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Mary Jones , Richard Harwood , Ian Lodge , David Sang
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B1 Cells

This chapter covers:

- the characteristics of living things
- the structure of animal cells and plant cells
- the functions of the different parts of cells
- how to calculate magnification.

B1.01 Characteristics of living things

Biology is the study of living things, which are often called organisms. Living organisms have seven features or characteristics which make them different from objects that are not alive (Figure B1.01). The definitions of these characteristics are shown in the key terms box. You should learn these definitions now, but you will find out much more about each of them later in this book.

KEY TERMS

movement: an action by an organism causing a change of position or place

respiration: the chemical reactions in cells that break down nutrient molecules and release energy

sensitivity: the ability to detect and respond to changes in the environment

growth: a permanent increase in size

reproduction: the processes that make more of the same kind of organism

excretion: removal from organisms of toxic materials and substances in excess of requirements

nutrition: taking in of materials for energy, growth and development

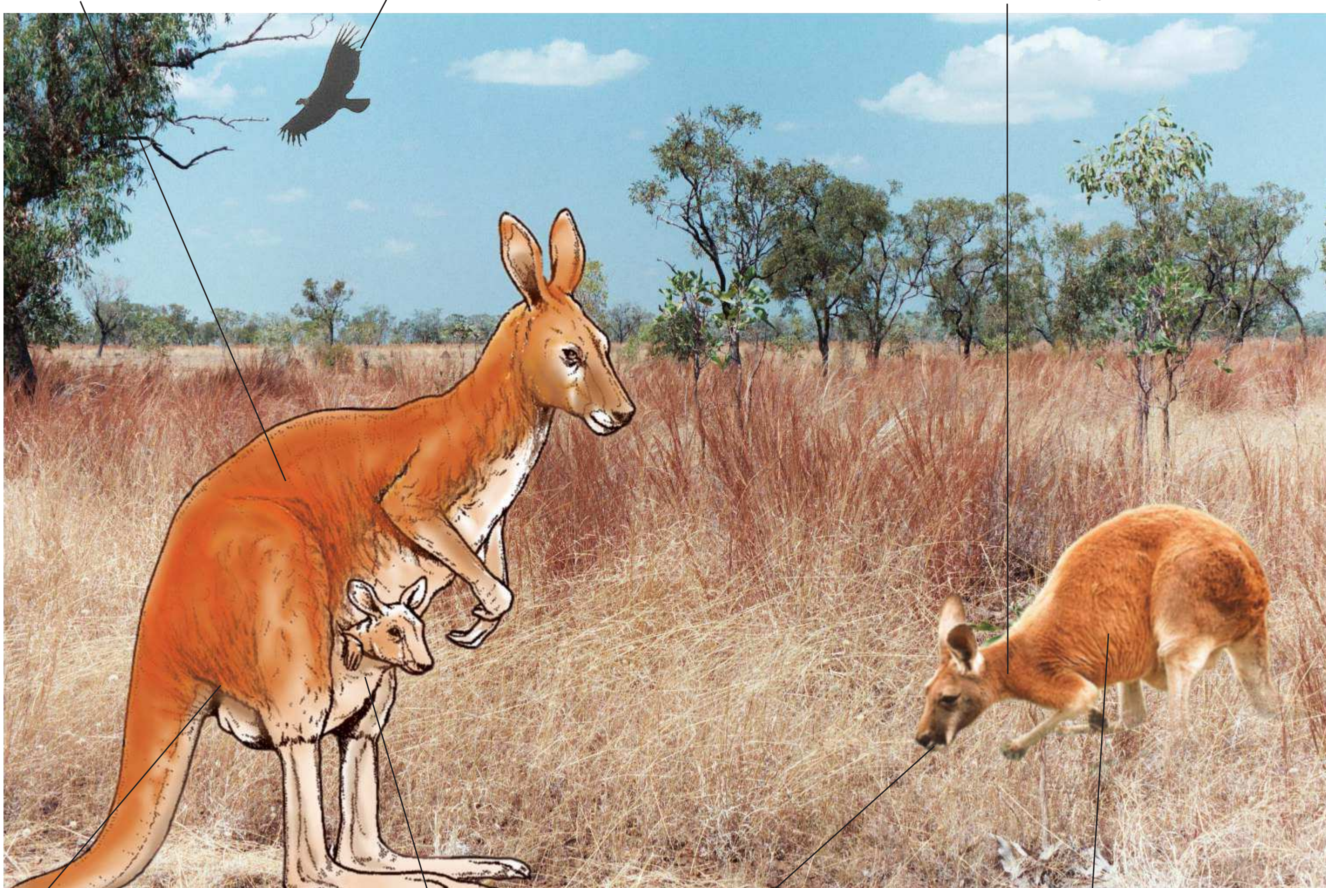

Figure B1.01 Characteristics of living organisms.

