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# Biology

# REVISION GUIDE

## Foundation



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REVISE EDEXCEL GCSE (9–1)

# Biology

# REVISION GUIDE

## Foundation

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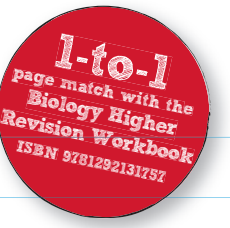
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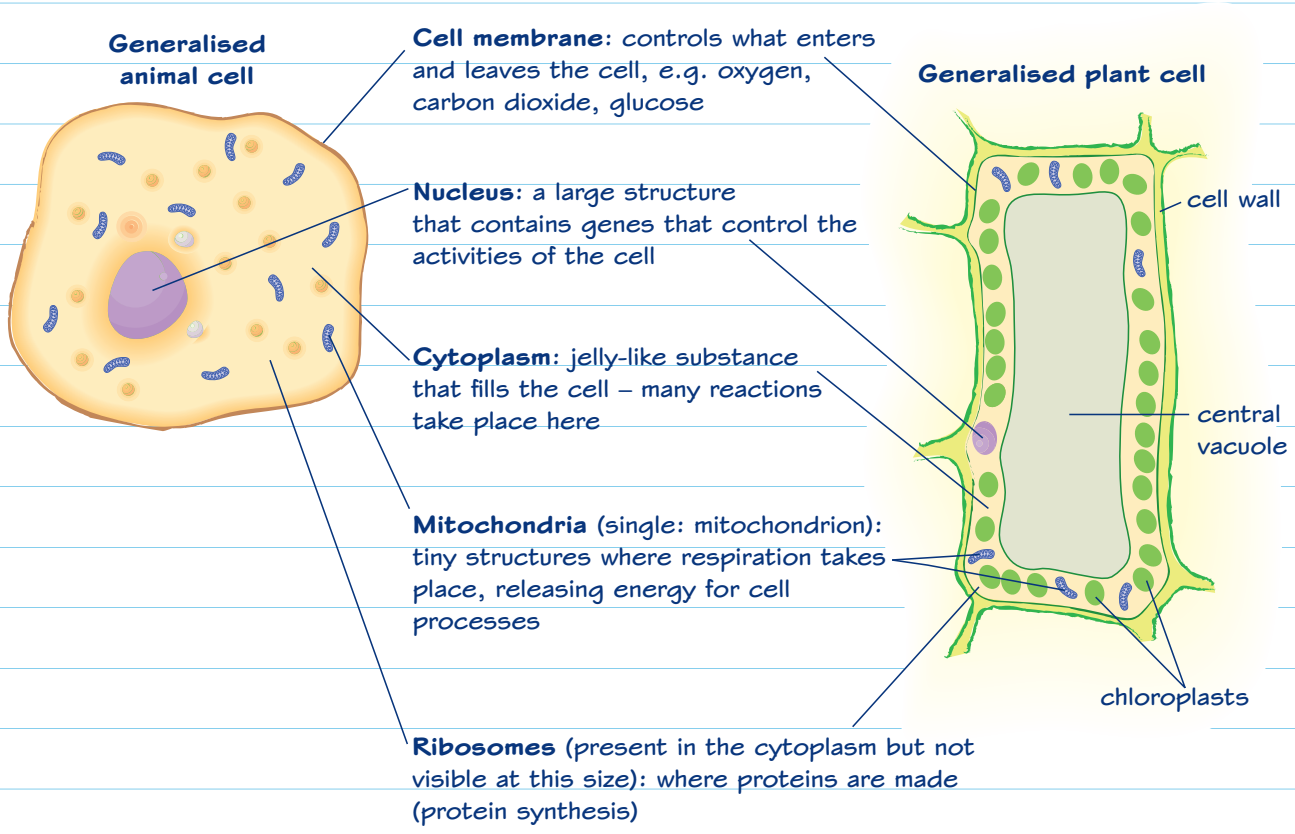
Had a look ☐ Nearly there ☐ Nailed it! ☐

Core

# Plant and animal cells

Animals and plants are formed from **cells**. Animal cells and plant cells have some parts in common. These parts have particular functions in a cell. Cells like these, with a nucleus and membrane-bound organelles such as mitochondria, are called eukaryotic cells.

## Generalised structures




## Worked example

Name the three structures that are found in most plant cells but not animal cells, and describe their functions. **(4 marks)**

Chloroplasts are the structures where photosynthesis takes place to make food for the plant cell.

The cell wall is made of cellulose, and is tough so that it helps support the cell and helps it keep its shape.

The large central vacuole contains cell sap, which helps to keep the plant cell rigid.

1 mark is for naming the three structures and there is 1 mark for each function.

Watch out! The cell membrane and cell wall are different and separate structures.

## Now try this

1 Muscle cells contain more mitochondria than skin cells. Suggest why. **(3 marks)**

2 State the names of four structures found in both plant cells and animal cells. **(4 marks)**

3 Suggest an explanation for why not all plant cells have chloroplasts. **(2 marks)**

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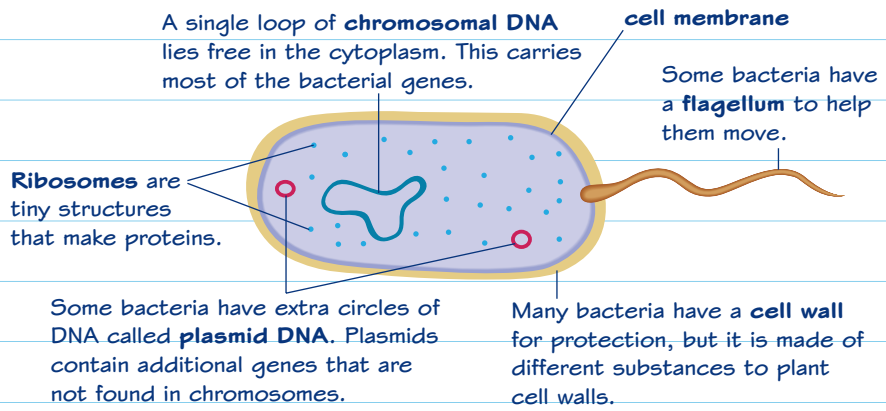


# Different kinds of cell

Some plant and animal cells are **specialised** for different functions. Bacteria have a different kind of **cell structure** from plant and animal cells.

## Bacterial cells

**Bacteria** have a simple cell structure. Like animal and plant cells, they have a cell membrane surrounding the cytoplasm. But they do not have a nucleus. These are called prokaryotic cells.




## Worked example

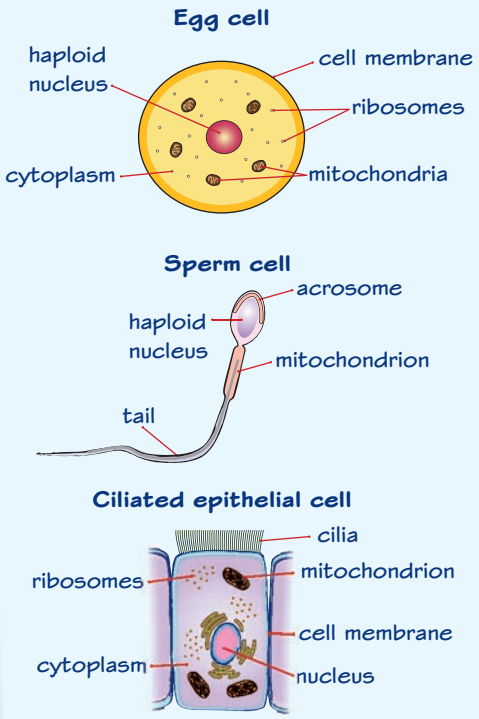
(a) Egg cells and sperm cells contain haploid nuclei. Explain how this is related to the function of these cells. **(2 marks)**

A haploid nucleus contains half the genetic information needed by an organism. When a sperm cell fuses with an egg cell, a diploid zygote is formed with all the genetic information needed for an organism.

