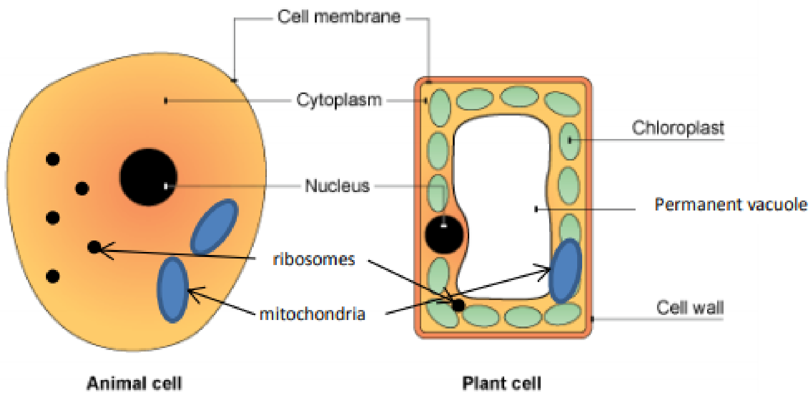
Biology Knowledge Organiser

Topic 1: Cells

Eukaryotic Cells

Eukaryotic cells include all plant and animal cells. Their most important feature is that they have a nucleus, unlike prokaryotic cells.

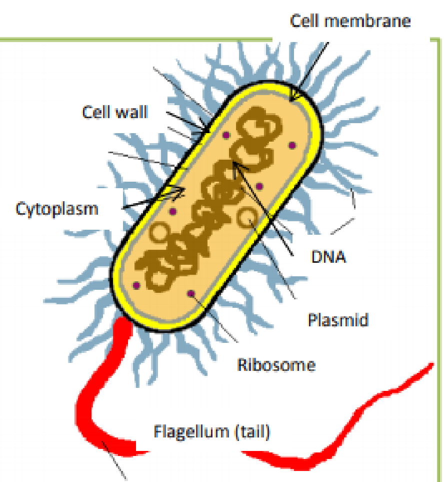


Prokaryotic Cells

Bacteria are prokaryotic cells (all bacteria are single-celled organisms). The most important differences to eukaryotic cells are that they are smaller and their genetic material (DNA) is not enclosed in a nucleus.

Prokaryotic cells have DNA in a loop, and, in addition to the main loop of DNA, they have small loops of DNA called plasmids.

Plasmids allow bacteria to swap genetic information between them.



Key Terms	Definitions
Cell	The basic unit of all forms of life.
Eukaryotic Cells	Cells with a nucleus – e.g. plant and animal cells.
Prokaryotic Cells	Bacterial cells; these don't have a nucleus to enclose their genetic material.
Cell Membrane	The border of all types of cell. The cell membrane separates the inside of the cell from the environment. It controls the movement of substances into and out of the cell.
Sub-cellular structure	A part of a cell. (Sub- means less than – so these are the component parts of cells.)
Nucleus	The enclosure for genetic material found in plant and animal cells.
Cytoplasm	The interior of a cell, where most of the chemical reactions needed for life take place.
Mitochondria	The sub-cellular structure where aerobic respiration takes place.
Ribosome	The sub-cellular structure where proteins are made (synthesised)
Chloroplast	A sub-cellular structure responsible for photosynthesis – only found in plant cells and algal cells.
Permanent Vacuole	A sub-cellular structure only found in plant and algal cells – it is filled with cell sap (a store of nutrients for the cell).
Cell Wall	A sub-cellular structure that is never found in animal cells. It is made of cellulose, it is outside the cell membrane and it strengthens the cell.
DNA	The molecule that holds the genetic information in a cell. In eukaryotic cells, it is one linear strand. In prokaryotic cells, the DNA forms a loop.
Plasmid	A small loop of DNA, only found in prokaryotic cells.

