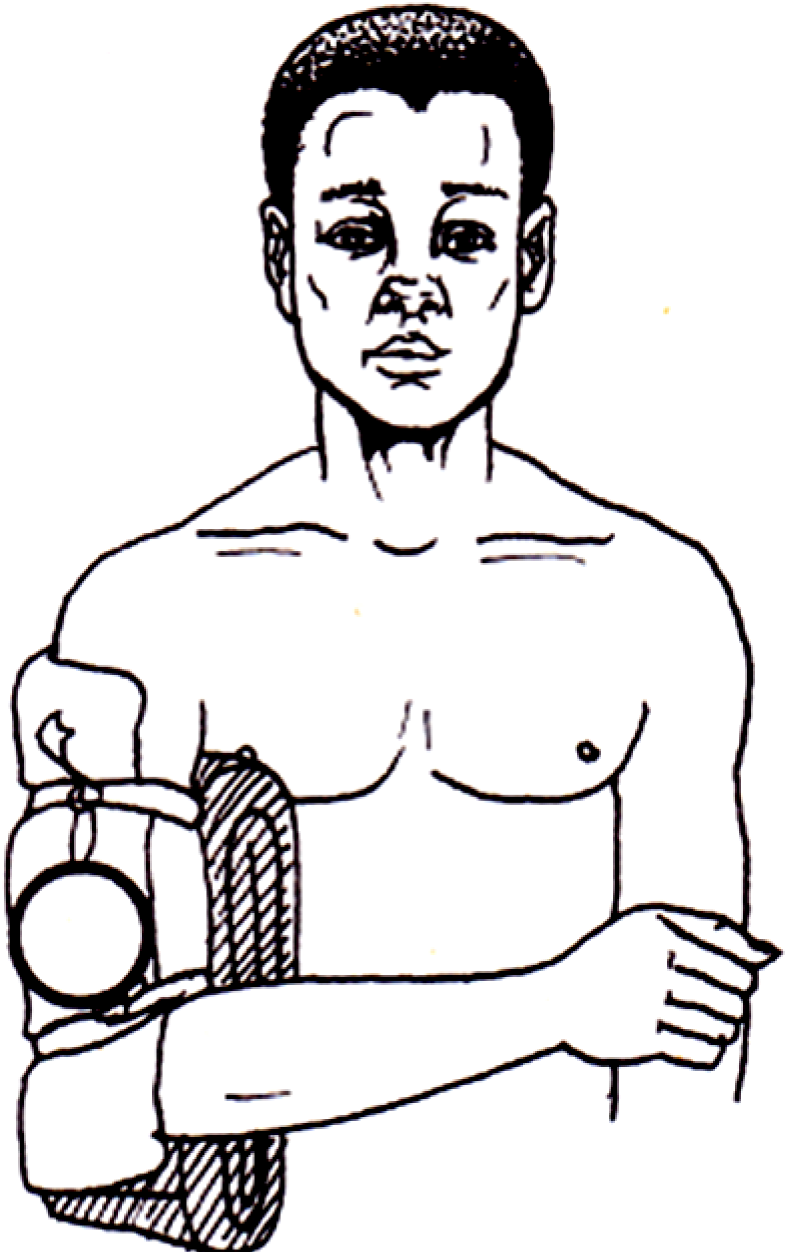

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Sprains

- Sprains are injuries to the soft tissues surrounding a joint, such as blood vessels, ligaments and tendons.
- These injuries are generally caused by over-twisting, over-stretching and tearing of the joints.
- Tendons, ligaments and blood vessels around movable joints can get partially or completely torn, depending on the force exerted on them.
- Knees, ankles, wrists and fingers are common areas that get sprained e.g. during sporting activities.

- When sprained, the joint swells up quickly, making it very uncomfortable and painful.

First Aid for a Sprain

a. Make the person rest comfortably then position the sprained joint in a way that gives least pain.

b. Apply a cold compress to the sprain for about 20 minutes. A pack of ice or a pad soaked in very cold water can be used.

The cold compress helps to reduce swelling, especially in a recent injury.

An ice-pack creates some numbness, which also helps to reduce pain.

c. Wrap the sprained joint in a thick layer of pads and tie it firmly. This further reduces swelling.
d. Support the injured limb in a raised position. This helps to prevent or reduce bruising.
e. Let the victim allow the sprained joint to rest for a few days. If the pain persists, take the person to the hospital for special treatment.

Dislocations

- A dislocation is when the end of a bone is forced out of its joint, possibly tearing some ligaments in the process.

- The most common dislocations are those of the shoulder, fingers, jaw and thumb.
- Dislocations of the hip occur occasionally.

Common Causes of Dislocations

a. A fall
b. Strong twisting action that forces a bone out of place and tears ligaments in the process.
c. Violent muscle contractions.

Signs/Symptoms of Dislocations

a. Temporary numbness followed by severe pain.
b. Deformity and swelling at the joint.

c. Inability to move the limb at the joint.

First Aid for a Dislocated Arm

a. Never try to push the dislocated bone back into its socket, or normal position.
b. Make the person sit down, then gently place the arm across the chest in a position that gives the person least pain.
c. Support the arm using a sling.
d. Place some soft materials such as padding between the arm and chest on the affected side. Keep the person in a sitting position.
e. Take the person to the hospital or call for an ambulance.

RESPONSE TO CHANGES IN THE ENVIRONMENT

- Living things use special systems or organs to detect changes in their environment and then respond accordingly.
- For instance, humans and other mammals use their sense organs such as the eye, ear, nose, tongue and skin.
- They then send information to the nervous system.
- The nervous system sends messages to various parts of the body for the right kind of response to occur.

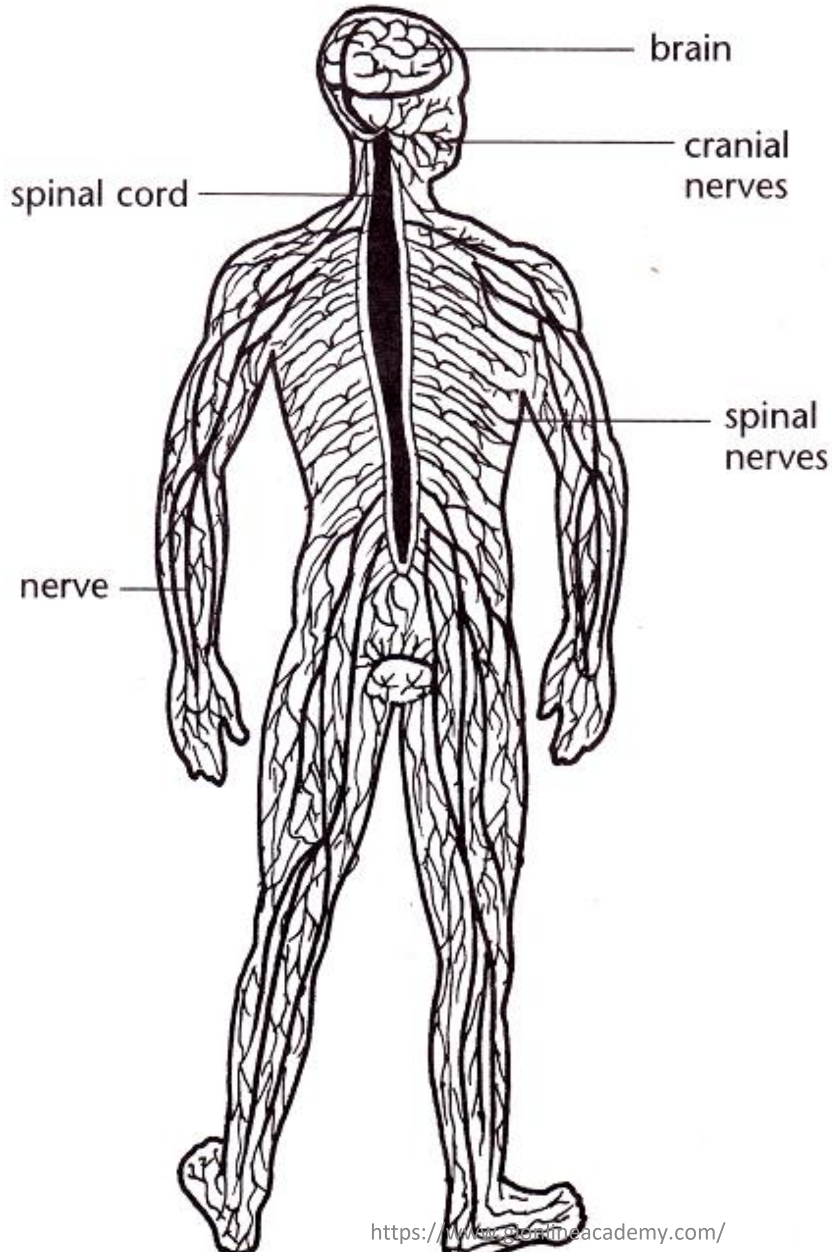
Stimulus and Response

- A **stimulus** is a change in the environment, which brings about a reaction or response in a living organism.
- The reaction to a stimulus (plural: stimuli) is called a **response**.

The Nervous System

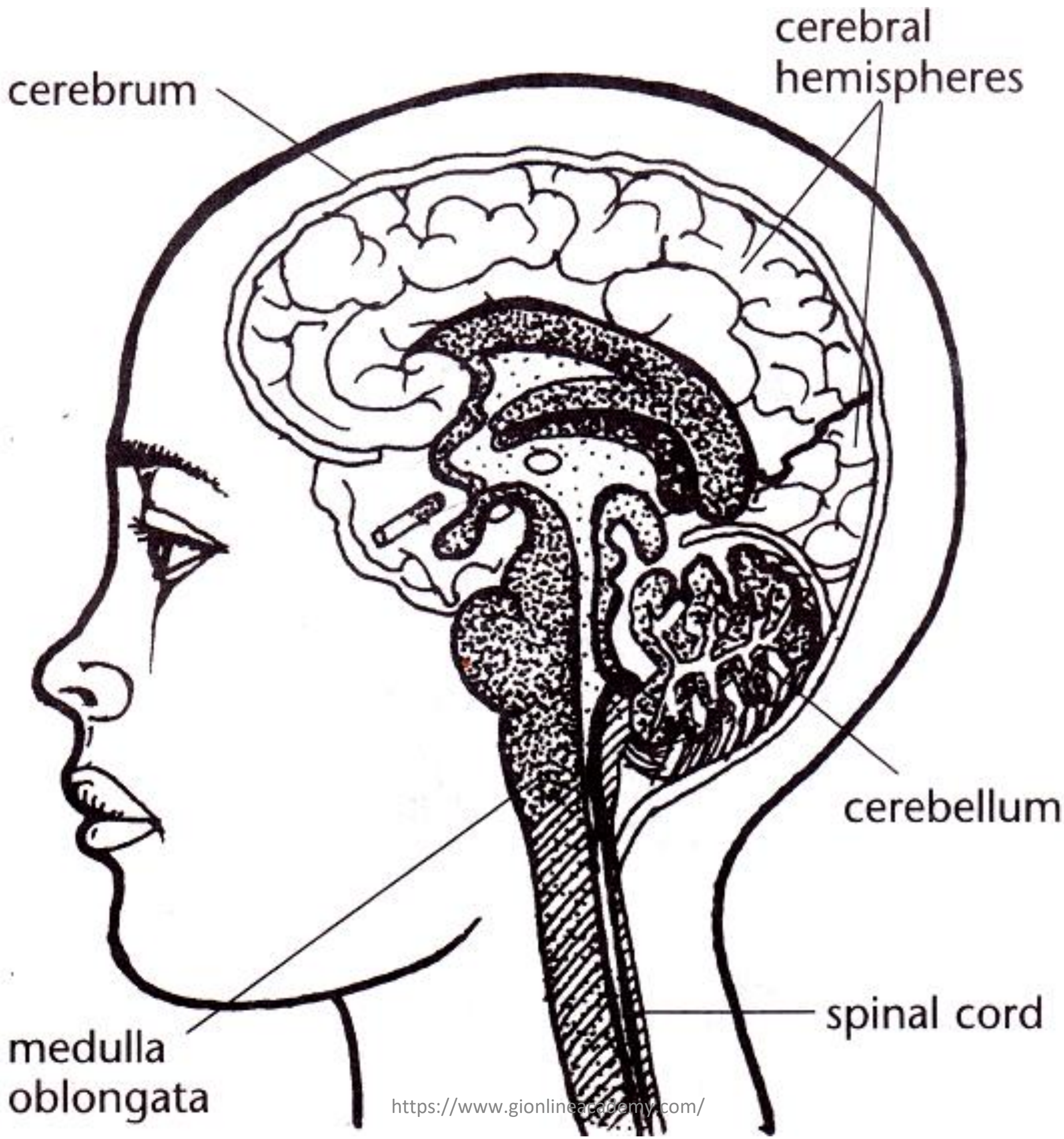
- The nervous system is a system in the body that helps living organisms to respond to stimuli.
- In humans, the nervous system consists of the **central**, **peripheral** and **autonomic** nervous systems.

The Nervous System



- The central nervous consists of the **brain** and **spinal cord**.
- The peripheral nervous system consists of **paired nerves** linking the brain and spinal cord to other parts of the body.
- The autonomic nervous system is a system of nerves linking the brain and spinal cord to internal organs.
- The central and peripheral nervous systems help us to respond to external stimuli.
- The autonomic nervous system is mainly concerned with response to internal stimuli e.g. secretion of digestive juices.

The Human Brain



- The brain has three main parts, namely the **cerebrum**, the **cerebellum** and the **medulla oblongata**.

The Cerebrum

- The cerebrum is the largest part of the brain.
- It has two halves called **cerebral hemispheres**.
- It has sensory areas that control **hearing**, **sight**, **smell** and **skin sensation**.
- It also has motor areas that control muscles of the legs, arms, face, eyes and head.
- It is also the centre for mental activities, will, intelligence, memory and judgement.

The Cerebellum

- The cerebellum is responsible for maintaining balance, locomotion and positioning of the body.
- It therefore controls muscular activities such as walking, talking, sitting and standing.

The Medulla Oblongata

- This arises from the cerebellum.
- It controls reflex actions including heart beat, breathing, respiration, coughing, swallowing, blood pressure, sneezing, yawning, vomiting and digestion.
- Reflex action are automatic responses to stimuli that you cannot control by will power.

Alcohol and Indian Hemp

- Alcohol such as beer, wine and spirits depresses the functions of the cerebrum.
- This leads to:
  - Clumsiness;
  - incoherent speech;
  - loss of self control;
  - reduced attention;
  - poor judgement;
  - muscular incoordination;
  - nervousness and
  - loss of feeling.

Effects of Alcohol

a. It affects one's personality, job and home life.
b. It ruins one's future.
c. It can damage the liver.