(b) For each of the three cells shown, explain one specialisation related to its function. Do not include ideas about the nucleus. **(3 marks)**

The egg cell contains nutrients in the cytoplasm to supply the growing embryo. The sperm cell has a tail for swimming to the egg cell for fertilisation. Epithelial cells line tubes, such as the trachea. Cilia move things along the tube, such as mucus. This cell has a lot of cilia to move mucus, containing dirt and bacteria, away from the lungs.

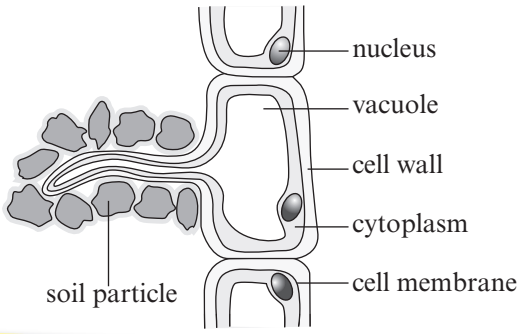
Make sure that you can recognise an unusual feature of a cell, which may be a specialisation to allow the cell to carry out a particular function. For example, in a sperm cell the acrosome contains enzymes to digest a way through the egg cell membrane.




## Now try this

**1** Give **one** similarity and **one** difference between a bacterial cell and an animal cell. **(2 marks)**

**2** The diagram shows a root hair cell.
Explain how the shape of this cell is related to its function. **(2 marks)**




A root hair cell in a plant absorbs minerals that have been dissolved in water.

Describe how the shape of the cell is different from other cells, and then give a reason why this is an advantage.

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# Microscopes and magnification

As microscope technology has developed over time, we have been able to see more of the **structures of cells** and to know more about the **role** of sub-cellular structures.

## Using microscopes

Before microscopes were invented about 350 years ago, people could not see the cells in organisms. Magnification enables you to see plant cells, animal cells and bacterial cells, and the structures inside them.

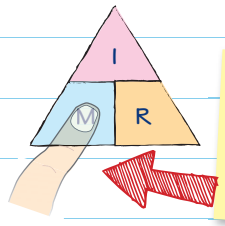
A **light microscope** uses light to magnify objects. The greatest possible magnification using a light microscope is about ×2000.

An **electron microscope** uses electrons to view an object. This makes it possible to magnify objects up to about ×10 million. You can see objects in cells more clearly and in far more detail with an electron microscope than with a light microscope.

### Maths skills Calculating magnification

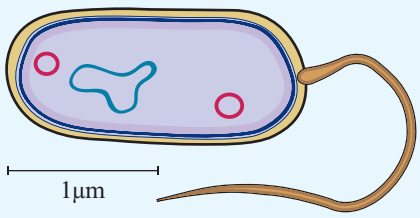
$$\text{Magnification (M)} = \frac{\text{Image size (I)}}{\text{Real size (R)}}$$

- Measure image in millimetres (mm).
- Multiply by 1000 to get measurement in micrometres (μm).
- If the image has a scale bar, use that to find the answer.




Cover up the term you are trying to find to show the expression required to calculate it.

### Worked example




Calculate the magnification of this image. **(2 marks)**

scale bar (image size, I) = 20 mm

$20 \times 10^3 = 20000\,\mu m$

so I = 20000 μm

real size (R) = 1 μm (from diagram)

magnification = I ÷ R = 20000 ÷ 1

magnification = ×20000

### Worked example

Some cells were viewed by microscope using a ×4 eyepiece and a ×20 objective. Calculate the magnification of the cells seen through the microscope (see page 5 for a diagram of a microscope). **(1 mark)**

Magnification of object

= magnification of eyepiece × magnification of objective

= 4 × 20 = 80

The cells will be magnified 80 times by the microscope.

Always show your working in a calculation. Even if you get the answer wrong you may be able to show that you understand the method.

### Now try this

A cell is viewed under a light microscope using a ×40 objective and a ×10 eyepiece.

(a) Calculate the total magnification. **(1 mark)**

(b) The image is 1.2 mm long. Use your answer to part (a) to calculate the actual length of the cell. **(1 mark)**

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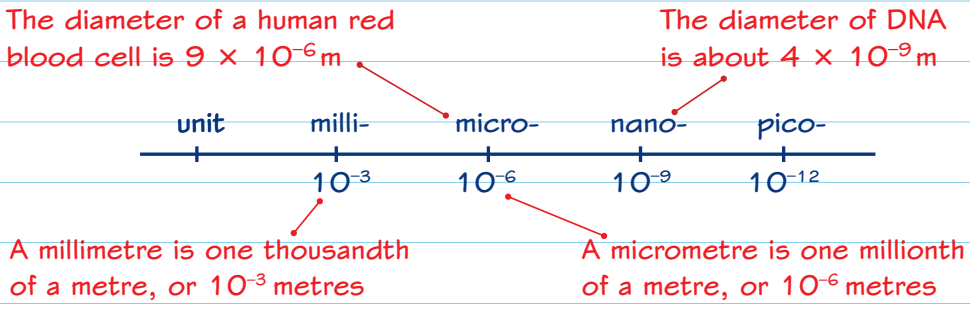


# Dealing with numbers

Many structures in biology are very small so you will use very small **units of measurement**.

## Describing small structures

Smaller structures need smaller units:




There are 1000 millimetres in a metre.

There are 1 000 000 micrometres in a metre.

There are 1 000 000 000 nanometres in a metre.

There are 1 000 000 000 000 picometres in a metre.

Also, notice that there are 1000 picometres in a nanometre, or 1000 micrometres in a millimetre.

### Worked example

A mitochondrion is 0.002 mm long.
Give this length in:

(a) micrometres **(1 mark)**

2 µm

(b) nanometres **(1 mark)**

2000 nm

Notice that there are 1000 nanometres in 1 micrometre.

### Now try this

**1** Match the structure to its correct average size.

| Protein molecule | Chloroplast | Cell | |
|---|---|---|---|
| 2 micrometres | 10 nanometres | 0.1 millimetres | **(2 marks)** |

**2** A human egg is 0.000 13 m long. State the length of the egg in micrometres. **(1 mark)**

**3** The bacterial cell on page 3 is 2 µm long. Use this information to estimate the width of the cell. **(1 mark)**

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# Using a light microscope

Practical skills

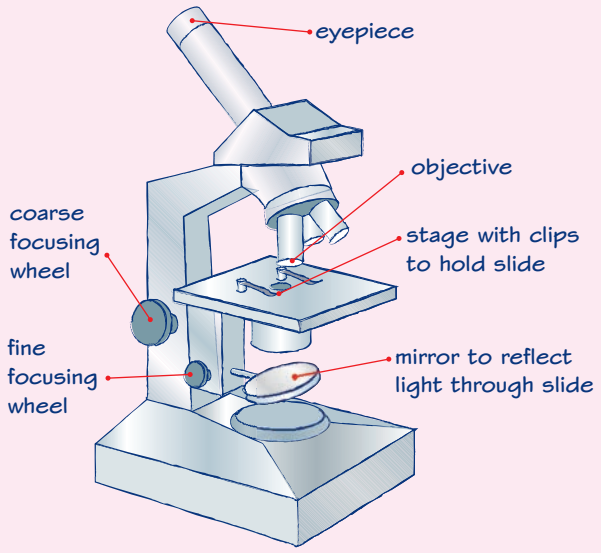
You can use a **microscope** to **observe cells**. You can then produce accurate labelled diagrams from your observations (see page 6 for how to produce a labelled diagram).

## Core practical

### Using a light microscope safely

- Always start with the lowest **power objective** under the eyepiece.
- Clip the **slide** securely on the stage.
- Adjust the **light source (mirror)** so that light goes up through the slide.

