Senior secondary

Biology: Study units 1-6

Scholar study workbook

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‘Keeping Girls in School’ Scholarship Programme

MSCE Resources: 2014–15

Contents

MSCE B1: Locomotion

What you are studying and why

Subject: Biology Unit B1

This unit is about locomotion in fish and birds.

At the end of this unit you should be able to:

1. describe how fish and birds move
2. draw and label structures in fish and birds which help them move
3. explain how fish and birds are adapted to move.

Introduction

This is the first unit for revising your Biology MSCE. Biology is the study of living things – you, animals and plants. We start by looking at two animals that you see around you, birds and fish. You will remember that all living things share a number of characteristics – they respire, digest, excrete, grow, reproduce and so on. They also all move.

In this unit we look at how birds and fish can move. They both move in different ways to us – by flying and swimming. We look at how their bodies are structured to enable them to fly and swim easily – much more easily than we can. You know that fish have scales and fins and a smooth shape but how does this help them to swim? Birds have wings and feathers – what is the purpose of these? As you study this unit look at birds and fish around you; notice their different parts and how they move. Try doing drawings and talking to your fellow scholars about what you notice.

Fish movement

We all know that fish live in water and move around the water by swimming. Their bodies help them to swim very efficiently.

Activity 1

Try moving your hand quickly through the air. Now do the same through a bucket of water. Which is easier?

You saw that it is much easier to move through air than water. This is because water is 800 times more dense than air. There is much more resistance in water than in air.

Activity 2

Draw a quick sketch here of the shape of the fish. Label any parts that you know.

Which parts move as the fish swims?

Fish are very good swimmers, much better swimmers than humans or any mammals. Why can fish swim so easily?

Fish have a shape that makes them able to slide more easily through water.

Activity 3

Think about any animal or object which moves fast and draw a quick sketch here.

What do you notice about its shape?

To move quickly we need to have a streamlined shape. All fish have very streamlined shapes – they don't have arms or legs that stick out (see Figure 1). The water can flow easily over the body of the fish as it moves. The bodies of fish generally taper towards the front, offering less resistance, enabling them to move smoothly through the water.

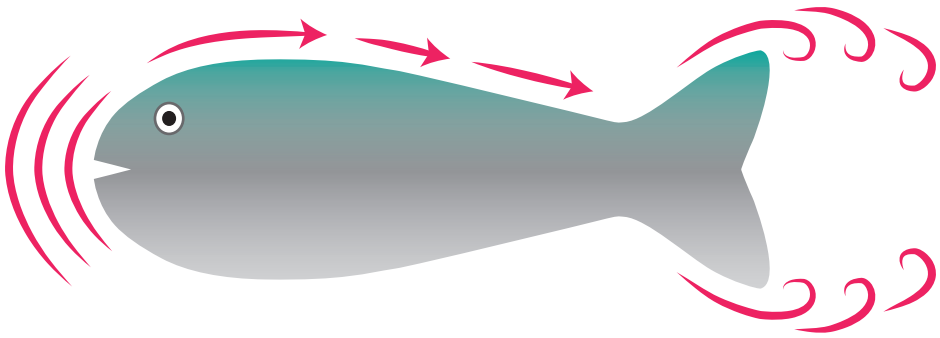

Figure 1: A fish's streamlined shape

The skin of a fish is covered in scales. These all have an oily substance on them. This also helps the water to flow easily over the surface of the fish.

How do fish swim?

The fish skeleton and muscles work together with its fins to help it to swim. Every fish has a large number of muscles – about 80% of its body is muscles.

The fins on a fish move the fish forward and change the direction in which the fish swims. They also give it stability. The fish has different types of fins on different parts of its body. There are two types of fins on a fish: median fins (non-paired) and paired fins.

The median fins

These are the non-paired dorsal, anal and caudal fins.

On Figure 2 below find the caudal fin. Mark this fin. This is the tail fin and it is the most important – this moves from side to side to push the fish forward.

The median fins also help the fish to be stable as it moves through the water. They do this by stopping the fish from moving from side to side as it swims (yawing). They also control rolling movements. This all helps the fish to swim faster.

The paired fins

These are pectoral and pelvic fins. These are on the sides of the fish and are the same size and shape on both sides. Find these fins and mark them on Figure 2.

These fins control up and down (pitching) movement of the fish. These fins can give the fish extra push and they can also act as brakes to slow down the fish. During rapid movement these fins are held close to the side of the body making the fish more streamlined. Stretching these fins will slow the fish down and stretching out the paired fins on one side of the fish will change the direction in which the fish is moving.

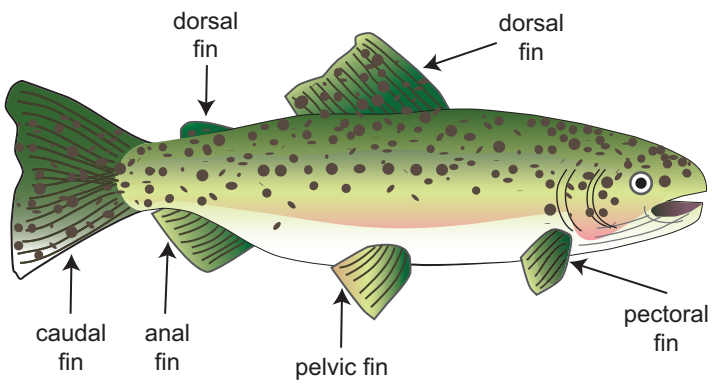

Figure 2: A fish and its fins

Now go back to your sketch of a fish in Activity 2. Mark on the caudal fin and dorsal fins.

Summary of adaptations of fish for locomotion

1. They have streamlined bodies, which help them to reduce friction as they move through water.
2. Their bodies are covered with backward pointing scales and oil, which also helps to reduce friction. This allows them to move faster through the water.
3. They have a tail and caudal (tail) fin, which, by swinging side to side, enables the fish to move forward.
4. The fish has fins. Median fins are responsible for pushing the fish forward and for stability. Paired fins (i.e. pelvic and pectoral) enable the fish to change direction or control its speed.

5. Some fish have swim bladders, which are air-filled bladders (see Figure 3). These enable the fish to float in water when the swim bladder becomes filled with air, or to sink when the air is released through the mouth.

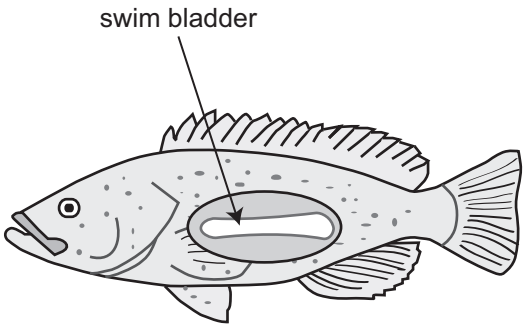

Figure 3: A fish and its swim bladder

Movement in birds

Birds can walk, run and swim but what is their most effective form of movement? It is flight. What feature makes them particularly well adapted to this form of movement?

For almost all birds their most effective movement is flying. Birds have wings and powerful muscles that enable them to fly. Wings are skin stretched over bones, which are equivalent to human arm bones, and are covered in feathers.

All birds have feathers. These come in lots of different colours and shapes. But there are two main types: down and flight (or quill) feathers.

Down feathers

Figure 4: A down feather

These cover the whole body of the bird and their function (purpose) is to trap a layer of air close to the body in order to keep the bird warm and also to repel water (Figure 4). (Remember from your Physics study that air is a good insulator; the trapped air helps to stop the bird losing too much body heat – this is important in colder climates.)

Activity 4

Find a down feather from a chicken in your village. What do you notice about the down feathers? Do a sketch here of a down feather:

Down feathers are usually small and very very soft (they don't have barbules).

Flight (or quill) feathers

These cover the wings and they help the bird to fly. The feathers help create the shape of the bird's wing.

Activity 5

Find a quill (flight) feather from a chicken and make a sketch of it here:

The quill feathers (Figure 5) are divided into:

1. Primary quill feathers

These are large in size and are found on the back of the wings; their function is to provide forward push and lift the bird.

2. Secondary quill feathers

These are small and are found on the front of the wing; their function is to provide lift.

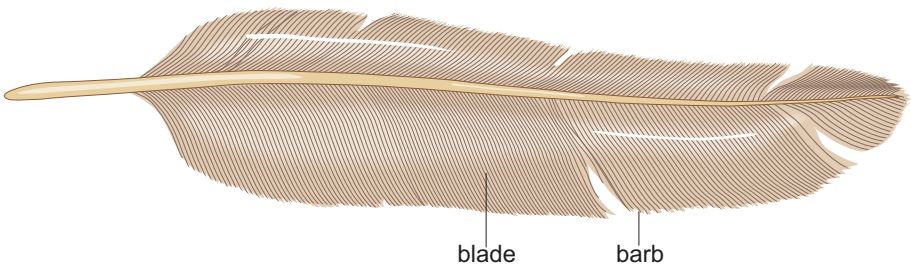

Figure 5: A quill (flight) feather

Look carefully at your feather. It has a central core with lots of small bits attached to it – these are called the 'barbs'. On the barbs we can find barbules – these are like hooks which allow all the barbs to join together. On your feather run your fingers down the barbs so that they separate. You have now 'unlocked' all the barbules. The barbules on the feather interlock when the wing is flapped downwards to maximise air resistance – the air is stopped from flowing through the feather. However the barbules unlock when the wing is flapped up in order to allow air to flow between them to minimise air resistance.

How does a bird fly?

There are two natural forces that a bird must overcome so that it can fly:

1. **Gravity** – the force that draws all objects to the ground.
If you let go of an object from your hand, it falls to the ground because of gravity.

2. **Drag** – the force that slows things down.
If you move your hand, palm facing forwards, through the air, this is the force you can feel on the palm or back of your hand.

The bird must generate a force called **lift** that pushes it away from the ground, and another force called **thrust** that pushes it forward through the air.

When a bird flies, there are two processes: (1) **flapping** and (2) **gliding**.

Watch birds near you to make sure you are clear about what a bird looks like when it is flapping and when it is gliding. Gliding is when a bird looks as if it is hanging in the air.

During **flapping**, the bird is **lifted** by both the down and up strokes of the wing.

A down stroke happens when a major muscle in the bird contracts, this pulls the bird's wing down and into the body.

An up stroke happens when this major muscle relaxes and a minor muscle contracts. The major and minor muscles are acting as an antagonistic pair.

Activity 6

You too have pairs of muscles to move parts of your body. Look at your arm. Move it up and down at the elbow (Figure 6). When you move your forearm and hand towards you the muscle on the top of your upper arm contracts – gets tighter and shorter. Can you see this? Now let your hand and lower arm go down. This muscle is now relaxed but the muscle underneath your arm has now contracted to pull your arm down.

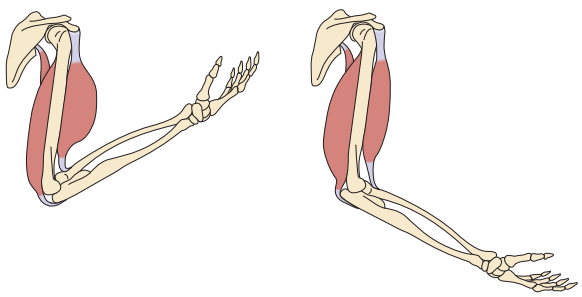

Figure 6: Movement in an arm

People who are very strong have large muscles and you can see these move as they move their arms. The same is happening in a bird as it moves its wings up and down.

On the up stroke the quill feathers are spaced far apart to allow air to flow between them whereas during the down stroke they overlap or lock into position to increase air resistance. This helps to give the bird lift.

During **gliding**, the wings and tail are spread out. Gliding uses much less energy but generally results in the bird losing height. The bird does not fall to the ground because the air flowing over the shape of the wing gives it lift.

Feathers also provide the shape needed to lift – they create an aerofoil shape. An aerofoil is a structure with a curved upper surface.

Owing to its shape the pressure is different on each side of the aerofoil and this results in the bird having lift and it is able to rise into the air (Figure 7).

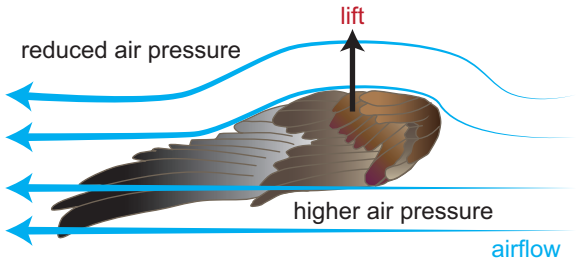

Figure 7: The bird's wing is an aerofoil shape

Summary of adaptations of birds for locomotion

1. They are streamlined in shape in order to reduce friction with the air.
2. Their bones are hollow; this reduces their weight enabling them to overcome the force of gravity more easily.
3. They have large and powerful pectoral muscles that provide the power to flap the wings as they fly.
4. The feathers have a large number of hair-like structures called barbs. Barbs in turn have further branches called barbules that hook together to form a solid structure.
5. The skeleton of the bird is strong with many hollow bones fixed together enabling the bird to fly.
6. Birds have air sacs that provide a large surface for gas exchange as they fly in the atmosphere.
7. The presence of down feathers, which provide insulation, helps the bird to retain heat energy as it flies at high altitudes. The down feathers also regulate its body temperature.
8. The tail and wing tips control steering.

Practice questions

Remember, talking about the ideas in the units is a very good way to learn. Ask one of your fellow scholars these questions and check their answers.

1. What are the two main types of feather a bird has and what are their main functions?
2. Which types of bird feather provide both lift and thrust?
3. Which type of flight uses most energy: flapping or gliding?
4. Explain how the shape of the wing helps a bird to get lift.
5. With reference to their skeletons, which evolutionary adaptations have helped birds more easily to overcome gravity and take to the air?
6. What are the two main types of fish fin and what is the difference between the two types?
7. What makes a fish move forward?
8. How are fish able to turn and change the direction in which they are moving?
9. How do fish slow down and speed up?
10. Mention any two observable adaptations of the fish to locomotion in water.

How am I doing?

This section is a study tool.

Now look back over this unit and be honest about what was difficult.

Later use it to discuss with your tutor any extra help you need.

Before the exam use this tool to revise.

	☺ **Easy** (Tick this box if you feel confident that you **understand this section well**)	**Fine** (Tick this box if you still **need a little work** on this section)	☹ **Difficult** (Tick this box if you **still need a lot** of work on this section)
Locomotion in fish			
Locomotion in birds			
Adaptations in fish			
Adaptations in birds			

Notes on what to do next:

Signed (by Scholar): ..... Date:.....

Signed (by Tutor): ..... Date:.....

Answers to practice questions

1. The two main types of bird feather are down feathers, which trap air close to the skin to insulate the bird against the cold air when flying at altitude and flight, or quill feathers which provide forward push and lift.
2. The flight, or quill, feathers provide both lift and thrust.
3. Flapping uses much more energy than gliding.
4. When the bird is moving through the air (gliding), the wing acts as an aerofoil. Air flows over it such that pressure below the wing is higher than pressure above it, hence the bird gets lift
5. Many bones are hollow and many unnecessary bones have been 'lost' over time.
6. The two types of fish fins are median fins and paired fins. As the name suggests, the latter are arranged in pairs, one on each side of the fish's body.
7. The side-to-side movement of the tail and caudal fin makes the fish move forward.
8. Fish change direction when swimming by holding in their paired fins on one side, which results in them turning in the opposite direction.
9. Fish slow themselves down by holding out their paired fins on both sides of their body. They speed up by holding their paired fins in close to their body.
10. - Fish have fins which enable and aid movement.
    - Streamlined bodies reduce friction.
    - They have powerful tail muscles.
    - They have scales that overlap backwards to reduce friction.

Glossary

Aerofoil	The name given to a streamlined shape with a rounded front edge and a pointed, tapering tail end. The wing of a bird or an aeroplane is an aerofoil.
Air pressure	This is the pressure caused by the force of moving air particles on any surface they are in contact with.
Altitude	This means height above sea level.
Anal	This means related to the anus, which is the back end of the food tube or alimentary canal.
Antagonistic pair (of muscles)	Antagonistic means working in opposite ways. With an antagonistic pair of muscles, one muscle of the pair can make an arm or leg bend, the other can make it straighten. This is because of how the muscles are attached to the bones.
Barb	One of the side branches on a feather.
Barbule	On the quill feathers, the barbs or side branches themselves also have side branches. These are called barbules.
Brake	A brake is something that stops or slows movement.
Caudal	This means related to the tail of an animal.
Characteristics	The main distinguishing points that we use to accurately and clearly describe or explain something.
Conduction	This is one of the ways in which heat can move through an object or material. (Convection and radiation are the other ways.)
Contract	Get shorter and tighter.
Dense/density	The density of different substances tells you how equal volumes of the substances vary in mass. For example, a 'spoonful' of water is heavier than a 'spoonful' of air – so we say water is more dense than air.
Dorsal	This means related to the upper or back surface of an animal.
Down feather	These are feathers which have side branches (barbs) which are light and fluffy.
Drag	Drag is a force that acts on moving things to try to stop them moving or slow them down.
Evolutionary adaptation	An adaptation is a way in which an animal or plant is well suited to its environment and way of life. Most biologists agree that the variety of life on earth today has gradually developed over hundreds of millions of years, by a process called evolution. Over the years as new types of organism developed, those that were well suited to their environment have remained and continue to reproduce, while those that are not well suited to their environment die out or become extinct.
Feather	Most of the skin of a bird is covered in feathers. Each feather has a central firm spine with side branches (barbs). The side branches of some feathers are firm. The side branches of other feathers are light and fluffy.
Fins	Flattened structures on the outside surface of a fish, which are used in locomotion. Some fins are in pairs. Some are single.
Flapping flight	This is forward movement of a bird through the air during which the wings move up and down.
Force	A force is a push, a pull or a twist. A force may change the speed or direction of a moving object, it may start or stop something moving, or it may change the shape of an object.

Friction	This is a force which tries to stop things moving or slows them down.
Gas exchange	In animals this usually means the movement of oxygen and carbon dioxide in opposite directions across a surface called a respiratory surface. In mammals, gaseous exchange happens across the walls of the air sacs or alveoli in the lungs.
Generate	To make or produce.
Gliding flight	This is the forward movement of a bird through the air during which the wings do not move up and down.
Gravity	This is the attractive force of the earth on all objects, which pulls them down to the ground.
Insulator	This is a material that slows down the rate at which heat can move through it by conduction.
Lift	This is a force acting on a streamlined object (such as the wing of a bird) as it moves through air. It is created due to the different speeds at which air moves over the upper and lower surface of the object (i.e. wing). The result is a force which pushes the object (i.e. the bird) upwards.
Locomotion	Movement of the whole body from one place to another.
Median	This means middle or central.
Pectoral	The shoulder region of the body. Pectoral fins of a fish are equivalent to the arms of a human.
Pectoral muscles	These are a pair of antagonistic muscles that stretch between the bones on the wing of a bird and its breast bone. Their contractions cause the wing to move up and down in flapping flight.
Pelvic	The hip region of the body. The pelvic fins of a fish are equivalent to the legs of a human.
Pitching	Up and down movement (usually unwanted) of an animal as it moves forward in water.
Pressure	This is how concentrated a force is or how much force acts on a given area. It is measured in newtons (unit of force) per metre squared (unit of area).
Quill or flight feather	These feathers are found on the wings of birds. The side branches (barbs) of these feathers are firm. See Figure 5.
Repel	To push away.
Resistance	Resistance is a force that tries to stop things moving or slow them down. The resistance against objects moving through air is less than the resistance against objects moving through water.
Scales	Bony plates on the skin of fish.
Stable/stability	To remain in a fixed position, or not wobble or vary greatly.
Streamlined shape	A shape that is elongated, smooth and gets narrower towards its tail, which causes least resistance as it moves through air or water.
Swim bladder	This is a sac containing gas found in bony fish. The fish can change the amount of gas in the sac so it can swim at deeper or shallower depths of the water.
Thrust	This is a pushing force.
Yawing	Side to side movement (usually unwanted) of an animal as it moves forward in water.

MSCE B2: Respiration

What you are studying and why

Subject: Biology Unit B2

This unit is about the respiratory system.

At the end of this unit you should be able to:

1. describe tissue respiration
2. distinguish between aerobic and anaerobic respiration
3. explain the importance of gaseous exchange in organisms and how it works in humans, fish and insects
4. explain the effects of smoking on the lungs.

Tissue respiration

We need energy for all the processes in our bodies such as moving, growing, reproducing and digesting our food. In this unit we look at the different parts of the process of respiration. Respiration is the process used by plants and animals to release energy for these processes. Respiration takes place in cells.

The inputs to this process are glucose and oxygen.

The outputs are carbon dioxide and water.

Animals get the glucose that they need from their food and the oxygen they need from breathing in air. Plants get the glucose and oxygen they need through photosynthesis (remember this happens in the green part of the plants during the day).

When the body is at rest this process is ***aerobic* respiration**. Glucose is broken down completely to give carbon dioxide and water.

Glucose + oxygen $\longrightarrow$ *energy + water + carbon dioxide*

$$C_6H_{12}O_6\ (s) + O_2\ (g) \rightarrow H_2O\ (l) + CO_2\ (g)$$

Activity 1

You have read a few notes about respiration, get up and run or jump on the spot for one minute. What do you notice happens to your body? Try to note down three things you notice.

1. .....
2. .....
3. .....

As you exercise you breathe faster and deeper and the heart beats faster to get oxygen to the muscles. During exercise, the muscle cells respire more than they do at rest. This means:

- oxygen and glucose must be delivered to them more quickly
- waste carbon dioxide must be removed more quickly.

Our bodies do this by increasing the breathing rate and heart rate. The increase in heart rate can be detected by measuring the **pulse rate**. You might also feel hot or you might have noticed that you have cramp or 'a stitch'.

During hard exercise, the oxygen supply may not be enough for the needs of the muscle cells. When this happens, **anaerobic respiration** takes place, as well as aerobic respiration. The glucose is not broken down completely and lactic acid is formed.

Glucose → energy + lactic acid

Lactic acid can cause muscle fatigue, aches and cramp. Lactic acid is poisonous and must be got rid of by the body. This is why you continue to breathe rapidly, or pant, at the end of a fast run; you are said to be in **oxygen debt** and are rapidly taking in the oxygen needed to break down the lactic acid to carbon dioxide and water. Once you have 'repaid' the oxygen debt your breathing returns to normal.

Differences between aerobic and anaerobic respiration	
Aerobic respiration	**Anaerobic respiration**
Uses oxygen	Does not use oxygen
Makes carbon dioxide and water	Makes lactic acid
Releases large amounts of energy	Releases small amounts of energy

We said earlier that respiration has two inputs – oxygen and glucose. We get the oxygen we need from breathing in air. The air is taken in through our mouth or nose and passes down the windpipe or trachea into our lungs (Figure 1). If you feel your neck you can feel the firm tube – this is your trachea. The trachea splits into two smaller tubes, which are called the left and right bronchi (Figure 2). These then split to form the bronchioles, or large airways. These split into smaller and smaller air passages in the lungs and finally end at large numbers of tiny air sacs or alveoli.

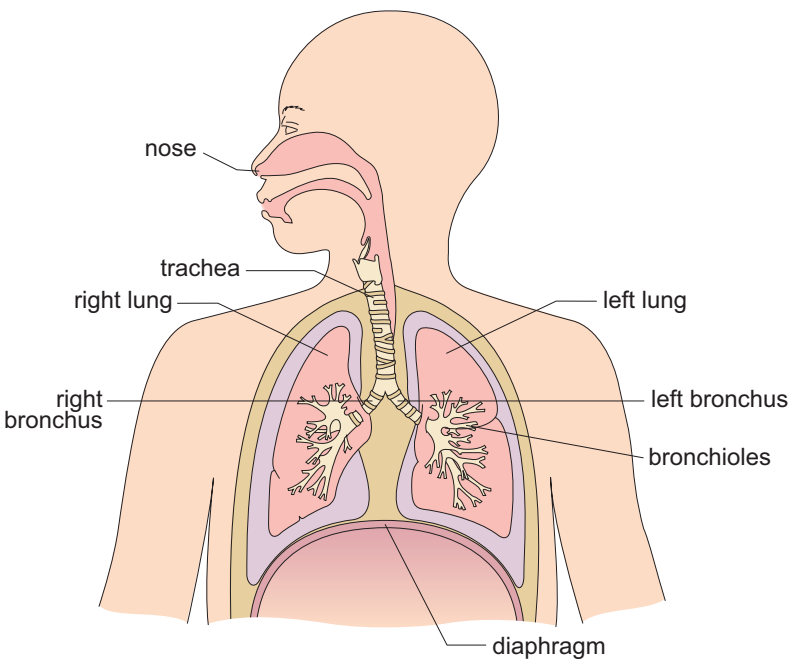

Figure 1: Trachea, lungs and diaphragm in the human body

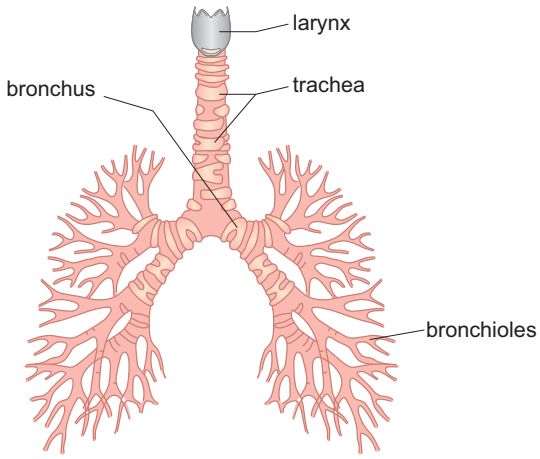

Figure 2: Trachea, bronchi and bronchioles

In the air sacs or alveoli we take oxygen into the bloodstream. Which gas do you think diffuses out of the bloodstream?

This movement of gases is called **gaseous exchange**; oxygen is taken in for respiration and carbon dioxide is removed from our bodies (Figure 3).

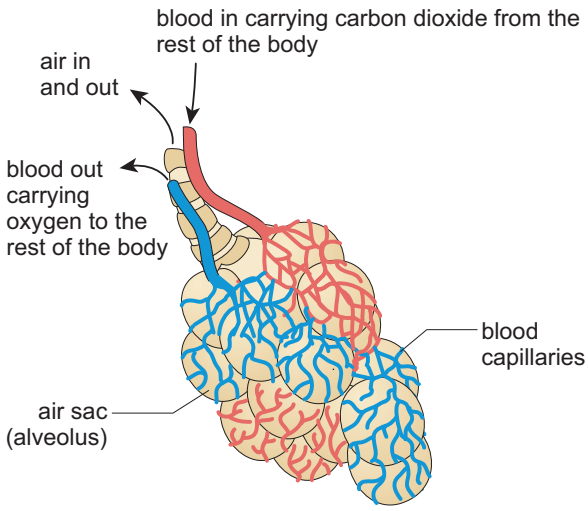

Figure 3: Gaseous exchange in the air sacs in the lungs

The alveoli are surrounded by many tiny blood vessels, or capillaries, and have very thin, **permeable** walls that allow small molecules, such as carbon dioxide and oxygen to pass through. The internal surface has a moist lining that dissolves the oxygen before it diffuses through the wall into the capillaries. They also have a very large surface area to ensure the maximum possible exchange of gas molecules takes place.

Activity 2

The paragraph above has lots of difficult words in it – capillaries, permeable, molecules, moist and internal. Circle each of these words.

Imagine you have to explain each of these words to a Standard 2 learner. Try to write your explanations in your notebook. Compare your ideas with other scholars when you next meet.

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Breathing

We rarely think about breathing unless we're out of breath. The act of breathing is part of the respiratory system, a complex process where air travels into and out of the lungs.

Breathing in (inhalation) and breathing out (exhalation) are two connected processes controlled by your **autonomic nervous system** so you don't have to worry about it (Figure 4). Both occur completely naturally.

These processes are caused by the movement of your diaphragm (a tough sheet of dome-shaped muscle at the bottom of your lungs) and by contraction and relaxation of muscles attached to your ribs. These are called your **intercostal muscles** situated between the ribs.

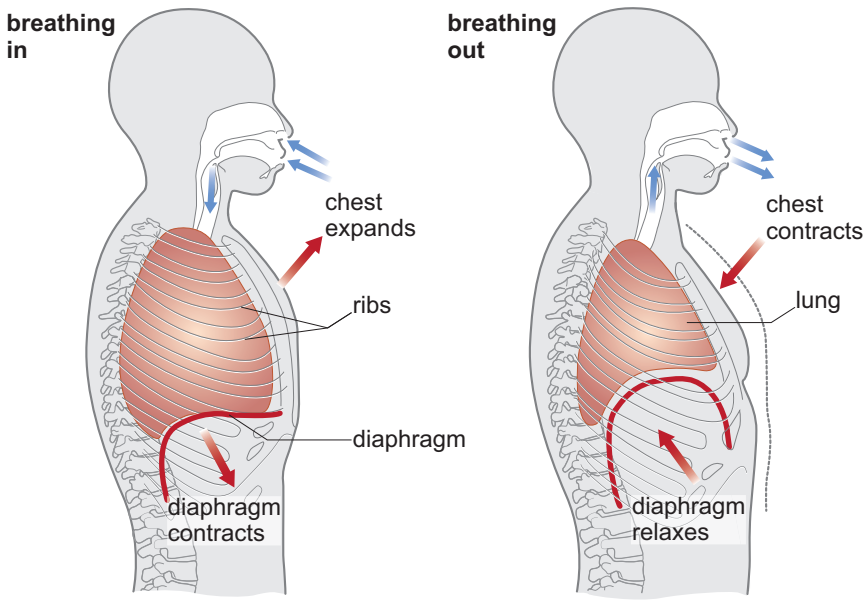

Figure 4: How our ribs and diaphragm move as we take in air and exhale air

Activity 3

Put your hands on your lower chest. Breathe in deeply. What happens to your ribs?

Now breathe out. How do your ribs move now?

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When you *breathe in:*

- the **intercostal muscles** contract, expanding the ribcage, which moves up and out
- the **diaphragm** contracts, pulling downwards to increase the volume of the chest
- pressure inside the chest is lowered and air is sucked into the lungs.

When you *breathe out:*

- the **intercostal muscles** relax, the ribcage drops inwards and downwards
- the **diaphragm** relaxes, moving back upwards, decreasing the volume of the chest
- pressure inside the chest increases and air is forced out.

The table below shows the temperature and relative proportions of the different main gases inhaled and exhaled in each cycle of breathing.

Gas	Inhaled breath/%	Exhaled breath/%	Change
Oxygen	21	16	24% decrease
Nitrogen	79	79	None
Carbon dioxide	0.04	4	100% increase
Water vapour	Variable	High	—
Temperature	Variable	High	—

Activity 4

In the space below write down two differences between your inhaled breath and exhaled breath.

Write a short report (about 100 words) to explain the differences between inhaled and exhaled breath.

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Poisons – carbon monoxide

If our breathing mechanism becomes damaged or we can't get sufficient oxygen into our cells, we can become very ill and possibly die.

One gas which can kill us is carbon monoxide. This is made when fuels burn with very limited oxygen. Think back to your chemistry unit – which elements are in carbon monoxide?

The formula of carbon monoxide is CO – one atom of carbon joined to one atom of oxygen. It is a colourless and odourless (no smell) gas; this makes it very dangerous.

How does carbon monoxide poison us? Carbon monoxide can pass into our blood and join onto specialised molecules in our red blood cells. These molecules usually carry oxygen around our bodies. But if we breathe in carbon monoxide, this joins to the oxygen-carrying molecules in our red blood cells and stops them carrying oxygen. If our cells don't get enough oxygen they will not be able to respire. This can then cause major organ breakdown and death.

Smoking

We all know many people who smoke but we know that smoking is harmful to our health. Smoking results in breathing hundreds of different chemical compounds. Some of these substances are potentially extremely harmful and can have both short- and long-term effects. The table below lists the most dangerous substances in cigarette smoke and their effects.

Substance in tobacco smoke	Effect
Nicotine	Causes physical addiction – smokers cannot stop wanting the next cigarette.
Tar	Tar is a thick sticky substance. This collects in the lungs and paralyses the cells which normally sweep harmful particles out of the lungs. Germs therefore remain and can cause infections, e.g. bronchitis. Tar also causes the production of cancerous tumours the presence of which can go undetected for 20 years or more. Mesothelioma is just one type of cancer that can affect the lungs.
Carbon monoxide	Carbon monoxide in smoke aids atherosclerosis, the laying down of fatty material in the arteries. This reduces the volume of the arteries and hence the amount of blood flow around your body. If you have lower levels of oxygen to your heart you are more likely to have a heart attack. Pregnant smokers also supply less oxygen to their unborn babies that might result in stunted growth or still birth (i.e. born dead).
Tobacco smoke	Bad breath

Activity 5

On Figure 5, add in the harmful chemicals in cigarettes to show which ones cause the illnesses.

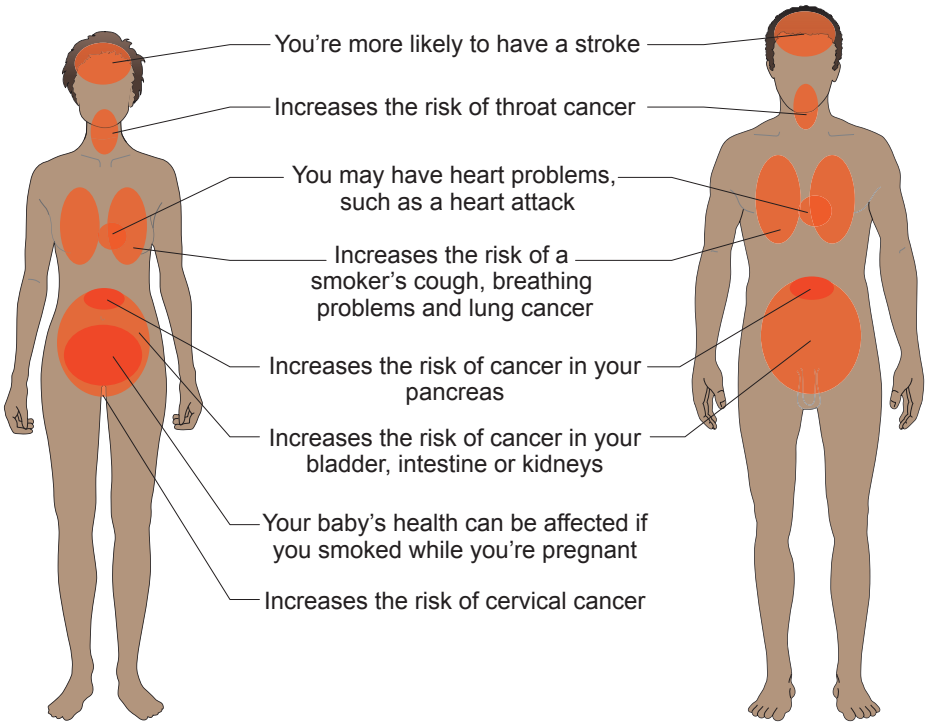

Figure 5: What smoking does to your body

Other animals

All living things respire but not all animals have lungs like humans. Here we look at two other living things – fish and insects.

Fish: respiratory system

Fish have a very different way of getting oxygen into their blood and getting rid of carbon dioxide.

Fish have to take oxygen for respiration from the water. They do this in their gills. The fish takes in water through its mouth and passes it through to the gills. Water doesn't have very much oxygen dissolved in it so the gills have to have a large surface area to be in contact with a large volume of water.

The gills are organised with lots and lots of gill filaments – these look like feathers and they all contain many blood capillaries. As the water passes over the gill filaments, oxygen from the water goes into the capillaries (Figure 6). Carbon dioxide passes from the fish's blood into the water.

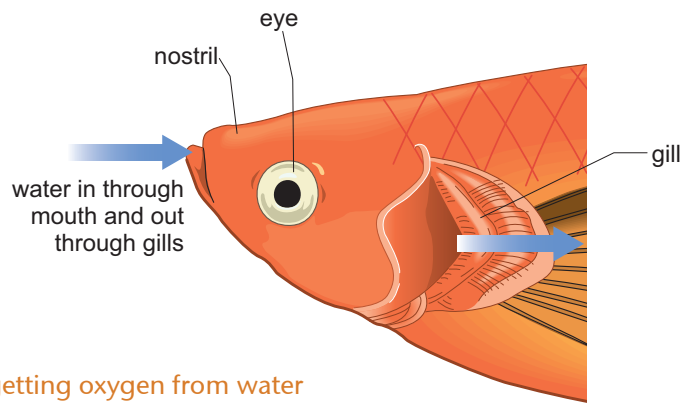

Figure 6: Fish getting oxygen from water

Activity 6

Observe a fish swimming – look carefully at its mouth. Write a short report on what you see. What do you think would happen to a fish left in a bowl of water for a long time?

(Reminder – look back at what you learnt about fish in the first Biology unit).

Insect: respiratory system

Insects don't have lungs. Instead they have a complex network of tubes known as the **tracheal system**. Air enters the insect's body through small valve-like openings, called **spiracles**, in the exoskeleton (Figure 7).

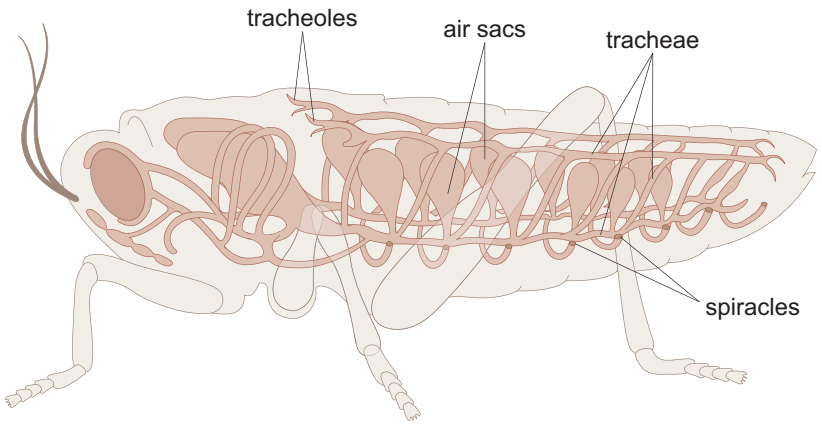

Figure 7: Insects getting oxygen from air

After entering the body, air travels through the **tracheal tubes**.

