Stem cells

Our bodies are made up of millions of cells, of many different kinds. Yet each began as just a single cell. How do all these different cells arise?

In a tiny embryo, each cell has the ability to divide and form new cells, and these new cells are able to turn into any of the different kinds of cells that make up your body (Figure 2.1). Cells that can do this are called stem cells. By the time a baby is born, most of its cells have already become specialised. Once they have done that, they cannot turn into any other kind of cell. They are not stem cells any more.

Doctors would like to be able to use stem cells to replace damaged cells in their patients’ bodies. For example, if someone has a damaged heart, perhaps we could put stem cells into their heart, which would divide and produce new heart muscle cells. In theory, this should be possible, but there are still a lot of problems to be solved before we will be able to use stem cells in this way.

Figure 2.1
In a tiny human embryo, each cell is able to divide to produce any of the specialised cells in a human body. (×000)
**2.1 Cells**

All living organisms are made up of cells. Bacteria have just one cell. Plants and animals are made up of millions of cells. You probably contain around one million million cells.

Cells are very small, so you can only see them using a microscope.

**Animal cells**

If you are able to do Investigation 2.1, you will be able to see some animal cells. They will probably look something like the cell shown in Figure 2.2.

All animal cells have **cytoplasm** and a **cell surface membrane** which completely surrounds the cell. Most animal cells also have a **nucleus**. Red blood cells, however, are unusual and do not have a nucleus.

**Plant cells**

If you are able to do Activity 2.2, you will be able to see some plant cells. They are often easier to see than animal cells, at least partly because they are often quite a bit larger.

Figure 2.3 shows the kind of plant cell that you might find in a leaf. You can see that it has several structures that animal cells don’t have. These are a **cell wall**, **chloroplasts** and large **vacuole** containing cell sap.

**The parts of cells**

Each of the different parts of a cell has its own particular function (role).

**Structures found in both animal and plant cells**

All cells have cytoplasm. This is a jelly-like substance. It is mostly water – about 70% in many cells – with proteins and other chemicals dissolved in it. Many different **metabolic reactions** take place in the cytoplasm.

All cells have a cell surface membrane which completely surrounds the cell and separates it from its environment (surroundings). This membrane controls what goes in and out of the cell. It will let some substances pass through, but not others, and so it is said to be **partially permeable**. Cell surface membranes are strong but very flexible.

Most cells have a nucleus. This contains a chemical called **DNA**. The DNA is arranged in long threads called **chromosomes**. You will not have seen chromosomes in the cells you looked at under the microscope, and they are not shown in Figures 2.2 and 2.3. This is because when a cell is not dividing the chromosomes are very long and thin, and so are invisible even with a good school microscope. But when a cell divides, the chromosomes get shorter and fatter, making it much easier to see them.

The DNA in the chromosomes contains coded instructions for how the cell should behave. It determines which proteins the cell should make, which in turn determines the characteristics of that cell and of the organism of which it is part.
**Structures found in plant cells only**

All plant cells, but never animal cells, have a cell wall outside their cell surface membrane. This cell wall is made of **cellulose**. Unlike the cell surface membrane, the cell wall does not control what goes through it, and so it is said to be **fully permeable**. The function of the cell wall is to hold the plant cell in shape and to stop it bursting when it takes up a lot of water.

Many plant cells in the leaves have green structures called chloroplasts. These are found in the cytoplasm. The chloroplasts are green because they contain a green pigment, **chlorophyll**. Chlorophyll absorbs energy from sunlight, and helps the chloroplast to use this energy to make sugars. This is called **photosynthesis**. Animal cells do not feed by photosynthesis, and they do not have chloroplasts.

Plant cells often contain a large, liquid-filled space called a vacuole. The vacuole is surrounded by a membrane which keeps its contents separate from the cytoplasm. The liquid inside the vacuole is called **cell sap**. It is mostly water, with sugars, amino acids and other substances dissolved in it. It is a storage area for the plant cell. Animal cells often have small vacuoles, but they are hardly ever as large as the vacuole in a plant cell, and they do not contain cell sap.