If you use the Sun as a source of light, make sure the microscope mirror does not point directly at the Sun as this could permanently damage your eyesight.




- Use the **coarse focusing wheel** to focus on the slide.
- Move the slide so that the cell you will draw is in the middle of the view.
- If needed, move a higher power objective into position above the slide.
- Use the **fine focusing wheel** to bring the cell back into focus.

Never use the coarse focusing wheel with a higher power objective, as it may crash into the slide.

If you cannot see the part of the slide you need with a higher power objective, go back to using the lower power objective to bring it back to centre view and to focus it before returning to the higher power objective.

## Now try this

A student is given a microscope slide of a section through a leaf.

(a) Describe how the student should use a light microscope to study xylem cells in the leaf section.

**(4 marks)**

(b) The lens closest to the specimen is called the:

- ☐ **A** subjective
- ☐ **B** eyepiece
- ☐ **C** objective
- ☐ **D** stage

**(1 mark)**

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# Drawing labelled diagrams

Practical skills

You can use a microscope to produce **accurate labelled diagrams** of cells and their structures (see page 5 for how to set up and use a light microscope).

## Core practical

### Aim

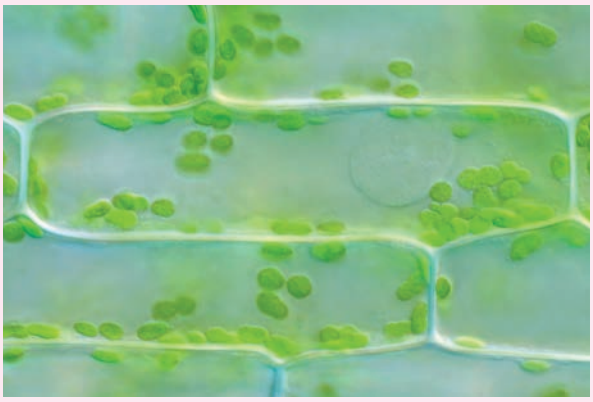
To produce a labelled diagram of a plant cell.

### Apparatus

- light microscope
- unlined paper
- sharp HB pencil
- rubber
- ruler

### Method

Focus the microscope on a single cell.

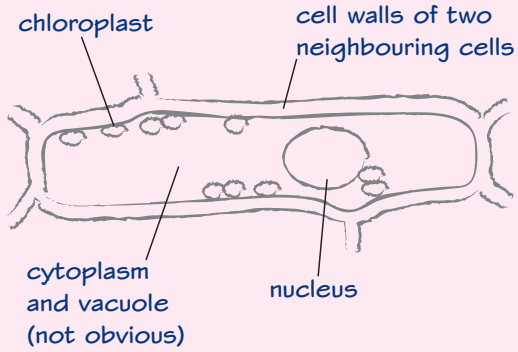


Carefully draw details of the parts that are important to your study. Other parts can be drawn just in outline.

Keep looking back at the specimen as you make the drawing, and only draw what you see, not what you think you ought to see.

### Results

Pondweed cell ×650




If a line is in the wrong place, rub it out cleanly before drawing it in the correct position. Your drawing should be as clear as possible.

Keep the relative sizes of structures approximately correct and label all the key parts of your drawing.

Labels should be outside the drawing and label lines must not cross.

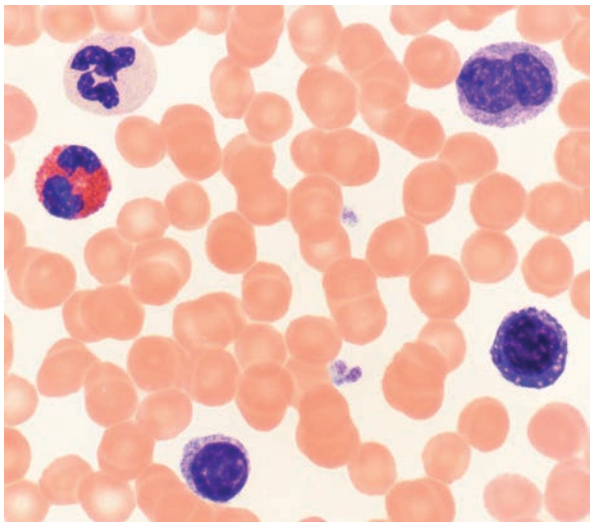
Use a ruler to draw label lines to link labels to the correct parts of the drawing.

Never use shading.

Give your drawing a clear title saying what the specimen is, and always give the magnification, e.g. ×100. (See page 3 to help you calculate the magnification.)

## Now try this

The photo shows some cells in a blood smear seen under a light microscope at ×1000.
Draw and label one example of each cell in the smear. **(3 marks)**



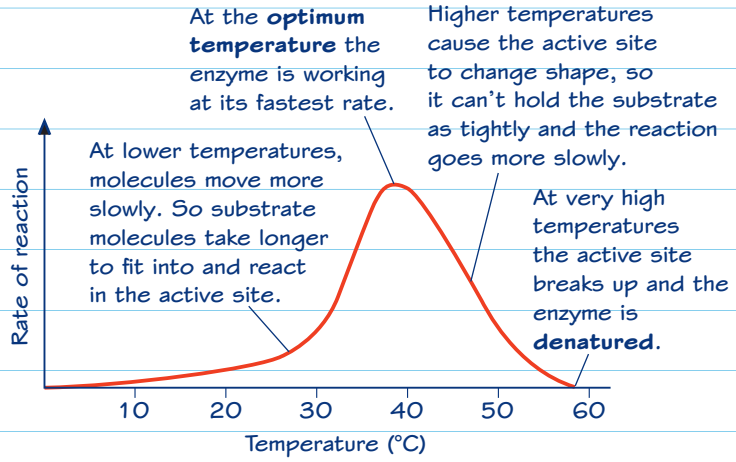
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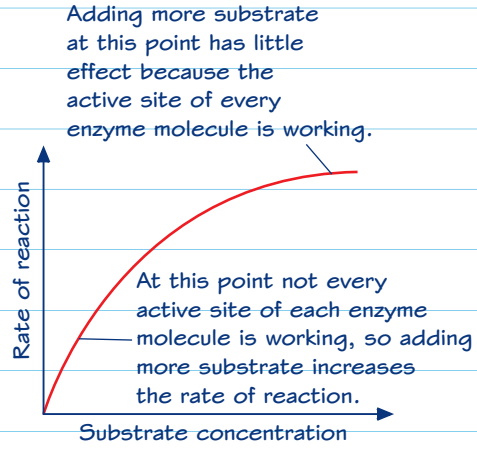


# Enzymes

Enzymes are biological **catalysts** that control reactions in the body. Each enzyme is **specific** (only works with one substrate) to its substrate and the **activity** of enzymes is affected by temperature, substrate concentration and pH.

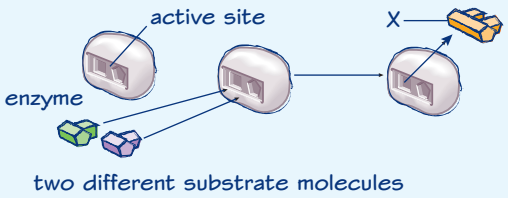
## Effect of temperature and substrate concentration




### Worked example

The diagram shows an enzyme-controlled reaction.