These divide into thinner and thinner tubes. The thinnest tubes at the ends of the branches are called tracheoles. Most gaseous exchange takes place across the walls of the tracheoles. Oxygen first dissolves in liquid in the tracheoles and then passes into the cytoplasm of an adjacent cell. Some gaseous exchange also occurs through the walls of the trachea.

The insect body also has **air sacs**, which are balloon-like structures that store reserves of air.

Summary and adaptations

Respiration happens in all living things.

Glucose + oxygen $\longrightarrow$ *energy + water + carbon dioxide*

$$C_6H_{12}O_6\ (s) + O_2\ (g) \rightarrow H_2O\ (l) + CO_2\ (g)$$

All living things need to take in oxygen and get rid of carbon dioxide. They have all adapted to do this as efficiently as possible.

Activity 7

Think about the three animals we have looked at – humans, insects and fish.

Each has adapted their structure to give a large surface area for gas exchange. Where is this large surface area in each animal? Jot down your answers.

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In fish and humans the oxygen needs to pass into the blood. The gills of the fish are permeable and allow gases to pass through their outer surface, and into and out of blood capilliaries inside the gills. In humans the lining of the alveoli is very thin, to allow the gases to pass across as easily as possible, and it has a moist layer to dissolve the oxygen.

In insects the oxygen goes straight to the cells – the gases are not carried in the blood.

You should have noted that each of the animals has a large surface area for gaseous exchange. These are found in:

- the gills with filaments in fish
- the tracheal tubes and tracheoles in insects
- the alveoli in the lungs. (If you could lay out all of the airways of one lung and put them all one in front of the other, the line would stretch for about 1500 km. This huge area testifies to how oxygen is incredibly important to our survival.)

Practice questions

Remember, talking about the ideas in the units is a very good way to learn. Ask one of your fellow scholars these questions and check their answers.

1. How do plants obtain the glucose and oxygen they need for respiration?
2. What are the two main types of respiration and what are the by-products in each case?
3. What is oxygen debt and how does it arise?
4. What name is given to the tiny air sacs in human lungs?
5. What drives the gaseous exchange at the interface between alveoli and capillary?
6. Why are small molecules able to pass through the walls of the alveoli and into the capillaries?
7. Which bodily system in humans controls breathing?
8. What are the names of the two different muscles that control the size of the chest during breathing?
9. Why is carbon monoxide poisonous?
10. What are the three most dangerous substances in cigarette smoke and what effects do they have on the body?
11. (a) Draw a table to illustrate the main differences and similarities between respiration in fish and humans.

    (b) How does air enter the body in insects?
12. Below are two equations **X** and **Y** for respiration. Use them to answer the questions that follow.

    X: $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + 2880kJ$

    Y: $C_6H_{12}O_6 \rightarrow 2CH_3CHOHCOOH + 150kJ$

    (a) State any two differences between the two equations.

    (b) (i) Which equation represents aerobic respiration?

    (ii) Give a reason for your answer to (i).

13. Name the site of gaseous exchange in:
    (a) fish
    (b) human beings.
14. Describe any two adaptations of the respiratory surfaces in fish.
15. Give any two ways of preventing carbon monoxide poisoning.
16. Mention any one difference between respiration in fish and insects.

How am I doing?

	☺ **Easy** (Tick this box if you feel confident that you **understand this section well**)	**Fine** (Tick this box if you still **need a little work** on this section)	☹ **Difficult** (Tick this box if you **still need a lot** of work on this section)
Aerobic respiration			
Anaerobic respiration			
Gaseous exchange			
Breathing			
Carbon monoxide poisoning			
Effects of smoking on health			
Fish respiratory system			
Insect respiratory system			
Adaptations of fish respiratory structures			
Adaptations of insect respiratory structures			
Adaptations of human respiratory structures			

Notes on what to do next:

Signed (by Scholar): ..... Date:.....

Signed (by Tutor): ..... Date:.....

Answers to practice questions

1. Plants obtain glucose and oxygen from photosynthesis. In the dark they must take in oxygen from the air.
2. The two main types of respiration are: aerobic, which produces carbon dioxide and water as by-products; and anaerobic, which produces lactic acid as a by-product. Both processes release energy.
3. Oxygen debt occurs during hard exercise when the cells need more oxygen than can be provided to them. Cells then move to obtain the energy they need anaerobically; this produces lactic acid. When you stop exercising you continue to breathe quickly to give the cells the oxygen that they need to break down the lactic acid to carbon dioxide and water.
4. Alveoli.
5. The difference between the amount of each gas in the alveoli compared to its amount in the capilliary drives the gaseous exchange. Each gas passes from where there is a lot of it to where there is less of it. Carbon dioxide passes one way and oxygen passes in the opposite direction.
6. This is possible because the walls of the alveoli and capillaries are permeable; i.e. they allow small particles to pass through them.
7. The nervous system controls breathing in humans.
8. The diaphragm and the intercostal muscles control the size of the chest during breathing.
9. Carbon monoxide is poisonous because it joins to specialised molecules in the red blood cells and stops them carrying oxygen.
10. Nicotine can lead to physical addiction to smoking.

    Tar can lead to lung infections and the growth of cancerous tumours in the lungs.

    Carbon monoxide can harm the unborn child of mothers who smoke leading to stunted growth or even still births or the death of the unborn child. CO can also cause atherosclerosis and heart attacks.
11. (a)

Humans	**Fish**
Breathe air	Breathe water
Have lungs	Have gills
Take in oxygen and excrete CO_2	Take in oxygen and excrete CO_2
Gas exchange occurs in tiny air sacs called alveoli	Gas exchange occurs in gill filaments

(b)Air enters the bodies of insects through tiny holes called spiracles.

12. (a) - X uses oxygen as one of the raw materials while Y does not.
    - X has a higher energy output than Y.
    - Carbon dioxide is a product of X but not Y.
    - Water is a product of X but not Y.
    - Lactic acid is a product of Y but not X.

    (b) (i) X

    (ii) Aerobic respiration uses oxygen.

13. (a) gill filaments

    (b) alveoli.

14. - Surface of gill filaments is one cell thick for efficient diffusion of gases.

    - Gill filaments contain a dense network of blood capillaries for efficient transportation of oxygen and carbon dioxide.

    - The total surface area of the gill filaments is very large.

15. - Allow complete combustion of charcoal on the charcoal burner.

    - When using the charcoal burner, ensure plenty of fresh air is available.

    - Do not smoke.

    - Avoid overcrowded smoky places (passive smoking).

16. In fish, gases are transported by blood to the tissue cells, while in insects gases diffuse directly from the spiracles to all cells throughout the breathing tubes.

Glossary

Ache	An ache is a long-lasting pain usually felt in the muscles.
Addiction	This is when you cannot stop wanting something or doing something, e.g. smoking.
Aerobic respiration	The release of energy from food using oxygen. More energy is released in aerobic respiration than in anaerobic respiration.
Air sacs	These are balloon-like structures in the body of an insect. They are connected to the tracheal system. They store reserves of air.
Alveoli	These are the air sacs found at the ends of the branching tubes (bronchioles) in the lungs. Gaseous exchange occurs here.
Anaerobic respiration	The release of energy from food without oxygen being used. Less energy is released in anaerobic respiration than in aerobic respiration.
Atherosclerosis	This is when a lot of fatty material builds up on the inside of artery walls. This cuts down blood flow. When it happens in coronary arteries, which supply the heart, it may cause a heart attack.
Autonomic nervous system	The nervous system of the body acts as a control centre and it helps to make the different parts of the body work well together. The autonomic nervous system is the part of the nervous system that controls the internal working of the body, e.g. the blood circulatory system and digestive system. It is not under voluntary control. It cannot be controlled by will.
Body system	This is a group of organs in the body that work together to do a particular job. For example, the brain, spinal cord and nerves make up the nervous system which controls and coordinates the different parts of the body.
Breathing	This is the process by which air is taken into and passed out of the body.
Bronchioles	This is a network of tubes which branch out from the bronchus in each of the lungs.
Bronchus	The lower end of the trachea or windpipe divides into two branches. One branch goes to the right lung, the other to the left lung. These branches are called bronchi. (One is a bronchus.)
Cancerous tumour	A tumour is a swelling or abnormal growth in the body. It is described as cancerous if it continues growing in an uncontrolled way.
Capillaries	These are the smallest blood vessels found in the body. They have thin walls, allowing substances to move between the blood inside them and the surrounding cells.
Carbon monoxide	This is a poisonous gas which is formed when fuels burn with limited oxygen. Cigarette smoke contains carbon monoxide. If too much carbon monoxide is breathed in, it can kill.
Chest	This is the upper part of the body. It contains the heart and lungs.
Contraction	This means to get shorter and tighter. It is used to describe muscle action.
Cramp	This is when a muscle contracts involuntarily (without your will), causing pain.
Cycle	This is when something goes round and round or repeats itself in a regular pattern. It may be a series of events that happen one after the other, finally returning to the first event.
Diaphragm	This is a tough sheet inside the body which separates the upper part of the body (chest) from the lower part of the body (abdomen). It is made of muscle and other tissue.

Diffusion	This is the movement of molecules or particles from an area where they are more concentrated to another area where they are less concentrated until they are equally spread out.
Dome shaped	This means a shape that is rounded and raised up in the middle, like half of a ball or sphere.
Energy	Our bodies need energy to grow, move, reproduce, digest food, etc.
Evaporation	This is when liquid water changes into water vapour.
Exhalation	This is when air is passed out of the lungs and out of the body.
Exoskeleton	This is a hard, protective covering on the outside of the body of animals such as insects.
Fuel	This is a material which is burned to give out energy.
Gaseous exchange	The movement of oxygen in one direction across a respiratory surface and the movement of carbon dioxide in the opposite direction. The gas molecules move by diffusion.
Gills	These are paired feathery structures found on both sides of the body of a fish, behind the head region. They have a good blood supply. As water flows over the gills, oxygen diffuses from the water into the blood. Carbon dioxide diffuses out in the opposite direction.
Glucose	A simple sugar.
Heart attack	If the blood vessels which supply the heart become blocked or narrowed by the build up of fatty material, the heart cannot work properly and may fail altogether.
Inhalation	This is when air is taken into the body and the lungs.
Intercostal	This means between the ribs. Intercostal muscles are the muscles between the ribs that help bring about breathing movements.
Internal	This is used as a describing word or adjective. It means inside.
Lactic acid	This molecule is a product of anaerobic respiration.
Moist	Slightly wet or damp.
Molecule	This is a small group of atoms held together by covalent bonds. It is the smallest single piece of a material (an element or a compound) that can normally exist.
Muscle fatigue	During hard exercise, oxygen cannot get to the muscle cells fast enough to release enough energy by aerobic respiration. Therefore anaerobic respiration occurs as well to supply the extra energy. Lactic acid, made as a by-product of anaerobic respiration, builds up. This causes the muscles to work less well and causes muscle pain and cramp.
Nicotine	This is a chemical found in cigarette smoke which causes physical addiction, i.e. it makes smokers unable to stop wanting the next cigarette.
Organ	A part of the body, which is made of different types of cells and does a particular job, e.g. the heart, lungs, brain, etc.
Oxygen debt	This is caused by the build up of lactic acid in muscles following anaerobic respiration during hard exercise. It is the extra oxygen needed by the body to break down the lactic acid. It explains why you continue to breathe rapidly even after you have stopped the hard exercise.
Pant	To breathe rapidly.

Paralyse	If something is paralysed it can no longer work properly – its power is taken away.
Permeable	Describes a surface or a material which allows substances to move freely through it.
Photosynthesis	The process by which green plants make food, the sugar glucose, from water and carbon dioxide using sunlight. Oxygen is produced as a by-product.
Pressure	This is how concentrated a force is or how much force acts on a given area. It is measured in newtons (unit of force) per metre squared (unit of area).
Principal	This is used as a describing word or adjective. It means main, chief or most important.
Pulse	Each beat of your heart makes a wave of pressure pass through the arteries (blood vessels). When an artery runs over a bone and near the surface of the body, this can be felt as a beat. The beat is called the pulse.
Pulse rate	This is how fast or slow the beat of your pulse is.
Relaxation	When describing muscles, this means that the muscle stops actively contracting or shortening.
Respiration	The release of energy from food, usually from the sugar glucose. It happens in all living cells.
Ribs	Pairs of curved bones in the chest region which are attached to the upper part of the backbone or spine. They form a cage, the rib cage, which protects the heart and lungs.
Spiracles	These are paired openings down the side of an insect's body. They connect the air tubes (tracheae or tracheal system) inside the body to the outside.
Stroke	This happens when the pressure of blood flowing through vessels in the brain rises and causes the vessels to burst. A stroke causes paralysis (stops muscles working properly). It may also affect the ability to speak and can cause death.
Tar	A thick sticky substance found in cigarette smoke that collects in the lungs of smokers. It can lead to infections and cancer.
Temperature	This is a measure of how hot something is.
Trachea	The tube that carries air between the throat and the lungs. It is also called the windpipe.
Tracheal system	This is a network of air-filled tubes (tracheae) inside the body of an insect, linked to the outside through spiracles.
Tracheoles	These are the very fine branches at the end of the air-filled tubes in the body of an insect. They are filled with fluid. Oxygen diffuses out of the tracheoles into the body cells of the insect and carbon dioxide diffuses in the opposite direction.
Valve	A mechanism for controlling the movement of air (or liquid) through an opening or tube.
Volume	This means the space that something takes up or fills.

MSCE B3: The circulatory system and the digestive system

What you are studying and why

Subject: Biology Unit B3

This unit is about the circulatory system and the digestive system.

In the first part you will study the **circulatory** or **blood system**. This carries things from one part of the body to another. The food you eat goes into the alimentary canal (food tube), but every living cell needs a food supply. All your body cells produce waste substances, but it is the kidneys that get rid of most of these. Food and waste are just two things that the blood carries from one part of the body to another. The circulatory system is also important in protecting your body against disease.

In the second part you will study the **digestive system**. You know that food is essential for life. However, it cannot be used directly. For example if you eat a piece of fish (animal muscle) it cannot go straight to your leg and become part of your own leg muscle. The food you eat must first be broken down into small, simple, soluble substances which can be absorbed by your blood and transported round the whole body. It is then built up into parts of your own cells, tissues and organs, or it is used as an energy source.

At the end of this unit you should be able to:

1. explain why the circulatory system is important
2. describe the structure and function of the heart
3. explain the similarities and differences between arteries, veins and capillaries
4. describe the structure of red blood cells, white blood cells and platelets and outline their functions
5. describe what causes heart attacks and high blood pressure and how to reduce the risks of suffering from them by how you live your life
6. state what digestion is and explain why it is necessary
7. recognise and name the main parts of the alimentary canal and explain their functions
8. explain physical and chemical digestion
9. explain what an enzyme is and outline how starch, protein and fat are digested
10. describe what happens to the final products of digestion.

The circulatory system

Re-read the first paragraph of this unit, then try Activity 1.

Activity 1

In addition to food and waste substances, what other things need carrying from one part of your body to another part? Try to think of at least five things.

For each of these things, say where you think it will be carried from and where you think it will be carried to.

Write your answers in the table below.

Substance	Carried from	Carried to

The structure of the circulatory system

Your circulatory system is made up of the **blood**. This is a fluid containing specialised cells. Blood moves around your body in a network of tubes called **blood vessels**. There are three types of blood vessel: arteries, veins and capillaries. Your **heart** is a muscular pump connected to this network of tubes. The heart keeps the blood moving round through the blood vessels.

Activity 2

- Put your hands on your rib cage. This bony structure surrounds and protects your lungs, and between the lungs, slightly to the left of centre, is your **heart.**
- Look at your wrists, hands and ankles. You may be able to see some of your **blood vessels** through the skin.
- Place the fingers of one hand lightly just above the inside of your wrist or at the side of your neck just below the lower jaw. Can you feel a throbbing? This is your **pulse.** This is the effect of your blood being squeezed from your **beating heart** round your body.
- Next time you slaughter a chicken at home, try to find its heart and some of the main blood vessels.

All the main parts of your body are supplied with blood by an **artery**. Blood returns from each part in a **vein**. Each artery breaks up into smaller and smaller vessels, eventually linking with the **capillaries**. The capillaries are the smallest of your blood vessels. They have very thin walls. Substances pass into and out of the blood circulatory system through the walls of these capillaries. The capillaries then lead into larger and larger vessels, which eventually link to the veins.

You can see examples of these three types of blood vessel in Figure 1 of the human circulatory system.

Look at the top of Figure 1.

Notice that the lungs get blood from the pulmonary artery. Also notice that the blood leaves the lungs in the pulmonary vein. Finally notice the network of small vessels that link the pulmonary artery and pulmonary vein. These are the capillaries.

Other main arteries and veins are named in the diagram. You will also see networks of small vessels linking each pair of arteries and veins. These are also capillaries.

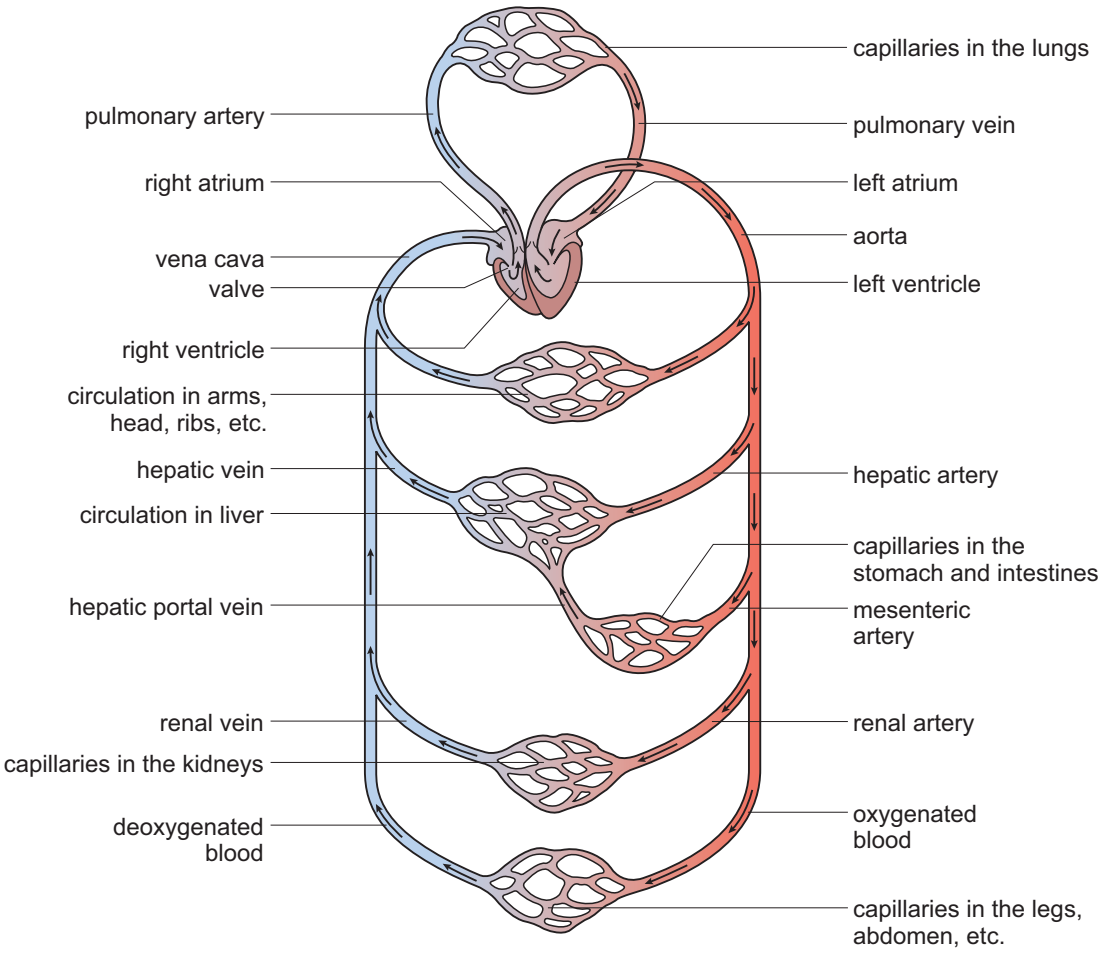


Figure 1: The human circulatory system

Activity 3

Use Figure 1 to find the names of the following blood vessels. Write your answers in the correct spaces.

1. The vessel that carries blood to the kidneys?

   .....

2. The vessel that carries blood away from the left ventricle of the heart?

   .....

3. The blood vessel that links the stomach and intestines to the liver?

   .....

4. The blood vessel that collects blood from most of the body and enters the right atrium of the heart?

   .....

Arteries, veins and capillaries

Revise what you know already about blood vessels by looking back at the previous section and at where the different blood vessels are in Figure 1.

Activity 4

Figure 2 shows what an artery, a vein and a capillary would look like if you were to cut across them.

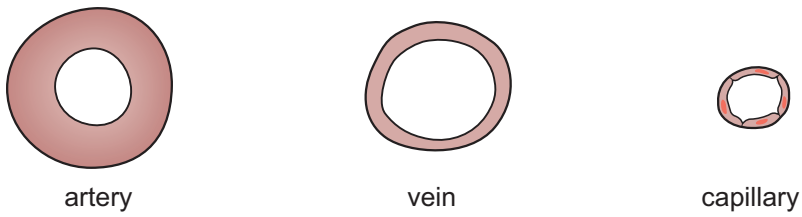


Figure 2: Sketch of a section through an artery, a vein and a capillary

Annotate each sketch (this means add labels and add notes to the labels) to outline the main differences between the three types of blood vessel. You may need to use a text book to help you.

Your annotations should refer to the features in the table below.

Tick the appropriate box in the table when you have added the annotation for each vessel.

Feature	Artery	Vein	Capillary
Are the walls thick or thin?			
Are the walls elastic or not?			
Is there a lot of, some, or no muscle in the walls?			
Compare the size of the lumen (cavity). Is it larger, smaller or tiny?			
Do these vessels have valves to prevent back-flow of blood?			
Is the pressure of blood in the vessel relatively high or low?			
Do these vessels carry blood to or from the heart?			
Do these vessels carry oxygenated or de-oxygenated blood (note any exceptions)?			
Can substances pass through their walls?			

The heart

Figure 1 showed you the arrangement of the main blood vessels and the heart in the human body.

You saw that the vena cava is the main blood vessel that collects up blood after it has flowed through most of the organs of your body and returns it to your heart.

You also saw that the aorta is the main artery which leaves your heart and leads into smaller arteries to supply most of the organs of your body with blood.

Activity 5

Look again at Figure 1. Start at the vena cava, trace with your finger and then write down the names of all the parts the blood would go through until it reached the aorta. The arrows in the vessels on the diagram show you the direction the blood travels in.

.....

.....

Figure 3 below shows your heart as seen from the front. (This is why the left and right labels seem to be on the wrong sides). The heart is the pump which forces the blood round your body.

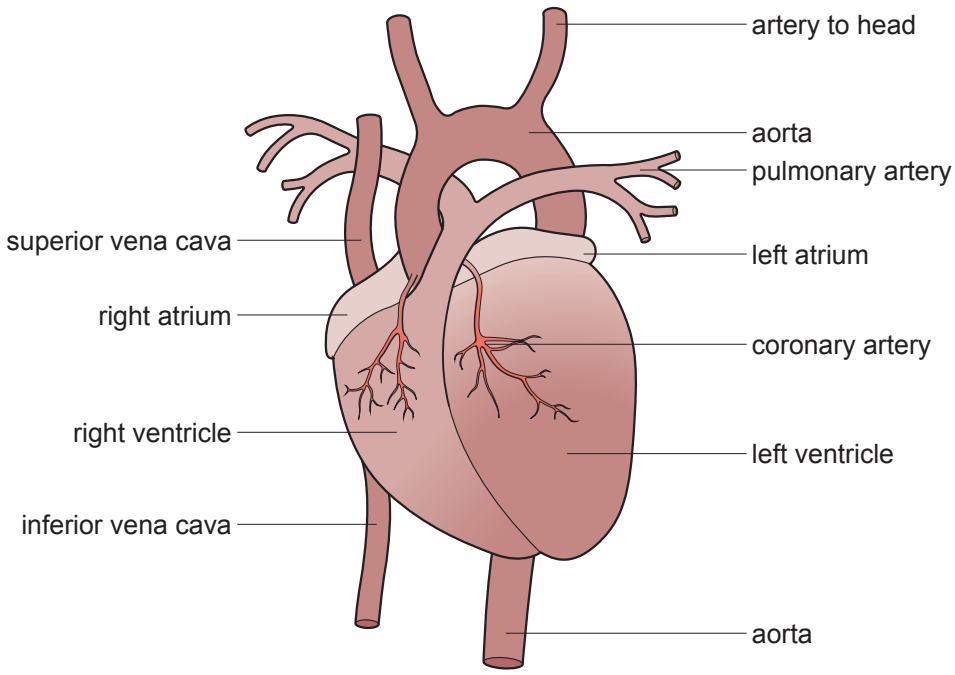


Figure 3: The heart seen from the front

The walls of your heart are made of muscle. This means they can contract and squeeze on the blood inside. This pushes the blood onwards.

The heart is hollow and made of four 'rooms' called chambers – the two chambers on the right are connected to each other and the two chambers on the left are connected to each other. Blood cannot pass directly from the right side of the heart to the left side, or vice versa.

Activity 5 showed you that blood entering the heart through the vena cava must go through the heart twice before it can be sent out along the aorta to most organs of the body.

It goes through the right side first (atrium, then ventricle).

It then goes to the lungs. As blood flows through capillaries in the lungs, oxygen is picked up here and carbon dioxide is given up.

Oxygenated blood then returns to the left side of the heart (atrium, then ventricle).

The left ventricle has the thickest walls of all four chambers. When the ventricle walls contract, this provides enough pressure to force blood out through the aorta and via the arteries to all organs of the body.

There are two kinds of **valve** found in your heart. Both kinds of valve help make sure your blood always flows in the correct direction and does not go backwards.

The valves between the atrium and ventricle on each side of the heart look a bit like parachutes.

The valves at the entrance to the aorta and pulmonary artery are called semi-lunar valves. They are like the shape of a half moon. Semi-lunar means half-moon.

Activity 6

Look at Figure 4 of a heart cut through to show its inside.

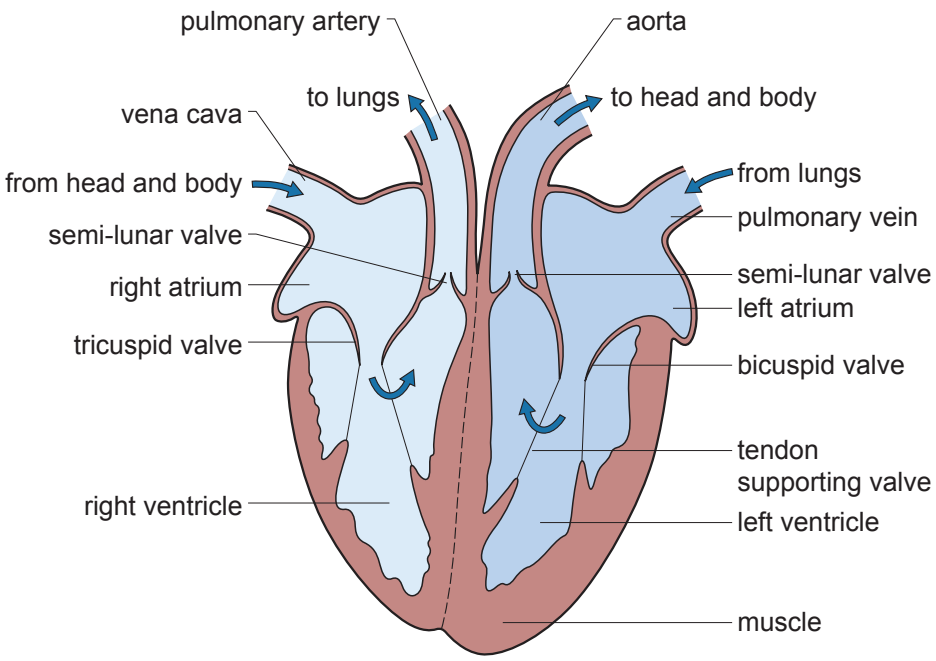


Figure 4: The heart cut through to show the inside

Find and write down the names of the four valves. For each one say what it does. The first one has been done for you. The order in which you write the names and the names themselves are less important than you understanding what the job of the heart valves is.

1. Tricuspid valve. This stops blood flowing backwards from the right ventricle to the right atrium.
2. .....
3. .....
4. .....

Our blood system is described as a **double circulatory system**.

One part goes from the heart (right ventricle) to the lungs and back to the left atrium.

The other part goes from the heart (left ventricle) to the rest of the body and back to the right atrium of the heart.

The pumping action of your heart

The heart is a **double pump**. The right side (right ventricle) pumps blood to the lungs. The left side (left ventricle) pumps blood to the rest of the body.

The left ventricle has thicker walls than the right ventricle so the left side pumps with a greater force. This is important as it has to send blood to all parts of your body (except the lungs). However, both sides of the heart work in the same way.

Activity 7

The sentences below describe how blood is pumped through one side of the heart. (They could describe either the left or the right side.) However, the sentences are not in the correct order. Sort the sentences into the correct order so they make a sensible explanation.

A. Parachute-like valves between the atrium and ventricle close over the entrance to the ventricle.

B. Blood under low pressure enters the atrium.

C. Blood is forced out into an artery (aorta or pulmonary artery), through the open semi-lunar valves.

D. The muscular walls of the ventricle relax and blood flows in from the atrium.

E. This prevents blood flowing backwards into the ventricle.

F. This prevents blood flowing backwards into the atrium.

G. The ventricle wall relaxes again.

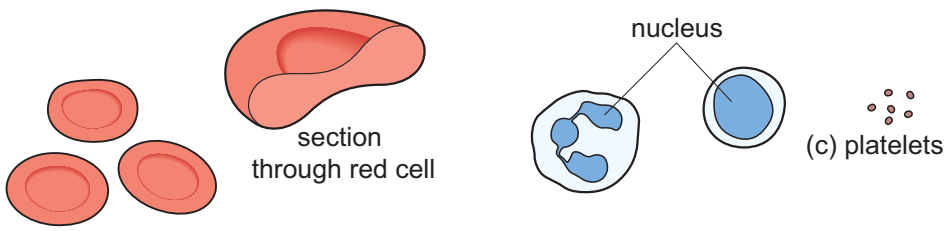
H. The ventricle wall contracts.

I. Semi-lunar valves close over the entry to the artery (aorta or pulmonary artery).

J. The atrium contracts to force more blood into the ventricle.

Types of blood cell and their functions

The blood contains **red blood cells**, **white blood cells** and cell fragments called **platelets**. These are shown in Figure 5 below. Like most cells, blood cells are tiny and they can only be seen by using a microscope.



(a) red blood cells (b) two types of white blood cell

Figure 5: Types of blood cell

Red blood cells

As you know, your blood is red in colour. This is because your red blood cells contain the red pigment, **haemoglobin**. The haemoglobin molecule can pick up oxygen molecules in the lungs, where there is a high concentration of oxygen. It carries the oxygen in the blood stream to all the cells of the body. There is a lower concentration of oxygen in the cells, as it is continually being used up. The haemoglobin releases the oxygen to the cells to be used for aerobic respiration.

At this point, it would be useful for you to refer back to Unit *S3 Periodic table and reactions* to revise your understanding of concentration and what it means. It is easier to learn about things in units or topics, but of course, in the real world, things are inter-connected and the things we learn about come together.

The shape of a red cell is described as a bi-concave disc. This is shown in Figure 5. Red cells have no nucleus when they are mature.

White blood cells or leucocytes

White blood cells are larger than red cells. There are fewer white cells than red cells. They all have a nucleus. They are all important in protecting the body from disease.

There are two main kinds of white blood cell.

About three quarters of all white blood cells are **phagocytic cells**. This means they can surround, engulf and destroy other cells, e.g. disease-causing bacteria.

About one quarter of white blood cells are called **lymphocytes**. These cells have a large rounded nucleus. Some will make and release antibodies. **Antibodies** can kill germ cells or make them clump together so they cannot work properly. Other lymphocytes make **antitoxins**. These neutralise poisons (toxins) produced by germ cells. You will learn more about this in unit B6.

Blood platelets and the clotting of blood

If you cut yourself your wound will bleed to start with. Soon the blood gets thicker and you stop bleeding. This is because your blood can clot. Clotting is important as it stops the loss of too much blood from cuts and wounds. It also reduces the chance of germs getting into the body at the site of a wound.

Clotting the blood is the job of the platelets. Platelets are cell fragments made from large cells produced in the bone marrow.

Your blood plasma contains a soluble protein called **fibrinogen**. This is converted to the insoluble protein, **fibrin**. Fibrin forms long branching fibres across the wound. Blood cells get caught in the fibres and this forms the clot.

These changes happen because the platelets that collect at the wound site release a substance called thromboplastin. This, together with calcium ions and vitamin K, activates an enzyme in the blood called **thrombin**. Thrombin converts fibrinogen to fibrin.

Sometimes clotting can be dangerous. You will find out more of this in the section on heart attacks.

Blood plasma

Blood plasma is the liquid part of the blood. The blood cells are suspended in it. The plasma also contains dissolved substances including digested food such as glucose and amino acids; salts; hormones; waste substances such as urea and carbon dioxide; and proteins such as antibodies.

Activity 8

For each of the phrases below, say whether it refers to red blood cells, white blood cells or both.

1. Have a nucleus. .....
2. Have a cell membrane. .....
3. Contain haemoglobin. .....
4. Can carry out phagocytosis. .....
5. Are present in the largest numbers in the blood. .....
6. Their shape is a bi-concave disc. .....
7. Protect the body against disease. .....
8. Carry oxygen. .....

Heart attacks

Look back at Figure 3. Notice the blood vessels on the outside of the ventricles. These are branches of the coronary artery. The coronary artery is important because it supplies the heart muscle itself with food and oxygen. If these vessels are blocked, the heart cannot work properly and may fail altogether. This is a heart attack.

The coronary artery may be blocked by fatty deposits forming inside it on the lining of its walls. The artery lining itself may also grow thicker. This makes the inner surface of the artery rougher than normal and makes it more likely that blood platelets will stick to it. The platelets can then cause a blood clot to form. This can block the artery.

The risk of heart attack can be reduced by avoiding over-eating, by not smoking and by taking regular exercise. Eating too much saturated fat (fat found in animal products such as fat in meat) also increases the risk of heart attacks. The typical Malawian diet does not include a lot of saturated fat.

High blood pressure or hypertension

High blood pressure puts an extra strain on the heart and may lead to heart failure. It also pushes against the artery walls and may cause them to burst. If this happens in the brain it may lead to a stroke. This may cause paralysis or impaired speech. If severe, it can cause death.

Factors causing high blood pressure are not completely understood. However, it is frequently associated with over-eating, drinking too much alcohol, smoking and the stresses of modern life.

Activity 9

1. Give some advice to a friend or relative on lifestyle tips for a healthy heart.
2. Explain to them how an unhealthy lifestyle could have dangerous results for their heart. Try to include the following terms in your explanation: blood clot, coronary artery, fatty deposits, heart attack, stroke.

The digestive system

As you learned at the start of this unit, the food that you eat cannot be used directly by your body cells. It must first be broken down into small, simple, soluble substances which can be absorbed by your blood and transported round the body to where it can be used in different ways.

The alimentary canal

The process of breaking down food is called **digestion**. It happens in the **alimentary canal**, also called the gut. The alimentary canal is a long, hollow muscular tube that runs from your mouth to your anus. It is much longer than your body length (over seven metres long) and therefore it has to be coiled up. It varies in size and shape along its length. Different parts have their own special jobs to do.

Other organs and glands are associated with the alimentary canal and are also important in the digestion of food. These include the salivary glands, the pancreas, the liver and gall bladder.

Digestion

There are two types of digestion: physical and chemical digestion.

Physical digestion

This is the breaking down of food into small pieces by the teeth and jaws, which makes it easier to swallow. The small pieces have a larger surface area for the action of the enzymes in the second stage of digestion.

Chemical digestion

The large molecules in food that must be broken down by chemical digestion are the proteins, carbohydrates and fats. They are broken down by special molecules called **enzymes**. There are different enzymes to break down each type of food.

The movement of food along the alimentary canal

The walls of the alimentary canal contain muscle fibres. You can feel and hear this when you are hungry and your 'tummy rumbles'. These muscle fibres are used to push food along the alimentary canal. They contract and relax producing a wave-like motion, called **peristalsis**. This pushes the food along the canal.

Figure 6 on the next page shows how the food you eat is digested and used by the body. Study it carefully and then answer the questions in Activity 10.

Activity 10

Explain to a friend the difference between:

1. Ingestion and digestion.
2. Absorption and assimilation.

Figure 7 shows you what your alimentary canal looks like in more detail. Study it carefully. In particular try to remember the parts labelled:

salivary gland, gullet (oesophagus), stomach, liver, gall bladder, bile duct, pancreas, pancreatic duct, small intestine, duodenum, ileum, colon, rectum, anus.