---

**QUESTION**

2.1 Make a comparison table to summarise the similarities and differences between plant and animal cells. Draw a table like this:

<table>
<thead>
<tr>
<th>Structure</th>
<th>Is it found in animal cells?</th>
<th>Is it found in plant cells?</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>cell surface membrane</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cytoplasm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>nucleus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cell wall</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>chloroplasts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>vacuole</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

You will need six rows, one for each of: cell surface membrane, cytoplasm, nucleus, cell wall, chloroplasts and vacuole. Make the ‘comment’ column wider than the others, so that you have room to write plenty of information in it.

---

2.2 How cells are organised

Some specialised cells

Although all animal cells are similar to each other, and all plant cells are similar to each other, they are not all exactly the same. Different cells have different functions, and they often have adaptations that help them to carry out these functions.

**Root hair cells**

Root hair cells (Figure 2.4) are specialised plant cells. They are found on the outside of plant roots, just a little way up from the root tip. Their functions are to help to anchor the plant in the soil, and to absorb water and mineral ions from the soil.
Each root hair cell has a long thin part reaching out into the soil. This gives the cell a much larger surface area than most cells. The large surface area means that a lot of water and mineral ions can get into the cell very quickly.

**Xylem cells**

Xylem cells are another type of specialised plant cell. They are perhaps the strangest of all, because they are completely empty and dead. They began as a normal, living plant cell, but then their cell walls gradually filled up with a substance called lignin. This is strong and waterproof. The contents of the cell gradually died, so that it ended up as a hollow tube with a wall containing lignin as well as cellulose.

An individual xylem cell is called a **xylem vessel element** (Figure 2.5). Each one has completely lost its end walls. Lots of these cells are arranged end to end, forming a long, continuous tube that can run all the way from the roots, up the stem and into the leaves of the plants. These tubes are called **xylem vessels**. The veins in a leaf contain many xylem vessels.

Xylem vessels have two functions. The first is to transport water and mineral ions from the roots to all the other parts of the plant. The second is to help to support the plant. The lignin in their walls is stiff and strong. You can feel the stiffness of the veins in a plant’s leaves. The wood in trees is also made of xylem vessels, so wood is mostly lignin.

**Ciliated cells**

Ciliated cells are specialised animal cells. We have ciliated cells in the lining of our trachea (windpipe) and bronchi (Figure 2.6).

Cilia are tiny extensions of the cell, covered with a cell surface membrane just like the rest of the cell. Cilia can move, and all the cilia on a cell and its neighbours beat together in a rhythmic way so that they look rather like a field of long grass with the wind sweeping over it. They help to sweep mucus up the bronchi and the trachea towards the back of the throat, where you swallow it. The mucus traps bacteria and dirt particles in the air that you breathe in, so the cilia are helping to keep this out of your lungs. You can read more about this on page 000.

**Muscle cells**

Muscle cells are found in many different animals, including humans. The cells shown in Figure 2.7 could be found in the biceps muscle in your arm.
Like all animal cells, muscle cells have a cell surface membrane, cytoplasm and a nucleus – but each muscle cell has many nuclei rather than just one. They look striped because they are made up of many strands of protein arranged in a pattern. The strands of protein can slide between each other, making the cell much shorter. This is called contraction. A lot of energy is needed for muscle cells to contract.

Red blood cells

Red blood cells are smaller than almost every other kind of cell in the human body. They have a cell surface membrane and cytoplasm, but no nucleus (Figure 2.8). The cytoplasm is full of a red protein called haemoglobin. Haemoglobin carries oxygen from your lungs to all the other parts of your body.

Being very small enables red blood cells to squeeze through the tiniest of blood capillaries, taking oxygen as close as possible to each cell that needs it. Red blood cells are circular and have a dent in the middle, which gives them a large surface area. This speeds up the rate at which oxygen can move into and out of them.

QUESTION

2.2 Figure 2.9 is an annotated diagram of a root hair cell. An annotated diagram explains something about the functions of what is drawn, as well as its structure.

Using Figure 2.9 as a starting point, make annotated diagrams of a xylem vessel, a muscle cell, a red blood cell and a ciliated cell. Your annotations should explain how the special features of each cell help it to perform its functions.
Tissues, organs and organ systems

A tissue is a group of similar cells that all work together to perform the same function. For example, the layer of cells lining the inside of your cheeks is a tissue. The layer of cells you peeled from the inside of a piece of onion, when you looked at plant cells under the microscope, is a tissue. A group of muscle cells makes up muscle tissue, and a group of xylem cells makes up xylem tissue.