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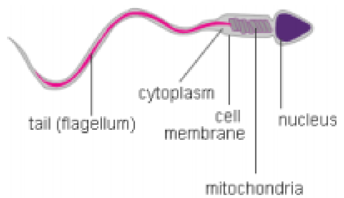
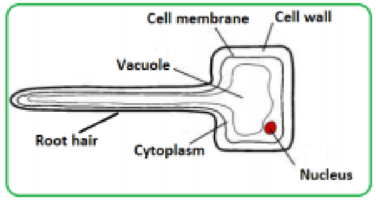
Biology Knowledge Organiser

Topic 1: Cells

Multicellular Organisms

You are a multicellular organism, just like all animals, plants and many types of fungus. But, not all your cells are the same. Cells become specialised by **differentiation**, which means they develop new features to help them perform a specific function. E.g. sperm cells and root hair cells.





Tissues are formed when cells with similar structures and functions work together. For example: muscle tissue in animals; phloem tissue in plants.

Organs are formed from multiple tissues working together. For example: the stomach in animals; the leaf in plants.

Organ systems are formed when multiple organs work together. For example: the digestive system in animals; the vascular (transport) system in plants.

Microscopy

Use of a microscope is called microscopy. Microscopes allowed scientists to discover cells and find all the sub-cellular structures.
Because cells and their parts are very small, it is not useful to measure them in metres. Instead, we use small divisions of the metre as follows:

Centimetre = 1/100 metre (10^{-2}). A centimetre is 1 one hundredth of a metre. (cm)
Millimetre = 1/1000 metre (10^{-3}). A millimetre is 1 one thousandth of a metre. (mm)
Micrometre = 1/1 000 000 (10^{-6}). A micrometre is 1 one millionth of a metre. (µm)
Nanometre = 1/1 000 000 000 (10^{-9}) A nanometre is 1 one billionth of a metre. (nm)

Electron microscopes were a vital invention for understanding cells. They have higher magnification and more resolving power than light microscopes, so they let you see smaller structures.

Key Terms	Definitions
Organism	Any living thing: can be made of one cell or be multicellular.
Multicellular	This describes an organism that is made of lots of cells – such as animals or plants.
Specialised Cell	Almost all cells in multicellular organisms have a particular job, or function. While they usually have all the parts labelled on your cell diagrams, they change to suit their functions. This may include developing different sub-cellular structures (e.g. the tail of a sperm cell).
Tissue	A group of cells with similar structures and functions – i.e. a group of specialised cells.
Organ	An organ is a collection (or aggregation) of tissues performing a specific function.
Organ System	Organs don't operate alone: they work together to form organ systems.
Organism (again)	An organism has many organ systems, all contributing to its survival.
Light microscope	A usual school microscope is a light microscope. You can see large sub-cellular structures like a nucleus with it, but not a lot more detail than that.
Magnification	This is the measure of how much a microscope can enlarge the object you are viewing through it.
Resolution	This is the measure of the level of detail you can see with a microscope.
Electron microscope	A type of microscope with much high magnification and resolution than a light microscope. Essential for discovering the smaller sub-cellular structures.

Equation	Meanings of terms in equation
$magnification = \frac{size\ of\ image}{size\ of\ real\ object}$	*The image Is how it looks through the microscope. The real object is what you are looking at. The image and object must be measured with the same unit, e.g. both in nm.*

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Biology Knowledge Organiser

Topic 1: Cells

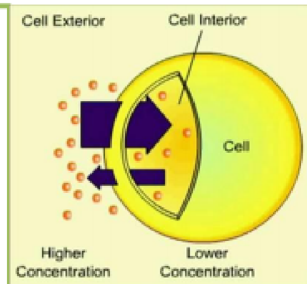
Exchange and Transport

To stay alive, all organisms must exchange substances with their environment. This means they must transport **into** cells the substances they need from the environment and transport **out** waste products to the environment.

Substances can be transported into or out of cells by: **diffusion, osmosis** or **active transport**.

Diffusion

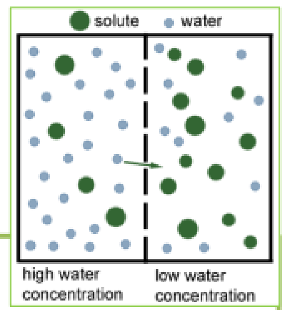
Diffusion allows many substances to move into or out of cells. Thanks to the random motion of particles in liquids and gases, particles will spread out until the concentration is equal throughout. If there is a cell membrane that lets the substance through (is **permeable**) in the way, it doesn't matter. Overall, the **net movement** of the substance will be from higher to lower concentration, as the diagram shows.