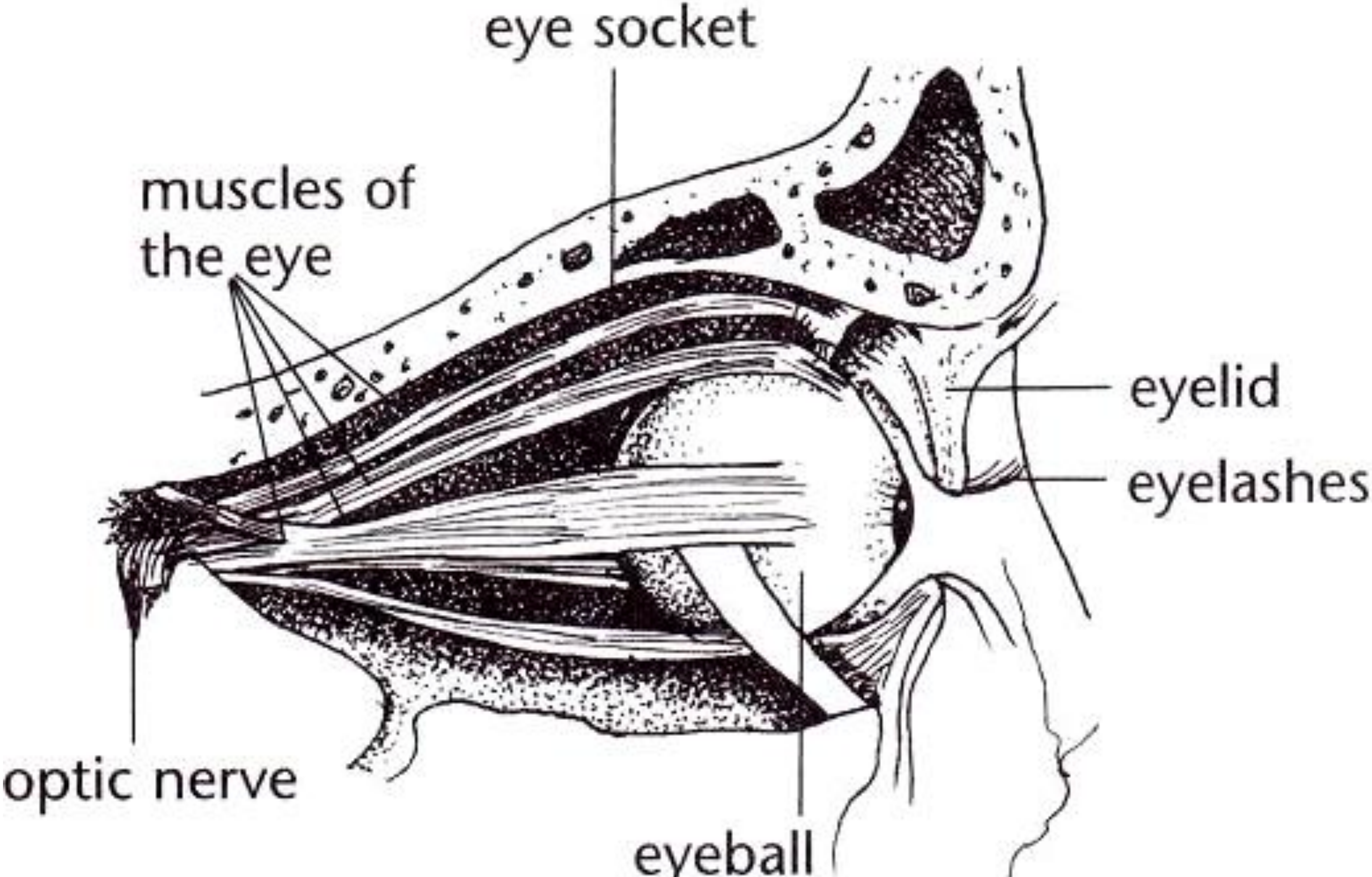
- Indian hemp is an illegal drug.
- It is usually smoked in hand-made cigarettes, but may also be soaked and drunk.
- Its effect on the brain are:
  a. It results in euphoria or a feeling of well- being.
  b. Hallucinations i.e. walking dreams associated with distorted images and vivid colours.

c. It can lead to personality disorders and madness.
d. It can lead to male impotence.

The Sense Organs

- The sense organs contain **sensory nerve cells**, which detect specific stimuli.
- Detection of stimuli produces impulses, which are sent to the central nervous system.
- The central nervous system makes individuals aware of the change in the environment.
- From the central nervous system, impulses pass along **motor nerve cells** to the body parts that can respond to the stimulus.

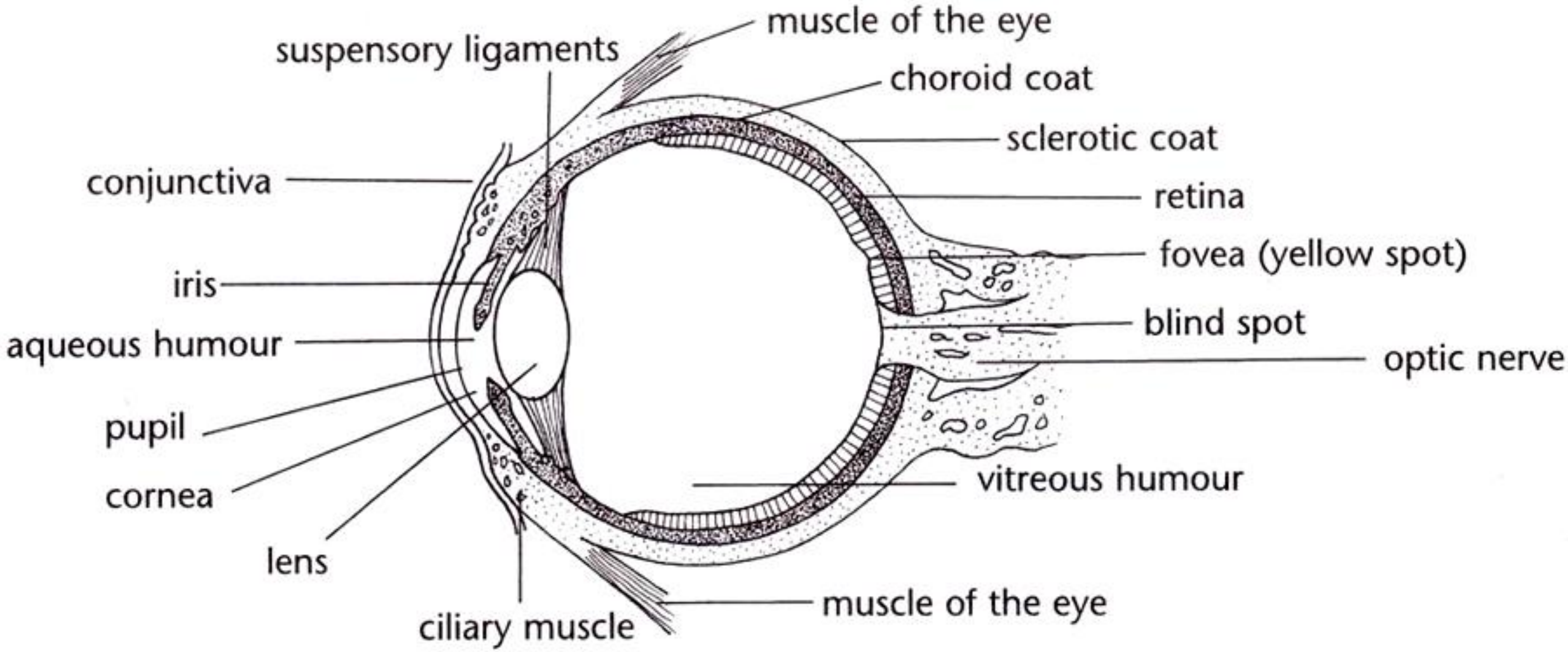
The Eye


eye socket
muscles of
the eye
eyelid
eyelashes
optic nerve
eyeball

- The eye is a sense organ that allows us to see.
- The exterior part is the front surface of a sphere called the **eyeball**.
- The eyeball lies in a cavity in the skull called the **eye socket** where it is protected by the surrounding bone.
- The eyeball is attached to its socket by six muscles that move it in different directions.
- The front of the eyeball is protected by the upper and lower **eyelids**.
- Eyelids have hairs along their edges called **eyelashes**.

- Above the upper eyelid are hairs called **eyebrows**.
- Eyebrows and eyelashes help prevent small foreign objects from entering the eye.
- Just above the eyeball, in the outer part of the eye socket, is a **tear gland**.
- The tear gland produces tears, which help to wash away dust and keep the eye moist.
- The outer layer of the eyeball that forms the white of the eye is called the **sclera**.
- The sclera protects the inner parts of the eyeball.

A Cross Section of the Human Eye



- At the front of the eyeball, the sclera is modified to form a transparent tissue called the **cornea**.
- The cornea allows light to enter the eye.

- The cornea also refracts or bends the light that enters the eye.
- The cornea is covered by a thin transparent skin called the **conjunctiva**.
- The middle layer of the eyeball is called the **choroid coat**.
- It is pigmented and contains many blood capillaries that supply oxygen and food nutrients to the eye.
- It also prevents reflection of light within the eyeball.
- The inside layer of the eyeball is **retina**.

- The retina is a very delicate sheet of tissue, which contains cells that are sensitive to light.
- These sensory cells are more closely packed together at the **fovea** or **yellow spot** than in the other parts of the retina.
- At the back of the eye is the **blind spot** where there are no sensory cells.
- The blind spot is where the optic nerve passes through the retina.
- The optic nerve transmits nerve impulses to and from the brain.

- At the front of the eyeball the choroid coat is modified to form a pigmented **iris**.
- The iris may be brown, blue, grey, or red in albinos.
- The hole in the centre of the iris is called the **pupil**.
- The pupil controls the amount of light that enters the eye.
- It widens in dim light and narrows in bright light due to contraction and relaxation of the **ciliary muscle**.
- At the front of the eyeball is the **lens**.

- The lens is attached to the ciliary muscle by the **suspensory ligaments**.
- The lens refract light that enters the eye.
- In front of the lens is a watery **aqueous humour** and behind is a jelly-like **vitreous humour**.
- Both of these are solutions of sugar salts and proteins for nutrition of the eye.
- The aqueous humour and the vitreous humour also refract light
- They also exert an outward pressure, which keeps the eyeball round.

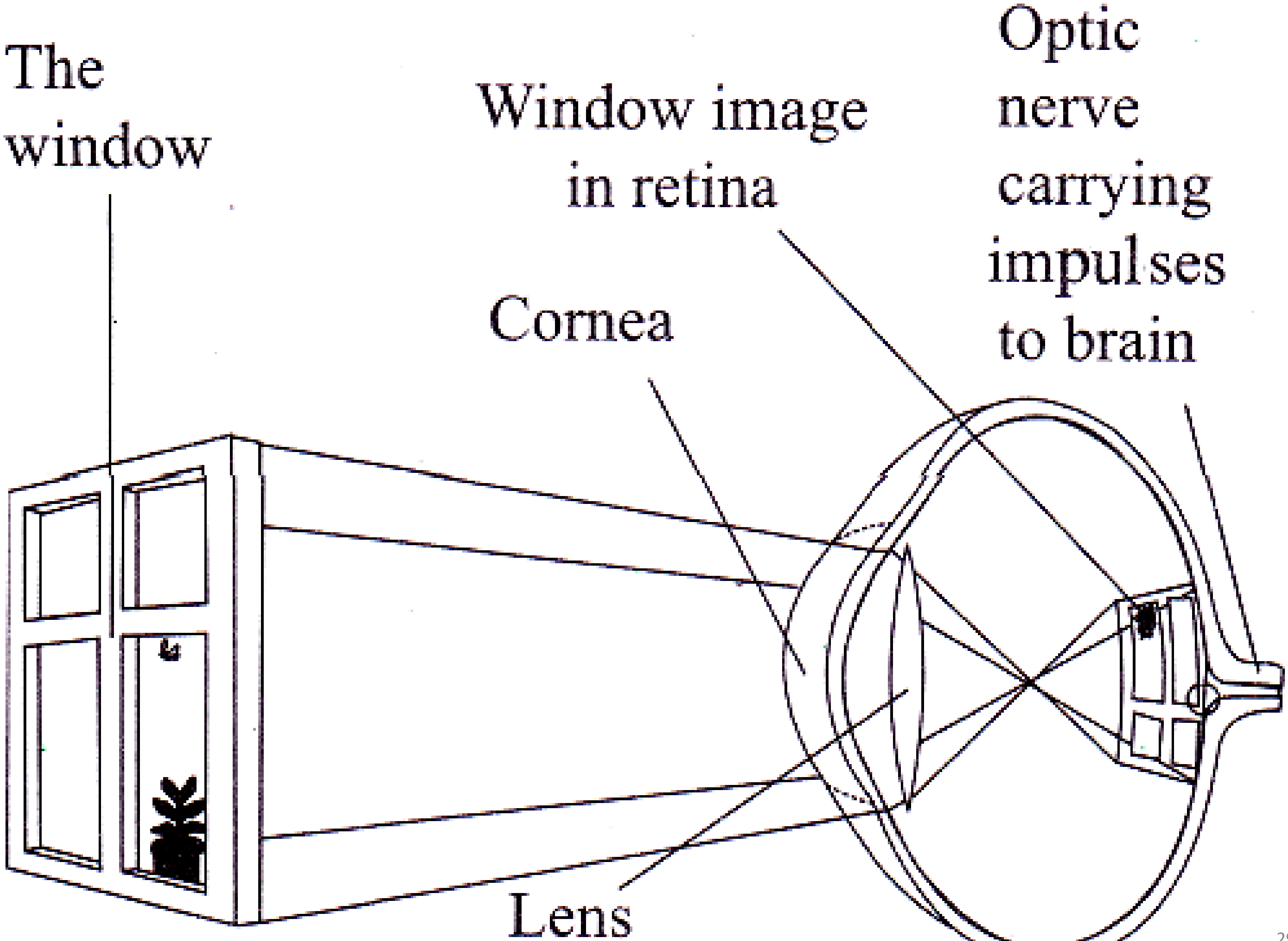
Formation of an Image on the Retina

- Light rays from an object enter the eye and are refracted to form a tiny **inverted image** on the retina.
- The cornea, aqueous humour, lens, and the vitreous humour all help to refract light rays.
- The lens focuses the image on the retina due to its ability to change shape according to the distance from the object.
- This is done through the contraction and relaxation of the ciliary muscles.

