Biology
GRADE 8

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Michael O'Callaghan
Pat Doyle
Orla Molamphy
Ger Reilly
Dyakina Yelena
Yntyk Shayakhmetova

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Exclusive Distributors
LLP 'EDU Stream'
104 Bogenbai batyr, 050002 Almaty, Kazakhstan
Tel: +7(727)293 85 89 – +7(727)293 94 20
Mobile: +7701 720 5916

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Contents

Introduction

For the student

Welcome to your new Biology textbook, *Grade 8 Biology*. Your textbook comes with a **Grade 8 Biology Student's Portfolio** and a range of *digital resources*. This book will build on your previous learning of Biology by helping you to understand the world around you. It aims to develop your learning skills in science. You will develop these skills yourself while also learning from your teacher and your fellow students.

Glossary

A comprehensive Glossary for the Textbook and Student's Portfolio book is included at the back of this book.

For the teacher

Written for the new Grade 8 Biology subject programme in Kazakhstan, *Grade 8 Biology* aims to give students a sense of enjoyment and an interest in the learning of science. The book is based on the Grade 8 Learning Objectives in the Grade 7- 9 Biology subject programme document. It develops students' knowledge of and about science through the four content and skills strands described in the Biology subject programme and highlighted throughout the text using four different logos (understanding science, researching and experimenting in science, communicating in science, and science and society).

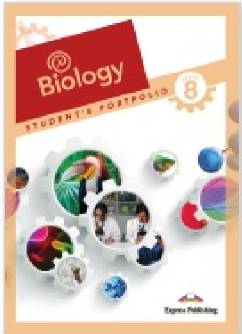
- **Learning outcomes** are stated at the beginning of each module in student-friendly language.
- **Keywords** are listed at the start of each module to allow students to become familiar with important new terms.
- **Activities** allow students to build on their knowledge by completing research.
- **Diagrams** have been fully labelled and are drawn in a simple style so that students can replicate them easily.
- **Questions** are interspersed within the text to offer teachers the opportunity to use different teaching strategies. In particular, there are chances for group work and pair work.
- **Did you know?** boxes feature interesting facts to stimulate students' interest in science.

- The **language** used is clear and simple to allow for use by students of varying reading levels.
- Simple and helpful **logos** are used throughout to enhance student understanding.

Activity | Corresponding page in Student's Portfolio | Key fact

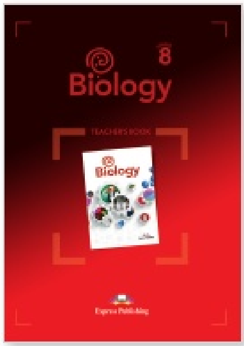
Question | Group work | Research

Student's Portfolio



The Student's Portfolio provides additional material, activities and tasks. The portfolio book enables students to maintain a record of specific activities and reflect on their learning, as well as focusing on key words and key facts, through mind maps and comprehension and recall activities. It also contains templates for self-assessment and peer assessment. This book works in conjunction with the Textbook.

Teacher's Book



The Teacher's Book works in conjunction with the Textbook and the Student's Portfolio book by providing:

- An outline of the Grade 8 content and skills priorities in the subject programme
- Learning outcomes for each module with explanations of how they are incorporated into lessons
- Information on topics, questions and research ideas that can be used to enhance the students' learning
- Answers to all student questions in the Textbook and Student's Portfolio book
- Outlines of digital resources for each module and suggestions for integrating them into classroom work
- Suggestions of ways to assess student activities with assessment templates
- A range of other information and suggestions to support teachers in the delivery of the new course
- Key skills, literacy and numeracy linked to relevant modules
- Guidance for the teacher through the module
- Additional activities and research activities

Digital resources

The *Grade 8 Biology* **digital resources** will further enhance classroom learning. These resources have been designed to integrate with the Textbook and to complement lessons suggested in the Teacher's Book. Following the principles of the new national Biology subject programme, material is provided to suit a range of learner types and to encourage participation and engagement on the part of the student.

A series of **videos** allows students to observe science in action across all modules. These videos reinforce the topic at hand and allow for other perspectives, which may be discussed in class. Similarly, a series of **videos** about **scientist biographies** presents a lively gateway to develop students' interest in science and initiate student-led research.

Further classroom discussion and participation is opened up through **PowerPoint presentations**, including a thematic presentation of information from the Textbook. **Experiment videos** allow for a visual review of activities carried out in the classroom. **Extra assessment material** is provided to support teachers in carrying out a range of oral and written formative and summative assessments.

Guidance for integration of digital resources in the classroom is provided by the **digital resource symbol** used throughout the Textbook, as well as the provision of detailed notes and suggestions in the Teacher's Book.

Laboratory equipment

Laboratory safety rules for pupils

The following rules are enforced to keep you and your classmates safe while in a school laboratory.

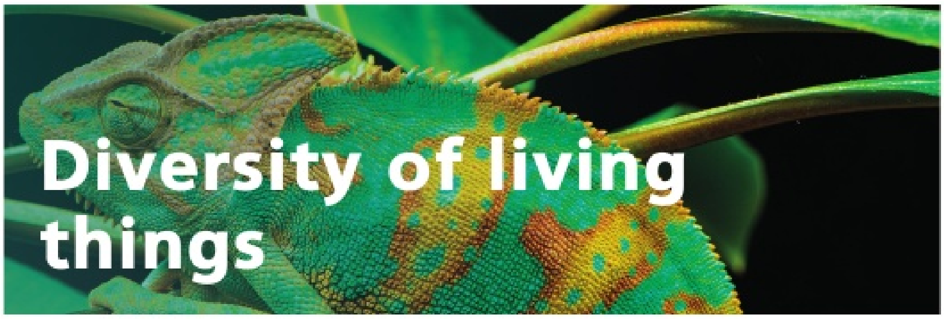
1. Do not enter the laboratory without permission.
2. Do not use any equipment unless permitted to do so by your teacher.
3. Make sure you know exactly what you are supposed to do. If in doubt, ask your teacher.
4. Make sure you know the position of all safety equipment in the laboratory, e.g. the fire extinguishers, first aid equipment etc.
5. Always wear eye protection or gloves when instructed to do so.
6. Long hair must be tied back during practical classes.
7. Place your bag and other personal items safely out of the way.
8. Never handle any chemicals with bare hands.
9. Nothing must be eaten, tasted or drunk in the laboratory.
10. Any cut, burn or other accident must be reported at once to your teacher.
11. Always check that the label on the bottle is exactly the same as the material you require. If in doubt, ask your teacher.
12. Any chemical spilled on the skin or clothing must be washed at once with plenty of water and reported to your teacher.
13. Test tubes should never be overfilled. When heating a test tube ensure that the mouth of the test tube is pointed away from you and everyone else.
14. All equipment should be cleaned and put back in its correct place after use.
15. Always wash your hands after practical work.
16. Students should behave in a responsible manner at all times in the laboratory.

Safety labels

The following labels appear on bottles in the laboratory. They also appear on many everyday chemicals such as cleaning products and solvents. These labels indicate chemicals that could be dangerous if not used or handled properly. We use these warning symbols on activities in this book.

Toxic		Substances which can cause death if they are swallowed, breathed in or absorbed through the skin. Example: weedkiller.
Harmful or irritant		Substances which should not be eaten, breathed in or handled without gloves. Though not as dangerous as toxic substances they may cause a rash, sickness or an allergic reaction.
Oxidising		Substances which provide oxygen, allowing other materials to burn more intensely. Example: hair bleach.
Highly flammable		Substances which easily catch fire. Example: petrol.
Corrosive		Substances which attack and destroy living tissue, including skin and eyes. Example: oven cleaner.
Warning sign		This sign is used to draw attention to a warning of danger, hazards and the unexpected.
Safety glasses		Wear safety glasses to protect your eyes.

MODULE 1



Diversity of living things

Learning outcomes

At the end of this module you will be able to:

- Recognise the diversity of living organisms
- Describe the distinctive features of different types of plants 8.1.1.1
- Describe the distinctive features of fungi and bacteria 8.1.1.2
- Recognise different classes of flowering plants (monocots and dicots) by their distinctive features 8.1.1.3
- Recognise ways of classifying animals by their distinctive features 8.1.1.4
- Recognise the features of and how to use a light microscope

Keywords

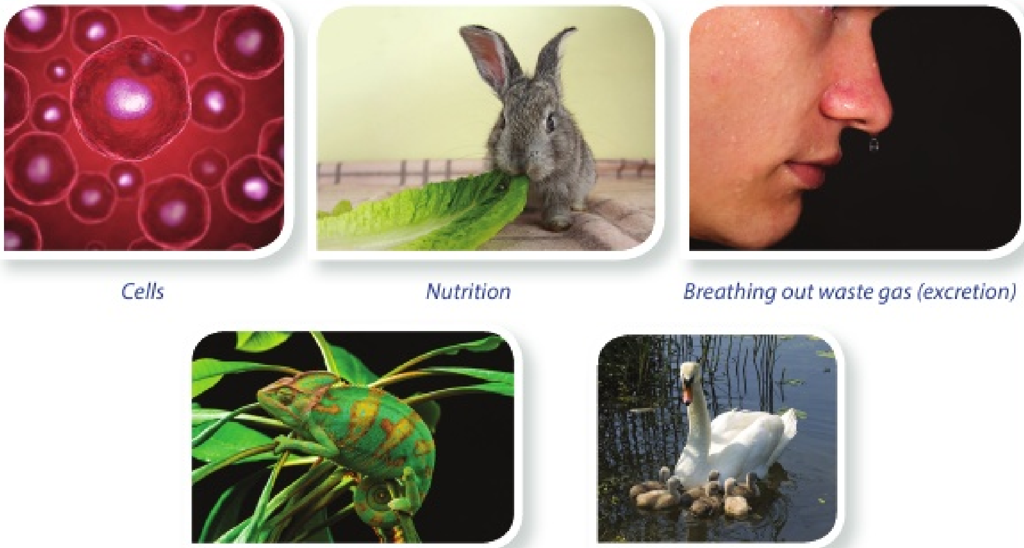
✔ organism ✔ vertebrate ✔ invertebrate ✔ diversity
✔ biodiversity ✔ fungi ✔ monocots ✔ dicots ✔ classification
✔ species ✔ seeds ✔ spores ✔ nutrition ✔ excretion
✔ response ✔ reproduction ✔ microscope

What are living things?

There is no simple way to tell the difference between living and non-living things. In general living things (which in biology are also called **organisms**) must have all of the features or characteristics shown in Table 1.1.

Table 1.1 The characteristics of all living things

Characteristic	Meaning
Cells	The basic building blocks of living things
Nutrition	The way in which living things get their food
Excretion	The way in which living things get rid of wastes that they produce
Response	The way in which living things react to changes in their surroundings
Reproduction	The way in which living things produce new living things

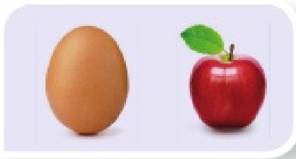


Cells — *Nutrition* — *Breathing out waste gas (excretion)*

Some animals respond very slowly — *Reproduction*

Figure 1.1 *Characteristics of all living things*

1.1 Why is it difficult to say whether an egg or a piece of fruit is living or non-living?



Some people claim that movement, growth and respiration (which is the **release of energy from food**) are also characteristics of living things. However, plants do not move (from place to place), animals continue growing throughout their lives but at a much slower pace, and the spores of bacteria can remain (be **dormant**) without the need for energy for long periods of time.

1.2 Find some other examples of living things that do not move, grow or get energy from food.

Classification of living things

To make it easier to find music on iTunes it is classified (or grouped) into headings, such as new releases or what's hot or compilations. In the same way living things are classified into groups. In general there are five major groups of living things, as shown in Table 1.2. For this book we will focus on plants and animals.

Table 1.2 Groups of living things

Group of living things	Examples
Bacteria	Tiny microscopic living things. Some cause disease, some cause decay, some are used to produce valuable substances
Fungi	Mushrooms, moulds and yeast
Plants	Trees, grasses, flowers
Animals	Humans, fish, insects
Others	Seaweeds, amoeba

Each of the five groups shown in Table 1.2 can be sub-divided into many smaller groupings. We shall look in more detail at how plants and humans (anthropoids) as an example of the animal kingdom, can be further classified.

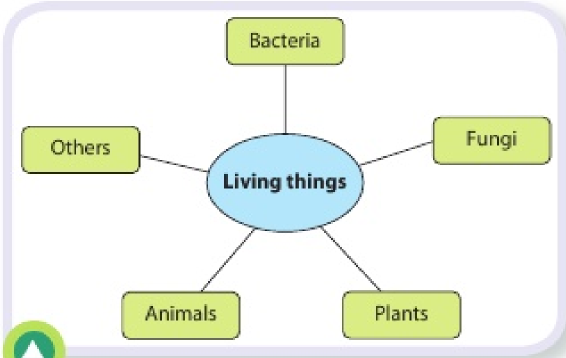


Figure 1.2 *Classification of living things*

Plant Kingdom

The major groups of plants are mosses, ferns and seed-producing plants. The seed-producing plants consist of non-flowering plants such as conifers and flowering plants such as grasses, cereals, flowers and many trees.

Flowering plants and trees produce seeds, whereas moss, fern and algae produce spores.

Figure 1.3 *Wildflowers*

Flowering plants comprise the greatest number of plant species (about 250,000), compared with about 30,000 species for all the other types combined.

Flowering plants can be further divided into two classes: monocots and dicots. Table 1.3 and Figure 1.5 below provide a summary of the main differences.

Table 1.3 Characteristics of monocots and dicots

Monocots	Dicots
One cotyledon in the seed	Two cotyledons in the seed
Fibrous roots, no main root	One large root known as a tap root
Narrow leaves with parallel veins	Broad leaves with netted veins
Vascular bundles are scattered in the stem	Vascular bundles are arranged in a ring in the stem
Flower parts are arranged in threes or multiples of three	Flower parts are arranged in multiples of four or five

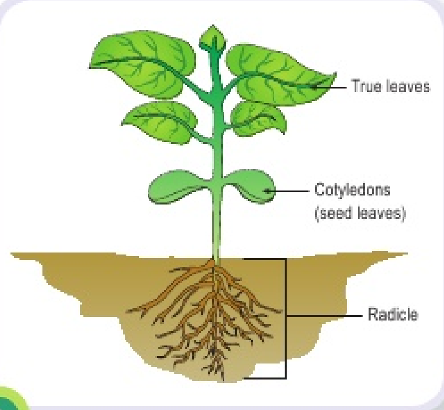


Figure 1.4 *Germinating plant*

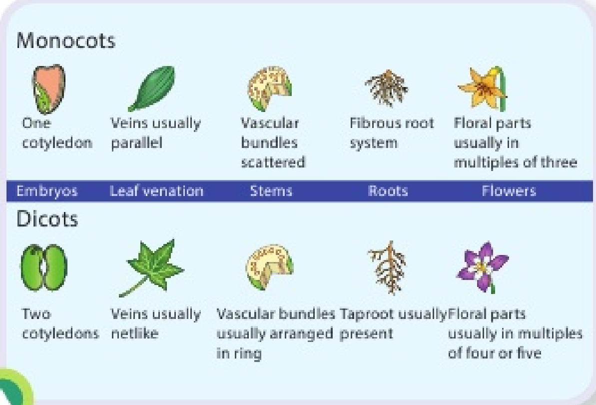


Figure 1.5 *Monocots and dicots*

The light microscope

A microscope is used to view objects that are too small to be seen by eyesight alone. The word **magnification** means how many times larger the object appears to be when viewed under the microscope.

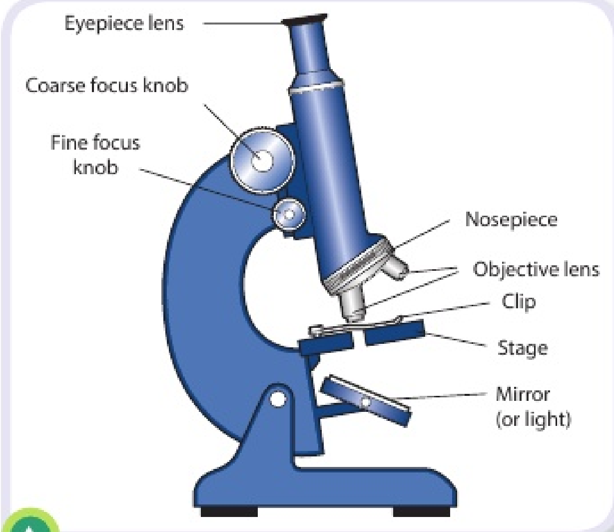


Figure 1.6 *A typical light microscope*

The parts of a microscope

Eyepiece lens

The eyepiece is the lens that is nearest to your eye. If it is marked **x10** it makes the object ten times larger (or it magnifies the object by ten).

Focus knobs

The **coarse** focus knob is used to see the image clearly at low magnification. The **fine** focus knob is used for delicate focusing at high power.

Objective lens

Each objective lens has a different magnification. The total magnification is found by multiplying the powers of the eyepiece and objective lenses being used.

Power of eyepiece x Power of objective lens = Total magnification

For example: An eyepiece marked x10 and an objective lens marked x20 will give a total magnification of x200:

$$10 \times 20 = 200$$

Nosepiece

The nosepiece can rotate to move the different objective lenses into position.

Stage

The stage is used to support the microscope slide. It has a hole in the centre to allow light to pass through.

Clips

The clips are used to hold the microscope slide in place.

Mirror or light

The mirror is used to reflect light from a lamp up through the object. Some microscopes have a lamp instead of a mirror.

R2 R3 R4

Activity 1.1

Question

How can we prepare a slide of a dicot stem to examine under a light microscope?

Equipment needed

Scalpel or safety blade
Herbaceous plant (busy Lizzie, begonia or geranium)
Elder pith
Petri dish
Water
Small paint brush
Microscope slides
Cover slips
microscope

Conducting the activity

1. Cut a section between two nodes.

Node: the point on a plant's stem where one or more leaves are attached.

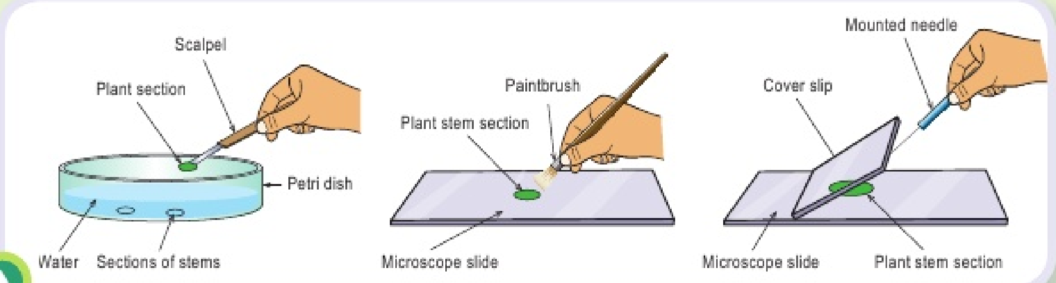


Figure 1.7 *Preparation of a slide of a dicot stem*

2. Lay the stem flat on the bench (or a dissection board) and use a wet blade to cut very thin sections of the stem. Cut at a right angle to the stem and away from your fingers. If this is proving difficult, place the stem into elder pith, which makes the stem easier to cut.
3. Place the cut sections of the stem into a petri dish with a small amount of water to prevent them from drying out.

4. Use a paintbrush to transfer the thinnest section of the stem to a microscope slide.
5. Place the cover slip at a 45° angle to the slide and, using a mounted needle, lower the cover slip onto the stem. This prevents air bubbles from becoming trapped under the cover slip.
6. Place the slide on the microscope stage and observe it first under low power and then under high power.
7. Draw a labelled diagram and note your observations.

Q U4 Research

1.3 Name two differences between monocots and dicots.

1.4 Describe one scientific observation you made about the dicot stem under the light microscope.

Animal Kingdom

Animals are typically classified using the following sub-divisions:

Kingdom: Phylum → Class → Order → Family → Genus → Species

A chimpanzee for example would be classified in the following way:

Table 1.4 Types of living things

Kingdom	Animal	
Phylum	Chordate	animals with a backbone type structure
Class	Mammal	warm-blooded animals that give birth to their young
Order	Primate	animals like apes
Family	Hominid	animals resembling humans
Genus	Pan	Common chimpanzee and bonobo
Species	Troglodyte	chimpanzee with four recognised sub-species

Q U4 Understanding

1.5 Humans only differ from chimpanzees in the final two classifications, can you name them?

1.6 What types of animals does the chordate classification cover?

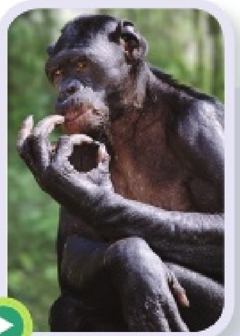


Figure 1.8 *Bonobo the closest living animal to humans*

Vertebrates and Invertebrates

- **Vertebrates** – animals that have backbones
- **Invertebrates** – animals that do not have backbones.

Examples of vertebrates and invertebrates are shown in Table 1.5.

Table 1.5 Types of living things

Vertebrates	Invertebrates
Horse	Spider
Seagull	Earthworm
Frog	Fly
Snake	Jellyfish

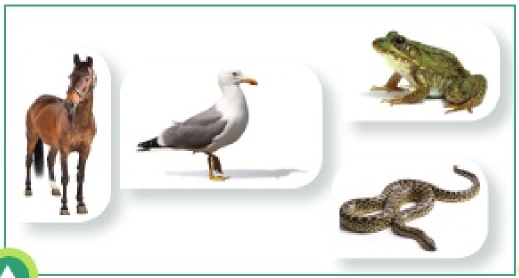


Figure 1.9 *Vertebrates are animals that have a backbone*

Figure 1.10 *Invertebrates are animals that do not have a backbone*

Bacteria

Bacteria are larger than viruses. They are very simple organisms; for example, they do not have a proper nucleus.

Figure 1.11 *A variety of bacteria found on human faeces*

In order to grow, bacteria need the following:

- food
- water
- a suitable temperature
- a suitable pH.

Under ideal conditions bacteria can reproduce very rapidly. Bacteria reproduce asexually. Many bacteria can double their numbers every twenty minutes.

Most bacteria live on dead material. These bacteria cause the material to rot or decay (i.e. they are decomposers).

Decay is vital as it returns materials to the soil to support new growth. In addition, decaying material improves the structure of the soil and allows plants to grow much better.

The main effects of bacteria are shown in Table 1.6.

Table 1.6 Effects of bacteria

Useful	Harmful
Cause dead plants and animals to decay	Cause disease
Make foods such as cheese, butter, yoghurt	Destroy foods, e.g. they cause milk to turn sour
Used in biotechnology	Destroy crops in the fields

Fungi

The fungi group consists of more than 70,000 species. Unlike plants, they do not contain chlorophyll. For this reason, they are not green and do not make their own food.

Different fungi are parasites on plants, on animals and even on humans. Many fungi feed on dead material and act as decomposers.

Some fungi are single celled (e.g. yeast), while many form long threads. Very often these threads are underground and only come to the surface as reproductive structures such as mushrooms.

The main effects of fungi are shown in Table 1.7.

Figure 1.12 *Bacteria on a woman's hand*

Table 1.7 Effects of fungi

Useful	Harmful
Cause dead plants and animals to decay	Cause human diseases, e.g. athlete's foot
Some can be eaten, e.g. mushrooms	Some are poisonous
Used to make alcohol, e.g. yeast	Cause food to rot, e.g. bread mould

Figure 1.13 *A selection of edible mushrooms*

Q U1

1.7 Name three conditions needed for bacteria to grow properly.

1.8 Name two ways in which bacteria benefit humans.

1.9 Give two examples of fungi.

1.10 How are fungi different to green plants?

Diversity of living things

There is a huge range (or **diversity**) of living things on Earth. For example, there are many different types of plants, birds, fish and insects. The range of living things is called **biodiversity**.

Each of these living things needs special conditions in which to grow. Unfortunately, many of these conditions are being lost due to human activities. For example:

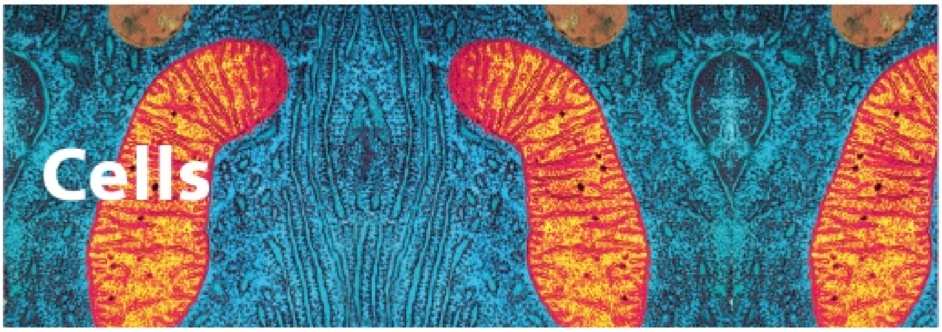
- Woodlands are destroyed for housing and roads
- Forests are being lost to supply wood for building
- Lakes are destroyed by pollution.

The resulting loss of biodiversity will be examined in Module 10.

Q U1

1.11 What other negative impacts to the environment can you think of in addition to the above examples?

MODULE 2



Cells

Learning outcomes

At the end of this module you will be able to:

- Describe the differences between animal and plant cells and identify these under a microscope 8.4.2.1
- Recognise the structure of prokaryotic and eukaryotic tissue 8.4.2.2
- Describe the differences between monomers and polymers 8.4.1.1
- Describe the properties and biological functions of carbohydrates and lipids 8.4.1.2
- Describe the properties and biological functions of proteins 8.4.1.3

Keywords

✔ cell ✔ cell membrane ✔ zygote ✔ nucleus ✔ cytoplasm ✔ vacuole ✔ mitochondrion ✔ chloroplasts ✔ prokaryotic cell ✔ eukaryotic cell ✔ carbohydrate ✔ lipid ✔ protein ✔ polymer ✔ monomer

Cells

Living things are made of cells. Cells are the basic building blocks of all living things. Most cells are too small to be seen with the naked eye. They can be seen only using a microscope. Cells can divide to form two cells. This is called **cell division**. Living things grow by cell division. For example, humans grow from a single cell (called a **zygote**) by cell division. As a result, an adult human has a hundred million million cells.

2.1 How many zeros are in a hundred million million?

Animal cells

Animal cells have three main parts:

- A cell membrane
- A nucleus
- Cytoplasm.

Cell membrane

The cell membrane is a very thin layer that surrounds the cell. Its function (i.e. what it does) is to hold the cell contents in place and control what passes into and out of the cell.

Did you know?

Eggs are single cells. An ostrich egg is the largest cell known.

For example:

- Cell membranes that are around the cells in the brain allow painkillers to pass into the brain cells. Painkillers cannot pass into many other body cells.
- When we exercise, our muscle cells allow glucose and oxygen to pass in from our blood vessels to supply energy to the cells.
- Wastes can pass out into the blood through our membranes so that we can remove the waste from our bodies.

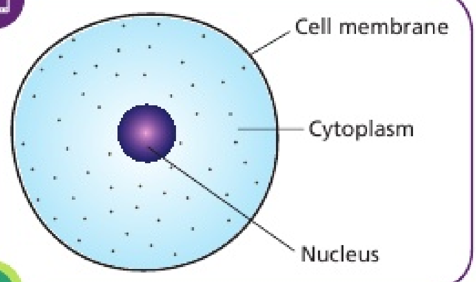


Figure 2.1 *A typical animal cell*

Nucleus

The nucleus is normally round. Its function is to act as the control centre of the cell.

The nucleus controls the cell by means of strands called **chromosomes**. Each chromosome has many genes. Each gene is made of DNA and controls one particular feature. These are the features that are passed on (or **inherited**) from parents to their children.

For example, humans have genes to control features such as eye colour, forming nails, height and the formation of fingers and toes.

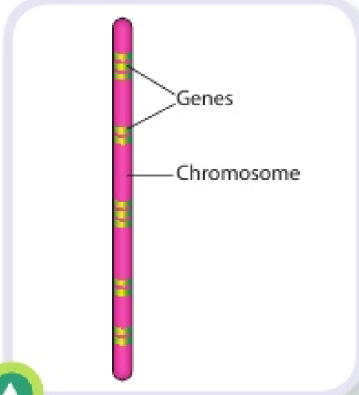


Figure 2.2 *The relationship between chromosomes and genes*

Q

2.2 Think of a new-born baby and list at least ten features that the baby inherits from its parents.

Did you know?

Human cells have forty-six chromosomes. These chromosomes contain around 20,000 genes.

Cytoplasm

Cytoplasm is a watery liquid found between the nucleus and the cell membrane. Its functions are to carry out some cell reactions and to support tiny cell structures.

These structures carry out many of the vital processes of the cell. They are too small to be seen using a light microscope. One such structure is the **mitochondrion**. These tiny structures supply energy to the cell.

Figure 2.3 *Human cheek cells as seen through a light microscope*

Plant cells

Plant cells have five main parts:

- A cell wall
- A cell membrane
- A nucleus
- Cytoplasm
- A vacuole.

Figure 2.4 *The inside of a mitochondrion as seen under an electron microscope*

Cell wall

A cell wall is found outside the cell membrane in plant cells. The function of the cell wall is to give strength to the plant cell. This is needed as plants, unlike many animals, do not have strong skeletons. The cell walls make plant cells stronger and less flexible than animal cells.

The material in cell walls is called **cellulose**. This forms everyday substances such as paper, cardboard and cotton.

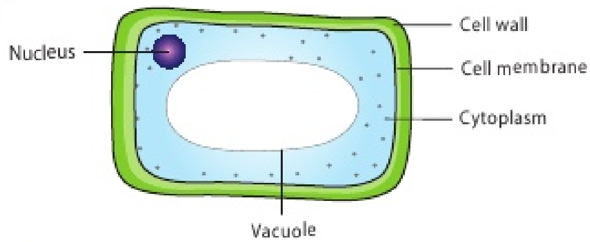


Figure 2.5 *A typical plant cell*

2.3 Why can animal cells (such as skin cells) be stretched, but plant cells (such as lettuce or cabbage leaves) cannot be stretched?

Cell membrane

Plant cell membranes are the same as animal cell membranes.

Nucleus

The nucleus of plant and animal cells is almost the same. However, the genes present in plant cells are different from those found in animal cells.

For example, plant cells have genes for features such as forming a cell wall and making the green chemical (**chlorophyll**) found in many plant cells.

Figure 2.6 *Onion cells as seen using a light microscope*

Cytoplasm

The cytoplasm in plant cells is similar to cytoplasm in animal cells. However, plant cytoplasm may have tiny green structures (**chloroplasts**), which allow the plant to make its own food in a process called **photosynthesis**.

Vacuole

A vacuole contains liquid. If the vacuole is full of liquid it forces the cytoplasm out to push against the cell wall. In this way the function of the vacuole is to give strength to the cell. Normally vacuoles cannot be seen using a light microscope.

R2 R3 R4

Activity 2.1

Question

How can we examine animal cells?

Equipment needed

Cotton wool buds or wooden spatula (lollypop stick)
Microscope slide
Cover slip
Methylene blue stain
Pen or pencil or seeker
Tissue paper/filter paper
Microscope

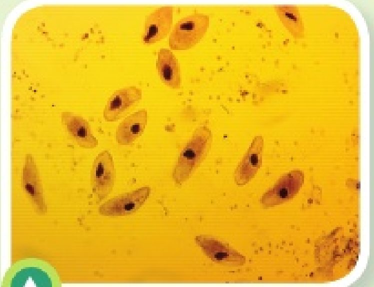


Figure 2.7 *Animal cells*

Safety

- Take care when placing the cover slip as it could break.
- Take care when using the focus knobs not to lower the objective lens onto the slide as it could crack it.

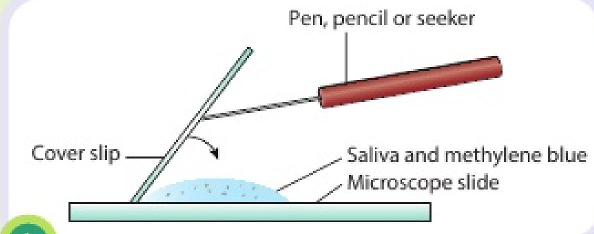


Figure 2.8 *Adding a cover slip to a microscope slide*

Conducting the activity

Preparing the slide

1. Gently scrape the inside of your mouth with the cotton wool bud (or the wooden spatula).
2. Scrape the saliva (which now contains many cheek cells) onto the centre of a microscope slide.
3. Add three or four drops of methylene blue stain to the saliva (this stain highlights parts of the cell, especially the nucleus).
4. Lower a cover slip gently at a 45 degree angle slowly over the check cells as shown in Figure 2.8.
5. Use the tissue paper to soak up any of the stain that may be outside the cover slip.

Viewing the slide under a microscope

1. Switch on the microscope light (or adjust the mirror so that light is shining through the opening in the stage of the microscope).
2. Turn the nosepiece so that the lowest power objective lens is in place.
3. Place the slide in the centre of the microscope stage and use the clips to hold it in place.
4. Look at the stage from the side and turn the coarse focus knob so that the objective lens moves as close as possible to the slide. (Be careful not to damage the slide or the lens.)
5. Look through the eyepiece and turn the coarse focus knob slowly so that the cells become visible.
6. If necessary, move the slide slightly so that you can see the best sample of cells.

7. Draw a diagram of one of the cells that you can see. Label the three main parts.
8. Turn the nosepiece to a higher power lens.
9. Use the fine focus knob to get a clear image of one of the cells.
10. Draw this cell and label the three main parts.