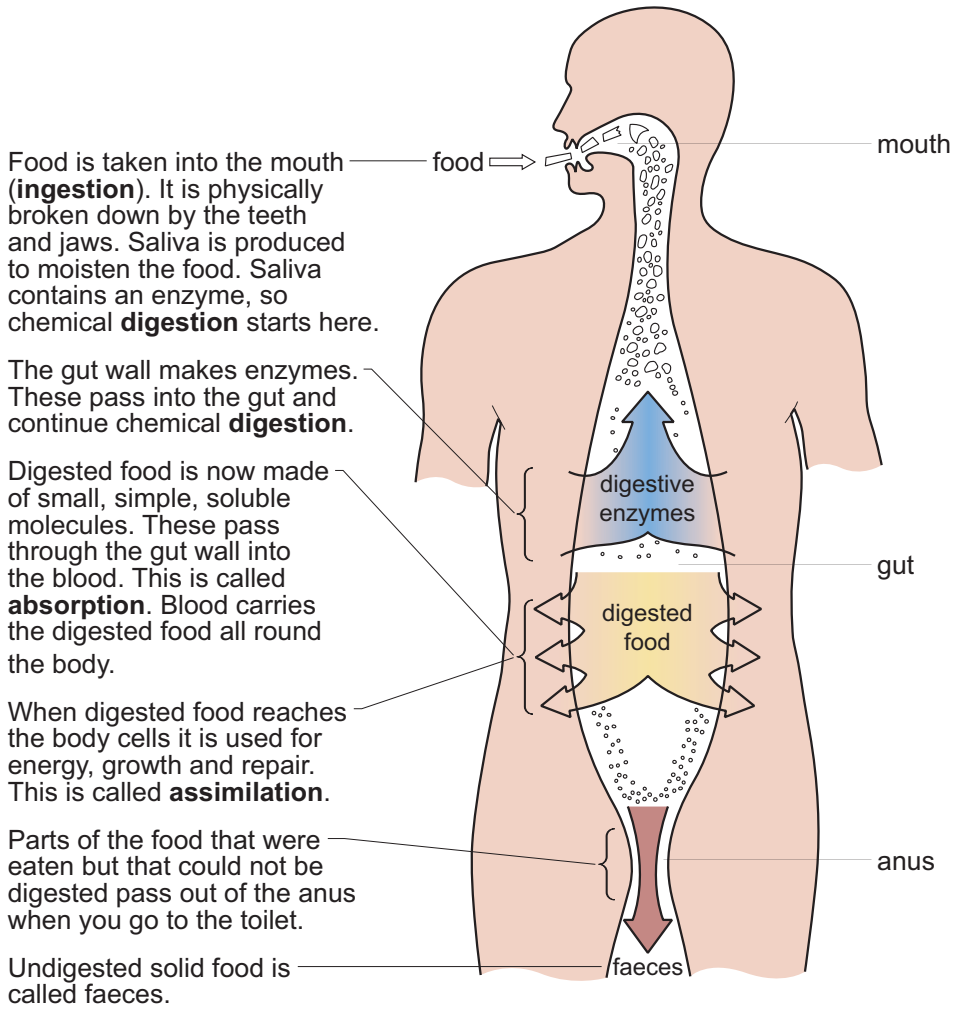


Figure 6: Summary of digestion and what happens immediately afterwards

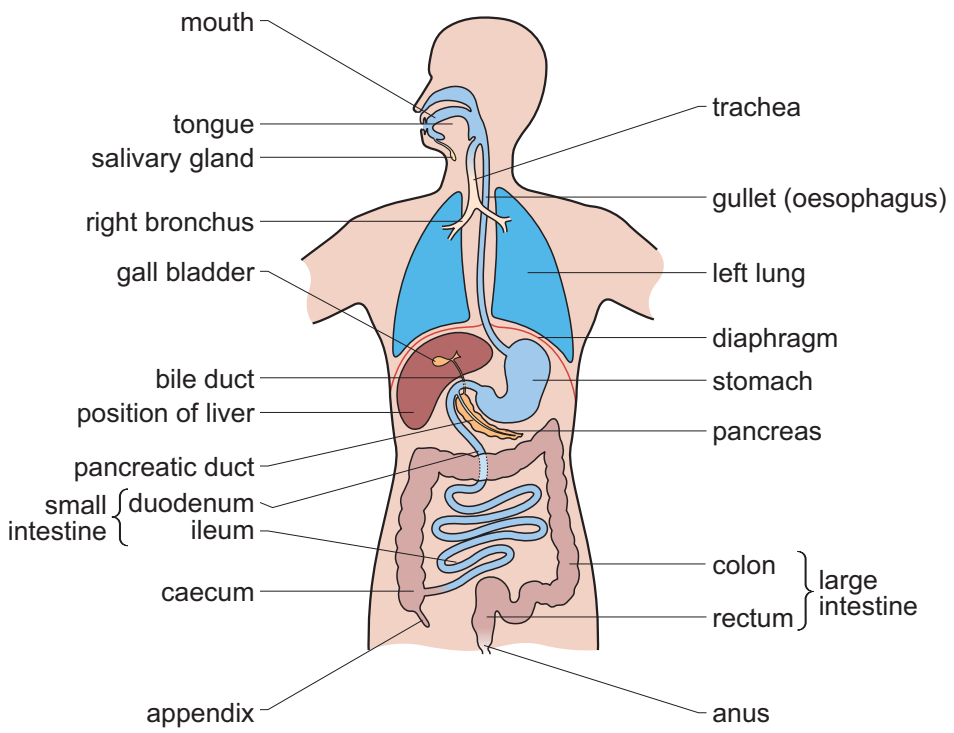


Figure 7: The human alimentary canal

Activity 11

You can do this activity with a fellow scholar and test each other.

1. What digestive gland is found in the mouth?

   .....

2. Name the part of the alimentary canal between the gullet and the small intestine.

   .....

3. Two ducts (tubes) join the small intestine near to its beginning. Name the ducts and say where they come from.

   .....

   .....

4. Can you see a part linked to the main alimentary canal that looks a bit like a long thin leaf? What is its name?

   .....

Certain parts of the alimentary canal produce liquids called **digestive juices**. These juices contain special substances called enzymes that do the work of digestion.

The table below shows you where these digestive juices are made.

Part of alimentary canal	**Name of digestive juice**
Mouth	Saliva
Stomach	Gastric juice
Pancreas	Pancreatic juice. This flows into the small intestine, where it does its work.
Small intestine	Intestinal juice
Bile is made in the liver and stored in the gall bladder. It flows into the small intestine, where it does its work. It does not contain enzymes, but it does contain salts that break large fat droplets down into tiny droplets. These are easier to digest later by enzymes.	

Activity 12

Write the information from the table above about digestive juices and the note about bile onto Figure 7 in the correct places.

Enzymes

Enzymes are protein molecules. They act as **catalysts**. This means they make chemical reactions go faster. Each enzyme can only work on one kind of reaction. Enzymes are not used up themselves during the reaction. They work best at a particular temperature and pH (acid, alkali or neutral condition).

Digestion of carbohydrates, e.g. starch, by enzymes

You probably eat nsima. This contains starch. Starch is a carbohydrate made of many glucose (sugar) molecules joined together like a string of beads. There are more than 1000 glucose molecules in one starch molecule.

The enzyme **amylase** can digest (break down) starch into pairs of glucose units.

Amylase is found in the saliva. It is also found in the pancreatic juice. The pancreatic juice passes in a small duct or tube from the pancreas into the small intestine. Pancreatic amylase does its work in the small intestine.

The enzyme **maltase** can break down the pairs of glucose units into single glucose units. This completes the digestion of starch.

Maltase is found in the intestinal juice.

Digestion of protein by enzymes

You may also eat fish. Fish contains protein. Protein molecules are made up of many smaller molecules called **amino acids** joined together. There are usually more than 100 amino acids in each protein.

Protein digesting enzymes, **proteases**, are found in the stomach, pancreatic juice and intestinal juice. There are different kinds of proteases, but it is not important that you know all their names at this stage.

The proteases break down proteins into amino acids.

Digestion of fat by enzymes

Do you use soya bean oil when you cook? Soya bean oil is a fat. Fats (also called lipids) are made up of **fatty acids** and **glycerol** units joined together.

The fat digesting enzyme is called lipase. It is produced in the pancreatic juice. It digests fats into fatty acids and glycerol.

The work of the digestive enzymes is summarised in Figure 8

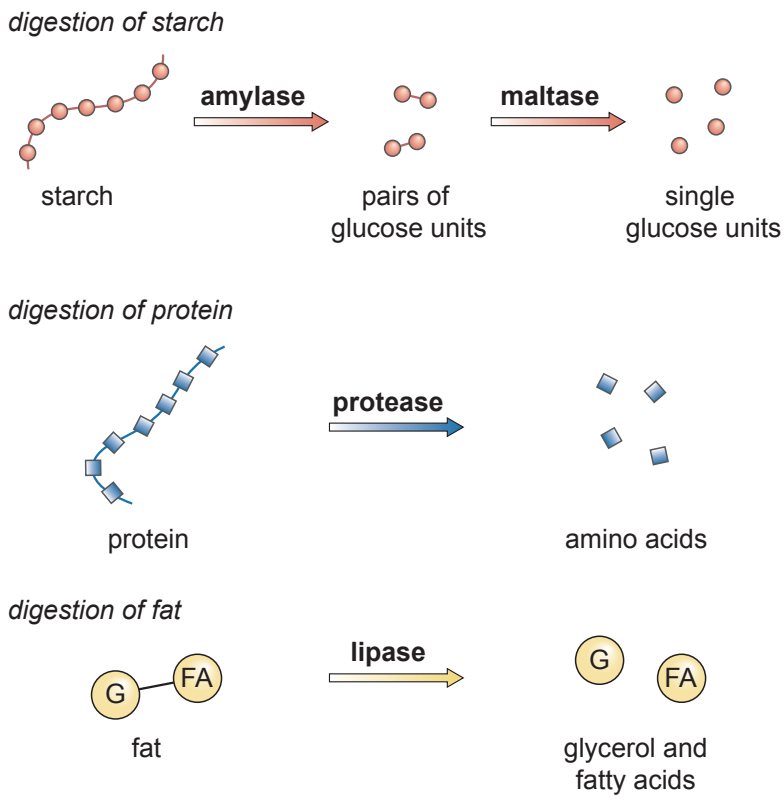


Figure 8: Summary of the work of the digestive enzymes

Activity 13

In the figure below, label the parts of the alimentary canal where the digestive enzymes described in the last section are made.

Annotate each label to show what enzyme is made and write what each enzyme does.

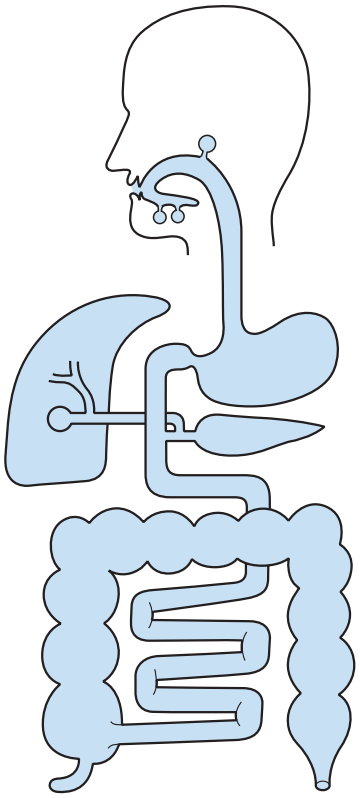


Figure 9: Simplified diagram of the human alimentary canal

Absorption and assimilation of digested food

Once digestion is complete, the glucose, amino acids, fatty acids and glycerol produced are **absorbed** into the walls of the second part of the small intestine, called the **ileum**. There are many capillaries in the walls of the ileum. The digested food passes into the blood in these capillaries and is carried away. You can revise where it goes next by looking back at the section on circulation (see Figure 1 of the human circulation system).

The inner surface of the ileum is covered with many finger-like structures. This is a clever design as it increases the surface area of the lining so more food can be absorbed.

Practice questions

Remember, talking about the ideas in the units is a very good way to learn. Ask one of your fellow scholars these questions and check their answers. The questions marked with an asterisk require some knowledge which is additional to what you have covered in Unit B3. Use your textbook to help with these answers.

1. Mention any two substances transported by the blood.
2. (a) Give two structural differences between veins and arteries.

   (b) For each type of vessel, say where it takes blood from and to.

   (c) State the difference in blood pressure between blood in the arteries and blood in the veins.
3. (a) Name the structures through which blood flows, starting from when it returns to the heart from the main organs of the body until it leaves the heart and flows back to the main organs.

   (b) What makes the blood flow along this path?
4. Give two structural differences between red blood cells and white blood cells.
5. How are red blood cells adapted to their function?
6. State three ways in which white blood cells can protect you against disease.
7. Why are your blood platelets important to you? What two substances do they need to help them perform their function?
8. What happens inside the body when someone has a heart attack?
9. State two ways in which problems of the circulatory system could be prevented.

*10. A teacher measured the pulse of a student and found that it was 60 beats per minute.

   (a) Describe how the pulse of the student was measured.

   (b) What effect could exercise have on the pulse of the student?

11. What is digestion and why is it important?

*12. State the function of each of the following food substances in the human body

   (a) carbohydrates

   (b) proteins.

For each food substance, say where in the body its chemical digestion begins.

13. Describe the digestion of cooked cassava in the body.

14 (a) What is an enzyme?

   (b) State three important things about how an enzyme works?

15. Explain how the small intestine is adapted to its function.

*16. Describe an experiment that could be conducted to determine the presence of protein in groundnut flour.

*17. (a) If the liver failed to produce bile, what effect would this have on the digestion of fats?

   (b) Explain how the liver regulates blood sugar levels.

   (c) State four functions of the liver in addition to those highlighted in (a) and (b) above.

*18. Give the causes of the following problems of the digestive system: constipation, diarrhoea.

How am I doing?

	☺ **Easy** (Tick this box if you feel confident that you **understand this section well**)	**Fine** (Tick this box if you still **need a little work** on this section)	☹ **Difficult** (Tick this box if you still **need a lot of work** on this section)
The structure and function of the heart			
The structure and function of arteries, veins and capillaries			
The structure and function of red blood cells, white blood cells and blood platelets			
Problems of the circulatory system – heart attacks and high blood pressure			
The structure of the alimentary canal			
Physical and chemical digestion			
Enzymes and digestion			
What happens to the final products of digestion			

Notes on what to do next:

Signed (by Scholar): ..... Date:.....

Signed (by Tutor): ..... Date:.....

Answers

Activity 1

Substance	Carried from	Carried to
Oxygen	Lungs	All cells
Carbon dioxide	All cells	Lungs
Hormones	From the gland where they are made	To the part of the body where they are required
Heat*	From places where heat is produced, e.g. muscles and the liver	To all parts of the body to distribute it evenly. Also to and from the skin to help keep your body temperature constant
White blood cells	From the bone marrow, lymph nodes and spleen, where they are made	To cuts and wounds where they attack germs such as bacteria

*Note that heat is actually a form of energy, not a substance.

Activity 3

1. The renal artery carries blood to the kidneys.
2. The aorta carries blood away from the left ventricle of the heart.
3. The hepatic portal vein links the stomach and intestines to the liver.
4. The vena cava is the blood vessel that collects up blood from most of the body and enters the right atrium of the heart.

Activity 4

Annotations:

Artery – thick walls, well supplied with muscle and elastic tissue; smaller lumen than veins; no valves; blood pressure higher than in veins; carry oxygenated blood (except pulmonary artery); carry blood **from** the heart; substances **cannot** pass through their walls.

Vein – thinner walls than arteries; little muscle or elastic tissue; larger lumen than arteries; contain valves to prevent back-flow of blood; blood pressure lower than in arteries; carry de-oxygenated blood (except pulmonary vein); carry blood **to** the heart; substances **cannot** pass through their walls.

Capillary – walls only one cell thick; no muscle or elastic tissue; the smallest vessels with the smallest lumen; no valves; blood pressure intermediate; carry blood between arteries and veins; substances **can** pass through their walls.

Activity 5

Vena cava, right atrium (of heart), valve, right ventricle of heart, pulmonary artery, (capillaries in) lungs, pulmonary vein, left atrium (of heart), left ventricle (of heart), aorta.

Activity 6

1. Tricuspid valve. This stops blood flowing backwards from the right ventricle to the right atrium.
2. Bicuspid valve. This stops blood flowing backwards from the left ventricle to the left atrium.
3. Semi-lunar valve at the base of the pulmonary artery. This stops blood flowing backwards from the pulmonary artery to the right ventricle.
4. Semi-lunar valve at the base of the aorta. This stops blood flowing backwards from the aorta to the left ventricle.

Activity 7

B. Blood under low pressure enters the atrium.

D. The muscular walls of the ventricle relax and blood flows in from the atrium.

J. The atrium contracts to force more blood into the ventricle.

H. The ventricle wall contracts.

A. Parachute-like valves between the atrium and ventricle close over the entrance to the ventricle.

F. This prevents blood flowing backwards into the atrium.

C. Blood is forced out into an artery (aorta or pulmonary artery), through the open semi-lunar valves.

G. The ventricle wall relaxes again.

I. Semi-lunar valves close over the entry to the artery, (aorta or pulmonary artery).

E. This prevents blood flowing backwards into the ventricle.

Activity 8

1.	Have a nucleus.	White blood cells
2.	Have a cell membrane.	Both
3.	Contain haemoglobin.	Red blood cells
4.	Can carry out phagocytosis.	White blood cells
5.	Are present in the largest numbers in the blood.	Red blood cells
6.	Their shape is a bi-concave disc.	Red blood cells
7.	Protect the body against disease.	White blood cells
8.	Carry oxygen.	Red blood cells

Activity 9

1. Do not over-eat, do not drink too much alcohol, do not smoke and take regular exercise. Try to do relaxation exercises and not get too stressed. Do not eat a lot of animal (saturated) fat.

2. Unhealthy lifestyles increase the chance of a heart attack or stroke. A heart attack is caused when there is a blockage in the coronary artery which supplies the heart with food and oxygen. A serious blockage can stop the heart working altogether, as it cannot get the food and oxygen it needs. The blockage can happen if the artery lining thickens and fat builds up in the lining. The tiny platelets in the blood are more likely to stick to the rough inner surface of this lining. This can trigger the formation of a blood clot which can block the artery.

   High blood pressure can cause an artery wall to burst. If this happens in the brain, it can cause a stroke. This may cause paralysis, impaired speech or even death.

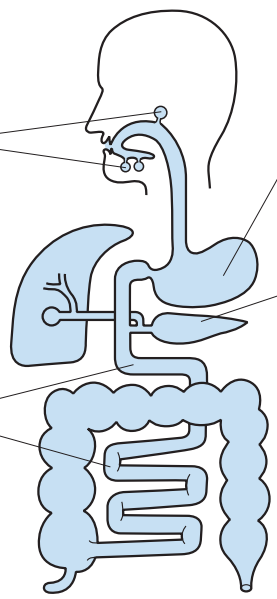
Activity 10

1. Ingestion is when food is taken into the mouth. Digestion starts when food is physically broken down into small pieces by the teeth and jaws. This is followed by chemical breakdown by digestive enzymes into small, soluble, simple molecules.
2. Absorption is when the liquid food passes through the gut wall into the blood. Assimilation is when food is taken from the blood by the cells of the body and used for energy, growth and repair.

Activity 11

1. The salivary gland is the digestive gland found in the mouth.
2. The stomach is found between the gullet and the small intestine.
3. The two ducts (tubes) that join the small intestine near to its beginning are the bile duct, which comes from the gall bladder in the liver and the pancreatic duct, which comes from the pancreas.
4. The pancreas looks a bit like a long thin leaf.

Activity 13



SALIVARY GLANDS
Amylase is made here. It digests *starch* into *pairs of glucose units*.

SMALL INTESTINE
1. Maltase is made here. It digests *pairs of glucose units* into single *glucose units*.
2. Protease is made here. It digests *proteins* to *amino acids*.

STOMACH
Protease is made here. It digests *proteins* to *amino acids*.

PANCREAS
1. Amylase is made here. It digests starch into pairs of glucose units.
2. Protease is made here. It digests *proteins* to *amino acids*.
3. Lipase is made here. It digests *fats* into to *fatty acids* and *glycerol*.
(These enzymes pass into the small intestine where they do their work.)

Answers to practice questions

1. Any two of the following: glucose, oxygen, carbon dioxide, hormones, urea, salts, toxic substances.

2. (a) Any two of the following: veins have a wider lumen, while arteries have a narrow lumen; veins have thin walls, while arteries have thick muscular walls; veins have valves, while arteries have no valves.

   (b) Arteries take blood from the heart to the different parts of the body. Veins take blood from the different parts of the body back to the heart.

   (c) Blood in the arteries is under high pressure, while blood in the veins is under lower pressure.

3. (a) Vena cava, right atrium (auricle) of the heart, right ventricle, pulmonary artery, capillaries in the lungs, pulmonary vein, left atrium (auricle) of the heart, left ventricle, aorta.

   (b) Each chamber of the heart relaxes to receive blood and then contracts to push the blood onwards. Valves prevent back flow of blood.

4. Red blood cells have no nucleus while white blood cells have a nucleus. Red blood have a biconcave shape while most white blood cells have an irregular shape.

5. Red blood cells are packed with haemoglobin which combines readily with oxygen in the lungs (where there is a lot of oxygen) and carries it round the body, releasing it to cells (where oxygen levels are lower).

6. 1. They can move in and out of the blood system, in a kind of patrol, ingesting germs. 2. They can make antibodies which kill germ cells or stop them working properly. 3. They can make anti-toxins which neutralise poisons made by germ cells.

7. Blood platelets are important for clotting blood. If you have a cut or wound, it is important that the blood clots in order to stop you losing too much. It also reduces the chance of germs getting into the body through the wound. Calcium and vitamin K aid the platelets in their job.

8. When someone has a heart attack, the coronary artery, which supplies the heart with food and oxygen, gets blocked. This stops the heart working properly. The blockage is caused by the artery lining thickening. Blood platelets are more likely to stick to this thick, rough lining and cause a blood clot.

9. Take a balanced diet and exercise regularly.

10. (a) One method is to count the number of beats in one minute. Repeat this several times and then calculate the average in beats per minute.

    (b) Pulse rate increases with exercise.

11. Digestion is the process of breaking down the food you eat into small, soluble, simple substances. It is only when it has been broken down that your food can be absorbed into the blood and carried round the body to all the cells. Your cells can then use the digested food for growth, repair and energy. If digestion did not happen, your body could not use any of the goodness in the food you eat.

12. (a) Carbohydrates are used in respiration to release energy. Carbohydrate digestion begins in the mouth with the action of salivary amylase produced by salivary glands.

    (b) Proteins are used for growth and to repair worn out tissues. Protein digestion begins in the stomach with the action of pepsin (a protease) produced in the stomach walls.

13. Cooked cassava is broken down physically into small pieces by the teeth. Salivary amylase acts on the food to change the starch in the cassava to maltose. More amylase is produced by the pancreas and completes this process in the small intestine. The maltose is broken down to glucose by the enzyme maltase in the small intestine.

14. (a) An enzyme is a special protein molecule which can alter the rate of a chemical reaction. It acts as a catalyst.

    (b) 1. Each enzyme can only work on one kind of reaction. 2. Enzymes are not used up themselves during the reaction. 3. They work best at a particular temperature and pH (acid, alkali or neutral condition).

15. The small intestine is adapted to its function in the following ways:

    It has finger-like projections called villi that create a large surface area for efficient absorption of food.

    It is supplied with a dense network of blood capillaries which create an efficient transport system to carry away digested food.

    The epithelium of the small intestine is one cell thick, so digested food can be absorbed quickly.

16. To test for protein, take a small amount of the groundnut flour, mix it with water and shake well. Add a few drops of sodium hydroxide and copper sulphate and shake further. A purple colour shows the presence of protein. A blue colour shows the absence of protein.

17. (a) Without bile, fats could not be broken down physically into small droplets in readiness for chemical digestion in the small intestine. Also, the acids from the stomach would not be neutralised so enzymes in the small intestine would not work efficiently.

    (b) When the concentration of glucose in the blood is high, liver cells convert excess glucose to glycogen which is stored for future use. When glucose levels are low in the blood, liver cells reconvert glycogen to glucose. This happens with the help of the hormones insulin and glucagon.

    (c) Detoxification, deamination, storage of vitamins A and D, production of body heat.

18. Constipation is caused by eating food that is very fine, or that has no fibre or roughage. Diarrhoea is caused by germs that irritate the lining of the digestive system, so that the cells fail to absorb water from the undigested food.

Glossary

Absorb (absorption)	To take in.
Alimentary canal	The food tube or gut. Food passes through this tube where it is digested. Useful substances pass through its walls into the blood, to be carried to cells throughout the body.
Amino acid	Protein molecules are made of many amino acid molecules joined together.
Amylase	This is an enzyme that digests starch molecules to smaller molecules.
Anus	The exit or rear opening of the alimentary canal.
Aorta	The largest artery in the body. It carries blood away from the left ventricle of the heart.
Artery	A blood vessel that carries blood away from the heart to organs in the body.
Assimilation	The process by which the products of digestion are built up into the molecules and structures in the body.
Atria (sing. = atrium)	This is name of the two upper chambers of the heart.
Bicuspid valve	This is a valve between the left atrium and left ventricle. It stops blood flowing backwards.
Bile	An alkaline solution made in the liver and stored in the gall bladder. It helps the digestion of fats in the small intestine.
Blood vessels	These are the tubes through which blood flows within the body. They include arteries, veins and capillaries.
Capillaries	These are the smallest blood vessels. Substances can pass in and out of the blood through their walls. They are found in all the main parts of the body.
Carbohydrates	These are found in foods such as maize, cassava and potato. They form an important part of our diet.
Catalyst	This is a substance that can speed up the rate of a chemical reaction. It is not used up itself during the reaction.
Chemical digestion	This is the breaking down of large, insoluble, complex food molecules into smaller, soluble, simpler molecules ; for example, the breakdown of carbohydrates to sugars.
Clot (blood clot)	This is a clumping together of fibres and cells in the blood. It happens at cuts and wounds, where it stops blood loss from the body and the entry of germs. It may also happen in vessels inside the body, where it can cause problems such as a heart attack or stroke.
Deoxygenated blood	This describes blood which has a low level or concentration of oxygen.
Diaphragm	This is a sheet of muscle and connective tissue which separates the chest area of the body from the lower area of the body or abdomen.
Enzyme	This is a type of protein which acts as a biological catalyst, i.e. it speeds up biological reactions.
Faeces	Solid undigested waste passed out of the body through the anus.
Fat	Fat is found in foods such as oils, some fish and seeds. It forms an important part of our diet.
Fatty acids	These are one of the building blocks or components of fat molecules.
Fibrin	These are long branching threads that form in the blood when it clots.
Fibrinogen	This is a soluble protein found in blood plasma. It changes into insoluble threads (fibrin) when blood clots.
Gall bladder	This is a small sac-like structure in the liver which stores bile.
Gastric juice	This is a solution containing digestive enzymes produced in the stomach.
Glucose	This is a simple sugar molecule.
Glycerol	This is one of the building blocks or components of fat molecules.
Haemoglobin	This is a red pigment, found in red blood cells. Its function is to carry oxygen round the body.

Heart	This is a pump with muscular walls which keeps the blood moving round the body.
Heart attack	This happens when the small blood vessels which supply the heart muscle become blocked or severely narrowed. The heart stops working and death often results.
Hormones	These are chemical messenger molecules made in tiny amounts by glands (endocrine glands). They help to control body activities and development.
Ingestion	This is the taking of food into the body.
Large intestine	This is part of the alimentary canal. It includes the colon and rectum. Water is absorbed into the blood in the colon.
Lipase	This is the enzyme that digests fats.
Liver	This is a large organ found in the abdomen under the diaphragm.
Maltase	This is the enzyme that completes the digestion of carbohydrates to glucose sugar.
Oesophagus	This is also called the gullet. It is the part of the food tube (alimentary canal) which passes from the throat to the stomach.
Oxygenated blood	This describes blood which has a high level or concentration of oxygen.
Pancreas	This is a leaf-like organ in the abdomen. It secretes digestive enzymes in the pancreatic juice, which passes into the small intestine.
Peristalsis	This is when waves of muscle contraction pass along the walls of the food tube and push the food inside onwards.
Phagocytosis	This is when a cell puts out extensions of itself to enclose a germ cell and then destroys it by digesting it. Many white blood cells and macrophages can carry out phagocytosis.
Physical digestion	This is the breaking up of food into small particles by the action of the jaws and teeth.
Plasma	This is the liquid part of the blood.
Platelets	These are small cell fragments found in the blood. They are important for the clotting of blood.
Proteases	These are enzymes that digest protein molecules to amino acids.
Protein	This is found in foods such as chicken, fish and seeds. It forms an important part of our diet.
Pulmonary artery	This artery carries blood from the right ventricle to the lungs. Unlike all other arteries, the blood it carries is deoxygenated.
Pulmonary vein	This vein carries blood from the lungs to the left atrium. Unlike all other veins, the blood it carries is oxygenated.
Semi-lunar valves	These valves are shaped like a half moon. They are found at the base of the two arteries where they leave the ventricles of the heart.
Small intestine	This is part of the food tube or alimentary canal. It comprises the duodenum and the ileum. Digestion happens here. Absorption of digested food happens in the ileum.
Starch	This is a type of carbohydrate.
Stomach	This is part of the alimentary canal or food tube. Protein digestion happens here.
Stroke	This is when blood vessels in the brain burst due to high blood pressure. It can lead to paralysis, impaired speech or death.
Tricuspid valve	This is a valve between the right atrium and right ventricle. It stops blood flowing backwards.
Vein	This is a blood vessel that carries blood towards the heart from the organs of the body.
Vena cava	This is the main vein bringing blood to the heart from the body. It has a superior and inferior branch.
Ventricles	This is name of the two lower chambers of the heart. Ventricle walls are very muscular.

MSCE B4:
Excretion and coordination

What you are studying and why

Subject: Biology Unit B4

In this unit you will be looking at two more important processes of living things – excretion and coordination. In the first part you will study excretion. This is how your body gets rid of unwanted waste products. Without an excretory system you would soon be poisoned! In the second part of the unit, you will revise how the nervous system links together the different parts and activities of your body so they work efficiently and cooperatively together. Other animals have excretory and coordination systems, but here you will be concentrating on humans.

At the end of this unit you should be able to:

1. define excretion
2. state the excretory products that are removed from the body by the kidney
3. describe the structure of the kidney and explain how it works
4. label parts of the kidney
5. explain the role of antidiuretic hormone (ADH) in osmoregulation and homeostasis
6. describe a kidney dialysis machine and explain how it works
7. define coordination and explain its importance
8. describe the main parts of the nervous system and explain what each part does
9. describe the structure of a nerve cell (neuron) and explain how it works
10. give examples of reflex actions and explain how they work
11. state the effects of painkillers, stimulants, sedatives and hallucinogens on brain activity and name one example of each type of drug.

Excretion

Excretion is the removal from your body of **waste products** of chemical reactions. These products would become poisonous if allowed to build up. The main products excreted from your body are **urea**, c**arbon dioxide**, **excess mineral salts**, **toxic substances** and **water**.

Remember, from Unit B3, that amino acids are formed when protein is digested. If your body contains more amino acids than it can use immediately, they must be broken down chemically and removed. This is because your body cannot store amino acids. These breakdown reactions happen in the liver.

amino acid → urea + carbohydrate

The **nitrogen-containing waste product** of these reactions is **urea**.

Carbon dioxide is one of the **products** of respiration.

Activity 1

Look back at Unit S3 if you have forgotten how to do word equations or what products are.

1. Write the word equation for respiration. Look back to Unit B2 if you need help in remembering about respiration.

.....

2. Name the **two products** of respiration.

.....

.....

Waste substances are collected from all over the body by the blood. As the blood flows through the kidneys the waste substances are filtered out and the blood flows away clean again. The solution of waste substances formed in the kidney is called **urine**.

Figure 1 below shows you the position of your two kidneys in the body.

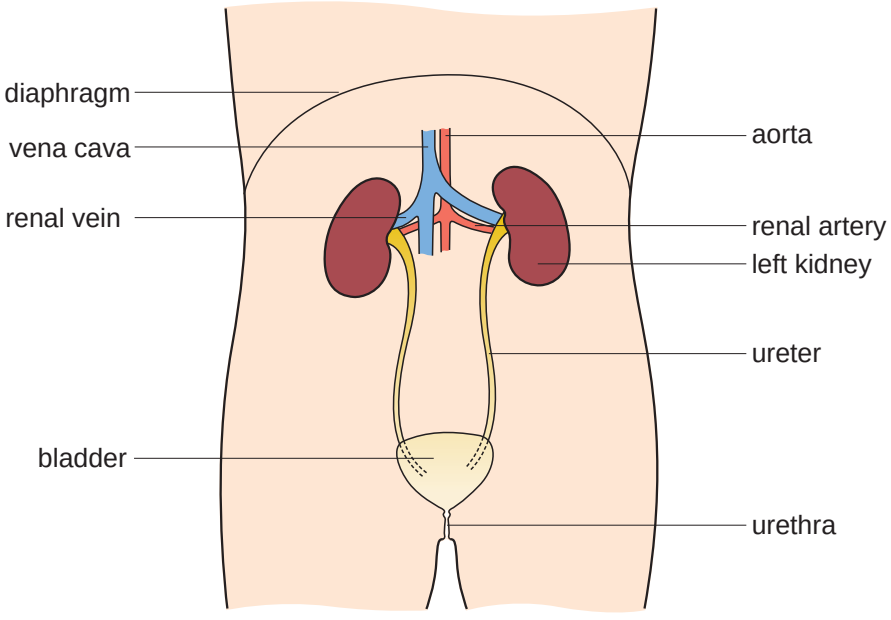


Figure 1: The position of the kidneys in the human body

Activity 2

1. Look for the four labelled blood vessels in Figure 1. Revise the work you did in Unit B3 on blood vessels. Notice that blood flows to the two kidneys in the two **renal arteries**. Blood flows away from the kidneys in the two **renal veins**.
2. Use a coloured pen or pencil to draw arrows on Figure 1 above to show the direction the blood flows through the aorta, renal arteries, renal veins and the vena cava. Write a key explaining that these arrows show the direction of blood flow.
3. Notice the shape of the two kidneys. You may well have seen kidneys from animals such as cows or sheep in a butcher's shop. They will vary in size, but they are all roughly shaped like a bean.
4. Notice the two tubes called **ureters**. These carry urine out of the kidneys. What two things must urine flow through next to get to the outside of the body?
5. Use a different coloured pen or pencil to draw arrows on diagram 1 to show the direction urine flows from the kidney to the outside of the body. Write a key explaining these arrows.

Activity 3

1. You have two kidneys, one on each side of your body. Put your hands on your hips. Your two kidneys are just underneath your two thumbs. It is possible to survive quite well with only one kidney. This could happen if one of your kidneys became damaged. Also, it means you could donate one of your kidneys to a sick relation, which could save their life.
2. Clench your fist. That is about the size of one of your kidneys.

Inside your kidney

Figure 2 shows a human kidney cut in half to reveal the main parts. Study the diagram carefully. You will see the two blood vessels you have already learned about – the renal artery and the renal vein. Notice also the names of the other four parts labelled. Try to remember these names:

The outer region of the kidney called the **cortex**.

The inner area called the **medulla.**

The space called the **pelvis** where the **ureter** (tube) leaves the kidney.

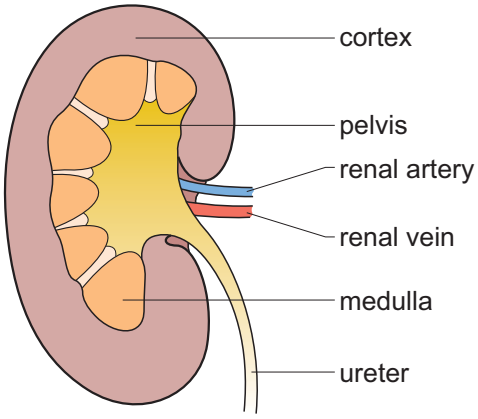


Figure 2: A human kidney cut in half

Look back at Figure 1 again to see how the **two ureters** from each kidney lead to the **bladder** and then to the outside of the body via the **urethra**.

Each of your kidneys is made up of about one million tiny tubes. These are called **kidney tubules** or **nephrons**. If you were to cut an animal kidney from the butcher's in half, these tubules would be too small to see. They are very important, however, because the urine is made inside them.

Figure 3 shows you what one of the tubules from your kidney looks like. The diagram also shows you that there are many blood capillaries (the smallest type of blood vessel) close to each kidney tubule.

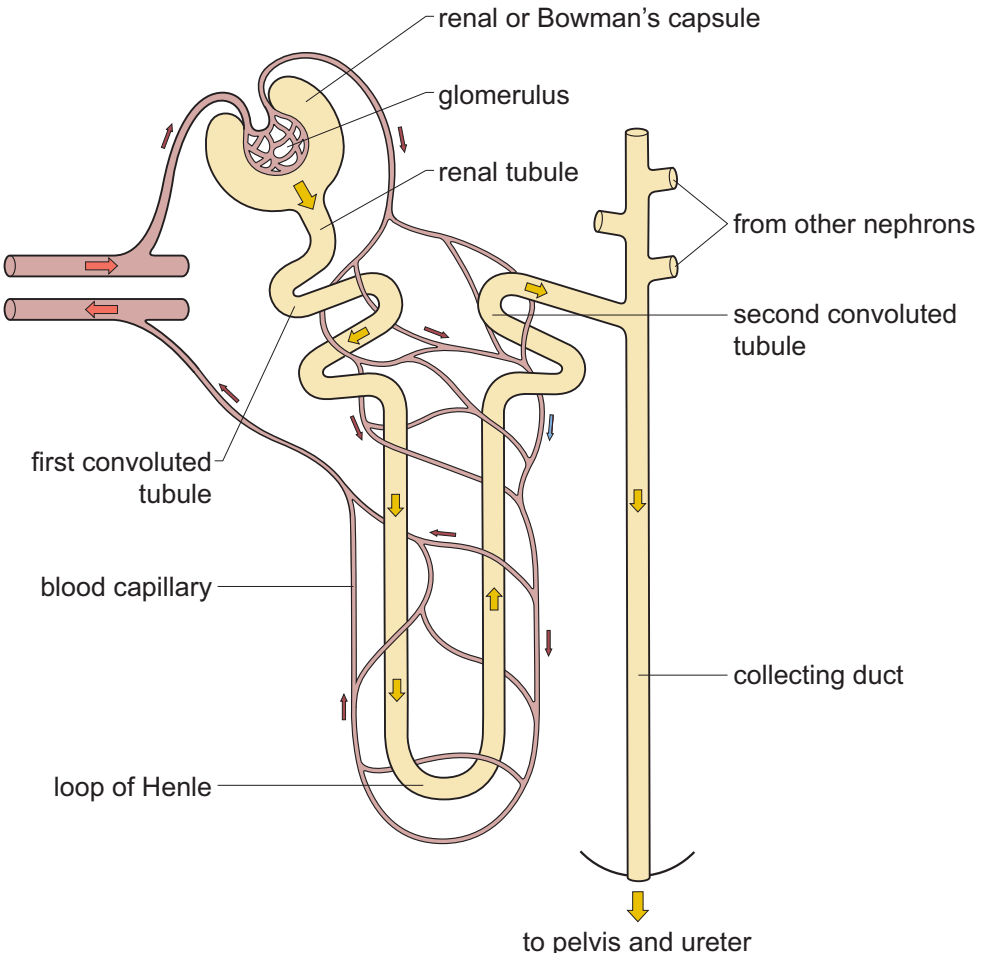


Figure 3: A kidney tubule or nephron

Activity 4

Study Figure 3.