(a) State the name of the part labelled X. **(1 mark)**

product molecule

(b) Explain the role of the active site in an enzyme-controlled reaction. **(4 marks)**

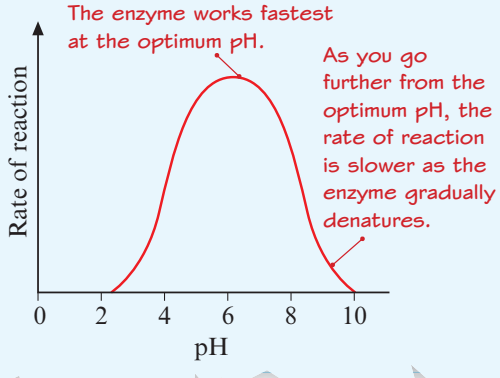
The shape of the active site matches the shape of the substrate molecules and holds them close together so bonds can form between them to make the product. The product molecule doesn't fit the active site well so it is released from the enzyme.

The **substrate** fits like a 'key' into the **active site** (the 'lock'). Enzymes are specific because only a substrate with the right shape can fit the active site.

### Worked example

Draw a graph of rate of reaction against pH for an enzyme with an optimum pH of 6. Label your graph to explain what you have drawn. **(2 marks)**

Changing the pH can change the shape of the enzyme's active site, and so change its ability to bond with the substrate.




### Now try this

1 Explain what is meant by the active site of an enzyme. **(2 marks)**

2 Enzymes in the human body have an optimum temperature of about 37 °C. Explain why our body temperature is controlled to stay at about 37 °C. **(2 marks)**

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# pH and enzyme activity

Practical skills

You can **investigate the effect of pH on the rate on enzyme activity** by measuring the rate of an enzyme-controlled reaction at one pH, and comparing it with the rate at other pH values. You can revise enzymes on page 7.

## Core practical

### Aim

To investigate the effect of pH on amylase activity.

### Methods and apparatus

Starch and amylase

- Add amylase to buffered starch solution in a test tube.
- Place the tube in a water beaker heated by a Bunsen burner for a constant temperature.
- Take samples of the mixture at regular intervals (e.g. every 10 s) and mix them with a fresh drop of iodine solution on a dimple tile.
- Repeat the test until the iodine solution stops changing colour when the starch/amylase mixture is added. Record the time taken for this to happen.
- Repeat the procedure at different pH values.

Starch is broken down by amylase to sugars.

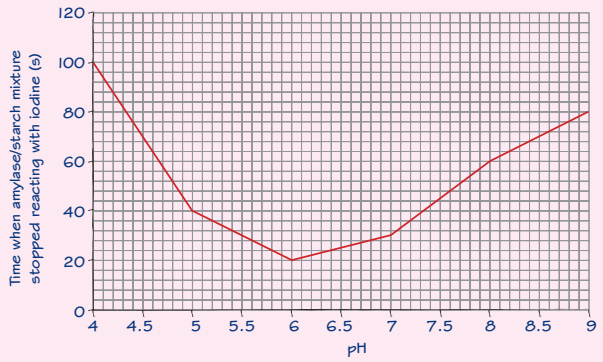
Buffering the solution makes sure the pH doesn't change during the experiment.

When controlling the temperature, bear in mind the effect of temperature on enzyme action. Keeping the solution at the optimum temperature for the enzyme is best.

Iodine solution is usually yellow/orange. In the presence of starch, it turns blue/black.

### Results

Record the values for each pH in a table. Then, you can draw a graph like the one given below.




### Conclusion

The results show that the time taken for all the starch to be digested by the amylase decreases from pH 4 to pH 6, and then increases again. The optimum pH for this enzyme is pH 6.

### Maths skills Reaction rate

You should be able to calculate the rate of reaction for a particular pH, as $\frac{1}{\text{time}}$. Remember to use the correct units. For example:

all starch was digested in 20 s at pH 6. The rate of reaction at pH 6 is $\frac{1}{20} = 0.05/\text{s}$.

### Improvements

This method can be improved by:

- using more accurate measuring apparatus
- taking the mean of several repeats at each pH to help reduce the effect of random variation
- taking measurements over a narrower range of pH.

## Now try this

1 (a) Calculate the rate of reaction of amylase at pH 9 in the core practical. **(1 mark)**
(b) Explain why the graph shows that the optimum pH for this enzyme was pH 8. **(2 marks)**

2 A student repeated the experiment using solutions of pH 7.2, 7.6, 8.0, 8.4 and 8.8. Explain why the results of this experiment could produce a more accurate answer for the optimum pH of the enzyme. **(2 marks)**

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# The importance of enzymes

Enzymes are biological **catalysts** that control reactions in the body. They catalyse reactions that **synthesise** large molecules from smaller ones and **break down** large molecules into smaller ones.

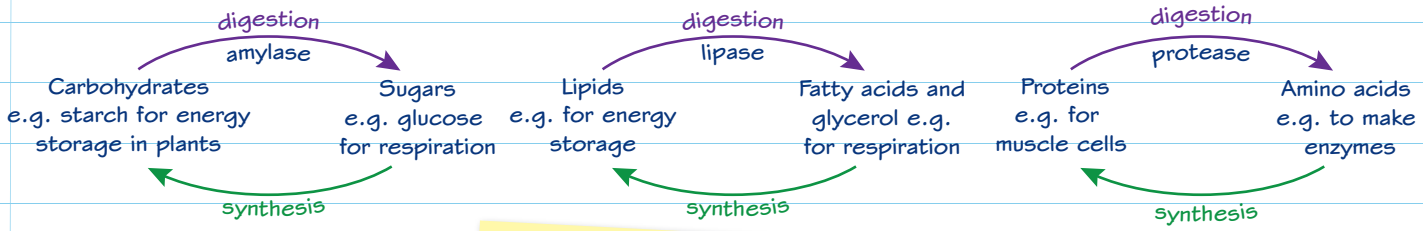
## Enzymes as catalysts

Enzymes **speed up** the rate of a chemical reaction but are not used up in the reaction. This means they can be used over and over again.

Make sure you remember at least some examples of enzymes and the reactions they catalyse.

## Digestion and synthesis

Some enzymes **digest** large molecules into smaller molecules. This happens in the gut where large food molecules are broken down so that they can be absorbed into the blood.




Some enzymes **synthesise** larger molecules from smaller molecules. This is important inside cells for supporting life processes and growth.

### Worked example

Complete the table. **(3 marks)**

| Large molecule | Smaller molecules it is broken down into |
|---|---|
| carbohydrates | sugars |
| proteins | amino acids |
| lipids | fatty acids and glycerol |

Remember you need to mention **both** fatty acids **and** glycerol to get the mark.

### Worked example

People with cystic fibrosis have thick mucus lining their gut. This stops enzymes being secreted into the gut. Explain why they need to take capsules containing enzymes before a meal. **(3 marks)**

The thick mucus stops the body's own enzymes from entering the gut to digest the food. If people with cystic fibrosis didn't take enzyme capsules before meals, their food would not be digested into smaller, soluble molecules. As a result, they would not absorb enough nutrients.

### Now try this

1 The enzyme that digests lipids will not digest proteins. Explain why. **(2 marks)**

2 Name the part of a cell where you expect to find enzymes needed to make proteins (protein synthesis). **(1 mark)**

Think about what you know about cell structure (see page 1 for the generalised structures of plant and animal cells).

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# Using reagents in food tests

Practical skills

You can use chemical reagents to **identify starch, reducing sugars, proteins and fats in food**. Each food substance has its own tests.

## Core practical

### Aim

To investigate the use of chemical reagents to identify substances in food.

### Apparatus

- test tubes
- water bath
- iodine solution
- Benedict's solution
- 0.1 mol $dm^{-3}$ potassium hydroxide solution
- 0.01 mol $dm^{-3}$ copper sulfate solution
- ethanol
- water
- food

**Safety note:**

- Handle iodine solution carefully as it can stain skin and clothing.
- Wear suitable eye protection for all these tests.
- Work safely with hot water, to avoid scalding. Use a heat-resistant glove or tongs to handle hot equipment.

### Method

*To test for starch:* Place a few drops of iodine solution on solid food, or mix with a solution of the food.

