Biology Knowledge Organiser
Cells

Microscopes

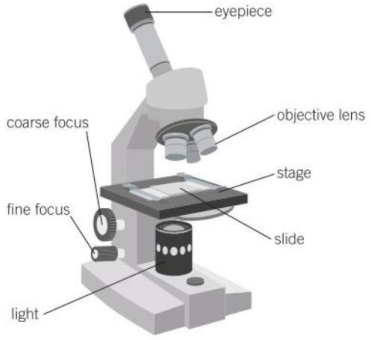
All living things are made from cells, they are the building blocks of life. They are so small that to view them a microscope must be used. There are two key terms to remember when looking at microscopy:

Magnification: how many times bigger is the image compared to the actual object.
Resolution: the ability to distinguish between two different points (in simpler terms, how much detail it can show)

There are two types of microscopes to remember:

Light Microscope

- Uses a beam of light to form an image.
- Max magnification of x2000
- Relatively cheap and can be used almost anywhere.
- Can be used to view live samples.
- There are two magnifying lenses, the eyepiece lens has a magnification of x10 and the objective lens can be changed to give different magnifications.
- To work out the total magnification times the two magnifications of the eyepiece lens and objective lens together.
- For example: if the eyepiece lens is x10 and the objective lens is x40 then the overall magnification would be 10 x 40 = x400.

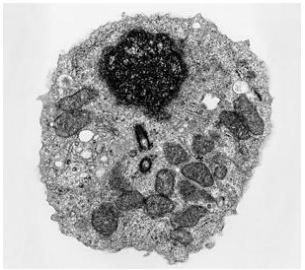


Electron Microscope

- Uses a beam of electrons.
- Much higher magnification than a light microscope, up to x2,000,000
- Can show images in 3D.
- Very large, expensive, must be used in special conditions.

Image examples

- The first picture is cells under a light microscope and the second is a cell under an electron microscope.

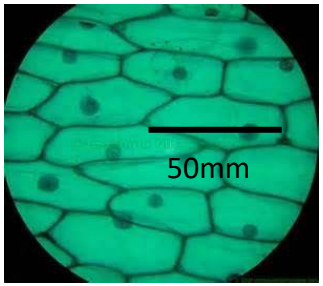


Magnification Calculations

To calculate the actual size of an object under a microscope you must use this equation:

$$\text{Magnification} = \frac{\text{size of the image}}{\text{size of the object}}$$

Let's say you want to calculate the actual size of this cell:



Step 1: Use a ruler to measure the image size in mm. For this example, it is 50mm.
Step 2: Find the magnification of the microscope. For this example it is x400
Step 3: Rearrange the equation to make object size the subject

Step 4: $\text{size of object} = \frac{\text{size of image}}{\text{magnification}}$

Step 5: Substitute your values

$$\text{Size of object} = \frac{50}{400}$$

Size of object = 0.125mm

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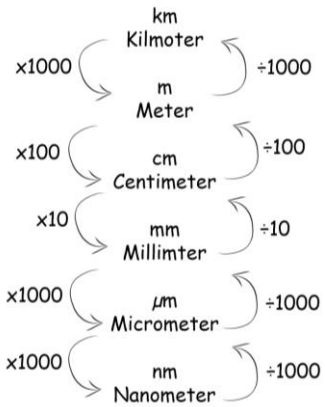
Converting Units

When scientists are using very small numbers when measuring cells and microorganisms it can get confusing. You will need to be able to convert numbers based on their units.



Lets convert our answer from before into µm. 0.125mm is 125µm. All I needed to do is x1000 as per the chart. Remember, as a rule smaller units give you bigger numbers.

It's important to not that when you use numbers whilst using the magnification equation you **MUST** use the same units or your answer will be wrong. For example:

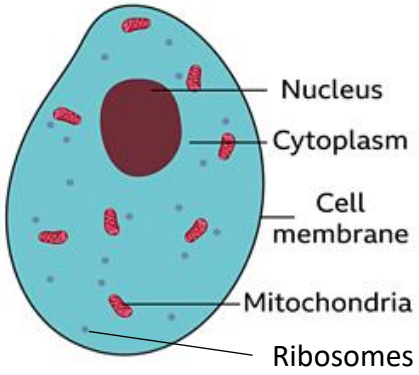
Lets say you wanted to find out the magnification of an object where the image size was 10mm and its object size was 5µm. You cannot do 10/5 you must convert so that they are both the same units. 10mm is 10,000µm then I can do 10,000/5 which would give me an answer of x2000.