KEY TERMS

movement: an action by an organism or part of an organism causing a change of position or place

respiration: the chemical reactions in cells that break down nutrient molecules and release energy for metabolism

sensitivity: the ability to detect or sense stimuli in the internal or external environment and to make appropriate responses

growth: a permanent increase in size and dry mass by an increase in cell number or cell size or both

reproduction: the processes that make more of the same kind of organism

excretion: removal from organisms of the waste products of metabolism (chemical reactions in cells including respiration), toxic materials and substances in excess of requirements

nutrition: taking in of materials for energy, growth and development; plants require light, carbon dioxide, water and ions; animals need organic compounds and ions and usually need water

In addition to these seven characteristics, living organisms have another feature in common: when we study living organisms under a microscope, we can see that they are all made of cells.

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B1.02 Cells

All organisms are made of cells. Cells are very small, so large organisms contain millions of cells. Some organisms are unicellular, which means that they are made of just a single cell. Bacteria and yeast are examples of single-celled organisms.

Microscopes

To see cells clearly, you need to use a microscope (Figure B1.02). The kind of microscope used in a school laboratory is called a light microscope because it shines light through the piece of animal or plant you are looking at. It uses glass lenses to magnify and focus the image. A very good light microscope can magnify about 1500 times, so that all the structures in Figures B1.03 and B1.04 can be seen.

Photomicrographs of plant and animal cells are shown in Images B1.01 and B1.02. A micrograph is a picture made using a microscope. A photomicrograph is a picture made using a light microscope.

To see even smaller things inside a cell, an electron microscope is used. This uses a beam of electrons instead of light and can magnify up to 500 000 times. This means that a lot more detail can be seen inside a cell. We can see many structures more clearly, and also some structures that could not be seen at all with a light microscope. Pictures made using an electron microscope are called electron micrographs.

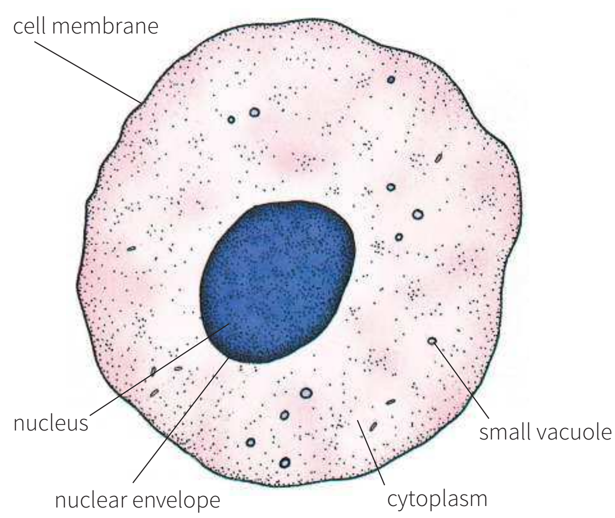
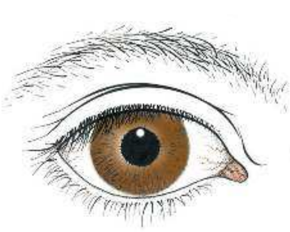
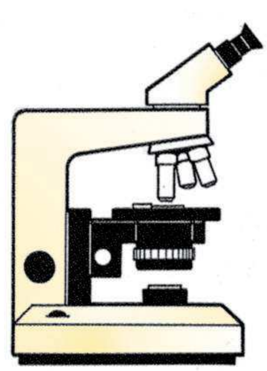


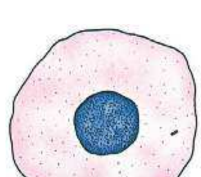
Figure B1.03 A typical animal cell – a liver cell – as seen using a light microscope.



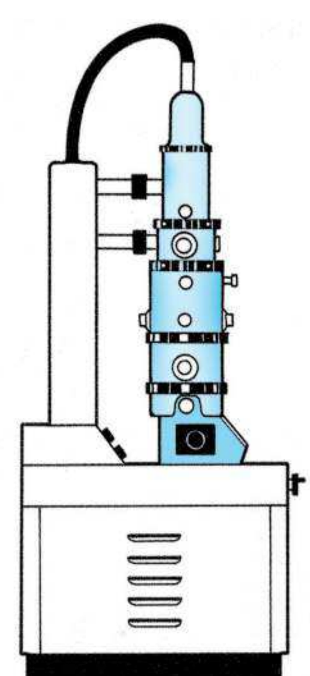
The human eye cannot see most cells.