1. Notice the shape of the kidney tubule. It has a **cup shaped end**. This leads to a **twisted bit of tubule**. Next comes a **U-shaped loop**. Finally a **second twisted bit of tubule**, which leads into a collecting tube or duct. Write the names of these four sections shown in bold. (Convoluted means twisted.)

   .....

   .....

   .....

   .....

2. Remember that **arteries carry blood** *to* **the organs of the body**. On Figure 3 above, find the large blood vessel that brings blood to the kidney tubule. This is a branch of the **renal artery** and carries blood with waste substances to the kidney. Label this vessel on the diagram. Add a note saying what it is carrying.

3. Remember that **veins carry blood** *away from* **organs** back to the heart. On Figure 3 above find the large blood vessel taking blood away from the kidney tubule. This is a branch of the **renal vein** and carries clean blood away from the kidney. Label this vessel on the diagram. Add a note saying what it is carrying.

4. Notice that there is a bunch of blood capillaries inside the cup-shaped end of the tubule. Where has blood in these capillaries just come from? What is the name of this bunch of capillaries?

   .....

5. There is also a network of capillaries over the surface of the rest of the length of the tubule. Where does the blood go to after flowing through these capillaries?

   .....

Functions of the kidney

> The kidney tubules remove waste substances from the blood and pass them out of the body as urine. This is a form of **excretion**.

The information in the box above summarises the work of the kidney. This information is important. You should learn it.

How the kidney tubule works

Figure 4 shows a straightened out kidney tubule. The annotations above and below the diagram explain how the kidney tubule does its work.

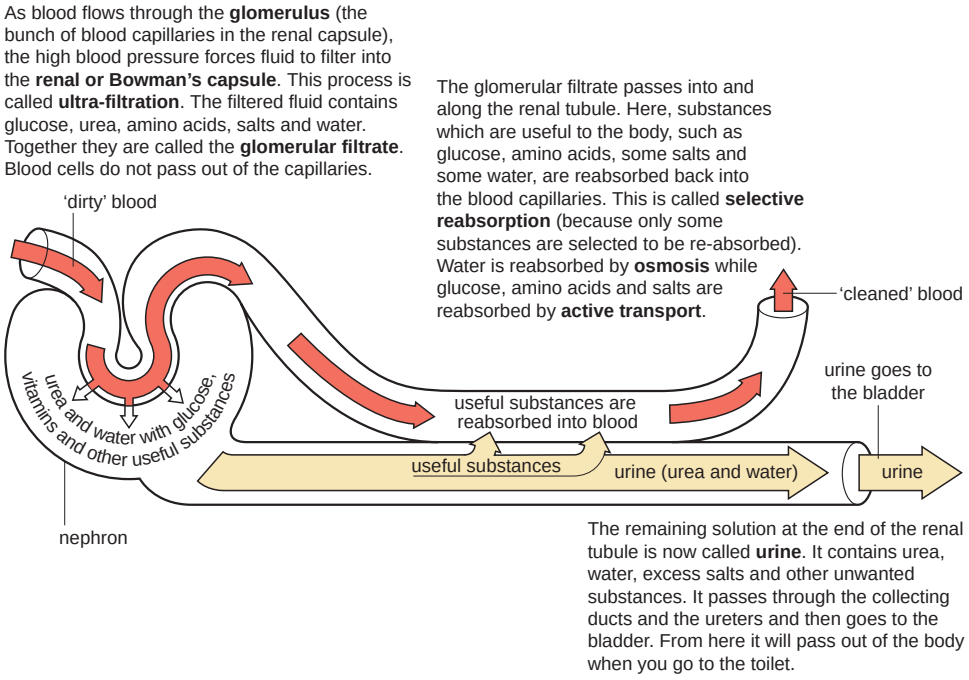


Figure 4: A straightened out kidney tubule or nephron with annotations to explain how it works

Activity 5

In the next table, column 1 lists the substances found in the blood arriving at the glomerulus.

Complete column 2 to show which substances pass by ultra-filtration into the renal or Bowman's capsule. Enter one of the following: none; some; all.

Complete column 3 to show which substances are reabsorbed from the kidney tubule back into blood capillaries. Enter one of the following: none; some; all; n/a (not applicable).

Table comparing the composition of blood in the glomerulus with the glomerular filtrate and with the substances re-absorbed back into the blood

Contents of blood arriving at the glomerulus	Substances filtered out into renal or Bowman's capsule	Substances reabsorbed into the blood
Amino acids		
Blood cells		
Blood proteins		
Glucose		
Salts		
Urea		
Water		

In addition to excretion, the kidneys also regulate the amount of water and salts in the body and the pH of the body.

Osmoregulation

Your body must maintain constant levels of water in the blood and tissue fluid. This is necessary to prevent too much water moving into or out of your cells by osmosis, which could result in the cells not working correctly. The process of keeping the amount of water in the body balanced is called **osmoregulation**. The kidney tubules are important in osmoregulation.

Your kidneys regulate the water levels of the blood with the help of **antidiuretic hormone (ADH)**. ADH is secreted into the blood by the **pituitary gland** in your brain when water levels in the blood fall. ADH causes the kidney tubule and collecting duct (see diagram 3) to become more permeable, so that water is reabsorbed into the blood stream, producing concentrated urine. This prevents loss of too much water from the body when the solute concentration in the blood is high, i.e. when the amount of dissolved substances including salts, glucose and amino acids in the blood is high.

There are **receptors** in the **hypothalamus** in your brain that detect the concentration of solutes in the blood. These send a nerve impulse or message to the **pituitary gland** in the brain and the pituitary gland secretes ADH. When there is more water in the blood, production of ADH is reduced. This causes the walls of the kidney tubule and the collecting tubule to become less permeable, so less water is reabsorbed. The result is that the urine produced is more dilute.

Activity 6

The definitions shown in the next table relate to six of the key words, shown in bold and used in the section on the functions of the kidney. Read the definitions carefully and choose the word which they explain.

Compare your answers with another scholar.

	Definition	Key word
1	The movement of a substance across a cell membrane by a process that needs energy.	
2	A bunch of blood capillaries found in the renal or Bowman's capsule of the kidney tubule.	
3	The cup shaped end of a kidney tubule.	
4	The diffusion of water molecules across a partially permeable membrane from a region of high water concentration to a region of low water concentration.	
5	The final solution of waste substances produced by the kidney.	
6	A nitrogen containing waste substance produced in the body from the breakdown of excess amino acids.	

Regulation of salts

The water content of your body is affected by the level of salts in the blood and body. Sodium, potassium and chloride ions are regulated in the kidney tubule.

Activity 7

1. Suppose you drink a lot of water on one day and a small amount on a second day. Predict how this will affect the amount of urine you produce on each day.

   .....

   .....

2. Suppose you take in the same amount of water on day 1 and day 2. The second day is very hot, so you sweat a lot. Predict how this will affect the amount of urine you produce on each day.

   .....

   .....

3. What hormone is involved in controlling these differences? Where is it made?

   .....

   .....

4. Write a few sentences about how this control works. Compare your answer with another scholar.

   .....

   .....

   .....

   .....

   .....

   .....

   .....

   .....

Homeostasis

Homeostasis means **staying the same**. It is concerned with keeping the composition of the tissue fluids in the body the same. This is important for cells to work properly and, therefore, for the maintenance of life. Homeostasis involves the regulation of the concentration of salt and sugar in the body. It is also concerned with the regulation of the pH of body fluids and with keeping the body temperature constant.

The kidneys work together with the liver, lungs and skin to keep conditions in the body the same. The work of the kidneys in controlling the levels in the body of water, salt and sugars (such as glucose) was described in the last two sections.

The kidneys are also important in regulating the pH of the blood. pH is how acid or alkali something is. The pH of your blood must be kept constant. It should be between 7.35 and 7.45. Remember that pH 7 is neutral. This means the blood is slightly alkaline.

Kidney failure

If one of your kidneys failed, you could survive using the remaining one. However, if both failed, you would be poisoned by the waste substances building up in your body. You could only survive for about one week, unless you were either given a kidney transplant or you were connected to a kidney dialysis machine. These machines are available in central hospitals in Malawi. However, there are not many of them.

Figure 5 shows how a kidney dialysis machine works.

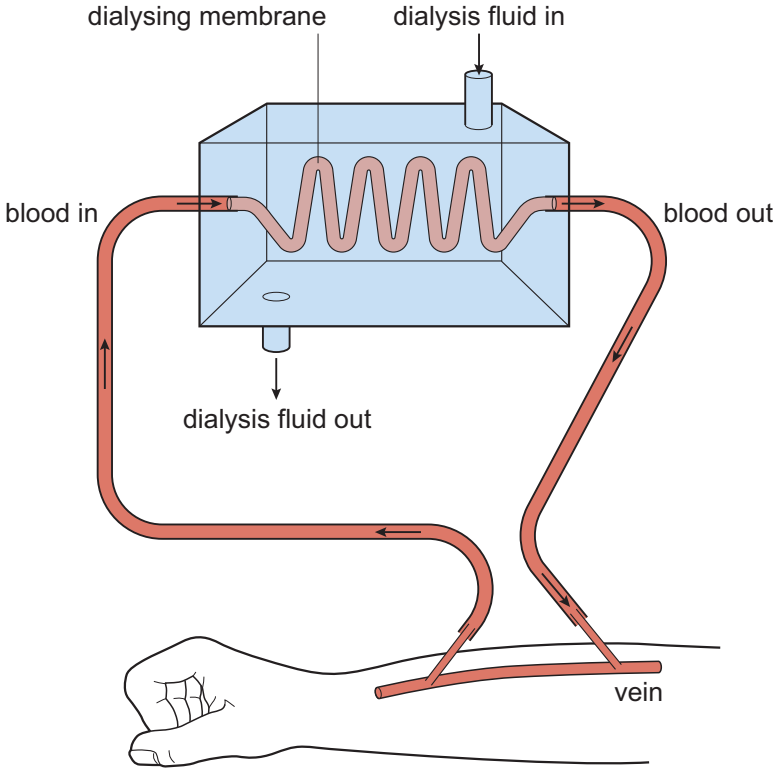


Figure 5: Kidney dialysis machine

The dialysis machine

- A kidney dialysis machine works by cleaning the blood in a similar way to our kidneys.
- Blood is drawn from a blood vessel in the arm though a tube. It then passes through special tubing inside the machine. The blood is returned to the blood vessel through a third tube.

Key features of the kidney dialysis machine:

1. The walls of the special tubing inside the machine are **partially permeable**. They allow small molecules to diffuse across them, but do not allow blood cells or large molecules such as blood proteins to pass through.
2. The blood flowing into the dialysis machine has a high concentration of waste substances, e.g. **urea.** The urea therefore diffuses out of the blood into the dialysis fluid.
3. The dialysis fluid is **warmed** close to blood temperature. This helps to increase the rate of diffusion and makes sure that the patient's blood is not cooled down as it passes through the machine.
4. The tubes are long and narrow, providing a **large surface area** to increase the rate of diffusion.
5. The dialysis fluid contains a solution of glucose and salts in similar concentrations to their concentrations in the blood. This stops these useful substances from diffusing out of the blood into the dialysis fluid.
6. **Fresh dialysis fluid**, containing glucose and salts and reduced amounts of waste substances, is continuously passed through the machine. This ensures that there is always a steep diffusion gradient down which waste substances pass from the blood into the dialysis fluid and that useful substances such as glucose and salts are kept at required levels in the blood.

Activity 8

What are the three important factors about the dialysis machine that increase the rate at which waste substances diffuse out of the blood and into the dialysis fluid?

1. .....
2. .....
3. .....

Coordination

All the different parts and activities of your body must work together cooperatively and efficiently. For example, digestive enzymes must be produced to break down food as it passes through the gut. Muscles must move bones in the correct order and in the right way to enable us to walk, to put food into our mouths and even to speak. This linking together is known as **coordination**. It is controlled by the **nervous system** and by the **endocrine (hormone) system**.

The nervous system

The nervous system is made up of specialised cells, called **neurons** (**nerve cells**). These cells have long fibre-like extensions. This makes them well adapted to form a network throughout the body to link together different parts and different activities.

Neurons are also specialised in being able to carry information, as electrical messages, rapidly along their length.

The central nervous system is made up of the **brain** and **spinal cord**.

The peripheral nervous system is made up of **nerves**. Nerves are bundles of nerve cell fibres.

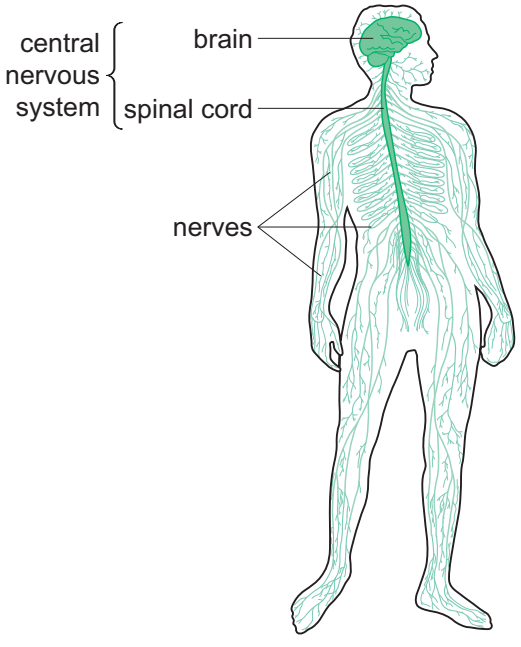


Figure 6: The main parts of the human nervous system

Figure 7 outlines five key words to do with coordination.

Study the diagram and then try Activity 9.

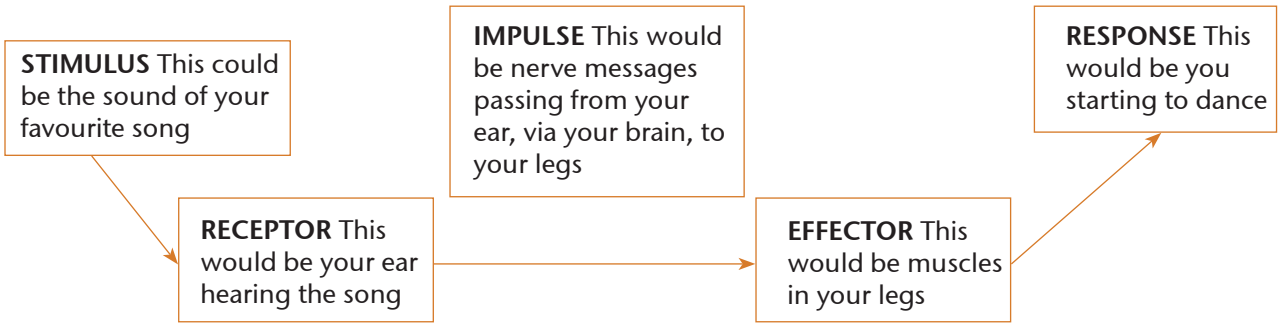


Figure 7: Summary of coordination by the nervous system

Activity 9

Figure 7 above outlines five key parts of coordination. Below is an explanation of each of the parts. Match each explanation with its key word. The explanations in the table are not listed in the same order as in Figure 7.

	Explanation of part of coordination	Key word in coordination
1	This is an electrical message or signal that is passed along nerve fibres.	
2	This is the action produced by muscles or glands once a nerve impulse reaches them.	
3	This is a structure that brings about an action once it receives a message from the nervous system. It is usually a muscle or gland.	
4	This is a local change in the external or internal environment of an organism. For example, if you touch a hot dish, it is the high temperature of the dish.	
5	This is a structure that contains sensory cells which receive stimuli from the internal or external environment and convert the stimuli into an impulse. Examples are sense organs such as the eye, ear and skin.	

When you have checked that your answers to Activity 9 are correct, you should learn these five words and their explanations.

Neurons or nerve cells

You have three types of neuron or nerve cell in your body. These are shown in Figure 8. They are (1) **sensory neurons**, (2) **motor neurons** and (3) **relay neurons** (also known as intermediate, multi-polar or association neurons).

Notice that all nerve cells have a compact **cell body**. The very long fibres of nerve cells are called **axons**. The shorter fibres are called **dendrites**.

Activity 10

Study Figure 8 and answer these questions.

1. Where do motor neurons carry impulses from and to?

   .....

2. Where do sensory neurons carry impulses from and to?

.....

3. Where would you find relay neurons? What do they do?

.....

.....

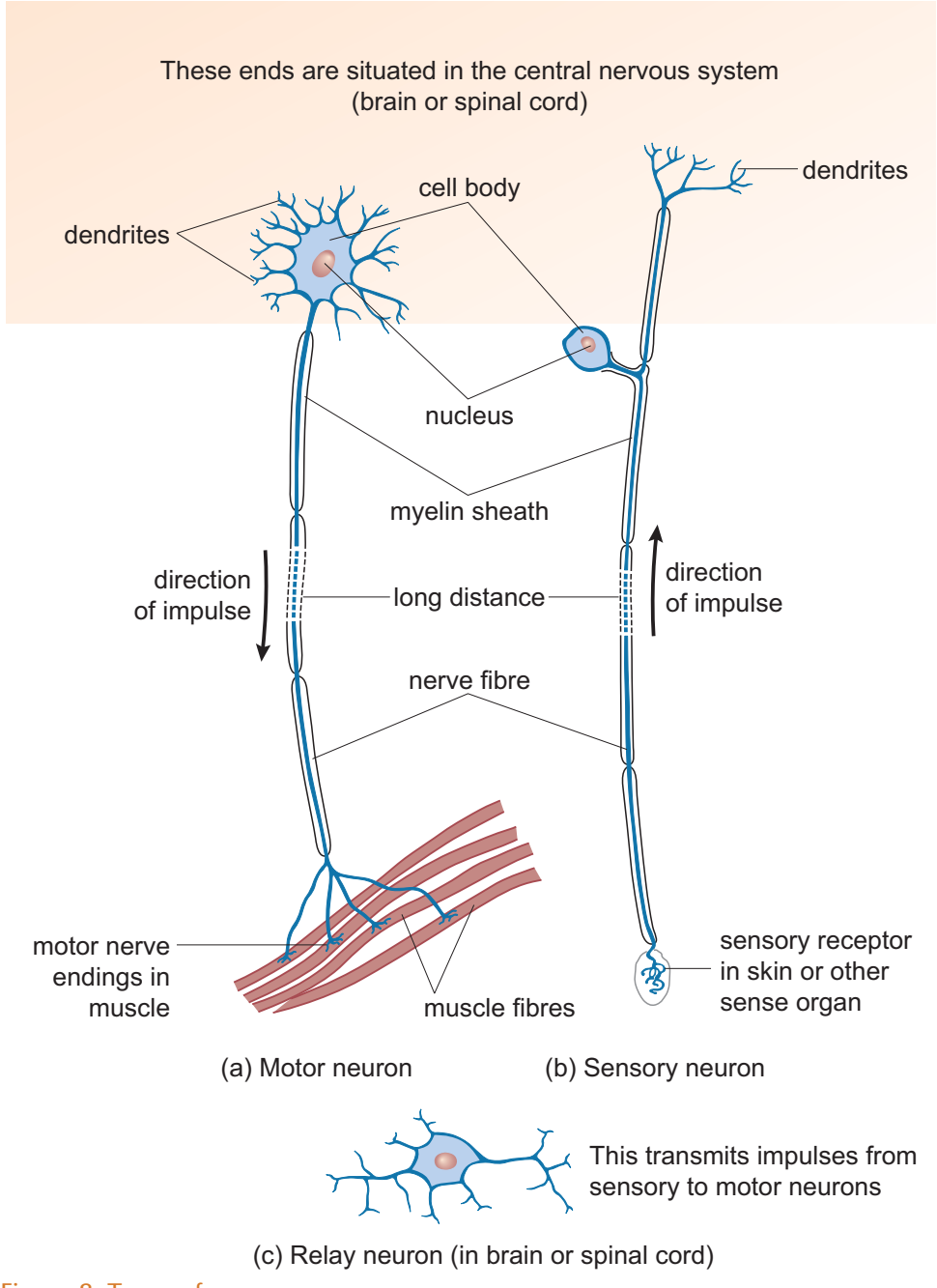


Figure 8: Types of neuron

Nerve impulses, synapses and neuro-transmitters

A nerve impulse is an electrical message which passes along a nerve fibre. Wherever the ends of the fibres of one neuron meet the ends of the fibres of another neuron, there is a tiny gap. This gap is called the **synapse**. The electrical message cannot pass across this gap. Instead, little packets of chemicals are released from the ends of the nerve fibres. These chemicals are called **neuro-transmitters**. They pass across the gap and start an electrical impulse in the second neuron.

Neuro-transmitters can only be produced at one end of each nerve fibre. This means each neuron can only pass messages in one direction.

Activity 11

Imagine you see an old friend getting off a bus. You will probably want to wave and walk towards her to greet her.

Choose words from the following list to fill in the blanks in the passage below which describes this meeting in terms of the nervous system. When you have finished, compare your responses with other scholars.

central nervous system, chemicals, effector organs, electrical, motor, neuro-transmitters, receptors, relay, sensory neuron, stimulus, synapse.

1. The ..... for these actions is the sight of your friend.
2. The ..... that receive this stimulus are the sense cells in the eye.
3. When these sense cells are stimulated this sends an impulse along a ..... to the ..... . In this case, the brain.
4. In the brain, impulses will pass to ..... neurons. These then pass impulses to ..... neurons which send impulses to the ..... . In this example these will be the muscles that move your arm for waving, your legs for walking – and probably your face for smiling.
5. The messages that pass along nerve fibres are ..... messages. The point where one neuron meets another is a gap called a ..... . The message is carried across this gap by ..... called ..... .

The central nervous system

Look back at the section on nerve cells just before Activity 10 and remind yourself what they look like by reviewing Figure 8.

If you looked at your brain and spinal cord under the microscope, some parts would appear grey and other parts white. The **grey matter** is where most of the cell bodies of the neurons are found. The **white matter** is mainly made up of the nerve fibres of the neurons. The white is caused by the **fatty myelin sheath** which surrounds the fibres. It is important for **insulating** the electrical nerve impulses.

The brain

The brain is surrounded and protected by the skull and a fluid (cerebrospinal fluid) which is contained within membranes called the meninges.

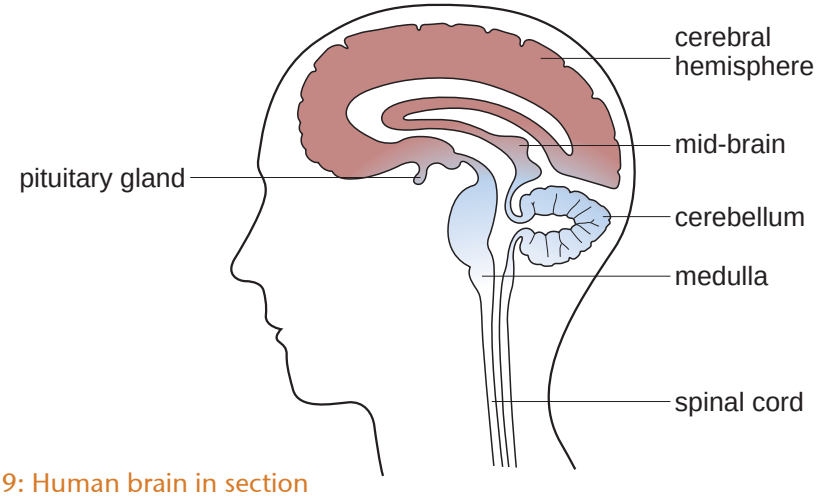


Figure 9: Human brain in section

There are three parts of your brain you should particularly know about.

Cerebral hemispheres or cerebrum

At the front of your brain you have two large hemispheres (half spheres), one on the right and one on the left side. These are your cerebral hemispheres. They are the largest part of the brain in humans. Their surface appears covered with folds and grooves. This region controls your intelligence, memory, learning and consciousness. It coordinates the voluntary activities of your body and many involuntary ones too.

Cerebellum

This is the roof of your hind brain. It controls and coordinates your muscles and organs of balance. It enables you to make precise and accurate movements.

Medulla oblongata

This is the floor of your hind brain. It controls all your involuntary actions (things that go on without you having to think about them), such as heart beat, peristalsis (movement of food along the alimentary canal), breathing and salivating.

The spinal cord

Your spinal cord starts from the end of your medulla oblongata and passes down to the end of your back. It is protected by your bony spine.

Study Figure 10 below which shows part of the spinal cord and then try Activity 12.

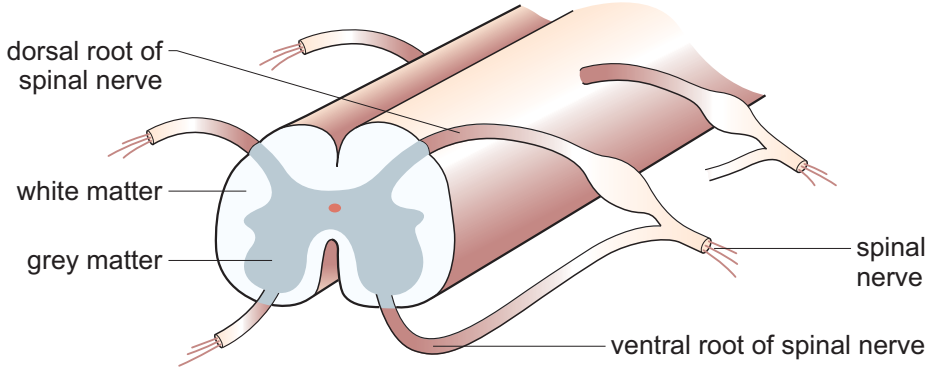


Figure 10: Part of the spinal cord with one end cut through to see inside

Activity 12

1. What are the names of the two branches coming out of the spinal cord which join to make each spinal nerve?

   .....

2. Remember that the nervous system is made up of neurons. What part of the neurons would you expect to find in the grey matter of the spinal cord?

   .....

3. What part of the neurons would you expect to find in the white matter of the spinal cord? What is the reason for the white colour?

.....

.....

Reflex actions

A reflex action is a **rapid, automatic response** to a stimulus, which you cannot consciously control. Examples include blinking if dust touches the cornea of your eye and quickly withdrawing your hand if you touch a hot object.

Most reflex actions are controlled by the spinal cord. Some, such as blinking of the eye, are controlled by the brain.

Reflex actions are important because they protect your body from mechanical injury.

Activity 13

What other actions can you think of that would be reflex actions?

Discuss your ideas with other scholars.

If you prick your finger on a thorn or a pin, you rapidly pull your hand away. This is a **reflex action**.

The path of the nervous impulses along the neurons that make a reflex action happen is called the **reflex arc**. Follow the arrows in Figure 11 below. This is the reflex arc for the reflex action that happens when you prick your finger.

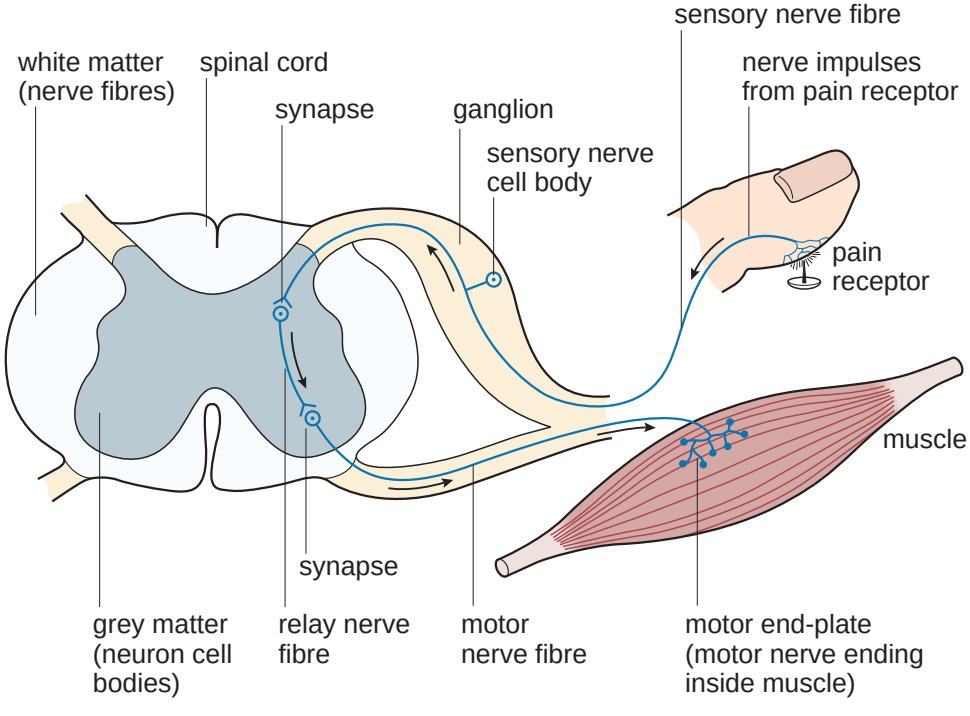


Figure 11: Reflex arc

Activity 14

The sentences below explain the reflex arc in Figure 11. However, they are not in the correct order. Sort the sentences into the correct order so they make a sensible explanation of the diagram.

A. The relay neuron synapses with a motor neuron.

B. The stimulus is perceived by pain receptor cells in the skin.

C. The motor neuron axon ends in muscle.

D. This causes an impulse to pass along a sensory nerve fibre to the spinal cord.

E. The impulse then passes along the relay neuron.

F. When the nerve impulse reaches the muscle, it causes the muscle to contract.

G. The stimulus is the prick caused by the pin.

H. This pulls the finger away from the pin.

I. In the spinal cord, the sensory neuron synapses with a relay neuron.

J. This causes an impulse to be set up in the motor neuron and to pass along its axon.

In some cases impulses can be sent to two effectors at the same time, for example one can be sent to arm muscles and another to muscles of the mouth and throat causing a person to scream.

Drugs, alcohol and the brain

A **drug** is any substance which alters the way the body works.

Drugs are dangerous because:

1. They can make you slow to react to stimuli.
2. They can affect your judgement.
3. They cause physical damage by killing cells – alcohol, cannabis and glue solvent can all damage the brain.
4. They can cause addiction.

Painkillers, stimulants, sedatives and hallucinogens are the four main groups of drugs which affect the brain.

Activity 15

The table below explains the effects of the four groups of drugs. Study it carefully.

Read through the following list of drugs. Using your general knowledge, discuss with your fellow scholars which group each drug belongs to. Write your answers in the correct boxes in the table.

alcohol, aspirin, caffeine, cocaine, cannabis, heroin, LSD (lysergic acid diethylamide), morphine, nicotine, paracetamol, valium.

Drug group	What the drugs do	Examples of drugs in this group
Painkillers	Suppress the part of the brain responsible for pain.	
Stimulants	Speed up the action of the brain. Make you more alert.	
Sedatives	Slow the brain down. Make you feel sleepy.	
Hallucinogens	Make you see, feel or hear things that are not really there.	

Practice questions

Remember, talking about the ideas in the units is a very good way to learn. Ask one of your fellow scholars these questions and check their answers. The questions marked with an asterisk require some knowledge which is additional to what you have covered in Unit B4. Use your text book to help with these answers.

1. Explain what excretion is and name four substances that your body excretes.
2. Figure 12 below shows a cross-section through a kidney.

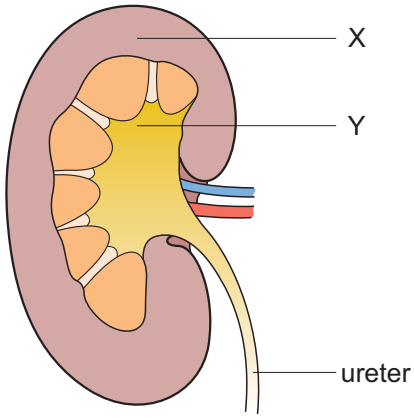


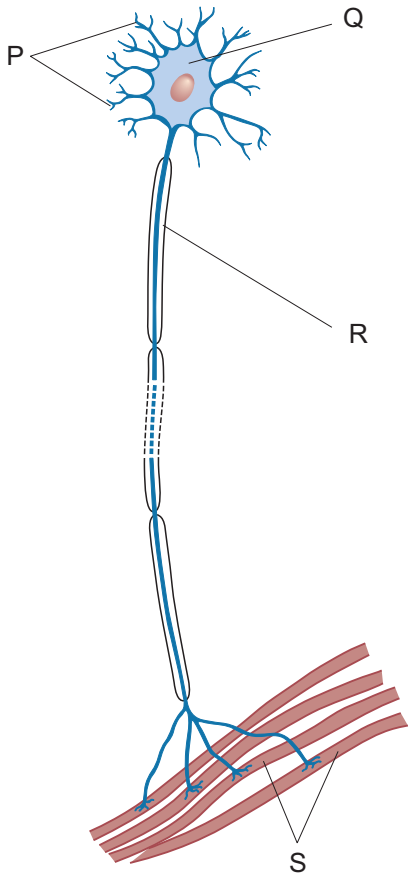
Figure 12: A human kidney cut in half

   (a) Name the parts labelled X and Y on the diagram.

   (b) What is the function of the ureter?

3. Your two kidneys are ..... shaped organs. They are made up of many tiny tubules called ..... . One end of each tubule is shaped like a cup. It is called the ..... . Inside the cup shaped end is a knot of blood capillaries called the ..... . Many tiny blood vessels or ..... are found close to the rest of the length of the tubules.
4. Explain how urine is formed.
5. Explain how the amount of water in the blood is controlled.
6. When is a dialysis machine used? How does it work?
7. What is coordination and why it is important? Name the two systems in the body responsible for coordination.

8. Figure 13 below shows a type of neuron.



*(a) What type of neuron is shown in Figure 13? Name two infectious diseases caused by microbes damaging this type of neuron.

(b) Name the parts marked P and Q.

(c) State the function of the parts labelled R and S.

9. Name the parts of the brain which control:

(a) breathing

(b) learning and memory

(c) balance.

10. (a) What is the difference between a stimulus and a response?

(b) Why is it important that organisms can respond to changes in the environment?

11. What is a reflex action? Give four examples of reflex actions.

12. What is a reflex arc? List the main components of a reflex arc.

*13. If someone is frightened, their heart beats faster and their breathing rate increases.

(a) Name the hormone responsible for these changes and say where it is made.

(b) Explain the importance of these changes to an organism.

14. How is brain activity affected by (a) painkillers, (b) stimulants, (c) sedatives and (d) hallucinogens? Name one example of each type of drug.

How am I doing?

	☺ **Easy** (Tick this box if you feel confident that you **understand this section well**)	**Fine** (Tick this box if you still **need a little work** on this section)	☹ **Difficult** (Tick this box if you still **need a lot of work** on this section)
What excretion is and why it must happen			
The structure of the kidney including the structure of the kidney tubule or nephron			
How the kidney carries out its work of excretion			
How the kidney carries out its work of osmoregulation and homeostasis			
How a kidney dialysis machine works			
How coordination is brought about by the nervous system and why this is important			
The structure and function of the three types of nerve cell			
The structure and function of the brain and spinal cord			
Reflex actions – why they are important and how they work			
Drugs and alcohol – how they affect the brain			

Notes on what to do next:

Signed (by Scholar): ..... Date:.....

Signed (by Tutor): ..... Date:.....

Answers

Activity 1

1. *Glucose + oxygen → energy + water + carbon dioxide*
2. Water and carbon dioxide

Activity 2

4. Bladder

   Urethra

Activity 4

1. Renal or Bowman's capsule

   First convoluted tubule

   Loop of Henle

   Second convoluted tubule.

4. Blood in these capillaries has just come from (a branch of) the renal artery. This bunch of capillaries is called the glomerulus.
5. Blood flows to (a branch of) the renal vein after flowing through capillaries over the surface of the length of the kidney tubule.

Activity 5

Contents of blood arriving at the glomerulus	Substances filtered out into renal or Bowman's capsule	Substances reabsorbed into the blood
Amino acids	Some	Some
Blood cells	None	n/a
Blood proteins	None	n/a
Glucose	Some	Some
Salts	Some	Some
Urea	All	None
Water	some	Some

Activity 6

	Definition	Key word
1	The movement of a substance across a cell membrane by a process that needs energy.	Active transport
2	A bunch of blood capillaries found in the Bowman's capsule of the kidney tubule.	Glomerulus
3	The cup shaped end of a kidney tubule.	Renal or Bowman's capsule
4	The diffusion of water molecules across a semi-permeable membrane from a region of high water concentration to a region of low water concentration.	Osmosis
5	The final solution of waste substances produced by the kidney.	Urine
6	A nitrogen containing waste substance produced in the body from the breakdown of excess amino acids.	Urea

Activity 7

1. More dilute urine is produced on the first day than the second day.
2. Less urine and more concentrated urine is produced on the second day.
3. ADH (antidiuretic hormone). Produced by the pituitary gland.
4. (1) When you drink more water, receptors in the hypothalamus of the brain detect the increased water in the blood. They send a message to the pituitary gland to produce less ADH. This causes the walls of the kidney tubule and collecting duct to become less permeable. Therefore less water is reabsorbed and more dilute urine is produced.

   (2) On the hot day much water is lost by sweating. This reduces the amount of water in the blood. Receptors in the brain detect this and more ADH is produced. The walls of the kidney tubule and collecting duct become more permeable. More water is reabsorbed. A smaller amount of more concentrated urine is produced.

Activity 8

1. The tubes are long and narrow which produces a large surface area.
2. The fluid is warmed.
3. The dialysis fluid is continuously renewed. This removes waste molecules so there is always a steep concentration gradient of waste substances between the blood and the dialysis fluid.