Animal Cells

The cells that make up your body, along with many other types of organism, are animal cells. Animal cells share these common features which are called **organelles**:

Nucleus – contains the genetic information and controls cell activities.

Cytoplasm – a jelly like substance which surrounds organelles and where the majority of chemical reactions take place, including anaerobic respiration.



Cell Membrane – controls what enters and exits the cell.

Mitochondria – where aerobic respiration takes place which releases energy from glucose for cell processes.

Ribosomes – the site of protein synthesis (where they are made).

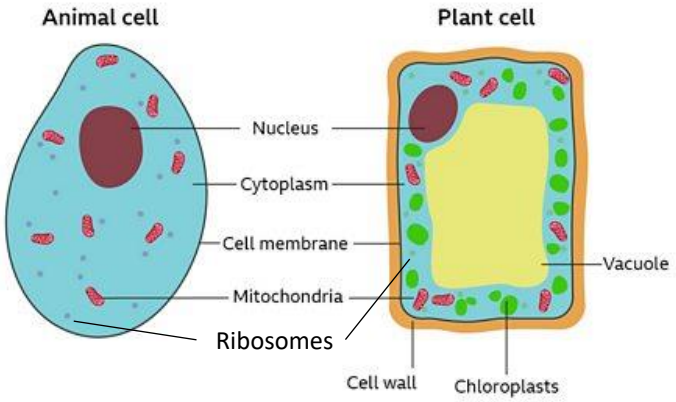
Plant Cells

Plant cells have a lot of similar organelles as you can see in the image to the right but there are some organelles that are unique to plant cells:

Cell Wall – made from cellulose it strengthens the cell and gives it support.

Permanent vacuole – filled with cell sap and keeps the cell rigid.

Chloroplasts – contain **chlorophyll** which is a green pigment. This is the site of photosynthesis



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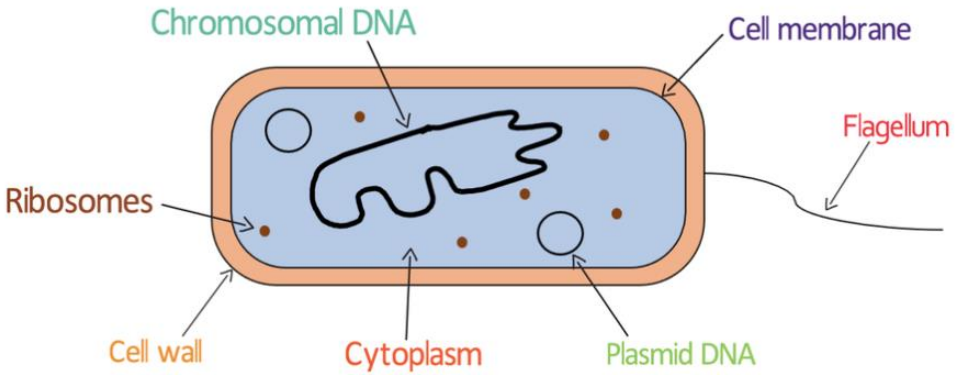
Cells

Eukaryotes and Prokaryotes

Plant and animal cells (eukaryotic cells) have a cell membrane, cytoplasm and genetic material enclosed in a nucleus.

Bacterial cells (prokaryotic cells) are much smaller in comparison. They have cytoplasm and a cell membrane surrounded by a cell wall. The genetic material is **not** enclosed in a nucleus. It is a single DNA loop and there may be one or more small rings of DNA called **plasmids**.



Part	Function
Plasmid	Small ring of extra bacterial DNA which contains a few genes i.e. antibiotic resistance.
Flagella*	A tail-like protein strand that lashes about, allowing the bacterial cell to move around.
Slime Capsule*	For protection and to stop the bacterial cell drying out.

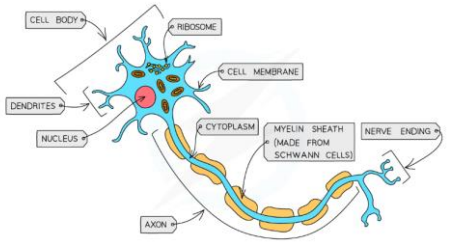
* = not all bacteria have this

Specialised cells (Animals)

A specialised cell is a cell that has a structure that aids its specific function.