Diffusion is the process by which oxygen is transported into the bloodstream, and carbon dioxide is transported out (in the lungs, or gills of fish). It is also how the waste product **urea** moves from cells into the bloodstream, before removal in the urine.

The <u>rate</u> of diffusion is affected by:

1. the steepness of the concentration gradient
2. the temperature (a higher temperature increases the rate of diffusion as particles have more kinetic energy)
3. The surface area of the membrane (a larger surface area of cell membrane increases the rate of diffusion into/out of a cell).



Osmosis

Osmosis is the movement of water from a more dilute solution (more 'watery') to a more concentrated solution (less 'watery') across a <u>partially permeable membrane</u>, such as a cell membrane. Osmosis causes cells to swell up if they are placed in a dilute solution, or shrivel up if they are placed in a concentrated solution (a solution of salt, for instance, or sugar).

Key Terms	**Definitions**
Diffusion	The net (overall) movement of particles from a higher concentration to a lower concentration, simply due to the random motion of particles in a liquid or gas. Diffusion happens across cell membranes, from higher to lower concentration. It does not require any energy from the cell.
Concentration gradient	The difference in concentration of a substance between two places. A 'steeper' concentration gradient means there is a bigger difference in concentration.
Surface area to volume ratio	The surface area divided by the volume of an organism, organ or cell. Generally, the smaller something is, the larger the surface area to volume ratio.
Exchange surface	A place, such as the walls of the small intestine, where exchange of substances takes place e.g. by diffusion across it.
Diffusion pathway	The distance over which a substance must diffuse. A thin wall or membrane is a short diffusion pathway.
Osmosis	Osmosis only describes the movement of water. It is the diffusion of water from a dilute solution to a more concentrated solution across a partially permeable membrane.
Partially permeable membrane	A membrane that only allows some substances through – others are prevented from travelling through.
Active transport	The movement of substances **against** the concentration gradient – from lower to higher concentration. This requires energy from respiration.

Active transport

Active transport is so-named because it <u>requires energy</u>. A good example of where it happens is in plant roots. Root hair cells (see specialised cells topic) absorb mineral ions (like magnesium ions and nitrate ions) from the very dilute solution in the soil by active transport. They need ions like these for healthy growth. An example in animals is absorption of sugar from the intestine into the blood – the blood has a higher sugar concentration so active transport is needed. The sugar is needed by all cells in the body for respiration.

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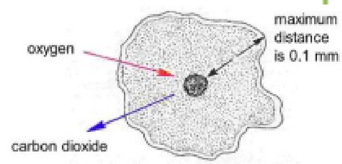
Topic 1: Cells

Adaptations for efficient exchange and transport



Unicellular organisms have a very large surface area to volume ratio compared to multicellular organisms. This means that they simply exchange substances through their cell membrane directly with their environment. They are small enough that diffusion is sufficient to meet their needs (see diagram).

However in multicellular organisms, cells that are not at the surface wouldn't be able to directly exchange substances with the environment. This is why organs with specialised exchange surfaces have evolved. Without lungs, gills, or leaves, for example, multicellular organisms wouldn't be able to obtain all the substances they need to survive, or be able to get rid of waste products efficiently.

Specialised exchange surfaces

To be effective at exchanging substances with the environment, any exchange surface must have a **large surface area**, and a thin wall/membrane for a **short diffusion pathway**. In animals, a constant blood supply also increases effectiveness, and in the lungs, ventilation (breathing in and out) increases effectiveness by refreshing the concentration gradient with each breath.