Different kinds of tissues are often arranged together to make an organ. An organ is a group of different tissues which work together to perform a particular function. For example, the brain and the kidneys are organs, and so is a leaf.

Figure 2.10 shows a leaf, which is an example of a plant organ. Leaves have many functions, including making sugars by photosynthesis. This is done by cells inside the leaf, in tissues called the palisade mesophyll and spongy mesophyll. These cells need a supply of water, which is brought to them in xylem vessels. Some of the sugar that they make is carried to other parts of the plant inside phloem tubes. The spongy mesophyll cells are arranged loosely, with air spaces in between them. Thin layers of cells on the top and bottom of the leaf, called the epidermis, let light through to the mesophyll cells but stop too much water vapour leaving the leaf, so that it does not dry out. Small openings in the lower epidermis, called stomata, allow gases to move in and out of the leaf.

Organs do not work on their own. Most organs work with other organs to help each other to perform particular functions. These organs form organ systems. An organ system can be defined as:

*a group of organs with related functions, working together to perform body functions.*

For example, the brain and the eye are both parts of the nervous system. The lungs and trachea are parts of the gas exchange system. The stomach and intestines are parts of the digestive system.

**QUESTION**

2.3 Using the index, look up the nervous system, gas exchange system and digestive system. Make a list of the organs in each of these three organ systems.
2.3 Magnification of drawings and micrographs

Many of the things that biologists study are quite small. When we make drawings of them, we often draw them larger than they really are.

For example, Figure 2.11 is a photograph of a leaf, shown life size.

Figure 2.12 is a diagram of the leaf. The diagram has been drawn larger than the actual leaf.

We can calculate the magnification of the diagram.

\[
magnification = \frac{\text{size of drawing}}{\text{size of specimen}}
\]

Measure the length of the real leaf. You should find that it is _____ mm long. Now measure the same distance on the drawing of the leaf. You should find that it is _____ mm long.

So the magnification of the drawing is:

\[
\frac{_____ \text{ mm}}{_____ \text{ mm}} = \times _____
\]

Notice how we write the magnification: \( \times \)...
2.4 A spider is 24 mm long. A drawing of the spider is 88 mm long. Calculate the magnification of the drawing, showing your working clearly.

2.4 Movement into and out of cells

Diffusion

All substances are made up of tiny particles called atoms. In some substances, these atoms have lost or gained one or more electrons, to become ions. In other substances, the atoms are grouped together to form molecules.

Atoms, ions and molecules are always moving. In a solid, each particle has a fixed position and it just vibrates in this position. In a liquid, the particles move more freely around each other, but stay in fairly close contact. In a gas, the particles are much further apart and move around freely.

Imagine the lid being taken off a bottle of ammonia solution. Molecules of ammonia gas move out of the bottle. Each molecule moves randomly – it is just as likely to go in one direction as another. The ammonia molecules bump into one another, and into other molecules in the air, such as oxygen and nitrogen molecules.

When one molecule hits another, both of them change course. Figure 2.13 shows how one ammonia molecule might move around. Each change in direction happens when the molecule bumps into another one.

When the lid of the ammonia bottle is first taken off, there are a lot of ammonia molecules inside the bottle. We say that there is a high concentration of ammonia inside the bottle. There are probably almost no ammonia molecules in the air in the room – so here there is a low concentration of ammonia molecules.

As the ammonia molecules bump randomly around, some of them move erratically further and further away from the bottle. After a while, some will have moved right into the far corner of the room. The ammonia molecules have diffused across the room.

It is important to realise that the ammonia molecules do not head purposefully across the room from the bottle. Each molecule just bumps randomly around. It is by chance that some of them end up a long way from the bottle. Some of them might even go back into the bottle. But, after a while, these random movements result in their being more ammonia molecules out in the room, and fewer inside the bottle. After a long time, you would probably end up with ammonia molecules spread evenly all over the room.

The overall or net result of diffusion is that particles spread out evenly. They tend to spread out from a place where they are in a high
concentration and into a place where they are in a low concentration. We say that they spread out down a **concentration gradient**. Diffusion can be defined as:

**the net movement of molecules from a region of their higher concentration, to a region of their lower concentration down a concentration gradient, as result of their random movement**

### Activity 2.4

How quickly does ammonia diffuse?