Q

2.4 Observe the cheek cells for features such as:

(a) Are they all the same shape?

(b) Are they all the same size?

(c) What colour is the cytoplasm?

(d) What colour is the nucleus?

(e) Can you see any particles in the cytoplasm?

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Activity 2.2

Question

What features of plant cells can we see under a microscope?

Equipment needed

Your teacher will give you a prepared slide of plant cells to examine.

Safety

- Take care when placing the cover slip as it could break.
- Take care when using the focus knobs not to lower the objective lens onto the slide as it could crack it.

Conducting the activity

Viewing the slide under a microscope

1. Switch on the microscope light (or adjust the mirror so that light is shining through the opening in the stage of the microscope).
2. Turn the nosepiece so that the lowest power objective lens is in place.
3. Place the slide in the centre of the microscope stage and use the clips to hold it in place.
4. Look at the stage from the side and turn the coarse focus knob so that the objective lens moves as close as possible to the slide. (Be careful not to damage the slide or the lens.)
5. Look through the eyepiece and turn the coarse focus knob slowly so that the cells become visible.
6. If necessary, move the slide slightly so that you can see the best sample of cells.

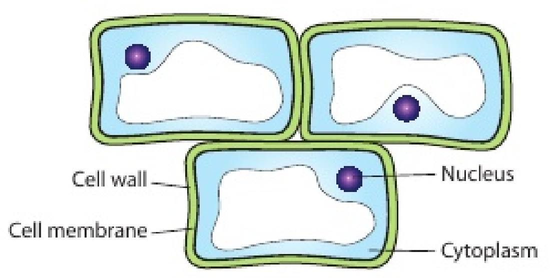


Figure 2.9 *Plant cells as seen under the microscope*

7. Turn the nosepiece to a higher power lens.
8. Use the fine focus knob to get a clear image of one of the cells.
9. Draw diagrams of the cells as they appear under the different magnifications. Note the magnification under each diagram.
10. Label the cell wall, cell membrane, cytoplasm and nucleus where possible.

Figure 2.10 *Onion cells as seen using a microscope*

Research R2 Research R3 Research R4 Portfolio 21

Activity 2.3

Question

How can we prepare a slide of plant tissue to investigate under a light microscope?

Equipment needed

Forceps	Cover slip	Microscope
Onion	Iodine solution	Notebook
Microscope slide	Tissue paper	Pencil

Safety

- Take care when placing the cover slip as it could break.
- Take care when using the focus knobs not to lower the objective lens onto the slide as it could crack it.

Conducting the activity

Preparing the slide

1. Use forceps, if necessary, to pull a small thin piece of tissue from the inside of a cut-up onion.
2. Place a few drops of water on a slide.
3. Place the onion tissue (which is made of a thin layer of cells) into the water. Make sure the layer of cells does not fold over.
4. Gently lower a cover slip onto the slide, as shown in Figure 2.11. The cover slip is lowered slowly at an angle. This means that fewer air bubbles get trapped on the slide.

5. Add a few drops of iodine solution to the microscope slide alongside the cover slip. Iodine will stain the nucleus a yellow/orange colour. This makes it easier to see.
6. Place some tissue or filter paper on the other side of the cover slip to draw the iodine across the cells.

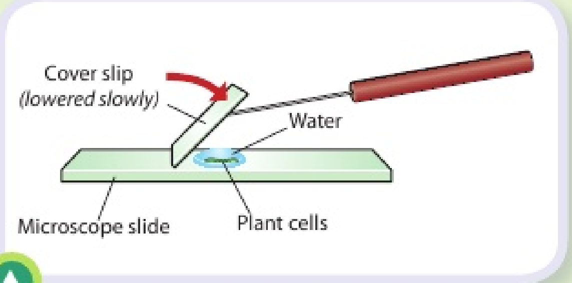


Figure 2.11 *Adding a cover slip to a microscope slide*

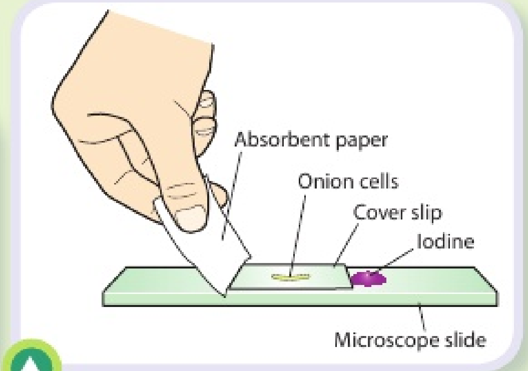


Figure 2.12 *Staining onion cells*

Viewing the slide under a microscope

1. View the slide in the same way you viewed the prepared slides in the last two activities.
2. Draw diagrams of the cells as they appear under the different magnifications. Note the magnification under each diagram.
3. Label the cell wall, cell membrane, cytoplasm and nucleus where possible.

Q Understanding U4 Society S1

2.5 Answer these questions on microscopes.

(a) Give one benefit of using a microscope.

(b) Microscopes are good for examining thin structures (such as cheek cells) but are not good for thick structures.

(i) Why is this?

(ii) What colour will thick objects appear under the microscope?

(c) If the focus buttons on a microscope did not work, what problem would you have in viewing objects?

(d) Anton van Leeuwenhoek was a Dutchman who is credited with first using microscopes. In the 1670s he discovered tiny structures such as single-celled living things, cell vacuoles, sperm cells and the structure of muscle cells.

(i) There was no electricity at the time, so what source of light would he have used?

(ii) In what kind of cells did he discover vacuoles?

Prokaryotic and eukaryotic cells

Living things (also called organisms) can be placed into two categories depending on the structure and complexity of their cells: prokaryotes and eukaryotes.

Prokaryotic cells do not have a nucleus or membrane-enclosed organelles.

Prokaryotic organisms:

- Are single-celled
- Have a circular loop of DNA (not surrounded by a membrane, i.e. do not have a nucleus)
- Have small cells
- Do not have a membrane and enclosed structures such as mitochondria and chloroplasts
- Include bacteria.

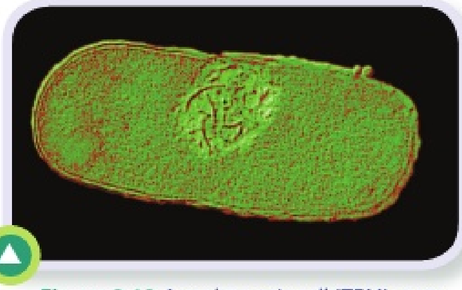


Figure 2.13 *A prokaryotic cell (TEM): note the absence of a membrane around the red chromosomes in this bacterial cell*

Eukaryotic cells have a nucleus and cell organelles, all of which are enclosed by membranes.

Eukaryotic organisms:

- Have a nucleus (i.e. DNA enclosed by a membrane)
- May have membrane-enclosed organelles such as mitochondria and chloroplasts
- Have large cells
- Include animals, plants and fungi

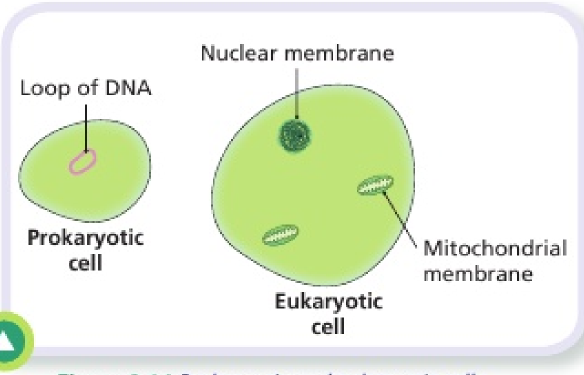


Figure 2.14 *Prokaryotic and eukaryotic cells*

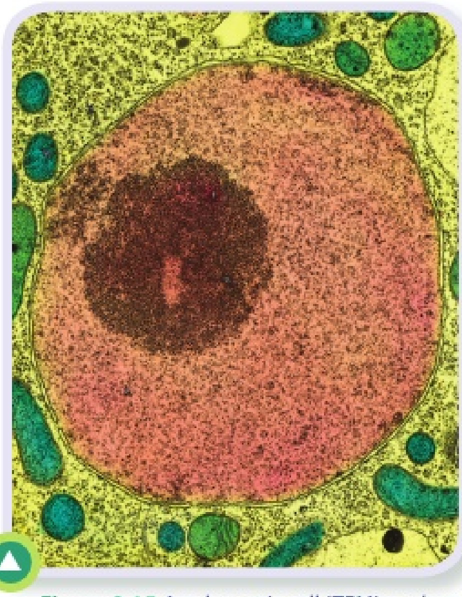


Figure 2.15 *A eukaryotic cell (TEM): a plant cell showing the pink nucleus surrounded by a double membrane; the nucleolus is brown*

Q Understanding U4

2.6 What are the differences between prokaryotic and eukaryotic cells? Discuss:

(a) nucleus
(b) cell organelles
(c) size
(d) examples in modern organisms

Q U4 S1

2.7 In 2010 an American businessman/scientist Craig Venter announced the creation of a new type of cell. His team took a bacterium, a virus and parts of other single-celled living things and combined them (and their DNA) to produce a single-celled organism. This organism was never present on Earth before and is an example of 'synthetic life'. He hopes that organisms such as this will be able to produce fuels, medicines and other useful products.

(a) What basic cell parts or structures do you think such synthetic cells would need?
(b) Which of the five groups of living things would they best fit?
(c) Suggest why Craig Venter would want to form a new type of life?

S1

2.8 Some people argue that Craig Venter should not be allowed to form new life types. Can you suggest reasons why they feel this way?

Substances in cells

Cells in the human body require many compounds to survive. The main substances found in every cell are a combination of lipids, carbohydrates, nucleic acids and proteins. Each of these substances plays a different role in the body, and all of them must either come from the diet or be manufactured using other chemicals in the body.

Monomers and Polymers

Monomers are individual molecules that can bond to other identical molecules to form a string which is called a polymer. Organic polymers which are formed by living organisms include strings of proteins [polypeptides] and chains of carbohydrates [polysaccharides].

Carbohydrates

Carbohydrates are one of the 4 basic macromolecules of life. They are a polymer made up of monomers called monosaccharides. These building blocks are simple sugars such as glucose or fructose.

The most natural monomer is glucose. It bonds into polymers such as cellulose, starch and glycogen.

Elements in carbohydrates

The elements present in carbohydrates are indicated by the name itself: carbon (C), hydrogen (H) and oxygen (O).

These elements are usually present in the ratio $C_x(H_2O)_y$, where x and y are the same number (i.e. x = y). This means there is twice as much hydrogen as carbon or oxygen in a carbohydrate.

Glucose is a simple carbohydrate in which x and y are both equal to 6. The formula for glucose is $C_6H_{12}O_6$.

Types of carbohydrates

There are three types of carbohydrates: monosaccharides, disaccharides and polysaccharides.

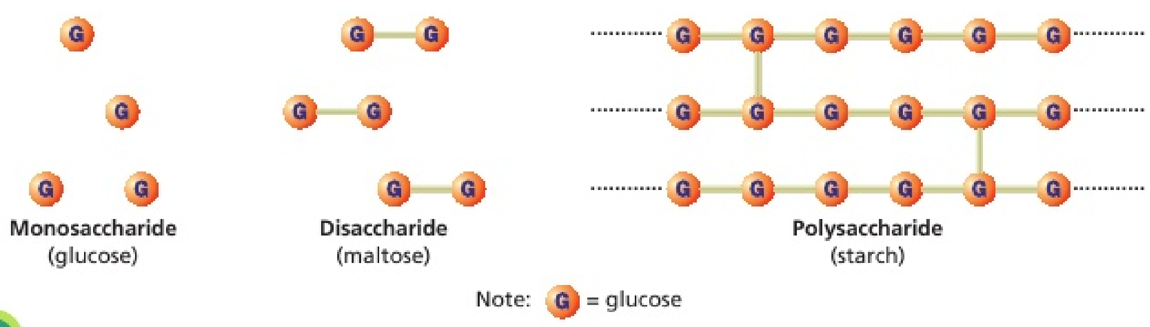


Figure 2.16 *Types of carbohydrates*

Monosaccharides

Monosaccharides are carbohydrates composed of a single sugar unit. A single sugar unit is a ring of carbon atoms. Monosaccharides are the simplest and smallest type of carbohydrate. They are sweet to taste and are soluble in water.

Glucose and fructose are examples of monosaccharides.

- Glucose is a very common molecule in biology. It is made by plants in photosynthesis and is the main molecule from which living things get their energy. It is commonly found in sweets, chocolate, fruit and soft drinks.
- Fructose has the same formula as glucose (however, its atoms are arranged differently). It is common in fruits and is much sweeter than glucose.

Disaccharides

Disaccharides are carbohydrates composed of two sugar units joined together.
Like monosaccharides, they are sweet-tasting and soluble in water. Examples include maltose and sucrose.

- Maltose is found in germinating seeds and is composed of two glucose molecules joined together.
- Sucrose, or table sugar, is composed of a glucose joined to a fructose.

Polysaccharides

Polysaccharides are carbohydrates composed of many sugar units.

Polysaccharides are insoluble or only slightly soluble in water and are not sweet-tasting. They are very large molecules, often consisting of thousands of monosaccharides. Examples include starch, cellulose and glycogen.

- Starch (also called amylose) is made of many glucose molecules joined together. It is the carbohydrate stored by plants. Common sources of starch are bread, potatoes, rice and pasta. Starch is easily digested as the glucose molecules are arranged in a chain. To extract glucose it is only necessary to break two bonds (see Figure 2.17).
- Cellulose is also composed of many glucose molecules linked together. However, in cellulose there is much more cross-bonding than there is in starch (see Figure 2.18). This cross-bonding also means that cellulose is:
  - Very strong (this is why it is used in the structure of cell walls)
  - Very difficult to digest (we use it as fibre or roughage in our diet).
- Glycogen is a complex polysaccharide. It is composed of large numbers of glucose molecules arranged in many-branched chains. Animals store glycogen in their liver and muscles.

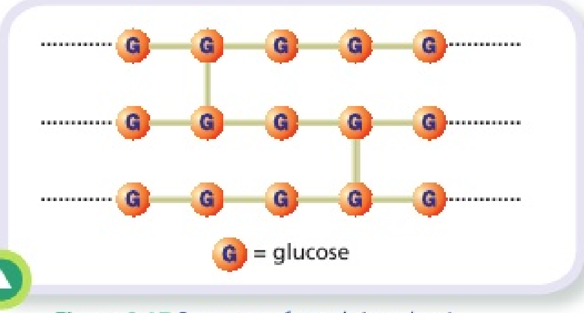


Figure 2.17 *Structure of starch (amylose)*

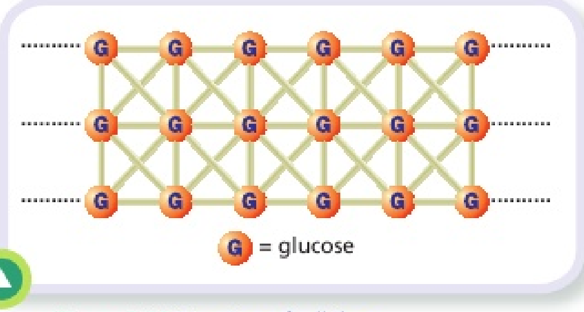


Figure 2.18 *Structure of cellulose*

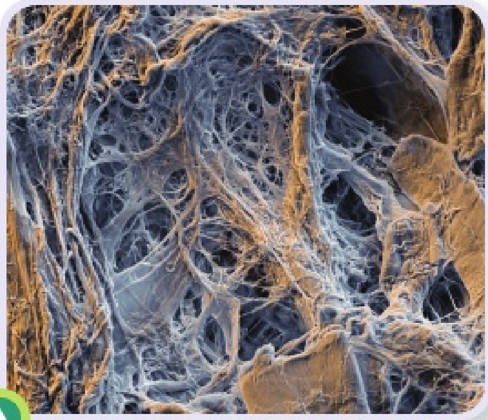


Figure 2.19 *Cellulose fibres in a plant cell wall*

Sources of carbohydrate

Common sources of carbohydrate in our diet are bread, potatoes, rice, pasta, sugars, fruits, sweets and cakes.

Figure 2.20 *Foods rich in carbohydrate*

Structural role of carbohydrates

Cellulose is used to form plant cell walls.

Metabolic role of carbohydrates

- Glucose is broken down in respiration to release energy. This energy is used to carry out many other metabolic reactions.
- Glucose is made in photosynthesis.

Lipids (fats and oils)

Lipid Function in the Body

Lipids, also known as fats, play multiple roles in the body. Fats are broken down in the digestive tract to form individual fatty acids and cholesterol molecules. Fatty acids and cholesterol are key components of the membranes that surround all cells. Cholesterol can also be used to make many other compounds in the body, such as steroid hormones. Finally, fatty acids represent an important source of energy, particularly for the purposes of long-term storage.

Elements in lipids

Lipids contain the elements carbon, hydrogen and oxygen. Unlike carbohydrates, the elements in lipids have no simple ratio. However, lipids have very little oxygen.

Fats are lipids that are solid at room temperature (20°C). Oils are lipids that are liquid at room temperature.

Structure of lipids

The smallest lipids are made of one molecule of glycerol linked to three fatty acid molecules. This structure is called a triglyceride. Different fats and oils have different types of fatty acids.

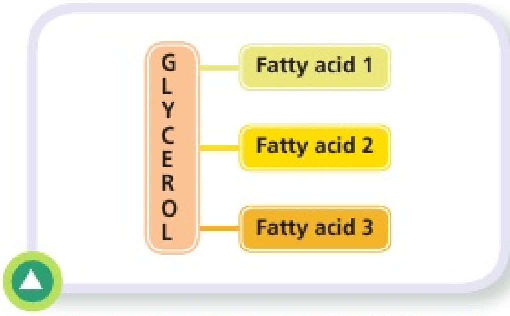


Figure 2.21 *Structure of a lipid (triglyceride)*

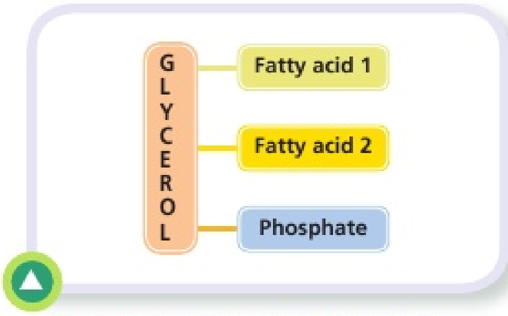


Figure 2.22 *Structure of a phospholipid*

Phospholipids are important in the structure of cell membranes.

Sources of lipids

Sources of lipids in our diet are butter, oils, margarine, cream, fat on meat and fried food. Lipids stain clothing.

Structural role of lipids

- Lipids are important food (or energy) stores in plants and animals. One gram of lipid contains twice as much energy as a gram of carbohydrate. This means that lipids can store twice as much energy compared with an equivalent amount of carbohydrate. This is especially important for animals that have to carry their stored energy around with them. In animals, the stored lipids have secondary functions, such as heat insulation (fat under the skin) and protection of organs (fat around the heart and kidneys).
- Lipids combine with phosphorous to form phospholipids and with proteins to form lipoproteins. Both of these are important in the structure of cell membranes.

Metabolic role of lipids

Lipids can be broken down in respiration to release energy.

Proteins

Elements in proteins

Proteins contain the elements carbon, hydrogen, oxygen and nitrogen. They sometimes contain smaller amounts of sulphur and some may contain phosphorus and other elements. There is no ratio for the elements in a protein, but proteins are very large and complex, often containing tens of thousands of atoms.

Structure of proteins

Proteins are composed of amino acids. There are 20 types of amino acids found in proteins, each with different chemical properties.

The bond between amino acids is called a peptide bond and a protein molecule is made from a long chain of amino acids, each linked by a peptide bond. This is why proteins are known as polypeptides. The amino acids that make up a protein can be thought of as letters in an alphabet. By combining them in sequences , nature can make a huge range of proteins.

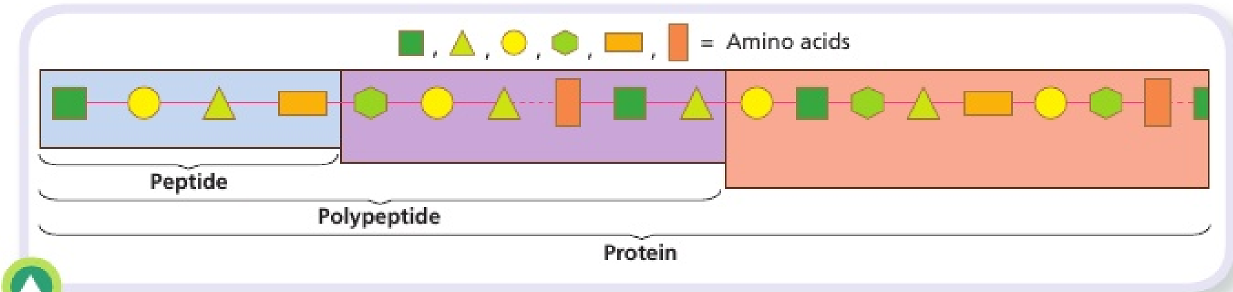


Figure 2.23 *Relationship between amino acids, peptides, polypeptides and proteins*

Sources of protein

Sources of protein include meat, fish, eggs, nuts, milk, peas and beans.

It is important to note that amino acids are not stored in the body. Surplus amino acids are taken to the liver and converted into urea, which is a toxic waste product. This process is called deamination. Urea is carried by the blood from the liver to the kidneys. In the kidneys, urea becomes part of urine and is excreted.

Figure 2.24 *Keratin: a protein found in hair and nails*

Figure 2.25 *Foods rich in protein*

Structural role of proteins

Fibrous protein such as keratin is found in skin and hair. Myosin is found in muscle.

Metabolic role of proteins

Proteins are used as enzymes to control reactions. They also form antibodies to fight infection. Some hormones are protein-based and are used to regulate body reactions.

Q Understanding U4

2.9 Name one structural role and one metabolic role for **(a)** carbohydrates **(b)** lipids **(c)** proteins

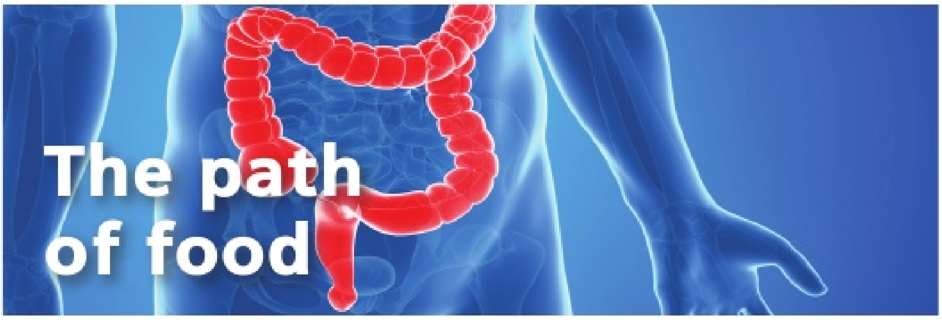
2.10 Name three different carbohydrates and their sources.

2.11 Give one use for phospholipids.

2.12 Say whether the following statements are true or false.

- **(a)** Carbohydrates contain hydrogen and oxygen in the same ratio as water (H_2O).
- **(b)** Amino acids do not contain nitrogen.
- **(c)** Fish is a good source of protein and lipid, but not carbohydrate.
- **(d)** Amino acids are required to make fatty acids.
- **(e)** Keratin is a protein found in egg white.
- **(f)** Fructose is a monomer.
- **(g)** Phospholipids are polymers.

MODULE 3



The path of food

Learning outcomes

At the end of this module you will be able to:

- Describe the structure and function of the human digestive system 8.1.2.3
- Describe the relationship of the structure of different types of teeth with their functions 8.1.2.2
- Compare the structure of the digestive system of invertebrates, ruminants and humans 8.1.2.1
- Identify the causes of digestive diseases and food poisoning 8.1.2.4

Keywords

- ✔ digestion ✔ enzyme
- ✔ catalyst ✔ amylase
- ✔ maltose ✔ oesophagus
- ✔ peristalsis ✔ fibre
- ✔ stomach ✔ organ
- ✔ small intestine ✔ liver
- ✔ bile ✔ pancreas
- ✔ faeces ✔ egestion
- ✔ large intestine

Introduction

The digestive system is a tube that runs from the mouth to the anus. Food is one of our most basic needs. Our digestive system allows us to convert food into a form that the body can use easily.

Digestion is the **breakdown of food**. Our digestive system breaks our food into smaller molecules. These molecules can then pass from our intestines into our blood.

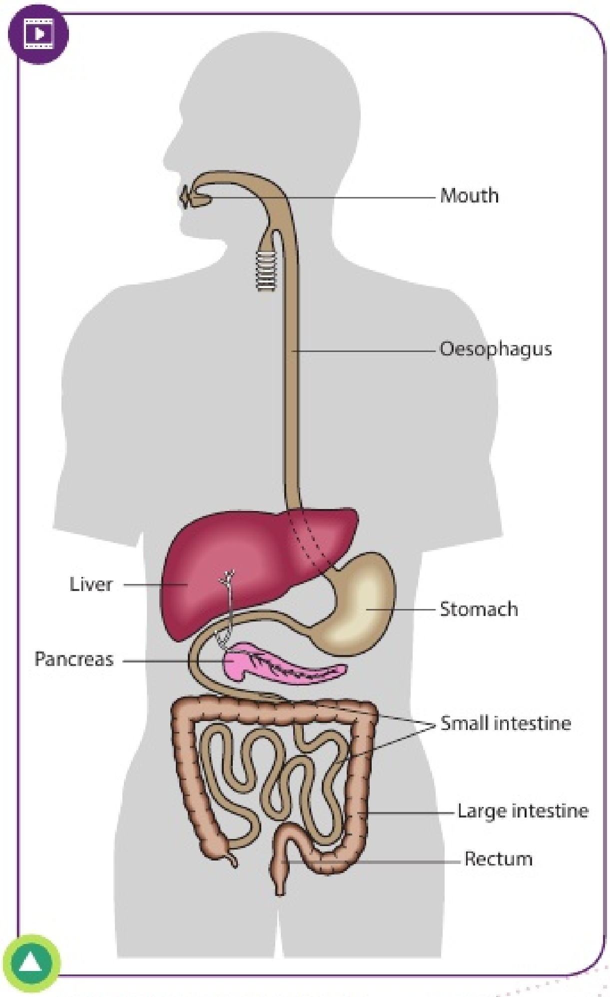


Figure 3.1 *The digestive system*

The blood carries the food molecules to all parts of the body. Any food that does not pass into our blood is removed from our bodies as waste called **faeces**.

Q U1 S2

Most humans are between 1.5 and 2 metres tall. Our digestive system is up to 9 metres long.

3.1 How do you think such a long tube can fit into a person's body?

3.2 What problem might this arrangement cause for the movement of food through our digestive system?

The functions of the parts of the digestive system

Mouth

The function of the mouth is to take in and digest or break down food. Two types of digestion take place in the mouth:

- Physical digestion
- Chemical digestion

What is physical digestion?

Physical digestion is the breakdown of food using mechanical or physical methods. An example of this occurs in the mouth when the teeth cut and chew food into smaller pieces. The smaller pieces of food can be more easily broken down later in the rest of the digestive system.

Teeth

There are four types of teeth in the adult human jaw. The sequence of the teeth from the front to the back of the jaw is given in Table 3.1.

Table 3.1 Teeth in an adult human jaw

Teeth – from the front to the back of the jaw	Appearance and Function
Incisors	Sharp edges, like a chisel Used to cut, slice and nibble food
Canines	Long and pointed Used to grip and tear food
Premolars	Large with flat surfaces Used for chewing, crushing and grinding food
Molars	Larger than premolars Used for chewing, crushing and grinding food

Q U1 S2

3.3 We are advised to chew food many times before swallowing it.

(a) Why might this be important?

(b) What problems might arise for a person who does not chew food thoroughly?

3.4 If a person loses most of their premolar and molar teeth, what problem would they have?

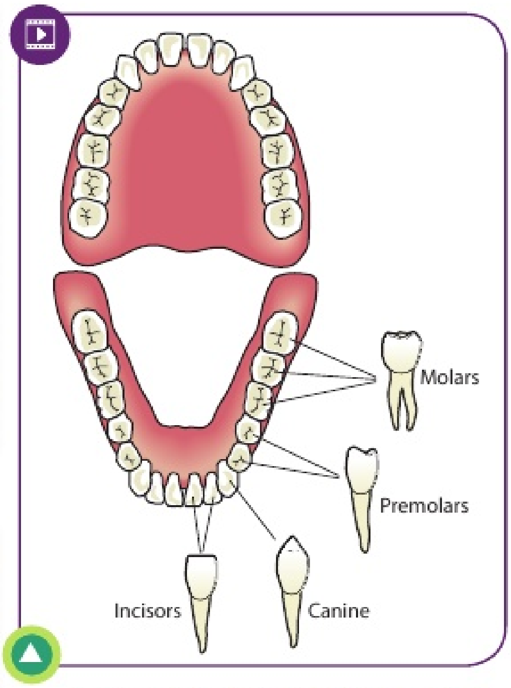


Figure 3.2 *The location and types of teeth in the human jaw*

C1 C3 S2

3.5 Some animals have large incisors and others have large canine teeth. Name one animal in each case and find out why they have such teeth.

What is chemical digestion?

Chemical digestion is the breakdown of food using **enzymes** (or hydrochloric acid in the stomach).

An enzyme is a chemical (made of protein) produced by the body that speeds up chemical reactions in the body without the enzyme being used up.

Scientists call substances that speed up reactions **catalysts**. Enzymes are called **biological catalysts**.

Salivary glands are located in the cheeks and under the tongue. They produce liquid called **saliva**. Saliva helps to soften and moisten food.

U1 S2

3.6 Why do we need to soften and moisten food before we swallow it?

Saliva also contains an enzyme called (salivary) **amylase**.

Amylase breaks down starch and turns it into a simple sugar called **maltose**. Our digestive system produces many enzymes, each one breaking down a different type of food.

$$\text{starch} \xrightarrow{\text{amylase}} \text{maltose}$$

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Did you know?

Many washing powders and detergents contain enzymes to break down food stains in a short space of time and at a very low temperature.

Oesophagus

The oesophagus or **food pipe** is a muscular tube. It forces food down from the mouth to the stomach using a wave of muscular action (called **peristalsis**). This muscular action is stimulated by **fibre** (also called **roughage**) in our diet.

Fibre is material that is not broken down or digested by enzymes in our digestive system. Good examples of fibre include:

- Fruit
- Vegetable
- Cereal grain
- Brown bread
- Muesli
- Porridge.

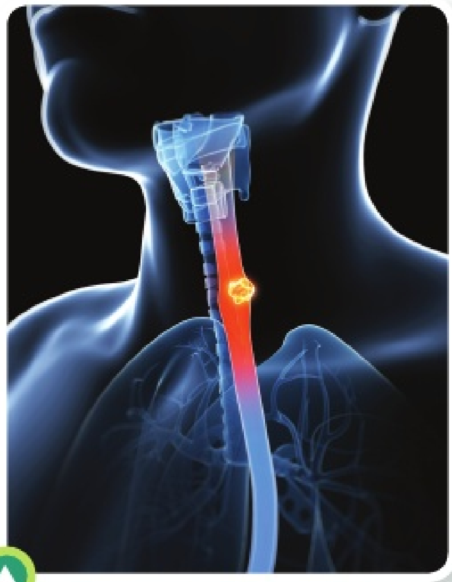

Figure 3.3 *The oesophagus*

Communicating C1 Society S2

3.7 We are told we should eat between five and seven portions of fruit and vegetable every day. Find out:

(a) how big a portion should be.

(b) what the benefits are of eating so much fruit and vegetables.

Communicating C1 Society S2

3.8 If a person standing on their head eats food, the food has to travel upwards. Find out:

(a) What force the food is going against.

(b) How the person can still swallow food.

(c) Astronauts in space experience low (or micro) gravity conditions. Can food pass through their digestive systems in the normal way? Explain your answer.

Stomach

The stomach is a muscular bag that holds food for a few hours.

Hydrochloric acid in the stomach kills bacteria and also softens food.

The stomach produces enzymes that chemically digest food. The stomach also churns and physically digests and mixes the food.

The stomach is an **organ**. An organ is a structure in a living thing that carries out a particular function (or functions).

Did you know?

If stomach acid gets into the oesophagus it causes a stinging sensation called heartburn.

Figure 3.4 *The stomach*

Q U1 (Understanding) S2 (Society)

3.9 Food stays in our stomachs for up to four hours. If food passes too quickly through the stomach a person may get many intestinal infections. Why might this happen?

Small intestine

The small intestine produces many enzymes that complete the breakdown of food. Most digestion takes place in the part of the small intestine just below the stomach.

In the rest of the small intestine the food is absorbed from the intestine into the bloodstream. Digested food is then transported all over the body by our blood.

Two organs, the **liver** and the **pancreas**, help to digest food. They pass their products into the small intestine.

Figure 3.5 *The small intestine*

Liver

The liver is a complex organ that carries out a range of functions. One of its many functions is to produce a liquid called **bile**. Bile passes from the liver into the small intestine. Bile helps to digest fat in the small intestine.

Figure 3.6 *The liver*

Did you know?

The liver is the largest organ inside the body.

Q U1 S2

3.10 People who have pain and discomfort after eating fried or fat-rich food are often suspected of having a liver problem. Explain why this might be suspected.

Pancreas

The pancreas produces many digestive enzymes. These enzymes pass from the pancreas into the small intestine where they help to digest food.