A hand lens magnifies about × 10. Cells can often be seen as dots.





The light microscope magnifies up to × 1500. With a light microscope you can see some structures inside a cell, such as a nucleus.



An electron microscope magnifies up to × 10 million. With an electron microscope much more detail can be seen.

Figure B1.02 Equipment used for looking at biological material.

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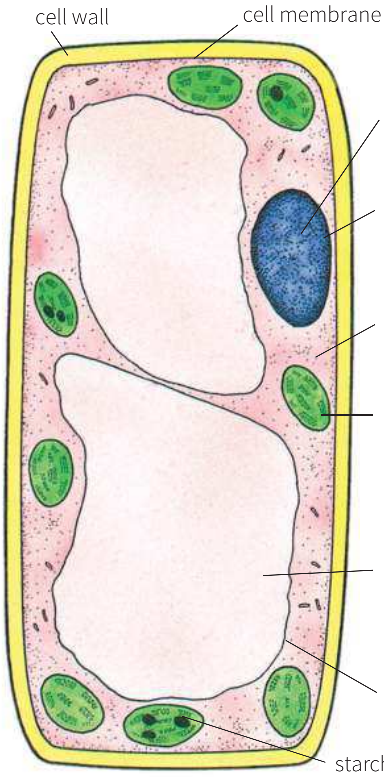


Figure B1.04 A typical plant cell – a palisade cell – as seen using a light microscope.

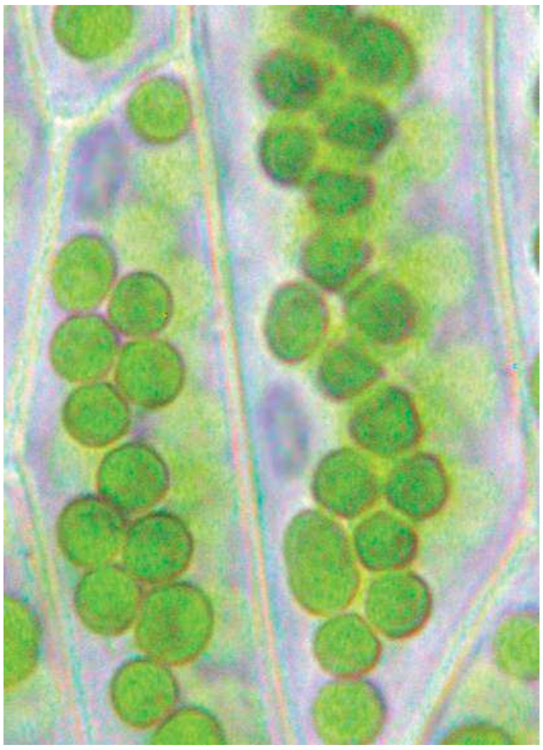


Image B1.01 Many plant cells contain green structures, called chloroplasts. Even if it does not have chloroplasts, you can still identify a plant cell because it has a cell wall around it (× 2000).

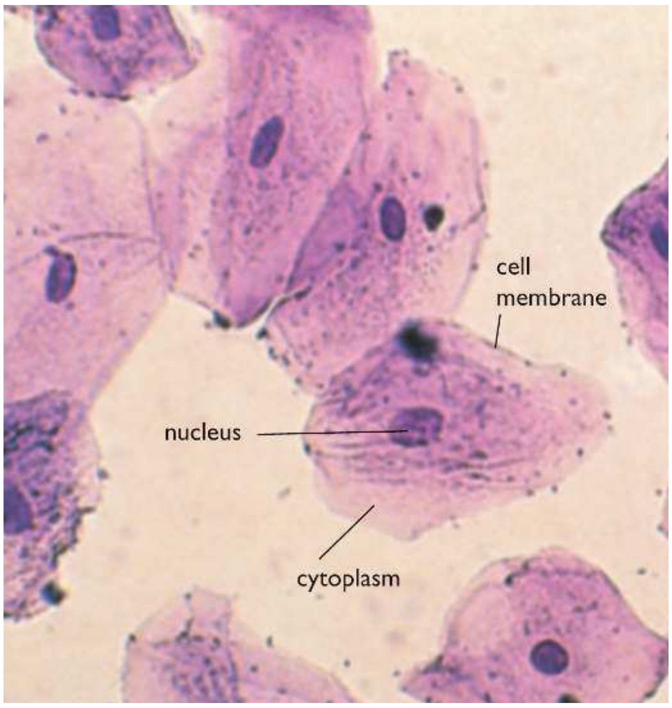


Image B1.02 Cells from the trachea (windpipe) of a mammal, seen through a light microscope (× 300).