*To test for reducing sugars:* Add an equal volume of Benedict's solution to a food solution and mix. Heat the mixture in a 95 °C water bath for a few minutes.

*To test for proteins (biuret test):* Add an equal volume of 0.1 mol $dm^{-3}$ potassium hydroxide solution to the food solution and mix. Add a few drops of 0.01 mol $dm^{-3}$ copper sulfate solution and mix.

*To test for fats:* Add an equal volume of ethanol to the food solution, and shake thoroughly. Add water to the mixture.

### Results

| Test reagent | Tests for ... | Colour of reagent/ negative result | Colour if food present |
|---|---|---|---|
| iodine solution | starch | yellow/orange | blue/black |
| Benedict's solution | reducing sugar | blue | green→orange→red (depending on how much sugar present) |
| biuret test | protein | pale blue | pale purple |
| ethanol | fat | clear | cloudy |

### Reducing sugars

These cause a reduction reaction with the reagent. They include sugars such as glucose and fructose, but not sucrose (table sugar).

## Now try this

The table shows the results of food tests carried out on a food sample.
Identify the substances in the food. **(4 marks)**

| Test reagent | Result |
|---|---|
| iodine solution | yellow/orange |
| Benedict's solution | green |
| biuret test | pale blue |
| ethanol | clear |

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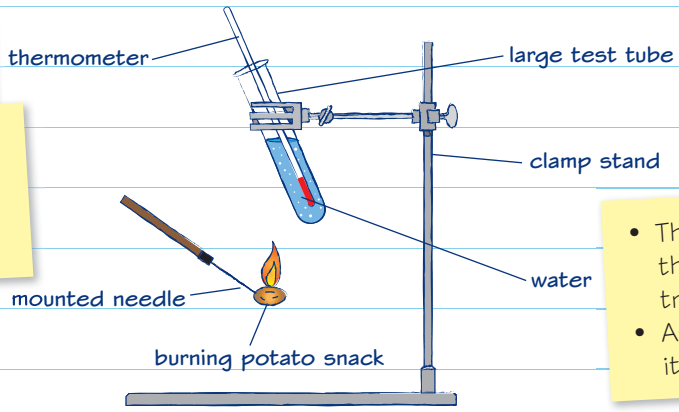
# Using calorimetry

You can find the **energy** in a sample of food using calorimetry.

1. The temperature of the water at the start is measured.
2. The mass of the food sample is measured.
3. The food is set alight (e.g. in a Bunsen flame), then placed immediately under the tube.
4. The temperature of the water at the end is measured, and the change in temperature is calculated.

The calorimeter contains a measured volume of water.

When all the food is burned, the increase in temperature is related to the energy released from the food.




- The energy released from the food by burning is transferred to the water.
- As the water gains energy, its temperature increases.

## Worked example

A student used calorimetry to measure the energy in a potato snack, using the apparatus shown above. The test tube contained 10 $cm^3$ water. Give **two** reasons why this may not be an accurate measurement. **(2 marks)**

Taking too long to move the burning food to under the tube, or holding the food at different distances from the tube. This would affect how much energy is transferred to the surrounding air and not the tube.

You could give other reasons, such as not measuring the mass of food/initial temperature/volume of water accurately, or the food not burning completely. You may be able to think of others.

## Maths skills Calculating the energy in food

It takes 4.2 J of energy to raise the temperature of 1 $cm^3$ of water by 1 °C. For example, the energy needed to raise the temperature of 20 $cm^3$ of water by 18 °C is:

$20 \times 4.2 \times 18$

$= 1512$ J

This is 1512/1000 = 1.512 kJ.

If 3 g of food was used to heat the water, the energy content of the food is:

1.512/3 = 0.504 kJ/g

So 125 g of the same food contains:

125 × 0.504 = 63 kJ of energy

## Now try this

When 2 g of crisps are burned, 100 $cm^3$ of water increases in temperature by 40 °C.

(a) Calculate the energy, in kJ, released by 2 g of crisps. **(1 mark)**

(b) Use your answer to part (a) to calculate the energy released by 1 g of crisps. **(1 mark)**

(c) Use your answer to part (b) to calculate the energy content of a 25 g bag of crisps. **(1 mark)**

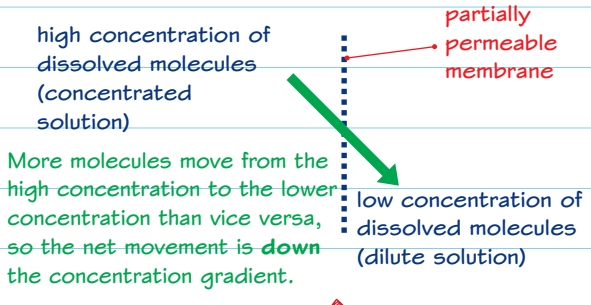
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# Getting in and out of cells

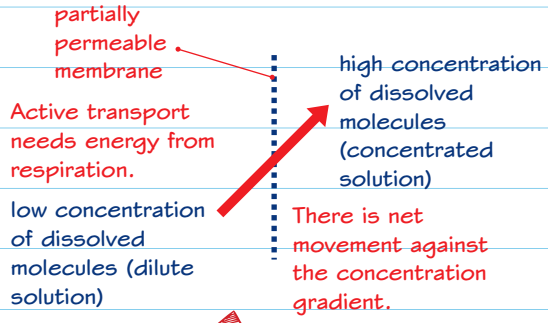
Dissolved substances (**solutes**) move into and out of cells by **diffusion** and **active transport**. Water moves into and out of cells by **osmosis**.

## Diffusion




Diffusion is important in the body, for example, to move oxygen into cells and to remove carbon dioxide.

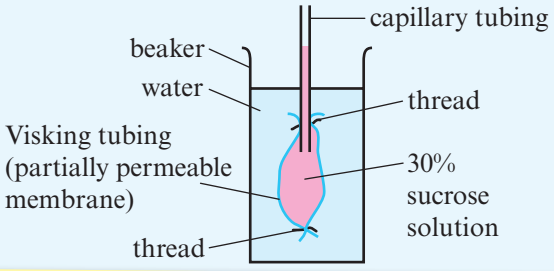
## Active transport




Active transport makes it possible for cells to absorb ions from very dilute solutions, e.g. root cells absorb minerals from soil water, and small intestine cells absorb glucose from digested food in the gut into the body.

## Worked example

The diagram shows the results of an experiment. At the start, the level of solution inside the tube and the level of water in the beaker were the same. Name the process that caused the change and explain what happened. **(3 marks)**




The process is called osmosis. To start with there were more water molecules in the water than in the same volume of sucrose solution, so more water molecules crossed the membrane into the tubing than going the other way. So the level of solution in the capillary rose.

**Osmosis** is the name given to a special case of diffusion. Osmosis is the net movement of water molecules across a partially permeable membrane from a low solute concentration to a high solute concentration.

## Now try this

1 Define **osmosis**. **(2 marks)**

2 (a) Give one similarity between diffusion and osmosis. **(1 mark)**
(b) Give one difference between diffusion and active transport. **(1 mark)**

3 A plant root is treated with a poison that prevents respiration. Explain why the root cells still absorb water from a dilute solution, but cannot absorb mineral ions. **(4 marks)**

Remember that respiration provides the energy for active transport but there are other ways that substances can enter cells which do not require energy from respiration.

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# Osmosis in potatoes

Practical skills

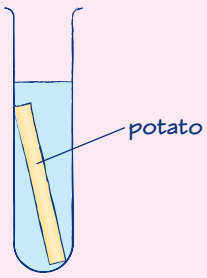
You can investigate **osmosis** by calculating the change in mass of pieces of potato that have been placed in solutions of different solute concentration.

## Core practical

### Aim

To investigate osmosis using potatoes.