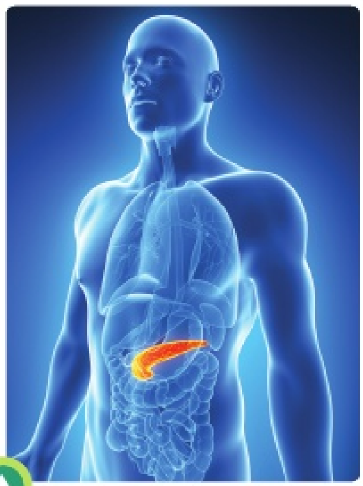

Figure 3.7 *The pancreas*

Large intestine

The material entering the large intestine contains a lot of liquid along with unabsorbed waste material. The large intestine takes water back into the bloodstream (**reabsorbs water**).

The semi-solid waste material left in the large intestine is called **faeces**.

- If too much water is taken back the waste becomes too solid, a condition called **constipation**.
- If too little water is taken back we produce liquid waste and suffer from **diarrhoea**.

Faeces are stored in the rectum and pass out of the intestine through the anus. The loss of unabsorbed food is called **egestion**.

Figure 3.8 *The large intestine*

C1 S2

3.11 Research fibre in the diet:

(a) Find out why a low-fibre diet might cause us to feel bloated and full.

(b) High-fibre diets are thought to reduce the risk of bowel cancer (cancer of the large intestine). Find out why this might be the case.

Q C1 S2

3.12 Why might children with diarrhoea often suffer from dehydration?

Digestion in the ruminant animal

Cattle and sheep are ruminant herbivores. They have a ruminant stomach with four chambers: the rumen, reticulum, omasum and abomasum. This allows them to digest cellulose which is found in grass, the main constituent of their diet.

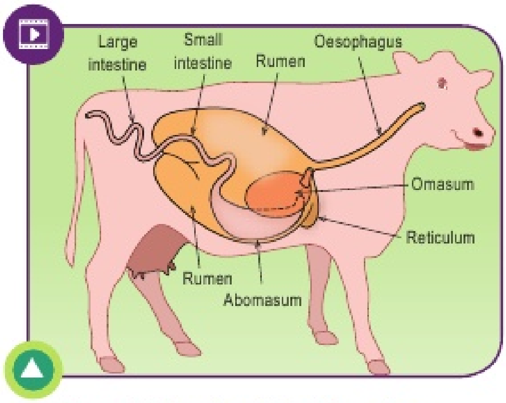

Figure 3.9 *Ruminant digestive system*

Did you know?

A **ruminant animal** has a stomach that is modified and adapted for the digestion of cellulose. The stomach has four separate chambers, each with a specialised function. The animal breaks down the plant material in their mouth and passes it to the first chamber where partial digestion takes place. The material, now known as 'cud' is then regurgitated from the second chamber and chewed a second time before being swallowed and continuing through the remaining two chambers where it is fully digested.

Q U1 C2 S2

3.13 In your groups research and prepare a short presentation comparing the digestive system of the human to either: **(a)** the digestive system of a cow or **(b)** the digestive system of an earthworm.

Your presentation should highlight similarities and key differences in the organs of the digestive system and digestion processes.

What happens if you eat too much food?

Eating too much food means that the surplus food is converted to fat and stored in the body. This leads to problems such as becoming overweight or obese (which means severely overweight). In turn this can lead to:

- Increased risk of heart disease
- High blood pressure
- Diabetes
- Gallstones
- Breathing difficulties
- Some forms of cancer.

What happens if you eat too little food?

Eating less food than the body needs results in weight loss. In addition it causes:

- Mood swings
- Depression
- Inability to think clearly
- Heart and circulatory problems
- Low blood pressure
- Reproductive problems
- Weak bones.

Food poisoning

Food poisoning is caused by harmful bacteria and contaminants. Foods which are high in protein such as dairy products, eggs, fish and meat are where bacteria are likely to thrive.

Bacteria spread quickly:

- In temperatures between 5°C-63°C
- In moist conditions
- over time i.e. when food is left out of the fridge for a long period

In catering industries, people that deal with food often refer to the 4 Cs which protect against food poisoning:

- cleaning
- cooking
- chilling
- cross-contamination

These processes are the most effective ways of keeping food safe.

Vitamins

Vitamins are complex carbon-based substances that the body cannot make. They are needed only in tiny amounts. Vitamins can be referred to by letters or by names based on their chemical structure.

Water-soluble vitamins

Vitamin B

B vitamins are found mainly in foods such as milk, eggs, whole grains, fish, liver and beans. Vitamin B group is a large group of vitamins that are important for many areas of human health.

Metabolic role of B vitamins

Vitamin B is necessary in:

- promoting the development of red blood cells (B12)
- helping enzymes to generate energy from fats and carbohydrates (B2)
- fostering the development of a baby during pregnancy (B9)

Deficiency of vitamin B

Disease: a deficiency of vitamin B can lead to anaemia

Symptoms: weakness, pale skin, dizziness

Vitamin C

Vitamin C is called ascorbic acid. It is soluble in water. Common sources of vitamin C include vegetables and fresh fruits, especially citrus fruits such as oranges and lemons.

Metabolic role of vitamin C

Vitamin C is necessary for:

- The formation of connective tissue (tissue that surrounds body structures and holds them together) such as skin, gums, cartilage, ligaments and the cells that line the inside of blood vessels
- The growth and maintenance of bones and teeth
- Helping wounds to heal
- Helping the immune system to function properly.

Figure 3.10 *Scurvy: one of the effects of a lack of vitamin C*

Deficiency of vitamin C

Disease: deficiency (lack) of vitamin C causes a disease called **scurvy**

Symptoms: symptoms (or signs) of scurvy include poor healing of skin, bleeding under the skin (often seen as bruising) and bleeding gums with loose teeth

Fat-soluble vitamins

Vitamin A

Good sources for vitamin A are foods such as dairy products, liver and fish oils and certain vegetables such as carrots and pumpkin.

Metabolic role of vitamin A

Vitamin A is important for good eyesight.

Deficiency of vitamin A

Disease: night blindness and in extreme cases complete **blindness**

Symptoms: dry eyes, failing vision

Vitamin D

There are a number of different types of vitamin D. The most common form is called calciferol. Vitamin D is soluble in fat.

Good sources of vitamin D include liver, fish oils such as cod liver oil, milk and egg yolk. Vitamin D can be made by the action of ultraviolet rays on chemicals in the skin.

Metabolic role of vitamin D

Vitamin D helps to absorb calcium from the intestine. Therefore, it is needed for healthy bone and tooth formation.

Deficiency of vitamin D

Disease: a deficiency of vitamin D in children results in **rickets**. The adult equivalent of rickets is called **osteomalacia**.

Symptoms: the symptoms of both osteomalacia and rickets are weak, deformed bones that tend to break easily.

Figure 3.11 *Rickets results from a vitamin D deficiency*

Q U1 (Understanding)

3.14 Complete the table.

	Important for ...	Lack of causes ...	Found mainly in ...
Vitamin A			carrots, fish oils
Vitamin B			
Vitamin C			fruit
Vitamin D	strong bones		

MODULE 4

Transport in the body

Learning outcomes

At the end of this module you will be able to:

- Describe the composition and function of blood 8.1.3.1
- Describe the functions of white blood cells 8.1.3.3
- Describe different forms of cellular immunity 8.1.3.4
- Describe the lymphatic system 8.1.3.5
- Investigate the features of blood cells of different organisms using ready slide mounts 8.1.3.2
- Explain the mechanism of agglutination and rhesus-conflict 8.1.3.7
- Describe the structure of the heart and blood vessels in animals 8.1.3.8
- Explain the relationship between the structure of the vessel walls and their functions 8.1.3.9
- Describe the types of circulatory systems of animals 8.1.3.10
- Investigate the effect of physical exercise on the heart 8.1.3.11
- Describe diseases caused by viruses, bacteria and fungus and prevention measures 8.4.3.1
- Assess the role of vaccination in the prevention of diseases 8.1.3.6
- Describe causes and symptoms of diseases of the circulatory system 8.1.3.12

Keywords

✔ plasma ✔ haemoglobin ✔ antibodies ✔ platelets
✔ arteries ✔ veins ✔ capillaries ✔ pulse ✔ lymphatic system
✔ rhesus factor ✔ micro-organisms ✔ immunisation
✔ vaccination ✔ parasites

How do materials pass around our body?

The human body needs a transport system to move materials from one place to another. For example, food, oxygen and waste products have to be moved to and from all the cells in our body.

Our **circulatory** or transport system is made up of:

- Blood
- A system of tubes or blood vessels
- The heart, which is needed to pump blood through blood vessels.

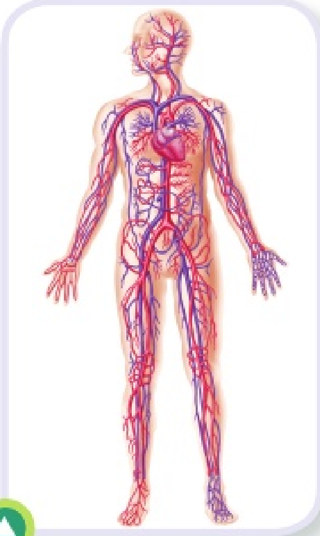

Figure 4.1
The circulatory system

What is in our blood?

Blood is made up of four parts or components:

- Plasma
- Red blood cells
- White blood cells
- Platelets.

Plasma

Plasma is the liquid part of blood. It is a pale yellow colour and is mostly made of water.

Plasma transports many dissolved chemicals around the body. These chemicals may be:

- Useful materials, such as foods and oxygen
- Wastes, such as carbon dioxide and salts.

Figure 4.2 *Blood plasma in a bag*

Plasma also transports heat from one part of the body to another. Heat is produced by chemical reactions in all our body cells. By transporting heat our blood plays an important role in maintaining our **body temperature at 37°C**.

Plasma also carries:

- Red blood cells
- White blood cells
- Platelets.

Q C1 S2 (Communicating, Society)

4.1 Discuss the following questions in groups. Each group should elect a spokesperson to report the group's findings to the class.

(a) What causes humans to get too hot?

(b) List the changes that take place in our bodies when we get too hot.

(c) Explain the benefit of the changes listed in (b) above.

How plasma affects body temperature

When we are **too hot**, extra blood (plasma) is sent to our skin (especially to the face, causing it to go red). This allows more heat to pass out of our body and we cool down. This can happen when we are ill. In this case our body temperature may rise (we have a fever). The high temperature helps to destroy the bacteria and viruses that are causing us to be ill.

When we are **too cold**, blood vessels in our skin become smaller. Blood also moves from our extremities to our core. This means we lose less heat from our body.

Red blood cells

Red blood cells are made in **bone marrow** located in the centre of bones. Red blood cells contain a red-coloured chemical (or pigment) called **haemoglobin**. To make haemoglobin we need iron. Our blood contains huge numbers of red blood cells.

Communicating C1 Society S2

4.2 Find out the answers to these questions on iron.

(a) Name any food in our diet that we need to eat in order to get iron.

(b) What is anaemia?

(c) How can you tell if someone is anaemic?

Haemoglobin, and therefore red blood cells, carries oxygen. Oxygen is needed to release energy from food.

Figure 4.3 *Red blood cells*

The path of oxygen

Oxygen enters our red blood cells in the lungs. It attaches to haemoglobin in the red cells. When blood reaches cells in other parts of our body (such as our muscles or the brain) haemoglobin releases the oxygen into these cells.

White blood cells

White blood cells are also made in bone marrow. White blood cells fight infection. They do this by:

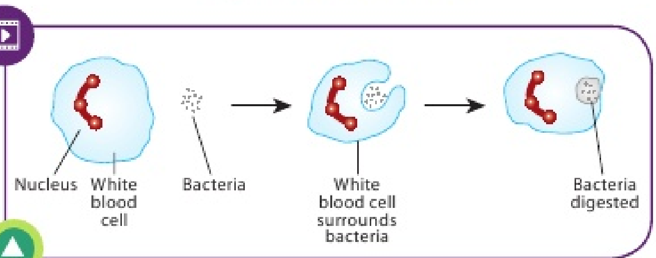

Figure 4.4 *White blood cell destroying bacteria*

- Some white blood cells surround micro-organisms (such as bacteria and viruses) and destroy them.
- Other white blood cells form proteins called **antibodies**. Antibodies help to destroy micro-organisms that have entered the body. Antibodies are very important. AIDS is a condition where the body does not produce any antibodies.

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Q C1 S2

4.3 Since blood contains white blood cells, why is blood not white instead of being red?

Platelets

Platelets are formed in bone marrow when large cells break down into smaller pieces. Platelets help to form blood clots. In this way they help to prevent:

- Loss of blood
- Micro-organisms entering the body.

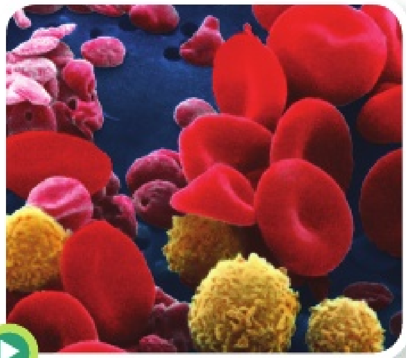

Figure 4.5 *Red blood cells (red), white blood cells (yellow) and platelets (pink)*

C1 C2 S2

4.4 Work in groups to find out what problems each of the following would cause. Each member of the group should report on at least one of these problems to the class group.

(a) A lack (or shortage) of iron
(b) A lack of red blood cells
(c) A lack of white blood cells
(d) A lack of platelets
(e) A lack of blood.

Along with the blood circulatory system, mammals have a second circulatory system called the lymphatic system. The lymphatic system is a **one-way** system of dead-ending vessels and lymph nodes. These lymph vessels collect the fluid that surrounds each cell in the body and return it to the blood.

Functions of the lymphatic system

The lymphatic system forms a link between different parts of the blood (i.e. plasma produces tissue fluid, tissue fluid forms lymph and lymph returns to the plasma).

The lymphatic system has the following functions:

- To collect tissue fluid and return it to the blood.

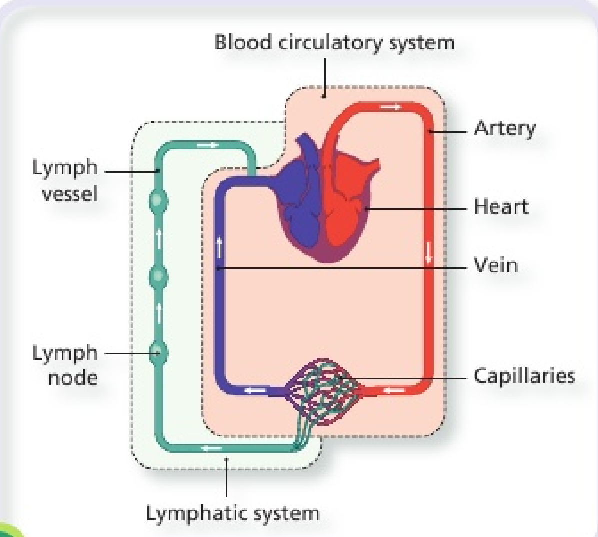

Figure 4.6 *The link between the blood and lymphatic circulatory systems*

- To defend the body against infection. It does this by:
  - Filtering micro-organisms in lymph nodes
  - Maturing and storing lymphocytes
  - Destroying micro-organisms by engulfing and digesting them or by antibody production.
- To absorb and transport fats in the digestive system. Lymph is found in lacteals (which are in the villi of the small intestine). Lymph often has a milky appearance because of its high fat concentration.

R2 R3 R5

Activity 4.1

Question

How do human and frog blood slides compare under the microscope?

Equipment needed

Microscope

Prepared blood slides

Conducting the activity

1. Get prepared slides of human and frog blood from your teacher.
2. Adjust the mirror so that the light is shining through the opening in the centre of the stage (or switch on the microscope light, if one is present).

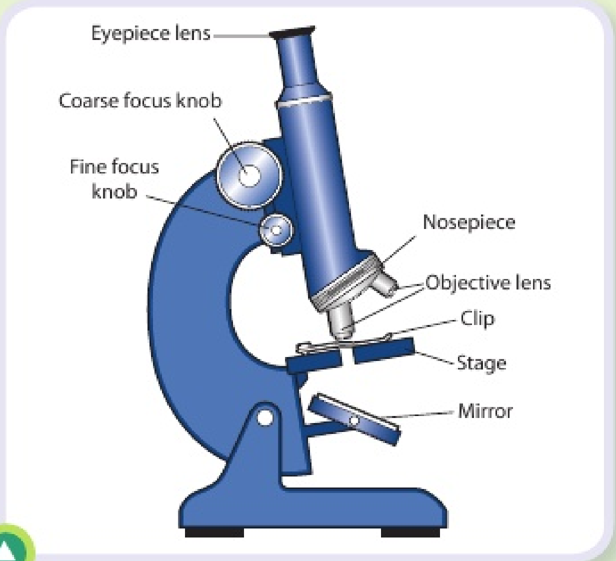

Figure 4.7 *Parts of a microscope*

3. Turn the nosepiece so that the lowest power objective lens is in place.
4. Place the slide under the clips on the stage.
5. Look at the stage from the side and turn the coarse focus knob so that the objective lens moves down as close as possible to the slide. (Be careful not to bring the objective lens down onto the slide or it might break the slide or damage the lens.)
6. Look through the eyepiece lens and turn the coarse focus knob slowly so that the objective lens moves slowly up, away from the slide.
7. When the cells are visible move the slide on the stage if necessary so that the cell or cells of interest are in the centre of the view.
8. Switch to a higher power objective lens and use the fine focus knob to form a clear image. (Only use the coarse focus knob along with the low-power objective lens; otherwise you risk breaking the slide.)

Q U1 R5

4.5 Complete the table.	Human blood	Frog blood
shape of red blood cells		
nucleus or no nucleus in red blood cells		
platelets or no platelets		

4.6 Can you locate the white blood cells? What are the similarities and differences between these on the two slides?

Why do we need blood?

We need blood for a number of reasons. Each of the four parts of blood has its own role (or function) as shown in Table 4 .1.

Table 4.1 What blood does

Part of blood	Function
Plasma	Transports materials such as foods and wastes Transports heat around the body
Red blood cells	Transport oxygen
White blood cells	Fight infection
Platelets	Clot the blood

What are blood vessels?

There are three main types of blood vessels:

- Arteries
- Veins
- Capillaries.

Figure 4.8 *Arteries, veins and tiny capillaries.*

Arteries

Arteries carry blood **away from** the heart.

(Remember **a** is for **a**rtery and **a** is for **a**way.)

As a result of carrying blood away from the heart, there is a strong flow of blood in arteries. We say that the blood in arteries is under **high pressure**.

Veins

Veins carry blood **to** the heart. The blood flow or pressure in a vein is **low**.

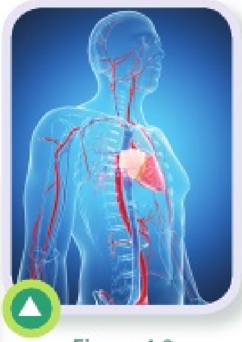

Figure 4.9
Arteries and veins

Q U1 (Understanding)

4.7 Apply your knowledge of arteries and veins to identify:

(a) Which of the two needs the thicker, stronger wall.

(b) Which of the two needs valves to prevent blood flowing backwards.

Capillaries

Capillaries are tiny blood vessels. They are found between arteries and veins.
There is a huge number of capillaries in the human body.
The walls of a capillary are very thin. This allows materials to pass into and out of capillaries. For example, in our intestines food passes *into* blood capillaries. This food is carried by the bloodstream to all the cells of the body. The food later passes *out of* the capillaries to enter the body cells.

Q U1 (Understanding) R5 (Research)

4 .8 The following diagram represents a number of different blood vessels.

(a) State whether each of A, B and C is an artery, a vein or a capillary.

(b) Which way do you think the blood is flowing (i.e. from A to C or from C to A)? Give a reason for your answer.

(c) Name one substance that might pass from the structures labelled B into the cells.

(d) Name one substance that might pass from the cells into the structures labelled B.

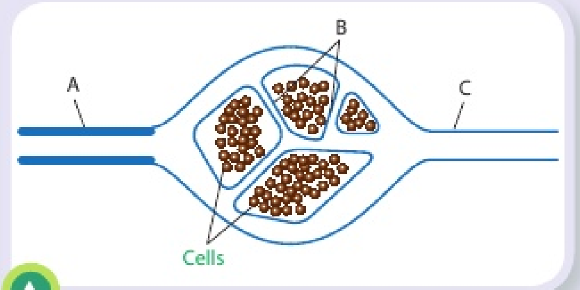

Figure 4.10 *Different blood vessels*

Blood groups

ABO groups

Red blood cells can be placed in four different categories (or blood groups), depending on the types of chemicals (if any) attached to their cell membranes. The four main (ABO) blood groups are A, B, AB and O.

When blood transfusions are given it is important to match the incoming blood group to the blood group of the recipient. Failure to do this may result in blood clumping in the recipient.

The Rhesus factor

Apart from the ABO blood groups there are many other blood types. The best known of these is the Rhesus factor. This is named after Rhesus monkeys, in which it was first discovered. Some people have a chemical called the Rhesus factor on the surface of their red blood cells. Those people who have this chemical are said to be Rhesus positive (Rh+). Members of the population who do not have the Rhesus chemical on their red cells are said to be Rhesus negative (Rh–).

- People of blood group A may be A positive (also called A+ and A Rh+). This means they are in blood group A and have the Rhesus chemical on their red blood cells.
- Those who are A negative (A– or A Rh–) do not have the Rhesus chemical. A similar situation applies for those who are B+ and B–, AB+ and AB–, O+ and O–.

Did you know?

The Rhesus factor is important for safe blood transfusions. It may also lead to problems for a Rhesus-negative mother who is pregnant with a Rhesus-positive child. Her first Rhesus-positive baby is normally born safely, but any further Rhesus-positive foetuses may be anaemic, brain damaged or stillborn. Treatment is now available to prevent such complications in pregnancy.

The heart

The heart is about the size of a clenched fist. It is located between the middle and the left-hand side of the chest.

The heart is made of a special type of muscle called **cardiac muscle**. Cardiac muscle is very strong and does not tire easily.

The heart contracts in order to pump blood around our body in blood vessels. The force of this blood causes a pulse.

When we are resting, the average rate of an adult heartbeat is **70 beats per minute**. When we exercise, the heart beats faster. This causes blood and the materials it carries to move faster around our bodies.

Q U1 (Understanding) S2 (Society)

4.9 Why do we need to pump blood around the body faster during exercise?

Structure of the heart

Parts of the heart

Chambers: The heart contains **four** chambers. The top two are the right and left **atrium** (plural atria) and the bottom two are the right and left **ventricle**.

Septum: The two sides of the heart are separated by a muscular wall called the septum.

Heart valves: Valves in the heart make sure that blood can flow only in one direction. In this way, they are similar to valves in a car tyre or football (which let air pass in, but not out).

How blood flows through the heart

- Blood from the arms, legs and other parts of the body enters the right atrium of the heart through the **vena cava**. This blood is low in oxygen.
- The **right atrium** contracts to pump the blood down through a valve into the **right ventricle**.
- When the right ventricle contracts, the valve shuts to prevent the blood from going back into the right atrium. As a result, blood is pumped out of the heart in the **pulmonary artery** to the **lungs**.

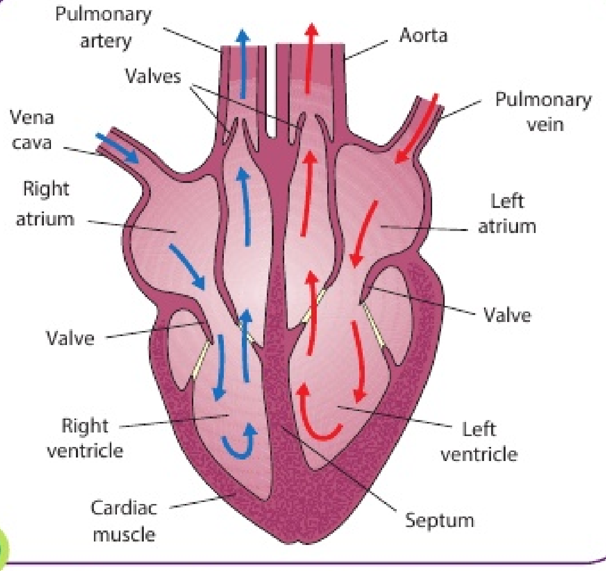

Figure 4.11 *Structure and blood flow of the heart*

- In the lungs, the blood gains oxygen (and also loses carbon dioxide and water vapour).
- Blood from the lungs flows back into the **left atrium** of the heart through the **pulmonary vein**. This blood is now rich in oxygen.
- The left atrium contracts to pump the blood through a valve and into the **left ventricle**.
- The left ventricle contracts, the valve snaps shut and blood is forced out of the heart through the **aorta**. It then passes all around the body.
- Eventually this blood will lose oxygen to the body cells. It will return to the heart in the right atrium. The cycle then starts all over again.

The ventricles of the heart

- The **right ventricle** pumps blood from the heart to the lungs. This is a reasonably short distance and so the muscular walls of the right ventricle are fairly thin.
- The **left ventricle** pumps blood from the heart all around the body. This is a very long distance and so the muscular walls of the left ventricle are very thick.

Pulmonary artery and vein

- Most of the arteries in the body carry oxygen-rich blood. However, the pulmonary artery is an exception to this rule as it carries blood low in oxygen.
- Most of the veins in the body carry blood low in oxygen. However, the pulmonary vein is an exception to this rule as it carries oxygen-rich blood.

Q U1 Understanding

4.10 Why are the walls of the atria thinner (and weaker) than the walls of the ventricles?

4.11 Many people suffer from problems caused by damage to the valves in their heart. In terms of blood flow, what problems might they have?

4.12 Compare blood in the pulmonary artery and in the pulmonary vein in terms of:

(a) Pressure

(b) Oxygen and carbon dioxide contents.

4.13 Why do most arteries contain oxygen-rich blood?

4.14 Why does blood in the pulmonary vein have lower pressure than the blood in the pulmonary artery?

The two blood circuits

The circulatory system consists of two circuits:

- In the **lung circuit**, blood flows from the heart to the lungs and back to the heart.
- In the longer, **body circuit**, blood flows from the heart to the rest of the body and back to the heart again.

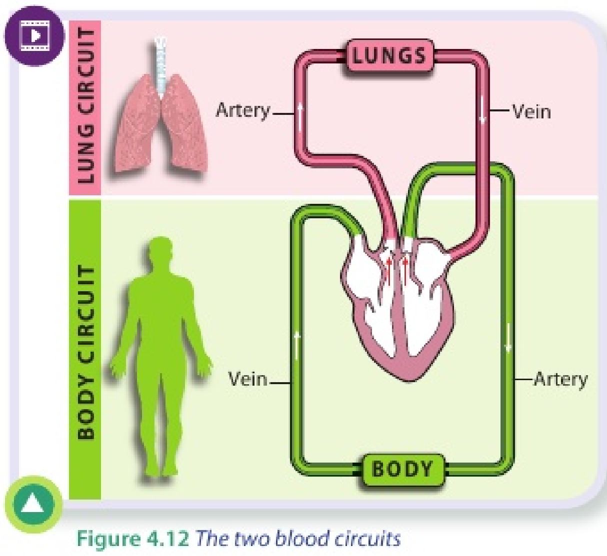

Figure 4.12 *The two blood circuits*

What is a pulse?

When blood is pumped through the arteries it causes a wave of pressure. This wave of pressure is called a **pulse**.

A pulse can be felt in areas of the body where the arteries are close to the surface, for example at the wrist and in the neck.

The pulse rate is used to measure the rate of heartbeat.

How exercise affects pulse rate

When we exercise, the cells in the body (especially in the muscles) need increased supplies of food and oxygen. In addition, the cells need to get rid of extra amounts of carbon dioxide and heat. As a result, exercise causes the heart to beat faster and our pulse rate increases.

Q U3 R4

4.15 The heart rate (in beats per minute, BPM) and average lifespan of different animals is given in Table 4.2.

Table 4.2 Heart rates and average lifespan of selected animals

Animal	Mouse	Rat	Small dog	Human
Heart rate (BPM)	650	410	120	72
Average lifespan (years)	4.2	2.5	10	75

(a) Suggest an explanation (or hypothesis) for the variations in the heart rates.

(b) How many times does a human heart beat (on average) every: (i) minute, (ii) hour, (iii) day, (iv) year, (v) 75 years, the average lifespan?

(c) Calculate the number of heart beats in the average life of each of the other animals.

(d) Some people say that every animal has roughly the same number of heartbeats in its life. Some of the figures given above support this idea, but the figures for one of the animals contradicts it. Which is the contradictory animal?

Figure 4.13 *Measuring heart rate*

R2 R3 R4 S2

35

Activity 4.2

Question

What is our resting heart rate?

Equipment needed

A stopwatch or timer

Conducting the activity

1. While you are resting, use the first finger and middle finger to locate your pulse in your wrist or neck. The pulse rate is a measure of the heart rate.
2. Count the number of pulses for one minute.
3. Repeat this three times.
4. Add the three values together and divide by three to get the average resting pulse rate. Getting an average rate is more reliable than taking a single reading.

5. Record your pulse rates in a table such as the one below.

Number of pulses per minute at rest	Total number of pulses in three minutes at rest	Average pulse rate per minute at rest

Activity 4.3

Question

What is the effect of exercise on heart rate?

The plan is to record the heart rate at rest and then record the heart rate after exercise. This is done by counting the pulse rates at rest and after exercise.

Equipment needed

A stopwatch or timer

Safety

- The exercise should be carried out in a safe environment (i.e. where the person exercising cannot trip or come to harm).
- The type of exercise should be controlled so that it is safe.
- The person being tested should be in good general health.

Conducting the activity

1. Record your resting pulse (or heart) rate as in Activity 4.2. If you prefer, you can use the information (or data) you collected in Activity 4.2.
2. Provided you are fit and healthy, exercise strongly for two minutes (e.g. step up and down on a step or run on the spot).
3. Immediately after exercising count the number of pulses per minute.
4. Continue to record the number of pulses per minute until the rate returns to the average resting rate.
5. Record how long it takes for the pulse rate to return to normal after exercise.
6. Record your results in a table such as the one below.

Number of pulses per minute at rest	Total number of pulses in three minutes at rest	Average pulse rate per minute at rest	Pulse rates per minute after exercise

What pathway around the body does the blood take?

Figure 4.14 is a model of the system that is used to circulate blood around the body.

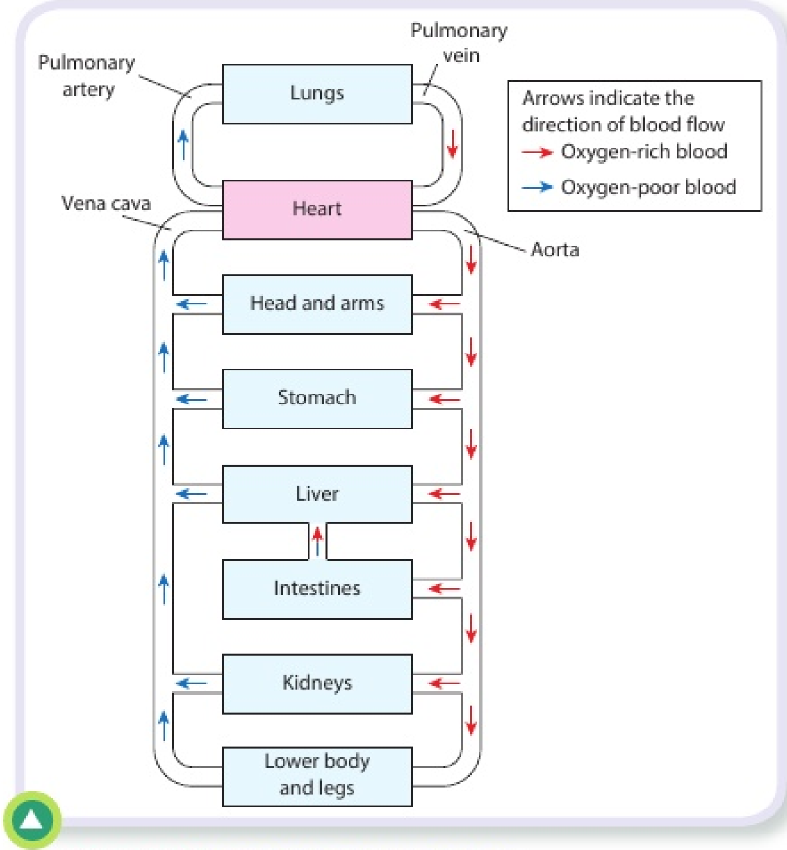

Figure 4.14 *The path of blood around the body*

What happens to blood in different parts of the body?

This is summarised in Table 4.3.

Table 4.3 What happens to blood in different parts of the body

Organ	Blood gains	Blood loses
Lungs	Oxygen	Carbon dioxide and water
Intestines	Food, water and carbon dioxide	Oxygen
Head/arms	Carbon dioxide and water	Oxygen and food
Lower body/legs	Carbon dioxide and water	Oxygen and food

Q U1 Understanding

4.16 Describe the changes in the blood that take place in:
(a) The heart (b) The intestines (c) The lungs.

4.17 Name the blood vessel that takes blood:
(a) From the heart to the lungs. (b) From the arms and legs to the heart.

4.18 Blood pressure is measured as *x* mm Hg. Human blood pressure is given as 120 mm Hg. The blood pressure in a giraffe is given as 300 mm Hg. Why is the blood pressure of a giraffe so high?