Activity 9

	Explanation of part of coordination	Key word in coordination
1	This is an electrical message or signal that is passed along nerve fibres.	**Impulse**
2	This is the action produced by muscles or glands once a nerve impulse reaches them.	**Response**
3	This is a structure that brings about an action once it receives a message from the nervous system. It is usually a muscle or gland.	**Effector**
4	This is a local change in the external or internal environment of an organism. For example, if you touch a hot dish, it is the high temperature of the dish.	**Stimulus**
5	This is a structure that contains sensory cells which receive stimuli, from the internal or external environment and convert the stimuli into an impulse. Examples are sense organs such as the eye, ear and skin.	**Receptor**

Activity 10

Answers to questions based on Figure 8.

1. Motor neurons carry impulses from the central nervous system (brain or spinal cord) to the effectors (muscles or glands).
2. Sensory neurons carry impulses from sense organs to the central nervous system.
3. Relay neurons are found within the central nervous system. They transmit impulses from sensory neurons to motor neurons.

Activity 11

1. The stimulus for these actions is the sight of your friend.
2. The receptors that receive this stimulus are the sense cells in the eye.
3. When these sense cells are stimulated this sends an impulse along a sensory neuron to the central nervous system. In this case, the brain.
4. In the brain, impulses will pass to relay neurons. These then pass impulses to motor neurons which send impulses to the effector organs. In this example these will be the muscles that move your arm for waving, your legs for walking – and probably your face for smiling.
5. The messages that pass along nerve fibres are electrical messages. The point where one neuron meets another is a gap called a synapse. The message is carried across this gap by chemicals called neuro-transmitters.

Activity 12

1. The names of the two branches coming out of the spinal cord which join to make each spinal nerve are the dorsal root of the spinal nerve and the ventral root of the spinal nerve
2. You would expect to find cell bodies of neurons in the grey matter of the spinal cord.
3. You would expect to find fibres of the neurons in the white matter of the spinal cord. The white is caused by the fatty myelin sheaths around the fibres. These fatty sheaths insulate the electrical impulses.

Activity 13

Other reflex actions may include:

constriction of the pupil of the eye in bright light; sweating; jerking of your knee if you tap your leg just below the knee when your legs are crossed; coughing; hairs standing up on your skin as a result of cold or fright and salivation.

Activity 14

G. The stimulus is the prick caused by the pin.

B. The stimulus is perceived by pain receptor cells in the skin.

D. This causes an impulse to pass along a sensory nerve fibre to the spinal cord.

I. In the spinal cord, the sensory neuron synapses with a relay neuron.

E. The impulse then passes along the relay neuron.

A. The relay neuron synapses with a motor neuron.

J. This causes an impulse to be set up in the motor neuron and to pass along its axon.

C. The motor neuron axon ends in muscle.

F. When the nerve impulse reaches the muscle, it causes the muscle to contract.

H. This pulls the finger away from the pin.

Activity 15

Drug group	What the drugs do	Examples of drugs in this group
Painkillers	Suppress the part of the brain responsible for pain.	aspirin, paracetamol, morphine, heroin
Stimulants	Speed up the action of the brain. Make you more alert.	cocaine, nicotine, caffeine
Sedatives	Slow the brain down. Make you feel sleepy.	valium, alcohol
Hallucinogens	Make you see, feel or hear things that are not really there.	LSD (lysergic acid diethylamide), cannabis

Answers to practice questions

1. Excretion is the removal of unwanted, waste products from your body. Your body excretes carbon dioxide, excess mineral salts, water, urea (a nitrogenous waste substance) and toxic substances.

2. (a) X – cortex; Y – pelvis.

   (b) The ureter is the tube which carries urine to the bladder.

3. Your kidneys are *bean* shaped organs. They are made up of many tiny tubules called *nephrons*. One end of each tubule is shaped like a cup. It is called the *renal or Bowman's capsule*. Inside the cup shaped end is a knot of blood capillaries called the *glomerulus*. Many tiny blood vessels or *capillaries* are found close to the rest of the length of the tubules.

4. When blood enters the knot of capillaries in the Bowman's capsule, it gets filtered due to high blood pressure there. The liquid that passes into the Bowman's capsule contains glucose, urea, salts and water among other things. As this liquid passes along the kidney tubules, useful substances like glucose and some salts are reabsorbed into the blood system while excess salts, water, toxins and urea form urine.

5. When there is too little water in the blood, this is detected by receptors in the hypothalamus. This causes the pituitary gland to produce ADH (anti-diuretic hormone). ADH passes in the blood to the kidney tubules causing them to become more permeable to water molecules. Re-absorption of water from the kidney tubules is increased and so more water is returned to the blood. If water levels in the blood are too high, production of ADH falls and more water is passed out of the body in the urine.

6. A dialysis machine is used when both kidneys in an individual fail. It works by drawing off blood from the patient and passing the blood through dialysis tubing in the machine. Waste substances are filtered out through the walls of the tubing and cleaned blood is returned to the patient.

7. Co-ordination is the linking together of the different parts and activities of your body. This is important in order to make sure that the different parts and activities of your body work together cooperatively and efficiently. This work is done by the nervous system and by the endocrine (hormone) system.

8. (a) Figure 13 shows a motor neuron. Poliomyelitis and tetanus are diseases in which motor neurons are damaged.

   (b) P – dendrites; Q – cell body.

   (c) R insulates the fibres of the neuron and allows impulses to pass rapidly. S represents muscle fibres which contract and bring about a response.

9. (a) The medulla oblongata controls breathing.

   (b) The cerebral hemispheres (cerebrum) control learning and memory.

   (c) The cerebellum controls balance.

10. (a) A **stimulus** is a local change in the external or internal environment of an organism. For instance if you touch a hot dish, the stimulus is the high temperature of the dish. A **response** is the action produced by muscles or glands once a nerve impulse reaches them. For instance, pulling your hand away from a hot dish.

    (b) Being able to respond to changes in the environment is important for survival.

11. A reflex action is a rapid automatic response to a stimulus, which you cannot consciously control. Examples of reflex actions are: blinking, withdrawing your hand from a hot object, sweating and coughing.

12. A reflex arc is the path of the nervous impulses along the nerve cells when a reflex action occurs. The main components are: receptor (sense cells), sensory neuron, relay (association) neuron, motor neuron, effector (muscle or gland).

13. (a) Adrenalin, made in the adrenal glands.

    (b) When someone is frightened, they may want to run away and this activity requires energy for the muscles in the legs to contract and cause movement. Food and oxygen are also required for respiration to take place more quickly. Heart beat increases so as to transport food and oxygen as fast as possible to areas where these substances are required (and also to remove waste substances to the excretory organs). Finally, breathing rate becomes fast and deep so as to take in as much oxygen as possible, and also to release carbon dioxide more quickly.

14. (a) Painkillers suppress the part of the brain responsible for pain. Examples include: aspirin, paracetamol, morphine and heroin.

    (b) Stimulants speed up the actions of the brain. Examples include: cocaine, nicotine and caffeine.

    (c) Sedatives slow down the actions of the brain. Examples include: valium and alcohol.

    (d) Hallucinogens affect the brain so that you see, feel, or hear things that are not really there. Examples include: LSD (lysergic acid diethylamide) and cannabis.

Glossary

Active transport	Movement of substances across a membrane by a process that needs energy.
Antidiuretic hormone, ADH	This is a hormone that is secreted by the pituitary gland and acts in the kidneys, where it stimulates the re-absorption of water from the kidney tubules back into the blood.
Axon	This is a long fibre-like part of a neuron. It carries nerve impulses away from the cell body of the neuron.
Balance	What allows us to maintain a steady, upright position, i.e. to avoid falling over.
Bladder	This is a sac with muscular walls which acts as a temporary store for urine.
Bowman's capsule	This is the cup-shaped end of a kidney tubule (nephron). It contains a bundle of capillaries, allowing ultra-filtration to happen here. It is also called a renal capsule.
Cell body	This is the part of a neuron (nerve cell) which contains the nucleus of the cell.
Central nervous system	This is the part of the nervous system that is made up of the brain and spinal cord.
Cerebellum	This is the part of the brain that controls complex muscle actions and balance.
Cerebral hemispheres (cerebrum)	These are two hemispheres at the front of the brain that control intelligence, learning, memory and consciousness. They coordinate many activities such as vision, hearing, speech, taste and smell.
Cerebrospinal fluid	This is a fluid which fills the cavities inside the brain and surrounds the brain. It provides nourishment and helps protect the brain from physical damage.
Consciousness	This word describes our sense of awareness or knowingness.
Coordination	This word describes the way in which things are linked together so that they work well and co-operatively with each other.
Dendrites	These are short, branched, fibre-like parts of a neuron. They carry nerve impulses towards the cell body of the neuron.
Drug	This is a substance which changes the way in which the body works.
Effector	This is a structure that brings about an action once it receives a message from the nervous system. It is usually a muscle or a gland.
Endocrine system	This is a system of glands in the body that make chemicals called hormones, which are transported by the blood and control aspects of the development and activity of the body.
Excretion	This is the removal of waste products from the body following chemical reactions that occur.
Glomerular filtrate	This is the solution formed after some liquid and some dissolved substances from the blood have passed through the capillary walls in a glomerulus and into the cup-shaped end of a kidney tubule, by the process called ultra-filtration.
Glomerulus	This is the name given to the bundle of blood capillaries in the cup-shaped end of a kidney tubule.
Grey matter	This refers to areas of the brain and spinal cord where the cell bodies of neurons are found. These areas are on the outside surface of the brain and on the inside of the spinal cord.
Hallucinogen	This is a type of drug which makes people feel, see and hear things that are not really there.

Homeostasis	This is the maintenance of a constant internal environment by the body. It involves the regulation of the water content; the concentration of salts and sugar; the temperature and pH of the body.
Hormone	This is a chemical messenger. It is produced by a ductless gland and passes into the blood, which carries it to where it is needed to work. Different hormones control different aspects of the activity and development of the body.
Hypothalamus	This is a part of the brain. It is the centre for regulating body activities to do with homeostasis.
Impulse (nerve impulse)	This is the term used for electrical messages carried along nerves.
Involuntary	This describes something that happens without you deciding or planning to do it.
Medulla oblongata	This is the name of the floor of the hind part of the brain. It controls involuntary actions such as heart beat.
Meninges	There are three meninges. These are membranes surrounding and protecting the brain.
Motor neuron	This is a nerve cell which carries impulses from the central nervous system to muscles or glands.
Myelin sheath	This is a fatty layer surrounding the fibres of nerve cells. It acts as an insulator for the electrical impulses.
Nephron	This is also known as a kidney tubule. It is responsible for producing the waste solution, urine, which is excreted from the body. Each kidney is made up of about one million nephrons.
Nerves	These form a network of threads throughout the body. A nerve is made up of a bundle of fibres from nerve cells.
Neuron	This is another name for a nerve cell. These cells have a compact cell body containing the nucleus and long fibres called axons and dendrites.
Neuro-transmitters	These are chemicals produced when a nerve impulse reaches the end of a nerve axon at a point called a synapse. The chemicals pass across the synapse to the fibres of the next nerve cell where they can start an impulse.
Osmoregulation	This is the regulation of the amount of water moving in and out of cells.
Osmosis	This is the net diffusion of water molecules from regions of high water concentration to regions of lower water concentration across a partially permeable membrane.
Partially permeable	A membrane that is partially permeable allows small particles, such as water molecules, to pass through it but not large particles, such as sugar molecules.
Pelvis	This is the space in a kidney into which the collecting ducts from the kidney tubules open and which leads into the ureter. Please note: The hip bones are also called the pelvis.
Peripheral nervous system	This is the part of the nervous system that is made up of the network of nerves throughout the body.
Pituitary gland	This is a gland attached to the fore-brain. It produces several hormones, including ADH.
Receptor	A receptor is a part of the body that contains sensory cells that receive stimuli from the environment (external or internal) and then send on nerve impulses. For example, receptors in the hypothalamus detect the concentration of solutes in the blood; receptors in the ear detect sounds.

Reflex arc	This is the path of the nerve impulses along the neurons that make a reflex action happen.
Reflex action	This is a quick automatic reaction to a stimulus which you cannot consciously control, e.g. constriction of the pupil of the eye in bright light.
Relay neuron (intermediate, multi-polar, association)	This is a nerve cell that links a sensory neuron to a motor neuron.
Renal capsule	This is the cup-shaped end of a kidney tubule or nephron. It contains a bundle of capillaries, allowing ultra-filtration to happen here. It is also called a Bowman's capsule.
Response	This is an action produced by muscles or glands once a nerve impulse reaches them.
Sedative	This is a drug which slows the brain down and makes you sleepy.
Selective re-absorption	This occurs as the glomerular filtrate flows along the kidney tubule. Useful substances from the filtrate are taken up into the blood capillaries. The solution at the end of the tubule contains only waste substances.
Sensory neuron	This is a nerve cell that carries impulses from sense cells to the central nervous system.
Stimulant	This is a drug which speeds up the action of the brain and makes you more alert.
Stimulus	This is a change in the environment (internal or external). It could be a change in the brightness of light, a noise such as the crying of a baby or food reaching the stomach.
Synapse	This is the tiny gap where fibres from one neuron meet fibres from another neuron. The fibres do not actually touch. An impulse passes from one neuron to the next via chemicals, called neuro-transmitters, which move across the synapse.
Ultra-filtration	This is the process by which water and some dissolved substances pass from blood in the capillaries in the glomerulus to the cup-shaped end of the renal capsule. It occurs due to the high pressure of the blood in the glomerulus.
Urea	This is a waste product and must be removed from the body as it would become poisonous if it accumulated. It is a nitrogen containing molecule formed in the liver by the breakdown of excess amino acids in the body.
Ureter	This is the tube that carries urine from the kidney to the bladder.
Urethra	This is the tube which carries urine from the bladder to the outside of the body.
Urine	This is a solution of waste substances produced by the kidneys. It contains urea, excess salts and sugar, toxic substances, and water.
Voluntary	This describes something that you decide or plan to do. It is controlled by your own will.
White matter	This refers to areas of the brain and spinal cord where the fibres of neurons are found. These areas are on the inside surface of the brain and on the outside of the spinal cord. They are white because of the fatty layer that surrounds and insulates the fibres.

MSCE B5: New generations

What you are studying and why

Subject: Biology Unit B5

This unit is about reproduction and genetics.

It is obvious to us all that sheep give birth to sheep, chickens produce young chickens and humans give birth to baby humans which grow to be human adults.

In this unit you will learn about **how this happens**. You will learn how human babies are produced – human reproduction. You will also learn **why this happens** in such an organised and precise way. You will learn about the hereditary system which ensures that characteristics, such as height or eye colour, are passed from one generation to another in a controlled way. You will see how the DNA, genes and chromosomes, which are found in the nucleus of every cell, are involved in this important process.

At the end of the unit you should be able to:

1. Explain the words chromosome, gene and DNA and explain how these three structures are related to one another.
2. Explain how genes control your characteristics such as height or eye colour.
3. Label the main parts of the female and male reproductive systems in humans. Explain the role of each part in the process of reproduction.
4. Explain fertilisation and describe the process of implantation.
5. Describe the structure of the human placenta and explain how it is adapted to support the developing embryo and foetus.
6. Describe the key stages of the human female menstrual cycle and explain the role of hormones in controlling the cycle.
7. Explain the meaning of contraception and outline the main methods for achieving contraception.
8. Describe the two ways in which the nucleus and its chromosomes can divide – mitosis and meiosis. State the similarities and differences between the two processes. Explain why each method of division is important.
9. Explain the terms dominant and recessive genes; homozygous and heterozygous; genotype and phenotype.

Chromosomes, DNA and genes

Of course, you know that sheep give birth to sheep, chickens produce young chickens and humans give birth to baby humans which grow to be human adults.

The instructions for making this happen are contained in long molecules of **DNA (deoxyribonucleic acid)**. Each DNA molecule is bundled up and packaged to make a thread-like structure called a **chromosome**. Chromosomes are found in the nucleus of every cell in your body and the bodies of all living organisms.

Every cell of your body, except the sex cells (egg and sperm cells), contains **23 pairs of chromosomes**. One of each pair came from your mother and the other from your father. This is why you have some characteristics (also called traits) from each parent.

Your characteristics – what your body looks like and how it works – are controlled by pairs of **genes**. A gene is a section of DNA, of which the chromosomes are made. The more complex characteristics are controlled by several pairs of genes working together. All cells of your body have the same genes or instructions, although not all genes are active in every cell.

When a cell is ready to divide to make more cells, the DNA bundles up, making the chromosomes into compact structures. You can see this in Figure 1.

Sometimes the DNA molecules from the chromosomes separate out like an unravelled ball of string. In this state they are active and doing their work of controlling the structure and activities of your cells and your body. You cannot see this 'unravelled' DNA with a light microscope.

Figure 1 below shows the relationship between chromosomes, DNA and genes. Study the diagram carefully and then do Activity 1.

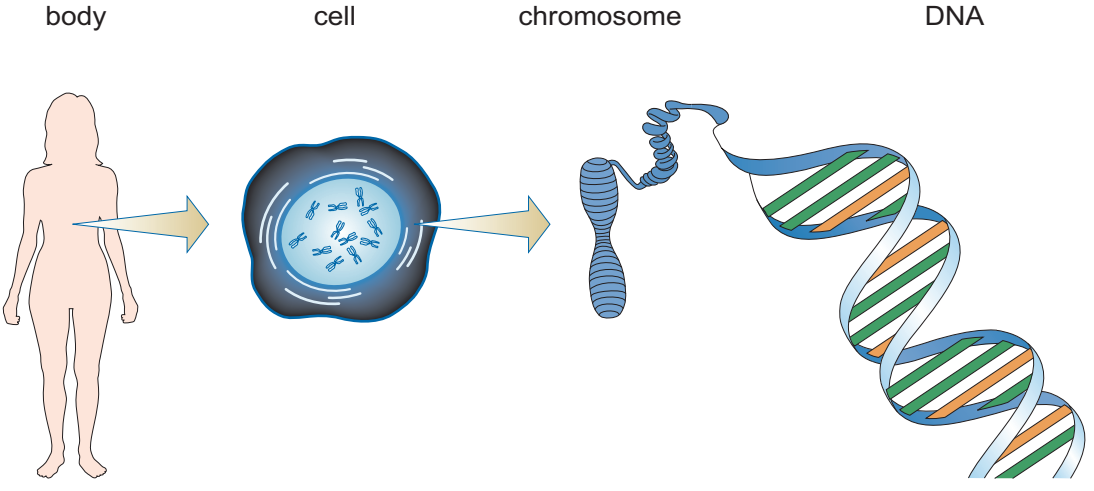


Figure 1: Relationship between chromosomes, DNA and genes.

Activity 1

Use the information from the text above and Figure 1 to match the terms in column A with one of the following words:

DNA; DNA and genes; gene; gene; genes; chromosome; chromosomes; chromosomes.

Write the words in the correct space in column B.

Column A	Column B
There are about 100,000 pairs of these in the nucleus of each of your cells.	
This is a section of DNA molecule.	
This controls a characteristic of your body.	
This is a chemical molecule with the shape of a double spiral or helix.	
You can see this structure in the nucleus when a long strand of DNA is bundled up just before a cell and nucleus is ready to divide.	
There are 46 of these in all human body cells (except the sex cells).	
These can be seen with a light microscope.	
These cannot be seen with a light microscope.	

Human reproduction

Human reproduction is a form of **sexual reproduction**. This means that **sex cells** or **gametes** are made. There are two types of gamete: female gametes or **egg cells** (also called ova, one is an ovum) and male gametes or **sperm cells**. For reproduction to happen an egg cell and a sperm cell must join together. This joining together is called **fertilisation** and the new cell that is produced is called a **zygote**. The zygote goes on to divide again and again and develops into an embryo and, finally, a new organism.

The female reproductive system

In a human female the egg cells are made in the **two ovaries**. These organs are about the size of a peanut pod. They are found one on each side of the abdomen (the cavity or space inside the lower part of your body). Figure 2 shows the position of the ovaries together with the other parts of the female reproductive system as seen from the front (diagram on the left) and from the side (diagram on the right).

When a girl is born, she already has many thousands of immature egg cells in her two ovaries. Once she reaches puberty (usually from the age of 11 upwards) one of these cells matures and is released from the ovary once a month. This process is called **ovulation.**

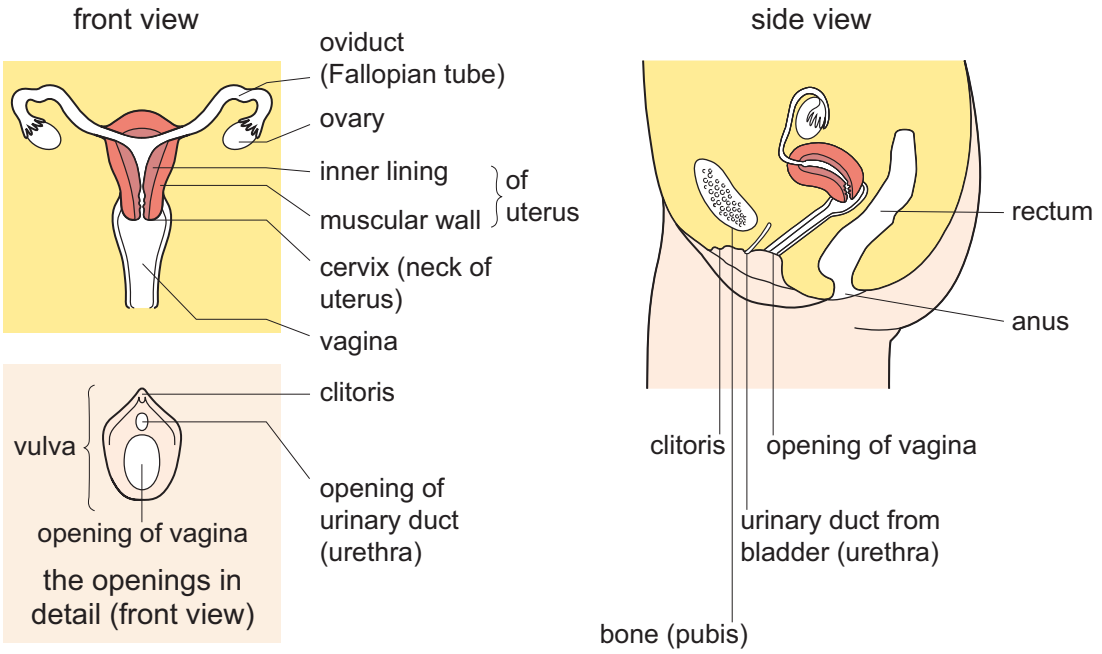


Figure 2: The human female reproductive system.

A tube called the **oviduct** or **Fallopian tube** leads from close to each ovary to the uterus or womb. The end of the oviduct near the ovary is open and shaped like a **funnel**. The inside of the funnel is lined with tiny hair-like structures called cilia. These hairs beat rhythmically and help to waft the released egg into the oviduct. More cilia line the inside of the oviduct. These slowly sweep the egg cell along towards the **uterus**. A human egg cell is about one tenth of a millimeter in diameter.

The uterus connects to the outside of the body through the **vagina**. Sperm enter here when the penis of a man is inserted into the vagina during sexual intercourse. The vagina is also where the baby comes out at the end of pregnancy.

The male reproductive system

The male reproductive system is shown in Figure 3. It is shown from the front in the diagram on the left and from the side in the diagram on the right. In a human male the sperm or male sex cells are made in the two **testes**. These hang outside the body in a bag of skin called the **scrotal sac**. This position keeps the testes at a temperature slightly below the rest of the body, which is best for sperm production.

There are a mass of tubules (small tubes) inside each testis and sperm are made in these tubules. Sperm are produced all the time, not just once a month. The tubules from each testis join up and lead into a larger tube called the **sperm duct**. This has muscular walls. The two sperm ducts lead to a tube called the **urethra**. The urethra runs down the centre of the **penis** to the outside of the body. The penis is the male reproductive organ used to transfer sperm into the vagina of the body of the female during sexual intercourse.

Study Figures 2 and 3 and use the written information about the female and male reproductive systems to complete Activity 2.

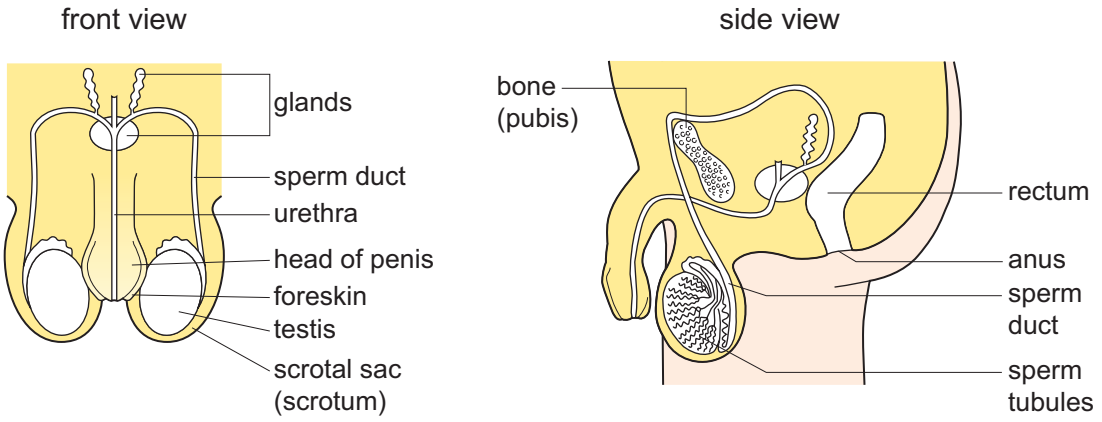


Figure 3: The human male reproductive system.

Activity 2

1. Name the female sex organ where female sex cells (eggs) are made.

   .....

2. Name the male sex organ where male sex cells (sperm) are made.

   .....

3. There are three openings in the lower part of the female body. Use Figure 2 to work out what each opening does. You may need to revise the Digestive system (Unit B3) and the Excretory system (Unit B4).

   .....

   .....

   .....

4. There are two openings in the lower part of the male body. Use Figure 3 to work out what each opening does.

   .....

   .....

   .....

5. Name the tube that an egg cell enters when it first leaves the ovary.

   .....

6. Name the tube that a sperm enters when it first leaves the testis.

   .....

7. What can you learn about the wall of the uterus from Figure 2?

.....

8. What is the name of the lower opening of the uterus where it meets the vagina?

.....

Fertilisation and implantation

For an egg and sperm to meet so that fertilisation can happen, **sexual intercourse** must take place between a woman and a man. This is also known as copulation. In animals, other than humans, it is called mating. For most of the time the man's penis is small and limp. However, it contains spongy tissue which can fill with blood under pressure. This makes the penis larger, more firm and erect. This happens when the man is sexually aroused or excited. The penis can then be placed inside the vagina of the woman. Stimulation of the penis by rubbing causes **ejaculation**. Ejaculation is a reflex action. It causes the sperm ducts to contract forcing sperm out through the urethra. At the same time the glands leading into the sperm duct pour fluid into the duct. Look for these glands in Figure 3. The resulting fluid plus sperm is known as **semen**. This semen passes into the body of the female during sexual intercourse.

Normally about 4 cm^3 of semen is produced each time a man ejaculates. This will contain about 500 million sperm. Each one is very tiny – much smaller than an egg cell. Sperm are shaped like tadpoles. They have a tail for swimming.

Once the sperm are in the body of the female, they swim up through the uterus and into the oviducts. If the female has just ovulated and there is an egg cell in the oviduct, one of the sperm may meet the egg cell. The nucleus in the head of the sperm cell enters the egg and the two nuclei join together. The resulting cell is a **zygote**.

The zygote divides into two cells. Each of these cells divides again to produce four cells. The cells continue to divide in this way to form a ball of cells. The ball of cells continues to move slowly down the oviduct until it reaches the uterus. It then sinks down into the thick spongy lining of the uterus wall. It is now known as an **embryo.** The sinking down process is called **implantation.** You can see this in Figure 4.

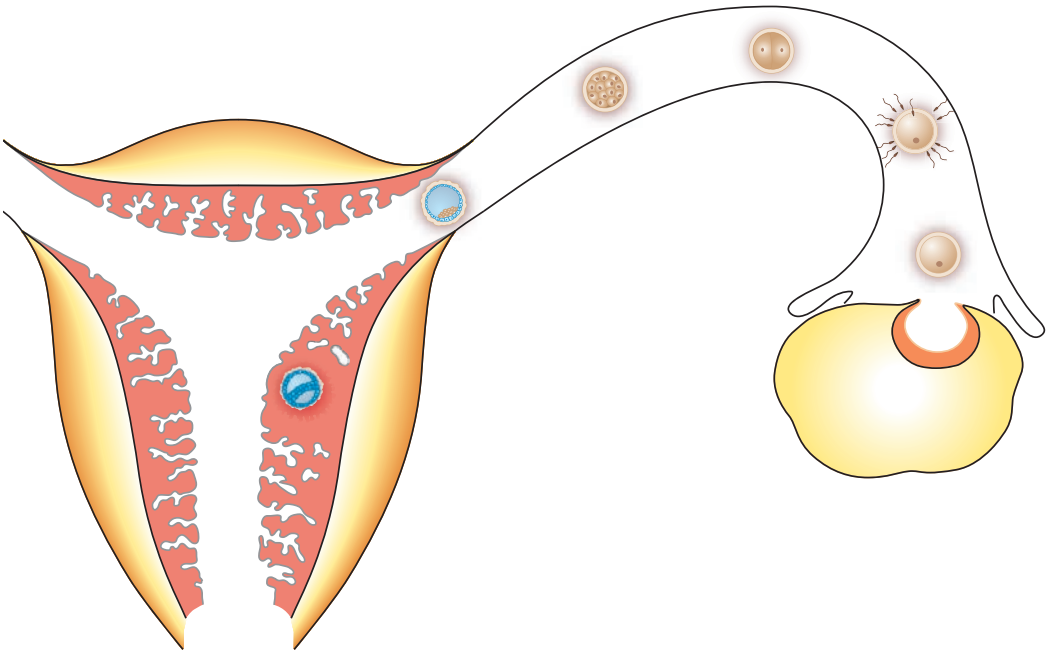


Figure 4: Fertilisation and implantation.

Activity 3

Look at Figure 4. Label the **ovary,** the **oviduct** and the **uterus.**

Add the six annotations below, with labelling lines, in the correct places on Figure 4.

1. Ovulation: a ripe egg is released into the oviduct.
2. Fertilisation: a sperm nucleus joins with the egg nucleus forming a zygote.
3. The zygote divides by mitosis.
4. After several hours a ball of cells is formed.
5. The cells in the ball keep dividing as it moves down the oviduct. It is now called an embryo.
6. Implantation: the embryo sinks into the soft lining of the uterus.

Structure and function of the placenta

Once the embryo is implanted in the wall of the uterus, it continues to grow and make new cells. The different types of tissues start to form and the organs begin to develop. The heart and blood vessels develop early so that blood can circulate around the body of the embryo. As the embryo grows, the uterus enlarges around it. A bag or sac filled with fluid forms around the developing embryo. It is called the **water sac** or **amnion**. This expands like a balloon as the embryo develops. The embryo floats in the middle of the water sac. The water helps to protect the embryo from being bumped and damaged.

After implantation, some of the cells of the embryo grow into a flat disc-shaped structure. This becomes closely attached to the uterus lining and is called the **placenta**. The placenta is attached to the rest of the embryo by a tube called the **umbilical cord**. Blood vessels form in the placenta and the umbilical cord. These connect directly to the blood vessels in the embryo.

Blood vessels in the mother's uterus wall lie very close to the embryo's blood vessels in the placenta. There are also large spaces in the uterus wall filled with the mother's blood.

There is no direct connection between the blood of the mother and the blood of the embryo. However, as they are so close, food and oxygen can pass from the mother's blood to the embryo's blood by diffusion. Waste substances, such as carbon dioxide and urea, can pass from the embryo's blood to the mother's blood and be carried away.

Once the main organs are developed, by 8–10 weeks, the embryo is known as a **foetus.**

Figure 5a shows you the developing baby in the uterus. You can see it is floating in a fluid sac. Look for the tube connecting the baby to the uterus wall. This is called the umbilical cord. Look for the placenta. This is the special part of the uterus wall which is connected to the umbilical cord.

Figure 5b shows you how blood vessels carry blood between the baby and the placenta through the umbilical cord.

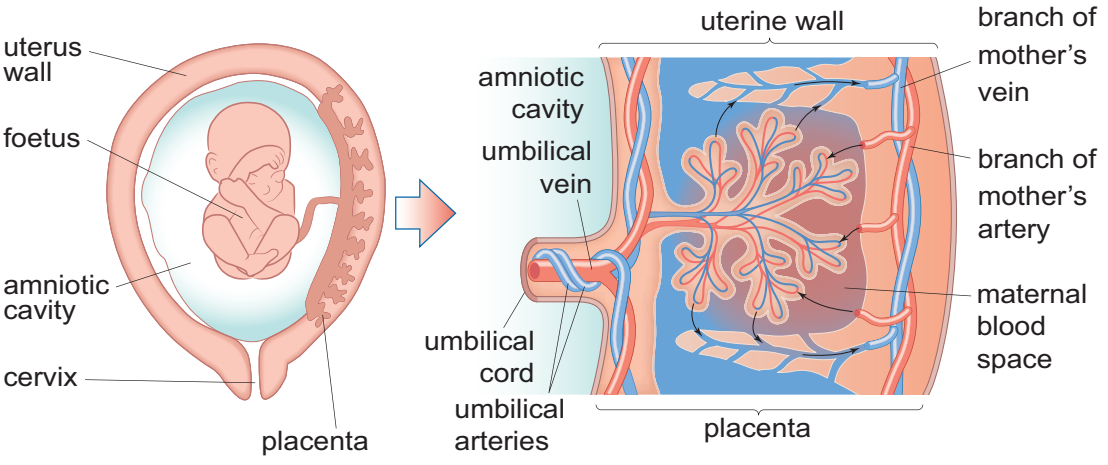


Figure 5a Figure 5b

Figure 5: Baby in the uterus with details of the placenta.

Activity 4

Figure 6 below is a simplified version of Figure 5b.

Add the annotations below to Figure 6 in the correct places, along one of the red arrows, to show how substances pass between the blood of the baby and the blood of the mother.

Oxygen, soluble food substances, salts and water pass from the mother's body to the uterus wall.

Oxygen, soluble food substances, salts and water pass from the mother's blood into the baby's blood.

Oxygen, soluble food substances, salts and water pass from the placenta to the developing baby.

Carbon dioxide and nitrogenous waste substances pass from the developing baby into the placenta.

Carbon dioxide and nitrogenous waste substances pass from the baby's blood into the mother's blood.

Carbon dioxide and nitrogenous waste substances pass from the uterus wall into the body of the mother to be removed.

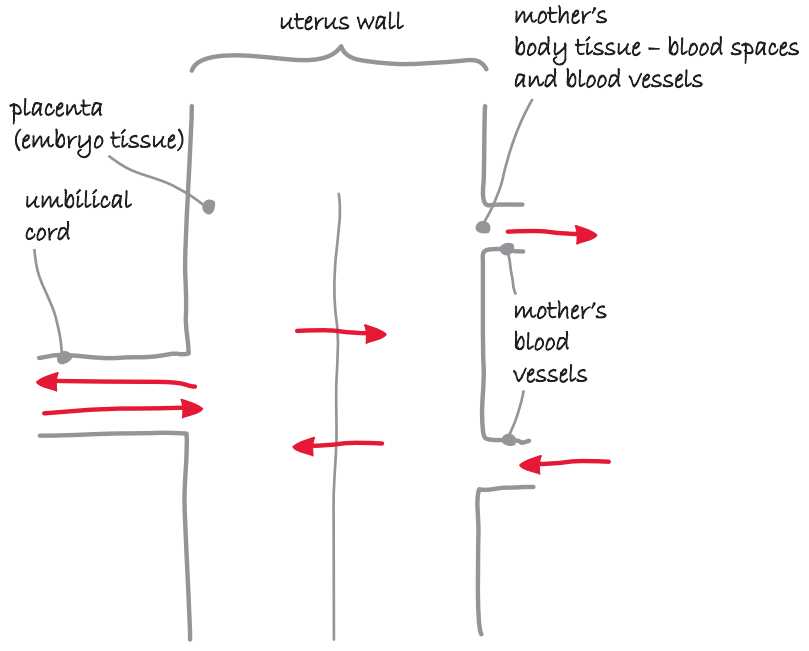


Figure 6: Exchange of substances between mother and baby.

This unit is written to help you concentrate on the most important and basic parts of reproduction and genetics. Try to study and learn what is in this unit first. Later, you may find it useful to read about these topics in your text book. You will find more information in your text book. If you have worked on this unit first, you should find the extra information easier to understand and learn.

If you have time, use your text book to find out more about the process of birth, the importance of breast feeding and some problems associated with reproduction.

The human female menstrual cycle

You know that girls start to have periods, usually sometime after the age of eleven. This means that once a month blood is lost from the vagina. This is a sign that she is starting to produce mature eggs, also once a month. The period is part of a monthly cycle that will go on in her body until she reaches the menopause. Periods stop at the menopause, which usually happens between the ages of 45 and 55. Ovulation, or release of one egg from one of the two ovaries, happens on day 14 of each monthly cycle.

The events of the menstrual cycle involve the ovaries and the uterus. It is helpful to describe the menstrual cycle by dividing the events into four stages. These are illustrated in the two parts of Figure 7. Study these diagrams carefully.