### Apparatus




- pieces of potato about 3 × 1 × 1 cm
- boiling tubes
- accurate balance
- paper towels
- forceps
- solutions of different solute concentration (0, 0.2, 0.4, 0.6, 0.8, 1.0 mol dm$^{-3}$)
- marker pen

### Method

1 Mark the value of one solute concentration on one tube and repeat using a different tube for each concentration. Fill each tube two-thirds full of the appropriate solution.

2 Blot a piece of potato dry on a paper towel, then measure and record its mass. Use the forceps to place it into one of the tubes, and record the tube. Repeat for all tubes.

3 After 20 minutes, use the forceps to remove each piece of potato, blot it dry and measure its mass again. Record all final masses.

### Results

The percentage change in mass of each potato slice is calculated and recorded, indicating whether mass was gained or lost.

### Conclusion

The results show that when the solution concentration is very dilute, water enters the potato cells. This is due to osmosis because the solute concentration of the potato cells is greater than the surrounding solution. As the solute concentration of the solution increases above that inside the potato cells, osmosis causes water to be lost from the potato.

Remember, finding the percentage change in mass allows you to compare results from the different tubes, because the pieces of potato weren't all exactly the same mass to begin with.

## Worked example

The initial mass of a potato slice was 16.52 g. After soaking in a solution the final mass was 20.15 g. Calculate the percentage change in mass. **(4 marks)**

$$\% \text{ change in mass} = \frac{\text{final mass} - \text{initial mass}}{\text{initial mass}} \times 100\% =$$

$$\frac{20.15 - 16.52}{16.52} \times 100 = 21.97\% \text{ gained}$$

(or +21.97%)

The solute in the solutions must be something that is too large to diffuse across the cell membrane. Sucrose is often used.

The change in mass may be very small. You should measure to 2 d.p.

Blotting removes surface water, and can help to increase the accuracy and repeatability of measurements.

Repeating the test at each solute concentration, and calculating the mean of the results, can help to reduce the effect of random variation.

## Now try this

The table shows the results of an osmosis experiment using potato pieces.

(a) Calculate the percentage change in mass of potato at each concentration. **(2 marks)**

(b) Use your answers to estimate the solute concentration of the potato cells. Explain your answer. **(2 marks)**

| Solution concentration (mol dm$^{-3}$) | Initial mass (g) | Final mass (g) |
|---|---|---|
| 0 | 16.52 | 20.15 |
| 0.2 | 15.90 | 16.70 |
| 0.4 | 17.06 | 15.69 |
| 0.6 | 16.88 | 14.36 |
| 0.8 | 16.23 | 12.32 |

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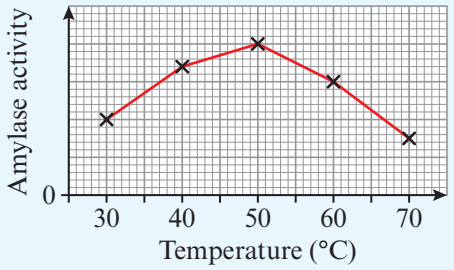
Had a look ☐ Nearly there ☐ Nailed it! ☐

# Extended response – Key concepts

There will be one or more 6-mark questions on your exam paper. For these questions, you will need to think scientifically, and structure your answer logically showing how the points you make are related to each other. For the questions on this page, you can revise the topics on **enzyme activity** on pages 7 to 9.

## Worked example

The graph shows the results of an experiment into the effect of temperature on the activity of the enzyme amylase on starch. Explain the results shown in the graph. **(6 marks)**




The graph shows that activity of the bacterial amylase increased from 30°C up to a maximum at 50°C, and then decreased as the temperature increased further to 70°C. The maximum activity is at the optimum temperature, which is about 50°C for this enzyme.

Enzyme activity increases with increasing temperature up to the optimum because particles move faster. Starch molecules fit into the active site of enzyme molecules more quickly and are broken down more quickly, releasing the active site for another starch molecule.

Beyond the optimum temperature, the shape of the active site starts to change, making it more difficult for the substrate to fit into it. So activity slows down. The active site shape changes more as temperature increases further, until the enzyme becomes denatured and stops being able to catalyse the reaction.

Before you explain the results, describe what the graph shows. Use values on the graph to add details to your answer. Remember to include important science words that are relevant in your answer.

Enzyme activity should be linked to how the active site of the enzyme and the substrate interact.

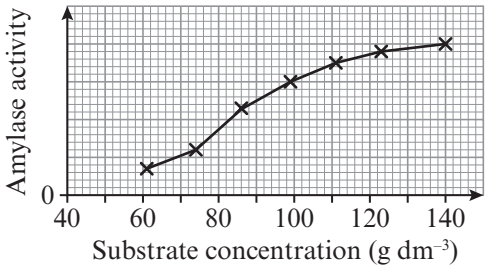
Make sure you explain each part of the graph clearly, linking your knowledge and understanding to give a good explanation of what is happening.

### Command word: Explain

An **explain** question requires a reason for what is happening. Use a word such as 'because' to clearly link a description with its reason.

## Now try this

The graph on the right shows the effect of starch concentration on the activity of a bacterial amylase. Explain the results shown in the graph. **(6 marks)**



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# Mitosis

There are two types of cell division, **mitosis** and meiosis. Mitosis is covered here; meiosis is covered on page 26.

Mitosis is a type of **cell division** that takes place in several stages. There are two types of **cell division**. **Mitosis** is the cell division that happens in body cells. A **body cell** is any cell except those that produce **gametes** (sex cells).

The cell that is dividing is called the **parent cell** and the two new cells that are formed are called **daughter cells.** The daughter cells are identical to the parent cell, so if the parent cell is diploid then the daughter cells will be diploid too. You should be clear about the differences between meiosis and mitosis.

## Three things to remember

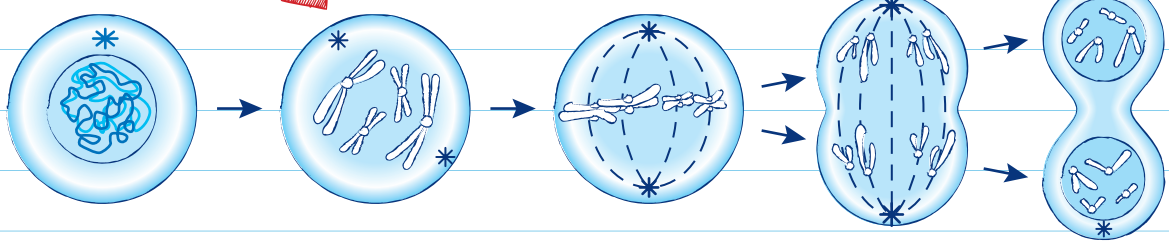
- Mi-to-sis makes two cells.
- MiTosis makes genetically idenTical cells.
- Diploid means Double (two sets of) chromosomes.

## Stages of mitosis

Each chromosome consists of two chromatids.

The chromatids separate and one chromatid from each pair is pulled to each pole of the cell. The chromatids can now be called chromosomes.

The cell splits into two. This is called **cytokinesis**.



Interphase | Prophase | Metaphase | Anaphase | Telophase

At the end of interphase, chromosomes start to become visible. The DNA has already been copied.

The nuclear membrane breaks down. Chromosomes line up along the middle of the cell.

Spindle fibres disappear and a new nuclear membrane forms round each group of chromosomes.

Remember the stages of mitosis using the mnemonic IPMAT:
Interphase
Prophase
Metaphase
Anaphase
Telophase

## Worked example

(a) Body cells have two sets of chromosomes. Explain how this happens. **(2 marks)**

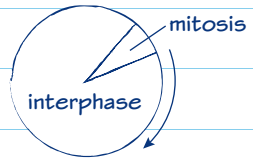
One set of chromosomes comes from the mother and one set comes from the father.

(b) Explain how the daughter cells are genetically identical. **(2 marks)**

Each chromosome is copied; one copy of each chromosome goes into each daughter cell.