Heart disease

Blood is supplied to the heart muscles by the coronary arteries. When fatty deposits build up in these arteries a heart attack can occur:

- blood clots form on fatty deposits
- the coronary becomes blocked
- cells in the heart muscle are deprived of oxygen
- cells die

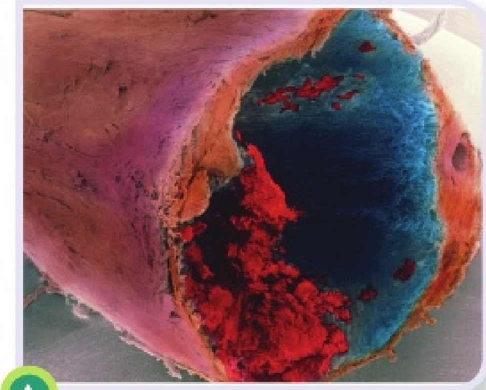

Figure 4.15 A blood clot (red) forming in a coronary artery: the artery wall is brown and the lining is blue

The most common risk factors in heart disease are:

- poor diet: eating foods with high levels of saturated fat and salt
- high blood pressure
- smoking

Q U1 Understanding

4.19 Which of these three factors is most directly connected to the process leading to a heart described above?

Micro-organisms and diseases

Micro-organisms are small living things. Most of them are too small to be seen with the naked eye. They can be seen only using special microscopes.

Micro-organisms are found in huge numbers almost everywhere. For example, they are present in the air, water and soil, on our skin, and inside plants, animals and humans.

There are three types of micro-organism:

- Viruses
- Bacteria
- Fungi.

Viruses and bacteria are too small to be seen by eye, but we can see some fungi.

Are all micro-organisms harmful?

Most micro-organisms are of benefit. For example, they are important as they play crucial roles in:

- Decomposition – which allows living things to be broken down and their minerals released so they can be recycled into new living things.
- Food production – they are involved in making many foods, alcohol, baking.
- Biotechnology – this is the use of living things, or parts of living things, to produce useful products such as drugs, flavourings, colourings, vitamins, artificial cloth, fuels.
- Water treatment.
- Digestive systems – they make vitamins, prevent the growth of disease-causing organisms and break down some foods.

What is the role of micro-organisms in human health?

Some micro-organisms (often called microbes or germs) are **pathogens**. This means they cause disease.

What diseases do micro-organisms cause?

Viruses

Viruses are the smallest micro-organisms. Up to one million viruses may fit across the thickness of a thumbnail (1 mm). Viruses cannot reproduce by themselves. For this reason it can be argued that they are not living things.

Viruses increase in numbers by invading other cells. They cause the other cell to form new viruses. For this reason all viruses are said to be **parasites** (i.e. they live on or in another living thing).

Examples of human diseases caused by viruses include:

- Measles
- Mumps
- Chicken pox
- Polio
- Colds
- Flu (influenza)
- Cold sores
- AIDS (caused by HIV)
- Ebola.

Figure 4.16 *Ebola virus emerging from a cell*

Very few chemicals or medicines can kill viruses. For example, antibiotics prevent bacterial infections but have no effect on viruses.

Our bodies fight off most virus infections when our white blood cells produce chemicals called antibodies.

Bacteria

Bacteria are larger than viruses. They are very simple organisms; for example, they do not have a proper nucleus.

In order to grow, bacteria need the following:

- Food
- Water
- A suitable temperature
- A suitable pH.

Under ideal conditions bacteria can reproduce very rapidly. Bacteria reproduce asexually. Many bacteria can double their numbers every twenty minutes.

Figure 4.17 *Bacteria on the sharp tip of a pin*

Examples of human bacterial diseases are:

- Tetanus (lockjaw)
- Tuberculosis (TB)
- Pneumonia
- Sore throats
- Tooth and gum decay
- Food poisoning
- Cholera
- Anthrax.

Antibiotics are chemicals made by bacteria and fungi, which kill or prevent the reproduction of other bacteria. Penicillin is an example of an antibiotic.

Q Understanding U1 Society S2

4.20 Why are antibiotics of no value in treating the flu?

4.21 What is the difference between antibiotics and antibodies?

Fungi

Fungi are simple organisms that do not contain chlorophyll. For this reason they are not green and cannot make their own food.

Some fungi are parasites on plants, on animals and even on humans. Many fungi feed on dead material and act as decomposers. Some fungi are single celled (e.g. yeast), while many form long threads. Very often these threads are underground and only come to the surface as reproductive structures such as mushrooms.

Figure 4.18 *Athlete's foot infection*

Examples of human fungus diseases are:

- Athlete's foot
- Ringworm.

How do we reduce the risk of infections?

Most pathogens spread through the air when we sneeze or cough. Some spread when we touch something and a small number spread in body fluids such as sweat, saliva, blood or semen. In addition some pathogens enter our body when we eat improperly cooked food.

Figure 4.19 *Some vaccinations are given to babies*

The best ways to reduce infections are to:

- Wash our hands in soap and warm water for at least 15 seconds. This is important before eating or preparing food and after we cough, sneeze, use the toilet, touch animals, play outside or visit a sick person.
- Make sure we get all our immunisations (often called vaccinations). These introduce a small amount of the pathogen into the body. This allows our bodies to produce antibodies against the pathogen. This means we will have long-term resistance to the pathogen. As the pathogen cannot reproduce, the vaccination will not cause us to suffer all the symptoms of the infection.
- Cook food properly. High temperatures kill micro-organisms.
- Eat a proper diet, get regular exercise and get enough sleep, which all help our bodies to fight off pathogens.

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4.22 It is suggested that the misuse of antibiotics has resulted in the evolution of antibiotic-resistant bacteria.

(a) Find out the name of two of the most common antibiotic-resistant bacteria in Kazakhstan.

(b) Research the ways in which antibiotics have been misused.

(c) What is the main danger of misusing antibiotics?

Did you know?

It is suggested that we wash our hands for the same length of time it takes us to sing one verse of the 'Happy Birthday' song.

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Activity 4.4

Question

How can we show that micro-organisms are present in different locations?

We will take samples from different locations and grow them on nutrient agar in petri dishes. Nutrient agar is a solid, jelly-like substance that contains food that micro-organisms need to grow.

Equipment needed

Nutrient agar	A beaker with boiled water	Disinfectant
Petri dishes (also called plates)	Masking tape	Basin
Cotton wool buds	Pen or marker	

Safety

Micro-organisms can cause disease so we have to reduce the risks by:

- Washing our hands before and after the activity
- Not putting anything dirty in or near our mouths
- Covering any cuts with a bandage or wearing plastic gloves
- Taping the dishes shut
- Killing any micro-organisms at the end of the activity by soaking the dishes in sterilising liquid or disinfectant.

Figure 4.20 *Micro-organisms growing on agar in a petri dish*

Conducting the activity

1. Dip a clean cotton wool bud in boiled water in a beaker. Rub the damp cotton wool bud over the surface to be tested. Sample surfaces are a door handle, a computer keyboard, a desk surface, a phone, the sink in a bathroom, a bin, the sole of your shoe, the inside of your mouth, under your finger nails, etc. Use a separate cotton wool bud in each location.
2. Open the lid of the plate slightly so that micro-organisms in the air do not enter. Rub the cotton wool bud gently over the surface of the agar in a petri dish. If you wish you could use half of each dish for two different samples, just remember which side has which sample. (You could also press your unwashed fingers gently on the surface of the agar in one dish and repeat this in a second dish after washing your hands.)

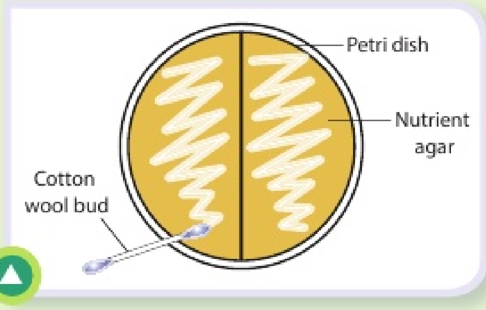

Figure 4.21 *Micro-organisms growing on agar in a petri dish*

3. Place the lid on the dish and seal it closed with tape.
4. Place a piece of (masking) tape across the base of the dish and use it to label the source of the sample(s) and your name.
5. Tape a petri dish shut without opening it. This dish will act as a control or comparison for the other dish(es).
6. Leave the dishes in a warm place (between 20°C and 30°C) to allow micro-organisms to grow.
7. Leave the dishes upside down to prevent water from dripping onto any micro-organisms that grow.
8. Leave the dishes for 4 to 7 days.
9. Examine the dishes, but do *not* open them.

Figure 4.22 *Micro-organisms growing on agar in a petri dish*

10. Take a note of which locations had:
    (a) The greatest and least numbers of different types of micro-organisms.
    (b) The greatest and least amounts of overall growth of micro-organisms.
11. Record your results in a table similar to the one below.

Observation	Location
Greatest number of different types of micro-organisms	
Least number of different types of micro-organisms	
The dish(es) with the most overall growth	
Dish(es) with no visible growth	
Control dish	

12. When you are finished, the dishes should be soaked in sterilising liquid or disinfectant before being placed in a bin (unless your teacher instructs you otherwise).

Q Understanding U1

4.23 Why did you use nutrient agar?
4.24 Why is it better to use a damp cotton wool bud rather than a dry one?
4.25 What problem might arise if the petri dishes were left in a cold place?
4.26 Why were the petri dishes left lying on their lids?
4.27 Name two types of micro-organisms that might grow on the agar.

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4.28 You are asked to compare how effective two liquid hand sterilisers are in killing micro-organisms. Work in groups to plan how you might carry out this investigation. Each group should present their findings to the class and then change their plan if necessary to respond to any good ideas they took from other groups in the class.

MODULE 5

The breathing system

Learning outcomes

At the end of this module you will be able to:

- Describe mechanisms of gas exchange in lungs and tissues 8.1.4.1
- Explain the mechanism of inhalation and exhalation 8.1.4.2
- Determine the vital capacity of the lungs and minute volume of respiration at rest and during physical activity 8.1.4.3

Keywords

✔ respiration ✔ excretion ✔ trachea ✔ bronchus ✔ bronchiole ✔ alveolus ✔ diaphragm ✔ inhaling ✔ exhaling ✔ lung

Why do we breathe?

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Activity 5.1

Question

What happens to our chests when we breathe?

Conducting the activity

1. Place your hand on your chest.
2. Breathe in (inhale) and breathe out (exhale) deeply and slowly a few times.
3. What do you feel? Do you notice your hand changing position?
4. When you breathe in does your chest get bigger or smaller?
5. When you exhale how does your chest change?

This is what takes place when we breathe:

- When we breathe in, air fills our lungs – this is why in **Activity 5.1** your chest was getting bigger when you breathed in and smaller when you breathed out.
- Oxygen from the air passes from our lungs into our bloodstream.
- The blood carries oxygen to all the cells of our body, where it is used to release energy from food. The release of energy from food is called **respiration**.
- Carbon dioxide and water vapour are produced by respiration in each body cell. They enter the bloodstream and are carried by the blood to the lungs.
- Carbon dioxide and water vapour pass from the blood into the lungs and are then breathed out.

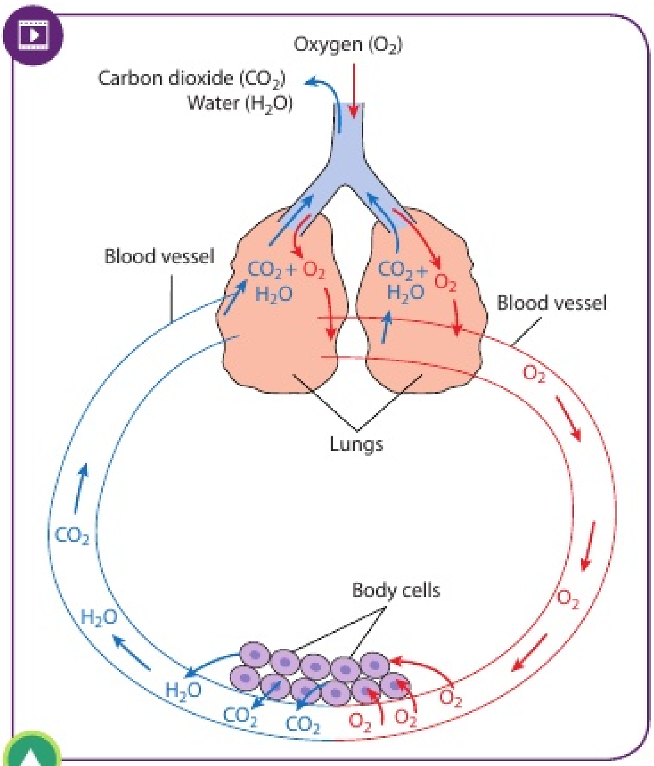

Figure 5.1 *Gas exchange between the lungs and body cells*

In this way the breathing system supplies oxygen for respiration and gets rid of the waste products of respiration (i.e. carbon dioxide and water).

The breathing system is also called the **respiratory system**.

Excretion is the getting rid of the waste products of reactions from the body. Carbon dioxide and water vapour are excreted by the breathing system.

Q U4 Understanding

5.1 Name the blood vessels that carry blood from:
- **(a)** The heart to the lungs.
- **(b)** The lungs to the heart.
- **(c)** The heart to the rest of the body.
- **(d)** From the body cells to the heart.

5.2 **(a)** Why does our body need oxygen?
- **(b)** Name two substances excreted by the body.

Did you know?

The left lung is slightly smaller than the right lung (to allow space for the heart).

The breathing system

What is the function of the parts of the breathing system?

The breathing system is made up of the following:

- Nose
- Trachea or windpipe
- Bronchus and bronchioles
- Alveolus
- Diaphragm
- Ribs and intercostal muscles.

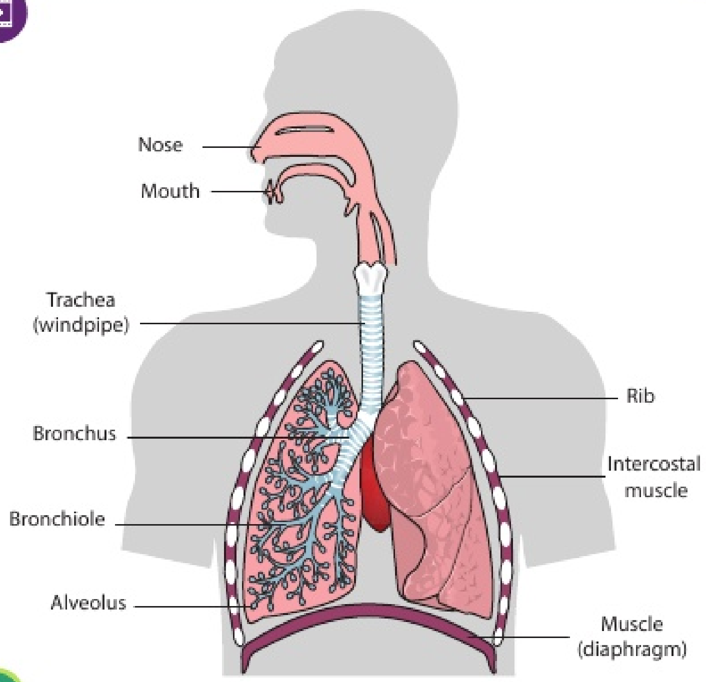

Figure 5.2 *The breathing system*

Nose

We are supposed to breathe in (**inhale**) through our noses. The reasons for doing this are:

- Hairs and mucus trap dirt particles and bacteria in the nose.
- Air is warmed and moistened as it passes through the nose. Warm and moist air helps oxygen to pass from the lungs into the bloodstream more easily.

Trachea or windpipe

The trachea or windpipe carries air to and from the lungs.

Bronchus and bronchioles

We have two bronchi. Each bronchus carries air between the windpipe and a lung.

The two bronchi subdivide many times to form tiny tubes called bronchioles. Bronchioles carry air to and from the air-sacs or alveoli.

Alveolus

Each lung contains millions of tiny air-sacs called alveoli. Each alveolus has a thin lining and is surrounded by many tiny blood vessels called **capillaries**. The function of the alveoli is gas exchange:

- Oxygen passes from the air in the alveolus into the blood vessels.
- At the same time carbon dioxide and water pass from the blood vessels into each alveolus.
- The gases pass in each direction by a process called **diffusion**.

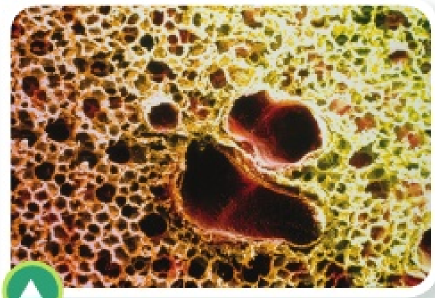

Figure 5.3 *Each of our lungs contains millions of alveoli*

Research R1 Understanding U1 Communicating C1

5.3 Research diffusion:

(a) What is meant by diffusion?

(b) Find out if diffusion works better:

(i) At high or low temperatures.

(ii) Across a dry or a moist surface.

(c) Based on your answers to part (b), how is our breathing system adapted to provide the conditions for diffusion to work best?

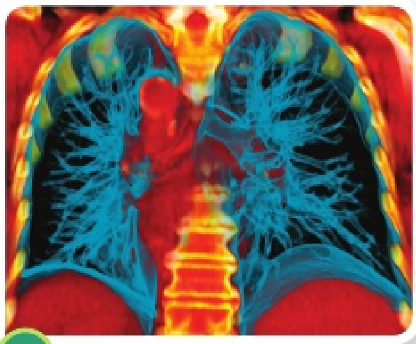

Figure 5.4 *A scan of a human chest, showing the lungs*

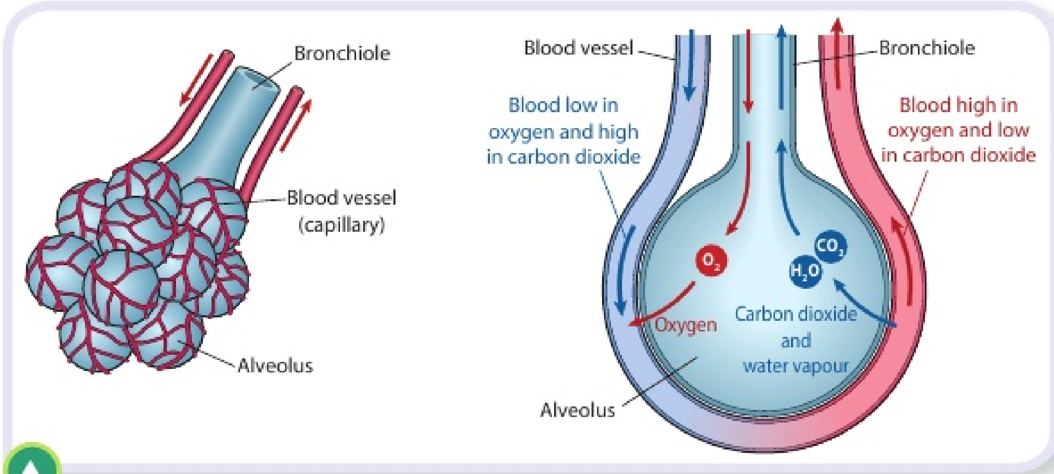

Figure 5.5 *Gas exchange in an alveolus*

Diaphragm

The diaphragm is a sheet of muscle that forms the base of the chest. Along with the ribs and **intercostal muscles** (located between the ribs) the diaphragm causes air to move into or out of the lungs.

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Activity 5.2

Question

Can a model of the chest show how we get air in and out of the lungs?

Equipment needed

Large (2 litre is best) empty soft drink plastic bottle to represent the chest

Balloon to represent the lungs

Rubber band

Plastic bag to represent the diaphragm

Scissors

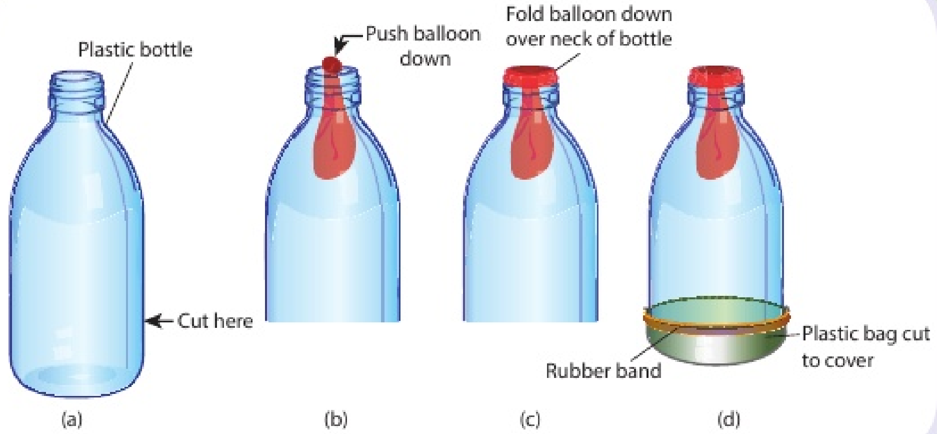

Figure 5.6 *Model of chest and lung*

Conducting the activity

This can be carried out alone, in pairs or in groups.

1. Cut around the plastic bottle about two-thirds of the way down and discard the bottom half.
2. Push the balloon down through the top or neck of the bottle.
3. Fold the top of the balloon down over the neck of the bottle.
4. Cut the plastic bag so that it covers the base of the bottle with about 4 cm spare all round.
5. Use the elastic band to hold the plastic over the base of the bottle so that it is flat but loose.
6. Pinch the middle of the plastic cover at the end of the bottle and pull down gently. What happens to the size of the balloon? Does this represent breathing in or out?
7. Push up gently on the middle of the plastic cover. What happens to the size of the balloon? Does this represent inhalation or exhalation?
8. We have two lungs. This model has only one 'lung'. Discuss in a group how you might alter this activity so that you could make a model with two lungs.

Q U1

5.4 (a) Why do we have two bronchi?
(b) Why do you think we have so many alveoli?
(c) State two ways that the structure of the alveoli is adapted to allow for gas exchange.

5.5 (a) Inhaled air contains lots of dust and disease-causing organisms. Suggest one way that these unwanted materials are prevented from entering the alveoli.
(b) Name the gas that passes from the alveoli into the blood.
(c) What part of the blood does this gas enter?
(d) Name an excretory product that passes from the blood into the alveoli.
(e) By what process do gases pass into and out of the alveoli?

What is the difference between air breathed in and air breathed out?

As a result of gas exchange in the alveoli, the contents of inhaled air are different from the contents of exhaled air. The approximate figures are given in Table 5.1.

Table 5.1 **Makeup of inhaled air and exhaled air**

Substance	% in inhaled air	% in exhaled air
Nitrogen	78	78
Oxygen	21	14
Carbon dioxide	0.04	5
Water vapour	Variable	Much higher than in inhaled air

Q U1 R4

5.6 What is the normal concentration of carbon dioxide in the air?

5.7 Why does exhaled air contain more carbon dioxide than inhaled air?

5.8 The table below shows the exhaled carbon dioxide concentrations of three people. One of the people was resting, one was walking and the third was running. Answer these questions based on the figures in the table:
(a) From the table, match up the three people with the three activities.
(b) Which person would have the greatest demand for oxygen?
(c) Why do you think that the person in part (b) required more oxygen? Identify in your answer any part(s) of the body that needed a higher supply of oxygen.
(d) Which person would have the lowest breathing rate (number of breaths per minute)?
(e) Why do you think that the person in part (d) requires less oxygen?

Person	Percentage of carbon dioxide in exhaled air
A	7
B	4
C	9

R2 R3 R4

Activity 5.3

Question

Can we compare the carbon dioxide levels of inhaled and exhaled air?

Limewater turns milky or cloudy in the presence of carbon dioxide. We will breathe in through one container of limewater and breathe out through a second container of limewater.

Equipment needed

Two test tubes
Two stoppers with holes
Tubing or straws
Clear limewater

Safety

- Glass tubing may crack and break. If possible use plastic tubing or straws.
- If you use tubing, it should be washed to make sure it is clean.
- Make sure that the tube or straw that you breathe in through is not in the limewater (to prevent you sucking in limewater).
- Care should be taken when inserting the stoppers into the test tubes (in case the test tubes break).
- Care should be taken to suck air in or blow air out through the correct tubes.
- The apparatus should not be shared, to reduce the risk of passing infections.

Conducting the activity

1. Place equal volumes of clear limewater in two test tubes, as shown in Figure 5.7.
2. Suck air in through tube X and hold your breath for as long as possible.
3. Breathe air out through tube Y.
4. Repeat steps 2 and 3 until the limewater in one of the test tubes turns milky.
5. In which test tube did the limewater first turn milky?
6. Why does the limewater in the second test tube eventually turn milky?

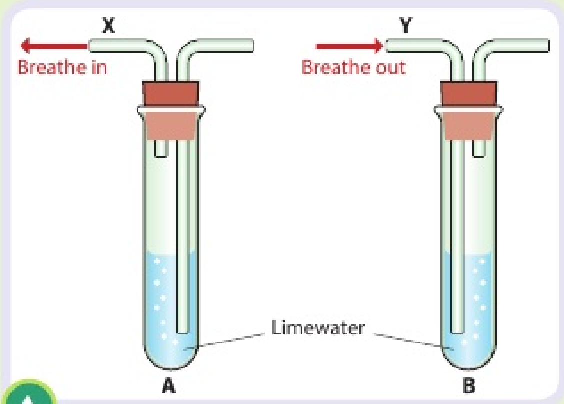

Figure 5.7 *Comparing CO_2 concentration*

What is breathing rate?

The breathing rate is how many breaths a person or animal takes per minute. One breath is one inhalation and one exhalation.

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Activity 5.4

Question

How can we find our breathing rate at rest?

Equipment needed

A stopwatch

Conducting the activity

1. Count the number of times you breathe in (inhale) per minute while you are at rest.
2. Repeat step 1 two more times, so you have three counts.
3. Add the three values together and divide by three. This gives the average number of breaths per minute at rest. This gives a more reliable result than a single measurement.
4. Record your breathing rate in a table similar to the one below.

Number of inhalations (breaths) per minute at rest	Total number of inhalations (breaths) in three minutes at rest	Average number of inhalations (breaths) per minute at rest

Did you know?

The normal breathing rate for an adult at rest is from 8 to 16 breaths per minute. For an infant, the normal rate is up to 44 breaths per minute.

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5.9 Why is the breathing rate of an infant greater than that of an adult?

5.10 **(a)** Research the breathing rates of other animals.

(b) Can you see a pattern relating breathing rate and the size of the animal? If so, then state the relationship.

(c) Can you see a pattern relating breathing rate and the life span of the animal? If so, then state the relationship.

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5.11 In general, fitter people have lower breathing rates. Their breathing rate also returns to normal faster after exercise than for unfit people. What does this suggest about the size of their lungs?

5.12 Breathing rates increase as people go higher up a mountain, even if they are inactively sitting in a car. Suggest an explanation (or hypothesis) for this change.

Did you know?

A **hypothesis** is when a scientist provides a suggested explanation for something when there is very little evidence. It is the basis for further investigation to find out whether the hypothesis is true.

Research R2 Research R3 Research R4 Society S2

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Activity 5.5

Question

How can we investigate the effect of exercise on the rate of breathing?

Equipment needed

A stopwatch

Safety

- Carry out an appropriate exercise (i.e. an exercise that is safe and not too strenuous for the person being tested). You should carry out this activity only if you are in good health.

Conducting the activity

1. Record your resting breathing rate as in activity 5.4. If you prefer you can use the information (data) collected in activity 5.4. This value acts as a control or comparison.
2. Exercise strongly for two minutes (e.g. jump up and down on the spot or run on the spot).
3. Immediately after exercising count the number of inhalations (breaths) per minute.
4. Continue to record the number of inhalations (breaths) per minute until the rate returns to the average resting rate.
5. Note how long it takes for the breathing rate to return to normal after exercise.
6. Record your results in a table similar to the one below. On a separate sheet of graph paper, or in your Student Portfolio book, draw a graph to show the results you obtained (putting time on the x-axis and the number of breaths per minute on the y-axis).

Number of inhalations (breaths) per minute at rest	Total number of inhalations (breaths) in three minutes at rest	Average breathing rate per minute at rest	Breathing rates per minute after exercise

Q Understanding U1 Research R4

5.13 The bar chart in Figure 5.8 shows the breathing rate of three people, A, B and C, at rest and after exercise. Answer the following questions based on the bar chart.

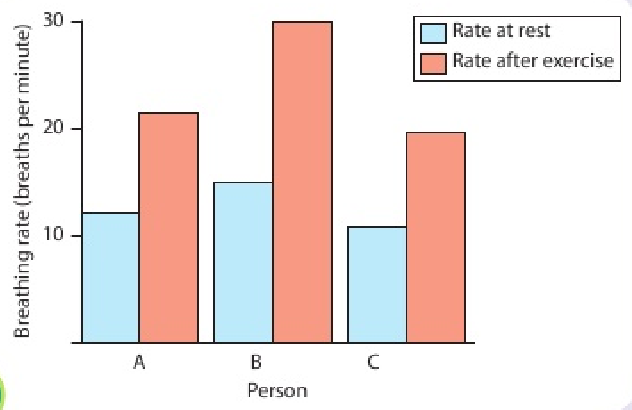


Figure 5.8

(a) Which person has the lowest breathing rate at rest?

(b) Which person has the highest breathing rate after exercise?

(c) Which person shows the greatest range of breathing rates?

(d) What is the percentage increase in breathing rates for person A?

(e) Calculate the average (mean) breathing rate for the three people:

  (i) At rest

  (ii) After exercise.

(f) Which person do you think is the fittest? Suggest two pieces of evidence from the chart in support of your answer.

Q Understanding U1 Research R5

5.14 Assel breathes in and out through the tube labelled X in Figure 5.9.

(a) Through which test tube will inhaled air pass?

(b) Name a liquid that could be used in the test tubes to detect a difference in composition between inhaled and exhaled air.

(c) After some minutes of breathing, how would the liquids in tubes A and B differ in appearance?

(d) What conclusion could you reach based on this difference?

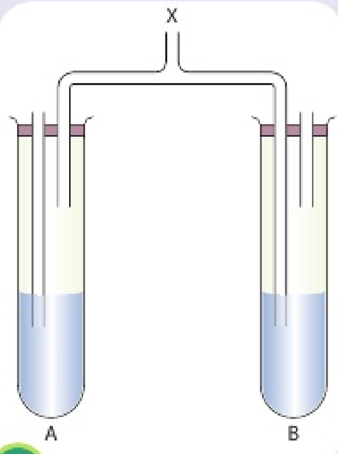


Figure 5.9

MODULE 6

Excretion

Learning outcomes

At the end of this module you will be able to:

- Describe the structure and function of the organs of the excretory system in humans 8.1.5.1
- Recognise the structural components of the kidney 8.1.5.2
- Describe the structure of the skin and its role in the excretion process 8.1.5.3
- Explain measures for prevention of skin diseases 8.1.5.4

Keywords

✔ kidneys ✔ ureters ✔ urea ✔ bladder ✔ urethra ✔ filtration
✔ skin ✔ sweat ✔ infection ✔ bacterial ✔ viral ✔ fungal

The human body carries out many reactions in order for it to work properly. These reactions produce waste products. These wastes are harmful to the body. The body needs to remove waste products before they cause problems.

The removal of waste from the body is called **excretion**.

Organs of excretion

The main organs of excretion are the lungs and the kidneys. The main substances excreted by these organs are given below.

Lungs

The lungs excrete carbon dioxide and water vapour. These wastes are produced by respiration in all the living cells of the body.

Kidneys

The kidneys excrete water, salts and a special substance called urea. The combination of these products is called urine.

The water and salts are produced from the liquids and salt-containing foods that we eat. Urea is made when we breakdown proteins that we do not need.

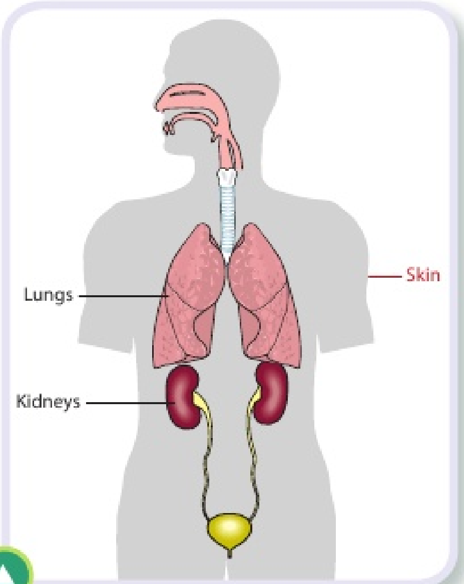


Figure 6.1 *The organs of excretion*

Organ	Substance(s) excreted
Lungs	Carbon dioxide, water vapour
Kidneys	Water, salts, urea
Skin	Water and salts

Figure 6.2 *Substances excreted by the lungs, kidneys and skin*

The urinary system

The urinary system consists of the kidneys (and the blood vessels entering and leaving them), the ureters, the bladder and the urethra.

The parts of the urinary system

Renal arteries

The renal arteries carry blood into the kidneys. The blood in the renal arteries contains excess water and salts, along with urea.

Kidneys

The kidneys remove excess water, salts and urea from the blood. These compounds are combined to form urine.

Renal veins

The renal veins take blood from the kidneys and carry it back towards the heart. The blood in the renal veins contains no waste materials.

Figure 6.3 *The kidneys, ureters and bladder*

Ureters

The ureters are tubes which carry urine from the kidneys to the bladder.