---

**Diffusion and living organisms**

Diffusion is very important to all living organisms, including humans. You will meet several examples as you continue your biology course. For the moment, we’ll look at one example of diffusion in animals, and one in plants.

**Gas exchange in human lungs**

Figure 2.14 shows a tiny part of the human lungs, greatly magnified. In the lungs, oxygen diffuses from the little air sacs (alveoli) into the blood. It is carried away inside the red blood cells.

The lungs are made up of hundreds of thousands of tiny alveoli. Each alveolus has tiny blood vessels called **capillaries** wrapped closely around it. These contain blood, which contains red blood cells.

Oxygen molecules in the air inside the alveoli move randomly around. Some of them go right through the cells making up the wall of the alveolus and the wall of the blood capillary, right through the blood plasma, and through the cell surface membrane of a red blood cell. Here, they combine with haemoglobin.
There are usually a lot more oxygen molecules in the air inside the alveolus than there are in the blood inside the capillary. So, although some oxygen molecules will travel from the capillary and into the alveolus, as a result of their random movements, there will be many more travelling in the opposite direction. The net movement of oxygen is from the alveolus and into the capillary. The oxygen moves down a concentration gradient, by diffusion.

**Gas exchange in a plant leaf**

In daylight, palisade mesophyll and spongy mesophyll cells in a leaf photosynthesise. They use carbon dioxide and water to make sugars. These sugars may then be turned into starch in the leaf. Where does the carbon dioxide come from, and how does it get to these cells?

Air contains carbon dioxide, though there is not very much of it – only about 0.04% of the air is carbon dioxide. These carbon dioxide molecules bump randomly around. Some of them, just by chance, will go through the stomata on the underside of a leaf, into the air spaces inside the leaf, into a mesophyll cell and into a chloroplast.

Carbon dioxide molecules arriving in a chloroplast can be made into sugar. This keeps the concentration of carbon dioxide molecules inside the chloroplasts much lower than in the air outside the leaf. So there is a concentration gradient from the air into the chloroplast. The net movement of the carbon dioxide molecules is down this concentration gradient. They move into the leaf by diffusion.

**Osmosis**

Osmosis is a special kind of diffusion, involving water molecules. Figure 2.15 shows how it happens.

This diagram shows a partially permeable membrane separating two sugar solutions. The membrane is partially permeable because it has tiny holes in it.

The sugar solutions are mixtures of water molecules and sugar molecules. Sugar molecules are much larger than water molecules. The water molecules can get through the holes in the membrane, but the sugar molecules are too big.

The sugar solution on the left is a dilute solution. It does not contain much sugar. The sugar solution on the right is a concentrated solution, containing a lot more sugar. There are the same number of water molecules on both sides of the membrane but there are more ‘free’ water molecules in the dilute sugar solution.

On both sides of the membrane, the water molecules and sugar molecules bounce around randomly. If a sugar molecule hits the membrane, it just bounces off. But if a water molecule bounces into a hole in the membrane, it can shoot through to the other side.

Because there are more ‘free’ water molecules on the left-hand side, more water molecules will go from left to right through the membrane than in the opposite direction. Although water molecules do go both ways, the net movement is from left to right.
Because there are more ‘free’ water molecules on the left-hand side we say that there is a higher water potential on the left-hand side of the membrane than on the right. Concentrated solutions have a lower water potential than dilute solutions. The net movement of water molecules is down their water potential gradient, from high water potential to low water potential.

You can probably see that osmosis is just like diffusion. The only thing that is different is that we have a membrane in the way, which lets the water molecules diffuse but stops the sugar molecules from diffusing. This sort of diffusion is called osmosis. We can define osmosis as:

**the diffusion of water molecules from a region of higher concentration (dilute solution) to a region of their lower concentration (concentrated solution), through a partially permeable membrane.**

In terms of water potential, we can diffuse osmosis as:

**the net diffusion of water molecules from a region of high water potential to a region of low water potential, through a partially permeable membrane.**

### Osmosis and animal cells

Figure 2.16 shows an animal cell in pure water. The solutions inside and outside the cell are separated by the cell surface membrane. This is a partially permeable membrane. Water molecules pass easily through it, but larger molecules cannot get through.