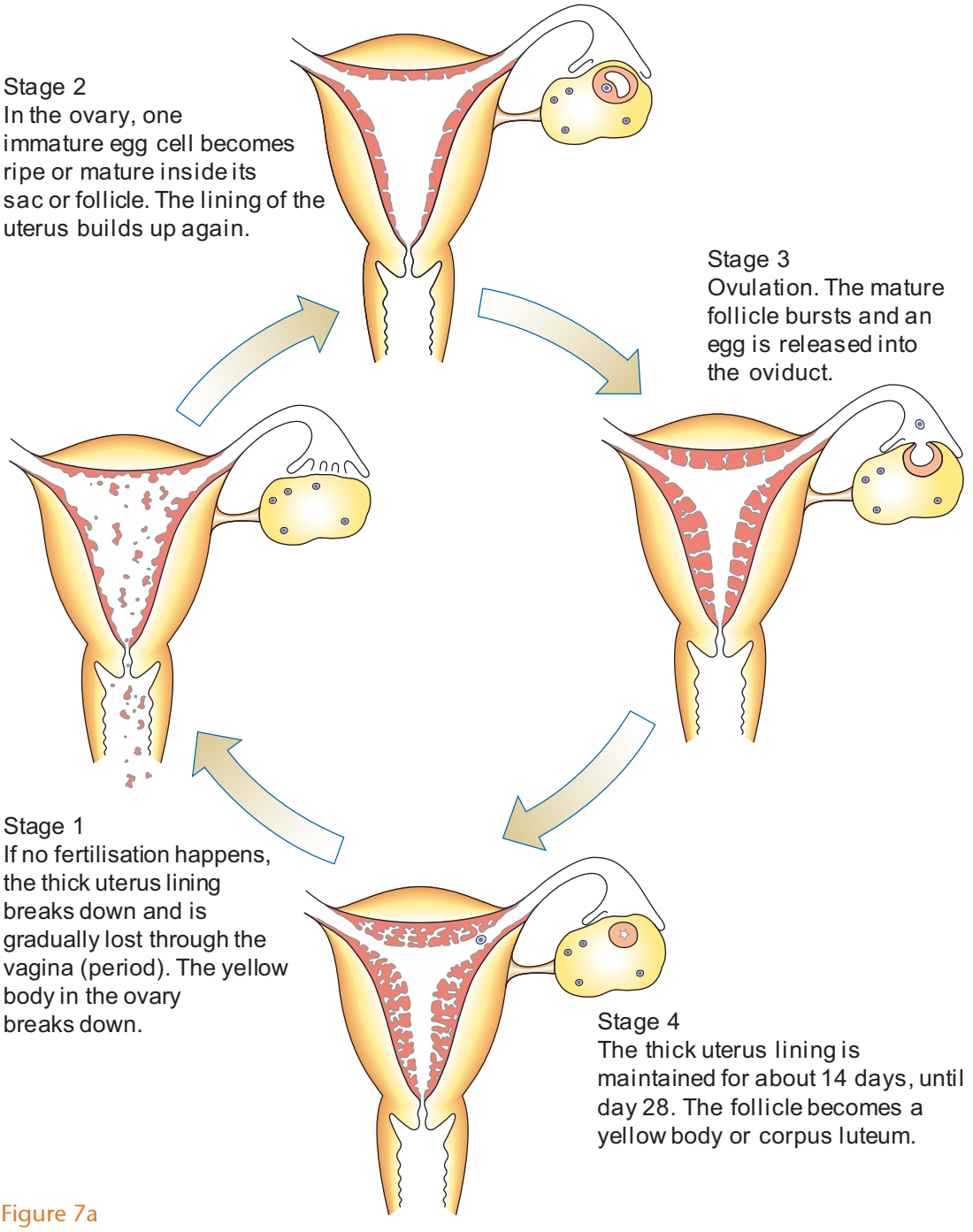


Figure 7a

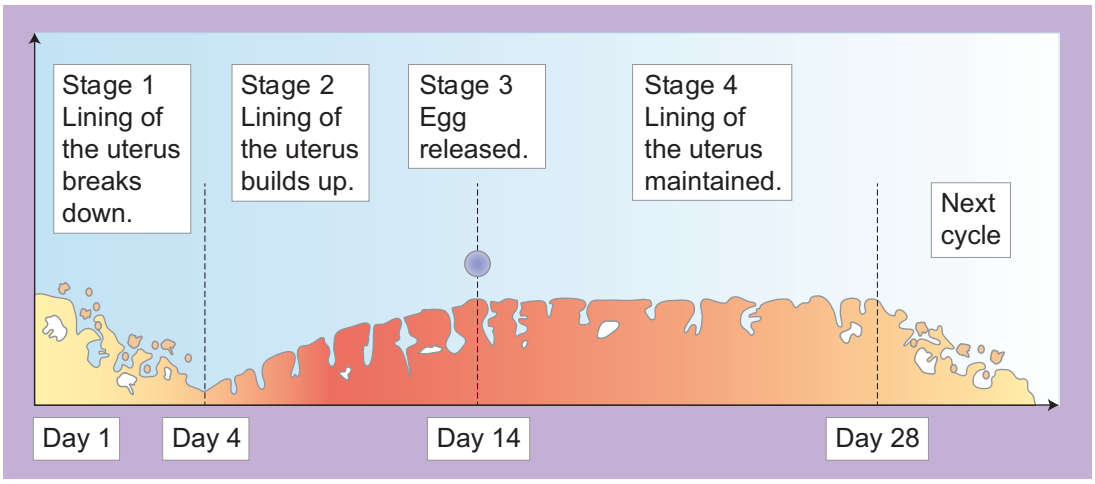


Figure 7b

Figure 7: Stages of the menstrual cycle.

Activity 5

Use the information from Figures 7a and 7b to complete the table below.

Stage number	What happens in the uterus	What happens in the ovary	What you would notice in your own body at this time
Stage 1 (starting at day 1)			
Stage 2			
Stage 3			
Stage 4			

Hormonal control of the menstrual cycle

The menstrual cycle is regulated by hormones secreted by the ovary, the uterus and the pituitary gland in the brain.

Four hormones are involved in controlling menstruation:

- **Oestrogen** and **progesterone** are important for the development and maintenance of the thick spongy lining of the uterus. Progesterone also prevents the release of more eggs once pregnancy occurs. Oestrogen is made mainly in the ovary. Progesterone is made in the ovary and in the placenta.
- **Follicle stimulating hormone (FSH)** and **luteinising hormone (LH)** cause eggs to mature in the ovary and be released into the oviduct (ovulation). Both these hormones are made in the pituitary gland in the brain. They are carried to the ovary in the blood stream.

Hormones in the cycle

Look back at Figure 7 as you read this.

Stage 2

Once a month as a follicle in an ovary develops to produce a mature egg, the follicle also starts producing increasing amounts of **oestrogen**. This causes the uterus lining to start to thicken. The concentration of oestrogen is greatest by day 11. This makes the pituitary gland produce both FSH and LH. This causes ovulation on day 14. The production of oestrogen now falls off.

Stage 3

In the week after ovulation, the remains of the follicle start producing **progesterone**. The follicle is now called the **yellow body** or **corpus luteum**. The progesterone keeps the uterus lining thick and spongy and well supplied with blood.

Stage 4

If fertilisation does occur the yellow body continues to produce progesterone until the embryo sinks into the uterus wall and the placenta develops. The placenta then takes over secretion of progesterone during pregnancy. This maintains the uterus lining. Progesterone stops the pituitary gland from making FSH and LH. This stops any more eggs ripening until after the baby is born.

If fertilisation does not occur, the yellow body continues to produce progesterone for a short while and the thick uterus wall is maintained. The yellow body then breaks down and progesterone levels fall and stop by day 28.

Stage 1

The fall in progesterone causes the thick lining of the uterus to breakdown. This is what causes bleeding during a period. Reduction of progesterone means that FSH and LH are no longer inhibited. Both these hormones start being made again. They are carried from the pituitary gland to the ovaries to cause another egg to be released. The cycle begins again.

Activity 6

Read the following eight sentences about hormones. For each sentence, decide if it relates to oestrogen, progesterone or FSH and LH. Write the sentence in one of the eight boxes in Figure 8 below.

a) These hormones cause eggs to mature and be released into the oviduct.

b) This hormone is produced by the follicle in the ovary as an egg is maturing.

c) This hormone is produced by the follicle when it becomes a yellow body.

d) This hormone causes the uterus lining to start building up.

e) This hormone is produced by the placenta to maintain the uterus lining during pregnancy.

f) This hormone stops the production of FSH and LH by the pituitary gland.

g) The fall in concentration of this hormone causes the uterus lining to break down. This causes menstrual bleeding.

h) These hormones are produced by the pituitary gland in the brain.

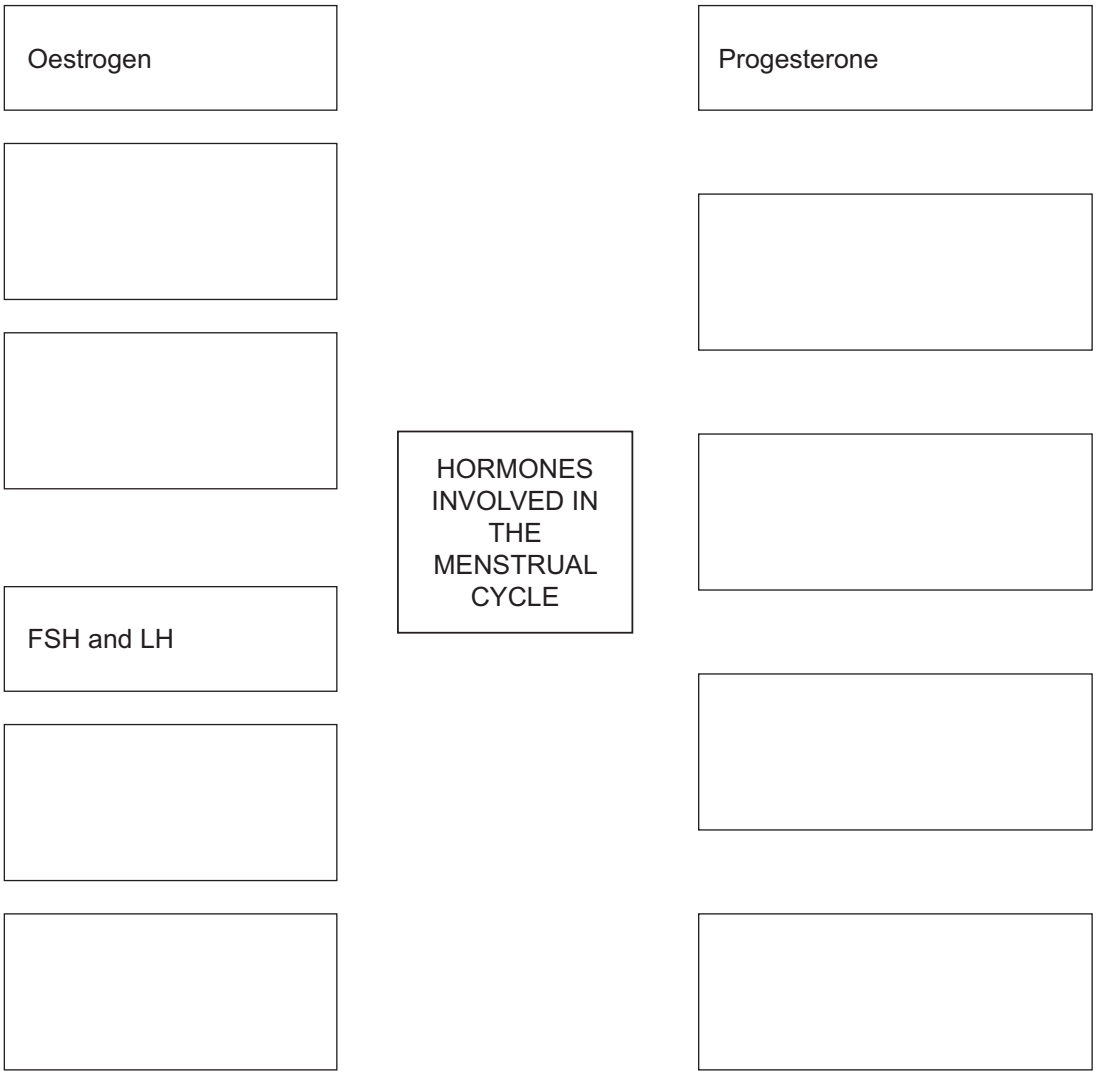


Figure 8: Hormones in the menstrual cycle.

Contraception

People usually wish to limit the size of their families and to continue to have sexual intercourse without the risk of pregnancy. There are now some very reliable methods of contraception, i.e. preventing a baby developing following sexual intercourse.

The table below shows common methods of birth control available and explains briefly how each works. The last column shows how reliable each method is. This is measured as the average number of pregnancies in every 100 women who use the method for one year.

Table showing common methods of birth control or contraception

Type	Method		Notes	Reliability (0 = 100% reliable)
Surgical	Sterilisation	In the female the oviduct is cut and tied. In the male the sperm duct is cut and tied.	Reliable. Safe. Not reversible.	0
Chemical – must always be used with a barrier	Spermicides	Creams, aerosols or foams that kill sperm.	Easily available, but should only be used together with a barrier method.	4
Barrier	Sheath or condom	Fits over erect penis	Easily available. Helps prevent sexually transmitted diseases, such as HIV/AIDS.	4
	Diaphragm (cap)	Fits inside vagina. Closes entry to uterus (womb).	Must be fitted by clinic.	4
Hormones	Pill	Prescribed by doctor. Instructions must be followed exactly.	Some side effects possible. Medical supervision essential.	0
Intrauterine device (IUD)	Coil or loop	Plastic device placed inside the uterus (womb).	Once inserted can remain in place for 2 years.	2
The 'safe' period i.e. avoid intercourse around ovulation time.		Depends on knowing the menstrual cycle and exactly when ovulation occurs.	Very unreliable.	30

Activity 7

Study the table above carefully and then answer the following questions about methods of contraception.

1. Which two methods are most reliable?

   .....

   .....

2. Which method is least reliable?

   .....

3. Which method is also an important protection against getting sexually transmitted diseases such as HIV/AIDS?

   .....

4. Which methods should be used in combination?

.....

5. What do the words **spermicide** and **intrauterine** mean?

.....

.....

Division of the nucleus and chromosomes

Look back at Figure 4: Fertilisation and implantation. It shows you how after fertilisation of the egg by a sperm, the resulting cell, the zygote, starts to divide. First it forms a ball of cells. Eventually this develops into an embryo and finally a new individual human being.

It is important that the chromosomes in the cells divide very precisely. The new cells made must have exactly the same number and the same types of chromosome as the original zygote cell. As you know, for humans, there are 46 chromosomes in each nucleus. All the cells of the embryo and the new individual must have an identical set of 46 chromosomes. That means they must have the same genes on them and their DNA must be identical. The process by which this happens is called **mitosis.**

Mitosis

Before a cell is ready to divide, the DNA of each chromosome replicates. Each chromosome now becomes a double structure, i.e. it is made of two strands. A human cell ready to divide will have 46 of these double-stranded chromosomes.

The nuclear membrane of the cell now breaks down and a sort of scaffold-type structure appears in the centre of the cell, called the spindle. The central region of the spindle is called the equator (like the equator of the world). The chromosomes all move to the equator of the spindle. See Figure 9.

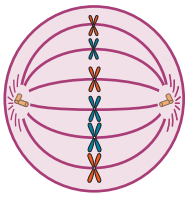


Figure 9: Chromosomes in a cell lining up ready to divide on the equator of the spindle (shown diagrammatically).

Each (two-stranded) chromosome now splits in two. One strand goes to one end or pole of the spindle, the other strand goes to the opposite pole. There are now two groups of chromosomes (each is one-stranded now) at each pole of the spindle. There will be 46 of them at each pole.

The spindle now breaks down. A new nuclear membrane forms around each group of chromosomes. So we have two nuclei. The cell itself now divides by the cell membrane pushing inwards. (In plant cells this happens by a new cell wall gradually building up to separate the two new nuclei.)

So now we have two new cells, each with its own nucleus. The nuclei of the two new cells will be identical to each other. They are also identical to the original or parent nucleus. Each new nucleus will have 46 chromosomes.

The need for a different kind of nuclear division: meiosis

Mitosis works well for the growth of an individual from a single cell, where all the cells in the body need to be the same. However, think for a moment about sexual reproduction. This involves the formation of sex cells or gametes – female egg cells and male sperm cells.

Imagine if eggs and sperm were made by mitosis like other cells. They would have 46 chromosomes each. When they joined at fertilisation, the zygote and hence all the cells of the new offspring would have 92 chromosomes. After a few generations, assuming the offspring survived, things would be chaotic!

Therefore, when eggs and sperm are made, they have a different form of nuclear division, which we call **meiosis**. Put simply, this involves the original parent **cell and nucleus dividing twice** to make four new cells, but the **chromosomes only divide once**. The four new cells each contain half the normal number of chromosomes – so in human gametes, they would contain 23 chromosomes.

Figure 10 shows the main stages in meiosis, side by side with the main stages in mitosis. In some ways they are the same, but there are some very important differences between them.

As in mitosis, at the start of meiosis, each chromosome replicates beforehand to become a double strand. Remember also that chromosomes are paired. So in humans, there will be 46 double-stranded chromosomes, or 23 pairs of double-stranded chromosomes.

In the first division of meiosis, the chromosomes themselves do not separate, but one of each pair goes to each end of the spindle. So you will have 23 double stranded chromosomes at each pole.

The second division of meiosis involves the chromosomes in each of these two groups of 23 double stranded chromosomes splitting into their two separate strands. Each one then separates out into two groups of single-stranded chromosomes.

So now there are four nuclei, each with 23 single-stranded chromosomes. In other words there are four nuclei with half the normal number of chromosomes. This is referred to as the **haploid chromosome number** of chromosomes (as opposed to the full or **diploid chromosome number**).

When gametes formed by meiosis join together at fertilisation, the resultant cell will now have the normal or diploid number of chromosomes. Hence for each species, each generation keeps an identical number of chromosomes.

This is why meiosis is important – to keep the chromosome number constant from generation to generation.

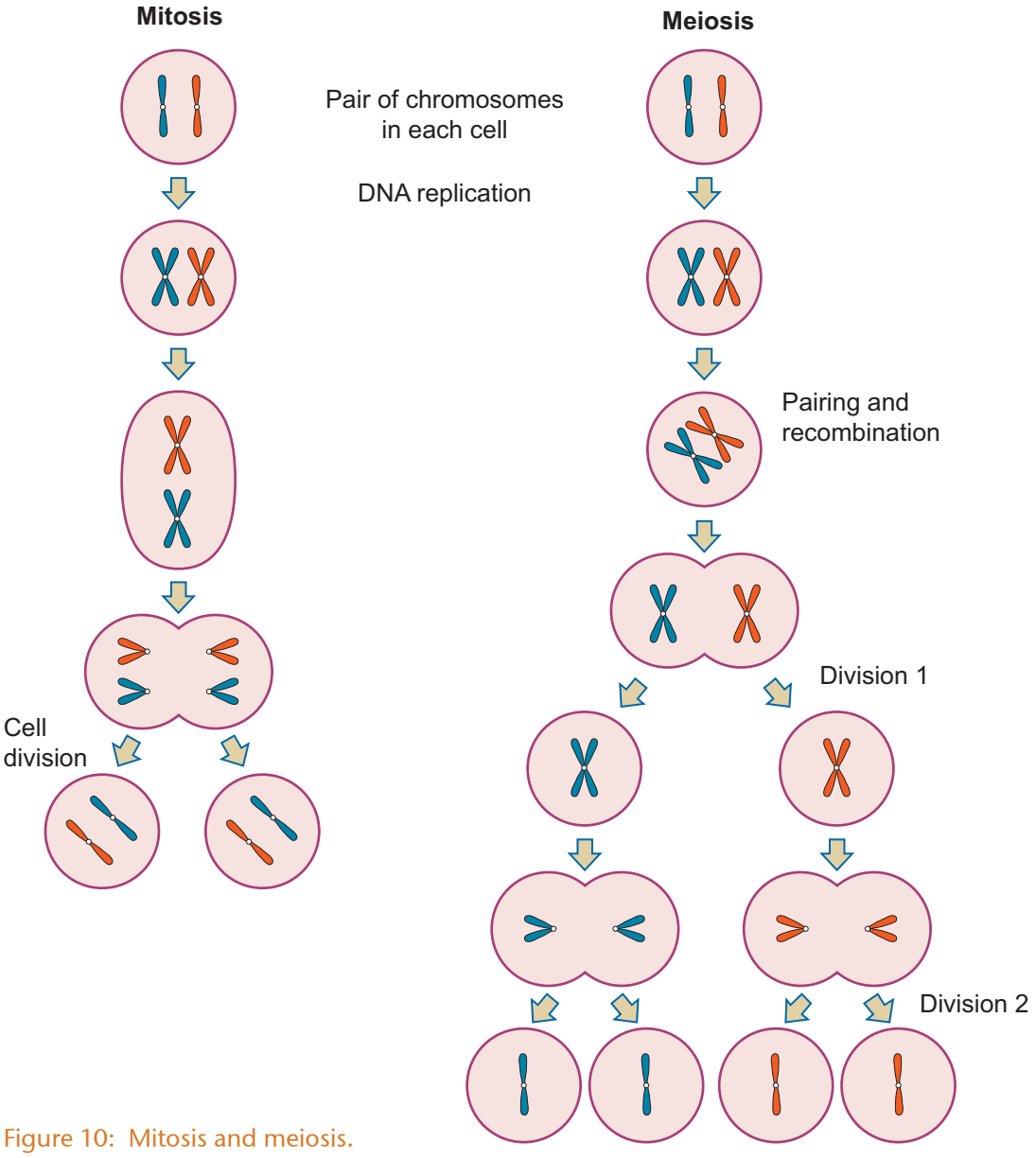


Figure 10: Mitosis and meiosis.

Another very important thing about meiosis

In the first division of meiosis it is each pair of chromosomes that separates. If you remember, one of each pair of your chromosomes comes from your mother and the other comes from your father. This means they are likely to have different genes. They will, of course, be controlling the same characters, say eye colour or curly or straight hair. However, green eyes and straight hair genes might be on the chromosome derived from one parent, whereas genes for brown eyes and curly hair might be on the chromosome derived from the other parent.

This means that the four nuclei formed by a meiotic division will not only have the halved (haploid) number of chromosomes, they will also have different genes, i.e. **they will show variation**. Variation is very important. It allows organisms to adapt. Without variation, natural selection and evolution could not happen.

Activity 8

Read over the account of mitosis and meiosis again and study Figure 10 carefully.

Decide what you think are the three most important differences between the two processes. Discuss this with other scholars.

Write the three important differences below.

1. .....

   .....

2. .....

   .....

3. .....

   .....

Looking at inheritance

An **inheritance** is something you get from your parents (or grandparents).

It could be a house, some money or a plot of land. In biology it means getting characteristics such as eye colour, height or straight or curly hair. More precisely it means getting the instructions for producing those characteristics. These instructions come as pieces of DNA which we call genes.

Genetics is the study of the way in which characters, and therefore the genes which control these characteristics, are inherited.

Some of your characteristics, such as being able to play football or play the drums are picked up as you go through life. These are acquired rather than inherited characteristics and you cannot pass them on to your children.

Inherited characteristics are controlled by **pairs of genes**. One of each pair of genes will have come from your mother and one from your father.

Some characteristics may be controlled by just one pair of genes. Examples include whether you can roll your tongue or not; whether your ear lobe is attached or free; whether you have the disease cystic fibrosis or not. The first two of these examples are illustrated in Figure 11.

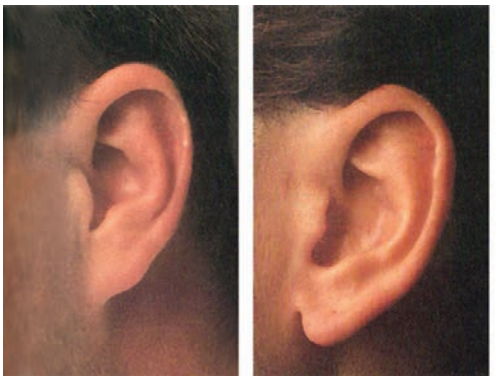


Figure 11a: Attached or free ear lobe.

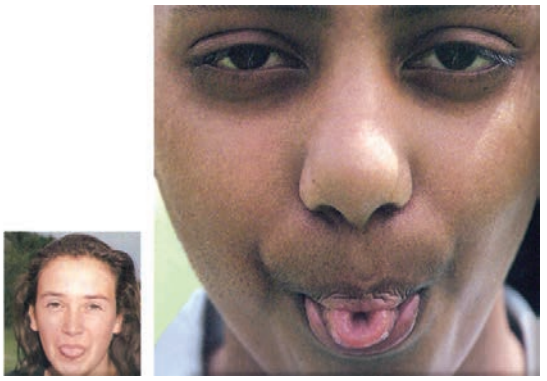


Figure 11b: Ability to roll your tongue or not.

Figure 11: Human characteristics controlled by a single pair of genes.

Most of your characteristics are controlled by several pairs of genes working together. Examples include, height, skin colour and susceptibility to certain diseases.

The gene that allows rolling of the tongue can be represented by **R**. The gene that does not allow rolling can be called **r**. Since any individual must have two genes to control whether or not they can roll their tongue, you can see that the individual could either have two R genes, or two r genes or one R and one r gene.

We say that their genetic constitution or **genotype** is either RR, rr or Rr.

If the two genes are the same, e.g. RR or rr, we say the individual is **homozygous** for that character. ***Homo*** means the same. If the two genes are different, e.g. Rr, we say the individual is **heterozygous** for that characteristic. ***Hetero*** means different.

If you were to meet three individuals, with each of the three different genotypes, you would find that the RR and the Rr individuals could both roll their tongues. This is because the R gene is **dominant.** This means that whenever it is present, it is expressed. Its effect can never be hidden by the presence of another gene.

The r gene is described as **recessive**. This means that it will have no observable effect unless it is homozygous. In other words it cannot have an effect if there is a dominant form of the gene, the R, present.

R and r are both forms of the same gene – the gene that controls tongue rolling. The different forms of a gene are referred to as alleles. Dominant alleles are represented by a capital letter. Recessive alleles are represented by little letters (lower case).

We use the word **phenotype** for the **characteristics that we see** in an organism due to its genes. So, the phenotype of RR and Rr individuals is ‘tongue rolling’. The phenotype of rr individuals is ‘non tongue rolling’.

Activity 9

1. If **E** is the dominant gene for brown eyes and **e** is the recessive gene for blue eyes, what colour eyes would people with the following genotypes have?

   (a) EE ..... (b) Ee .....

   (c) ee .....

2. For each individual in question 1, say whether they are homozygous or heterozygous.

   (a) ..... (b) .....

   (c) .....

This unit is written to help you concentrate on the most important and basic parts of reproduction and genetics. Try to study and learn what is in this unit first. Later, you may find it useful to read about these topics in your text book. You will find more information in your text book. If you have worked on this unit first, you should find the extra information easier to understand and learn.

If you have time, use your text book to find out more about variation and its causes and about mutations.

Practice questions

Remember, talking about the ideas in the units is a very good way to learn. Ask one of your fellow scholars these questions and check their answers.

1. What is a gene?
2. What are chromosomes and what are they made of?
3. Describe the structure of a DNA molecule.
4. Name the female sex cell or gamete and say where it is made.
5. Name the male sex cell or gamete and say where it is made.
6. Explain the following words: fertilisation, zygote and ovulation.
7. Where does fertilisation happen in humans?
8. In what part of the female does the baby develop?
9. Explain the following words: implantation; water sac or amnion; placenta; umbilical cord; foetus.
10. Why is the placenta important?
11. What are the two main organs of the body of a female that are involved in menstruation?
12. Name the four hormones that control the menstrual cycle.
13. Explain the term contraception.
14. Name seven methods of birth control (contraception).
15. What is the name of the type of nuclear division used by most cells during growth?
16. What is the name of the type of nuclear division that happens when eggs and sperm are made?
17. What are the three main differences between the two types of nuclear division in questions 15 and 16?
18. Explain the terms dominant gene and recessive gene.
19. State whether the following genotypes are homozygous or heterozygous:

    (a) RR (b) Rr (c) tt (d) Tt (e) EE

How am I doing?

	☺ **Easy** (Tick this box if you feel confident that you **understand this section well**)	**Fine** (Tick this box if you still **need a little work** on this section)	☹ **Difficult** (Tick this box if you still **need a lot of work** on this section)
I know about chromosomes, genes and DNA and can explain how these three structures are related to one another.			
I know that characteristics are controlled by pairs of genes. I can explain the terms dominant and recessive genes; homozygous and heterozygous genotypes.			
I can label the main parts of the female and male reproductive systems in humans and explain the role of each part in the process of reproduction.			
I can explain fertilisation and describe the process of implantation.			
I can describe the structure of the human placenta and explain its importance for the developing embryo and foetus.			
I can describe the key stages of the human female menstrual cycle and explain the role of hormones in controlling the cycle.			
I can explain the meaning of contraception and outline the main methods for achieving contraception.			
I can describe mitosis and meiosis, state the similarities and differences between the two processes and explain why each method of division is important.			

Notes on what to do next:

Signed (by Scholar): ..... Date:.....

Signed (by Tutor): ..... Date:.....

Answers to activities

Activity 1

Column A	Column B
There are about 100,000 pairs of these in the nucleus of each of your cells.	Genes
This is a section of DNA molecule.	Gene
This controls a characteristic of your body.	Gene
This is a chemical molecule with the shape of a double spiral or helix.	DNA
You can see this structure in the nucleus when a long strand of DNA is bundled up just before a cell and nucleus is ready to divide.	Chromosome
There are 46 of these in all human body cells (except the sex cells).	Chromosomes
These can be seen with a light microscope.	Chromosomes
These cannot be seen with a light microscope.	DNA and genes

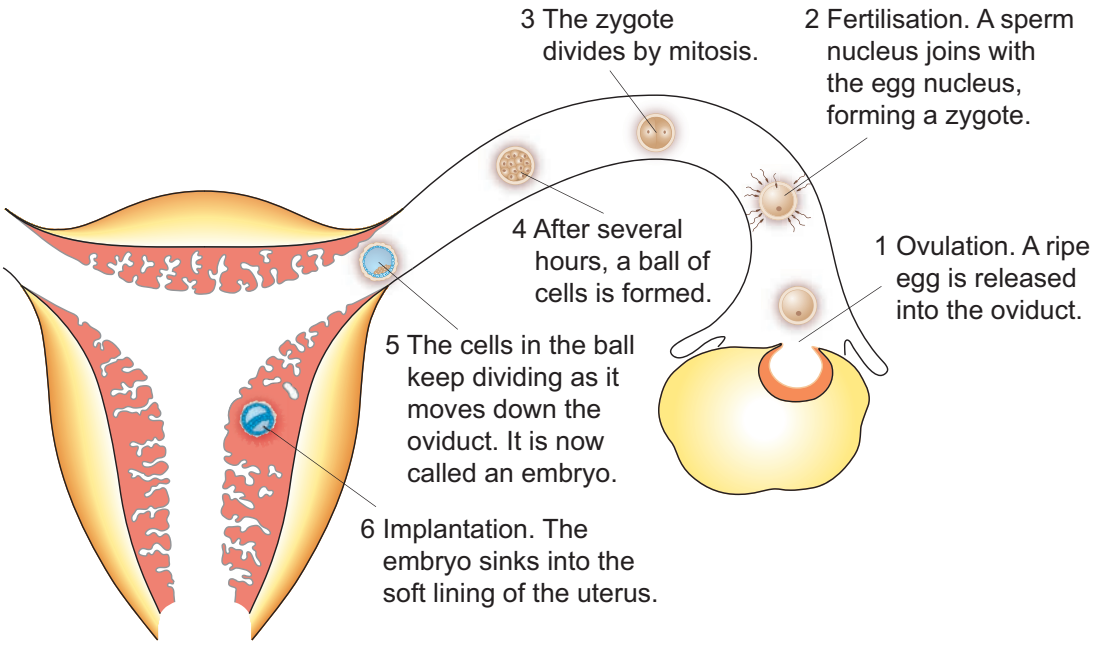
Activity 2

1. Female sex cells (eggs) are made in the ovary.
2. Male sex cells (sperm) are made in the testis.
3. The three openings in the lower part of the female body are:

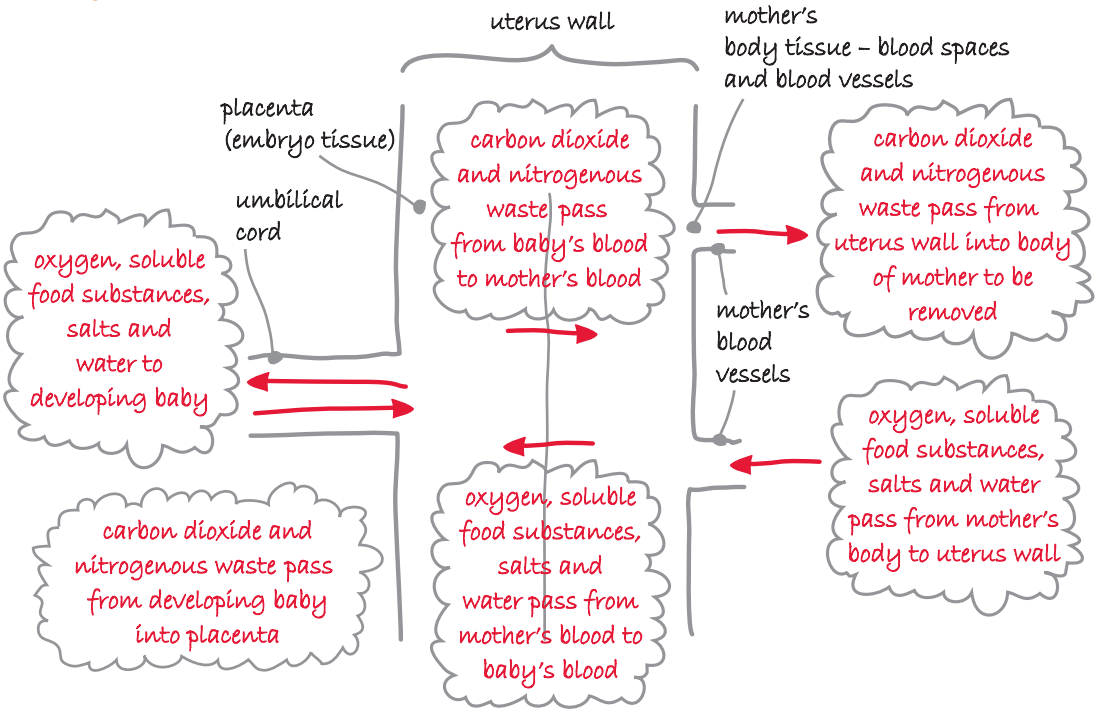
   (1) Opening of the vagina. Sperm get in here from the man's penis. The baby is born through here. (2) Opening of urinary duct or urethra. Urine comes out here when you go to the toilet. (3) Anus. This is the end of the food tube or alimentary canal. Solid waste, called faeces, passes out of the body here.
4. The two openings in the lower part of the male body are:

   (1) Opening of the end of the urethra at the end of the penis. Urine comes out here from the bladder. Sperm come out here. N.B. urine and sperm can never come out at the same time. (2) Anus. This is the end of the food tube or alimentary canal. Solid waste, called faeces, passes out of the body here.
5. The tube that an egg cell enters when it first leaves the ovary is the oviduct (or Fallopian tube).
6. The tube that a sperm enters when it first leaves the testis is the sperm duct.
7. The wall of the uterus is very thick. It contains muscle and an inner lining.
8. The lower opening of the uterus is called the cervix.

Activity 3



Activity 4



Activity 5

Stage number	What happens in the uterus	What happens in the ovary	What you would notice in your own body at this time
Stage 1 (starting at day 1)	Lining of uterus breaks down.	Yellow body breaks down.	Bleeding – a period.
Stage 2	Lining of uterus starts to build up again.	A follicle develops to produce a mature egg.	
Stage 3	Lining of uterus continues to build up.	The mature follicle bursts and the egg is released from the ovary into the oviduct (day 14).	
Stage 4	Lining of uterus continues to be maintained.	The follicle becomes a yellow body.	

Activity 6

HORMONES INVOLVED IN THE MENSTRUAL CYCLE

Oestrogen

This hormone is produced by the follicle in the ovary as an egg is maturing.

This hormone causes the uterus lining to start building up.

FSH and LH

These hormones cause eggs to mature and be released into the oviduct.

These hormones are produced by the pituitary gland in the brain.

Progesterone

This hormone is produced by the follicle when it becomes a yellow body.

This hormone is produced by the placenta to maintain the uterus lining during pregnancy.

This hormone stops the production of FSH and LH by the pituitary gland.

The fall in concentration of this hormone causes the uterus lining to break down. This causes menstrual bleeding.

Activity 7

1. Sterilisation and the pill are the most reliable methods.
2. The 'safe' period method is the least reliable method.
3. The sheath or condom is also an important protection against getting sexually transmitted diseases, such as HIV/AIDS.
4. Both the sheath or condom and the diaphragm or cap can be used in combination with a spermicide, but a spermicide must always be used with a condom or diaphragm.
5. Spermicide means it kills sperm. Intrauterine means inside the uterus.

Activity 8

The three important differences between mitosis and meiosis are:

1. The nuclei of cells made by mitosis have the same number of chromosomes as the original or parent cell. The nuclei of cells made by meiosis have half the number of chromosomes of the original cell.
2. The chromosomes in the nuclei of cells made by mitosis are identical to each other and to the original parent cell. The chromosomes in the nuclei of cells made by meiosis are different from each other and from the original parent cell.
3. In mitosis, two new cells and two new nuclei are produced at the end. In meiosis four new cells and four new nuclei are produced at the end.

Activity 9

1. (a) EE Brown eyes.
   (b) Ee Brown eyes.
   (c) ee Blue eyes.
2. (a) Homozygous.
   (b) Heterozygous.
   (c) Homozygous.

Answers to practice questions

1. A gene is a section of a DNA molecule that controls a characteristic, such as height or eye colour.
2. Chromosomes are paired thread-like structures which are found in the nucleus of a cell. They are made of bundled up DNA.
3. DNA is a molecule shaped like a ladder that has been twisted into a spiral shape.
4. The female sex cell or gamete is the egg or ovum. It is made in the ovary.