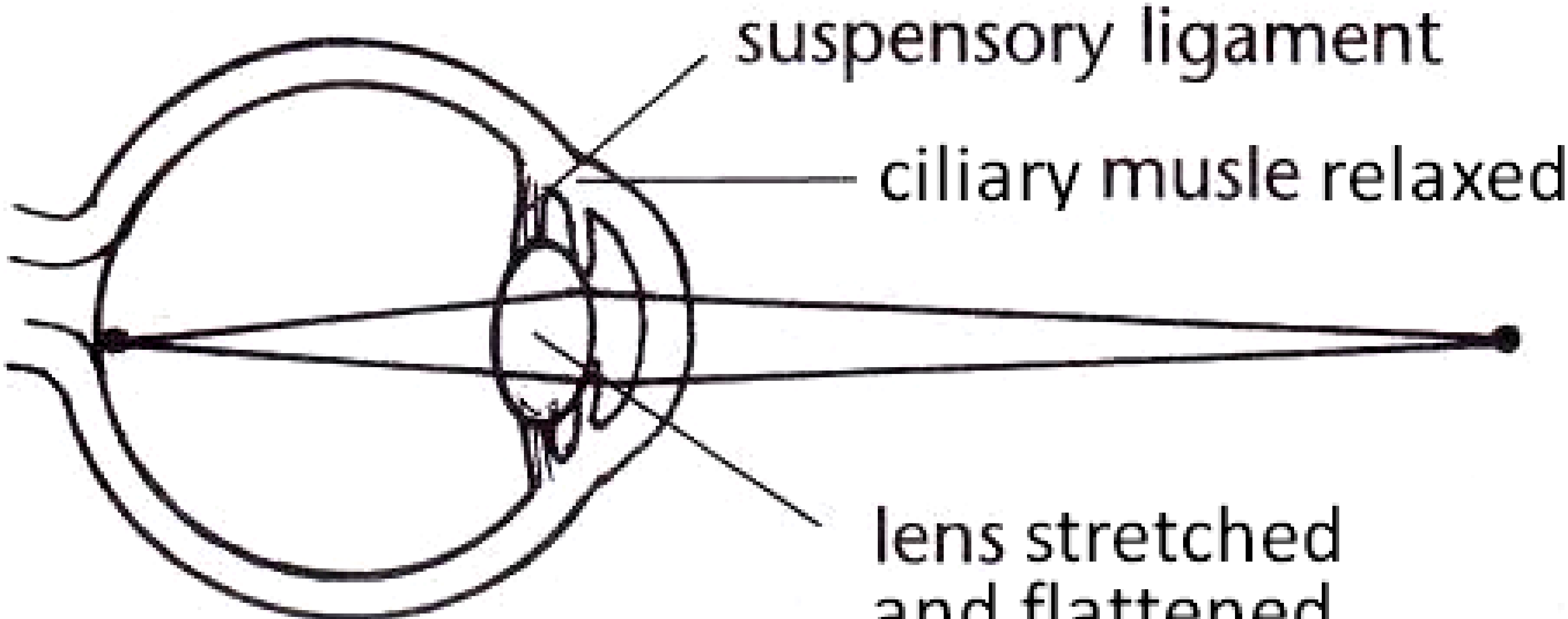
- When viewing distant objects, the ciliary muscles relax.
- This pulls the suspensory ligaments, which stretch and flatten the lens.
- When viewing near objects, the ciliary muscles contract.
- This relieves tension on the suspensory ligaments so that the lens bulges out and is more curved.
- This is called **accommodation** or the ability to focus the eye.

- The lens focuses the light rays to the retina through the vitreous humour.
- On the retina an upside down or inverted image is formed.
- This stimulates the cons and rods on the retina to form an impulse and send it to the brain through the optic nerve.
- The brain interprets the impulse to an actual image of what was observed.
- The image is then seen as an upright one.

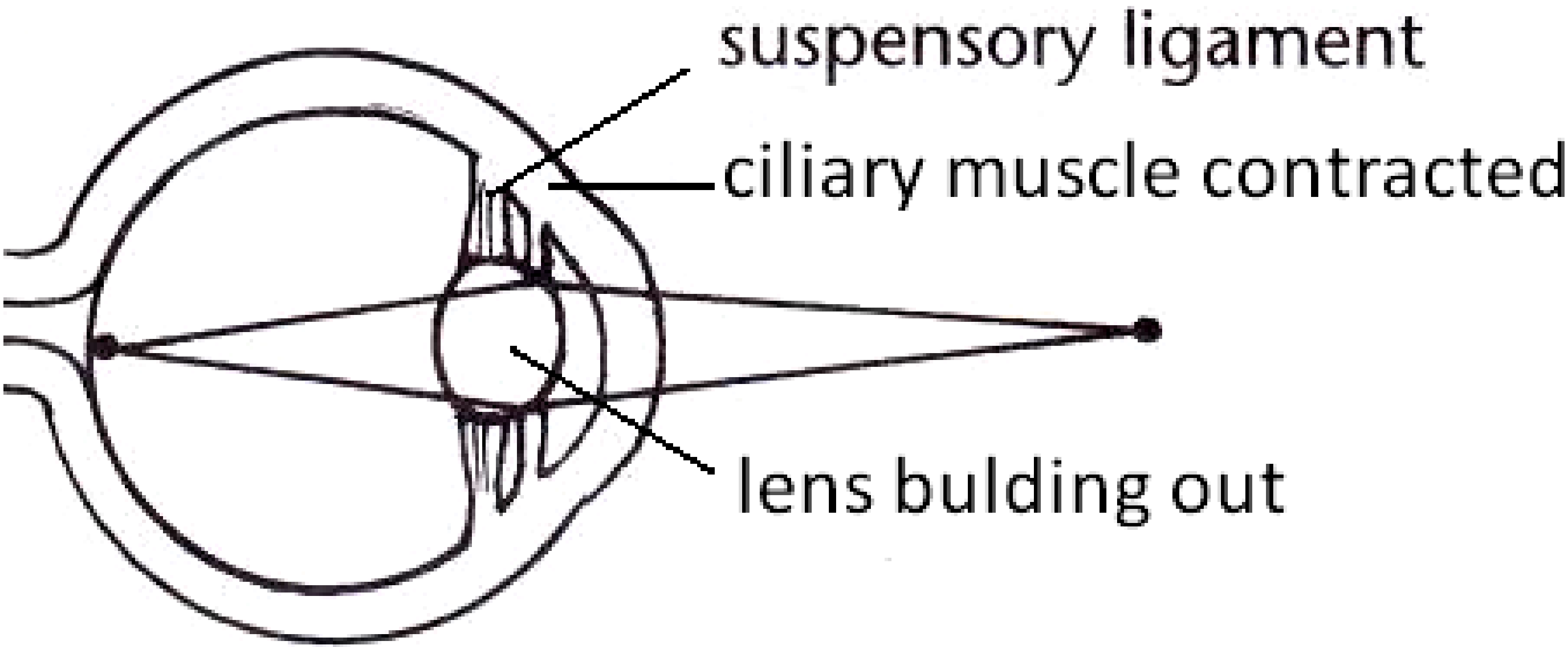
Image Formation on the Retina



Formation of an Image for a Distant Object



Formation of an Image for a Near Object



Defects of the Eye

- There are several defects of the eye including **long-sight**, **short-sight**, **blindness**, **cataract**, **glaucoma**, **astigmatism** and **lack of accommodation**.

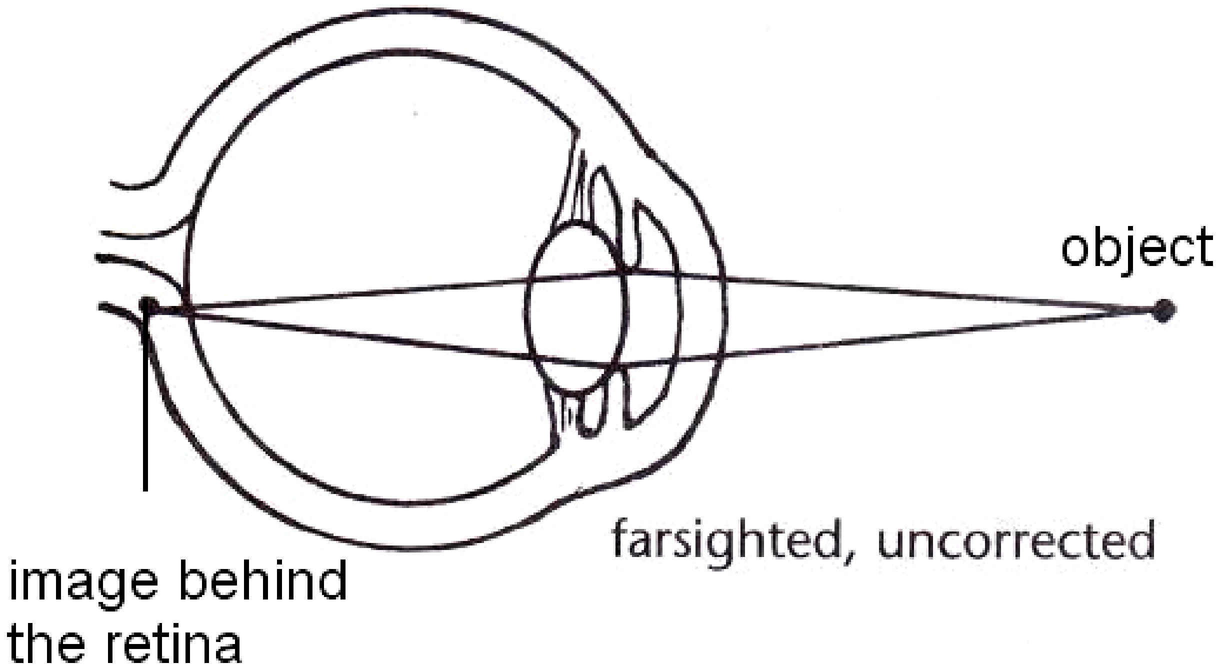
Long-sight or Far-sight

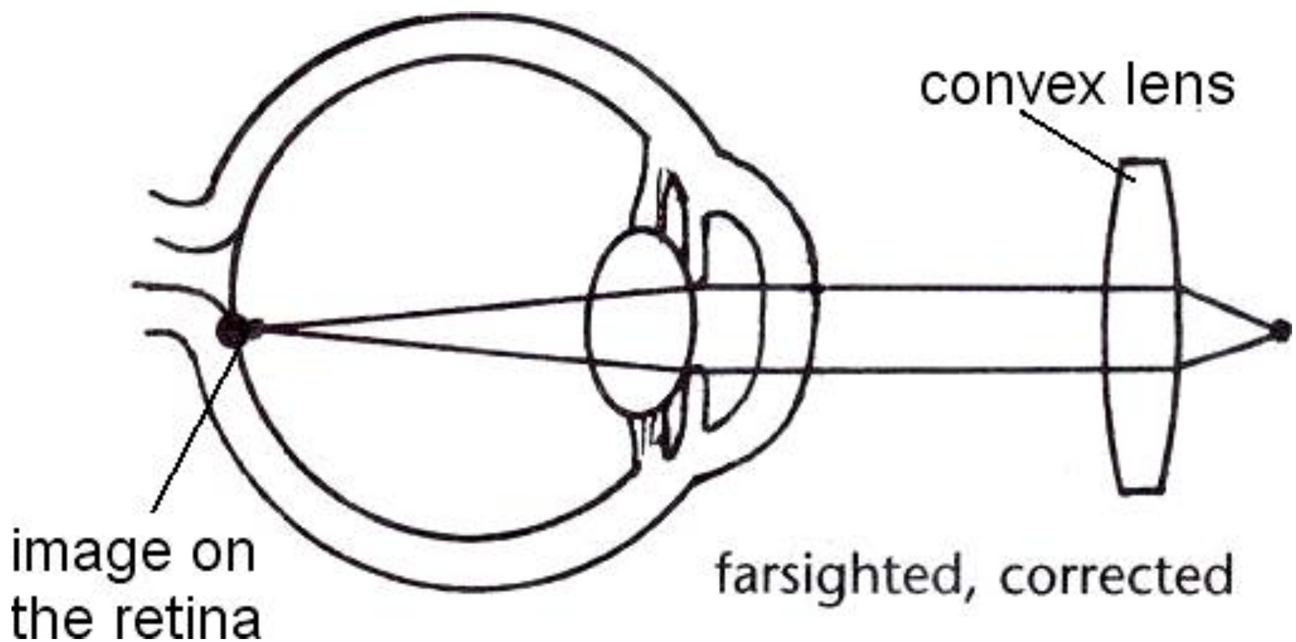
- This occurs when the eyeballs are too short so that the lens cannot focus an image from a near object.
- This defect allows an individual to see distant objects clearly, but not near objects.

- This is because images from distant objects fall on the retina while those from near objects fall behind the retina.

Correction of Long-sight

- Using spectacles with **convex** or **converging lenses**.
- These lenses converge the light before it enters the eye.
- This helps the eye-lens to focus the images of near objects on the retina


object
image behind
the retina
farsighted, uncorrected


convex lens
image on
the retina
farsighted, corrected

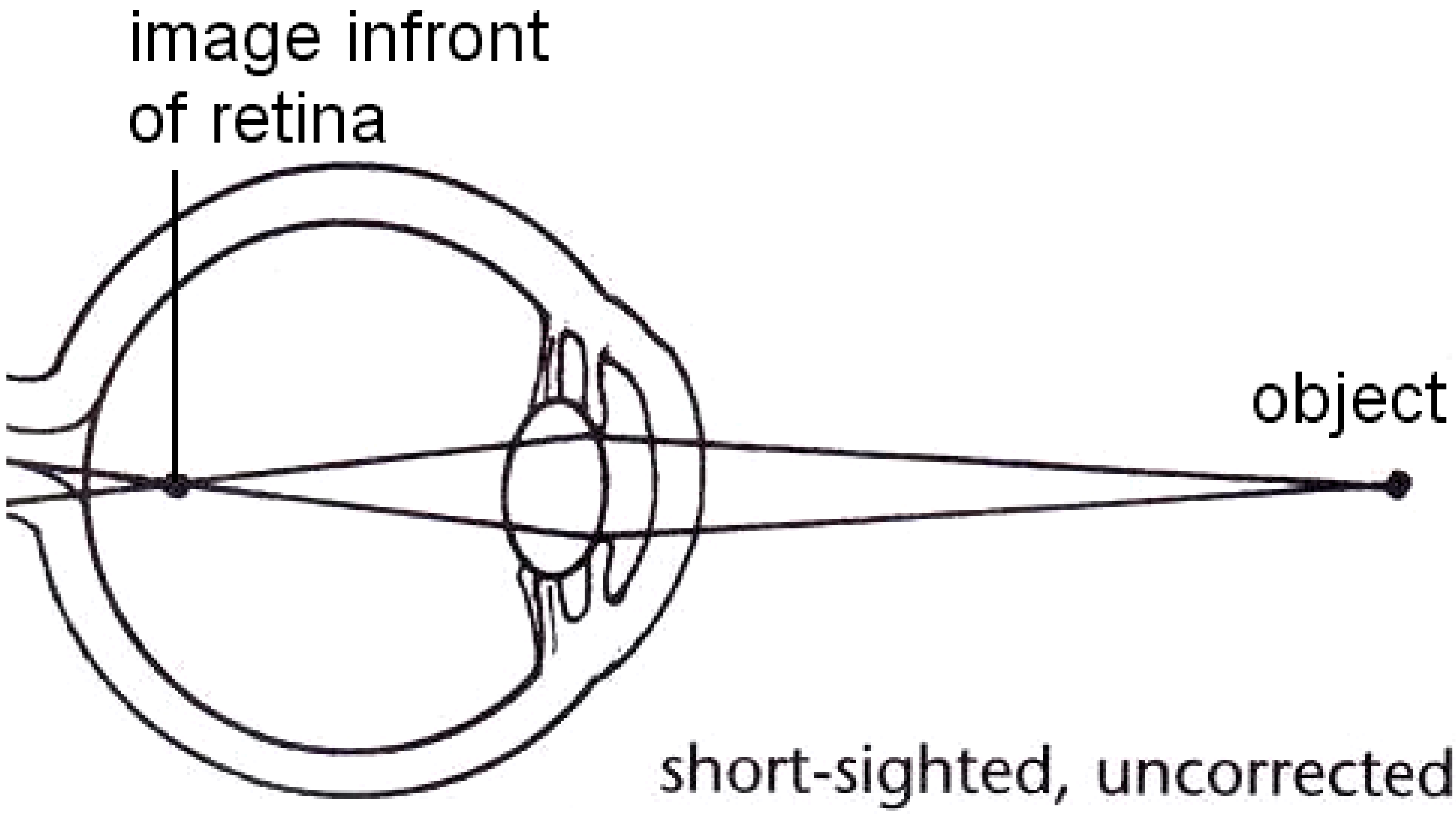
Short-sight

- Short-sight occurs when the eyeballs are too long so that the lens cannot focus an image from a distant object.
- A short-sighted person will see near objects clearly but not distant objects.
- Images from near objects fall on the retina, while those from distant objects fall in front of the retina.