## Interphase

A cell spends most of its time in interphase.




## Now try this

A cell divides by mitosis. Describe the daughter cells. **(2 marks)**

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Had a look ☐ Nearly there ☐ Nailed it! ☐

# Cell growth and differentiation

Mitosis is used for growth, repair and asexual reproduction. After growth, cells can then **differentiate** into specialised cells. Growth and differentiation happen in different ways in plants and animals.

## When does mitosis happen?

Normally cells only divide by mitosis when new diploid cells are needed for:

- growth
- repair (replacement of damaged cells)
- asexual reproduction.

## Uncontrolled cell division

Cancer cells are abnormal cells that divide uncontrollably by mitosis to form a **tumour**.

Cells usually stop dividing when growth has finished, except when repair is needed. Sometimes the controls that tell cells when to stop dividing go wrong which leads to cancer.

## Worked example

Aphids are insects that are pests of crop plants. In the summer they reproduce rapidly by asexual reproduction. Will the offspring of a single aphid be varied? Explain your answer. **(3 marks)**

The offspring will be produced by mitosis, so they will all be genetically identical to the parent aphid. They will all be diploid like the parent aphid.

Mitosis is used for asexual reproduction. This also occurs in plants, for example, when plants reproduce using bulbs or runners.

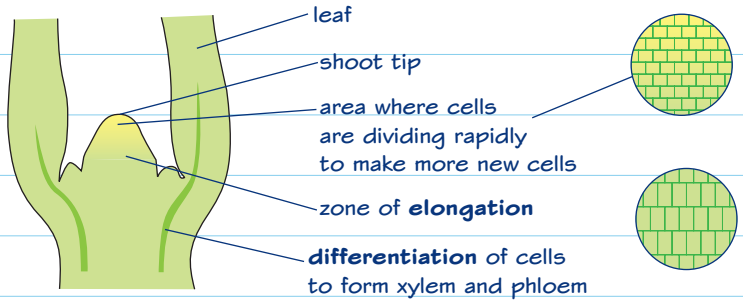
## Growth in animals

In **animals**, a fertilised egg, or zygote, divides by mitosis to produce genetically identical daughter cells. These cells grow and divide by mitosis, and eventually **differentiate** into different types of cells to make up a whole organism. Differentiation creates **specialised cells** adapted to carry out a particular function. Examples of specialised animal cells include:

- red blood cells
- egg and sperm cells
- nerve cells
- bone cells
- smooth muscle cells.

## Growth in plants

**Plant cells** divide by mitosis, just behind the tips of shoots and roots. After this the cells grow by enlarging. Young cells have small vacuoles which take in water by osmosis and enlarge, causing the cells to **elongate**. These cells can differentiate into specialised cell types. Most plant cells can **continue** to grow and differentiate throughout life.




Examples of specialised plant cells include:

- xylem
- phloem
- mesophyll cells
- root hair cells
- stoma cells.

## Now try this

1 Some drugs stop mitosis. Explain why they are used to treat cancer. **(2 marks)**

2 State what is meant by a specialised cell. **(1 mark)**

3 Explain why cell differentiation is important. **(2 marks)**

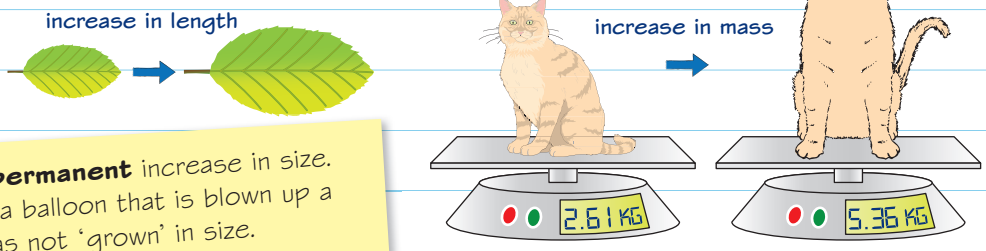
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# Growth and percentile charts

When organisms **grow** they get bigger. Growth can be measured in different ways.

## Estimating growth



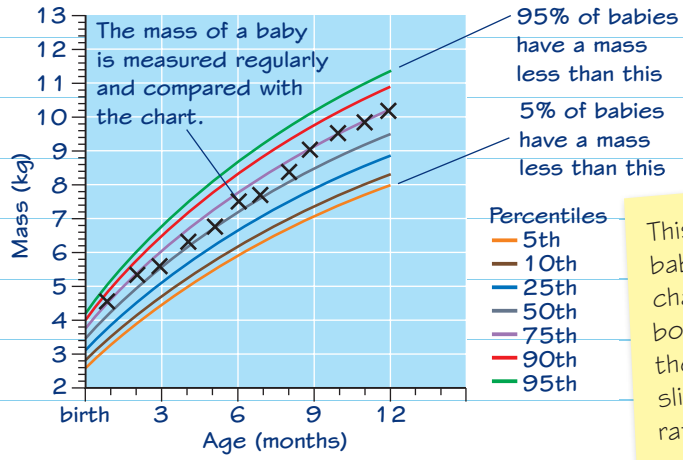

Growth is a **permanent** increase in size. For example, a balloon that is blown up a little more has not 'grown' in size.

## Percentile charts

**Percentile charts** can help to show if a child is growing faster or slower than is normal for their age.

Babies with a mass above the 95th line or below the 5th line may not be growing properly.

A baby whose mass decreases by two or more percentiles over their first year may not be growing normally.




This chart is for baby girls. The chart for baby boys is similar, but they grow at a slightly different rate to girls.

### Worked example

Look at the percentile chart. The crosses mark the mass of a baby girl measured each month.

(a) State the percentile that she belonged to in her first month. **(1 mark)**

75th percentile

(b) Do you think there was concern about this baby's mass increase in her first year? Explain your answer. **(2 marks)**

No, because her mass varied only between the 75th and 50th percentiles, and this amount of variation is normal.

### Worked example

BMI is a measure of a healthy body mass. The government has produced percentile charts for BMI in children. A child has a clinically healthy weight if their BMI is between the 2nd and 91st percentile. A parent has been told that her son is on the 70th centile for BMI. Explain to her what this means. **(2 marks)**

This means the child has a higher BMI than 70% of children and a lower BMI than 30% of children. Because this falls between the 2nd and 91st percentile, the child has a clinically healthy weight.

### Now try this

1 Describe one way in which you could measure the growth of a plant. **(2 marks)**

2 Describe what a percentile chart is used for. **(2 marks)**

3 Explain why an increase in the size of a balloon is not an example of growth but an increase in the size of a child is. **(2 marks)**

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# Stem cells

Stem cells have different functions in plants and animals. In humans, they have many potential uses in medicine.

## What are stem cells?

Cells in an embryo are unspecialised. They divide to produce all the **specialised cells** in the body, such as neurones and muscle cells. Once the cells have differentiated they cannot divide to produce other kinds of cell.

**Stem cells** are cells that can divide to produce many types of cell. There are three kinds of stem cell:

- **Embryonic stem cells** are taken from embryos at a very early stage of division (e.g. 8 cells).
- **Adult stem cells** are found in differentiated tissue, such as bone or skin – they divide to replace damaged cells.
- Plants have **meristems** that are found in rapidly growing parts of the plant, e.g. tips of roots and shoots. These cells can divide to produce any kind of plant cell.