Inside the cell, the cytoplasm is a fairly concentrated solution of proteins and other substances in water. Outside the cell, there is pure water. So the water outside the cell has more ‘free’ water molecules than the solution inside the cell.

The tap water outside the cell has a higher water potential than the solution in the cytoplasm inside the cell. Therefore, the water molecules diffuse down the water potential gradient into the cell.

The water therefore diffuses into the cell. The random movements of the water molecules result in more of them moving into the cell than move out of it. The water moves into the cell by osmosis.

What will happen to the cell? As more and more water enters the cell, the cell swells up. After a while, it may get so big that it bursts the cell surface membrane. The contents of the cell escape, and the cell dies.

**QUESTIONS**

2.5 Figure 2.17 shows an animal cell in a concentrated sugar solution. The sugar solution is much more concentrated than the solution inside the cell.

a) Which has the higher water potential – the sugar solution or the cytoplasm?

b) In which direction will the net movement of water take place?

c) What do you think the sugar molecules do?

d) Will the cell get bigger or smaller?

---

**Activity 2.6**

Using Visking tubing to investigate osmosis
Osmosis and plant cells

Figure 2.18 shows a plant cell in pure water. As in the animal cell (Figure 2.16), the cell surface membrane, which is partially permeable, separates the concentrated solution inside the cell from the pure water outside. Water therefore moves into the cell by osmosis as the water molecules move from the less concentrated solution to the more concentrated one. Here there is a solution with a high water potential outside the cell and a solution with a lower water potential inside the cell. These solutions are separated by the partially permeable cell surface membrane. Water moves by osmosis into the cell, from the solution with the higher water potential to the solution with the lower water potential.

However, this time the cell does not burst. This is because the plant cell has a strong outer covering – its cell wall. As more and more water goes into the cell, the cytoplasm and vacuole get bigger and bigger, and push outwards on the cell surface membrane and the cell wall. But the cell wall will not give way. It prevents the cell from expanding enough to break the cell surface membrane.

A plant cell like this, as full as it can be, is very firm and rigid. It is said to be turgid. The cells of a well-watered plant are all turgid. This helps to keep the soft parts of a plant, such as its leaves and flower petals, firm and in shape. Turgidity helps to support the plant.

2.6 A scientist took a sample of human blood, and divided it between three tubes. She then added liquid to each tube, as follows:
- tube A distilled water
- tube B salt solution of the same concentration as the cytoplasm of the red blood cells
- tube C very concentrated salt solution.

She mixed the contents of each tube very thoroughly. After a few minutes, she observed the following:
- tube A a clear red solution
- tube B a red cloudy liquid
- tube C a red cloudy liquid.

She then took a few drops from each tube, put them onto microscope slides and looked at them using a microscope.

a) Name the substance that makes blood look red.
b) If you look at blood through a microscope, you see red cells floating in a colourless liquid called plasma. Why are the blood cells red?
c) When blood is in a test tube, it looks cloudy because of the cells floating in the plasma. Suggest why the contents of tubes B and C stayed cloudy, but the contents of tube A went clear.
d) Describe and explain what happened to the cells in each tube. Suggest what the scientist would have seen when she looked at each sample using a microscope.
2.7 Look back at Figure 2.4, which shows a root hair cell.

Imagine the root hair cell is growing between soil particles. There is a dilute solution, containing a lot of water, in between the soil particles.

a) Which has the higher water potential – the dilute solution between the soil particles, or the more concentrated solution inside the root hair cell?

b) In which direction will the water move by osmosis?

c) Where is the partially permeable membrane through which the water moves?

d) Imagine that someone gives the plant too much fertiliser. The salts in the fertiliser dissolve in the water in the soil. Now the concentration of the solution in the soil is much greater than the concentration inside the root hair cell. What will happen?

Figure 2.19 shows a plant cell in a concentrated solution. The water molecules diffuse out of the cell. Water moves out of the cell by osmosis.

The solution outside the cell has a lower water potential than the solution inside it. The water molecules move by osmosis from the higher water potential to the lower one, so they move out of the cell.