Correction of Short-sight

- Use of spectacles with concave or diverging lenses corrects short-sight.

- The concave lenses spread out the light before it enters the eye.
- The lenses of the eye then focus the images of distant objects on the retina



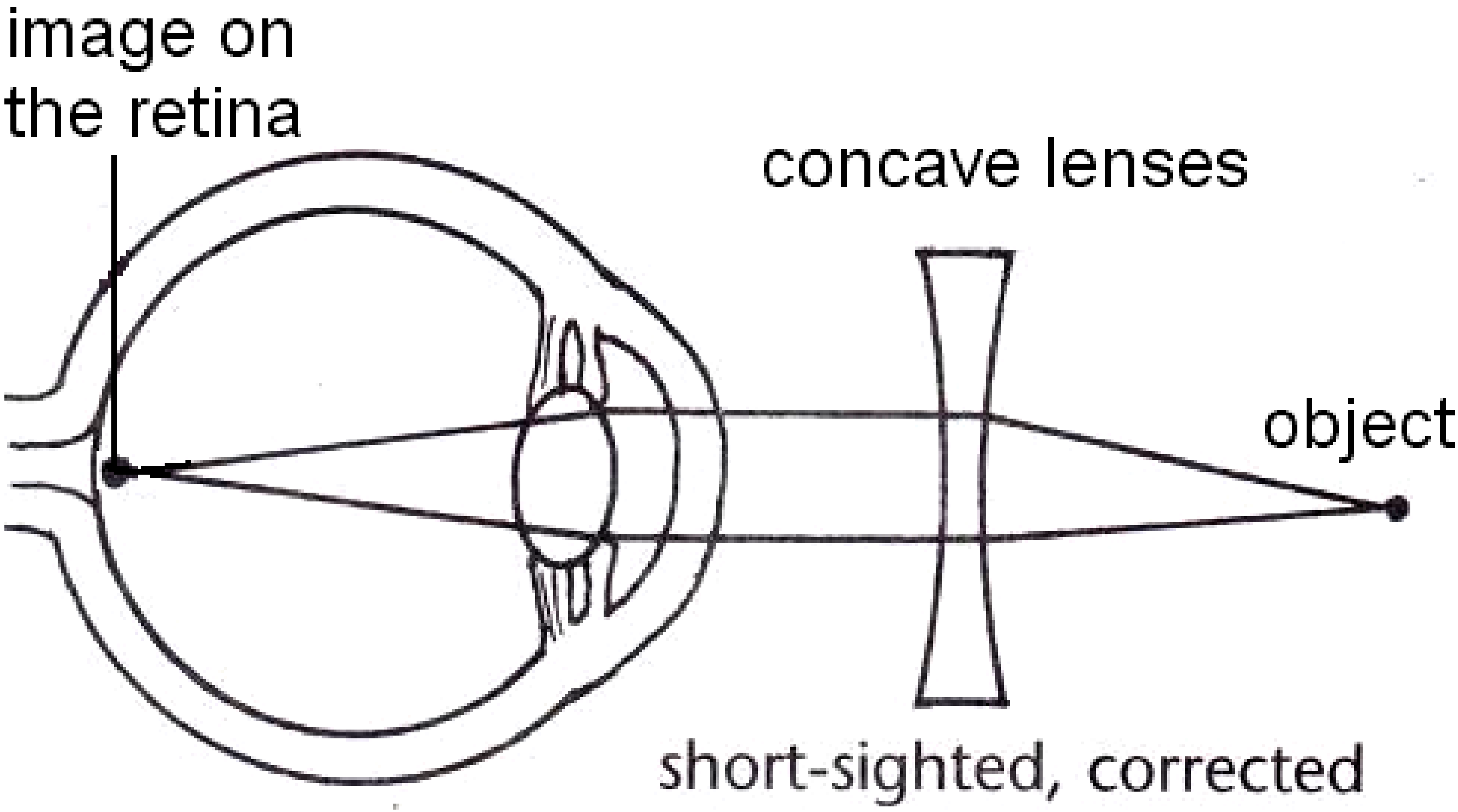


image on
the retina
concave lenses
object
short-sighted, corrected

Blindness

- Blindness occurs in various forms, including colour blindness, night blindness and total blindness.
- Colour blindness is the inability to distinguish between red, green and yellow colours, which is inherited from parents.
- Night blindness is the inability to see properly in dim light, which is caused by lack of retinol.
- Total blindness is a total loss of sight, which may be caused by diseases such as trachoma, syphilis, gonorrhoea or physical damage to the eye and its nerves.

Cataract (*Ching'ala*)

- Cataract occurs when the eye-lens loses its transparency to become stiff and opaque.
- Cataract may be due to **ageing**, **diabetes**, **exposure to intense heat** or **atomic radiation**.
- This results in less light entering the eye, making accommodation of the eye inefficient such that the person does not see well.
- It can be corrected by surgically removing the opaque lens and replacing it with a clear plastic or artificial lens.

Glaucoma

- This is a condition that mainly occurs in old people due to loss of the lens’ elasticity.
- It is caused by increased pressure inside the eyeball that damages the optic nerve, and causes blindness and great pain.
- This can be corrected surgically by making an incision in the sclera to allow the fluid to filter out.
- This ensures that pressure does not build up in the eyeball.

Astigmatism

- This is caused by an uneven surface of the lens or retina.
- Astigmatism distorts images falling on the retina, such that some parts of the image may be out of focus.
- The condition can be corrected by spectacles that are thickened in appropriate places.

Lack of Accommodation or Old Sight

- This occurs as people grow older, due to the gradual weakening of the ciliary muscles and loss of eye-lenses' elasticity.
- This results in the defective lenses' inability to accommodate to view near as well as far objects.
- It can be corrected by using **bifocal lenses**, which are spectacles with both **concave** and **convex** lenses.

Care for the Eyes

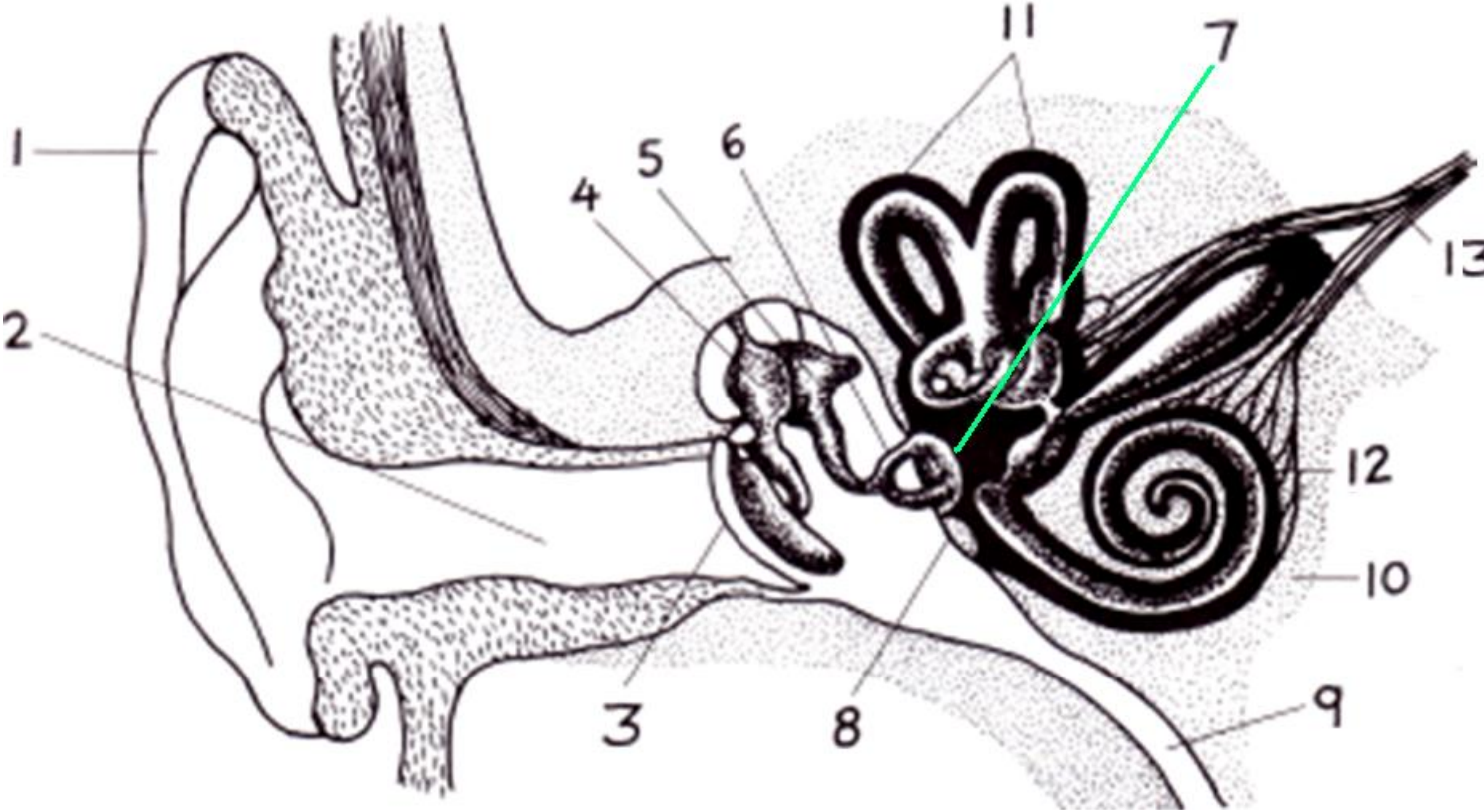
1. Avoid reading in very bright light , looking directly at the sun or at a very bright light. This can damage the retina.
2. Avoid holding a book too close when reading. This can make the ciliary muscles contact continuously, making them weak so that the eyeball loses elasticity.
3. Avoid reading in poor light such as candle light, because this can strain the eyes.
4. Avoid reading in a moving vehicle, because this can also strain your eyes.

5. Avoid using sunglasses indoors or at night. This can lead to poor sight.
6. Do not use spectacles that have not been prescribed by a doctor. This can also lead to poor sight.
7. If small particles or insects fall into your eyes, blink continuously or bathe your eyes in clean water. If the particles do not come out, then see a doctor.

The Ear

- This is a sense organ that allows us to hear and maintain balance.
- It contains sensory nerves that detect sound waves and movements of the head.
- It has **three** main parts:
    a. the outer ear
    b. the middle ear and
    c. the inner ear

The Human Ear



Parts of the Human Ear

1. Pinna
2. Auditory canal
3. Eardrum
4. Hammer
5. Anvil
6. Stirrup
7. Oval window
8. Round window
9. Eustachian tube
10. Skull bone
11. Semicircular canals
12. Cochlea
13. Auditory nerve

The Outer Ear

- The outer ear consists of the **pinna / earlobe**, **auditory canal** and the **eardrum**.
- The auditory canal is a narrow passage, which is covered by hairs and has glands that produce wax.
- The wax and hairs prevent dust and dirt from entering the ear.
- The eardrum is a flexible membrane that passes sound vibrations from the outer ear to the middle ear.
- It separates the outer ear from the middle ear .

The Middle Ear

- The middle ear is an air-filled chamber with **three** tiny bones collectively known as the **ossicles** suspended in it.
- The ossicles i.e. **hammer**, **anvil** and **stirrup** connect the eardrum to the oval window.
- They receive sound vibrations from the eardrum, amplify them and then pass them to the oval window.
- The Eustachian tube connects the middle ear to the pharynx.
- It equalises air pressure on both sides of the eardrum i.e. atmospheric and middle ear.

- If there is a difference in pressure between the air in the middle ear and atmospheric pressure, the Eustachian tube opens when you swallow or yawn.
- This allows air to enter or leave the middle ear.
- The **oval** and **round** windows are thin flexible membranes that transmit sound vibrations to the cochlea in the inner ear.

The Inner Ear

- The inner ear is located inside the skull bone and is filled with a watery fluid.

- The inner ear consists of the **semicircular canals**, **cochlea** and the **auditory nerve**.
- The cochlea is involved in hearing while the semicircular canals are for maintenance of balance and posture.

Hearing

- Sound waves passing through the air are collected by the pinna.
- The pinna directs the sound waves through the auditory canal to the eardrum.
- On reaching the eardrum, they cause it to vibrate.

- Vibration of the eardrum causes the ossicles to vibrate in turns.
- As these vibrations pass through the ossicles, they are amplified or strengthened.
- The vibration of the ossicles causes the oval window to vibrate and transmit the sound vibrations to the round window.
- This in turn sets up vibrations of the fluid inside the cochlea.
- The sensory cells connected to the cochlea are stimulated by these vibrations to produce nerve impulses.

- The nerve impulses are transmitted to the brain through the auditory nerve.
- The brain then interprets the nerve impulses as sound, which is learnt as it came from the source.

Defects of the Ear

- In some individuals, the vibrations from the outer ear may reach the inner ear but no stimulus is perceived.
- In other individuals, the ear becomes totally functionless leading to **deafness**.

Deafness

- Deafness is a condition where an individual is unable to hear.
- There are two forms of deafness: **conductive** and **nerve** or **absolute deafness**.

Conductive Deafness

- This is a condition where a person is partially unable to hear due to interruption of sound vibrations from the environment to the inner ear.
- Interruption of sound vibrations from the environment may be due to:

i. Failure of ossicles to amplify and pass sound vibrations to the inner ear.
ii. Failure of the eardrum to vibrate

Causes of Conductive Deafness

a. Accumulation of wax in the auditory canal.
b. Damage or puncturing or rupturing of the eardrum due to blows on the head or very loud sounds or sharp objects.
c. Ear infections leading to production of pus that reduces sound movement in the ear.
d. Use of certain drugs e.g. chloroquine in some individuals.

Correction of Conductive Deafness

a. Treatment of ear infections by ear specialists or Audiologists.
b. Removal of excess wax by audiologists.
c. Use of hearing aids. These are devices that are fixed in the auditory canal to amplify sound vibrations reaching the inner ear.
d. Learning lip reading skills and use of sign language in speech.
e. Surgery in case of too much bone growth in the ossicles.

Absolute or Nerve Deafness

- This is a condition where the sound impulses are unable to reach the brain.
- This may be due to:
  i. Damaged auditory nerve by the presence of tumour.
  ii. Damaged cochlea making them unable to perceive stimulus.
  iii. Damaged brain cells that are involved in sound reception.

Causes of Nerve Deafness

a. Infections of the inner ear e.g. measles, mumps and meningitis.

b. Skull fractures.

c. Loud explosions that damage he inner ear.

d. Deterioration of sensory nerve cells in the cochlea in old people.

e. Heredity, where a child is born with some parts of the inner ear either missing or functionless.