ACTIVITY B1.01

Making drawings of biological specimens

Skill:

AO3.3 Observing, measuring and recording

Scientists need to be able to look closely at specimens – either with the naked eye or using a microscope – and note significant features in them. It is also important to be able to make scientific drawings. These need to be simple but clear.

In this Activity, you will be provided with a specimen of an animal to draw.

Here are some points to bear in mind when you draw:

- Make good use of the space on your sheet of paper. Your drawing should be large, but do leave space around it so that you have room for labels.

- Always use a sharp HB (medium hard) pencil and have a good eraser with you.
- Keep all lines single and clear.
- Don't use shading unless it is absolutely necessary.
- Don't use colours.
- Take time to get the outline of your drawing correct first, showing the right proportions.

Here are some points to bear in mind when you label a diagram:

- Use a ruler to draw each label line.
- Make sure the end of the label line actually touches the structure being labelled.
- Write the labels horizontally.
- Keep the labels well away from the edges of your drawing.

ACTIVITY B1.02

Calculating magnification

Skill:

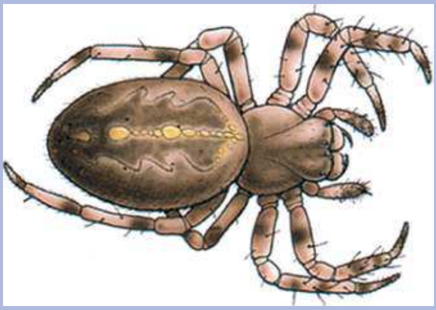
AO3.3 Observing, measuring and recording

Drawings and photographs of biological specimens are usually made at a different size from the actual object.

The magnification of a diagram or photograph is how much larger it is than the real thing:

$$\text{magnification} = \frac{\text{size in drawing or photograph}}{\text{size of the real object}}$$

For example, measure the length of the spider's body in the diagram. You should find that it is 40 mm long.



The real spider was 8 mm long. So we can calculate the magnification like this:

$$\text{magnification} = \frac{\text{length in drawing}}{\text{length of real spider}}$$

$$= \frac{40\text{ mm}}{8\text{ mm}}$$

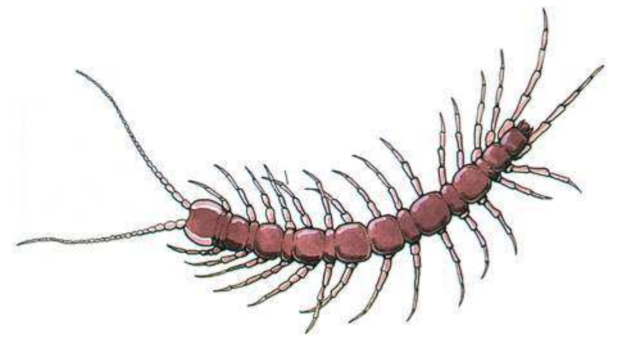
$$= \times 5$$

The following are two very important things to notice:

- You must use the same units for all the measurements. Usually, millimetres are the best units to use.
- You should not include any units with the final answer. Magnification does not have a unit. However, you must include the 'times' sign. If you read it out loud, you would say 'times five'.

Questions

A1 Measure the length of the lowest 'tail' (it is really called an appendage) on the centipede below. Write your answer in millimetres.



A2 The real length of the appendage was 10 mm. Use this, and your answer to question A1, to calculate the magnification of the drawing of the centipede.

QUESTIONS

B1.01 How many times can a good light microscope magnify?

B1.02 If an object was 1 mm across, how big would it look if it were magnified ten times?

Cell structure

Cell membrane

Whatever sort of animal or plant they come from, all cells have a **cell membrane** (sometimes called the cell surface membrane) around the outside. Inside the cell membrane is a jelly-like substance called **cytoplasm**, in which are found many small structures called **organelles**. The most obvious of these organelles is usually the **nucleus**. In a plant cell, the nucleus is very difficult to see, because it is right against the cell wall.

The cell membrane is a very thin layer of protein and fat. It is very important to the cell because it controls what goes in and out of it. It is **partially permeable**, which means that it will let some substances through but not others.

Cell wall

All plant cells are surrounded by a **cell wall** made mainly of **cellulose**. Paper, which is made from cell walls, is also made of cellulose. Animal cells never have cell walls made of cellulose. Cellulose belongs to a group of substances called **polysaccharides**, which are described in Chapter B2. Cellulose forms fibres that criss-cross over one another to form a very strong covering to the cell (Image B1.03). This helps to protect and support the cell. If the cell absorbs a lot of water and swells, the cell wall stops it from bursting.