- This could relate to cell shape, or the combination of cellular structures present within the cell
- Cells specialise by undergoing a process known as differentiation

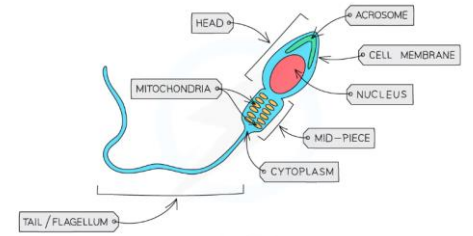
Nerve cells



Function: -Conduction of impulses
Special features that aid function:

- Nerve cells are **long**, meaning that they can **conduct nerve impulses** between different areas of the body
- Extensions of the cytoplasm known as **dendrites** allowing nerve cells to **communicate** with other nerve cells, muscles and glands
- The axon is covered with a **fatty sheath** which **speeds up** nerve impulse transmission

Sperm cells



Function: - Transfer of genetic material to an egg cell for fertilisation
Special features that aid function:

- The mid-piece is packed with **mitochondria** to release **energy** (via respiration) for the tail
- The **tail** rotates, propelling the sperm cell forward and allowing it to **move**
- The **acrosome** in the head contains **digestive enzymes** that can **break down the outer layer of an egg cell** so that the haploid nucleus can enter to fuse with the egg's nucleus
- The head contains a **nucleus** with **half** the normal number of **chromosomes**, allowing the sperm cell to fuse with an egg cell to **restore the normal chromosome number**

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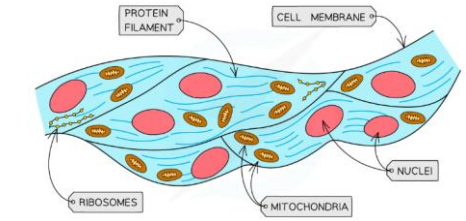
Cells

Specialised cells (Animals)

Muscle cells



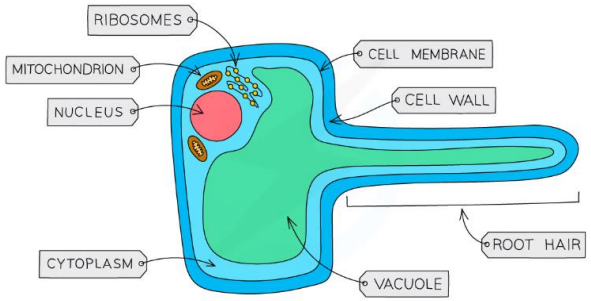
Function: - Contraction for movement

Special features that aid function:

- Muscle cells have many **mitochondria** to **release energy** for contraction
- All muscle cells contain **protein filaments** that can slide over each other to allow muscle **contraction**

Specialised cells (Plants)

Root hair cells



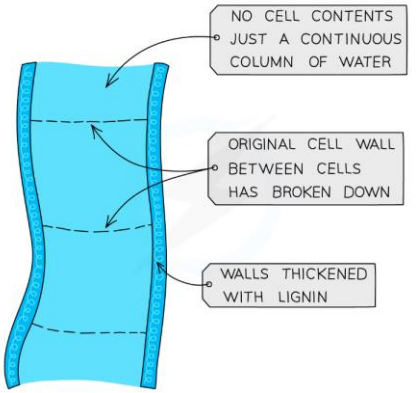
Function: - Absorption of water and mineral ions from soil

Special features that aid function:

- **Root hairs** increase **surface area** (SA) so the rate of water uptake by osmosis is greater
- **Thinner walls** than other plant cells so that water can move through easily due to **shorter** diffusion distance
- **Mitochondria** release **energy for active transport** of mineral ions

Specialised cells (Plants)

Xylem vessels

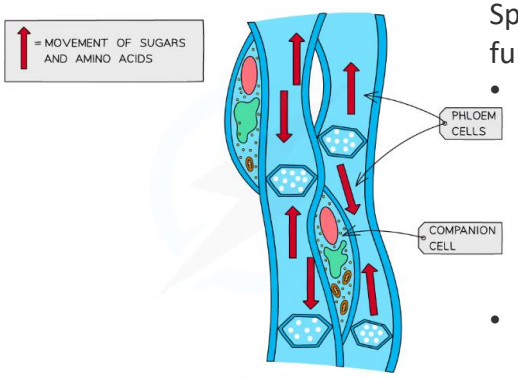


Function:- Transport of water and dissolved ions

Special features that aid function:

- **No walls** between cells to form **continuous hollow tubes** through which water is drawn upwards towards the leaves
- Cells contain **no organelles or cytoplasm**, allowing **free passage of water**
- Outer walls are thickened with a substance called lignin, waterproofing and strengthening the tubes.