5. The male sex cell or gamete is the sperm. It is made in the testis.
6. **Fertilisation** is the joining together of a female egg cell and a male sperm cell. A **zygote** is the cell formed when the egg and sperm join together. **Ovulation** is the release of an egg cell from the ovary of a woman into the oviduct. (This happens once a month between puberty and menopause).
7. Fertilisation happens in the body of the female, in the oviduct.
8. The baby develops in the uterus or womb.
9. **Implantation** is when the developing embryo sinks into the thick spongy lining of the uterus wall. **The water sac** or **amnion** is like a bag of liquid that surrounds the developing embryo in the uterus wall and helps protect the embryo from bumps and damage. **The placenta** is a flat disc-shaped structure made from some of the embryo's tissue. It grows into the uterus lining. **The umbilical cord** is a tube that joins the developing embryo to the placenta. It contains blood vessels. **The foetus** is the name given to the embryo once its main organs are developed.
10. The placenta is where food and oxygen pass from the mother's blood into the blood of the embryo. Carbon dioxide and nitrogenous waste pass away from the blood of the embryo into the mother's blood in the placenta.
11. The main body organs in a woman that are involved in menstruation are the ovary and the uterus.
12. The four hormones that control the menstrual cycle are oestrogen, progesterone, FSH (follicle stimulating hormone) and LH (luteinising hormone).
13. Contraception means preventing a baby developing following sexual intercourse. It is also called birth control.
14. Seven methods of birth control or contraception are: sterilisation, spermicides, sheath or condom, diaphragm or cap, the contraceptive pill, the coil or loop and the 'safe' period method.
15. The name of the type of nuclear division used by most cells during growth is **mitosis.**
16. The name of the type of nuclear division that happens when eggs and sperm are made is **meiosis.**
17. The three main differences between mitosis and meiosis are:

    (1) The nuclei of cells made by mitosis have the same number of chromosomes as the original or parent cell. The nuclei of cells made by meiosis have half the number of chromosomes of the original cell. (2) The chromosomes in the nuclei of cells made by mitosis are identical to each other and to the original parent cell. The chromosomes in the nuclei of cells made by meiosis are different from each other and from the original parent cell. (3) In mitosis, two new cells and two new nuclei are produced at the end. In meiosis four new cells and four new nuclei are produced at the end.

18. A **dominant gene** is a gene that is expressed whenever it is present in the genotype of an individual. A **recessive gene** cannot have an effect if it is present in the genotype of an individual together with a dominant form of the gene. It only has observable effects if it is homozygous.

19. (a) RR; (c) tt; (e) EE are all homozygous.
    (b) Rr; (d) Tt are both heterozygous.

MSCE B6:
Drugs and disease

What you are studying and why

Subject: Biology Unit B6

This unit is about drugs and disease.

In this unit you will learn about some of the diseases which occur in Malawi. You will find out what causes them, and some of the ways in which people can control and treat them. You will also learn about how your own body keeps you healthy by preventing disease and fighting off those diseases that you do get.

At the end of the unit you should be able to:

1. state what an infectious disease is
2. name the four main types of microbe that can cause infectious diseases
3. recognise and describe signs and symptoms of selected diseases caused by bacteria, viruses, fungi and protozoa
4. describe how infectious diseases are spread
5. describe methods of prevention and control of selected diseases
6. describe your lymphatic system and explain how it helps to protect you against disease
7. explain what is meant by natural and artificial immunity, and describe how they work
8. explain how HIV weakens the immune system.

What is an infectious disease?

A disease that is caused by microbes entering your body, then growing and reproducing there, is called an **infectious disease**. The disease may be caused by the microbes feeding on your body cells. Sometimes, it may be caused by the action of waste substances made by the microbes which are poisons or **toxins**. An organism that lives on another living organism in order to feed off it is called a **parasite**. All microbes that cause diseases are parasites. Microbes can reproduce asexually; this means they can multiply rapidly and makes them very effective at causing disease.

There are four main kinds of microbe that can cause disease. These are bacteria, viruses, fungi and protozoa. They are all tiny – much smaller than human cells. Their cell size is measured in units called microns (μm) or nanometers (nm). Look at a millimetre on a ruler. There are 1000 μm in one millimetre. There are 1,000,000 nm in one millimetre.

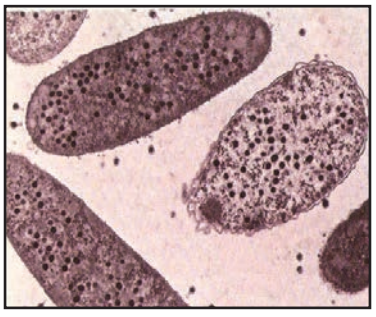
1mm = 1000 μm 1 μm = 1000 nm

Bacteria are single-celled organisms. They vary in shape but their average diameter is 0.5–5.0 μm. They reproduce by splitting into two and this can happen very rapidly. They have a central nuclear region but no true nucleus, and are surrounded by a cell membrane and a cell wall. Some bacteria form **spores.** When this happens, the cell shrinks and becomes surrounded by a very thick wall. Spores can survive extremes of temperature and dehydration. Bacteria may also reproduce sexually.

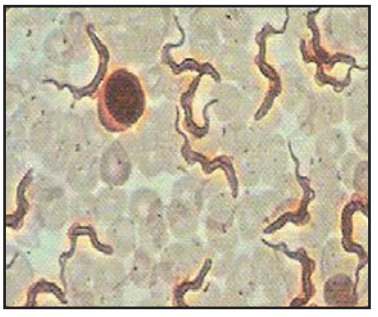
Viruses are much smaller than bacteria. Their average diameter is 20–2000 nm and they can only reproduce inside other living cells. A virus is not a true cell. It has an outer protein coat with nucleic acid (its genetic material) inside.

Fungi are made up of microscopic cylindrical threads called hyphae. The average diameter of a hypha varies from 2–10 μm. A mass of these threads is called a mycelium. Fungal hyphae have cell walls, cell membranes and nuclei. Fungi reproduce both asexually, by making spores, and sexually, by making gametes. Few fungi cause human disease but they are a major cause of disease in plants.

Protozoa are single-celled organisms. Their cells have a true nucleus and are surrounded by a cell membrane. Their average diameter is 50–150 μm. Only about 20 species cause human diseases but these include some of the world's most difficult health problems. Protozoa can reproduce by sexual reproduction as well as by simply splitting in two.



The large shapes in this photo are bacteria. The tiny dots are viruses. This photo shows what you can see with an electron microscope.



The curled shapes are the protozoa that cause sleeping sickness. This photo shows what you can see with a light microscope.

The long shapes are part of the fungus that causes athletes foot. This photo shows what you can see with an electron microscope.

Figure 1: Microscope photographs of some microbes that cause disease

Activity 1

Complete the table below as a summary of the information about disease-causing microbes that you studied above. You will need to fill in the last row as you go through this unit. When you have filled it all in, this table will be useful for your revision. Look at it again when you have finished this unit.

	Bacteria	Viruses	Fungi	Protozoa
What is the cell like?				
How big is the cell? (Use the correct units of measurement.)				
How do they reproduce?				
Examples of diseases they cause.				

Signs and symptoms of some infectious diseases

A sign is a clue or indication that a microbe has infected an individual. If you are infected by a microbe, changes happen in your body. These changes are characteristic of each particular disease and are called **symptoms**.

You should be able to describe the signs and symptoms of the following diseases:

Bacterial diseases: Pneumonia, TB (tuberculosis), cholera, typhoid

Viral diseases: Common cold, flu (Influenza), measles, chickenpox, AIDS

Fungal diseases: Ringworm, thrush, athlete's foot

Protozoan diseases: Malaria, sleeping sickness

The signs and symptoms of the bacterial, viral and fungal infections listed above (except HIV/AIDS, which is covered in a later section) are shown in the following table.

Table showing signs and symptoms of bacterial, viral and fungal infections

Words with a * are explained at the end of the table.

Disease	Part of the body affected	Signs and symptoms of the disease
Pneumonia (Bacteria)	The air sacs in the lungs become inflamed* and the cells of the lungs are destroyed. Fluid collects in the lungs.	Fever, chest pains, coughing and headaches.
TB (tuberculosis) (Bacteria)	The lungs. Lymph glands, kidneys, brain and bones may also be affected. Sometimes the bacteria can infect the body without showing symptoms.	Chest pain, coughing up mucus, coughing up blood, night sweats, tiredness, fever and weight loss.
Cholera (Bacteria)	The cells lining the small intestine. When the bacteria die they release toxins (poisons). These poisons make the cells lose large amounts of water and salts.	Acute diarrhoea*. Loss of a lot of water and salt. Dehydration and kidney failure.
Typhoid (Bacteria)	The cells lining the intestines.	Fever, sweating, diarrhoea* or constipation*, nausea*, vomiting*, abdominal pain, headaches and sometimes a rash.
Common cold (Virus)	The cells in the upper part of the throat.	Runny nose, blocked nose and sneezing. You may also have a sore throat, cough, headache, muscle aches, chills and fever. The symptoms are like those of flu but less severe.
Influenza or flu (Virus)	The cells in the throat, windpipe and lungs.	Chills, fever, sore throat, muscle pains, bad headaches, weakness and tiredness.
Measles (Virus)	The cells of the respiratory system.	Fever, cough, runny nose, red eyes and sensitivity to light. Greyish white spots in the mouth and throat. After a few days a red-brown spotty rash appears, starting behind the ears and spreading to the rest of the body. Measles can lead to other problems such as meningitis and pneumonia.
Chicken pox (Shingles) (Virus)	Skin and nerve cells. The chicken pox virus is highly contagious. This means it is very easy to catch through contact with infected people. The virus can remain inactive in nerve cells in the body and become reactivated later in life, causing shingles.	First an itchy* skin rash appears. Other symptoms are muscle pain, nausea*, fever, headaches, sore throat, pain in ears. Shingles produces a painful skin rash with blisters on one side of the body, often in a stripe.
Ringworm (Fungus)	The outer layers of the skin.	Itchy coloured patches appear on the skin. If the head is affected, patches or 'rings' may develop where hair falls out.

Thrush (A one-celled fungus like yeast)	The inside of the mouth, the vagina or the head of the penis. The fungus often lives together with harmless bacteria. These bacteria stop it causing disease. However, if the body becomes weak, the fungus may increase rapidly. The symptoms of the disease then develop.	Vaginal thrush causes itching*, soreness and redness. The vagina may also produce a liquid substance. Mouth infections cause a thick white or cream-coloured coating on the tongue and inside of the mouth. These surfaces may become red, painful and tender.
Athlete's foot (Fungus)	The fungus infects the skin, especially between the toes. The fungus causing athlete's foot is closely related to the one that causes ringworm.	The skin flakes, cracks, becomes inflamed* and itches*.

*

Constipation: This is when you go to the toilet and find it difficult to get rid of faeces (solid waste).

Diarrhoea: This is when faeces (or solid waste that your body gets rid of) become very watery.

Inflamed/Inflammation: This is when part of your body becomes red, hot, painful and swollen.

Itching skin or an itch: This is when your skin feels uncomfortable or irritated and you want to scratch it.

Nausea: This means feeling sick.

Vomiting: This means being sick.

Activity 2

Study the table above again carefully and then answer the questions below.

1. If you have the following symptoms, what disease are you likely to have?

   (a) An itchy skin rash on the body and head, with some muscle and ear pain, nausea, fever, headaches and a sore throat.

   .....

   (b) Soreness, redness and itching of the vagina, together with a liquid substance being made.

   .....

   (c) Acute diarrhoea and loss of body fluids.

   .....

2. Name two diseases of the lungs that are caused by bacteria.

   .....

   .....

3. Name three diseases of the respiratory system that are caused by viruses.

.....

.....

4. What organ of the body is affected by ringworm and athlete's foot?

.....

Using knowledge of how microbes are spread to help prevent infectious diseases

Microbes that cause infectious diseases must be carried or transmitted from one person to another. There are a number of ways in which this can happen. It is important to understand how a disease is spread and you can then use this understanding to reduce the chance of catching diseases yourself.

Transmission in the air: When you cough or sneeze, thousands of tiny droplets shoot out of your mouth and nose. These may be breathed in by other people. The common cold, flu, pneumonia, measles, chickenpox and TB are passed on in this way. You should put your hand over your mouth and nose when you cough or sneeze. In hospitals gauze masks are sometimes worn over the mouth and nose. Rooms should be well ventilated.

Transmission in water: The microbes causing cholera, typhoid and dysentery are spread in water. Water that is used in the home for drinking and food preparation must be treated to remove or destroy harmful bacteria that may be present. Human sewage must be disposed of in such a way that it does not contaminate water supplies.

Transmission in food: If food is kept in unhygienic conditions, bacteria can breed on it. Typhoid, TB and cholera can be caused in this way. Food should be kept covered from flies, which may spread microbes onto food. Cooking food destroys many microbes and storing food in a refrigerator will stop microbes breeding, thus reducing the chance of disease. You should wash your hands before working with food.

Transmission by vectors: A vector is an animal that can pass on a disease. Mosquitoes and tsetse flies act as vectors. Malaria, sleeping sickness and elephantiasis are transmitted in this way.

Transmission by contact: Some diseases can be caught by touching an infected person or their clothes, towels or hair brushes. Diseases spread by touch are described as **contagious**. Chickenpox, measles, athlete's foot and ringworm can be spread in this way. Contact with people infected by contagious diseases should be avoided. Also avoid contact with their clothes, towels and bed linen.

Transmission by blood and other body fluids: AIDS can be spread in this way. It can be spread in body fluids during sexual intercourse or by reusing syringes.

Transmission by human carriers (who do not get the disease): Some individuals have microbes that can cause disease in their body, but they do not get the disease themselves. These individuals are called **carriers** because they carry the disease and pass it on to others. Typhoid can be passed on in this way.

Activity 3

Use the information from the previous section to complete the mind map below as a visual summary of ways in which diseases can be spread. On each horizontal line of the mind map, write the name of a disease that is spread in the different ways.

Prevention, control and treatment of named bacterial, viral and fungal diseases

Once you have an infectious disease, there may be **drugs** that can be used to treat it. For some diseases it is also possible to receive a **vaccine**, which can stop you getting the disease. You will learn more about vaccines later in this unit.

Activity 4

On the next page are five plans to avoid getting or spreading an infectious disease. The table underneath shows you drugs and vaccines that are available to treat the infectious diseases described in this unit. Complete the last column of the table by choosing the best plan for each disease. Use the information in the last section to help you.

1. Avoid overcrowded and poorly ventilated places. Put your hand over your mouth and nose when coughing or sneezing.
2. Treat drinking water to remove harmful microbes. Remove human sewage safely. Prevent food contamination.
3. Transmission is by direct contact with infected person or their clothes, etc. Avoid such contact.
4. Avoid sexual contact with infected individuals.
5. Avoid overcrowded and poorly ventilated places, **and** avoid direct contact with infected people and their clothes, etc. Put your hand over your mouth and nose when coughing or sneezing. Transmission is by droplet infection and by direct contact.

Infectious disease	**How the disease can be treated by vaccines and drugs**	**How to reduce your chance of getting and/or spreading the disease**
Pneumonia	Treat with antibiotics. Antibiotics are chemicals made by bacteria or fungi. They kill many types of bacteria. Antibiotics can now be manufactured.	
TB	Uninfected people should be given BCG vaccine. Combinations of drugs are used to treat TB. A balanced diet and rest are needed for successful recovery.	
Cholera	A vaccine will give immunity for 3–6 months. Antibiotics such as tetracycline will kill the bacteria. It is important to restore the salt–water balance of the body after diarrhoea, by drinking water with dissolved sugar and salt.	
Typhoid	Typhoid vaccines are available. Antibiotics and other drugs are used to treat typhoid.	
Common cold	No drug treatment available.	
Influenza	Anti-viral drugs are available. Often, resting and drinking plenty of liquid is as good as drug treatment.	
Measles	A vaccine is available against measles. There is no specific treatment for it, though. The symptoms may be treated with drugs, for example, to reduce fever and pain.	
Chicken pox	There is no specific treatment for chicken pox. The symptoms may be treated with anti-itching creams.	
HIV/AIDS	Anti-retroviral drugs slow the progress of the disease. There is no cure.	
Ringworm	Treat with anti-fungal drugs.	

Thrush	Treat with anti-fungal drugs.	This yeast lives harmlessly on the skin and in the mouth, gut and vagina. Disease symptoms may develop due to general poor health or when a course of drugs for another condition is started. Regular careful washing of the genital areas using water and unscented soap, and avoiding wearing tight underwear or trousers can help prevent the disease developing.
Athlete's foot	Treat with anti-fungal drugs. Keep toes aerated by wearing open shoes and keep the skin between the toes dry.	

Infectious diseases caused by protozoa and nematode worms – including their control and treatment

Malaria, sleeping sickness and elephantiasis are different from the diseases you studied earlier in this unit. This is because an insect is needed to carry the parasite from one person to another. The insect that carries the disease-causing organism is called a **vector.** The human affected by the disease is called the **host**.

Malaria

Activity 5

Malaria is caused by a protozoan parasite called plasmodium. Figure 2 shows you how the malarial parasite spreads from one person to another. Starting at the point labelled A, study this figure and then answer questions 1–4.

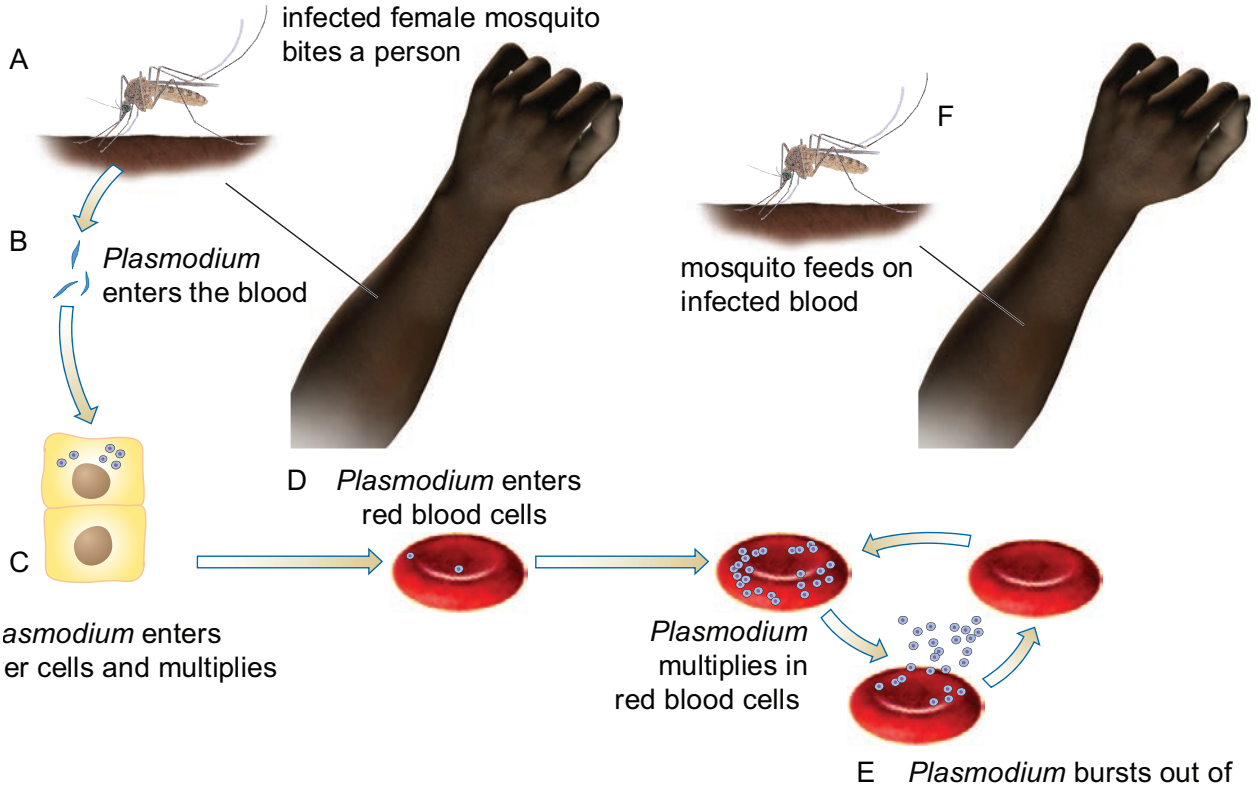


Figure 2: How malaria is spread

1. If a mosquito infected with a malarial parasite bites your arm, to which part of your body will the parasite go first?

   .....

2. Where in your body will the parasite go next? What does it do there?

   .....

3. What is the third place in your body it goes to? What does it do there?

   .....

4. When the mosquito at F in the diagram pierces your arm with its tubular mouth parts, what two things will it suck up?

   .....

When the parasites burst out of the red blood cells in the human host, poisonous waste substances also burst out, causing fever. The cycle in which the parasite feeds on the cells, reproduces and is then released from red blood cells is repeated regularly. The human host also experiences fever regularly. This happens every two or three days depending on the species of plasmodium.

Symptoms of malaria include: a high temperature (fever), sweats and chills, generally feeling unwell, muscle pains, headaches, coughing, diarrhoea and vomiting. Complications of severe malaria can develop. These include anaemia and damage to the brain. Anaemia is caused by the destruction of red blood cells, meaning the red blood cells cannot carry enough oxygen. In rare cases, infected red blood cells block the blood vessels to the brain. The result can be brain damage, a coma or death.

Female anopheles mosquitoes feed on human blood. They use their specialised mouth parts to pierce the skin and then suck up the blood. If a mosquito picks up malarial parasites when it bites a host, the parasites can multiply inside its body. Eventually, large numbers of parasites collect in the salivary glands of the mosquito. They will infect the blood of the next person the mosquito bites.

Activity 6

Figure 3 shows you the life cycle of the mosquito. Study the figure carefully and then answer the questions below.

1. Where does a female mosquito lay her eggs?

   .....

2. What do mosquito eggs hatch into?

   .....

3. Where do you find the larvae and the pupae of a mosquito?

   .....

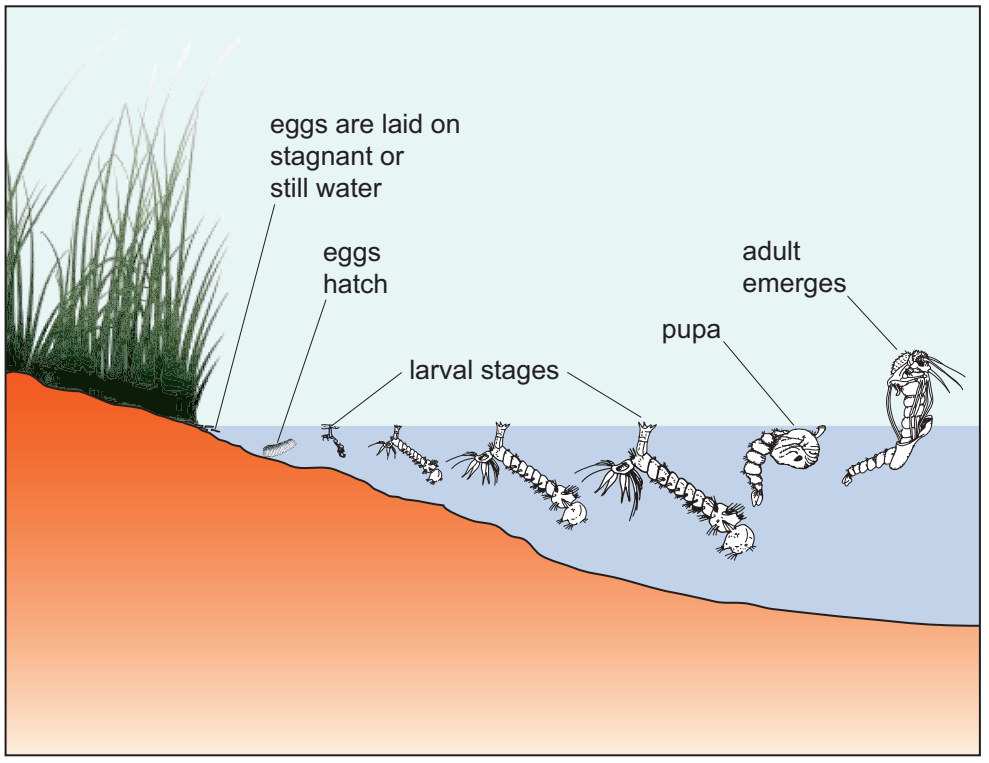


Figure 3: The life cycle of the anopheles mosquito, which carries the malaria parasite

When the pupa of a mosquito changes into an adult, it leaves the water and goes into the air. It starts to fly and look for food. Adult mosquitoes are active at night and rest in the day.

Control

Malaria is difficult to control. The best method is to control the mosquito that carries the malarial parasite. Some ways of controlling mosquitoes are listed below.

- **Insecticides** have been used to spray and kill mosquitoes while they are resting. This was effective, however, now many mosquitoes are resistant to the sprays. Insecticides can also damage the environment.
- **Oil** has been sprayed onto the surface of stagnant water where mosquito larvae live. This blocks their breathing tubes and kills them. This is expensive and also harmful to the environment.
- **Swamps and open water have been drained** to reduce the number of places where mosquitoes can breed. Empty containers can be removed or turned upside down, so that water cannot collect in them and act as breeding areas for mosquitoes.
- **Fish or ducks** have been introduced to water where mosquitoes breed. The fish and ducks eat the larvae. **Bacteria** that are harmless to fish and humans have also been used to kill mosquito larvae.
- **Mosquito nets** are used to cover people when sleeping at night to stop them being bitten. Wearing long-sleeved shirts and long trousers or skirts – especially at dusk and dawn – will help to reduce the chance of being bitten by a mosquito. Insect repellent creams and sprays can also be used on the skin, although these are not completely effective.

Treatment for malaria

If you travel from a non-malarial area to one where the disease occurs, you should take anti-malarial drugs. These will kill the parasites that get into your blood before they cause disease. If you get malaria, it can be treated with drugs, such as quinine, chloroquine, paludrine and fansidar. Unfortunately, parasites have become resistant to many of the drugs and some also have unpleasant side effects.

Sleeping sickness

Sleeping sickness is caused by a protozoan called a trypanosome, which also causes the disease 'nagana' in cattle. These protozoa have a tail called a flagellum allowing them to swim. They live in the blood stream of humans but, in later stages of the infection, the parasite moves into the central nervous system. Figure 1 shows a photograph of trypanosomes.

Symptoms of sleeping sickness include fever, headaches, joint and muscle pains, swollen or tender lymph nodes, and itching. Later symptoms include confusion, dementia and convulsions. The patient becomes very tired and difficult to wake before finally going into a coma.

The trypanosome parasite that causes sleeping sickness is carried by the tsetse fly. The mouth parts of the fly pierce the human skin and suck up blood. If a person has sleeping sickness, the trypanosomes in their blood will be sucked up by the tsetse fly. The trypanosomes reproduce in the body of the fly and then pass to its salivary glands. When a tsetse fly bites another human, the parasite infects that person.

Control

The tsetse fly is found in bushy areas near streams, lakes and game parks in central Africa. The numbers of tsetse flies can be reduced using insecticides. Another method is to sterilise male flies, so that when they mate no offspring are produced.

Treatment of sleeping sickness

A number of drugs are available for treating sleeping sickness.

Elephantiasis

This disease is caused by a nematode worm. The adult worms live in the human lymphatic system and block the lymph vessels. This slows down the drainage of fluids from the tissues to the blood and parts of the body swell up as a result. The worms reproduce in the lymphatic system, where the young larvae that are produced pass into the blood stream of the host.

Symptoms of elephantiasis include swelling in the lower body, especially the limbs. Male genital organs and female breasts can also be affected. The skin and tissues under the skin become thickened in the infected regions.

Anopheles and culex mosquitoes carry the small nematode worms that cause elephantiasis. They spread the worms from one person to another.

Control

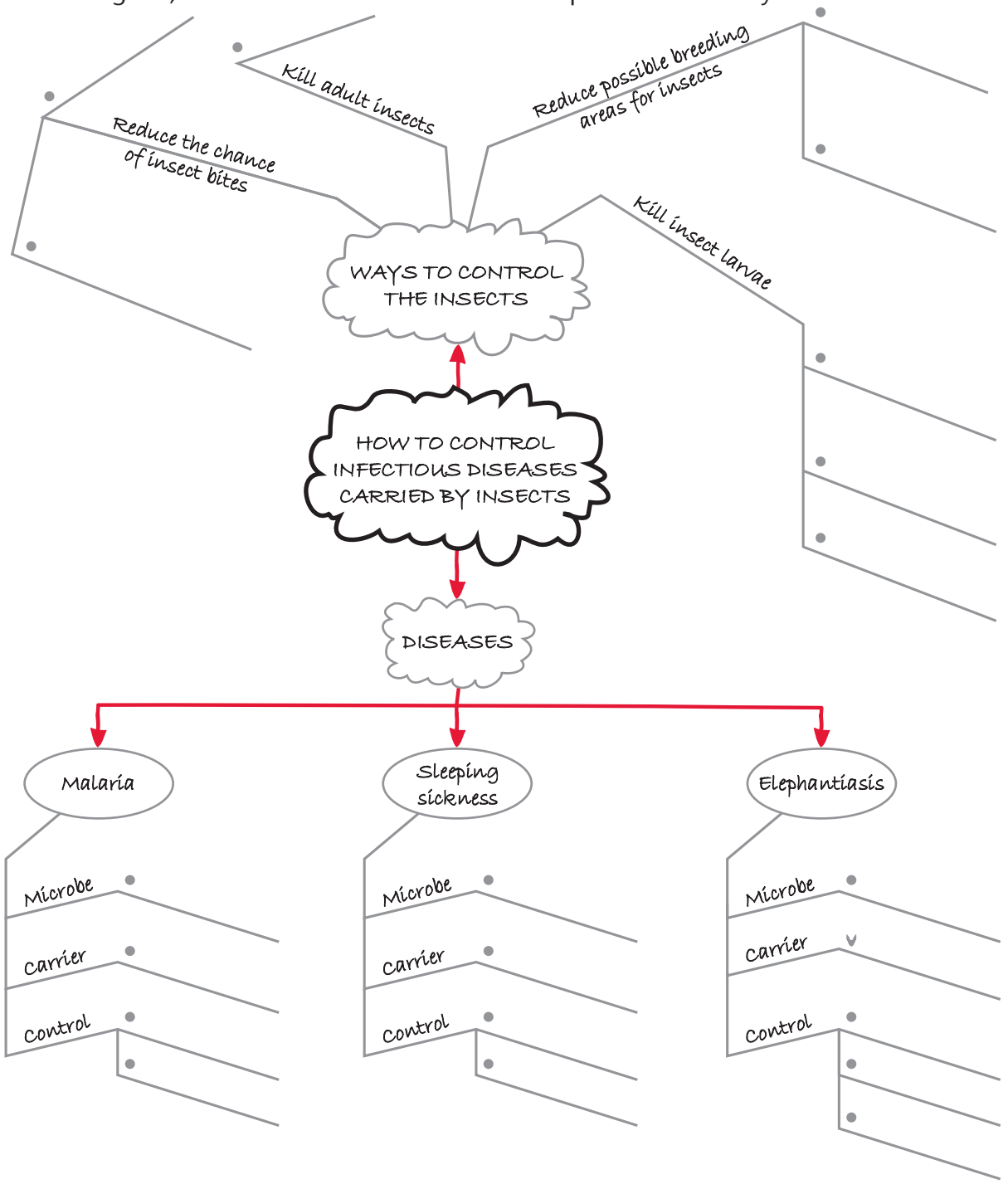
The disease is controlled by preventing insect bites. The methods of controlling elephantiasis are the same as for malaria.

Treatment

Drugs are available for treating the disease but patients should also be especially careful when washing themselves. This is important in order to prevent secondary infection, which can make the disease worse.

Activity 7

The diagram below is a mind map containing a summary of information about how infectious diseases carried by insects can be controlled. The final details of the summary are missing. Wherever you see a bullet point on the diagram, write a word or a few words to complete the summary.



Diseases of the nervous system

The four diseases in this section are caused by viruses or bacteria that could affect your nervous system. This is a good opportunity for you to look back at MSCE Unit 4, Excretion and coordination, and to revise the nervous system.

The figure below shows a motor neuron, which you have seen before in Unit B4. You will remember that motor neurons carry impulses from the brain or spinal cord to the muscles.

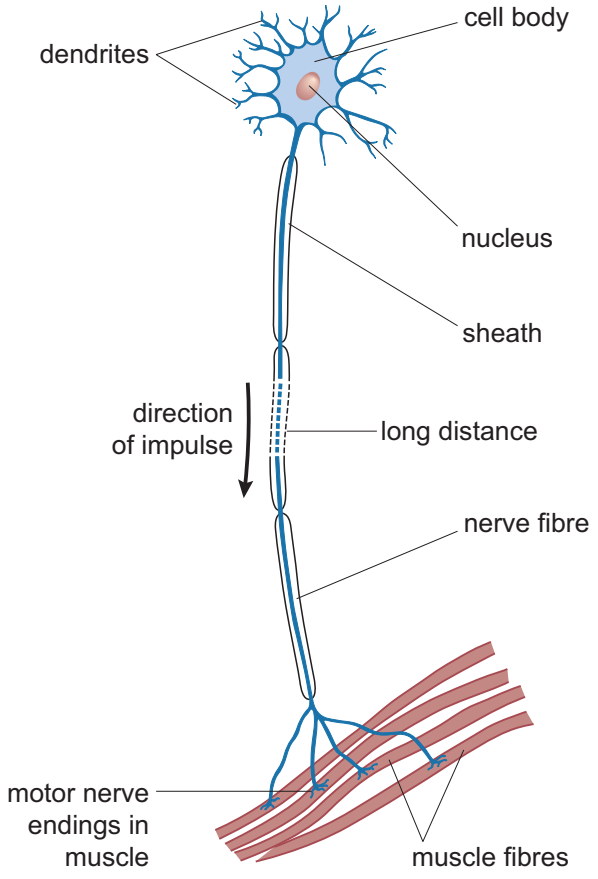


Figure 4: A motor neuron

Polio (or poliomyelitis)		
Polio is caused by a virus that enters the body through the mouth. The virus attacks the cells lining the nose, throat and intestines. It may pass into the blood and be carried to the spinal cord. The virus enters and damages motor neurons in the spinal cord.		
First symptoms are a sore throat, slight fever, headache and vomiting. If the leg muscles become affected, the legs become loose and floppy. If the muscles of the ribs and diaphragm are affected, the patient needs help to breathe artificially. When the muscles are affected, other symptoms include high fever, headaches, stiffness in the back and neck, and muscle pain.	The polio virus is present in the faeces of infected people. It is spread by contamination of water and food. House flies also help to spread the virus. Good personal hygiene, clean water supplies, and efficient sewage disposal and treatment are the best ways of controlling the disease.	**Prevention**: Polio can be prevented by vaccination and several vaccines are available. The one used most often is based on a weakened form of the virus and is given by mouth. It may cause some mild symptoms but it gives lasting immunity. **Treatment:** There is no cure for polio. Treatments include antibiotics to prevent additional infections, pain-killers, exercise, a nutritious diet and physiotherapy.

Tetanus (also known as lockjaw)		
Tetanus is caused by a type of anaerobic bacteria which lives in soil. The bacteria enter the body through a cut or wound. Cutting the umbilical cord of a new born baby with a dirty knife, or being wounded by a long thorn or dirty nail that has been lying on the ground are some ways in which the bacteria can get into the body. Tetanus begins when spores of the bacteria enter the body. The spores change into rod-shaped bacteria and produce a poison known as tetanus toxin. This toxin passes to cell bodies in the spinal cord and brain stem, blocking the passage of nerve impulses to muscles.		
The symptoms are prolonged contractions of skeletal muscles. Later, strong, sudden muscle contractions (spasms) develop in the jaw and face. The neck gets stiff and it is hard to swallow. The chest and calf muscles become rigid.	Tetanus cannot be passed from one person to another.	**Prevention**: Tetanus can be prevented by avoiding getting dirt in cuts. It can also be prevented by vaccination and adults should have a booster vaccine every ten years. **Treatment**: A tetanus infection must be treated quickly. If it is not treated, it can be fatal. A solution that contains antibodies that kill the tetanus bacteria can be injected into a vein. This provides immediate but short-term protection. Antibiotics may be used to treat tetanus infections. They work by stopping the bacteria from multiplying.

Activity 8

Use the following words to complete the paragraph below about polio and tetanus.

IMPULSES	LEGS	MOTOR	MUSCLES	NEURON
STRONGLY	SUDDENLY	TOXINS	VIRUS	WEAK

A nerve cell is called a ..... A motor neuron carries nerve impulses from the brain and spinal cord to the ..... The polio ..... enters and damages motor neurons. It stops nerve ..... passing to the muscles. ..... from the tetanus bacteria pass to cell bodies in the brain stem and spinal cord. The toxins stop nerve impulses passing along ..... neurons to the muscles. The muscles affected in polio are mainly the leg, rib and diaphragm muscles. These muscles become ..... and cannot work well. The muscles affected by the tetanus toxin are the muscles of the ....., jaw, face, neck and chest. They may contract ..... and .....

The figure on the right will remind you about the brain and spinal cord. You saw this figure in Unit B4. You will remember that the brain is protected by membranes called the **meninges** and by a fluid called the **cerebrospinal fluid**.

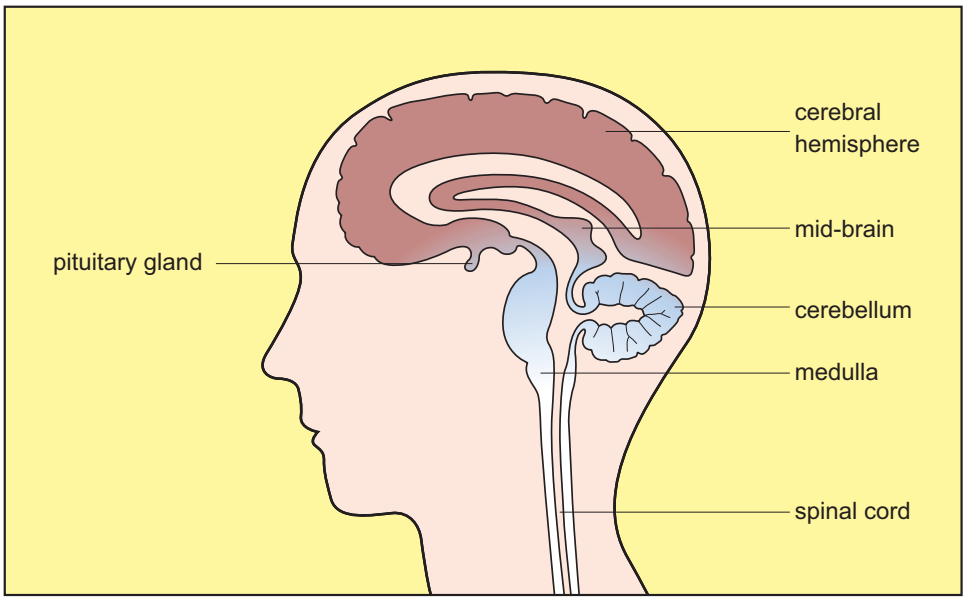


Figure 5: Human Brain

Meningitis		
Meningitis may be caused by bacteria or viruses. In Malawi, bacterial infections are the usual cause of meningitis. The bacteria are carried by the blood from the nasal cavity to the brain. The meninges become inflamed and fluid collects around the brain. This causes swelling and pressure in the brain, reducing its blood supply. This stops brain cells getting enough food and oxygen, so they die.		
The most common symptoms of meningitis are headaches, a stiff neck, fever, feeling confused, vomiting and not being able to tolerate bright light or loud noises.	The disease is spread by direct contact and by respiratory droplets.	**Prevention:** Meningitis can be prevented by reducing direct contact, exposure to respiratory droplets and overcrowding in living spaces such as schools. Patients with the disease should be isolated. **Treatment:** Meningitis can be treated by antibiotics.