Because of the spaces between fibres, even very large molecules are able to go through the cellulose cell wall. It is therefore said to be fully permeable.

Cytoplasm

Cytoplasm is a clear jelly. It is nearly all water; about 70% is water in many cells. Many substances are dissolved in it, especially proteins. Many different **metabolic reactions** (the chemical reactions of life) take place in the cytoplasm.

Vacuoles

A **vacuole** is a space in a cell, surrounded by a membrane and containing a solution. Plant cells have very large vacuoles, which contain a solution of sugars and other substances, called **cell sap**. A full vacuole presses outwards on the rest of the cell, and helps to keep it in shape. Animal cells have much smaller membrane-bound spaces, called **vesicles**, which may contain nutrients or water.

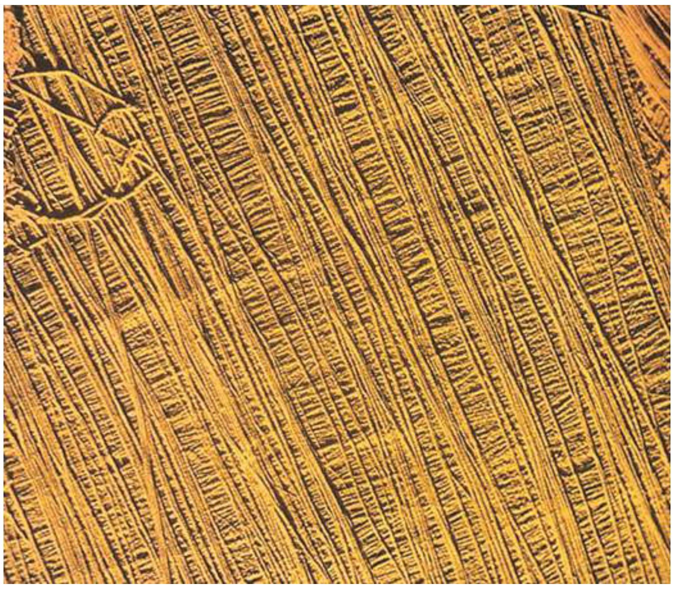


Image B1.03 Cellulose fibres from a plant cell wall. This picture was taken using an electron microscope (× 50 000).

Chloroplasts

Chloroplasts are never found in animal cells, but most of the cells in the green parts of plants have them. They contain a green colouring or pigment called **chlorophyll**. Chlorophyll absorbs energy from sunlight, and this energy is then used for making food for the plant by photosynthesis (Chapter B4).

Chloroplasts often contain starch grains, which have been made by photosynthesis. Animal cells never contain starch grains. Some animal cells, however, do have granules (tiny grains) of another substance similar to starch, called glycogen. These granules are found in the cytoplasm, not inside chloroplasts.

Nucleus

The nucleus is where the genetic information is stored. This helps the cell to make the right sorts of proteins. The information is kept on the **chromosomes**, which are inherited from the organism's parents. The chromosomes are made of **DNA**.

Chromosomes are very long, but so thin that they cannot easily be seen even using the electron microscope. However, when the cell is dividing, they become short and thick and can be seen with a good light microscope.

Table B1.01 compares some features of plant cells and animal cells.

Plant cells	Animal cells
have a cellulose cell wall outside the cell membrane	have no cell wall
have a cell membrane	have a cell membrane
have cytoplasm	have cytoplasm
have a nucleus	have a nucleus
often have chloroplasts containing chlorophyll	have no chloroplasts
often have large vacuoles containing cell sap	have only small vacuoles
often have starch grains	never have starch grains; sometimes have glycogen granules
are often regular in shape	are often irregular in shape

Table B1.01 A comparison of plant and animal cells.

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ACTIVITY B1.03

Using a microscope

Practise using a microscope to look at very small things.

ACTIVITY B1.04

Looking at animal cells

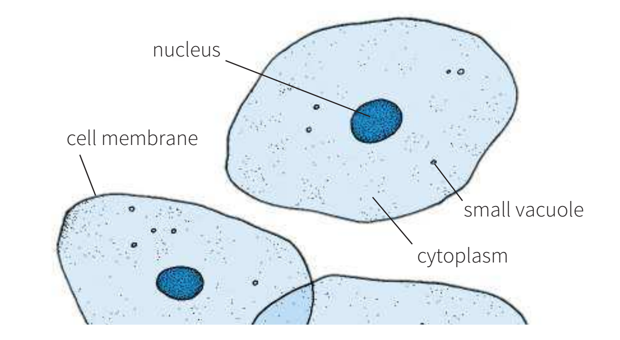
Skills:

AO3.1 Using techniques, apparatus and materials

AO3.3 Observing, measuring and recording

⚠ Wash your hands thoroughly after handling the trachea and cells.