Correction of Nerve Deafness

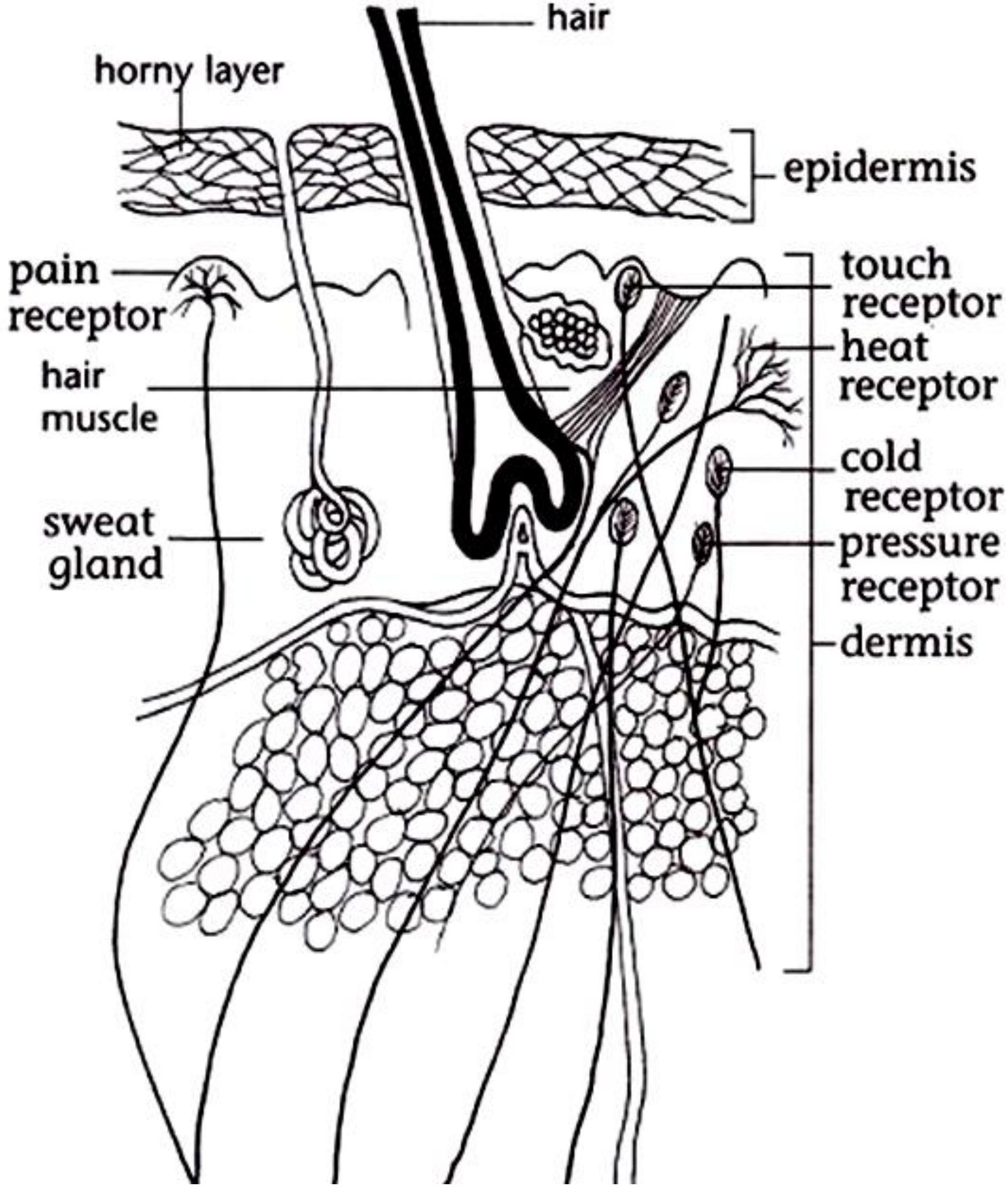
a. Use of sign language during speech

b. Learning lip-reading skills

Ear-care

a. Never scratch inside the ears with sharp objects to avoid damaging the eardrum.
b. Do not put substances into painful ears as this may introduce germs to an inflamed area.
c. Seek medical help if you have earache, ear discharge or hearing problems.
d. If an insect enters the ear, do not shine a light into the ear to look for it.
e. This makes the insect move deeper into the ear.
f. Do not attempt to remove a foreign object from a child's ear, but take the child to a doctor.

Parts of the Skin



- The skin is a sense organ that detects **touch**, **pressure**, **pain**, **cold** and **heat**.
- It has **two** main layers, the **epidermis** and the **dermis**.

The Epidermis

- The outer most layer in the epidermis is the **horny** or **cornified layer**.
- It consists of dead cells, which form a protective layer that acts as a barrier to against entry of micro-organisms.
- It also reduces water loss and protects inner cells from mechanical damage.

The Dermis

- The dermis is located below the epidermis and is thicker than it.
- It contains different kinds of receptors for detecting touch, pressure, pain, cold and heat.
- These are more concentrated in certain parts of the body than in others.
- For instance the fingertips have more touch receptors while the upper arm has more heat and cold receptors.
- The dermis also contains blood capillaries, hair follicles, sweat glands and sebaceous glands.

- Blood capillaries supply the cells in the skin with oxygen and nutrients, and remove waste products.
- The sweat glands produce sweat, which is removed from the skin through sweat ducts.
- Excess salts, urea, lactic acid, water and other wastes are excreted from the skin as sweat.
- The sebaceous glands produce oil, which keeps the skin soft.
- The oil also prevents certain kinds of bacteria from entering the body.
- It also makes the hair repel water.

Other Functions of the Skin

a. Regulation of body temperature.
b. Prevention of entry of bacteria into the body.
c. Prevention of water loss.
d. Prevention of frictional damage especially on the soles of the feet and palms of hands.
e. Excretion of waste products.
f. Protection against radiation from the sun.
g. Storage of fats.
h. Production of vitamin D when the sun shines on the skin.

Skin-care

a. Clean your skin regularly by taking a warm bath or shower daily. Washing the body with soap and warm water helps to remove sweat, natural oils and dirt.
b. Keep your skin dry, especially between toes to avoid fungal infection after washing.
c. Avoid applying chemicals that can destroy the skin.
d. Wear gloves when handling some chemicals in the home or in industry.
e. Examine your skin regularly for signs of diseases and seek medical help accordingly.

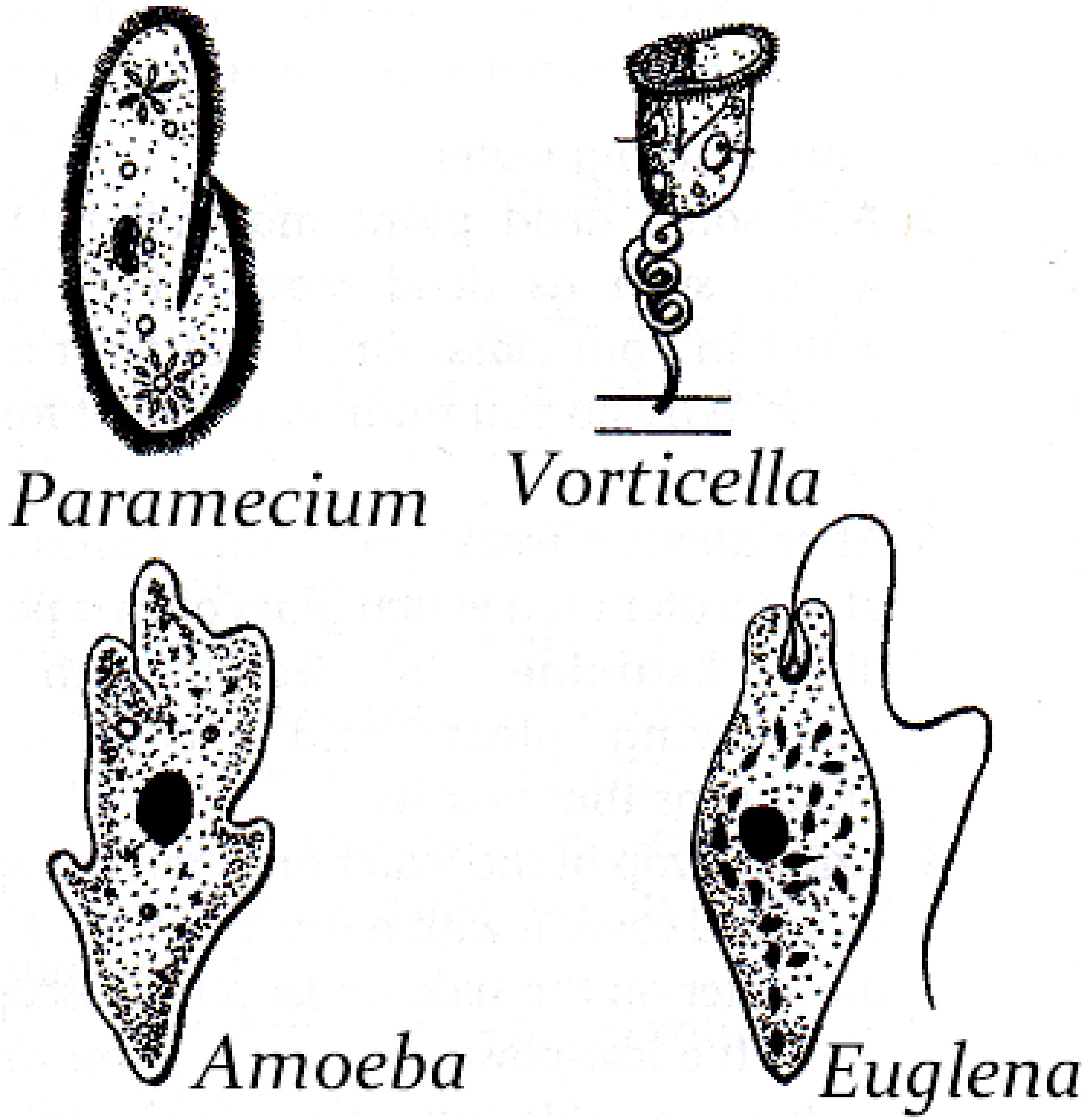
MICRO-ORGANISMS

- Micro-organisms are living things that cannot be seen with the naked eye.
- They include protozoa, bacteria, viruses and many groups of algae and fungi.
- Examples of micro-organisms include amoeba, volvox, spirogyra, paramecium and euglena among others.

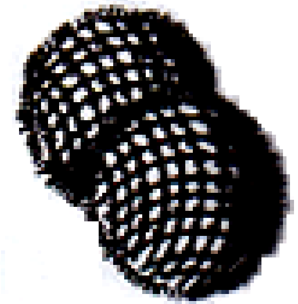
Groups of Micro-organisms

- The main groups of micro-organisms are **fungi**, **bacteria**, **protozoa**, **algae** and **viruses**.

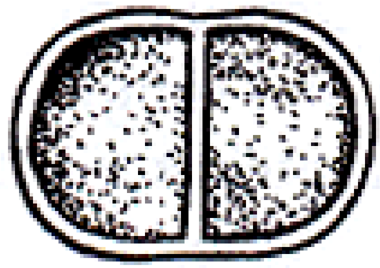
Examples of Micro-organisms Found in Water



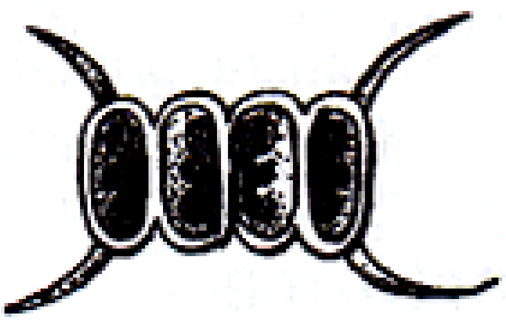
Diatom



Volvox



Protococcus



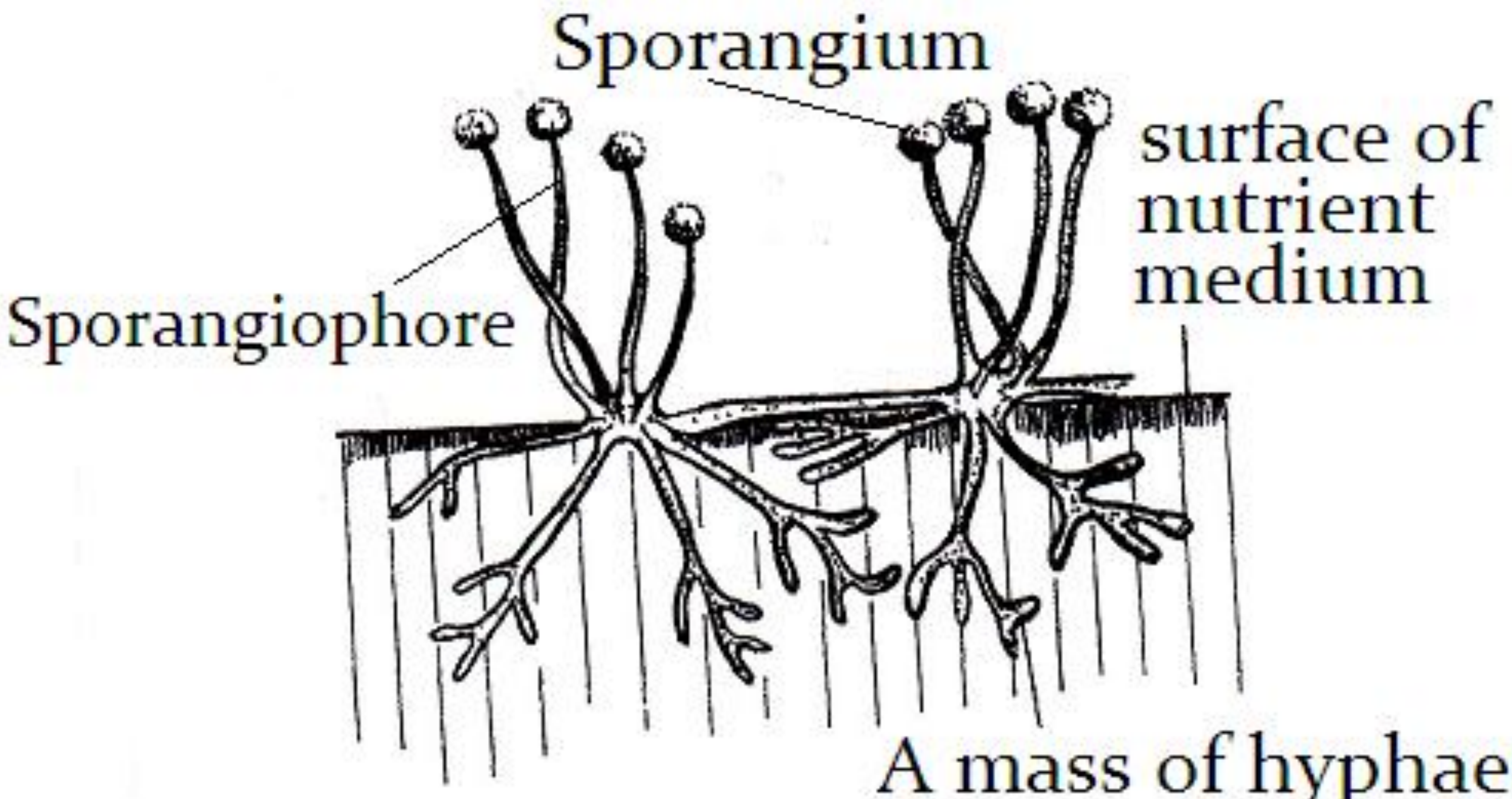
Spyrogyra

Stylonychia

Fungi

- Examples of fungi include bread mould, yeast and mushrooms among others.
- Although some kinds of fungi look like plants, they do not have roots, stems and leaves.
- Thus they cannot make their own food, but live on dead and decaying plant or animal matter, or on other living organisms.
- For instance, bread mould grows on materials containing starch, like bread and *nsima*.