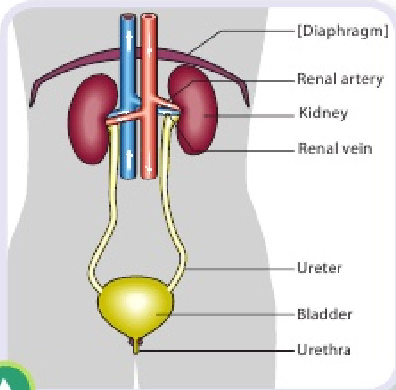


Figure 6.4 *The urinary system*

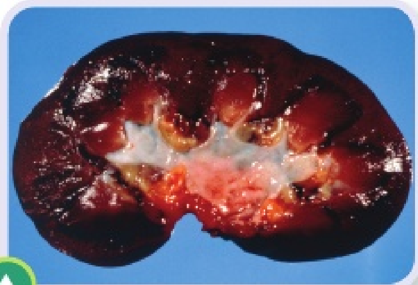


Figure 6.5 *Kidney cross section*

Bladder

The bladder stores urine until it can be released from the body.

Urethra

The urethra is a tube which takes urine from the bladder and passes it out of the body.

Q U1 Understanding

6.1 (a) What is meant by excretion?

(b) Why is excretion necessary?

6.2 (a) Name two organs of excretion.

(b) Name the main materials excreted by each of the named excretory organs.

6.3 Apart from being an organ of excretion, give another function for the lungs.

Filtration in the kidneys

- Blood enters each kidney through the renal artery.
- In the kidney, waste substances are removed from the blood by filtration.
- The main wastes are water, salts and urea. The salts and urea dissolve in the water to form urine.
- Urine is made in the kidney.
- Urine passes from the kidney, through the ureters to the bladder.
- The blood that leaves the kidneys in the renal veins does not contain waste products.

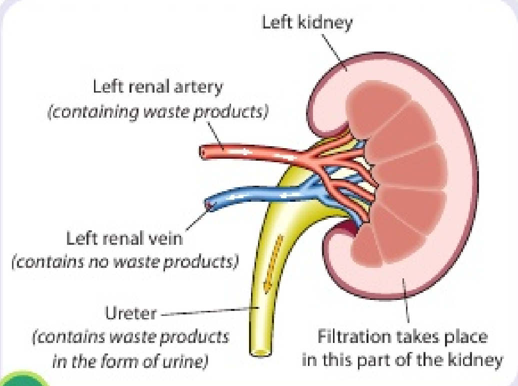


Figure 6.6 *The kidney*

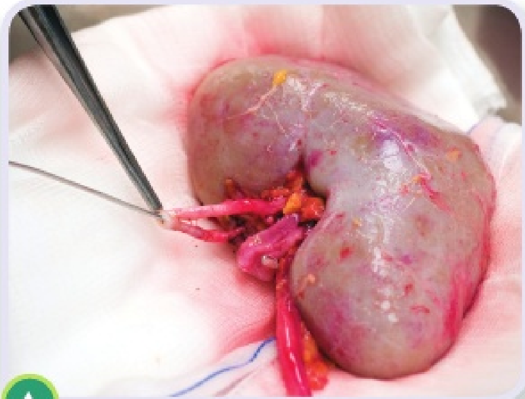


Figure 6.7 *A healthy human kidney being used for transplant*

Q U1 Understanding

6.4 Figure 6.8 represents the human urinary system.

(a) Name the parts labelled A, B, C, D, E, F, G and H.

(b) Name the process that takes place in structure A that is responsible for the formation of urine.

(c) Name one substance in each case that is found in higher concentrations in

(i) C compared to G

(ii) B compared to H

(iii) D compared to G.

(d) To which organ are B and H both connected?

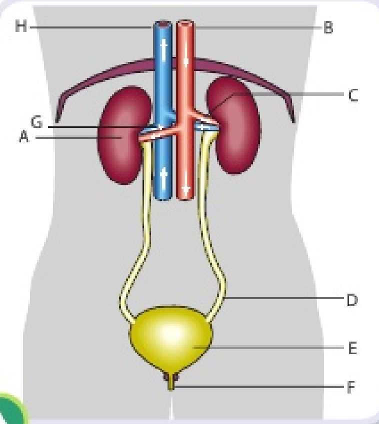


Figure 6.8

The role of skin in excretion

Sweat glands act as organs of excretion. Sweat contains water and salts. When sweat passes out of the skin these wastes are removed from the body.

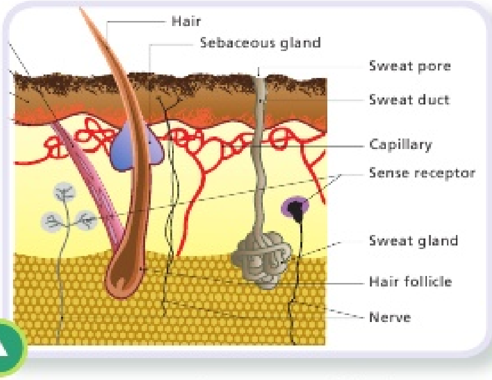


Figure 6.9 *Vertical section (VS) of the skin*

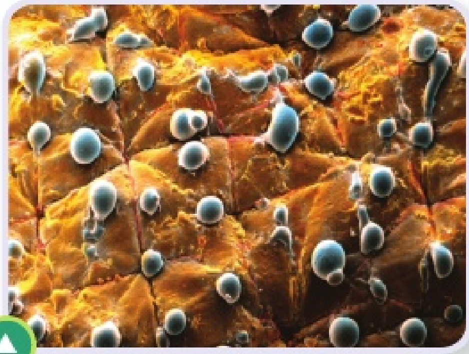


Figure 6.10 *Droplets of sweat on the skin*

Sweat is produced and released onto the skin. When the water evaporates it lowers our body temperature. At normal room temperature we can lose as much as one litre of sweat in a day. In hot weather and during exercise, the loss of water and salts in the form of sweat is much greater. It is important to drink water and salts before, during and after exercise to maintain the salt/water concentration of the body. Salt tablets are often taken before competing in sports events in very warm weather to replace salt that will be lost in sweat.

Q Understanding U1

6.5 As well as excretion, what other physical function does sweating through the skin have. What are the organs of excretion?

Excretion and Homoeostasis

The role of the excretory system in homoeostasis can be summarised as:

- Regulating body temperature
- Controlling osmosis (i.e. controlling the salt and water balance of the body)
- Controlling the concentration of body fluids
- Removing waste products of metabolism from the body.

Q Understanding U1 Communicating C1

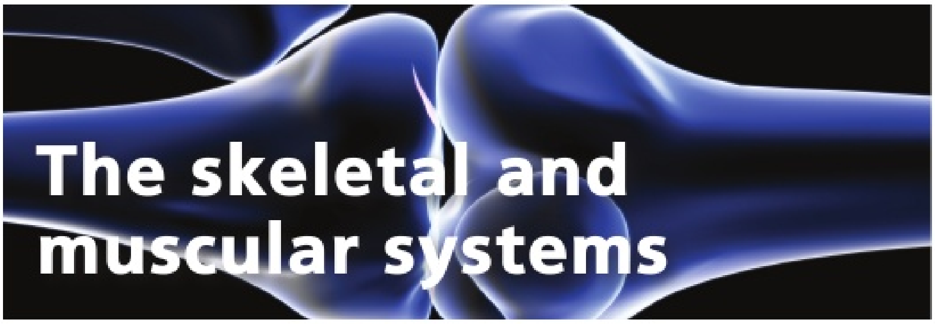
6.6 In small groups research different types of skin infection. Find at least two infections of each of the following kind:

- bacterial
- viral
- fungal

Prepare to report back to the class on measures to prevent such skin infections.

MODULE 7

The skeletal and muscular systems



Learning outcomes

At the end of this module you will be able to:

- Describe the functions of the musculoskeletal system 8.1.6.1
- Investigate the chemical composition and structure of bone 8.1.6.2
- Compare the types of bone joints 8.1.6.3
- Explain the connection between the structure and function of different types of joints 8.1.6.4
- Describe the structure and type of different muscles 8.1.6.6
- Describe the health consequences of human inactivity 8.1.6.7
- Identify causes and symptoms of poor posture 8.1.6.8
- Investigate biomechanical features of human movement in walking 8.4.4.1

Keywords

✔ skeleton ✔ muscles ✔ joints ✔ tendons
✔ ball and socket ✔ hinge ✔ ligaments
✔ antagonistic pairs ✔ cartilage ✔ bone structure

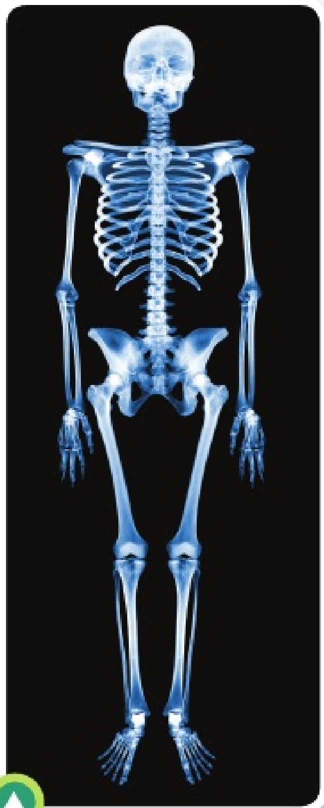


Figure 7.1 *An X-ray of the human skeleton*

Our skeleton is made up of over 200 bones. The bones give our body its basic shape. In addition, they support and protect the body.

Our bones, along with our ligaments and muscles, allow us to move.

Functions of the skeleton

The main functions of the skeleton are:

1 To support the body

The bones of the skeleton keep the body upright and give it shape. Without a skeleton our bodies would collapse like a tent without the tent poles.

2 To allow movement

A joint is where bones meet. Some joints are not able to move, but many are moveable. Bones move when muscles contract to pull on a bone.

3 To protect the internal parts of the body

The skull protects the soft material of the brain.

- The backbone surrounds and protects the nerves in the spinal cord.
- The ribs protect the lungs and heart.

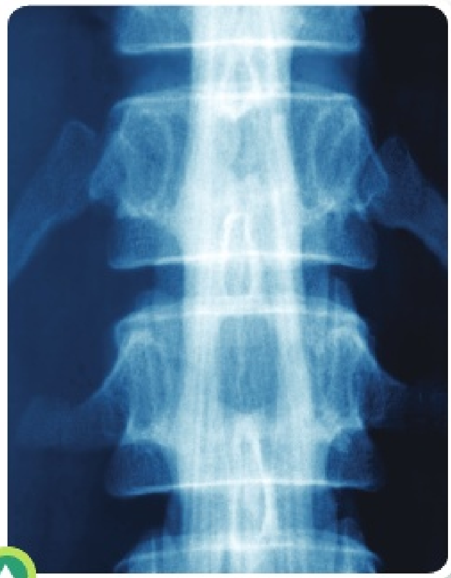


Figure 7.2 *The backbone protecting the spinal cord*

The parts of the human skeleton

The major bones in the human body are shown in **Figure 7.3**.

Joints

Some **joints**, such as those in the skull, do not move. These joints help to protect the body. However, most joints allow some amount of movement.

Muscles

Muscles are made of protein. Muscles can contract (i.e. become shorter). Each muscle is attached to bones on either side of a joint.

When a muscle contracts it pulls on one of the bones to which it is attached. This causes the bone to move, while the other bone does not move.

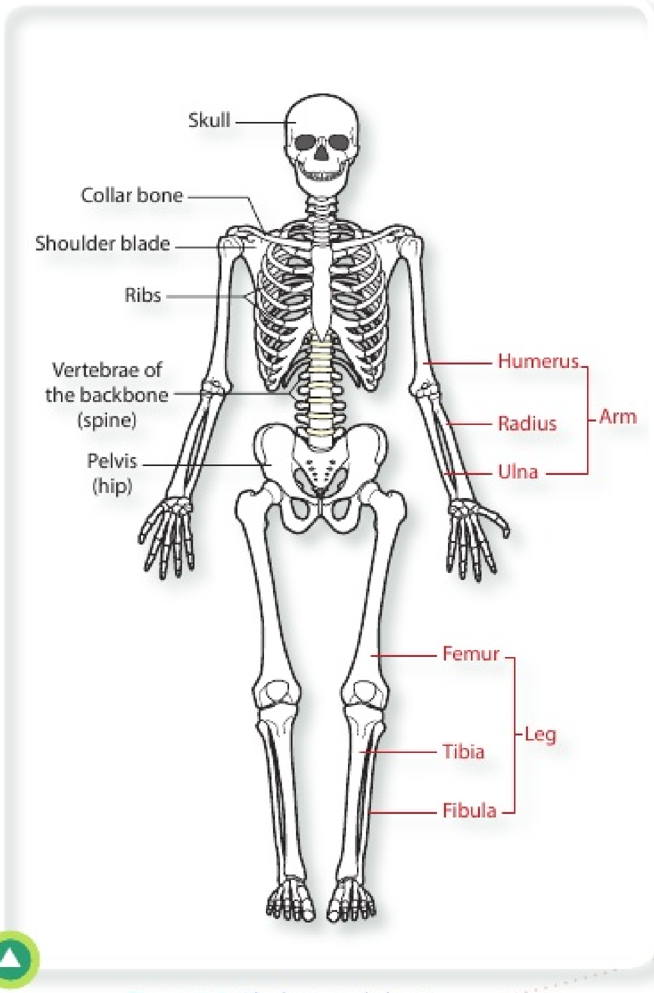


Figure 7.3 *The human skeleton*

For example, in the upper arm a muscle (the biceps) is attached to the shoulder blade and to one of the bones in the lower arm. When this muscle contracts it pulls the lower bones in the arm upwards (see Figure 7.4).

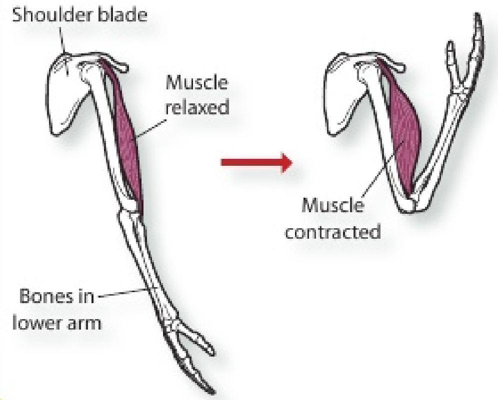


Figure 7.4 *Movement of the lower arm*

Tendons

When a muscle contracts the pull of the muscle is passed to the bone through a **tendon**.

To allow them to work properly tendons do not stretch. This is why they are sometimes damaged if we exercise too strenuously when we have not warmed up.

Tendons can be seen in the arm just below the wrist (especially if you clench your fist). They can also be felt in the underside of the thigh close to the knee.

Ligaments

Ligaments prevent joints from being damaged by reducing the amount of movement between the bones at a joint.

Antagonistic pairs

Muscles can contract but they cannot make themselves lengthen. Each muscle needs a second muscle to stretch it again. This means that muscles work in pairs, with each one being lengthened when its partner contracts.

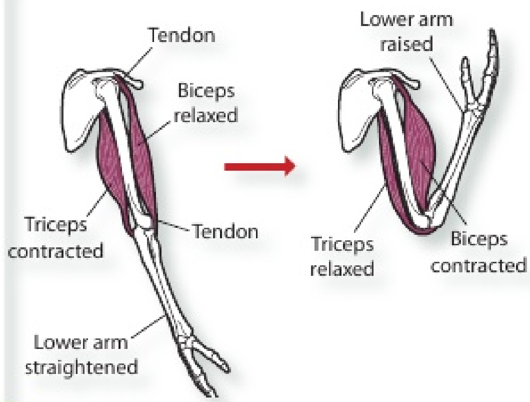


Figure 7.5 *The actions of the biceps and triceps*

For example, the biceps contracts to pull up the lower arm. A second muscle called the triceps contracts to pull down the forearm. This allows the arm to straighten.

By carrying out opposite effects, the biceps and triceps form an **antagonistic pair** of muscles.

Muscle	State of muscle	Effect on forearm	Effect on second muscle
Biceps	Contracts	Raised	Elongates triceps
Triceps	Contracts	Lowered	Elongates biceps

Figure 7.6 *The actions of the biceps and triceps*

Q U1 Understanding

7.1 **(a)** Give three functions for the skeleton.
(b) Explain briefly how each function is carried out.

7.2 Name the bones in each of the following cases:
(a) The bones that form the backbone
(b) The bones that protect the brain
(c) The bone at the base of the spine to which the legs connect
(d) The bone located between the top of the chest and the shoulder at the front of the body
(e) The bones that protect the lungs.

7.3 Write out and complete the following:
(a) The skeleton ____________ soft inner parts of the body. It also gives our body its ____________ . The skeleton ____________ the body and prevents it from collapsing. The ____________ protects the spinal cord.
(b) ____________ contract to move ____________ at joints. Muscles are made of ____________ and connect to ____________ on either side of a ____________ . An example of a muscle is the ____________ in the upper arm. When the biceps ____________ it causes the lower arm to be raised.

7.4 **(a)** What is an antagonistic pair?
(b) Name any antagonistic pair.
(c) Give one function for each member of the antagonistic pair you named.

Types of joints

There are two main types of joints: fused joints and freely moving joints.

Fused joints

In fused (also called fixed or immovable) joints there is no movement between the bones. The bones in the skull of an adult form a number of fixed joints.

Freely moving joints

Freely moving joints normally contain a liquid called synovial fluid. This liquid oils the joint and allows the joint to move more freely. Freely moving joints are also called synovial joints.

In most freely moving joints, the ends of the bones are covered with a tough pad of **cartilage**. This protects the end of the bone and reduces friction in the joint.

There are two different types of freely moving joints: ball and socket joints and hinge joints.

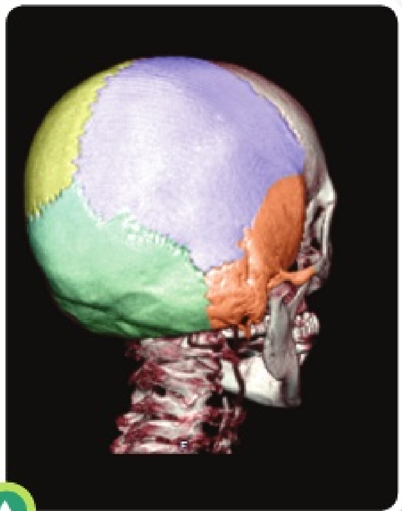


Figure 7.7 *Fixed joints in the skull*

Ball and Socket joints

Ball and socket joints are located in the shoulders and hips. They allow movement in all directions.

Hinge joints

Hinge joints are located in the elbows and knees. They allow movement in one direction only (similar to the hinge on a door).

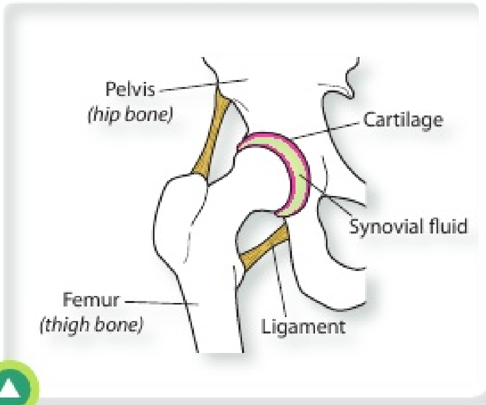


Figure 7.8 *The hip joint*

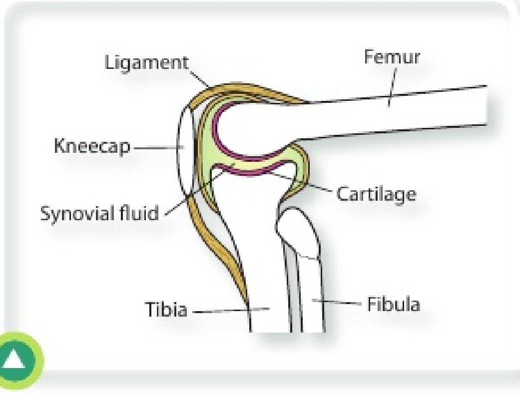


Figure 7.9 *The knee joint*

Figure 7.10 *The knee joint*

Understanding U1

7.5 Figure 7.11 shows the structure of an elbow. Name bone A and identify the type of moveable joint B.

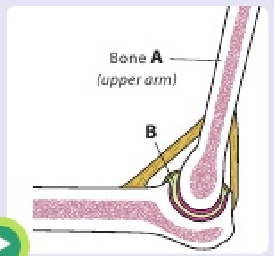


Figure 7.11

The structure of bone

- **Cartilage** is a layer of tissue that is found on bones in between joints. It is softer than bone and reduces friction where bones meet as joints.
- **Spongy bone** occurs in long bones and contains red bone marrow, which is responsible for the production of red blood cells.

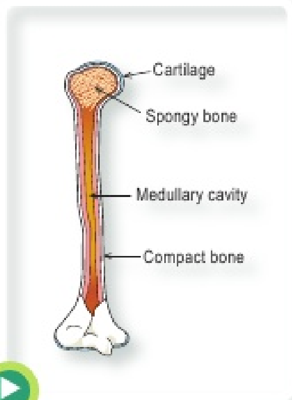


Figure 7.12 *Structure of bones found in the mammalian body*

- The **medullary cavity** is also known as the marrow cavity. It contains yellow marrow that is responsible for the production of white blood cells.
- **Compact bone** is the outer layer of bone. It is white in appearance and it is hard.

The composition of bone is both organic and inorganic. One of the main organic components of bone is collagen, a form of protein which is mainly found in connective tissues such as tendons, ligaments and cartilage in addition to bone. It is not found in plants. The inorganic component of bone consists of bone minerals.

Q U1 Understanding

7.6 Name two minerals stored in bone.
7.7 What is the function of bone marrow?
7.8 What is the difference between cartilage and bone?

R2 R3 R4 Research Portfolio 58

Activity 7.1

Question

How can we show that bone contains both organic and inorganic material?

Safety

- Care should be taken not to spill water to avoid the danger of somebody slipping.
- Exercise caution when using the Bunsen burner and holding objects in the flame.

Equipment needed

Fresh chicken bones with flesh removed
Dilute hydrochloric acid
Beakers
Tongs
Bunsen burner
Balance

Conducting the activity

Part A

1. Take two chicken bones of similar size and weigh each bone.
2. Add 50 cm^3 of dilute HCl to a beaker and place one of the bones in the beaker.
3. Add 50 cm^3 of water to a second beaker and place the second bone in this beaker as a control.
4. Change the acid and water in each beaker every day for a week, ensuring the same volume of water and acid is used each time.

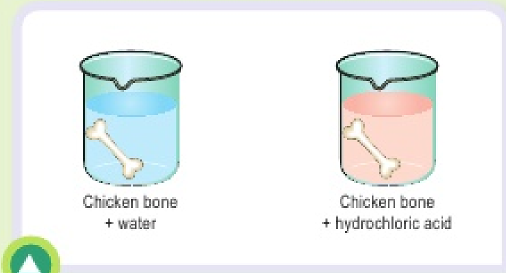


Figure 7.13 *Testing for the presence of inorganic material in bone*

5. Use tongs to remove the bone from the acid and rinse with water. Repeat for the control.
6. Reweigh both bones.
7. Test each bone for flexibility by bending it.
8. Record your results in a table similar to Table 7.1.

Table 7.1 Result

Bones	Initial mass	Final mass	Difference in mass	Flexibility test
Bone A (acid)				
Bone B (water)				

Q Understanding U1 Research R5

7.9 What can you conclude from Part A of the experiment about
(a) the amount of organic material in bones?
(b) its function in the bone?

Conducting the activity

Part B

1. Weigh a fresh, clean chicken bone.
2. Using tongs, hold the chicken bone in the flame of a Bunsen burner.
3. Reweigh the bone every 5 minutes and record its mass.
4. When the mass of the bone does not change, remove the bone from the flame.
5. Weigh the bone again and record its final mass.
6. Using the initial mass and final mass, calculate the mass of organic matter than was removed from the bone by burning.
7. When the bone has sufficiently cooled, test it for flexibility.

Figure 7.14 *Testing for the presence of organic material in bone*

Table 7.2 Result

Bone	Initial mass	Final mass	Difference in mass	Flexibility test

Q Understanding U1 Research R5

7.10 Part B of this activity removes organic matter which performs what function in the bone?

Muscular problems and problems of posture

Aspects of modern sedentary lifestyle where people sit all day at work and get very little exercise, and not giving sufficient attention to our posture when sitting or standing can lead a range of health problems.

A lack of physical activity can cause muscle structures in the body to gradually weaken and the metabolism to change so that weight is gained more quickly. High levels of inactivity are more likely to lead to cardiovascular problems and have been linked with the progression of bone diseases such as osteoarthritis.

Good posture is important because it allows us to sit or stand with minimal effort and without putting strain on our bodies, avoiding stiffness. Poor posture is usually caused by sitting or standing in a slouched position.

Did you know?

Looked at from behind your spine should look like it runs in a straight line but viewed from the side, it should have natural curves.

When the spine is not in the correct position some muscles will become tight and others will stretch leading over a long period of time to joints in the spine and ribs becoming stiff.

Figure 7.15

Your neutral spine position is what you need to find to sit with good posture. You can find this position in three simple steps.

Step 1: Sit and move your hips and pelvis forwards.

Step 2: Then move them backwards.

Step 3: Stop in the mid position as you feel all of your weight going through your sitting bones.

It is important to adjust your workstation and position of your chair to be able to sit in this position.

Figure 7.16

Walking

7.11 Work in groups and model the different phases of walking. Can you put the five phases of walking shown below in order?

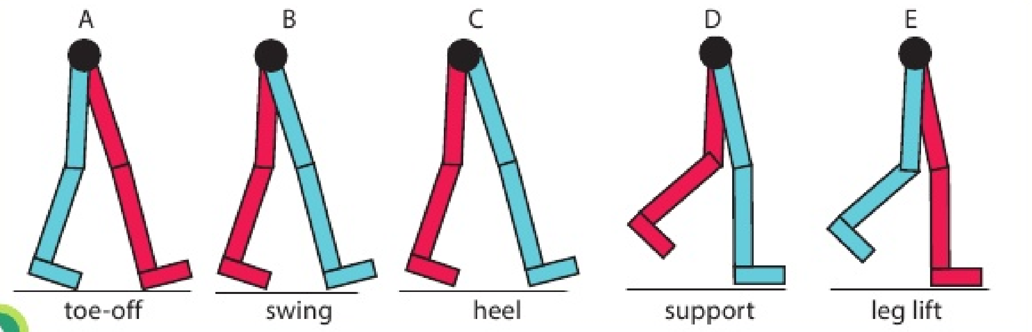


Figure 7.17

Good standing posture again involves standing with the spine in neutral position. You can check this by standing sideways in a mirror.

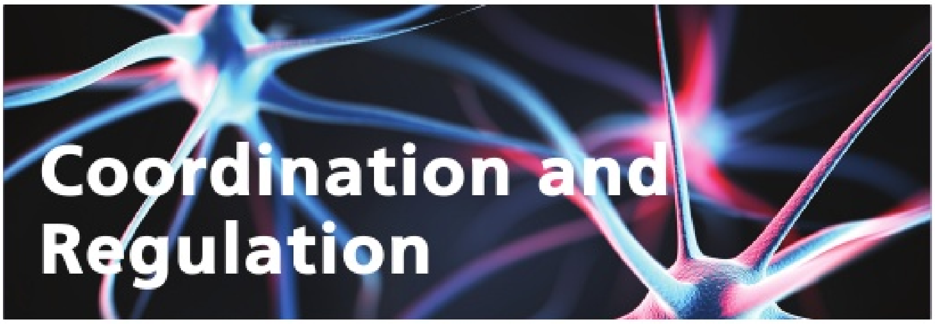
With your spine in neutral position and your breastbone gently raised, bring your shoulders back and down a little. You should find that:

- your weight is spread evenly through both feet
- your ankle, knee, hip and tip of your ear are in line
- your shoulders are back and relaxed

7.12 Research online the condition called 'flat feet'. What kinds of bone and posture problems can it lead to?

7.13 Can you identify an antagonistic pair of muscles involved in walking movement?

MODULE 8



Coordination and Regulation

Learning outcomes

At the end of this module you will be able to:

- Investigate features of visual perception and describe good eye-care habits 8.1.7.1
- Investigate features of auditory perception and describe ways to look after your hearing 8.1.7.2
- Explain the structure and functions of visual and auditory receptors 8.1.7.3
- Describe the location of the endocrine, exocrine and mixed glands 8.1.7.4
- Explain the basic functions of the glands 8.1.7.5
- Describe diseases related to the pancreas and thyroid 8.1.7.6
- Investigate the sensitivity of skin 8.1.7.7
- Describe the role of skin in maintaining constant body temperature in warm-blooded animals 8.1.7.8

Keywords

✔ stimulus ✔ response ✔ neuron ✔ spinal cord ✔ optic nerve
✔ lens ✔ pupil ✔ retina ✔ iris ✔ cochlea ✔ eardrum ✔ ossicles
✔ auditory canal ✔ pancreas ✔ thyroid ✔ insulin ✔ endocrine
✔ hormone ✔ epidermis ✔ receptors

Our sensory system makes us aware of what is happening in and around us. It also allows us to respond to these changes.

Our sense organs provide us with information about our surroundings. Our nervous system processes this information and allows us to respond in a suitable manner.

Stimulus and Response

Anything in our surroundings that causes us to take an action is called a **stimulus** (plural stimuli). The action we take is called a **response**.

- For example, the sound of a car horn is a stimulus. Our response might be to jump out of the way of the car.

Sense organs

Our sensory system is made up of five senses. Each sense is associated with a different sense organ, as shown in Figure 8.1.

Sense	Organ	Stimulus
Touch	Skin	Touch and ___________________
Taste	Tongue and lining of the throat	_______________ (salty, sweet, bitter)
Smell	Nose	
Sight	Eyes	
Hearing	Ears	

Figure 8.1 *Senses and sense organs*

Q Understanding U1

8.1 Complete the table above with:

(a) chemicals in gas state

(b) light

(c) temperature

(d) sound

(e) dissolved chemicals

The central nervous system

The central nervous system consists of the brain and the spinal cord.

- The brain is a complex structure containing many millions of nerve cells. Nerve cells are also called neurons.
- The spinal cord contains many nerves which take messages to and from the brain.

The rest of the nervous system contains nerves which run to and from the central nervous system.

Sense organs and the central nervous system

- Nerves carry messages from sense organs to the brain. In this way, the sense organs allow us to gather information from our surroundings. Messages travel along nerves as electrical impulses.
- When the brain receives information from the sense organs it makes sense of the message, memorises it and decides on the correct response.
- The brain then sends a message along different nerves to a muscle (or a group of muscles). In this way, the brain causes us to respond to a stimulus.

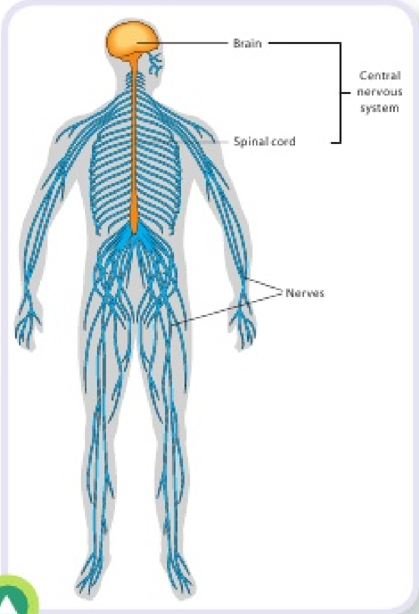


Figure 8.2 *The nervous system*

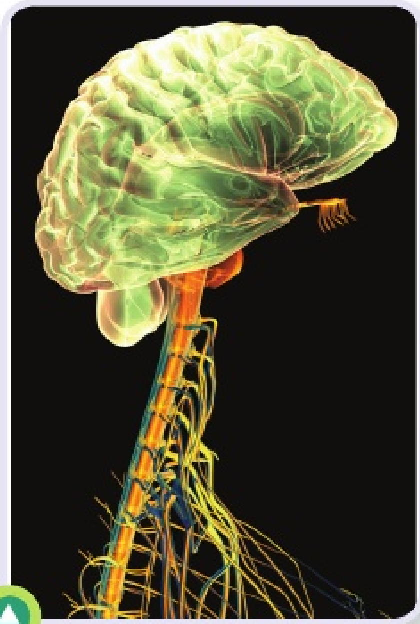


Figure 8.3 *The brain and spinal cord (with nerves attached to it)*

Q Understanding U1

8.2 The processes that take place when we see, smell, taste, etc. are written below, but not in the correct order.

- **(a)** The brain determines the response.
- **(b)** The message causes a muscle to respond.
- **(c)** A sense organ is stimulated.
- **(d)** A message passes down the spinal cord.
- **(e)** A message passes to the brain.

Put them in the correct order.

Responding to a stimulus

When pouring a cup of tea, the eye detects that the cup is almost full of tea. This is the stimulus. A message is sent along a nerve from the eye to the brain.

The brain decides to stop pouring tea. It sends a message along another nerve, down the spinal cord and out to muscles in the arm or hand. We respond by raising the teapot.

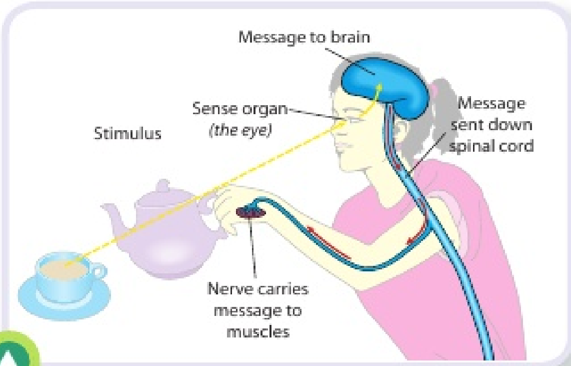


Figure 8.4 *Responding to a stimulus*

Sensory and motor nerves

There are two types of **neurons** or nerve cells: sensory and motor nerve cells. Sensory nerves carry messages to the brain or central nervous system.