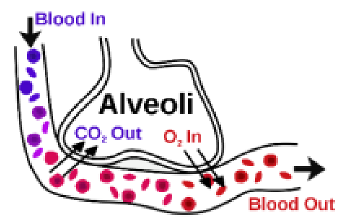
Exchange in animals and plants

Gas exchange in many animals, including us, happens in the lungs. The structures in the lungs where it happens are the **alveoli**. There are millions of these tiny air sacs, so in total their surface area is gigantic. They also have a short diffusion pathway, a good blood supply and air supply due to **ventilation**. (look at the diagram of one alveolus)

In fish, gills are where gas exchange takes place (see diagram). Again, a huge surface area increases the efficiency of gas exchange, along with a short diffusion pathway and good blood supply. The huge surface area comes from the division of gills into very thin plates of tissue called lamellae. This also creates the short diffusion pathway.

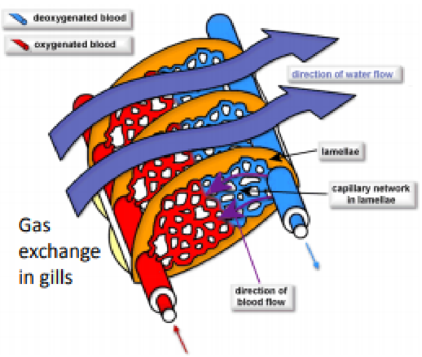
In plants, the roots absorb water and mineral ions. The root hair cells have **long projections** that increase the surface area of this exchange surface, and shorten the diffusion pathway. The leaves are responsible for gas exchange, including oxygen out and water vapour out, and carbon dioxide in. Being flat and broad increases the effectiveness of the leaves as exchange surfaces, by increasing the surface area and shortening the diffusion pathway. In leaves, exchange happens through microscopic holes called **stomata**.

Key Terms	Definitions
Small intestine	The organ in the digestive system where products of digestion are absorbed into the bloodstream.
Lungs	The organs were gas exchange takes place. The air sacs where gases are actually exchanged are called **alveoli**.
Gills	The organs in fish where gas exchange takes place. Oxygen is absorbed from the water into the blood, and carbon dioxide is transferred to the water.
Leaves	The plant organs responsible for gas exchange.
Ventilation	Technical term for breathing in and out. Breathing in brings fresh air, with a relatively high oxygen concentration, into the lungs, and breathing out removes the air with a relatively high concentration of carbon dioxide (and low concentration of oxygen).

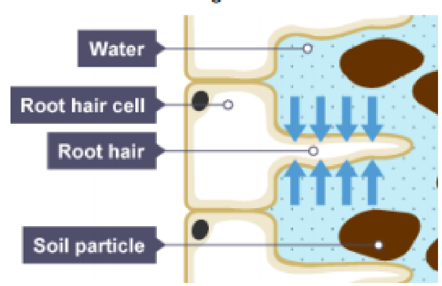


Gas exchange in lungs

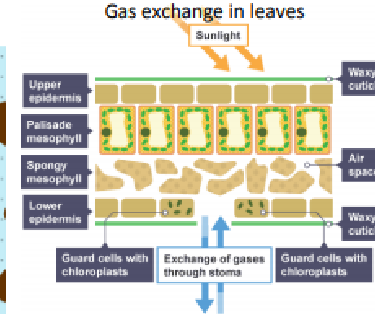
Gas exchange in gills



Substance exchange in roots



Gas exchange in leaves



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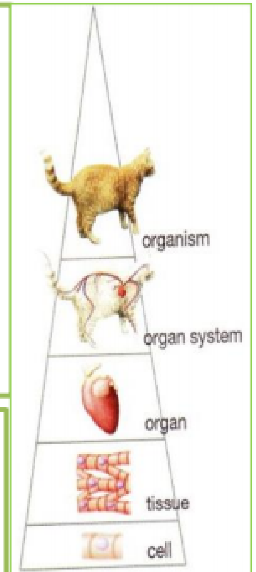
Biology Knowledge Organiser

Topic 1: Cells

Unicellular vs. multicellular organisms

Unicellular organisms' bodies are simply one cell. All bacteria and other prokaryotic organisms are unicellular. **Multicellular** organisms are made of many cells and are much more complex. In multicellular organisms, cells **differentiate** to become **specialised cells**, carrying out specific roles in the organism.