Phloem cells



Function:- Transport of dissolved sugars and amino acids

Special features that aid function:

- Cells are **joined** end-to-end and contain **holes in the end cell walls** (sieve plates); this forms tubes which allow sugars and amino acids to **flow easily**
- Cells have very **few subcellular** structures to aid the flow of materials

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Cells (BIOLOGY ONLY)

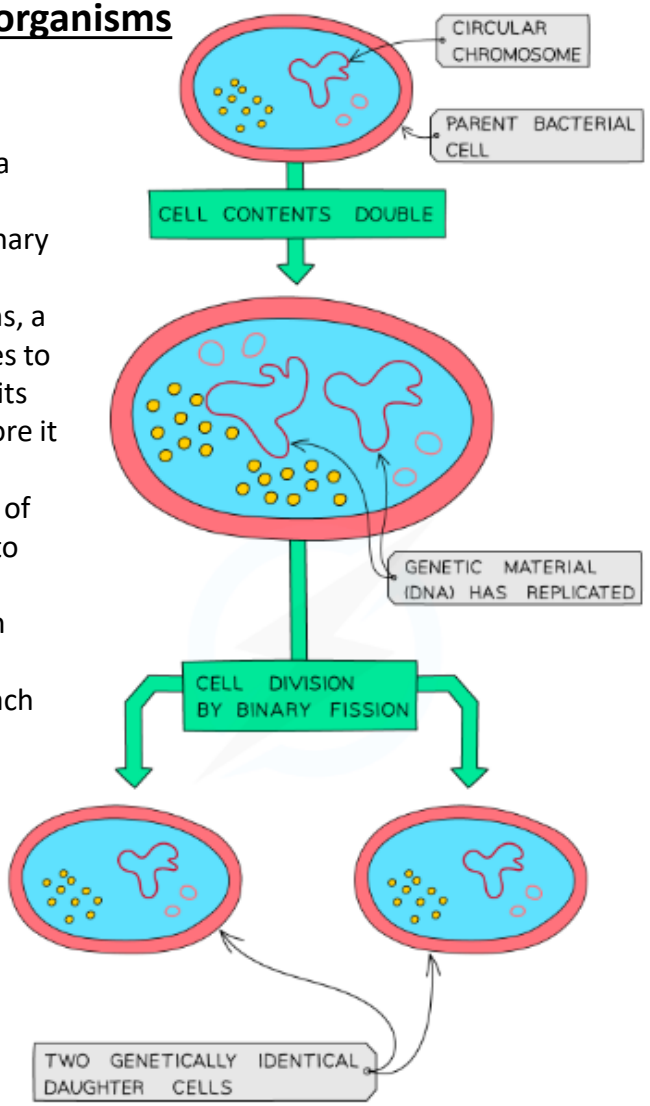
Culturing microorganisms

Binary Fission

Bacteria multiply by a type of simple cell division known as binary fission

In the right conditions, a bacterial cell prepares to divide by replicating its genetic material before it increases in size.

A copy of each piece of circular DNA moves to each end of the cell before the cytoplasm divides, and new cell walls form around each daughter cell.



Growing Bacterial Cultures in the Lab

The effect of **disinfectants** and **antibiotics** on microorganisms can be investigated using cultures of bacteria grown in the lab.

In the right conditions, some species of bacteria (such as *coli*) can multiply as much as once every **20 minutes**. This is ideal as large cultures of bacteria for study can be grown in relatively short periods of time.