This means that sensory neurons carry impulses from the sense organs **towards** the brain. Sensory neurons make our central nervous system aware of a stimulus.

Motor nerves carry messages **away from** the brain. A motor nerve carries a message away from the brain or central nervous system to a muscle. Motor nerves (or neurons) cause us to carry out a response.

Figure 8.5 *The brain*

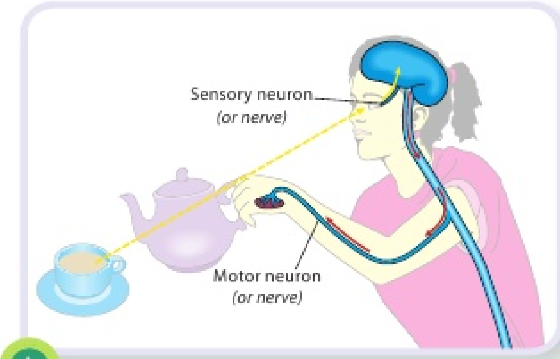


Figure 8.6 *Sensory and motor neurons*

Q U1 Understanding

8.3 Traffic lights turning red are an example of a __________. The response to the red lights should be to __________ the car.

8.4 What is the main difference between sensory and motor nerves?

The eye

The functions of the parts of the eye

Iris

The iris is the coloured part at the front of the eye. Its function is to expand or contract to control the amount of light entering the eye.

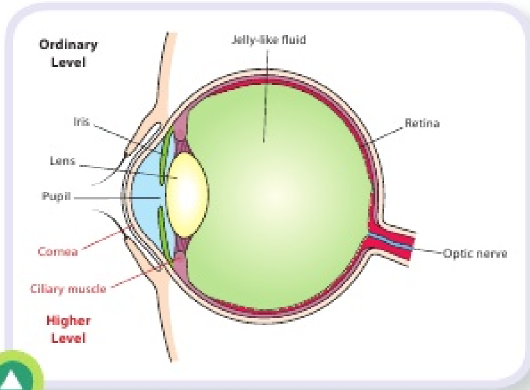


Figure 8.7 *The structure of the eye*

Pupil

The pupil is the black circle in the middle of the iris. Its function is to allow light to enter the eye. The pupil changes size due to changes in the iris.

In bright light, the pupil is small (to prevent too much light entering the eye). In dim light, the pupil enlarges (to allow more light into the eye; see Figure 8.8).

Light passes into the eye through the pupil. All the light is absorbed by the retina. No light is reflected out of the pupil. As a result, the pupil appears black.

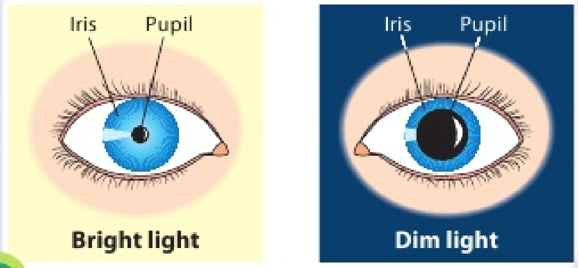


Figure 8.8 *The effect of light on the pupil*

Lens

The lens is a flexible structure. It changes shape depending on whether we are looking at a near or a far object. The function of the lens is to focus light on the retina.

If the lens does not take up the correct shape the object we are looking at will appear blurred. In such cases, glasses or contact lenses are needed to allow us to see clearly.

Retina

The retina is a light-sensitive layer at the back of the eye. It contains millions of cells which are sensitive to light. The function of the retina is to absorb light and to allow us to see.


Figure 8.9 *Section through a human eye*

Optic nerve

The optic nerve carries messages from the eye to the brain. It provides the link between the eye and the central nervous system.

Cornea

The cornea is a transparent section of the covering of the eye. The function of the cornea is to allow light to pass into the eye.

Ciliary muscle

The ciliary muscle surrounds the lens. The ciliary muscle contracts or relaxes to cause the lens to change shape.

Q Understanding U1

8.5 Rewrite the following table to match the parts of the eye with their functions.

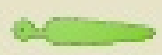
Part of eye	Function
Retina	Lets light into eye
Iris	Carries message to the brain
Lens	Controls light entering the eye
Pupil	Absorbs light
Optic nerve	Helps from a clear image on the retina

Rods and Cones

Light receptors (rods and cones) are located on the retina. Cones are found mostly in an area of the eye called the fovea (see Figure 8.10). It is the region of sharpest vision and it is here that most images are focused. When we stare at or concentrate on an object its image forms on the fovea.

Figure 8.10 The fovea (blue) appears as a pit in the retina

Table 8.1 Comparison of rods and cones

Rods	Cones
	
120 million per eye	6 million per eye
Detect black and white	Detect colours (red, green, blue)
Work in dim light	Work in bright light
Found all over retina	Found mostly at fovea

Q U1 Understanding

8.6 **(a)** Name the parts labelled A, B and C.

(b) What is the evidence that this eye is adapted to dim light?

(c) Draw a similar diagram to show how this eye would appear in bright light.

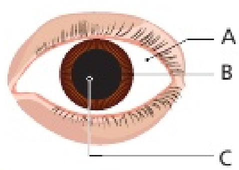


Figure 8.11 The front view of an eye

R2 R3 R4 Research — Portfolio 66

Activity 8.1

Question

How the eye perceives colour?

Equipment needed

Colour slide presentation

Conducting the activity

1. Follow the projected presentation of the colour slides.
2. Note down which colours are seen by other members of your group.

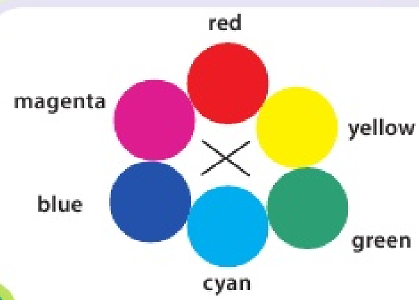


Figure 8.12

3. At the end of the presentation, discuss the results in your group.

Q U4 Research

8.7 Can you explain the results?

8.8 Your teacher will now explain about three kinds of colour receptor in the retina. How does this fit with your observations in the experiment above?

Caring for your eyes

Eat a well-balanced diet:

Obesity is linked to type-2 diabetes, which is a leading cause of blindness in adults.

Wear sunglasses:

Choose a pair that blocks out 99% to 100% of UVA and UVB rays and never stare directly into the sun.

Wear safety eyewear or goggles:

Always wear goggles or protective eyewear when working with chemicals and power tools or playing sports like ice hockey.

Look away from the computer screen:

Rest your eyes every 20 minutes and look 20 feet away for 20 seconds. Get up at least every 2 hours and take a 15-minute break.

Visit an eye doctor regularly:

Young children and adults need regular eye tests to check for nearsight, farsight, astigmatism (a curved cornea that blurs vision) and any other eye conditions.

The ear

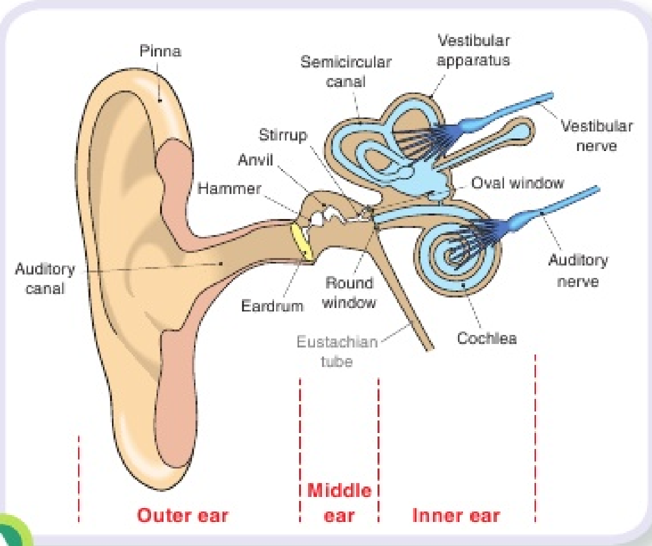


Figure 8.13

Did you know?

According to the World Health Organisation, over one billion teenagers and young adults could develop hearing problems because of their use of personal audio devices.

Outer ear

The outer ear is filled with air.

- The **pinna** is made of cartilage. It collects vibrations in the air and channels them into the ear.
- The **auditory canal** carries vibrations to the eardrum.
- The **eardrum** is a tightly stretched membrane that vibrates when stimulated by vibrations in the auditory canal.

Middle ear

The middle ear is filled with air.

- The **ossicles** are three bones called the hammer, anvil and stirrup. The stirrup is the smallest bone in the body. They increase (amplify) the vibrations and pass them on to the oval window.
- The **Eustachian tube** is not really part of the ear. It is a tube that connects the middle ear to the pharynx (or throat). Its function is to equalise pressure on either side of the eardrum.

Inner ear

The inner ear is filled with a fluid called lymph.

Cochlea

The **cochlea** is a spiral tube similar to a snail's shell. Its function is hearing.

- Vibrations pass into the lymph in the cochlea through a membrane called the oval window.
- As the vibrations pass along the cochlea they stimulate pressure receptors that form a layer called the organ of Corti in the cochlea.
- Impulses pass from these receptors to the cerebrum along the auditory nerve.

Vestibular apparatus

The **three semicircular** canals are all at right angles to one another. They form part of a structure called the vestibular apparatus. Their function is balance.

- Receptors in the semicircular canals detect when our head is not upright or when it is rotating.
- The receptors send impulses to the cerebellum of the brain through the vestibular nerve.

Q Understanding U1

8.9 **(a)** State two functions of the ear.
(b) Name the parts of the inner ear associated with balance.
8.10 What is connected to the middle ear by the Eustachian tube?
8.11 What is the function of the Eustachian tube?

R2 R3 R4

Activity 8.2

Question

Can we show how sound is perceived by the ear?

Equipment needed

Wire coat-hanger String

Figure 8.14 *Metal coat hanger*

Figure 8.15 *Ball of string*

Conducting the activity

1. Tie the centre of a 1m length of string to the hook of a wire coat-hanger.
2. Wrap each end of the string around your index fingers.
3. Place your hands over each ear.
4. Now lean forward and tap the coat-hanger against a table and note what you hear.
5. Compare what you heard with other members of your group.

Q U1 R5

8.12 How do you explain how the intense sound was perceived by your ears?

Caring for your ears

Use earplugs around loud noises:

Wear earplugs when around dangerous levels of sound such as at clubs, concerts or when using lawnmowers or chainsaws.

Turn the volume down:

It is recommended that you listen at 60% volume for only 60 minutes a day and wear over-the-ear headphones.

Do not insert anything into your ear canal:

The ears are self-cleaning organs and wax prevents dust and other harmful particles from entering the ear canal.

Keep ears dry:

Excess moisture can allow bacteria to enter and attack the ear canal causing ear infections such as 'swimmer's ear'. Gently towel-dry ears after bathing or swimming.

Get moving:

Cardio exercises like walking, running and cycling get the blood pumping to all parts of the body and keep the ears healthy.

Go for regular check-ups:

Hearing loss can develop gradually so regular hearing consultations are recommended. Hearing loss has been linked to other health problems such as depression, dementia and heart disease.

Nervous and endocrine coordination

There is a second system in addition to the nervous system that is used to co-ordinate body responses. This is called the endocrine (hormonal system).

Table 8.2 Comparison of the nervous and endocrine systems

Feature	Nervous system	Endocrine system
Example	Catching an object	Growth
Speed of response	Fast-acting	Slower-acting
Method by which messages are carried	Mostly electrical	Chemical
Duration of response	Short-lived	Long-lasting
Location affected	Localised (i.e. one effector reacts)	Effects may be widespread

Glands

Glands are structures that secrete substances. There are two types of gland: exocrine and endocrine.

Exocrine glands release their product into ducts or tubes.

Examples of exocrine glands include salivary glands, sweat glands, tear glands in the eye, gastric glands in the stomach, sebaceous glands in the skin and mammary glands in the breasts.

An **endocrine gland** is a ductless gland that produces hormones, which are released directly into the bloodstream.

Endocrine glands secrete hormones into tissue fluid and from there the hormones pass into the bloodstream. For this reason endocrine glands have a rich supply of capillaries, because their hormones are transported by the blood.

Q Understanding U1

8.13 Distinguish between the nervous and endocrine systems in terms of:
- **(a)** Speed of action
- **(b)** Method by which the message is carried
- **(c)** Duration of effect
- **(d)** Areas affected.

8.14 Distinguish between exocrine and endocrine glands, giving two examples of each type.

Hormones

Although hormones are carried to all parts of the body in the bloodstream, they affect only specific areas, called target tissues or organs. Hormones are sometimes said to be chemical messengers.

Most hormones are made of **protein**. However, some hormones are steroid-based (especially male and female reproductive hormones). A steroid is a form of lipid.

Did you know?

A hormone is a chemical messenger produced by an endocrine gland and carried by the bloodstream to another part of the body, where it has a specific effect.

Hormones are usually slow to act. For example, sex hormones may take many years to cause all the changes that occur during puberty. Once produced, however, hormones remain active for long periods of time. Hormones are said to be slowacting but sustained in their effects.

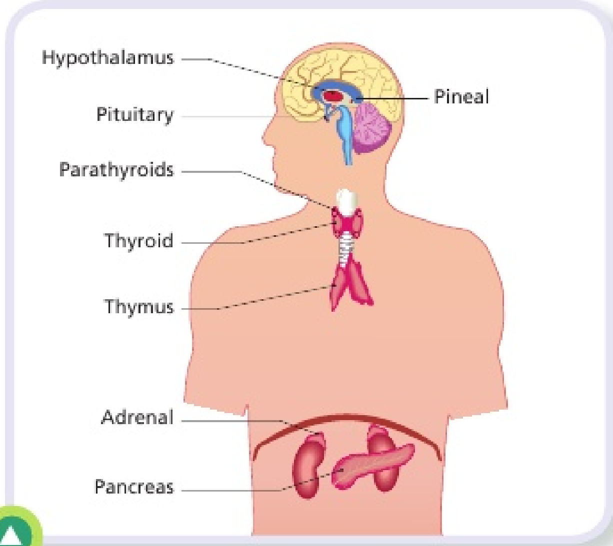


Figure 8.16 *Some of the main endocrine glands*

Role of principal endocrine glands

Pituitary

The pituitary is often called the master gland. This is because it produces a range of hormones that regulate other endocrine glands.

- Among a range of other hormones produced by the pituitary gland is **growth hormone (GH)**. This causes body cells to absorb amino acids and form proteins. In this way it causes growth. In particular, it causes the elongation of the bones of the skeleton.

Figure 8.17 *Robert Wadlow (died 1940) was the tallest person ever, at 8 feet 11 inches (2.7 m): he had an overproduction of growth hormone*

Hypothalamus

The hypothalamus links the nervous and endocrine systems. It secretes hormones that control the pituitary gland in response to messages from the brain and other hormones.

- An example of a hormone produced in the hypothalamus is **anti-diuretic hormone (ADH)**. This hormone is then stored in the pituitary and released from there when needed. ADH causes water to be reabsorbed in the kidneys (it controls osmoregulation).

Pineal

The pineal is a tiny gland located within the brain. It was once thought to be the site of the soul.

- It produces a number of hormones, the best known of which is **melatonin**. This hormone is mainly produced when we are asleep. The function of melatonin is not fully understood, but it seems to be involved in biological rhythms such as ovulation, sleep, activity patterns and sexual maturity.

Thyroid

The thyroid is an H-shaped gland located on the trachea in the neck.

- It produces the hormone **thyroxine**. This is made when an amino acid (tyrosine) combines with iodine. Thyroxine controls the rate of all the body's reactions, i.e. it controls metabolism.

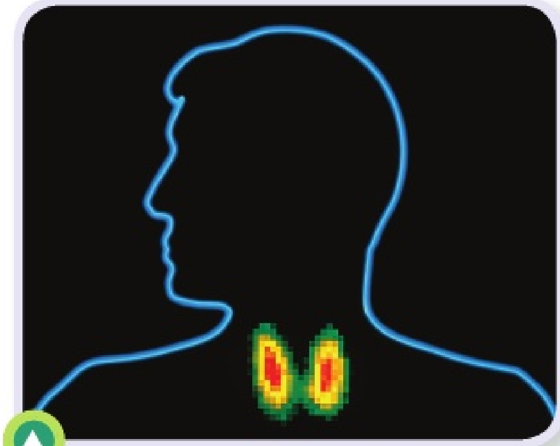


Figure 8.18 *Scan of a normal thyroid gland*

Thyroxine deficiency

Symptoms

Underproduction of thyroxine in young children results in low metabolic rates and retarded mental and physical development. This condition is called cretinism.

Deficiency of thyroxine in an adult results in a reduced metabolic rate. This is seen as tiredness, lack of energy, slow mental and physical activity and weight gain caused by the build-up of fluid under the skin. These symptoms are collectively called myxoedema. Deficiency of thyroxine also causes the thyroid gland to swell, a condition known as goitre.

Corrective measures

Newborn babies are tested for low thyroxine levels as part of what is called the 'heel test'. If necessary, thyroxine can be administered to prevent the occurrence of cretinism. In adults, thyroxine tablets or iodine can be taken to prevent myxoedema.

Thyroxine excess

Symptoms

Overproduction of thyroid hormone results in an increased metabolic rate (often 60% higher than normal). This causes symptoms such as bulging eyes, hunger, loss of weight, heat production, nervousness, irritability and anxiety. The metabolic condition is called Graves' disease.

Corrective measures

Graves' disease can be cured by surgically removing part of the thyroid or by killing part of the gland using radioactive iodine.

Goitre

Goitre normally indicates the underproduction of thyroxine. This is usually caused by a lack of iodine in the diet (sources of iodine are seafood and iodised table salt). A low concentration of thyroxine in the blood causes the pituitary to produce TSH. TSH is carried by the blood to the thyroid.

Normally TSH combines with iodine in the thyroid to produce thyroxine. However, if this cannot happen (due to a shortage of iodine) then TSH is stored in the thyroid. This causes the thyroid to swell, causing goitre. This form of goitre can be treated by increasing the intake of iodine in the diet.

Q Understanding U1

8.15 In the case of the thyroid:
- **(a)** Name a hormone it secretes.
- **(b)** Give the function of this hormone.
- **(c)** Name two disorders associated with abnormal activity of this gland.
- **(d)** Give three symptoms for each disorder.
- **(e)** Suggest a correction for each disorder.

8.16
- **(a)** Name two substances needed to produce thyroxine.
- **(b)** What hormone causes thyroxine to be produced?
- **(c)** Where is the hormone you have named in **(b)** produced?

Figure 8.19 *Goitre is an enlargement of the thyroid gland*

Pancreas

The pancreas is both an exocrine and an endocrine gland.

Exocrine function

The bulk of the pancreas cells produce enzymes (such as amylase). These flow to the duodenum through ducts. In this respect, the pancreas is an exocrine gland.

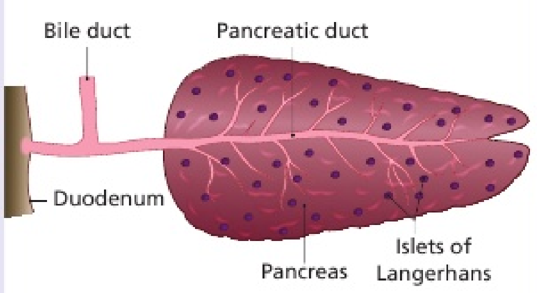


Figure 8.20 *The pancreas*

Endocrine function

The pancreas also contains about a million groups of cells called **islets of Langerhans** (after the German biologist Paul Langerhans).

These cells produce the hormone **insulin**, which is carried away by the bloodstream. In this respect, the pancreas (or the islets of Langerhans) is an endocrine gland.

Insulin is a vital hormone, because it is the only hormone that reduces blood glucose levels. It causes cells, especially muscle and fat cells, to absorb glucose from the blood. The absorbed glucose is either used in respiration or converted to glycogen. Glycogen is mostly stored in the liver and muscles.

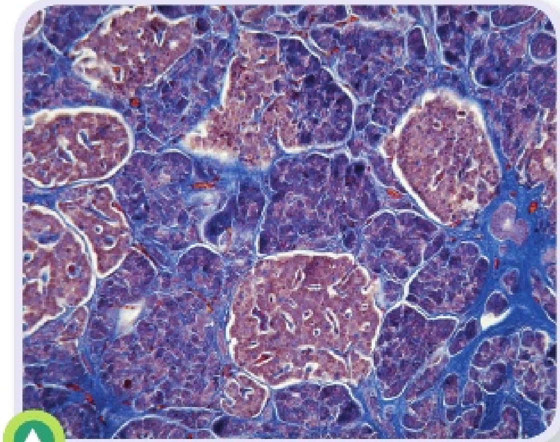


Figure 8.21 *Islets of Langerhans in the pancreas*

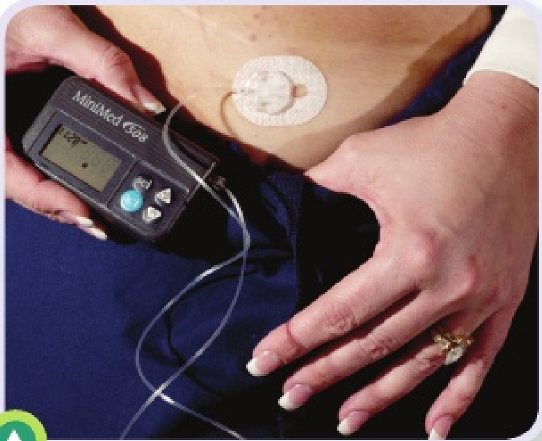


Figure 8.22 *An insulin pump*

Hormone supplements

Insulin

Low insulin production, or an inability of cells to take up insulin, results in a disorder called diabetes. If this develops in young people, it is normally caused by the failure of the islets of Langerhans in the pancreas to work properly. The symptoms of diabetes are high glucose concentration in the blood and urine, the production of large amounts of urine, severe thirst, loss of weight and tiredness.

Severe diabetes is controlled by regular (between one and four times daily) **injections** of insulin. Alternatively an insulin pump can be used, which reduces the need for frequent injections. In addition to injections or a pump, the intake of carbohydrate needs to be controlled, physical activity increased and normal weight maintained.

Insulin cannot be taken into the digestive system, because it is a protein and would be broken down by digestive enzymes.

Q Understanding U1

8.17 State a biological reason for each of the following:

- **(a)** Taking extra iodine in the diet.
- **(b)** Testing newborn babies for thyroxine levels.
- **(c)** Testing urine samples for glucose.
- **(d)** Insulin is not taken in tablet form.
- **(e)** Endocrine glands have rich blood supplies.
- **(f)** Diabetics often carry a sugar sweet or some chocolate.

Skin

The structure of the skin is shown in Figure 8.23.

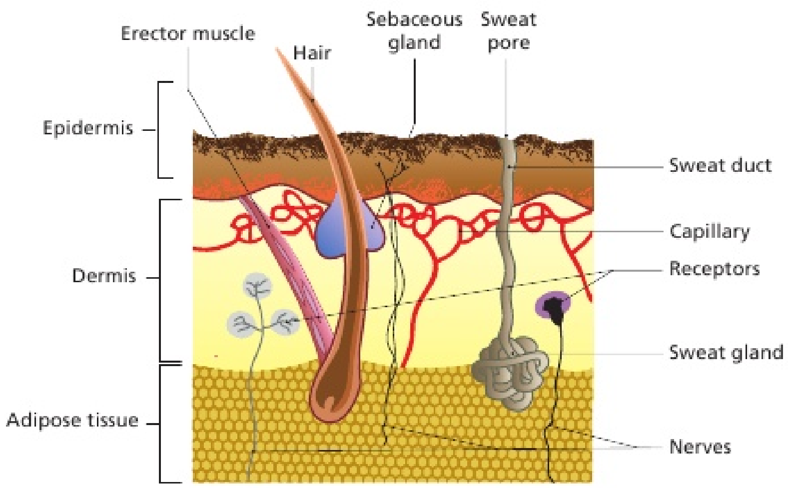


Figure 8.23 *Vertical section (VS) of skin*

The skin contains receptors for pain, touch and temperature. These receptors are found in different concentrations in skin at various locations around the body. For example, there are few touch receptors in the skin at the heel of the foot, but there are many temperature receptors at the elbow which is why the elbow is often used when testing the temperature of a baby's bath.

Functions of the skin

Protection

- The **epidermis** protects the body from damage and acts as a barrier to prevent the loss of water and the entry of pathogens.
- The **dermis** protects internal organs from damage due to bumps and bangs.
- **Melanin** protects the skin from ultraviolet radiation (which can cause skin cancers).
- **Sebum** is an oil produced by sebaceous glands that are located alongside hair follicles. It passes out of the hair follicle and onto the epidermis. Sebum keeps hair moist and flexible and also prevents the skin from drying up and becoming cracked. For this reason sebum can be considered to protect the body.

Did you know?

Sebaceous glands are especially concentrated on the face and scalp of humans. At puberty excessive production of sebum, due to hormonal influences, may cause acne.

Temperature regulation

Cold conditions

In cold conditions, the skin helps to retain heat in two ways.

- Erector muscles contract (forming goose bumps). This causes the hairs to stand up on the skin. A layer of warm air is trapped close to the skin by the hairs. This air helps to reduce heat loss from the body.
- Blood vessels in the skin contract when we are cold. This reduces heat loss through the skin.

A third mechanism also helps us to maintain our temperature in cold conditions. A part of the brain responds to low blood temperature by causing muscles throughout the body to contract and relax very rapidly. This results in shivering, which produces heat to raise our temperature.

Note that fat stored under the skin insulates the body from heat loss.

Did you know?

Many animals produce large amounts of insulating fat, e.g. seals, polar bears and water birds such as ducks. This is why duck meat is very fatty.

Warm conditions

In warm conditions, the skin acts in two ways to reduce our temperature.

- Sweat is produced and released onto the skin. When the water evaporates it lowers our body temperature. At normal room temperature we can lose as much as one litre of sweat in a day. In hot weather and during exercise, the loss of water and salts in the form of sweat is much greater. It is important to drink water and salts before, during and after exercise to maintain the salt/water concentration of the body. Salt tablets are often taken before competing in sports events in very warm weather to replace salt that will be lost in sweat.

- When we are too hot, blood vessels in the skin (especially in the face) expand (or dilate). This increases heat loss through the skin and reduces body temperature. This is why we turn red in the face after exercise.

Did you know?

Our temperature also rises when we are embarrassed; we then try to cool down by opening blood vessels in our face, which causes blushing.

Q U4 (Understanding)

8.18 Give a biological reason for each of the following:

(a) We shiver when we are cool.
(b) We blush when we are embarrassed.
(c) Whales have a lot of blubber.
(d) We sweat heavily after exercise.
(e) A boxer is fanned with a towel between rounds.

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Activity 8.3

Question

Is the skin more sensitive in some areas of the body?

Equipment needed

A number of consenting volunteers
Three toothpicks
Blu-tack

Safety

- Do not press the toothpicks too hard.

Conducting the activity

1. Place two toothpicks in one ball of blu-tack and one toothpick in the other.
2. Ask the volunteers to close their eyes
3. Touch the volunteers arm lightly with either the one or two toothpicks between five and eight times randomly asking each time how many toothpicks they can feel. The two toothpicks should be at least 5 cm apart at the beginning of round of the experiment.
4. Follow this by just using the two toothpicks, each time moving the toothpicks closer together. Ask each time how many toothpicks the volunteer can feel.
5. A point will be reached where the volunteer can only feel one toothpick.
6. At this point measure the distance between the two toothpicks.
7. Record your results in the table.

Area of the body	Distance between toothpicks
Arm	
Hand	
Index finger	
Base of foot	
Elbow	
Heel	
Back of neck	

Q R1 R5 (Research)

8.19 Why did you randomly touch the volunteer with one or two toothpicks at the start of each round?

8.20 What can you conclude from your results?

MODULE 9

Reproduction in animals and plants

Learning outcomes

At the end of this module you will be able to:

- Explain the significance of mitosis and meiosis for living organisms 8.2.2.1
- Compare sexual and asexual reproduction in animals 8.2.1.1
- Explain different features of plants that reproduce sexually and asexually 8.2.1.2
- Explain features in the lifecycle of different varieties of plants 8.2.1.3
- Explain the role of heredity and variation in evolution 8.2.4.1
- Describe the importance of artificial selection in selective breeding and crossbreeding 8.2.4.2
- Present information about the centre of origin of cultivated plants 8.2.4.3
- Research important varieties of cultivated plants and livestock breeds in Kazakhstan 8.2.4.4

Keywords

✔ mitosis ✔ meiosis ✔ asexual and sexual reproduction ✔ gametes ✔ zygote ✔ fertilisation ✔ genes ✔ chromosomes ✔ sepals ✔ carpel ✔ stamen ✔ stigma ✔ pollination ✔ dispersal ✔ germination ✔ natural selection ✔ adaptation ✔ selective breeding

Cell division

All cells develop from previous cells. Cells are made up of chromosomes and chromosomes are made up of genes. Every species has a definite number of chromosomes in the cell – humans have forty-six chromosomes in each body cell – and each chromosome is composed of hundreds, or even thousands, of genes.

In humans, genes control features such as eye colour, the shape of the face and something like another 20,000 features. In plants, genes control petal colour, leaf shape, fruit taste and a whole lot more.

Mitosis

Mitosis is a cell division process where one nucleus divides to form two nuclei, each containing the same number of chromosomes with identical genes.

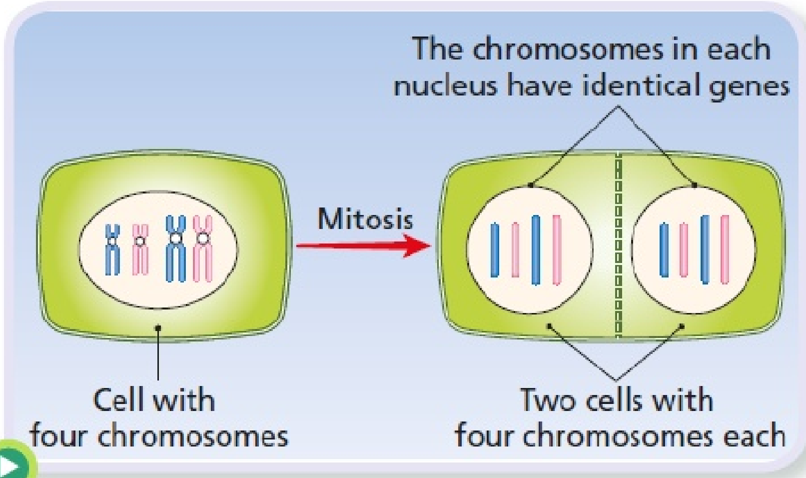


Figure 9.1

In single-celled (unicellular) organisms mitosis increases the number of individuals and is used as a method of reproduction. This happens with organisms such as bacteria.

In many-celled (multicellular) organisms mitosis is responsible for **growth and repair of cells**. In these organisms mitosis produces new cells, not new individuals.

Mitosis is responsible for the single-celled zygote growing into an embryo.

Even when a person is fully grown, mitosis is essential to replace old and damaged cells. This is seen when new blood cells are produced, when skin damaged by a cut is repaired or when torn muscles are healed.

Mitosis is also responsible for growth and repair in plants.

Meiosis

Meiosis is a form of cell division in which the new cells formed have half of the chromosomes of the cell that formed them. Most human cells have 46 chromosomes. Meiosis occurs in the ovaries and testes to produce gametes called eggs and sperm. As a result of meiosis, there are 23 chromosomes in each egg or sperm.

Meiosis has two basic functions in multi-cellular organisms. It allows for sexual reproduction and it allows for new combinations of genes to be formed, which leads to variation among organisms.

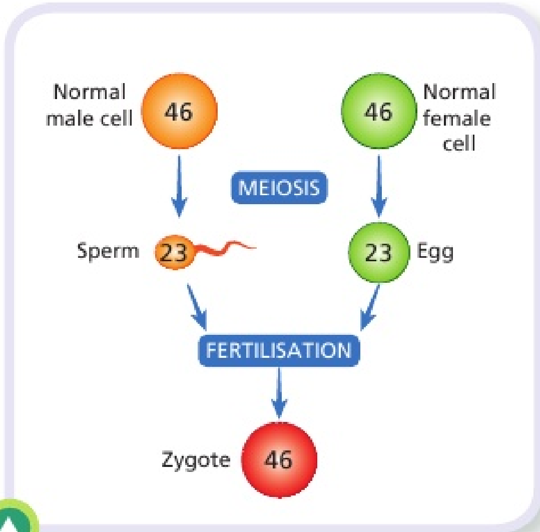


Figure 9.2 *Meiosis and fertilisation in humans*

Q Understanding U2

9.1 In which type of cell division does one cell make an identical copy of itself?

9.2 In human reproduction, how many chromosomes does the egg get from the parent cell?

9.3 What are the two functions of mitosis?

Reproduction

The formation of new living things is called reproduction. This is one of the characteristics of living things. There are two types of reproduction, asexual and sexual:

- **Asexual reproduction** is the formation of living things from one parent cell only.
- **Sexual reproduction** is the production of living things by combining cells from two parents.

Asexual reproduction

Asexual reproduction happens when one cell splits into two, or when one organism divides to form two or more living things. Asexual reproduction does not require sex cells to join together, i.e. it does not require fertilisation.