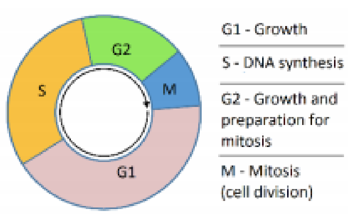
The levels of organisation in multicellular organisms form a **hierarchy**. In biology, hierarchies get simpler as you go down; or more complex as you go up because the upper things are made up of the things below them. The organisational hierarchy in multicellular organisms is shown here.

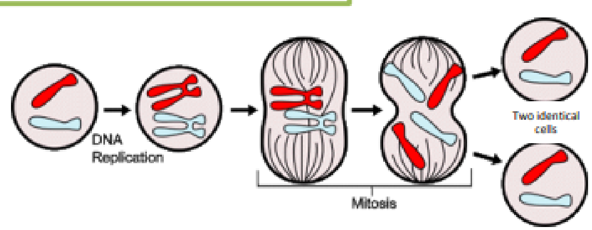


Stem cells

Once cells are specialised, they can't go back to being an unspecialised cell. This is why we all start life as a mass of unspecialised cells, called **stem cells** – this is what an embryo is. Stem cells can divide to make new cells and can differentiate to become specialised cells.

In an young embryo, all the cells are stem cells, so they can be taken, cloned and used to produce any human cells by differentiation.
In adults, there are not many stem cells left – most have differentiated. But there are some, for repair and replacement of specialised cells. For instance, there are stem cells in the bone marrow. These can be collected, cloned and made to differentiate into any type of blood cell. Using stem cells in this way is an active area of medical research, to treat conditions like diabetes and paralysis.





Key Terms	Definitions
Unicellular	Describes organisms formed of only one cell: like all prokaryotic organisms
Multicellular	Describes organisms made of many cells.
Differentiation	The process of becoming a specialised cell. Specialised cells are the result of differentiation of **stem cells**.
Stem cells	Cells that are undifferentiated. Stem cells are capable of forming many more cells of the same type (by cell division), and forming certain types of specialised cell by cell division.
Embryo	A very young multicellular organism, formed by fertilisation. Embryos are made of stem cells.
Cell cycle	The series of stages during which cells divide to make new cells. In the cell cycle, the DNA is replicated (copied exactly) and the cell splits by mitosis into two cells with one set of DNA each.
Mitosis	The specific part of the cell cycle where the cell divides to make two new cells, which are identical.
Chromosome	A structure containing one molecule of DNA. One chromosome contains many genes. In body cells, chromosomes are found in **pairs** (since you inherit one copy of each chromosome from your mother and one copy from your father).

The cell cycle – diagram bottom left

Cells divide to make new cells, for growth and repair, in the **cell cycle**. It isn't as simple as the cell splitting in two: it must prepare before doing that.

1. The cell grows larger and makes more sub-cellular structures, such as ribosomes and mitochondria. (It makes enough for two cells!)
2. The genetic material (**DNA**) is doubled by making an exact replica of the chromosomes. So, there are two copies of every chromosome at this point (labelled S on the cell cycle diagram).
3. Tiny fibres in the cell pull the copies of each chromosome to opposite ends of the cell, breaking the replica chromosomes apart. This means the nucleus can divide into two, each with the full set of chromosomes.
4. The cytoplasm and cell membranes divide to form two genetically identical cells. This is summarised in the diagram left.

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Required Practical
Biology - Microscopy

Objective: Use a light microscope to observe, draw and label biological specimens.