Some simple animal cells line the mouth and trachea (or windpipe). If you colour or stain the cells, they are quite easy to see using a light microscope (see Image B1.02 and the drawing below).



A drawing of tracheal cells seen through a light microscope after staining with methylene blue.

1. Using a section lifter, gently rub off a little of the lining from the inside of the trachea provided.
2. Put your cells onto the middle of a clean microscope slide, and gently spread them out. You will probably not be able to see anything at all at this stage.
3. Put on a few drops of methylene blue.
4. Gently lower a coverslip over the stained cells, trying not to trap any air bubbles.
5. Use filter paper or blotting paper to clean up the slide, and then look at it under the low power of a microscope.
6. Make a labelled drawing of a few cells.

Questions

A1 Which part of the cell stained the darkest blue?

A2 Is the cell membrane permeable or impermeable to methylene blue? Explain how you worked out your answer.

ACTIVITY B1.05

Looking at plant cells

Skills:

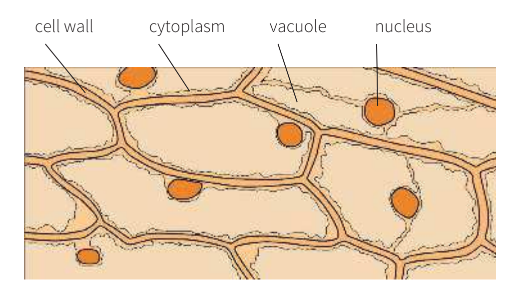
AO3.1 Using techniques, apparatus and materials

AO3.3 Observing, measuring and recording

⚠ Take care with the sharp blade when cutting the onion.

To be able to see cells clearly under a microscope, you need a very thin layer. It is best if it is only one cell thick. An easy place to find such a layer is inside an onion bulb.

1. Cut a small piece from an onion bulb, and use forceps to peel a small piece of thin skin, called epidermis, from the inside of it. Do not let it get dry.
2. Put a drop or two of water onto the centre of a clean microscope slide. Put the piece of epidermis into it, and spread it flat.
3. Gently lower a coverslip onto it.
4. Use filter paper or blotting paper to clean up the slide, and then look at it under the low power of a microscope.
5. Make a labelled drawing of a few cells. The drawing below may help you, but do not just copy it. Do remember not to colour your drawing.



A drawing of onion epidermis cells seen through a light microscope after staining with iodine.

6. Using a pipette, take up a small amount of iodine solution. Very carefully place some iodine solution next to the edge of the coverslip. The iodine solution will seep under the edge of the coverslip. To help it do this, you can place a small piece of filter paper next to the opposite side of the coverslip, which will soak up some of the liquid and draw it through.
7. Look at the slide under the low power of the microscope. Note any differences between what you can see now and what it looked like before adding the iodine solution.

Questions

A1 Name two structures which you can see in these cells, but which you could not see in the tracheal cells (Activity B1.04).

A2 Most plant cells have chloroplasts, but these onion cells do not. Suggest a reason for this.

A3 Iodine solution turns blue-black in the presence of starch. Did any of the onion cells contain starch?

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QUESTIONS

B1.03 What sort of cells are surrounded by a cell membrane?

B1.04 What are plant cell walls made of?

B1.05 What does 'fully permeable' mean?

B1.06 What does 'partially permeable' mean?

B1.07 What is the main constituent of cytoplasm?

B1.08 What is a vacuole?

B1.09 What is cell sap?

B1.10 Chloroplasts contain chlorophyll. What does chlorophyll do?

B1.11 What is stored in the nucleus?

B1.12 Why can chromosomes be seen only when a cell is dividing?

B1.03 Cells and organisms

A large organism such as yourself may contain many millions of cells, but not all the cells are alike. Almost all of them can carry out the activities which are characteristic of living things, but many of them specialise in doing some of these better than other cells do. Muscle cells, for example, are specially adapted for movement. Most cells in the leaf of a plant are specially adapted for making food by photosynthesis.

Table B1.02 lists examples of specialised cells and the parts of the book where you will find information about how their structures help them to carry out their functions.