Leprosy		
Leprosy is a chronic (long-lasting), infectious disease caused by bacteria. The disease mainly affects the skin, nerves, lining of the upper respiratory tract and also the eyes.		
Left untreated, leprosy can cause permanent damage to the skin, nerves, limbs and eyes.	Leprosy is transmitted via droplets, during close and frequent contact with untreated cases. It is not highly infectious.	**Prevention:** Leprosy can be prevented by avoiding direct contact with infected individuals and exposure to their respiratory droplets. **Treatment**: Early diagnosis is important. Leprosy is treated with multi-drug therapy, which consists of three drugs. This drug combination kills the bacteria and cures the patient.

Activity 9

Decide whether each statement below is about meningitis or leprosy.

Statement	Meningitis/ Leprosy	Statement	Meningitis/ Leprosy
Symptoms include headaches and a stiff neck		Can be treated by antibiotics	
Symptoms include damage to skin, nerves, limbs and eyes		Causes damage to brain membranes, swelling and death of brain cells	
Can be treated by multi-drug therapy		Causes damage to skin, nerves, respiratory tract and eyes	

Your body's own defences against disease

Your body has evolved a number of methods of defending itself from attack by the many microbes in your environment. These methods are really very effective. Of course, they're not perfect! This is why you sometimes get diseases. In this part of the unit you will learn about the ways in which your body protects itself from microbes that can cause disease.

Barriers that stop microbes getting into your body

Skin: Your skin has an outer layer of dead cells. This forms a physical barrier against microbes. Glands in the skin also make an oily antiseptic liquid. Antiseptic means preventing the growth of bacteria.

Lining of your nose, mouth and air passages: This lining is made of cells that make a sticky fluid called mucus. The cells lining your air passages have tiny hairs, which sweep the mucus, with any trapped microbes, to the mouth where it is swallowed. It passes out of the body finally in the faeces.

Lining of your stomach: Your stomach lining produces acid. This acid is needed for digestion but it also kills microbes.

Tears and ear wax: Your tear glands produce an antiseptic liquid which bathes your eyes every time you blink. Ear wax traps and kills some bacteria.

The lymphatic system and how it protects the body against disease

In MSCE Unit 3, The circulatory system and the digestive system, you studied the circulatory system. You learned how blood flows around your body in tubes or vessels, transporting substances from one part of the body to another. There is another system of vessels containing fluid in your body that is linked to the blood system. It is called the **lymphatic system.**

The thin-walled vessels of your lymphatic system form a network throughout your body. The smallest vessels are called lymph capillaries. One end of these capillaries is closed or blocked off, while the other ends join up to form larger tubes called lymph vessels. These finally join the blood stream just before the main vein (the vena cava) enters the right atrium of the heart.

The lymph capillaries and lymph vessels are filled with a fluid called **lymph**. Lymph is similar to blood plasma but contains less protein. Most importantly it contains the type of white blood cells called **lymphocytes.**

At various points in the network of lymph vessels there are little swellings in the vessels called **lymph nodes**. The main lymph nodes are in the neck, armpits and groin. White blood cells and antibodies are made in the lymph nodes. Figure 6 shows the lymph vessels and lymph nodes in the head and neck region.

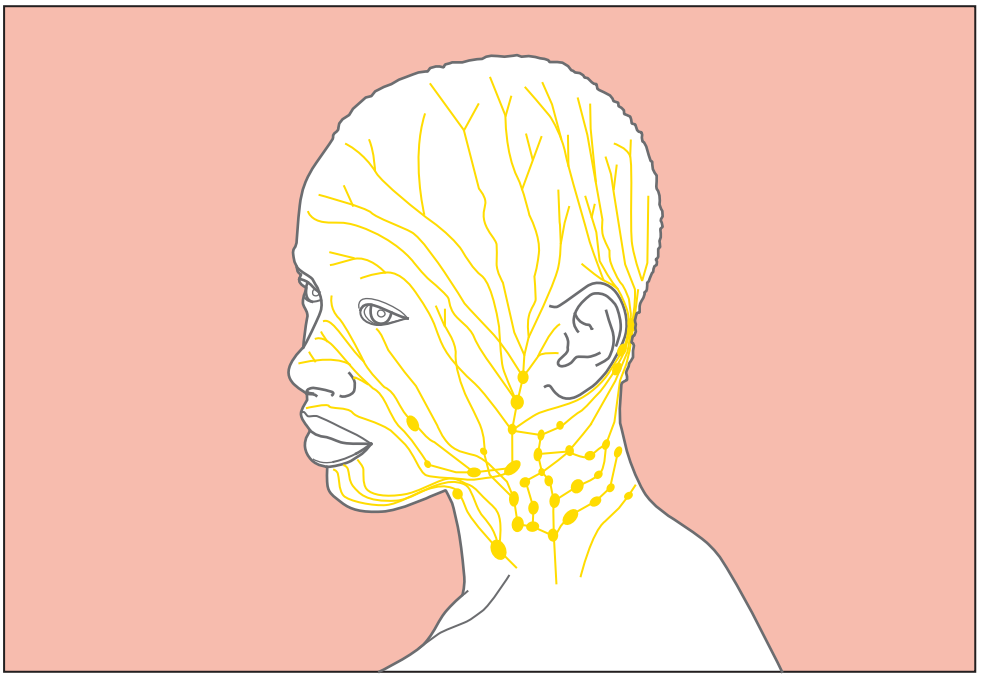


Figure 6: The lymphatic system in the head and neck region

Each lymph node is like a sponge filled with spaces. The spaces are packed with **lymphocytes** and **macrophages**. Macrophages are phagocytic cells, which means they can surround, engulf and destroy microbes. Figure 7 shows how macrophages destroy microbes by phagocytosis.

The lymph nodes are the 'glands' that your doctor feels when you are ill. For example, if you get a throat infection, the microbes get trapped in the lymph nodes in your neck. The nodes swell up due to the microbes collecting here and the microbe-fighting cells that multiply here to attack them. The doctor can feel you have 'swollen glands'. Lymph glands are not true glands, but it is what doctors usually call them.

Lymph is kept moving by the action of skeletal muscles contracting around them and squeezing the fluid along. The pressure of fluid that collects in the tissues of the body also helps to keep the lymph flowing. Some lymph vessels have valves to prevent backflow of fluid – like the valves in veins.

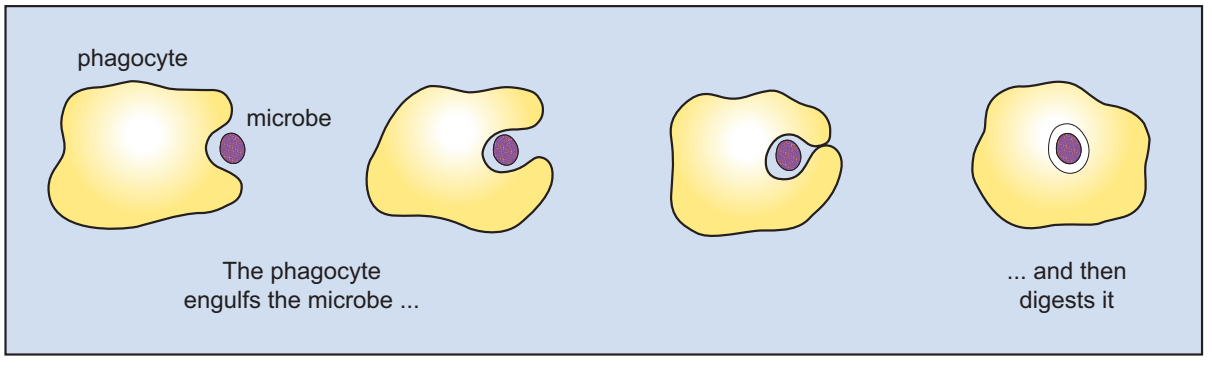


Figure 7: How phagocytes destroy microbes

Activity 10

Read the statements in the table below. Decide whether each statement describes the blood system, the lymph system or both.

	Statement	Applies to blood, lymph or both
1	The fluid in this system does not flow in a circular pathway.	
2	The fluid in this system flows in a circular pathway.	
3	This system has nodes and glands.	
4	Substances move through this system by contraction of skeletal muscles and pressure of fluid in the tissues.	
5	Substances move through this system by contractions of a muscular heart.	
6	The tubes in this system contain a fluid, lymphocytes and macrophages.	
7	The tubes in this system contain a fluid, red blood cells, white blood cells (phagocytes and lymphocytes) and platelets.	
8	This system helps to protect the body against disease.	
9	The capillaries in this system join with arteries and veins.	
10	The capillaries in this system are closed at one end.	
11	This system has arteries and veins.	
12	This system carries substances in tubes (vessels) throughout the body.	

How your body fights infections using antibodies

If microbes get into your body, your body can recognise that the microbe cells are 'foreign'. Look at the invading microbes in Figure 8 overleaf. You will see that they have **antigens** on their outside. Antigens are special protein molecules. Each kind of microbe has its own kind of antigen. Your body recognises that microbes are 'foreign' because of these antigens.

You have already learned about **lymphocytes**. They are found in the blood and the lymph. There are several kinds of lymphocyte and each has its own job to do. The **B-lymphocytes** in your body can make **antibodies** to act against the antigens. Your body makes different antibodies against each kind of microbe and its antigens. Antibodies are also known as **immunoglobulins.**

Antibodies fight infection in several ways, as shown in Figure 8. Some kill the microbes, while others make microbes clump together so they cannot work properly. Some antibodies stick onto the antigens and make the microbes harmless. Others can also make microbes more easily attacked by phagocytes, or make the poisons or toxins made by microbes harmless.

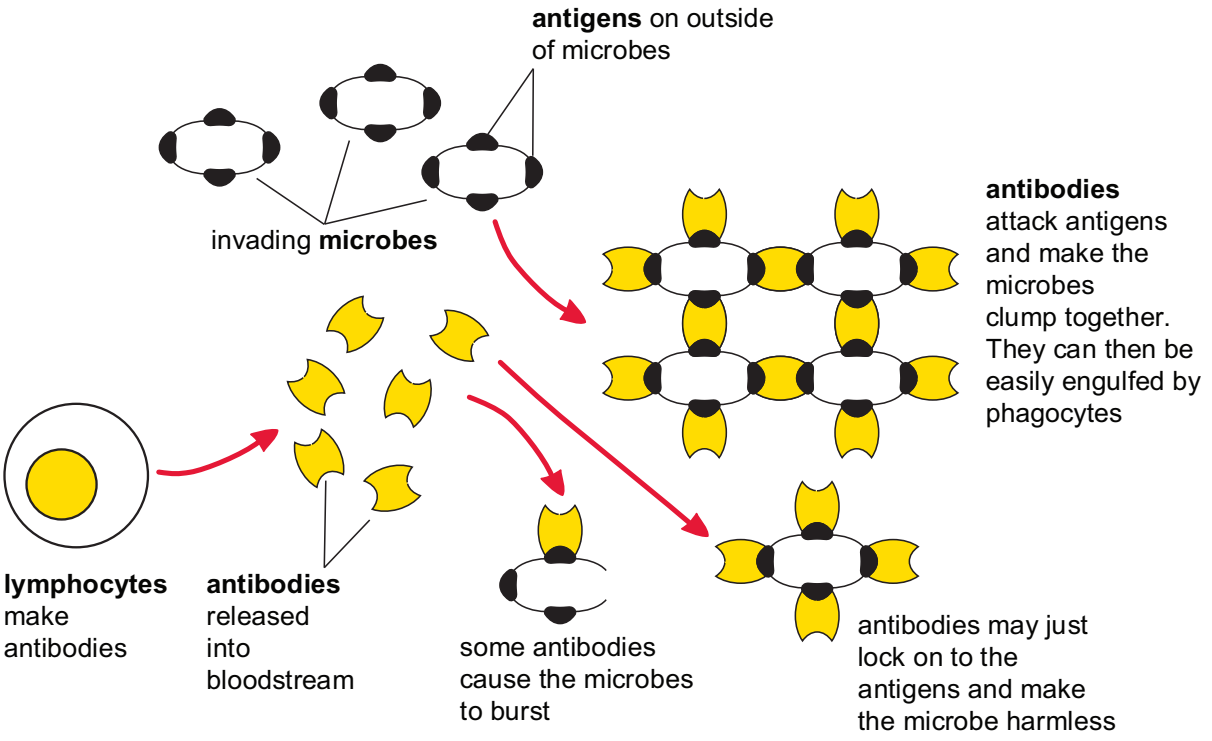


Figure 8: How antibodies destroy microbes

When your body makes antibodies against invading microbes, we call this an **immune response**. It usually takes several days for enough antibodies to be made to fight off all the microbes.

Once your body has made the antibodies against a particular disease, it can make those antibodies again quickly if you are infected by the same microbes later. This stops you getting the disease for a second time, so we say you are **immune** to that particular disease. We also say you have got **natural acquired immunity** to the disease because your body does it without any medicines. It is acquired because you only get this immunity once you have had a disease.

You also have **T-lymphocytes** in your body. Their job is to destroy tumor and body cells infected by viruses. They're also involved in acquired immunity.

Babies are protected against certain diseases by getting ready-made antibodies from their mother. Antibodies can pass from the mother's blood to the baby's blood in the placenta. Look back to MSCE Unit 5, New generations, to revise the placenta. These antibodies only last for a short time, but are important in protecting the baby from disease at the start of its life. After a few weeks the baby can make its own antibodies.

Artificial immunity

Once scientists learned about antibodies and natural immunity, they were able to develop artificial immunity. This can be used in emergency situations. It can also be used to give protection to your body before the microbes get into it. This prevents you catching a disease.

Some microbes and microbe poisons can be changed slightly so they do not cause disease. However, they still have their antigens on their outside surface. A **vaccine** contains either a changed microbe, a killed microbe or a changed microbe poison. When you are given a vaccine for a particular disease, you won't get the disease but your body will make antibodies against the microbes that cause the disease.

Vaccines give you **active artificial immunity**. It is called 'active' because the body is encouraged to actively make its own antibodies. It is called 'artificial', because a nurse or doctor gives you the vaccine; you don't get the immunity naturally. Once your body has made a particular antibody, it can store the information and make more rapidly at a later time. You are given a vaccine **before** you get the disease, either as an injection or by swallowing drops of liquid.

Vaccines containing changed microbes are used against tuberculosis, polio, smallpox and rabies. Vaccines containing killed microbes are used against cholera, typhoid, influenza, polio, rabies and whooping cough. Vaccines containing changed microbe poison are used against tetanus and diphtheria.

For some diseases, in an emergency, you could have an injection containing ready-made antibodies after you have caught a disease. This immunity is only temporary. For example, anti-tetanus serum can be used against tetanus. This is called **passive artificial immunity**. It is passive because your body does not do the work of making antibodies.

Activity 11

The following key words have been used in the preceding three sections of this unit. Look back to find where the words have been used. Write your own explanation for each one. Compare your explanations with those written by your fellow scholars.

- **Antibody** • **Antigen** • **Active artificial immunity**
- **B-lymphocyte** • **Immune** • **Immune response**
- **Natural acquired immunity** • **Immunoglobulin**
- **Passive artificial immunity** • **Phagocyte** • **Vaccine**

HIV/AIDS

AIDS (acquired immunodeficiency syndrome) is caused by a virus called the **human immunodeficiency virus** or **HIV** for short. This virus is so damaging because it attacks the body's immune system. In other words, it attacks the system the body has developed to protect itself from disease.

HIV belongs to a group of viruses called retroviruses. This means its genetic information is stored as RNA – not as DNA, as in most cells. The three main ways people get HIV are by sexual contact, contact with infected body fluids or tissues, and by infected mothers passing the virus to their babies in the uterus.

When HIV gets into the body, it enters a type of T-lymphocyte called a T-helper cell or a CD-4 cell. The virus makes this T-cell produce more of the viruses. At the same time, the T-cell is destroyed. When this happens the new viruses are freed, and they go on to attack and destroy more T-cells. The body tries to overcome this by producing more T-cells. However, eventually the number of T-cells falls. B-lymphocytes and macrophages are also affected by the virus. Eventually there are not enough antibodies to destroy microbes, and not enough phagocytes to engulf and remove them. This means the immune system gradually stops working.

Individuals with HIV keep getting diseases that are normally quite harmless to most people. They suffer more because they cannot fight off these diseases like other people. People with HIV/AIDS often have symptoms of fevers, sweating, swollen glands, chills, weakness and weight loss. They often die from pneumonia.

People with HIV/AIDS also have an increased risk of developing various cancers such as cancer of the immune system (lymphoma), cervical cancer and a skin cancer called Kaposi's sarcoma. HIV can infect brain cells as well, causing loss of memory, personality changes and eventual death.

There is no known cure or vaccine for HIV/AIDS. Drugs called antiretroviral drugs can help to delay death and reduce the chance of new infections. However, these drugs are expensive and they are not available everywhere. Once you get HIV, it continues to get worse as more and more of the T-cells of the immune system are destroyed.

Activity 12

Write a short paragraph explaining in simple terms, to a younger sister or brother, why HIV and AIDS are so dangerous.

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Practice questions

Remember, talking about the ideas in the unit is a very good way to learn. Ask one of your fellow scholars these questions and check their answers.

1. (a) Define an infectious disease.

   (b) Name the four main types of microbe that cause infectious disease in humans.

2. Below is a list of infectious diseases in humans.

   • ATHLETE'S FOOT • CHICKENPOX • CHOLERA
   • COMMON COLD • ELEPHANTIASIS • HIV/AIDS • INFLUENZA
   • LEPROSY • MEASLES • MALARIA • MENINGITIS • POLIO
   • PNEUMONIA • RINGWORM • SLEEPING SICKNESS
   • TETANUS • THRUSH • TUBERCULOSIS • TYPHOID

   (a) Which of these diseases are caused by bacteria?

   (b) Which of these diseases are caused by viruses?

   (c) Which of these diseases are caused by protozoa?

   (d) Which of these diseases are caused by fungi?

   (e) Which of these diseases need a vector?

   (f) Which of these diseases affect the nervous system?

3. Name seven ways in which infectious disease can be spread.

4. Name three diseases which can be prevented by ensuring that drinking water is clean, sewage is removed safely, and food is kept covered and protected from flies.

5. Name eight diseases that can be spread by droplets in the air, especially by coughing and sneezing.

6. Name five diseases that are spread by direct contact.

7. For each of the diseases below, name:

   (a) the organism which causes the disease

   (b) the organism which carries the disease from one human to another.

   MALARIA SLEEPING SICKNESS ELEPHANTIASIS

8. State four ways of reducing the numbers of mosquitoes.

9. State two ways that you can reduce the chance of being bitten by a mosquito.

10. Name two diseases that affect motor neurons and the muscles they act on. For each disease, say how the muscles are affected.

11. Name an infectious disease that affects the brain. How can it be treated?
12. Name four barriers in your body that help to stop microbes getting in.
13. Name the network of tubes (vessels) that carries substances throughout the body and which joins with the blood system in the area of your neck.
14. (a) What is a lymph node?

    (b) Where in your body are your main lymph nodes?

    (c) What two kinds of cell are found in your lymph nodes?

    (d) What is the job of each type of cell?
15. How does your body recognise that a microbe is a cell that it must fight off?
16. How do antibodies fight infections?
17. What is the immune response?
18. How does HIV weaken the immune system?

How am I doing?

	☺ **Easy** (Tick this box if you feel confident that you **understand this section well**)	**Fine** (Tick this box if you still **need a little work** on this section)	☹ **Difficult** (Tick this box if you still **need a lot of work** on this section)
Knowing what an infectious disease is and what the four main agents of infectious diseases are			
Recognising and describing signs and symptoms of selected diseases caused by bacteria, viruses, fungi and protozoa			
Describing the different ways in which infectious diseases are spread			
Describing methods of preventing and controlling selected infectious diseases			
Describing how the lymphatic system protects the body against disease			
Knowing what is meant by natural and artificial immunity, and describing how each works			
Explaining how HIV weakens the immune system			

Notes on what to do next:

Signed (by Scholar): ..... Date:.....

Signed (by Tutor): ..... Date:.....

Answers

Activity 1

	Bacteria	Viruses	Fungi	Protozoa
What is the cell like?	Single cells. Varied in shape. Surrounded by a cell wall and cell membrane. They have a central nuclear area but not a true nucleus.	Not true cells. They have an outer protein coat with genetic material inside.	Made of multi-cellular threads called hyphae. The hyphae have cell walls, cell membranes and true nuclei.	These are single cells. Each has a single nucleus and is surrounded by a cell membrane.
How big is the cell? (Use the correct units of measurement.)	Average diameter is 0.5–5.0 μm.	Average diameter is 20–2000 nm.	Average diameter of a hypha varies from 2–10 μm.	Average diameter is 50–150 μm.
How do they reproduce?	They reproduce by splitting in two (asexual) and by sexual reproduction.	They can only reproduce inside another living cell.	They reproduce by forming spores (asexual) and by sexual reproduction.	They reproduce by asexual and sexual reproduction.
Examples of diseases they cause.	Pneumonia, TB, cholera, typhoid.	Common cold, flu, measles, chickenpox, HIV/AIDS.	Ringworm, thrush, athlete's foot.	Malaria, sleeping sickness.

Activity 2

1. (a) Chickenpox (b) Thrush (c) Cholera (or typhoid)
2. Pneumonia and TB (tuberculosis).
3. Common cold, influenza and measles.
4. Skin

Activity 3

Activity 4

Infectious disease	How the disease can be treated by vaccines and drugs	How to reduce your chance of getting and/or spreading the disease
Pneumonia	Treat with antibiotics. Antibiotics are chemicals made by bacteria or fungi. They kill many types of bacteria. Antibiotics can now be manufactured.	*Avoid overcrowded and poorly ventilated places. Put your hand over your mouth and nose when coughing or sneezing.*
TB	Uninfected people should be given BCG vaccine. Combinations of drugs are used to treat TB. A balanced diet and rest are needed for successful recovery.	*Avoid overcrowded and poorly ventilated places. Put your hand over your mouth and nose when coughing or sneezing.*
Cholera	A vaccine will give immunity for 3–6 months. Antibiotics such as tetracycline will kill the bacteria. It is important to restore the salt–water balance of the body after diarrhoea, by drinking water with dissolved sugar and salt.	*Treat drinking water to remove harmful microbes. Remove human sewage safely. Prevent food contamination.*
Typhoid	Typhoid vaccines are available. Antibiotics and other drugs are used to treat typhoid.	*Treat drinking water to remove harmful microbes. Remove human sewage safely. Prevent food contamination.*

Common cold	No drug treatment available.	*Avoid overcrowded and poorly ventilated places. Put your hand over your mouth and nose when coughing or sneezing.*
Influenza	Anti-viral drugs are available. Often, resting and drinking plenty of liquid is as good as drug treatment.	*Avoid overcrowded and poorly ventilated places. Put your hand over your mouth and nose when coughing or sneezing.*
Measles	A vaccine is available against measles. There is no specific treatment for it, though. The symptoms may be treated with drugs, for example, to reduce fever and pain.	*Avoid overcrowded and poorly ventilated places, and avoid direct contact with infected people and their clothes, etc. Put your hand over your mouth and nose when coughing and sneezing. Transmission is by droplet infection and by direct contact.*
Chicken pox	There is no specific treatment for chicken pox. The symptoms may be treated with anti-itching creams.	*Avoid overcrowded and poorly ventilated places, and avoid direct contact with infected people and their clothes, etc. Put your hand over your mouth and nose when coughing and sneezing. Transmission is by droplet infection and by direct contact.*
HIV/AIDS	Anti-retroviral drugs slow the progress of the disease. There is no cure.	*Avoid sexual contact with infected individuals.*
Ringworm	Treat with anti-fungal drugs.	*Transmission is by direct contact with infected person or their clothes, etc. Avoid such contact.*
Thrush	Treat with anti-fungal drugs.	This yeast lives harmlessly on the skin and in the mouth, gut and vagina. Disease symptoms may develop due to general poor health or when a course of drugs for another condition is started. Regular careful washing of the genital areas using water and unscented soap, and avoiding wearing tight underwear or trousers can help prevent the disease developing.
Athlete's foot	Treat with anti-fungal drugs. Keep toes aerated by wearing open shoes and the skin between the toes dry.	*Transmission is by direct contact with infected person or their clothes, etc. Avoid such contact.*

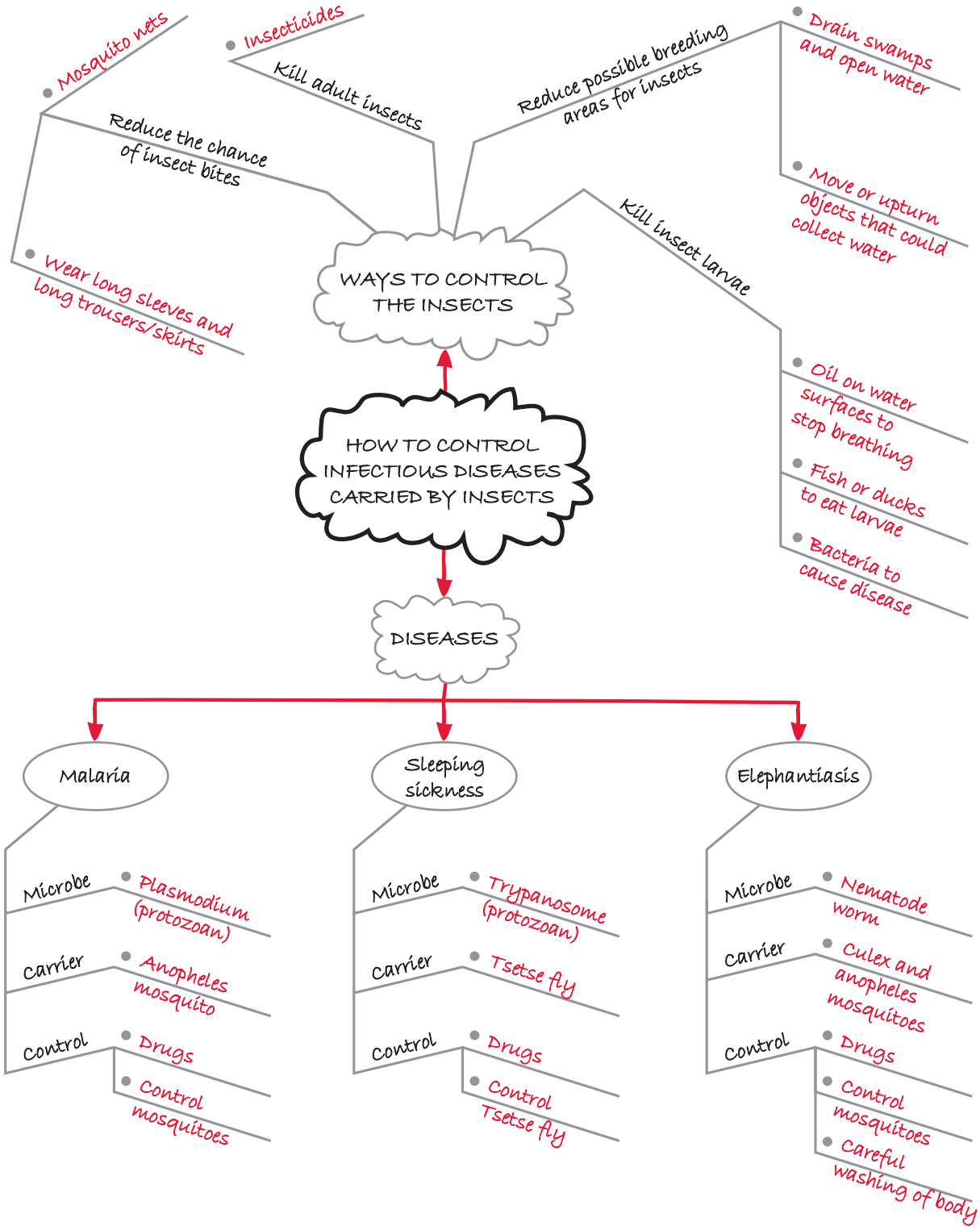
Activity 5

1. The blood.
2. The liver. The parasite multiplies here.
3. The parasite goes to the red blood cells, where it multiplies. The newly formed parasites burst out of these red blood cells to infect even more red blood cells.
4. The mosquito will suck up your blood and the malarial parasite.

Activity 6

1. A female mosquito lays her eggs on stagnant or still water.
2. Mosquito eggs hatch into larvae.
3. The larvae and the pupae of a mosquito are found in water.

Activity 7



Activity 8

A nerve cell is called a *neuron*. A motor neuron carries nerve impulses from the brain and spinal cord to the *muscles*. The polio *virus* enters and damages motor neurons. It stops nerve *impulses* passing to the muscles. *Toxins* from the tetanus bacteria pass to cell bodies in the brain stem and spinal cord. The toxins stop nerve impulses passing along *motor* neurons to the muscles. The muscles affected in polio are mainly the leg, rib and diaphragm muscles. These muscles become *weak* and cannot work well. The muscles affected by the tetanus toxin are the muscles of the *legs*, jaw, face, neck and chest. They may contract *strongly* and *suddenly*.

Activity 9

Statement	Meningitis/ Leprosy	Statement	Meningitis/ Leprosy
Symptoms include headaches and a stiff neck	*Meningitis*	Can be treated by antibiotics	*Meningitis*
Symptoms include damage to skin, nerves, limbs and eyes	*Leprosy*	Causes damage to brain membranes, swelling and death of brain cells	*Meningitis*
Can be treated by multi-drug therapy	*Leprosy*	Causes damage to skin, nerves, respiratory tract and eyes	*Leprosy*

Activity 10

	Statement	Applies to blood, lymph or both
1	The fluid in this system does not flow in a circular pathway.	*Lymph*
2	The fluid in this system flows in a circular pathway.	*Blood*
3	This system has nodes and glands.	*Lymph*
4	Substances move through this system by contraction of skeletal muscles and pressure of fluid in the tissues.	*Lymph*
5	Substances move through this system by contractions of a muscular heart.	*Blood*
6	The tubes in this system contain a fluid, lymphocytes and macrophages.	*Lymph*
7	The tubes in this system contain a fluid, red blood cells, white blood cells (phagocytes and lymphocytes) and platelets.	*Blood*
8	This system helps to protect the body against disease.	*Blood and lymph*
9	The capillaries in this system join with arteries and veins.	*Blood*
10	The capillaries in this system are closed at one end.	*Lymph*
11	This system has arteries and veins.	*Blood*
12	This system carries substances in tubes (vessels) throughout the body.	*Blood and lymph*

Activity 11

Antibody: Antibodies fight infections caused by microbes. They are special proteins made by B-lymphocytes. Your body makes different antibodies to fight against each kind of microbe. Antibodies can fight infection in several ways.

Antigen: Antigens are special protein molecules. They are found on the outside of cells. Each kind of microbe cell has its own kind of antigen. Your body recognises that microbes are 'foreign' because of these antigens. Your body recognises different kinds of microbe because the antigens of each microbe are different.

Active artificial immunity: Vaccines give you active artificial immunity. This immunity is active because the body is encouraged to 'actively' make its own antibodies. It is artificial because a nurse or doctor gives you the vaccine, so you don't get it naturally.

B-lymphocyte: B-lymphocytes are found in the blood and the lymph. They make antibodies to act against the antigens.

Immune: If you are immune to a disease, it means you will not get it. If you say you have **immunity** to the disease, this means the same thing.

Immune response: This is when your body makes antibodies because microbes have got in.

Natural acquired immunity: Once your body has made the antibodies against a particular disease, it can make those antibodies again quickly if you are infected by the same microbes later. We say you have got natural acquired immunity to the disease. It is natural because your body does it without medicines. It is acquired because you only get it once you have already had the disease.

Immunoglobulin: This is another name for an antibody.

Passive artificial immunity: If you get some diseases, in an emergency, you could have an injection containing ready-made antibodies. This immunity is only temporary. It is passive because your body does not do the work of making antibodies.

Phagocyte: This is a kind of white blood cell. It can surround, engulf and destroy other cells such as disease-causing bacteria.

Vaccine: A vaccine contains a changed microbe, a killed microbe or a changed microbe poison. You have it as an injection or by swallowing drops of liquid. When you are given a vaccine for a particular disease, you will not get the disease but your body will make antibodies against the microbes that cause the disease. You are given a vaccine **before** you get the disease.

Activity 12

Key points to include in your explanation to a younger sister or brother about why HIV and AIDS are so dangerous:

- AIDS is caused by a virus called the human immunodeficiency virus or HIV for short.
- This virus is so damaging because it attacks the defence system that your body normally uses to protect itself from disease, i.e. the immune system.
- You can get the HIV virus by sexual contact and by contact with infected body fluids or tissues.
- You need to know that if you are a woman and you have HIV or AIDS, you can pass it on to any children you have.
- If you get HIV/AIDS, you will be ill quite a lot of the time, because you cannot fight off diseases like other people. You are likely to suffer from fever, sweating, swollen glands, chills, weakness and weight loss.
- You will have an increased chance of getting certain cancers. The brain can also be infected, affecting memory and personality. You will not have a long life and are quite likely to die from pneumonia.
- There is no known cure or vaccine for HIV/AIDS. There are drugs that can help to delay death and reduce the chance of new infections. However, they are expensive and are not available everywhere. Once you get HIV/AIDS, it continues to get worse as more and more of your immune system is destroyed.

Answers to practice questions

1. (a) An infectious disease is a disease caused by microbes entering your body and growing there. The microbes may feed on your cells or make poisons.

   (b) The four main types of microbe that cause infectious disease in humans are bacteria, viruses, fungi and protozoa.

2. (a) CHOLERA, LEPROSY, MENINGITIS, PNEUMONIA, TETANUS, TUBERCULOSIS and TYPHOID are caused by bacteria.

   (b) CHICKENPOX, COMMON COLD, HIV/AIDS, INFLUENZA, MEASLES and POLIO are caused by viruses.

   (c) MALARIA and SLEEPING SICKNESS are caused by protozoa.

   (d) ATHLETE'S FOOT, RINGWORM and THRUSH are caused by fungi.

   (e) ELEPHANTIASIS, MALARIA and SLEEPING SICKNESS need an insect carrier or vector.

   (f) LEPROSY, MENINGITIS, TETANUS and POLIO are diseases that affect the nervous system.

3. Infectious disease can be spread by: transmission in the air as tiny liquid droplets; transmission in water; transmission in food; transmission by vectors or carriers; transmission by touch or contact (contagious diseases); transmission by blood and other body fluids; transmission by human carriers (who do not get the disease themselves).
4. Cholera, typhoid and polio.
5. Chickenpox, common cold, influenza, leprosy, measles, meningitis, pneumonia and tuberculosis.
6. Athlete's foot, chickenpox, measles, meningitis and ringworm are five diseases that are spread by direct contact.
7. MALARIA is caused by plasmodium (a protozoan) and is carried by the anopheles mosquito.

   SLEEPING SICKNESS is caused by trypanosomes (protozoa) and is carried by the tsetse fly.

   ELEPHANTIASIS is caused by nematode worms and is carried by culex and anopheles mosquitoes.
8. The numbers of mosquitoes can be reduced by: (any four of the following) insecticides to kill the insects; draining swamps to reduce possible breeding sites; removing or upturning empty containers to reduce possible breeding sites; spraying oil on open water to stop larvae breathing; introducing ducks or fish to eat the larvae; introducing bacteria to kill the larvae.
9. You can reduce the chance of being bitten by a mosquito by using mosquito nets, and by wearing long-sleeved shirts and long trousers or skirts.
10. Polio and tetanus are two diseases that affect motor neurons and muscles. Polio makes the muscles weak. Tetanus makes the muscles keep contracting, so they become stiff and rigid.
11. Meningitis is an infectious disease that affects the brain. It can be treated with antibiotics.
12. Your skin; the lining of your nose, mouth and air passages; stomach acid; tears and ear wax.
13. The lymphatic system.
14. (a) A lymph node is a swelling in a lymph vessel.

    (b) The main lymph nodes in your body are in the neck, the armpits and the groin.

    (c) Lymphocytes and macrophages are found in your lymph nodes.

    (d) Lymphocytes make antibodies. Macrophages engulf microbes by phagocytosis.
15. Microbes have protein molecules called **antigens** on their outer surface. Your body recognises that a microbe is a cell that it must fight off because of these antigens.

16. Antibodies fight infections by killing microbes; making them clump together so they cannot work; sticking onto them so they cannot work; making them more easily attacked by phagocytes; making their toxins harmless.
17. The lymphocytes in your body recognise an infectious microbe by its antigens and make antibodies to fight off that particular microbe. This is known as the immune response.
18. The HIV/AIDS virus weakens the immune system in the following way. When HIV gets into the body it enters some of the T-lymphocytes. The virus makes these cells produce more viruses. At the same time, the T-lymphocyte cells themselves are destroyed. When this happens the new viruses are freed. They go on to attack and destroy more T-cells and the body tries to overcome this by producing more T-cells. However, eventually the number of T-cells falls. B-lymphocytes and macrophages are also affected by the virus. In the end, there are not enough antibodies to destroy microbes, and not enough phagocytes to engulf and remove them. This means the immune system gradually stops working.

Acknowledgements

Photographs (page 338):

'Viruses attacking bacterial cells':
Mackean, D.G., page 243, *Life Study: A Textbook of Biology*, © Murray, J., Hodder Education, 1991, London, UK.

'Light micrograph of blood infected by parasitic protozoans – as purple ribbon-like bodies' **and** 'Scanning electron micrograph of the fungus that causes athlete's foot':
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