Just as in an animal cell, this makes the contents of the cell shrink. As the cell loses more and more water, the cytoplasm and vacuole get smaller and smaller. They stop pushing outwards on the cell wall. Instead of being firm and stiff, the cell becomes soft. It is said to be flaccid.

If water keeps on going out of the cell, and the cytoplasm keeps on shrinking, the cell surface membrane will eventually be pulled away from the cell wall. When this happens, the cell is said to be plasmolysed.

2.8 Look at Figure 2.19.

a) Is the cell wall of a plant cell partially permeable, or is it fully permeable? What does this mean?

b) Use your answer to (a) to predict what will be in space X.
A student decided to test this hypothesis:

**Cells in onion tissue immersed in a concentrated sugar solution will become plasmolysed, but if they are immersed in a dilute sugar solution they will not become plasmolysed.**

She took an onion and cut 6 equal-sized pieces of epidermis. She immediately placed each piece into a drop of distilled water or sugar solution on a microscope slide. Then she lowered a cover slip onto each drop and left the slides for 15 minutes.

She then looked at each slide in turn under the microscope. She focussed on a small area, and counted how many of the cells she could see were plasmolysed, and how many were not plasmolysed. She repeated this in two more areas on the same slide. She kept counting until she had counted a total of 100 cells on each slide.

Table 2.1 shows her results.

<table>
<thead>
<tr>
<th>Concentration of sugar solution/%</th>
<th>0 (distilled water)</th>
<th>0.5</th>
<th>1.0</th>
<th>1.5</th>
<th>2.0</th>
<th>2.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of plasmolysed cells out of 100</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>75</td>
<td>98</td>
<td>100</td>
</tr>
</tbody>
</table>

a) Display these results as a line graph.

b) Explain why no cells were plasmolysed in a 0.5% sugar solution.

c) Explain why all the cells were plasmolysed in a 2.5% sugar solution.

d) Suggest why only some of the cells were plasmolysed in the 1.0% solution or the 1.5% solution.

e) Do the results support the student’s hypothesis? Explain your answer.

f) State three factors that the student should have kept the same for all of the tissue samples.

g) Which of the following could have been serious sources of error in the student’s investigation? Explain each of your answers.
   (i) cutting the pieces of epidermis not all exactly the same size
   (ii) counting the same cells more than once on the slides
   (iii) not leaving all of the pieces for exactly the same time before counting the plasmolysed cells

h) Suggest two more possible sources of error (other than mistakes made by the student).

i) Suggest two ways in which the student could make her results more reliable.
Active transport

Sometimes, a cell needs to absorb a substance that is in a very low concentration in its surroundings. For example, a plant needs to take in nitrate ions through its root hairs from the soil. But the concentration of nitrate ions dissolved in the water in the soil is usually much less than the concentration of nitrate ions inside the root hair cell. If left to themselves, the nitrate ions would diffuse down their concentration gradient, out of the cell and into the soil.

The plant, however, can make the nitrate ions move in the opposite direction, up their concentration gradient. There are special protein molecules, called transport proteins, embedded in the cell surface membranes of the root hair cells. Nitrate ions from the soil bump into these proteins, and the proteins then push the ions through the membrane and into the cell. This needs energy, which the cell provides through respiration. The process is called active transport. We can define active transport as:

the movement of ions in or out of a cell through the cell membrane, from a region of their lower concentration to a region of their higher concentration, against a concentration gradient, using energy released by respiration.

Another example of active transport is the uptake of glucose molecules from the small intestine into the blood. You can read about this on page 000.

Summary

Now that you have completed this chapter, you should be able to:

• identify and describe the structure of plant cells and animal cells, and describe the functions of their parts
• describe the differences between plant cells and animal cells
• explain the structure and function of ciliated cells, root hair cells, xylem vessels, muscle cells and red blood cells
• define the terms tissue, organ and organ system, and give examples
• calculate magnification and size of biological diagrams
• define the term diffusion, and explain its importance in diffusion of gases and solutes and give examples in living organisms
• define the term osmosis and explain its importance to animal and plant cells, including the uptake of water by plant roots
• define the term osmosis, using the term water potential, and explain its importance to animal and plant cells, including the uptake of water by plant roots
• define the term active transport and discuss its importance to living cells