Type of cell	Where it is found	Function	Where you can find out more
root hair cells	near the ends of plant roots	absorb water and mineral salts	Chapter B6, Section B6.02
palisade mesophyll cells	beneath the epidermis of a leaf	photosynthesis	Chapter B4, Section B4.03
red blood cells	in the blood of mammals	transport oxygen	Chapter B7, Section B7.04
sperm and egg cells	in testes and ovaries	fuse together to produce a zygote	Chapter B11, Section B11.01
ciliated cells	lining the trachea and bronchi	move mucus upward	Chapter B8, Section B8.02

Table B1.02 Some examples of specialised cells.

Summary

You should know:

- the seven characteristics of living organisms
- the structure of an animal cell and a plant cell as seen using a microscope, and be able to compare them
- the functions of the different parts of animal cells and plant cells
- how to calculate magnification using millimetres (mm)
- some examples of specialised cells.

End-of-chapter questions

1 a Without looking back at the beginning of this chapter, decide which **five** of the following characteristics are found in all living things:

movement **blood system** **sight** **growth** **photosynthesis**
nutrition **sensitivity** **speech** **excretion**

b List the other **two** characteristics of all living organisms.

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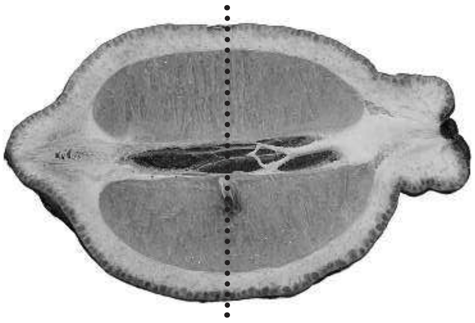
2 State which part of a plant cell:

a makes food by photosynthesis
b controls what goes in and out of the cell
c stores information about making proteins
d contains cell sap
e protects the outside of the cell

3 Distinguish between each of the following pairs of terms:

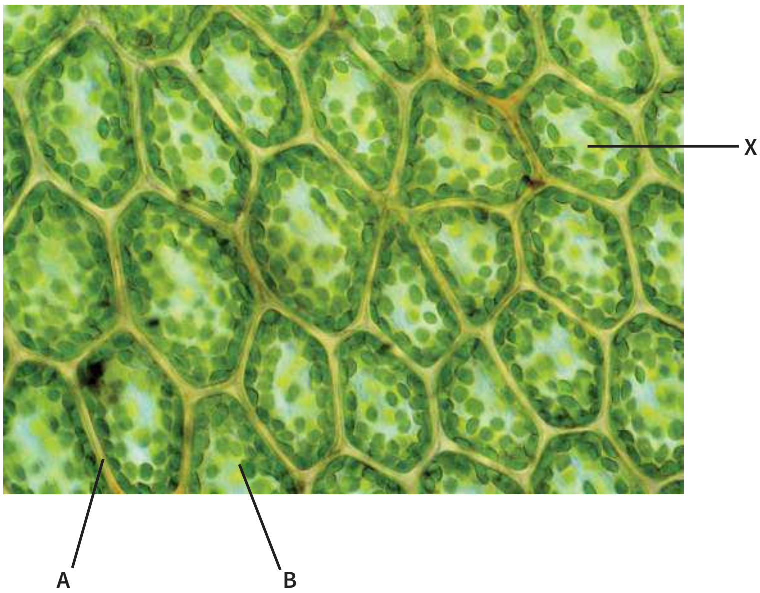
a chloroplast, chlorophyll
b cell wall, cell membrane

4 The photograph shows a section through a fruit.



a Make a large diagram of the fruit. You do not need to label your diagram. [5]
b The photograph shows the fruit at a magnification of x 0.6. Calculate the diameter of the actual fruit at the point indicated by the dotted line. Show your working, and remember to include the unit. [3]

5 The micrograph shows a group of cells from a plant.



a Name the parts of the cell labelled **A** and **B**. [2]
b State **two** ways in which you can tell that the cells in the micrograph are plant cells and not animal cells. [2]
c i Measure the maximum diameter of the cell labelled **X**. Record your measurement in millimetres. [1]
ii The micrograph has been magnified 250 times. Calculate the real maximum diameter of the cell labelled **X**. Show your working clearly. [2]