Bread Mould


Sporangium
surface of nutrient medium
Sporangiophore
A mass of hyphae

Reproduction in Fungi

- Most fungi reproduce asexually through spores.
- When spores land on moist bread or *nsima*, they germinate and grow fungal threads or filaments called **hyphae**.
- As the mould grows older, some of the hyphae grow upright with little black dots called **sporangia**, forming at the ends.
- Each sporangium or spore case contains many small spores.
- Sporangia are white when young but turn black as the spores ripe.

- The sporangia eventually burst and release the spores that are easily blown away by wind.

Useful Fungi

a. Edible mushrooms.
b. Yeast used in baking bread and brewing beer.
c. **Penicillium** from which penicillin is extracted.
d. Moulds that decompose dead plants and animals into humus.

Harmful Fungi

a. Those that spoil bread and other foods;
b. Those that cause food poisoning.
c. Those that destroy.
d. Those that destroy certain kinds of plastic and leather.
e. Those that cause skin infections such as athlete's foot (*nyasi*) and ringworm (*chipere*).

Yeast

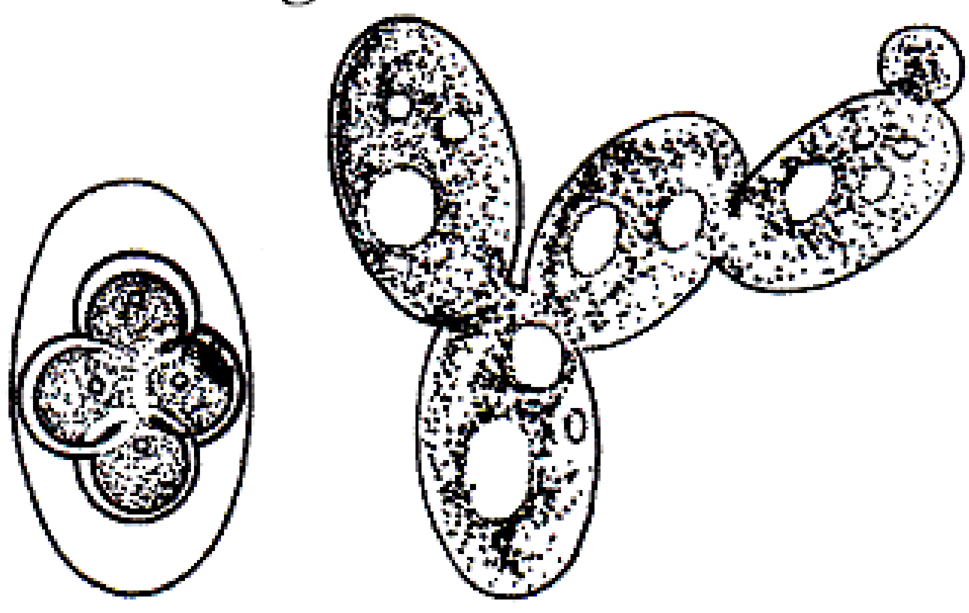
- Yeast is a fungus that consists of small single cells.
- It is naturally found in solutions containing sugar such as the juices of ripe fruits.
- The yeast cells feed on sugar, and grow and reproduce.

Reproduction in Yeast

- Yeast cells reproduce by **budding**.
- Each cell forms a projection called a bud, and the cell's nucleus divides into two.

- One part of the nucleus moves into the bud, which eventually separates off.
- Budding takes place so fast that a new bud may form on the young bud before it separates from the parent cell.
- In this way it forms a chain of cells.

Budding in Yeast Cells



Commercial Uses of Yeast

1. **Bread-making**

   When yeast is added to flour paste or dough, carbon dioxide escapes from the dough, which makes it to rise.

2. **Beer-making**

   Malt i.e. sugar obtained from germinating millet or maize grains, is fermented by adding yeast to produce alcohol.

3. **Wine-making**

   Fructose that is naturally found in grapes is fermented to produce alcohol.

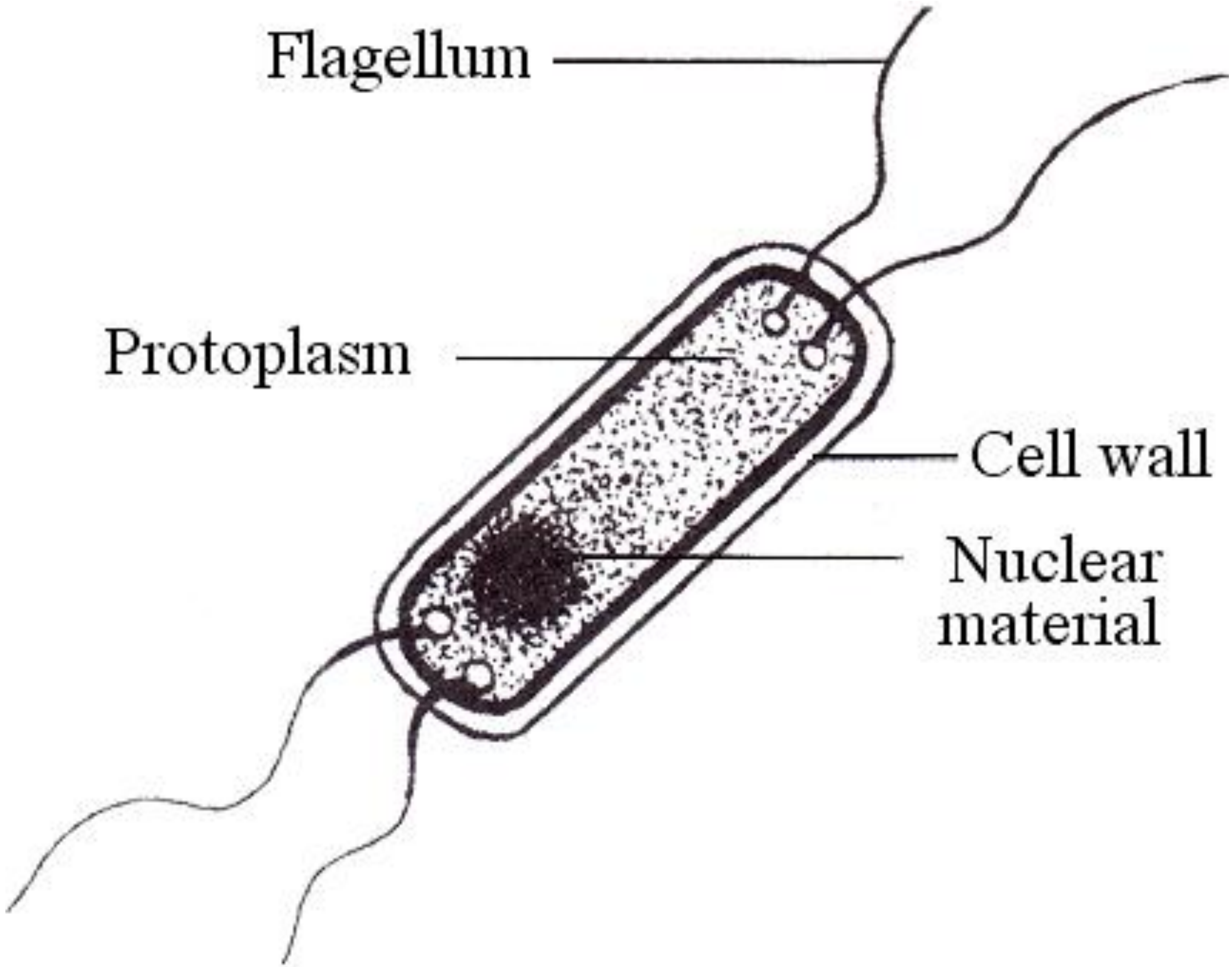
4. **Vitamin Supplements**

   Yeast cells are rich sources of the vitamin B complex, so they are used to make vitamin supplements.

5. **Production of Antibiotics**

   - Some moulds that produce antibacterial substances are used to make antibiotics such as *Penicillin*.
   - Many antibiotics such as **streptomycin** come from *Actinomycetes*, which are micro-organisms living in the soil.

Bacteria



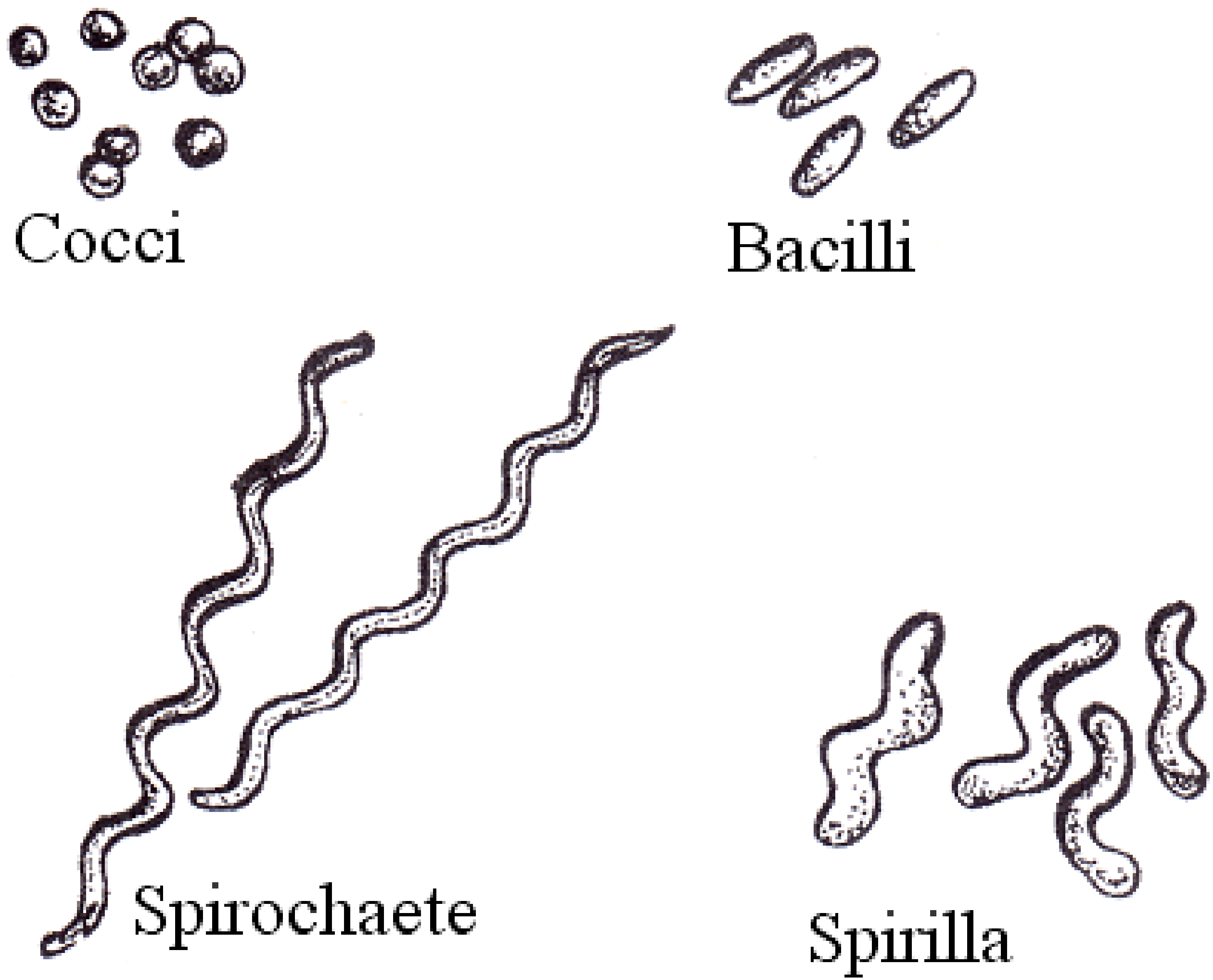
- Bacteria are unicellular organisms which are so small that they are only just visible with the high-power objective.
- On average, a bacterium is about 0.0001 mm wide.
- A bacterium consists of a mass of protoplasm surrounded by a cell wall.
- The cell wall consists of protein material that may also contain lipids.
- However, bacterial cell wall does not have cellulose as in most plant cells.

- Its nuclear material does not form a definite nucleus and is not bounded by a nuclear membrane.
- Some bacteria have one or more filaments called **flagella** (singular: flagellum).
- Flagella help the bacteria to move through liquids like water and blood.
- Most bacteria have no chlorophyll and cannot make their own food, hence they live as saprophytes or parasites.

Reproduction in Bacteria

- Bacteria reproduce by binary fission.
- Thus each bacterial cell divides into two.

Classification of Bacteria



Cocci (singular: coccus)

- These are spherical in shape and are of different types:
  - **Crumps**, which occur in groups clumped together e.g. **Staphylococcus aureus** that causes boils.
  - **Diplococcus**, which occur in pairs but joined together within a membrane e.g. **Pneumoniae** that causes pneumonia
  - **Streptococcus**, which occur in chains e.g. the bacteria that cause sore throat.

Bacilli (singular: Bacillus)

- These are rod-shaped bacteria.
- They may have one/more flagella or may lack the flagellum.
- Examples include ***Bacillus anthracis*** which causes anthrax; ***Bacillus typhosus*** which causes typhoid; ***Vibrio cholerae*** which causes cholera.

Spirilla (singular: Spirillum)

- These are spiral in shape with cured rods.
- An example is the ***Treponema pallidum*** which causes syphillis.

Beneficial Effects of Bacteria

1. Some bacteria help to improve of soil fertility.
   a. Saprophytic bacteria in the soil decompose organic matter
   b. Rhizobium bacteria fix nitrogen in the soil, which is needed by plants.
2. Other bacteria help to manufacture vitamins B12 and K in some mammals' colon.
3. Certain bacteria help to digest cellulose in the herbivores' alimentary canal.
4. Some bacteria are needed for butter and cheese-making.

5. Some bacteria are used to manufacture certain kinds of antibiotics.
6. Certain bacteria are used to manufacture vitamin B12 and other substances, which are important in the food industry e.g. enzymes, vinegar, lactic acid and citric acid.
7. Bacteria and other micro-organisms are used in sewage treatment.
8. Saprophytic bacteria decompose dead plant material during compost-making.
9. Production of hormones such as insulin.

Harmful Effects of Bacteria

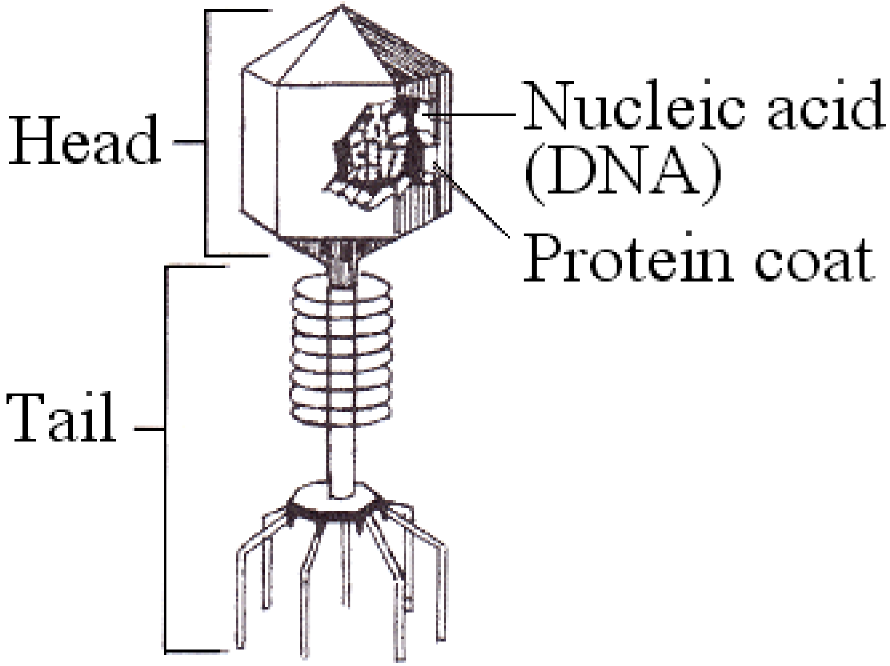
1. Causing diseases in humans, animals and plants e.g. Tuberculosis, Diptheria, Tetanus, Whooping cough, Leprosy, Meningitis etc.
2. Causing food spoilage e.g. fresh fish start to rot when bacteria feed on it.
3. Causing damage to wood in buildings.