To multiply this quickly, bacteria require an adequate supply of **nutrients** (carbohydrates, proteins, minerals and vitamins) and an **appropriate temperature** (which varies depending on the species being grown)

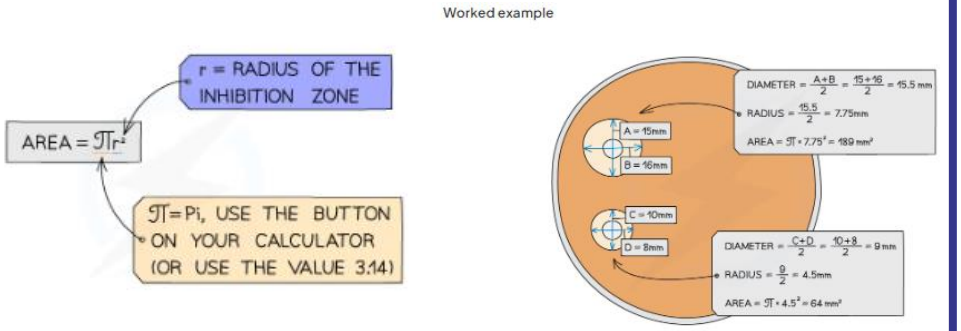
- Warmer temperatures promote faster growth, but in a school lab the maximum allowed temperature for growth is 25°C
- Above this temperature, more harmful pathogens are likely to grow

Bacteria can be grown in a **nutrient broth solution** or as colonies on an **agar gel plate**

Calculating Inhibition Zone Area

The effectiveness of different antibiotics, antiseptics or disinfectants can be determined by calculating the area of an inhibition zone around a disc of the substance being tested.

To calculate the area of an inhibition zone you should use the equation:



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Cells (BIOLOGY ONLY)

Uncontaminated Cultures & Aseptic Techniques

It is vital that uncontaminated cultures of microorganisms are grown in the lab.
The presence of competing species can affect the growth of cultures, as well as the validity of any study performed on them
Some important aseptic techniques are outlined in the table below:

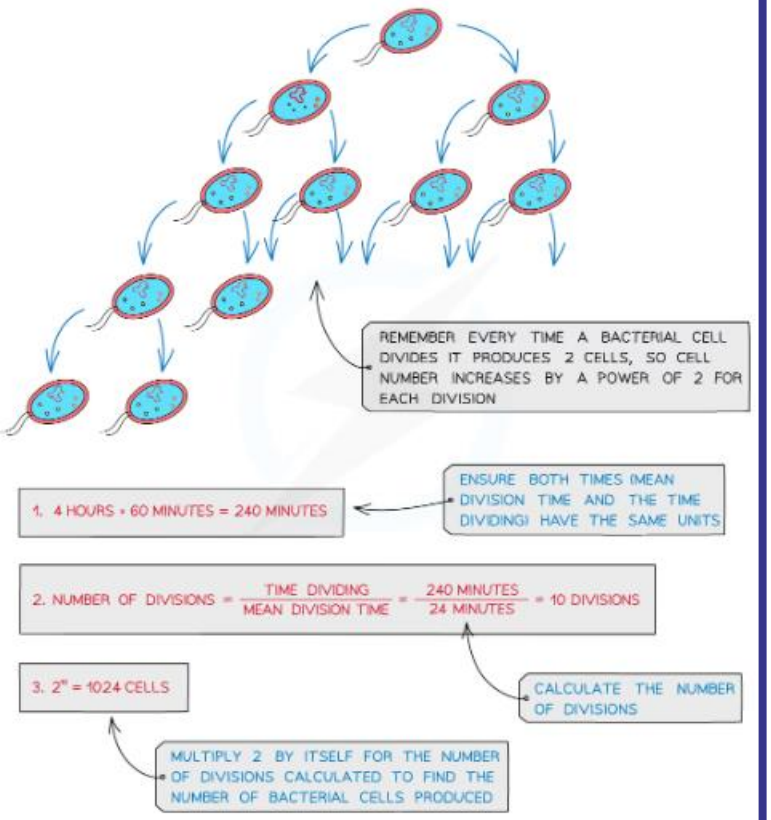
Steps	Explanation
1. Whenever working aseptically, all work should be carried out in front of a lit Bunsen burner with a yellow flame.	The flame creates a convection current above the bench, preventing contamination of any microorganisms in the air.
2. Hot agar jelly is poured into a sterilised petri dish. The agar is left to cool and set.	The petri dish and culture medium are heated to a high temperature to kill any potential microorganisms that could contaminate the experiment.
3. An inoculating loop is passed through a hot flame before it is used to transfer bacterium to the culture medium.	Any microorganism on the loop are killed to prevent contamination.
4. Petri dishes should only be opened as little as possible, at the side facing the Bunsen burner.	This decreases the risk of microorganism contaminating the dish.
5. The lid of the petri dish should be secured with tape at intervals around the dish and stored upside down.	This prevents drops of condensation (another source of contamination) from dropping onto the surface of the agar.
6. The culture should not be incubated above 25°C in a school laboratory.	This restricts the growth of harmful pathogens (which are more likely to grow at higher temperatures)

Calculating Bacteria in a Population

The average amount of time it takes for a bacterial cell in a population to divide is the **mean division time**

The number of times a cell has divided and how many cells it produces can be determined if you know the **mean division time** and **how long** division has been occurring

If a bacterial cell has a mean division time of 24 minutes and has been dividing for 4 hours, how many cells will it have produced?