In asexual reproduction the offspring are identical to the parent cell. An example of this in animals occurs in aphids in spring: only females are present in the population during this time, so an unfertilised egg develops into a female identical to its mother.

Q

9.4 Antibiotics are drugs that kill bacteria. Bacteria do not reproduce sexually. If you have a sore throat and the antibiotic is effective, why would you expect it to kill *all* the bacteria?

Examples of asexual reproduction

(a) Bacteria are single-celled organisms. When they divide they form two identical cells.

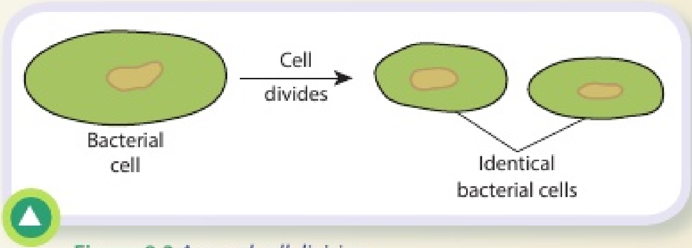


Figure 9.3 *Asexual cell division*

Figure 9.4 *A bacterium reproducing asexually*

(b) Strawberry (and buttercup) plants produce special stems (called **runners**), which grow overground from the base of the parent plant.
Some distance away from the parent plant, the runners form new plants, which are identical to the parent plant.

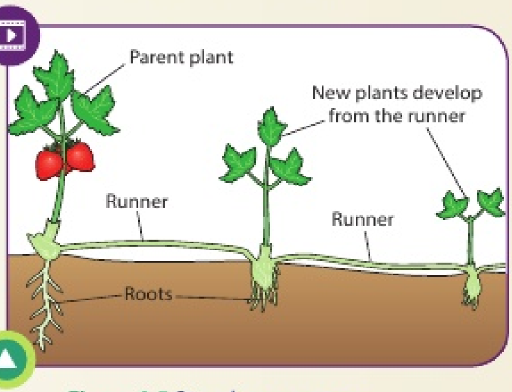


Figure 9.5 *Strawberry runners*

Figure 9.6 *Strawberry runners forming new plants*

Sexual reproduction in animals

Sexual reproduction involves two sex cells (called **gametes**) joining together to form a single cell (called a **zygote**).

Q U2 Understanding

9.5 What are the names of the gametes found in humans?

The joining or fusion of sex cells is called **fertilisation**.

Figure 9.7 *A sperm fertilising an egg*

As a result of sexual reproduction the offspring formed have features or characteristics of both parents. This means the offspring are **not** identical to the parents. This can be an advantage for the organism as the genetic combination inherited by the offspring of a pair of animals may be superior to that of either parent and they may be better adapted to the environment in which they live. This is the main benefit of sexual reproduction.

The most common way animals reproduce is by sexual reproduction. Plants can reproduce either sexually or asexually.

Q U2 Understanding

9.6 Would you expect bacteria to have gametes? Explain your answer.

9.7 Brothers (or sisters) may be very similar. However, they normally show some differences due to being formed by sexual reproduction. List five differences that are often visible between brothers or sisters.

9.8 What inherited differences might there be between dog pups from the same parents?

What is reproduction?

Reproduction is the production of new individuals.

Humans reproduce sexually. Sexual reproduction involves two parents. Each parent produces sex cells (also called **gametes**). The male gametes are the sperm. The female gametes are the eggs.

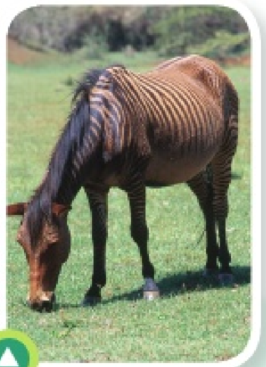


Figure 9.8 *A male zebra and a female horse produce a zorse*

U1 Understanding C1 Communicating

9.9 Figure 9.8 shows a zorse. This is the result of crossing a male zebra with a female horse.

- **(a)** Name the male and female gametes that form a zorse.
- **(b)** What structures in the gametes cause the zorse to have features of a horse and of a zebra?
- **(c)** While zorses are produced by sexual reproduction, they cannot reproduce (i.e. they are sterile). Give two other examples of sterile animals produced by crossing two different species?

Sexual reproduction in plants

The flower of a plant contains the structures needed for sexual reproduction.

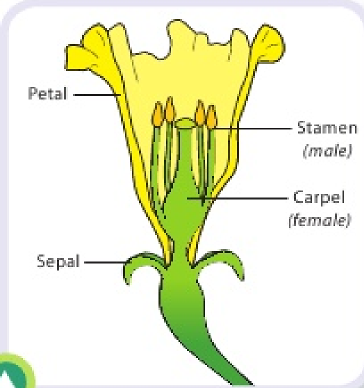


Figure 9.9 *The structure of a flower*

The functions of the parts of a flower

Sepals

The sepals protect the flower when it is a bud, i.e. before the petals open out and the flower blooms.

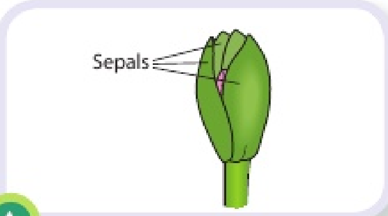


Figure 9.10 *Sepals protecting a bud*

Figure 9.11 *Sepals*

Petals

Petals protect the internal parts of the flower. In many plants, the petals are brightly coloured in order to attract insects to the flower.

Carpel

The carpel is the female part of the flower.

- Each carpel produces an egg cell.
- The nucleus of the egg is the female gamete.
- Some flowers have more than one carpel.

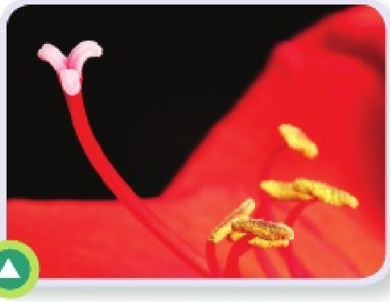


Figure 9.12 *Carpel and stamens*

Stamen

The stamen is the male part of the flower.

- The stamen produces pollen grains.
- The nucleus in the pollen grain is the male gamete.
- Most flowers have a large number of stamens.

Q U2 Understanding

9.10 Match the parts to their function in the box.

(a) petal
(b) carpel
(c) flower
(d) sepal
(e) stamen

Parts	Functions
	Forms female gametes
	Organ of sexual reproduction
	Forms pollen
	Protects the flower as a bud
	Attracts insects

Structure of the carpel

Stigma

The stigma is the place where pollen grains will land.

Style

The style connects the stigma to the ovary. In some plants the style is very short.

Ovary

The ovary contains one or more ovules. Each ovule produces an egg. The nucleus of the egg is the female gamete.

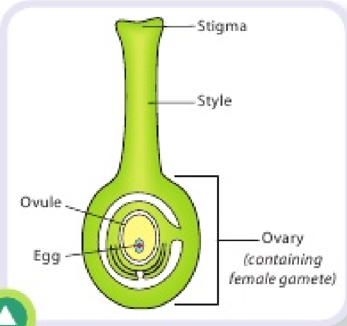


Figure 9.13 *The parts of a carpel*

Structure of the stamen

Filament

The filament is a stalk that supports the anther. It ensures that the anthers are located high up in the flower, so that the pollen can leave the flower more easily.

Anther

The anther makes pollen grains. The nucleus in each pollen is the male gamete.

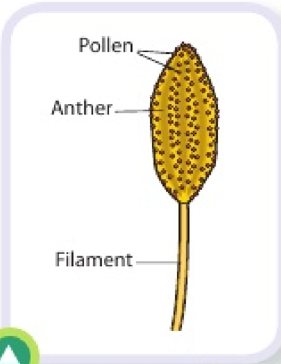


Figure 9.14 *The parts of a stamen*

Pollination

Pollination is the transfer of pollen from a stamen to a carpel. In order for sexual reproduction to take place the male gamete (located in the pollen) must reach the female gamete (located in the ovary).

Plants cannot move from place to place. As a result, plants depend on external agents to transfer the pollen to a carpel.

The agents used for **pollination** are wind and insects. Flowers have different features to adapt them for **wind** or **insect pollination**.

Figure 9.15 *Wind pollination*

Wind pollination

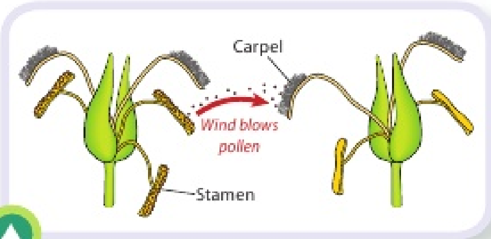


Figure 9.16 *Typical wind-pollinated flowers*

Insect pollination

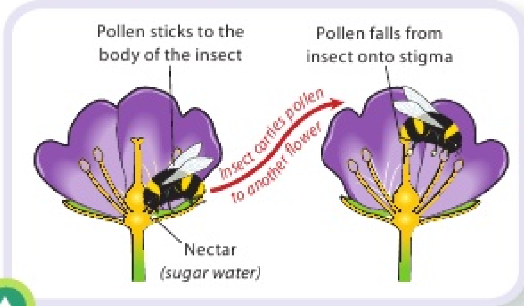


Figure 9.17 *Typical insect-pollinated flowers*

Fertilisation

Fertilisation occurs when the male and female gametes join to form a zygote. Pollen are carried by wind or by an insect to the top of the carpel. The pollen then forms a tube which grows down through the carpel.

The pollen nucleus passes down the pollen tube. It joins to the nucleus of the egg. **Fertilisation** takes place in the base of the carpel.

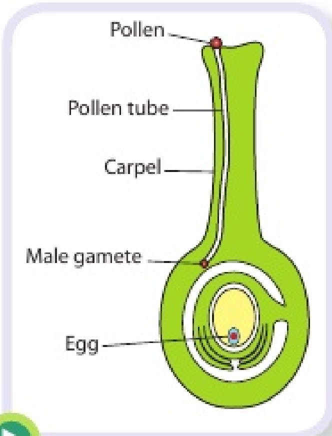


Figure 9.18 *The growth of a pollen tube*

Figure 9.19 *Pollen tubes*

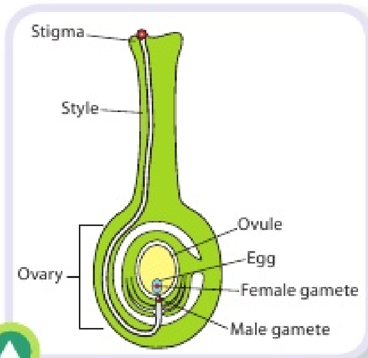


Figure 9.20 *The parts of the carpel just before fertilisation*

Fertilisation results in the formation of a single cell called a zygote. The zygote will grow to form a seed.

Q Understanding U2

9.11 **(a)** What is meant by fertilisation?

(b) Name the part of the flower in which fertilisation takes place.

(c) After pollination is completed, name the structure that allows the male gamete to get to the female gamete.

Seed structure

Once fertilisation is complete the ovule forms a seed. Each seed starts off as a zygote surrounded by a food supply.

The zygote grows to form a tiny plant called an embryo. The embryo consists of a plumule and a radicle.

- The plumule will form the future shoot of the plant.
- The radicle will form the future roots of the plant.

After fertilisation, the ovule swells with food (such as starch and oils). A hard, tough outer wall called the testa forms around the ovule. The testa forms the coat of the seed.

Figure 9.21 *Seed structure: note the embryo in the top right*

Fruit

The ovary forms the fruit which surrounds and protects the seeds.

- If the ovary had many ovules then the fruit will contain many seeds (often called pips), e.g. oranges and tomatoes.
- If the ovary contained only a single ovule then the fruit will contain only a single seed, e.g. peaches and plums (where the seed is called a stone).

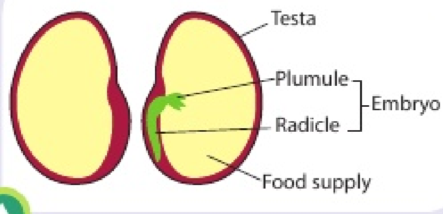


Figure 9.22 *The parts of a seed*

Seed (and fruit) dispersal

Dispersal is the carrying of the seed (and the surrounding fruit) as far as possible from the parent plant.

The main benefit of dispersal is that the young plants do not have to compete for scarce resources with the parent plant.

This means that dispersal reduces competition between the seedlings and the parent plant for light, space, water and minerals.

Plants use four main methods of seed dispersal: wind, animal, self and water dispersal.

Wind dispersal

Seeds that are wind dispersed are often small and light, e.g. orchid seeds.

Some wind-dispersed seeds are larger but have special devices so that the wind can carry them longer distances.

For example, dandelions have hairy tufts which act like parachutes. Ash and sycamore seeds have wings which allow them to spiral down like helicopters.

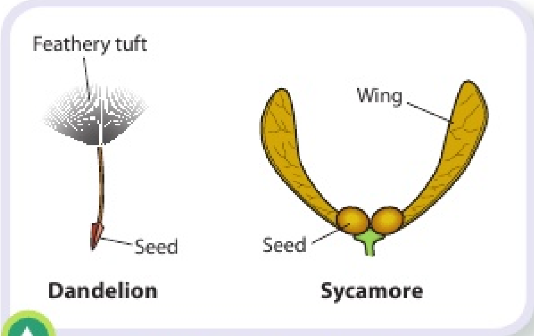


Figure 9.23 *Wind-dispersed seeds*

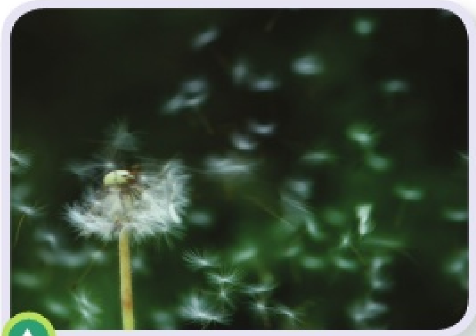


Figure 9.24 *Wind dispersal in a dandelion*

Animal dispersal

Animals such as birds, bats and squirrels disperse seeds in the following two ways:

- They swallow the fruits (and seeds). The fruit is digested and the seeds are passed out some time later, e.g. strawberries, blackberries and tomatoes.
- The fruits or seeds stick to the animal and are carried away to fall off later, e.g. burdock, cleavers and goose- grass.

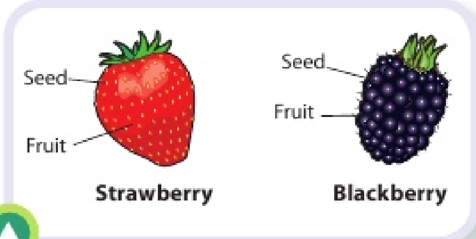


Figure 9.25 *Animal-dispersed seeds (edible)*

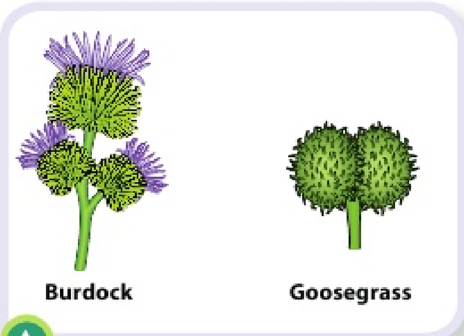


Figure 9.26 *Animal-dispersed seeds (sticky)*

Figure 9.27 *Animal dispersal: burdock has many fruits with hooks*

Self dispersal

Self dispersal usually involves the fruit (pod) bursting open when it is ripe. In this way, the seeds are flung away as far as possible, e.g. peas, beans, lupins and gorse plants.

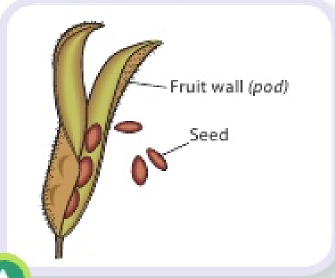


Figure 9.28 *Self-dispersed seeds*

Water dispersal

Some fruits or seeds are able to float. This allows them to be carried away by streams, rivers and ocean currents, e.g. coconuts, water lilies and alder.

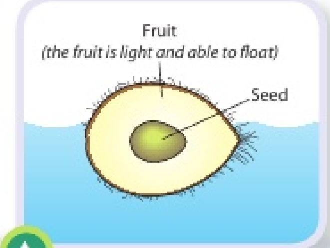


Figure 9.29 *Water dispersal*

Q U2 Understanding

9.12 **(a)** What is meant by dispersal?

(b) Give one major advantage of seed dispersal for a plant.

(c) Choose a plant from the box below which disperses its seeds using:

(i) animals **(ii)** wind **(iii)** self-dispersal **(iv)** water.

blackberry	water lilly	bean	dandelion

Germination

The growth of a seed to form a new plant is called germination. Once the seeds have been dispersed, they will germinate (or sprout), provided the conditions are suitable.

The conditions necessary for **germination** are:

- water
- oxygen
- a suitable temperature, i.e. warmth.

Low temperatures in winter often prevent germination. Once the temperatures rise in spring, seeds can germinate.

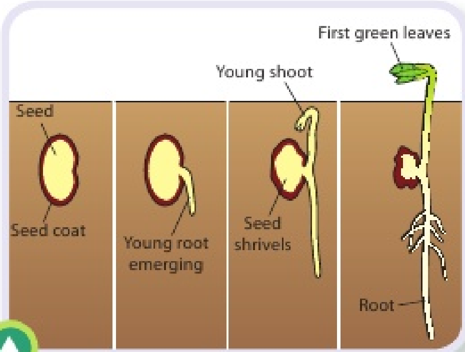


Figure 9.30 *Germination*

The main events in germination

- Food from the seed allows the root and shoot to grow.
- The root grows down into the soil.
- The shoot grows up into the air.
- Once the shoot emerges above the ground it forms green leaves and begins to make food for itself.

Figure 9.31 *Germination in a bean seed*

Q U2 Understanding

9.13 Rearrange the following into the order in which they occur in plant reproduction.

(a) germination
(b) pollination
(c) seed dispersal
(d) fertilisation
(e) seed formation

R2 R3 R4 Research — Portfolio 75

Activity 9.1

Question

What are the conditions necessary for germination?

Equipment needed

Test tubes	Cotton	Cress (or similar) seeds	Boiled cooled water
Stoppers	Wool	Oil	Fridge

Conducting the activity

1. Set up four test tubes as shown in Figure 9.32.

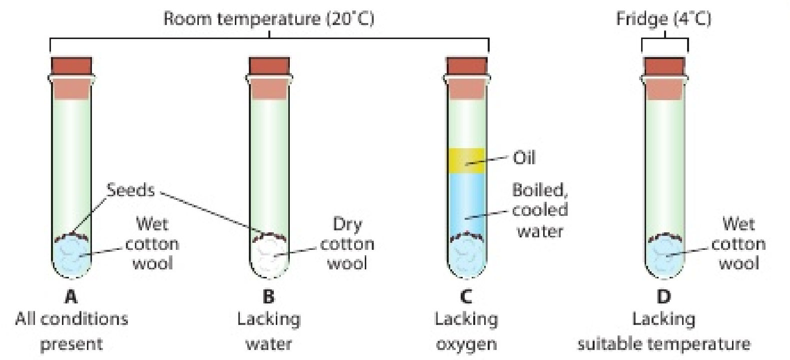


Figure 9.32 *Investigating the conditions needed for germination*

- Tube A has five cress seeds on wet cotton wool and is in a warm place. This tube is the control.
- Tube B has five cress seeds on dry cotton wool and is in a warm place.
- Tube C has five cress seeds covered by boiled, cooled water and is in a warm place.
  - Boiling removes the oxygen from the water.
  - A layer of oil is placed on the water to prevent oxygen passing back into the water.
- Tube D has five cress seeds on wet cotton wool and is placed in a cold place.

2. Leave tubes A, B and C in a warm room. Put tube D in a fridge.
3. Observe the seeds each day for about one week.

Q U1 Understanding R5 Research

9.14 Which seeds germinated?

9.15 What can you conclude about the conditions necessary for germination from this experiment?

Charles Darwin

There are a number of suggestions as to how the variety of living things may have arisen.

However, the most widely accepted explanation based on evidence is the theory of evolution by natural selection. This theory was first put forward by Charles Darwin (in association with Alfred Russel Wallace) in 1859.

Figure 9.33 *Charles Darwin, aged 40*

Evolution by natural selection

Evolution is the process by which different kinds of living things develop from earlier forms during the history of Earth. Before we look at Darwin's theory of evolution, we need to look at a couple of important terms: species and mutation.

Scientist Biography

Watch a video to find out more about Darwin and his theories.

Species

A species is a group of living things that can reproduce together to produce offspring which themselves can reproduce. For example, humans are a species; dogs are a species; so are daffodils, cabbages, cats and rabbits.

A cat and a rabbit cannot reproduce together and so you know they are **different** species.

The members of a species have similar genes and so they have many characteristics in common. However, the members of a species may show variations that are inherited because they are caused by changed genes.

Q U2 C1 S2

9.16 A cocker spaniel and a poodle can breed together to produce a cockapoo (a 'designer' dog). A poodle and a cat cannot breed together. What does this tell you about:

(a) Cocker spaniels and poodles?

(b) Poodles and cats?

9.17 Name two other 'designer' dogs that humans have developed.

Mutation

We know that characteristics of an organism are controlled by genes and that genes are passed from parents to their offspring during reproduction. Changes in genes are called **mutations**. The genes in the members of a species are different due to mutations and due to events that occur in sexual reproduction.

Figure 9.34 *Most humans have five toes: if the gene is altered the person may have extra toes*

For example, while humans are similar in having two eyes, they show variations in eye shape and eye colour. These variations are passed on to the next generation because they are inherited or gene-controlled variations.

Theory of evolution

Darwin's theory of evolution is based on three things he noticed (called **observations**) and from these he made two predictions (called **conclusions**).

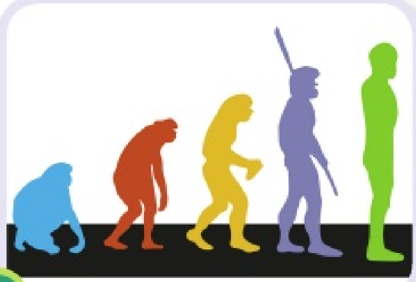


Figure 9.35 *Theory of evolution of the human*

Darwin's theory of evolution

Observation 1

Living things produce huge numbers of offspring.

For example, a tree may produce thousands of seeds, or a fly may lay thousands of eggs.

Figure 9.36 *A tree can produce thousands of seeds*

Observation 2

The environment (or surroundings) can support only a limited number of living things.

For example, there is not enough space for all the seeds to grow or there may not be enough food for all the flies to live.

Observations 1 and 2 lead to **conclusion 1** as follows.

Conclusion 1

If more living things are produced than can survive, they will struggle to get scarce resources. Darwin called this the struggle for existence. It is now often called competition for scarce resources.

For example, seeds may struggle to get enough space and light to grow; the flies may struggle for food and water.

Observation 3

Darwin studied animals such as pet pigeons and cows on farms. Also, on his voyage around the world he noticed that species showed inherited variations. He realised that species could have differences that they would pass on to their offspring.

Observation 3 leads to **conclusion 2** below.

Figure 9.37 *Variations in pet pigeons*

Conclusion 2

Suitable variations

Darwin realised that some of the variations would help the living thing to survive better.

For example, if some seeds produced longer or bigger roots, those seeds would grow better; if the wings of some flies developed more quickly, they could fly away to get more food.

An adaptation is a characteristic that helps an organism to survive and reproduce. Living things that are best suited or adapted to their environment survive more easily. If they survive, they have a better chance of reproducing and so passing on their genes (and their suitable variations) to the following generations.

Unsuitable variations

However, some variations do not help living things to survive better. These living things are not adapted to their environment and so may die. This means they do not pass their genes (and unsuited variations) on to the next generations.

Natural selection

The way in which organisms whose variations are suited to their environment survive and reproduce is called natural selection. Nature selects those organisms that are best suited (or adapted) to their environment.

Table 9.1 Summary of the theory of evolution by natural selection

Observation	Conclusion
1 Living things produce large numbers of offspring	1 Living things struggle to survive
2 The environment can support only a limited number of living things	
3 The members of a species have inherited (genetic) variations	2 Nature selects the organisms with variations that help them to live in the environment. These organisms survive and reproduce to pass on their genes and their variations

C1 Communicating

9.18 Find out three major adaptations that have allowed humans to survive in their environment.

Figure 9.38 *The light-coloured moth is hard to see on the lichen-covered tree*

Selective breeding

Selective breeding is also known as **artificial selection** and it can be used to eliminate undesirable traits. Selective breeding of animals produces **breeds** and selective breeding of plants produces **varieties** or **cultivars**.

> Selective breeding is the process of breeding animals or plants with desirable traits and concentrating those desirable traits in their offspring.

Crossbreeding

Crossbreeding or outbreeding involves the mating of animals or plants from two different breeds, varieties or species. The offspring in many instances inherit favourable genes from both parents, leading to improved health traits over either parent. This is referred to as hybrid vigour or heterosis.

> Crossbreeding involves the mating of animals or plants from two different breeds, varieties or species.

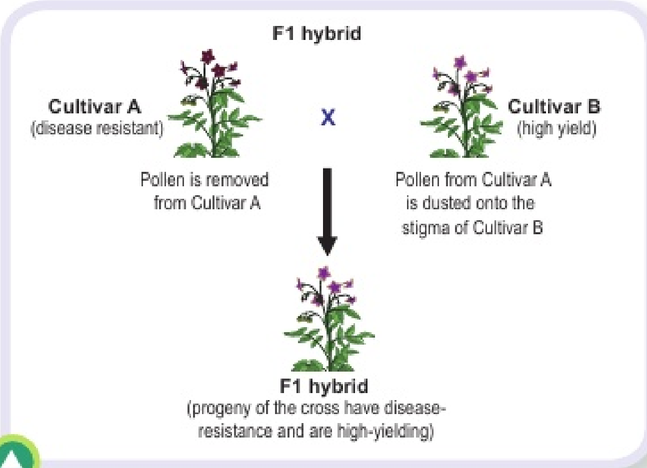


Figure 9.39 *Production of a disease resistant hybrid plant*

Hybrid plants can be produced which are resistant to diseases and produce higher yields. See Figure 9.39 .

U2 Understanding

9.19 What are the main advantages of cross-breeding?

9.20 Can you think of any disadvantages?

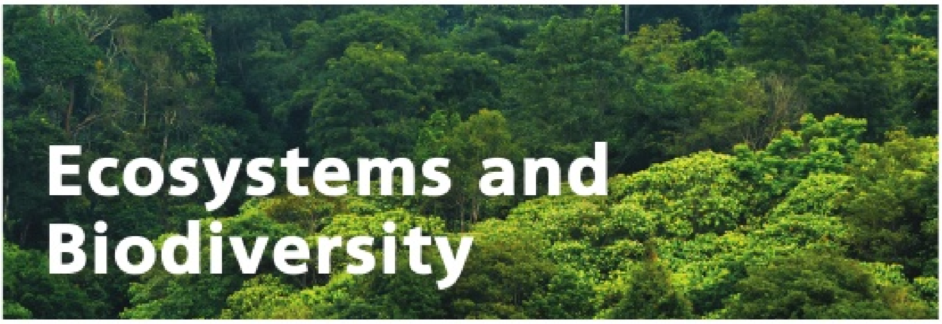
R1 Research C2 Communicating

9.21 Prepare in small groups a presentation on one of the following topics:

(a) The work of Russian scientist Nikoli Vavilov in identifying the centre of origin of cultivated plants.

(b) The varieties of important cultivated plants and livestock breeds that are found in Kazakhstan.

MODULE 10



Ecosystems and Biodiversity

Learning outcomes

At the end of this module you will be able to:

- Explain the overall structure of an ecosystem 8.3.1.1
- Compare plant and animal adaptations in aquatic and terrestrial ecosystems 8.3.1.2
- Describe the main characteristics and features of population structure 8.3.1.3
- Research the different strategies for survival of organisms 8.3.1.4
- Explain predator-prey relationships and their impact on population size 8.3.1.5
- Describe the types of interaction between organisms 8.3.1.6
- Explain how living organisms adapt to changes in environmental conditions 8.3.1.7
- Discuss the need for conserving ecological biodiversity 8.3.2.1
- Evaluate the significance of the World Seed Bank in terms of global food production 8.3.2.2
- Describe issues relating to environmental problems in Kazakhstan 8.3.2.3

Keywords

✔ ecosystem ✔ habitat ✔ adaptations ✔ competition ✔ interdependence
✔ producers ✔ consumers ✔ herbivores ✔ carnivores ✔ omnivores
✔ decomposers ✔ food chain ✔ food web ✔ conservation ✔ biodiversity
✔ global food production

What are ecosystems and habitats?

Ecosystems

Ecology is the study of how plants and animals interact with each other and with their surroundings (or environment). The living world is divided into ecosystems, which are similar groups of plants, animals and environments. Examples of major ecosystems are:

- Deserts
- Grasslands
- Tropical rainforests
- Seashores.

Figure 10.1 *Examples of major ecosystems*

Habitats

Ecosystems are large areas containing similar types of environments and living things. Normally an ecosystem is too large to study. Instead, a small, local part of the ecosystem called a habitat is studied. A **habitat** is the place where an organism lives.

There are wide varieties of habitats that can be studied. These include:

- Grassland
- Hedgerow
- Rocky seashore
- Woodland
- Bog
- Local park
- School field
- Pond.

Figure 10.2 *Using a pH and temperature meter*

Q Understanding U1

10.1 Answer these questions on habitats:

(a) What is the difference between an ecosystem and a habitat?

(b) Which is larger, an ecosystem or a habitat?

(c) Name three different types of habitats found in Kazakhstan.

What are adaptations?

In order to survive, living things must adapt to their environment. An **adaptation** is a structure or habit that helps an organism to survive in its habitat or within its community.

A **community** consists of all the organisms living in a particular area.

Adaptations to their environment are very important in allowing organisms to live longer. If they continue to breed they will produce more offspring and the adaptation will pass on to the next generation. This is central to the process of evolution by natural selection.

For example, adaptations shown by grassland organisms are:

- Plants such as primroses grow and produce flowers early in the spring. This means primroses get more light and grow better than the other plants in their habitat, because the other plants have not produced their leaves in early spring.

- Grasses grow from the base (most plants grow at their tips). This means grasses can survive when grazed by animals.
- Grasses have very branched roots. This means they are not easily pulled out of the ground.
- Caterpillars have a similar colour to the plants they feed on; this allows them to be well camouflaged. Caterpillars have strong mouth parts, so they can bite and chew leaves.
- Butterflies have long tubular mouth parts, so they can drink nectar (sugary water) from flowers.

Understanding U1 Communicating C2

10.2 **(a)** Suggest the benefit of each of the following adaptations:

(i) Rabbits have large ears.

(ii) Foxes have brown coats.

(b) Animals and plants in different habitats show many adaptations. Research and explain the benefit of each of the following adaptations:

Animals:

(i) Hedgehogs have spines.

(ii) Hawks have good eyesight.

(iii) Rabbits can run fast.

(iv) Foxes have large ears.

(v) Frogs hibernate in winter.

(vi) Swallows migrate to Africa in winter.

Plants:

(vii) Dandelions have long, deep roots.

(viii) Seaweeds are very flexible.

(ix) Some seaweeds have air bladders.

(x) Blackberry plants have thorns.

(xi) Ivy can cling to the bark of a tree.

(xii) Buttercups have bright yellow flowers.

Figure 10.3 *A butterfly drinking nectar*

Figure 10.4 *A caterpillar chewing on a leaf*

Population and population structure

Changes in the size and structure of the population of a species in a particular location at a particular time can provide important information about an ecosystem. The main indicators used when investigating a population are birth and death rates and patterns of migration. The factors which will limit the size of a population are of two kinds: density-dependent and density-independent.

Density-dependent factors

This term is used to describe the factors linked to an increase in population density which can lower the chances of survival of an individual. These include:

- predation
- competition for resources
- parasites and disease

Density-independent factors

These factors may cause higher death rates, lower birth rates or populations to migrate to or from a particular area, regardless of current population density and include:

- temperature
- precipitation (rainfall)
- natural disturbances

Predator and prey populations

We shall see how within an ecosystem, all living things are interdependent and factors which directly cause an increase in the size of one population will necessarily impact on other organisms.

The relationship between the size of predator and prey populations is a particularly clear example of this. An increase in the size of a prey population in an ecosystem will lead to an increase in predator numbers as their food supply increases. A point will be reached, however, when the food supply can no longer sustain the increased predator numbers and the predator population will start to fall. This increase and decrease in population numbers is known as the predator-prey cycle.

What is competition?

Competition takes place when two or more organisms require something that is in scarce supply. In any habitat:

- **Animals** compete for space, food, water and partners.
- **Plants** compete for light, space, water and minerals from the soil.

Figure 10.5 *Red deer competing for a mate*

Types of competition

Competition can occur between plants and animals of the same type. For example:

- Grasses compete with each other for light and space.
- Foxes compete with each other for food.

Competition also occurs between different types of plants and animals. For example:

- Grass and dandelions compete with each other for light.
- Robins and blackbirds compete with each other for food.

What is interdependence?

All the organisms in a habitat depend on other organisms for their survival. Examples of how plants and animals are interdependent include:

- Animals depend on plants, e.g. rabbits depend on grass for food.
- Plants depend on animals, e.g. flowers depend on bees for pollination.
- Plants depend on each other, e.g. plants depend on each other for shelter.
- Animals depend on other animals, e.g. foxes depend on rabbits for food.