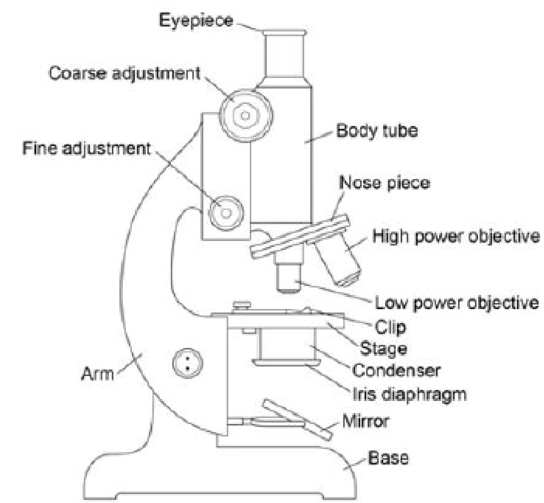
In this practical you will:

- use an optical microscope to look at and draw the cells on your microscope slide.
- identify structures within the cells.
- make a note of the magnification used.

Total magnification = Eyepiece lens magnification × Objective lens magnification

Instructions for using a microscope:

1. Put the slide on the microscope stage.
2. Turn the nose piece to select the lowest power objective lens (this is usually ×4 objective lens). The end of the objective lens needs to almost touch the slide.
3. Turn the coarse adjustment knob to move the lens towards the slide. Look from the side (not through the eyepiece) when you are adjusting the lens.
4. Now look through the eyepiece. Slowly turn the coarse adjustment knob in the direction to increase the distance between the objective lens and the slide. Do this until the cells come into focus.
5. Slightly turn the fine adjustment knob to bring the cells into a clear focus. Use the low power objective lens (totalling x40 magnification) to look at the cells.
6. When you have found some cells, turn the nose piece to switch to a higher power lens (×100 or ×400 magnification).
7. You will have to use the fine adjustment knob again to bring the cells back into focus.
8. Make a clear, labelled drawing of some of the cells. Make sure that you draw and label any component parts of the cell. Use a pencil to draw the cells.
9. Write the magnification underneath your drawing. Remember to multiply the objective magnification by the eyepiece magnification.



Apparatus

- a microscope
- prepared slides of plant and animal cell

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Required Practical
Biology - Microscopy

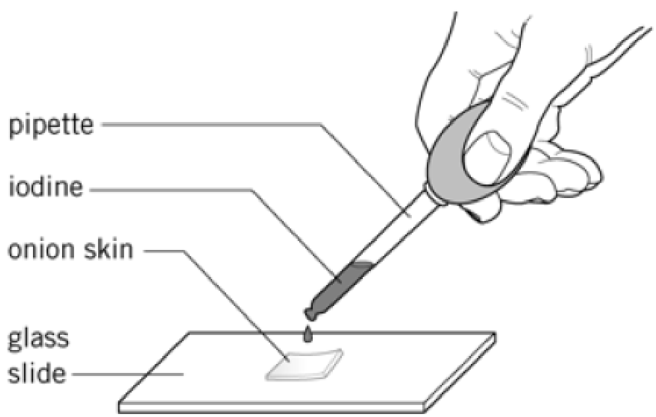
Objective: Use a light microscope to observe, draw and label biological specimens.

In this practical you will:

- use an optical microscope to look at and draw the cells on your microscope slide.
- identify structures within the cells.
- make a note of the magnification used.

Preparing your slide

1 Collect a sample of the cell you want to observe.
2 Remove the inner skin of a layer of onion using forceps, or a thin layer or *Elodea* or filamentous algae using the scalpel.
3 Place the thin slice onto a clean glass slide. Use your forceps to keep the onion skin flat on the glass slide.
4 Using a pipette, add one or two drops of dilute iodine solution on top of the onion skin or slice of algae or plant.



5 Hold the coverslip by its side and lay one edge of the cover slip onto the microscope slide near the specimen.
6 Lower the cover slip slowly so that the liquid spreads out.

Safety

- Take care when handling glass slides as they are very fragile.
- Avoid getting iodine solution on your skin.
- Wear eye protection.
- Take care not to break the slide by moving the objective lens too far downwards.

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Required Practical
Biology - Osmosis

Objective: Investigate the effect of a range of concentrations of salt or sugar solutions on the mass of plant tissue.