Viruses

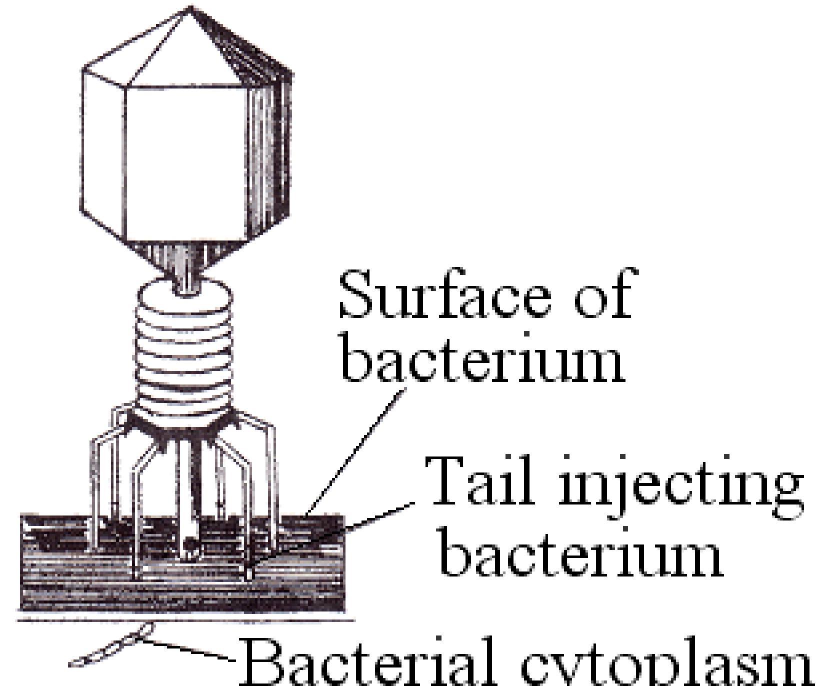
- Viruses are much smaller than bacteria and can only be seen through the use of an electron microscope, with a very large magnification.

- Viruses have simple structures.
- They can only grow and reproduce inside a plant, animal or bacterial cell.
- This is because they are parasites that need materials from other organisms for their survival.
- Viruses are sometimes grouped according to their host organisms i.e. animal viruses, plant viruses and bacterial viruses.
- Animal viruses cause diseases like measles, mumps, chicken pox, common cold, influenza and poliomyelitis in humans.

- They also cause rabies and foot and mouth disease in animals.
- Plant viruses cause mosaic disease of cassava and tobacco.
- Bacterial viruses are also known as phages or bacteriophages.
- Some viruses have projections that help them to attach to the cell they infect.
- Once a virus has attached itself to a cell, it makes the cell replicate more of the viruses.
- Eventually the cell is killed and the new viruses break out and infect other cells.



A Bactriophage



A bacteriophage attacking a bacterium

Biotechnology

- *Biotechnology* is the use of living systems and organisms to develop or make useful products and materials.
- It also refers to any technological application that uses biological systems and living organisms to make or modify products or processes for specific use.
- For example, a cell is taken from the best plants in a crop and then cultured in the laboratory to produce cell tissues.

- The tissues develop into similar plants from which the original cell was taken.
- This system of growing plants from a single cell is called **tissue culturing**.
- Tissue culturing technique has enabled the development of superior strains of banana trees that grow faster and produce better fruit, which increases banana output tremendously.
- Microbes such as bacterial and fungi or biological systems such as enzymes can be used to perform specific industrial or manufacturing processes.

- For example, the use of a fungus to make a protein-rich food called **mycoprotein** in a technique known as ***Fusarium*** as follows:
    - The fungus is first cultured in a carbohydrate.
    - It is then artificially flavoured and spun so that it has the taste and texture of chicken and other forms of meat.
    - Mycoprotein is useful where other sources of protein are in short supply and is also suitable for vegetarians.

Other Examples of Biotechnology in Use Today

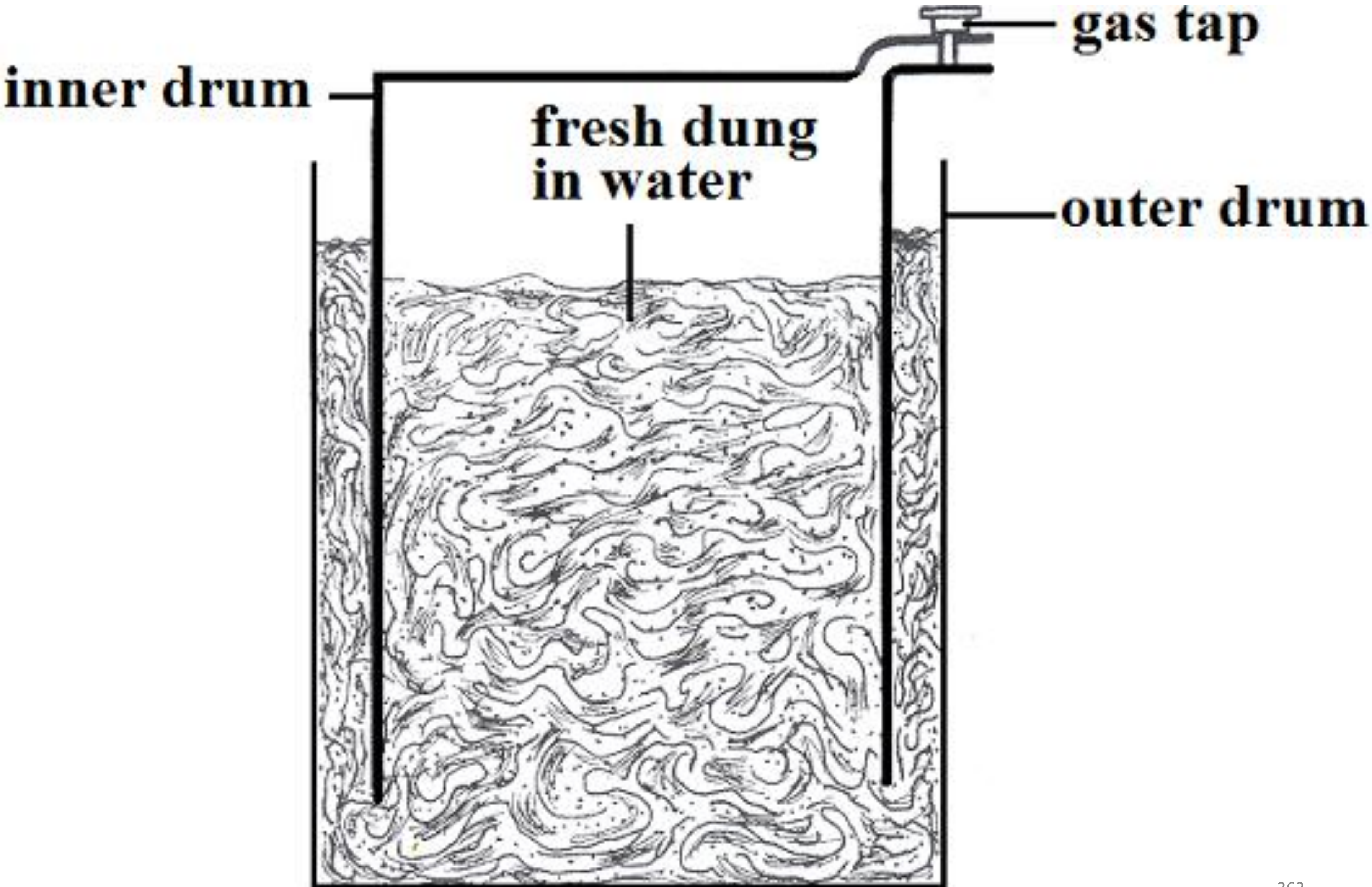
a. Production of the synthetic hormones such as insulin, which is used by diabetic patients to control their blood sugar.

b. Production of new breeds and types of crops to improve agricultural production through **tissue culturing**.

c. Production of genetically modified organisms (GMO), where plants and animals' genes are altered to produce certain desired traits.

d. Conversion of organic waste to harmless forms and cleaning up of oil spills in the ocean.

Using Bacteria to Produce Fuel (Biogas)



- One of the alternative sources of energy to fuelwood is **biogas**.
- Biogas is a methane gas produced during the bacterial decomposition of animal dung in a biogas digester.

Procedure

1. Fill three-quarters of a large drum with fresh dung.
2. Invert a smaller drum over the larger drum and attach a pipe and a tap closed tightly to the smaller drum.

- Methane gas, which is one of the products of decomposition, can be used as fuel.
- As the gas is produced, it lifts the inner drum and can be let out through the tap when required.
- Biogas can be used for lighting or cooking if connected to a gas lamp or a gas stove.
- Afterwards, the dung can be used as manure in fields.

Distribution of Micro-organisms in Nature

- Micro-organisms such as bacteria are found everywhere.
- They are found in air, water, soil, objects, food, mouth, alimentary canal, skin, clothes and surfaces of tables among others.
- They reproduce very quickly.
- For instance, one bacterium cell can reproduce very rapidly to form a large number collectively called a **colony**.
- A colony contains thousands of microbes, which together can be seen with a naked eye.

- The process of growing micro-organisms is called **culturing**.
- When conducting experiments on micro-organisms, **aseptic techniques** are used.
- Micro-organisms on the apparatus and in the surroundings can be destroyed through a process called **sterilisation**.
- Antiseptics and disinfectants are chemicals that kill or inhibit the growth of micro-organisms on an object.
- Disinfectants include Dettol and Javel while antiseptics include methylated spirit, soaps and also Dettol.

Food Storage and Preservation

- Micro-organisms cause a lot of damage to stored foods such as meat, fish, milk, fruit and vegetables.
- Necessary steps need to be taken to control the growth and multiplication of micro-organisms that spoil food.
- The following are various ways of preserving foods, which either kill micro-organisms or make them inactive, so that they do not multiply.

1. **Pasteurisation**
    - This method is used for preservation of liquids or liquid pulps such as ice-cream.
    - The liquid's temperature is raised to 65–70˚C for 30 minutes and then cooled rapidly to 10˚C and refrigerated.
    - Pasteurisation reduces the number of microbes in the liquid e.g. milk.
2. **Refrigeration and Freezing**
    - This involves storing the food in extremely low temperatures, usually 4˚C and below, which make the micro-organisms inactive.
    - Meat, fish and milk can be preserved in this way.

3. Salting

- In this method salt is applied on a food substance.
- Salt causes water to leave the tissues of the food substance, which becomes dehydrated.
- At the same time all the micro-organisms on the food are dehydrated and they die.
- Meat and fish can be kept in salt for long periods without decay.

4. Smoking

- Smoking dries the surface of food and coats it with substances that stop micro-organisms' growth. Meat and fish can be smoked.

5. **Drying or Dehydration**
   - This minimises moisture, which makes the micro-organisms inactive and hence no decay can take place on food.
6. **Canning and Bottling**
   - The food is heated at high temperatures and pressures, which kill micro-organisms.
   - The cans and bottles are then sealed in a vacuum under carbon dioxide to discourage any growth or entrance of micro-organisms
   - Meat, fish, fruit and vegetables are examples of food preserved by canning.

7. Chemical Preservation

- Substances such as lactic acid, vinegar, sulphur dioxide, benzoic acid or sodium benzoate, which are harmful to microbes, but not harmful to humans are used.
- For example many vegetables, fruits and fruit juices are preserved by acidic chemicals.

8. Sugar

- High concentrations of sugar make water unavailable for micro-organisms' growth.
- For example jam and honey have high sugar concentrations and do not spoil easily.

9. Wood Treatment and Seasoning

- Apart from food, other materials such as timber can be damaged by micro-0rganisms.
- These materials can be treated by chemicals that kill micro-organisms.
- Painting for example prevents microbes from getting into contact with the materials.
- Wood treatment involves infusion of chemicals into wood to prevent rotting due to fungal attack.
- Wood seasoning involves drying wood to ensure that it is not easily attacked by fungi.

Conditions for the Growth of Micro-organisms

- There are **six** conditions that support the growth of micro-organisms, with the exception of viruses i.e. food, pH levels, warmth/temperature, time, air/oxygen and moisture.

Food

- Micro-organisms need nutrients to grow on and are especially happy with carbohydrates and proteins.

pH Levels

- Micro0rganisms grow well in the slightly acidic range of 4.6 – 7.5, which also happens to be where most foods lie.

Warmth/Temperature

- Most micro-organisms like warmth and will grow at temperatures between 5°C and 63°C, commonly referred to as the **growth** or '**danger**' **zone**.
- They have an optimum temperature for growth of about 37°C, where they multiply more rapidly.
- Micro-organims stop growing at temperatures above 63°C, however, they are destroyed at temperatures above 70°C for 2 minutes during the normal cooking process.

Time

- Microorganisms need time to grow and with the right environmental conditions, they are capable of doubling their numbers in just 20 minutes.
- If food is left in the danger zone for four hours or more, the levels of microorganisms could be high enough to make someone ill.

Air/Oxygen

- Some micro-organisms need oxygen in order to multiply, but not all of them do as others are anaerobic.

Moisture

- Microorganisms need the free flow of water, which is vital for their cells to exchange materials and for their metabolic processes.
- Most food-borne microorganisms need some amount of moisture to grow/multiply.
- The moisture in potentially hazardous foods is just right to provide the organisms what they need to grow.

Note:

Understanding what microorganisms need to grow will help to keep them from growing, thus helping to keep food safer.

DIARRHOEAL DISEASES

Diarrhoea

- Diarrhoea is the continual defecation of loose watery stools due to an infection of the gut.
- The intestines fail to hold food to allow digestion or even absorption of water to occur.
- Diarrhoeal diseases are the fifth most common causes of death of children under five years of age.
- Examples of diarrhoeal diseases include Cholera, Typhoid and Dysentery

Cholera

- Cholera is an acute infection of the intestinal tract.
- It is caused by a bacterium called ***Vibrio cholerae***, which is spread through contaminated water.
- Cholera is therefore a water-borne disease.
- Cholera is a very common problem in the rainy season, especially where sanitation is poor and where disposal of faeces lead to water and food contamination.

- Once contaminated food or water is ingested, the bacteria undergo an incubation period of 1 to 6 days.
- They then multiply rapidly in the ileum and produce highly toxic substances that are responsible for the sudden severe symptoms of cholera.