Q Understanding U1

10.3 Figure 10.6 shows a sea bird nesting on a rocky cliff.

(a) Name two things for which sea birds such as this might compete.

(b) Research and find examples of how changes such as temperature and level of rainfall can affect the survival of animals in a habitat.

Figure 10.6 *Sea bird nesting on a cliff*

Food interdependence

One of the main ways in which living things depend on each other is for food. Organisms get their food in different ways, and can be categorised as:

- Producers
- Consumers
- Decomposers.

Producers

Producers are green plants that make their own food. Examples of producers are:

- Grasses
- Buttercups
- Nettles.
- Dandelions
- Daisies

Consumers

Animals do not make their own food. Instead, they get their food by eating (or consuming) plants or other animals. For this reason animals are called consumers. Depending on what they eat, consumers can be placed into three different groups:

- **Herbivores** are animals that eat plants only, e.g. rabbits, sheep, slugs and snails.
- **Carnivores** are animals that eat other animals, e.g. foxes, hawks and ladybirds.
- **Omnivores** are animals that eat both plants and other animals, e.g. badgers, thrushes, blackbirds and humans.

Figure 10.7 *A slug is a herbivore*

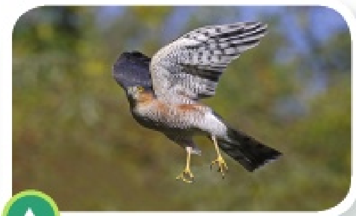


Figure 10.8 *A sparrowhawk is a carnivore.*

Figure 10.9 *Badgers are omnivores*

Decomposers

Decomposers are organisms that feed on dead plants and animals. Decomposers include a range of small animals (such as woodlice and earthworms) along with bacteria and fungi.

Decomposers are of great value as they release chemicals back into the environment. This allows other organisms to use these chemicals.

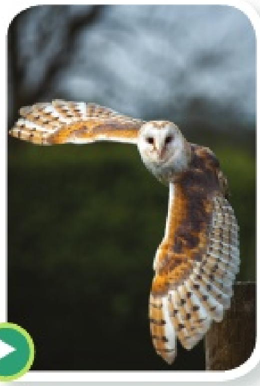


Figure 10.10 *A barn owl in flight*

Q Understanding U3

10.4 Barn owls (shown in Figure 10.10) feed on small animals, which they hunt at night. Their feathers are specially arranged so that they can fly silently.

(a) Is this an example of adaptation, competition or interdependence?

(b) What is the possible benefit to barn owls of being able to fly silently?

What is a food chain?

A food chain is a list of organisms in which each organism is eaten by the next one in the chain. It is a simple way of explaining how energy and nutrients pass from one living thing to another. The arrows in a food chain show the direction in which the energy and nutrients pass.

An example of a simple food chain is where grass is eaten by a rabbit and the rabbit is then eaten by a fox. This food chain is shown below:

grass ⟶ rabbit ⟶ fox

This food chain has three feeding levels:

1. Grass – normally the first feeding level is a plant or a producer.
2. Rabbit – it is a herbivore and a consumer.
3. Fox – it is a carnivore and it is also a consumer.

A summary of this food chain is given in Figure 10.12.

Figure 10.11 *A fox chasing a rabbit – this is part of the food chain*

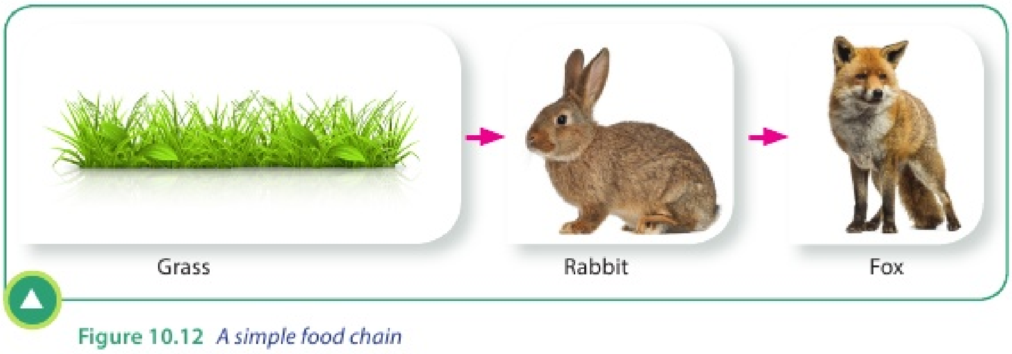


Figure 10.12 *A simple food chain*

An example of another food chain is given in Figure 10.13.

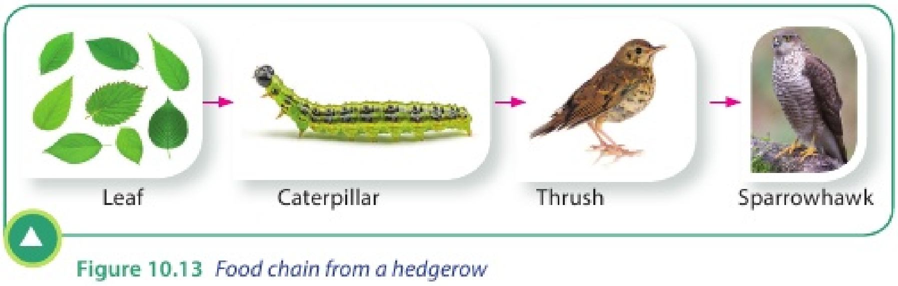


Figure 10.13 *Food chain from a hedgerow*

Do food chains involve decomposers?

Another way to show a food chain is to refer to the decomposers. Decomposers act on dead plants and animals and on the waste products (such as urine and faeces) of animals. The food chain in Figure 10.14 shows the role of the decomposers.

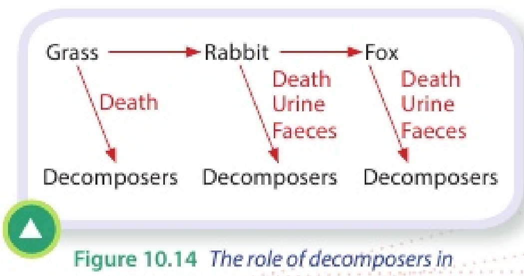


Figure 10.14 *The role of decomposers in the food chain*

What is a food web?

Food chains are a simple way to show how organisms feed in a habitat. For example, the simple food chain described earlier (grass → rabbit → fox) suggests that grass is eaten only by rabbits. It also suggests that rabbits are eaten only by foxes. Both of these situations are untrue.

A food web consists of a number of interlinked food chains. A food web provides a more complete and realistic explanation of the way in which organisms in a habitat feed.

In all food webs, the dead plants and animals are broken down by decomposers. Examples of food webs are given in Figures 10.16 and 10.17.

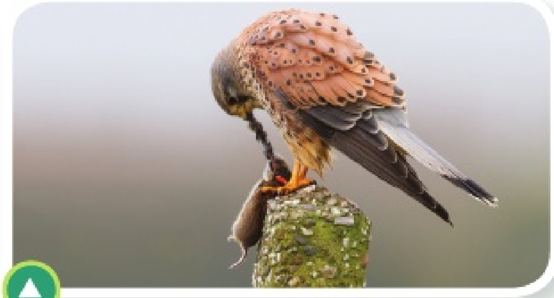


Figure 10.15 *A kestrel with a mouse*

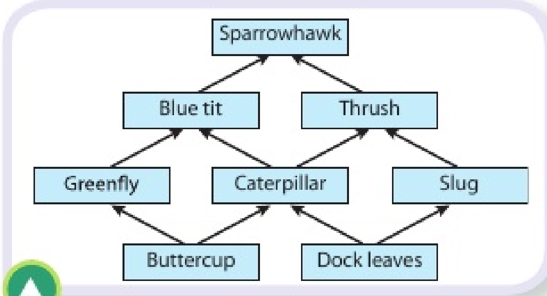


Figure 10.16 *A food web*

Understanding U1

10.5 Answer the following questions in relation to the food web shown in Figure 10.17.

(a) Write out a food chain with four organisms in it.

(b) Name the producer in the web.

(c) Name two consumers in the web.

(d) Name a herbivore in the web.

(e) Name two carnivores in the web.

(f) Give one example of competition shown in this web.

(g) Give one example of how mice depend on the ash tree.

(h) Give one example of how the ash tree depends on mice.

(i) If all the robins died, what might happen to the number of:

(i) Owls (ii) Caterpillars.

(j) How many organisms feed on the ash tree?

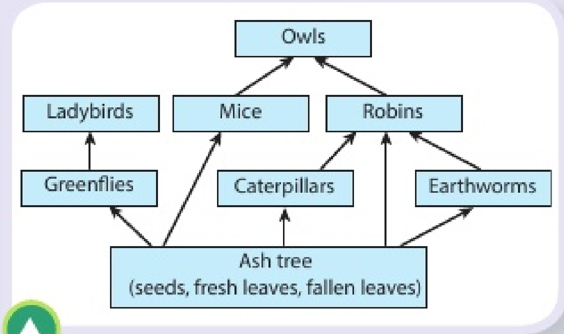


Figure 10.17 *A food web*

How does energy flow in an ecosystem?

Energy is the ability to do work. It can change from one form to another.

The main source of energy for every ecosystem is the Sun (or **solar energy**). The Sun's energy is converted into food by **photosynthesis**.

Energy flows along a food chain when each organism eats the previous one in the chain. However, not all of the energy flows from each organism to the next one. Some of it is lost:

- The organisms lose heat to their environment.
- The organisms may excrete waste such as urine and faeces (both contain energy).
- Some parts of organisms are not eaten (e.g. roots, bones, fur, teeth).
- Lots of energy is lost as heat when dead things decompose.

Only about 10% of the energy passes from organism to organism in a food chain. This means about 90% of the energy is lost at each step. As a result food chains cannot be too long as there will be very little energy available at the end of a long food chain.

Energy is lost from ecosystems (mainly as heat). Energy is said to **flow through** an ecosystem.

Q Understanding U3

10.6 Tests show that for every 100 kJ of food eaten by a cow it gains only 5 kJ in weight. Wastes (such as faeces, urine and gases) account for 60 kJ. The remaining energy is lost as heat in respiration.

(a) How much energy (expressed as a %) is lost as heat?

(b) How efficient (as a %) is a cow at transferring food into body weight?

10.7 In the following food chain the grass was calculated to contain 10,000 kJ of energy. Assuming a 90% energy loss at each step of the food chain, calculate how much energy would be available to the hawk.

grass ⟶ grasshopper ⟶ frog ⟶ hawk

How does matter flow in an ecosystem?

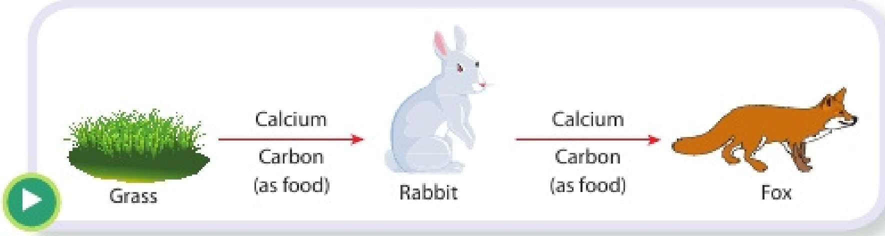
Matter is anything that occupies space (such as food, chemicals and elements or minerals such as calcium and carbon). Matter is absorbed by plants from their environment. For example:

- Calcium is absorbed by the roots from the soil.
- Carbon is absorbed from the air in the form of carbon dioxide.

Matter passes from one organism to another in a food chain as each organism is eaten, e.g.

- Calcium passes from grass to rabbits to foxes.
- Carbon (in the form of food) passes from grass to rabbits and from rabbits to foxes.

Figure 10.18 *Calcium and carbon passing through a food chain*



Matter is not normally lost from an ecosystem (unless living things leave the ecosystem). Matter is said to be **cycled** in the ecosystem. In a food chain, for example, any waste and the parts that are not eaten pass into the soil. Here it is broken down (by decomposers) and the elements are released into the soil. These elements may then be reabsorbed by plants and the cycle starts all over again.

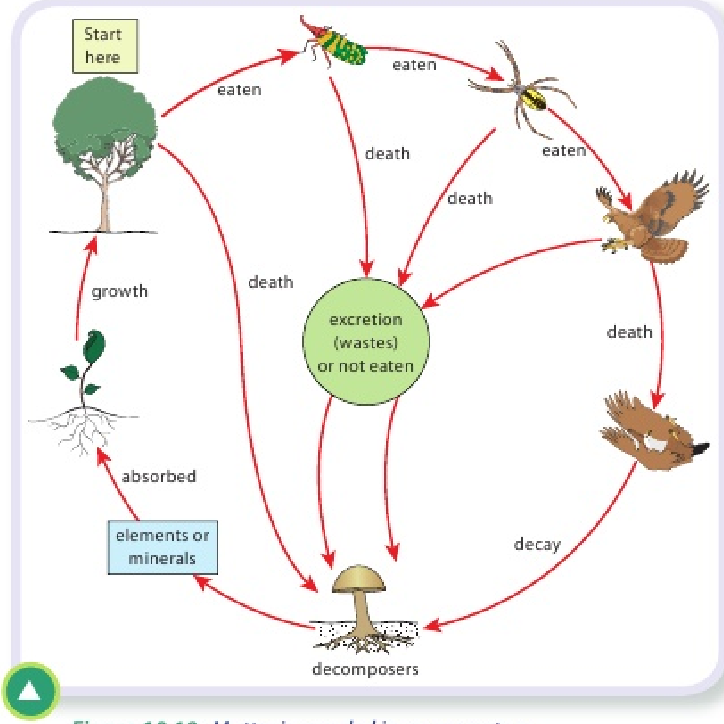


Figure 10.19 *Matter is recycled in an ecosystem*

What is conservation?

Conservation is the protection of plants, animals and natural areas from the damaging effects of human activity. If we look after our wildlife and their habitats we can prevent them from being wiped out (becoming **extinct**).

Failure to conserve can result in the death of organisms in their habitats. In some cases the entire species or type of organism may become extinct.

The decrease in the number of types of plants and animals means there is a decrease in **biodiversity** (i.e. the different types of living things). To prevent the loss of habitats and wildlife it is necessary to look after our natural resources.

Communicating C1 Communicating C2 Communicating C3 Society S2

10.8 Work in groups to discover the names of two plants in Kazakhstan from each of the following categories:

- **(a)** Extinct
- **(b)** Critically endangered (i.e. in danger of becoming extinct)
- **(c)** Endangered (i.e. whose numbers are declining).

10.9 Select one of the plants you have listed and:

- **(a)** Find an image (drawing or photograph) of it.
- **(b)** Explain why it is in danger.
- **(c)** Present your results to the class and vote on the best presentation.

10.10 Work in groups to research what is meant by a **protected species** in Kazakhstan.

10.11 Name two animals in Kazakhstan that are protected species.

10.12 Select one of the animals you have listed in question 10.11 and:

- **(a)** Find an image (drawing or photograph) of it.
- **(b)** Explain why it is protected.
- **(c)** Present your results to the class and vote on the best presentation.

Why do we need conservation?

Conservation is necessary for the following reasons:

- To prevent organisms from becoming extinct. At present, many organisms are facing this threat.
- To maintain the balance of nature. The loss of any one type of organism can cause dramatic results for other types of organisms.
- Future generations have the right to the same natural resources as are found at present, e.g. the world would be a poorer place if elephants, tigers or any other animal or plant became extinct.
- Plants are the source of many medicines. As plants become extinct, we lose the ability to test them for new medications.
- If our natural resources are not protected there is a danger that human lifestyles (and even our survival) would be at risk.

Understanding C1 Communicating C2 Society C3 Society S2

10.13 Give three examples of how the loss of named living things might cause problems for other named living things? (Hint: how is the reduction in honey bees affecting plants?)

10.14 Why would it be a tragedy if elephants (or any animal or plant) became extinct?

What can we do to support conservation?

The only species on Earth that threatens conservation is humans. It is up to us, both as a species and as individuals, to support conservation measures. Humans can support conservation by:

- Making themselves aware of the issues
- Joining conservation groups
- Supporting groups in society that encourage proper conservation
- Refusing to join in any activity that threatens conservation
- Refusing to buy products that have been sourced unethically.

Communicating C1 Society S2

10.15 Gulnaz wants to support conservation in Kazakhstan.

(a) Find out the names of three groups that she could join to achieve her aim.

(b) Explain the role of one of these groups in more detail.

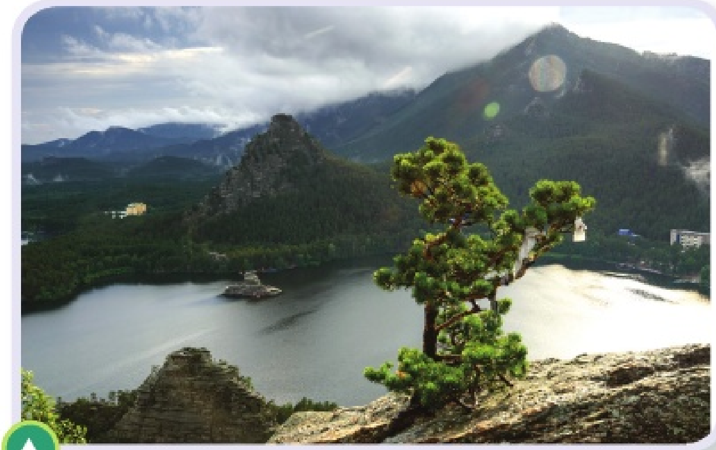


Figure 10.20 *National park Burabai, Kazakhstan*

Communicating C1 Communicating C2 Society S2

10.16 Work in groups to research two chemicals, drugs or medicines that we get from plants. Explain the benefit of these substances.

Communicating C1 Communicating C2 Communicating C3 Society S2

10.17 Work in groups to discover the five most threatened big animals (i.e. larger than a cat) on Earth.

10.18 Discuss why the animals you named in question 10.17 should be conserved and agree on the three most important reasons.

What are the main causes of loss of biodiversity?

Some of the factors that are responsible for organisms being killed off (resulting in a loss of biodiversity) are:

- Habitat loss or fragmentation
- Pollution
- Invasive species (organisms that are introduced to an area and which cause harm)
- Climate change
- Over-exploitation (the overuse of wildlife by people)
- Human population numbers.

How can we conserve ecological biodiversity?

To conserve organisms we must control the factors listed earlier (habitat loss and fragmentation, pollution, invasive species, climate change, over-exploitation and human population numbers). Some of the ways these factors can be controlled are considered below.

Preventing habitat loss and fragmentation

Habitats can be preserved by:

- Reducing pollution (which may destroy plant and animal life)
- Planting native vegetation, which will support native animals
- Controlling or limiting building to preserve habitats
- Preventing the entry and growth of invasive (or non-native) species
- Developing national parks and special areas of conservation where wildlife is protected by law.

Controlling pollution

Pollution can be controlled by proper waste management.

Waste management

The large numbers of humans and the modern style of life produce huge amounts of waste materials. These wastes include dirty water, urine, faeces, plastics and packaging, along with agricultural and industrial wastes.

These wastes can be managed by using the **3Rs**. These are:

- **Reduce** the use of unnecessary goods and packaging (e.g. plastic bags).
- **Reuse** as many materials (e.g. glass or second-hand furniture) as possible.
- **Recycle** as much waste as possible (e.g. paper, glass, metals and plastics).

Q U3 Understanding

10.19 List three ways in which you or your family use, or could use, the 3Rs.

Communicating C1 Communicating C2 Communicating C3 Society S2

10.20 A good example of recycling is composting.

(a) Find out what is meant by composting.

(b) What substances can be composted?

(c) List two advantages and two disadvantages of composting.

(d) Investigate the possibility of your school or class making your own compost.

Figure 10.21 *Garden and kitchen waste in a compost heap*

Communicating C1 Communicating C2 Communicating C3 Society S2

10.21 At present most household waste in Kazakhstan is disposed of by **landfill**. However, there are problems associated with this method. Some people suggest that **incinerators** would be a better way to dispose of household waste.

Research the words in **bold** and answer the following questions.

(a) What is meant by landfill?

(b) What are the main problems associated with landfill?

(c) What are incinerators?

(d) What are the main benefits of incinerators?

(e) Why might you not like to live close to an incinerator?

Figure 10.22 *A waste incinerator*

Figure 10.23 *Waste being burned in an incinerator*

Figure 10.24 *A landfill site*

Communicating C1 Communicating C2 Communicating C3 Society S2

10.22 Perennial ragweed and the nutria are two invasive species in Kazakhstan. Research both of these and explain:

(a) How or why they are thought to have entered Kazakhstan.

(b) The problems they are causing.

(c) What can be done to control or prevent them from spreading.

10.23 Research national parks in Kazakhstan.

(a) Name a National Park in Kazakhstan.

(b) What are the five main benefits of this park to people in Kazakhstan?

(c) Suggest why there are more plant and animal species in national parks than in land outside the parks.

How can humans contribute to global food production?

At present there are slightly over 7 billion people on Earth. It is predicted that the number of humans in 2050 will be between 9 and 10 billion. As the numbers rise it will be necessary to increase the global or world food supply.

This need for more food is not a new problem. In the late 1950s and the 1960s the human population was increasing faster than it is now. However, the 'green revolution' at that time resulted in huge increases in the production of food worldwide. As a result food production matched the rise in human numbers.

The green revolution resulted in some problems also. For example:

- The number of crops grown fell dramatically as the new 'super-crops' were planted widely.
- The new crops needed large amounts of fertilisers and had to be sprayed with pesticides to kill off insect pests.
- The new crops also used much more fresh water and needed a higher level of farm technology (tractors, sprayers, etc.).
- Natural land that contained many species of plants and animals was converted to growing single crops (such as rice, wheat or oil palm). These single crops are called **monocultures** and result in huge loss of biodiversity.

Figure 10.25 *A wheat field in winter*

Figure 10.26 *An oil palm plantation. Note there is only one type of plant growing*

There are two possible ways to produce more food:

- Convert more land to growing crops
- Increase the yield of crops grown on present farm land.

Can we increase the amount of farmland worldwide?

At present only about 10% of the world's surface is used for growing crops (66% of Earth's surface is water, some land is too dry or too hot or too cold, or the soil is too poor to grow crops).

If we use more land for crops it will mean we have to destroy habitats. This will result in loss of biodiversity. For this reason this option is not the best one.

Can we increase the yield of crops?

A huge amount of research is going on worldwide to increase the yield of crops. Some of this involves using older crops that were preserved as seeds (in seed banks). Much of the research is attempting to develop new strains of crops by adding genes to existing plant crops.

It is hoped that the new crops will be able to produce increased yields, resist higher global temperatures, use less fresh water, resist pests and diseases, have improved taste and contain more nutrients. In addition, attempts are being made to allow plants to produce more than one crop each year. This could potentially increase food production hugely.

Communicating C1 Communicating C2 Communicating C3 Society S1

10.24 The photograph in **Figure 10.27** shows the entrance to the Svalbard Global Seed Bank. This is a project sponsored by Bill Gates and a number of multinational companies to store seeds from every plant on Earth in a huge underground vault.

Research this project and find out:

(a) Who Bill Gates is.

(b) Where the project is located.

(c) Why they are doing it.

(d) Why some people question this project.

Figure 10.27 *The Svalbard Global Seed Bank*

Communicating C1 Communicating C2 Communicating C3 Society S2

10.25 Most of the world's food is produced by a small number of plants.

(a) Research the top five food plants worldwide.

(b) Which of the plants named in part (a) can grow in Kazakhstan?

How can we reduce the food gap?

The food gap refers to the difference between the amount of food produced and the amount of food needed worldwide. This gap can be reduced in a number of ways:

- Reduce the loss or waste of food. At present it is estimated that up to 33% of food produced for human use is not eaten.
- Adjust our diets. It takes far more land to produce meat (especially beef) than it does to produce the same energy content in plants. The world's population is increasingly demanding more meat in its diet. This may not be sustainable.
- Increase our use of poor-quality land.
- Improve how we use our existing land and water resources.
- Control human population increases.
- Increase our use of water-based food production (aquaculture).

Figure 10.28 *Feeding fish on a fish farm – this is one type of aquaculture*

Glossary

A

abiotic Non-living.

acid rain Rainwater with a pH of less than 5.5.

adaptation A change in the behaviour or structure of an organism that allows it to be better suited to its environment.

aerobic respiration Oxygen is needed to release energy from food.

alveolus A tiny air sac in the lungs.

amnion A membrane that surrounds the baby in the womb.

amniotic fluid Liquid that surrounds (and protects) the baby in the womb.

amylase An enzyme that converts starch to maltose.

anaerobic respiration Oxygen is not used to release energy from food.

antibiotics Chemicals made by fungi or bacteria that kill or prevent the growth of bacteria.

antibodies Proteins produced by white blood cells to destroy micro-organisms that have entered the body.

artery A blood vessel that takes blood away from the heart.

asexual reproduction New individuals are formed from only one parent.

atom The smallest part of an element that still has the properties of that element.

atrium (plural atria) The upper chambers of the heart.

B

bacterium (plural bacteria) Micro-organisms made of a single cell. Cause disease and decay and may be used to produce useful substances.

balanced diet The need to take in the correct amounts and proportions of the different food types to maintain good health.

bile A green/brown fluid produced by the liver that breaks down fat.

biodiversity A range of living things.

bioplastics Biodegradable plastics made from renewable biological sources.

birth When the baby comes out of (emerges from) the uterus of the mother.

bronchiole A subdivision of a bronchus.

bronchus A subdivision of the windpipe.

C

canines Teeth that are long and pointed and used to grip and tear food.

capillary A tiny blood vessel that links arteries to veins.

carbon footprint The amount of carbon dioxide released that results from the activities of a person, persons or community.

carnivore An animal that eats other animals only.

cell wall Found outside the cell membrane in plant cells.

cellulose The substance that makes cell walls and provides fibre in the human diet.

centre of gravity of a body A point about which the turning effects due to gravity are balanced.

cervix The neck or opening into the uterus (or womb).

characteristics A trait or feature of an individual that distinguishes them from another individual.

chlorophyll The green pigment found in plants (acts as a catalyst for photosynthesis).

chloroplasts Contain the green pigment called chlorophyll.

chromosome Thread-like structure in the nucleus containing genes.

climate change A change in the climate patterns of the earth over time.

community All the organisms of different species living in an area.

competition Takes place when two or more organisms require something that is in short supply.

composting Where organic waste such as food waste decomposes in the presence of oxygen, with no production of methane gas.

conservation The protection and wise management of natural resources in order to maintain biodiversity (or in order to prevent extinction of a species).

consumers Animals that get their food by eating plants or other animals.

contraception The use of artificial methods to prevent pregnancy.

cytoplasm The liquid part of the cell that surrounds the nucleus.

D

decomposers Organisms that feed on dead plants and animals.

deoxyribonucleic acid The chemical of which genes are made.

diaphragm The muscle at the base of the chest that helps us to breathe.

digestion The breakdown of food.

distribution The transportation of the finished product from factories to warehouses then to stores and eventually to your home.

diversity A variety or range.

DNA Deoxyribonucleic acid.

dominant The version of a gene that prevents the other (recessive) version from working.

E

ecology The study of the relationships between plants, animals and their environment.

enzyme A chemical (protein) that speeds up chemical reactions without the enzyme being used up.

evaporation The changing of a liquid to a gas.

excretion The removal from the body of the waste products of chemical reactions in the body.

exploration Investigations that are undertaken in an unfamiliar area.

F

faeces The waste matter that is left in the intestines after food has been absorbed.

fallopian tube A structure linking the ovary to the uterus in females.

fertile period The time in the menstrual cycle when fertilisation is most likely to occur.

fertilisation The joining of the male and female gametes to form a zygote.

fibre Indigestible plant material (also called roughage) that stimulates peristalsis.

food chain A list of organisms in which each organism is eaten by the next one in the chain.

food energy value The energy content in a given mass (or weight) of a particular type of food.

food gap The difference between the amount of food produced and the amount needed for the world's population.

food pyramid A diagram or image showing the number of helpings of each of the food types needed for a healthy diet.

food web Consists of two or more interconnected food chains.

fossil The remains of something that was once living long ago.

fossil fuel A natural fuel, coal, oil, peat and gas, that was formed over millions of years from the remains of dead plants and animals.

fungus (plural fungi) Simple non-green organisms that may be single celled (yeast) or made of many cells. May cause disease, decay and some are edible (mushrooms).

G

gamete A sex cell.

gene A structure on a chromosome that controls a characteristic (by causing a protein to be formed).

gene disorders A condition caused by a missing or altered (or mutated) gene or genes.

genetics The study of how traits or characteristics are inherited.

global food production The ability of planet Earth to make and allow access of all the world's population to sufficient amounts of the correct foods.

global warming An increase in the temperature in the Earth's atmosphere due to the greenhouse effect.

gravity Force in space that causes gases to condense, get smaller and come together.

greenhouse effect When the heat energy of the sun is trapped within the Earth's atmosphere.

H

habitat The area where a plant or animal lives.

haemoglobin The red pigment found in blood that transports oxygen.

health The state of complete physical, mental and social well-being.

herbivore An animal that eats plants only.

hydrocarbons Compounds made up of hydrogen and carbon.

hydro-electricity Energy from the potential and kinetic energy of water.

I

immunisation The process of being made immune (or resistant) to a disease, often called vaccination.

implantation The attachment of the embryo to the lining of the uterus.

incisors Teeth that have sharp edges used to cut and nibble food.

infiltration How water on the ground enters into the soil.

inhaling Taking air into the lungs.

intercostal muscles Muscles located between the ribs that help us to breathe.

intercourse The act of sexual union (i.e. the placing of the penis in the vagina).

interdependence Living things depend on each other for survival.

intestine The part of the digestive system beyond the stomach.

invertebrates Animals that do not have a backbone.

in-vitro-fertilisation (IVF) The joining of the egg and sperm outside of the body.

J

joint A place where two or more bones meet.

K

key A list of questions that are used to name an organism.

L

lactic acid The product formed due to anaerobic respiration in humans (causing muscles to cramp).

liver A large organ located to the right of the stomach carrying out many functions.

M

maltose A type of carbohydrate or sugar.

meniscus The curved surface of a liquid in a vessel.

menstrual cycle A series of changes that take place in the female over 28 days between puberty and the menopause (provided she is not pregnant).

menstruation The loss of blood every month from the uterus of a female (provided she is not pregnant).

micro-organism A small living thing.

mitochondrion A structure in a cell in which respiration takes place.

molars Larger teeth that are used for chewing, crushing and grinding food.

mutation A sudden change in a gene.

N

natural material Any product that comes from plants, animals or the ground.

natural selection The process whereby organisms that are better adapted to their environment tend to survive and produce more offspring.

non-renewable Sources of energy that cannot be replaced once they are used.

nutrition The way in which an organism gets its food.

O

oesophagus The food pipe.

omnivore An animal that eats both plants and animals.

organ A group of cells (or a structure) that carries out a particular function.

organism A living thing.

ovary The female reproductive organs in which eggs are produced.

ovulation The release of an egg from the ovary.

P

pancreas An organ located near the stomach that produces many digestive enzymes.

parasite A living thing that gets its food from another living thing and usually causes harm.

penis The structure in a male used to pass sperm to a female and to excrete urine.

peristalsis The way in which food is pushed through our intestines by muscular action.

photosynthesis The way in which green plants make food.

placenta The organ that connects the developing baby to the lining of the womb.

plasma The liquid part of blood which transports chemicals and heat.

platelets Structures in blood that cause blood clotting.

pollution The addition of harmful or unwanted materials to an environment.

precipitation Rain, hail, sleet or snow that falls to the ground.

pregnancy The length of time the baby spends developing in the uterus.

premolars Large rounded teeth used for chewing, crushing and grinding food.

producers Plants that make their own food.

puberty The age of sexual maturity.

pulse The expansion felt in an artery due to blood being forced through it by a heartbeat.

Q

quadrat A frame used to estimate the number of plants in a habitat.

R

recessive The version of a gene that is prevented from working by another (dominant) version.

recycle Find other uses for as much of what we do not need as possible.

red blood cells Cells that transport oxygen.

renewable A source of energy that can be reused.

reproduction The production of new organisms.

respiration The release of energy from food.

response The reaction to a stimulus.

S

scrotum The sac that contains the testes.

sexual reproduction Two sex cells joining together.

species A group of organisms that can reproduce together to produce offspring that themselves can reproduce.

sperm The male sex cell or gamete.

stem cells Cells that can develop into any type of body cell.

stomach An organ located at the bottom of the oesophagus.

sustainable development Where demands on the environment by people can be met without compromising the environment for future generations.

T

temperature A measure of how hot or cold an object is.

terrestrial Relating to the earth.

testis (plural testes) The organ in a male that produces sperm.

tidal and wave energy Energy generated by the movement of the tides and waves.

trachea The windpipe.

transpiration The loss of water vapour from a plant.

U

umbilical cord A tube connecting the baby (at the navel) to the placenta.

uterus The womb.

V

vaccination The introduction of a small, non-reproductive dose of a disease causing organism into the body to stimulate us to produce antibodies.

vacuoles Membrane-bounded compartments that support the cell and store substances such as food, wastes and water. Mostly found in plant cells.

vagina A muscular tube in females leading to the uterus.

variation A difference between one organism and another.

vein A blood vessel that takes blood to the heart.

ventricle The lower chambers of the heart.

vertebrates Animals that have a backbone.

virus The smallest type of micro-organism, normally cause a disease.

W

water cycle The natural circulation of water on the planet.

wind energy Energy from the kinetic energy of the wind.

Z

zygote The single cell that results from the joining of a sperm and an egg.