In this practical you will:

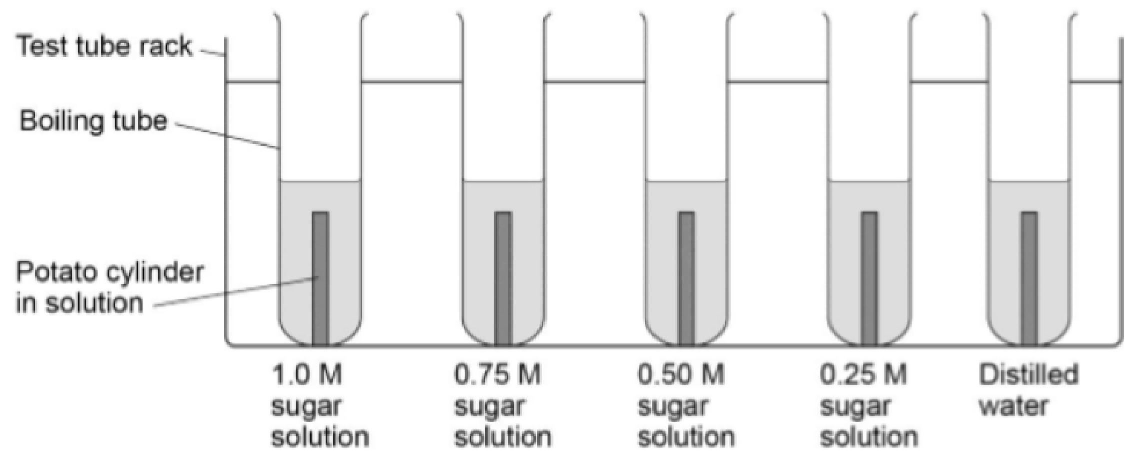
- prepare samples of potato and place them in different concentrations of sugar or sodium chloride (salt) solution.
- make measurements of mass and length of your samples before and after soaking them in the solutions.

Method

1. Use a cork borer to cut five potato cylinders of the same diameter.
2. Use the knife to trim off any potato skin on each potato cylinder. Then trim each potato cylinder so that they are all the same length.
3. Accurately measure the mass of each potato cylinder.
4. Accurately measure the length of each cylinder.
5. Record your measurements in a table like the one shown over the page.
6. Measure 10 cm^3 of each concentration of sugar or salt solution and put into boiling tubes. Label each boiling tube clearly.
7. Measure 10 cm^3 of the distilled water and put into the fifth boiling tube. Label the boiling tube clearly.
8. Add one potato cylinder to each boiling tube.
9. Leave the potato cylinders in the boiling tubes for a chosen amount of time.
10. Remove the potato cylinders from the boiling tubes and carefully blot them dry with the paper towels.
11. Measure the new mass and length of each potato cylinder again. Record your measurements for each concentration in your table.

Analysis of your results

- Calculate the change in mass and length of each potato cylinder. Record your results in your table.
- Calculate the percentage change in mass and length of each potato cylinder and record your results in your table.
- Write a paragraph to state what has happened and how this relates to the theory of osmosis in cells.



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Required Practical
Biology - Osmosis

Objective: Investigate the effect of a range of concentrations of salt or sugar solutions on the mass of plant tissue.

Apparatus

- a potato
- a cork borer
- a ruler
- A $10cm^3$ measuring cylinder
- labels
- five boiling tubes
- a test tube rack
- paper towels
- a sharp knife or scalpel
- a white tile
- a range of sugar or salt solutions
- distilled water
- a top-pan balance accurate to at least 0.01 g

Health and safety

Take care with sharp knives.

	1.0 M sugar solution	**0.75 M sugar solution**	**0.5 M sugar solution**	**0.25 M sugar solution**	**Distilled water**
Initial mass in g	6.08	5.97	6.10	5.92	5.98
Final mass in g	4.05	3.82	4.00	4.45	6.48
Change in mass in g	−2.03	−2.15	−2.10	−1.47	+0.05
Percentage change in mass	-33.4	-36.0	-34.4	-24.8	+8.3
Initial length in cm	3.2	3.3	3.3	3.1	3.2
Final length in cm	2.5	2.7	2.8	3.2	3.7
Change in length in cm	−0.7	−0.6	−0.5	+0.1	+0.5
Percentage change in length	−22.0	−17.0	−1.4	+2.0	+16.0