Symptoms of Cholera

a. Severe diarrhoea.
b. Nausea and severe vomiting.
c. Severe abdominal pain.

d. Acute thirst and muscle cramps.
e. Severe dehydration.
f. Collapse, shock and in many cases death.

Prevention and Treatment of Cholera

a. Isolation of patients and care givers.
b. Give patients plenty of fluids, such as water and oral rehydration solution (ORS).
c. Vaccination of people in areas under threat of infection during a cholera outbreak.
d. Construction of proper toilets or pit latrines, especially in crowded areas.

e. Boiling or properly treating drinking water to ensure that water is safe.
f. Observation of general rules of hygiene such as washing hands with soap and water before and after touching the cholera patient.
g. Ensuring cleanliness of hands before touching or preparing food, and after using the toilet.

Dysentery

- Dysentery is diarrhoea with blood in faeces.
- It is caused by a bacterium called ***Shigella***.

- It is transmitted through contaminated food and water, and through direct person-to-person contact (e.g. on contaminated hands).
- When the bacteria reach the large intestine, they cause ulcers that may form holes in the intestinal wall.
- This can result in death.

Symptoms of Dysentery

a. Visible blood, mucus or pus in the stools.
b. Fever.
c. Nausea and vomiting.

d. Stomach cramps.

e. Flatulence.

- Another form of dysentery, **Amoebic Dysentery**, is caused by an amoeba called ***Entamoeba histolytica***.
- The amoeba is transmitted through uncooked and unhygienic preparation of food.
- *E. histolytica* lives and multiplies in the colon, where it destroys the gut epithelium and the blood capillaries, and causes formation of ulcers.

- The ulcers lead to the release of blood into the intestine.
- The parasite then feeds on the red blood cells.

Symptoms of Amoebic Dysentery

a. Acute diarrhoea with blood and mucus.
b. Abdominal pain and cramps.
c. Fever.
d. Nausea and vomiting.
e. Very weak and ill.
f. In chronic cases, the patient becomes anaemic.

Prevention and Treatment of Dysentery

a. Taking the patient to the hospital for proper medical attention.
b. Washing hands after visiting the toilet; contact with faecal matter and soiled napkins; before preparing and eating food, and before feeding children.
c. Exclusive breast-feeding until babies are six months old.
d. Food safety.
e. Disinfection of linen, clothes and other articles in the patients surrounding.

f. Proper disposal of human waste.
g. Intensifying health education messages about diarrhoea prevention and control.
h. Giving oral rehydration solution (ORS).

Typhoid

- Typhoid is a deadly diarrhoeal disease that is quite common in Malawi.
- It is caused by a bacterium called ***Salmonella typhi***.
- The bacteria are transmitted through contaminated water and food.

- The disease can also be spread through flies, which feed on infected excreta and deposit it on human food.
- In addition, ***Salmonella typhi*** can be spread by *carriers*.
- A *carrier* is a healthy person who is infected with the pathogen but does not show any signs of the disease.
- Foods most readily contaminated with ***Salmonella typhi*** include tinned meat, fruits, salads and milk and milk products such as yoghurt and *chambiko*.

- *Salmonella Typhi* has an incubation period of two weeks.

Symptoms of Typhoid

a. Abdominal pain.
b. Severe diarrhoea followed by constipation.
c. General weakness.
d. Fever.
e. Headache and poor appetite.

- *Salmonella* cause ulceration and breakdown or rupture of the intestinal wall, which may result in death.

- Organs such as the liver and spleen can also become infected if the bacteria penetrate through the intestine into the bloodstream.

Prevention and Treatment of Typhoid

a. Isolation of the patients to avoid spread of the disease by contact.
b. Seeking medical attention as soon as possible.
c. Sterilising the patient’s clothes by boiling or using disinfectants.
d. Food handlers in schools, hospitals, hotels, lodges, restaurants etc should go for regular check-ups and treated if found infected.

e. Proper disposal of faeces and urine.
f. Water treatment and purification.
g. Proper sewage treatment to kill or destroy the bacteria.
h. Households and their surroundings should be kept clean to prevent flies from breeding in them.
i. Vaccination in the case of outbreaks of the disease.
j. Giving civic education to avoid contamination.
k. Any known typhoid carriers should be isolated and treated.

Home Treatment for Diarrhoeal Diseases

- There are several ways to treat diarrhoeal diseases at home, which include:
  a. Give the patient plenty of fluids to prevent dehydration.
  b. Continue the patient's usual diet during and after diarrhoea.
  c. If the child is being breast-fed, continue breast-feeding. Breast milk is a nourishing food and an important fluid for children suffering from diarrhoea.

d. Give infants below four months of age ORS or water that is boiled and cooled.
e. Give infants and children above four months salt-containing fluids, *thobwa*, thin porridge, rice water or vegetable soup.
f. Take the patient to the hospital.

General Prevention and Control of Diarrhoea

a. Vaccination.
b. Water treatment.
c. Proper disposal of human excreta.
d. Observing personal and food hygiene.
e. Health education.

SEXUALLY TRANSMITTED DISEASES

- Sexually transmitted diseases (STDs) are a group of contagious diseases that are spread by sexual contact.
- They are a great concern throughout the world, including Malawi.
- STDs can result in serious complications that may lead to death.
- Some STDs can be treated, but others cannot be cured.
- Males usually show STDs' symptoms faster than females.

Common Sexually Transmitted Diseases

- Gonorrhoea (*Chinzonono*)
- Syphilis (*Chindoko*)
- Chancroid (*Mabomu*)
- Chlamydia
- Candidiasis
- Genital warts
- Genital herpes
- Herpatitis B.
- Trichomoniasis
- HIV and AIDS

1. Gonorrhoea

- Gonorrhoea is caused by a bacterium known as ***Neisseria gonorrhoea***.
- The bacteria affects the urethra in males and the vagina in females.

Mode of Transmission

- Through sexual intercourse with an infected person.
- At birth for newborn babies if the mother is suffering from the disease.

Signs and Symptoms of Gonorrhoea

a. Yellowish discharge from the urethra in males. (It is more difficult to notice the discharge in females because it may be masked by normal vaginal secretions).
b. Narrowing of the urethra resulting in painful urination in males.
c. Abdominal pain in females.
d. Menstrual problems in females.

Effects of Gonorrhoea

a. Blockage of sperm ducts or oviducts which leads to sterility.

b. Destruction of red blood cells thereby causing anaemia.
c. Destruction of liver cells causing jaundice or yellowing of the eyes and skin.

Prevention and Treatment of Gonorrhoea

a. Abstaining from sex before marriage.
b. Early diagnosis and treatment using the prescribed antibiotics.
c. Engaging in safe sex through use of condoms.

2. Syphilis

- Syphilis is caused by a spirochaete bacterium called ***Treponema pallidum***.
- Like gonorrhoea, syphilis affects the urethra and the vagina and is more serious than gonorrhoea.

Mode of Transmission

- Through sexual intercourse with an infected person.
- At birth to the newborn baby by an infected mother.
- Through transfusion of infected blood.

- *Treponema pallidum* can also pass from the mother to the foetus during pregnancy. (When this happens, the foetus may die before birth or the child may be born with congenital syphilis that results in blindness, deafness, and heart and mental disorders.

Signs and Symptoms of Syphilis

- Syphilis occurs in **three** phases:

First Phase

a. Painful sore called chancre on the cervix or the tip of penis.

Second Phase

b. Reddish-brown bumpy rash usually appears on the palms and bottoms of the feet.

c. Swelling of the lymph glands.

d. Sore throat.

e. Burning sensation and itching around genitals.

f. Weight and/or appetite loss.

g. Muscle and/or joint aches, and fatigue.

f. Pain in the pelvic area.

g. Falling of hair.

h. Mild fever.

Third Phase

h. Destruction of the nerves leading to paralysis.
i. Damage to the brain leading to muscular incoordination.
j. Damage to the eyes that can lead to blindness.
k. Fever.
l. Painful, non-healing skin ulcers.
m. Damage to the aorta.

Control and Prevention of Syphilis

a. Abstaining from sex before marriage
b. Treatment with antibiotics such as penicillin.

c. Health education to create awareness in the community.

d. Engaging in safe sex such as condom use.

3. Genital Herpes

- Genital herpes is caused by ***herpes simplex virus***.

Mode of Transmission

a. Through sexual intercourse with an infected person.

b. At birth from an infected mother to the newborn baby.

Signs and Symptoms of Genital Herpes

a. Genital itching.
b. Painful blisters on the genitals.
c. Open painful ulcers that may heal or re-occur.

Effects of Genital Herpes

a. Damages the eyes of the newborns at birth.
b. Damages the central nervous system leading to mental retardation in children.

Control and Prevention

a. Abstaining from sex before marriage.
b. Engaging in safe sex e.g. condom use.
c. Treatment with antibiotics.

4. Candidiasis

- Candidiasis is caused by a fungus known as ***Candida albicans***.

Mode of Transmission

- Through sexual intercourse.

Signs and Symptoms of Candidiasis

a. Soreness and itching penis.
b. Irritation or itching of the vulva.
c. Vaginal discharge.
d. Painful sexual intercourse or dyspareunia.
e. Reddened and oedematous vulva.

Prevention and Control of Candidiasis

a. Abstaining from sex before marriage.
b. Treatment with antifungals.

5. Chlamydia

- Chlamydia is caused by a bacterium called ***Chlamydia trachomatis***.
- The disease is very similar to gonorrhoea in many ways and it is very difficult to distinguish between the two.

Mode of Transmission

- Through sexual intercourse.
- During childbirth.

Signs and Symptoms of Chlamydia

a. Inflammation of the pelvis or lower abdomen.
b. Pain and discomfort.
c. Abnormal discharge from the genitals.
d. Bleeding, especially after sexual intercourse.
e. Burning sensation when urinating.
f. Infertility.

Prevention and Control of Chlamydia

a. Abstaining from sex before marriage.
b. Treatment with antibiotics e.g. Penicillin.
c. Engaging in safe sex such as condom use.

6. Chancroid

- Chancroid is caused by a bacterium called ***Haemophilus ducreyi***.

Mode of Transmission

- Through sexual intercourse.

Signs and Symptoms of Chancroid

a. Painful sores/ulcers on the genitalia.
b. Swelling in the groin.
c. Painful urination.
d. Painful sexual intercourse.
e. Abnormal vaginal discharge.

Prevention and Control of Chancroid

- Abstaining from sex before marriage.
- Treatment with antibiotics.
- Engaging in safe sex such as condom use.

7. Genital Warts

- Genital warts refer to small bumps or tiny cauliflower-shaped warts growing on the genital organs.
- It is caused by ***human papilloma virus*** (HPV).

Mode of Transmission

- Through sexual intercourse.

Signs and Symptoms of Genital Warts

a. Bump-like growths on the genitals and anus.
b. Itching or discomfort around the genitals.
c. Burning, tenderness and pain.
d. Bleeding in some cases.

Prevention and Control of Genital Warts

a. Removal of the warts using liquid nitrogen.
b. Treatment using prescribed drugs.
c. Exercising protected sex.

8. HIV and AIDS

- AIDS is the most dangerous STD as it cannot be cured.
- It is caused by a virus called ***Human Immuno-deficiency Virus*** (HIV).
- The virus is found in body fluids such as blood, semen or vaginal fluid.
- The virus destroys the white blood cells, which protect the body against infection.
- This makes the infected individuals vulnerable to many other diseases such as tuberculosis, (TB), diarrhoeal and skin diseases.

Mode of Transmission

- Through sexual intercourse (most common).
- Through transfusion of infected blood.
- From mother to child during birth or during breast-feeding.
- By using unsterilised surgical or piercing instruments such as syringes, blades, needles.

Behaviours that Promote HIV Transmission

a. Having multiple sex partners.
b. Certain traditional practices e.g. polygamy, initiation ceremonies, *chokolo*, *skazi* and *fisi.*

Signs and Symptoms of AIDS

a. Chronic diarrhoea for more than a month.
b. Sudden loss of weight.
c. Night sweats.
d. Frequent fevers.
e. Skin rashes.
f. Constant, persistent and severe coughs lasting for more than a month.
g. Attacks by opportunistic illnesses such as tuberculosis, pneumonia, chest infections, shingles and brain diseases.

h. Inflammation of the lymph nodes.
i. Ulcers in the mouth.

Effects of HIV and AIDS

- Loss of immunity, which leads to death.

Control and Prevention of AIDS

a. Abstaining from sex before marriage.
b. Having protected sex e.g. by using condoms.
c. Screening blood for HIV before transfusion.
d. Avoiding the use of unsterilised surgical or piercing equipment.
e. Using antiretroviral drugs (ARVs), which slow down the spread of the virus in the body.

Prevention and Control of STDs

a. Abstaining from sex before marriage.
b. Being faithful to one's sexual partner.
c. Engaging in safe sex e.g. proper condom use.
d. Having regular physical examination to test for STIs and STDs.
e. Females infected with HIV and other STDs should avoid getting pregnant .
f. Getting medical treatment when one suspects an STI.
g. Using antiretroviral drugs (ARVs)

Effects of Sexually Transmitted Diseases

a. On the Individual

1. Loss of body weight.
2. Sterility for example, due to gonorrhoea.
3. Blindness in children born to mothers with syphilis or genital herpes.
4. Deafness in children born to mothers with syphilis.
5. Low productivity because the persons are too weak to work.
6. Mental disorders in children born to mothers with syphilis and genital herpes.

7. Insanity/madness in adults with syphilis if the bacteria affect the nervous system.
8. If not managed early, some STDs such as HIV and AIDS can lead to death.

b. On the Family

1. Loss of family income, especially when the wage-earner becomes too weak to work and eventually dies.
2. If both parents die, children are orphaned.
3. Children are subjected to adult roles.
4. Partners are widowed if one dies.

c. On the Nation

1. High cost of medical care, which places financial strain on the country through providing health care.
2. Low national productivity because people have reduced productivity.
3. Loss of national manpower due to death.

Care and Support for People with HIV & AIDS

- There are many ways of caring for people with HIV and AIDS, which include the following:

a. **Physical Care**

When weak, they need community and family members to wash their clothes, bathe, clothe and feed them.

b. **Material Support**

People with HIV and AIDS need basic items such as clothes, food, soap, bedding etc.

c. **Emotional and Spiritual Support**

- When one is diagnosed with HIV, they may suffer from shock, anger, loneliness, fear, depression and isolation.

- There is need to make them feel loved and wanted by among other things, talking to them and keeping them company, praying with them & accepting them in work places.

d. Good Hygiene

Since HIV and AIDS patients are easily attacked by opportunistic illnesses, they need to keep good hygiene.

- They should take a bath daily;
- They should change their clothes and beddings frequently.
- They should wash their hands with soap and clean water after visiting the toilet.

e. Adequate Diet

A person with HIV and AIDS needs enough nutrients to keep the body healthy and strong.

A balanced diet should always be provided.

f. Medical Care

As soon as opportunistic diseases such as skin diseases, diarrhoea and tuberculosis are detected, the patients should seek medical treatment to prevent their getting worse.

They should be given anti-retroviral drugs (ARV) that help their bodies to fight HIV.

g. Counselling

- When first told that they are HIV positive, people refuse to accept the condition and may not believe the doctors.
- Due to depression, they easily become angry and develop mental worries.
- As such, people living with HIV and AIDS need counselling to help them cope and overcome the mental worries.
- Counselling involves telling the patients to learn to live positively with the disease.
- It also helps them to learn how to control the opportunistic diseases.