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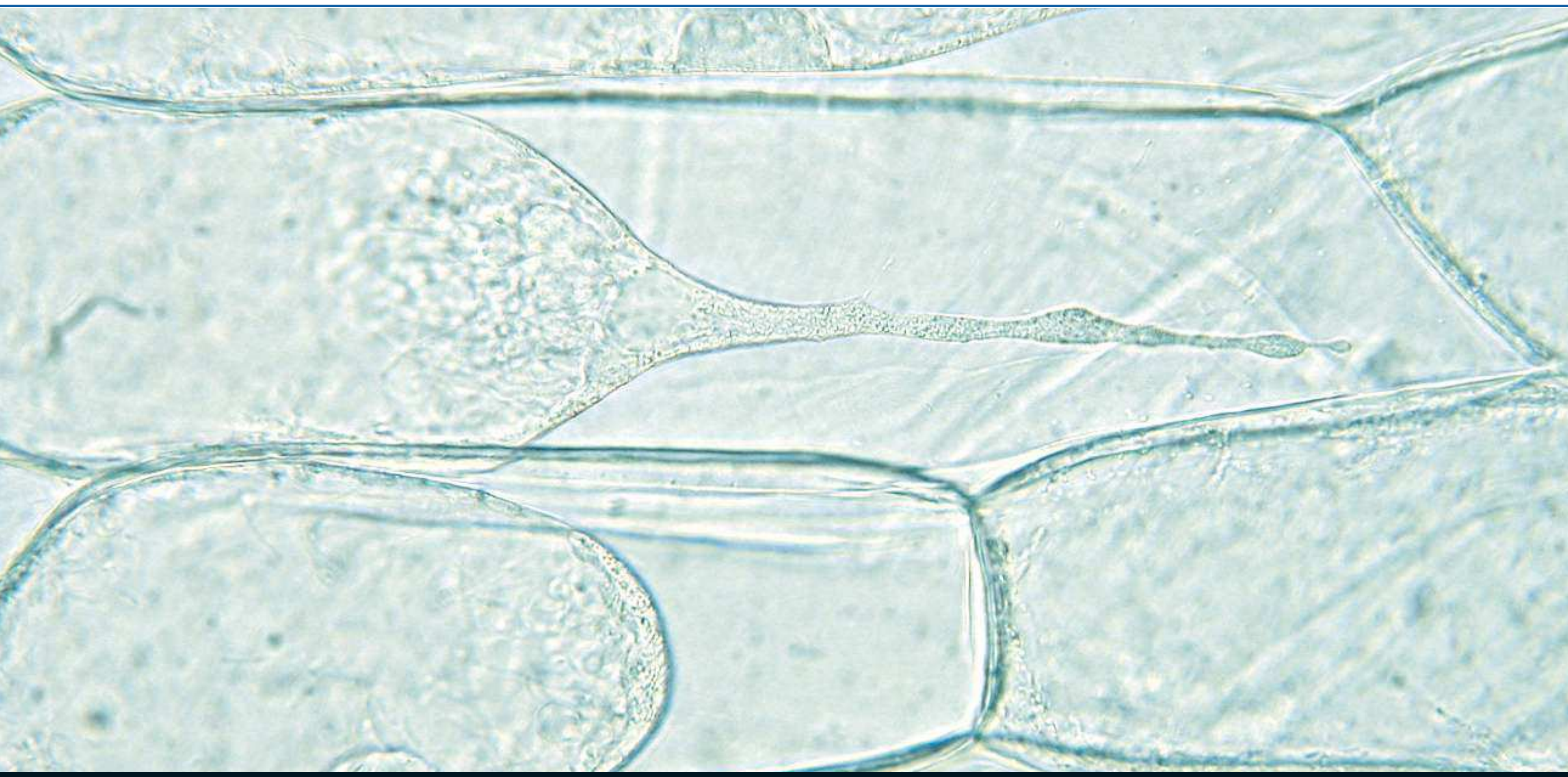

B2
Movement in and out of cells

This chapter covers:

- movement of materials by diffusion
- how substances move into and out of cells by diffusion through the cell membrane
- the effects of osmosis in moving water in and out of cells through the cell membrane
- how to investigate the effects of surface area, temperature, concentration gradients and diffusion distance on the rate of diffusion
- movement of water by osmosis (a special kind of diffusion)
- how osmosis affects plant tissues.

B2.01 Diffusion

Atoms, molecules and ions are always moving. The higher the temperature, the faster they move. In a solid substance the particles cannot move very far, because they are held together by attractive forces between them. In a liquid they can move more freely, knocking into one another and rebounding. In a gas they are freer still, with no attractive forces between the molecules or atoms.

Molecules and ions can also move freely when they are in solution.

When they can move freely, particles tend to spread themselves out as evenly as they can (Figure B2.01). This happens with gases, solutions, and mixtures of liquids. Imagine, for example, a rotten egg in one corner of a room, giving off hydrogen sulfide gas. To begin with, there will be a very high concentration of the gas near