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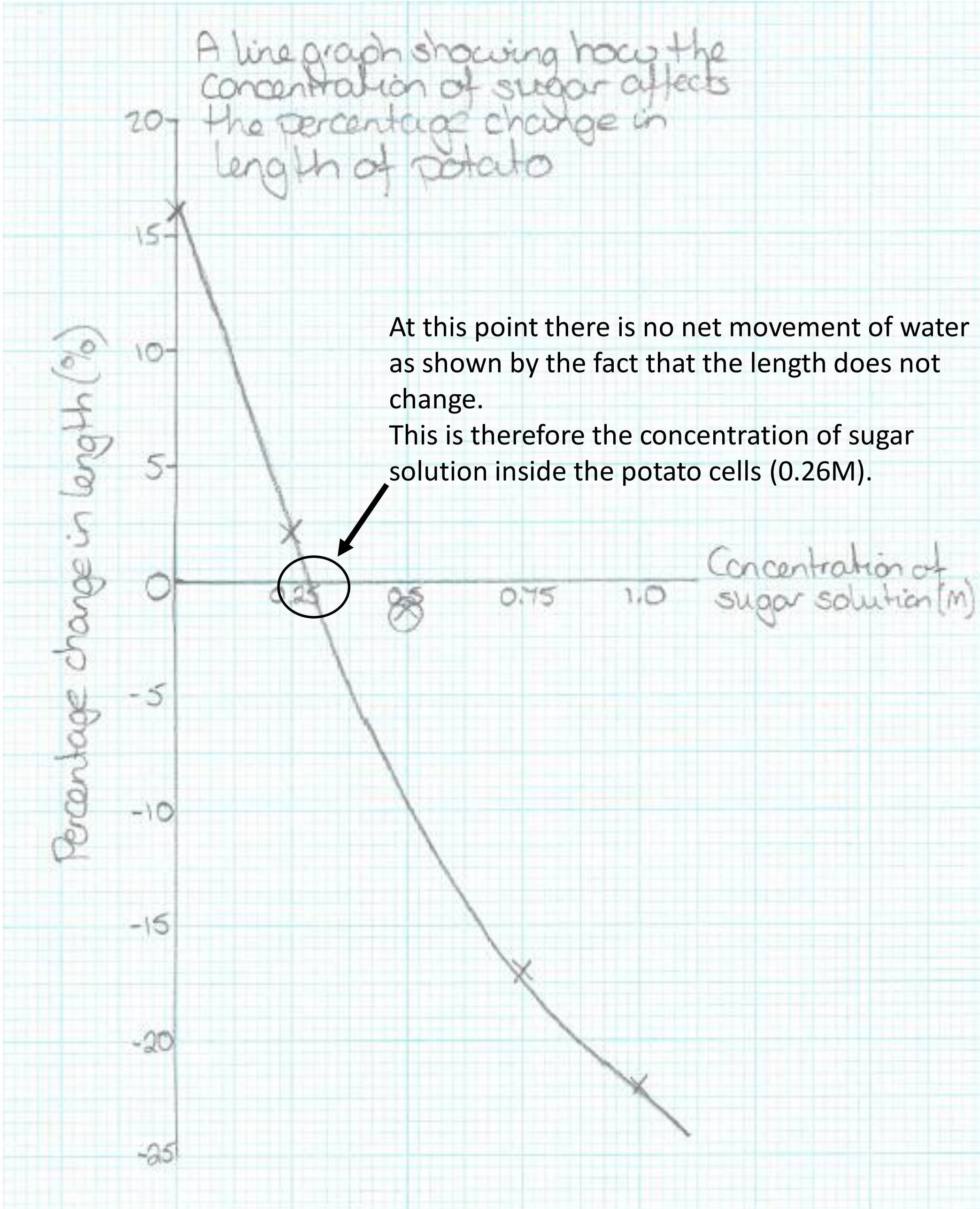

At this point there is no net movement of water as shown by the fact that the length does not change.

This is therefore the concentration of sugar solution inside the potato cells (0.26M).

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