## Embryonic stem cells

**Embryonic stem cells** have many uses, including:

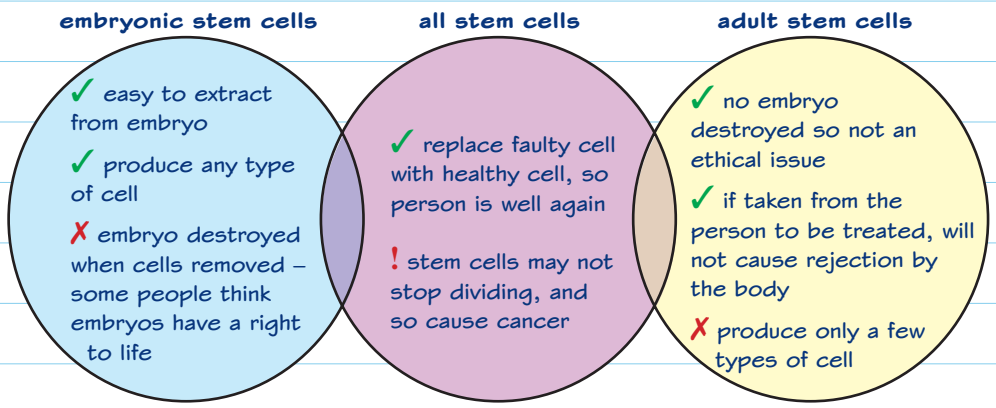
- replacing or repairing brain cells to treat people with Parkinson's disease
- replacing damaged cells in the retina of the eye to treat some kinds of blindness
- growing new tissues in the lab to use for transplants or drug testing.

## Adult stem cells

**Adult stem cells** (from bone marrow) can only form a limited number of cell types. They can be used for:

- treatment of leukaemia
- potentially growing new tissues that are genetically matched to the patient.

## Using stem cells




## Now try this

**1** State what is meant by **a stem cell**. **(2 marks)**

**2** When gardeners cut off the top of a plant, the plant usually continues to grow sideways but does not grow taller. Explain why. **(2 marks)**

**3** Explain **two** disadvantages of research into embryonic stem cells. **(2 marks)**

**4** (a) State why embryonic stem cells could be more useful than adult stem cells to replace faulty cells. **(1 mark)**

(b) Describe **one** practical advantage of using adult stem cells from the patient instead of embryonic stem cells to replace faulty cells. **(2 marks)**

If an exam question asks for **two** advantages or disadvantages, make sure you give two **different** examples.

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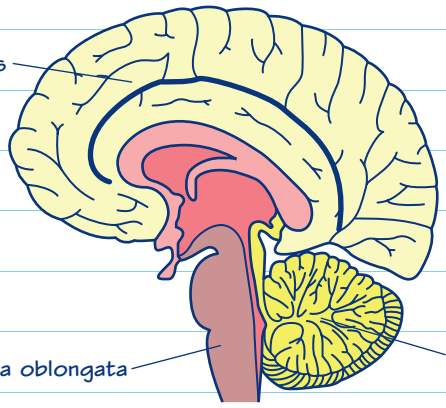


# The brain and spinal cord

The brain and the spinal cord make up the **central nervous system**.

## Parts of the brain

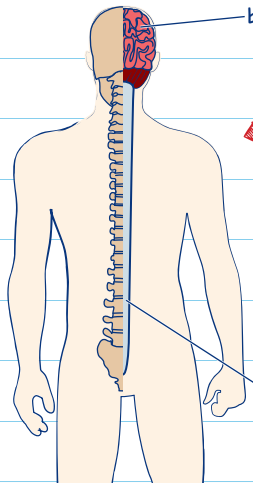
The cerebral hemispheres control **voluntary movement**, **interpret** sensory information and are responsible for **learning** and **memory**.




The cerebellum coordinates and controls precise and smooth **movement**.

The medulla oblongata regulates the **heart beat** and **breathing**.

## The brain and spinal cord




The spinal cord contains many neurones that carry impulses between all parts of the body and the central nervous system.

Watch out! Don't confuse the **spine**, which is the bony structure in your back, with the **spinal cord**, which is made of nerves. The spinal cord lies inside the spine for protection.

## Worked example

A person who has broken their spinal cord is paralysed from the point of the damage downwards. This means they cannot feel anything from the lower part of their body or move it. Explain why. **(2 marks)**

Nerve impulses to and from the lower part of the body pass through the spinal cord. If these nerves are damaged there is no way that impulses can be sent between the brain and the lower part of the body.

To answer this question fully, you will need to describe both the **role** of the spinal cord and the **effect** of damage to it.

## Now try this

Complete the table to show the part of the brain responsible for each activity. **(2 marks)**

| Part of brain | Activity |
|---|---|
| | increasing heart rate during exercise |
| | reading a book |
| | balancing on a skate board |
| | recognising a person from a photograph |

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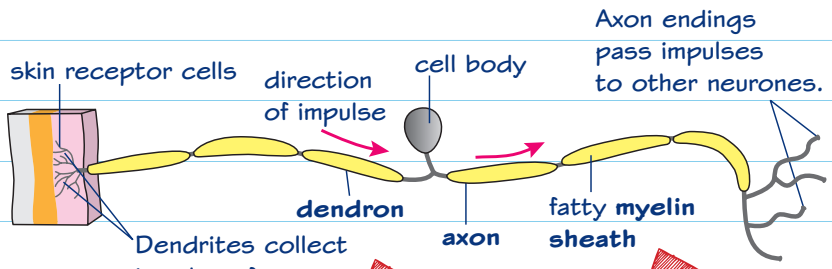
# Neurones

Stimuli are detected by sensory **receptors** that send impulses along sensory **neurones** to the central nervous system. Neurones are specialised cells that carry nervous impulses.

## Types of neurones

There are three main types of neurones. **Sensory neurones** carry impulses to the central nervous system. **Motor neurones** carry impulses from the central nervous system to effector organs. **Relay neurones** are found only in the central nervous system.

### Sensory neurone

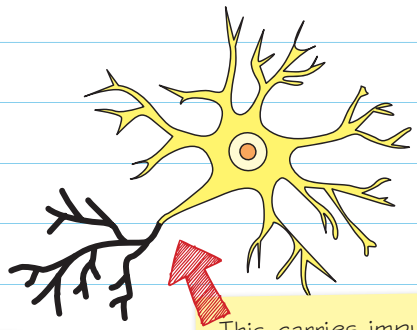



carries impulses towards cell body

carries impulses away from cell body

insulates the neurone

### Relay neurone

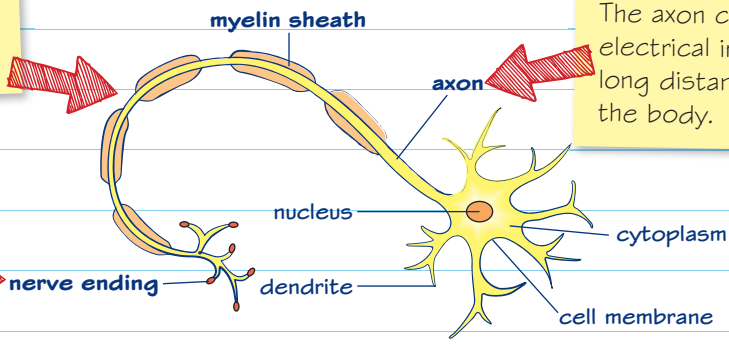


This carries impulses from one part of the central nervous system to another.

### Motor neurone

The electrical impulse cannot cross the fatty myelin sheath.

The electrical impulse jumps from one gap in the myelin sheath to the next, speeding up the rate of transmission.




The axon carries the electrical impulse over long distances through the body.

The nerve ending transmits the impulse to an effector, such as a muscle or gland.

## Worked example

Complete the table with the name of the structure that corresponds to each function listed. **(3 marks)**

| Structure | Function |
|---|---|
| axon | carries impulses away from the cell body |
| dendrite | receiving impulses from other neurones |
| myelin sheath | a fatty layer that provides electrical insulation around the neurone |

## Now try this

1 Give the roles of sensory, motor and relay neurones in the nervous system. **(3 marks)**

2 Explain how the structure of a sensory neurone is related to its function. **(2 marks)**