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Cell Division

Chromosomes

The nucleus of a cell contains chromosomes made of DNA molecules. Each chromosome carries a large number of genes. In body cells the chromosomes are normally found in pairs(one from the father and one from the mother).

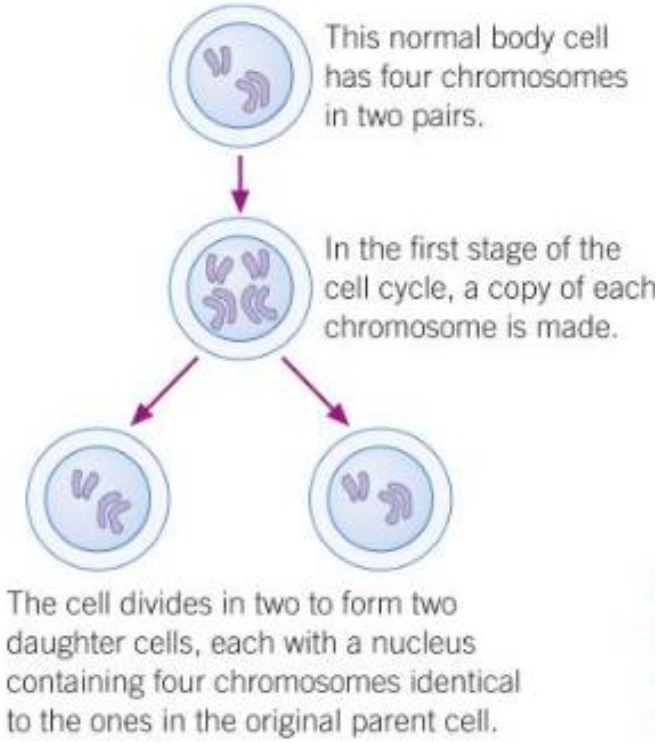
Cell Division

Mitosis is a type of cell division which is required for growth and repair. It produces two identical cells. Cells divide in a series of stages called:

Stage 1 – **Growth Stage**
DNA replication &
production of new cell
subcellular structures e.g.
ribosomes & mitochondria

Stage 2 – **Nuclear Division (Mitosis)**
one set of chromosomes
is pulled to each end of the cell
and the nucleus divides.

Stage 3 – **Cytokinesis**
cytoplasm
and cell membrane
split to form 2
identical cells.



Cell differentiation

As an organism develops, cells differentiate to form different types of cells. As a cell differentiates it acquires different subcellular structures to enable it to carry out a certain function. It has become a specialised cell.

Cell differentiation in animals

- Most types of animal cell differentiate at an early stage.
- In mature animals, cell division is mainly restricted to repair and replacement.

Cell differentiation in plants

- Many types of plant cells retain the ability to differentiate throughout life.

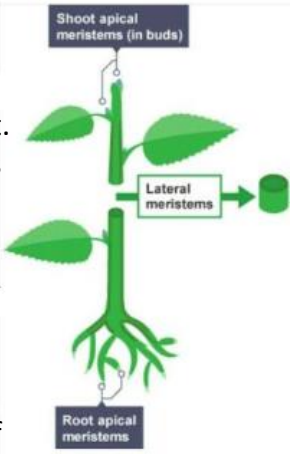
Stem cells

A stem cell is an undifferentiated cell that can divide to give rise to many more cells of the same type, and from which certain other cells can arise from differentiation.

Plant stem cells

Meristem tissue in plants can differentiate into any type of plant cell, throughout the life of the plant. Stem cells from meristems in plants can be used to produce clones of plants quickly and economically.

- Rare species can be cloned to protect from extinction.
- Crop plants with special features such as disease resistance can be cloned to produce large numbers of identical plants for farmers.



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Animal stem cells

A fertilized egg cell divides to form an embryo. The embryo is made up of identical cells these **are embryonic stem cells**.
Embryonic stem cells can divide and differentiate form the many different types of specialised cells required in the body.

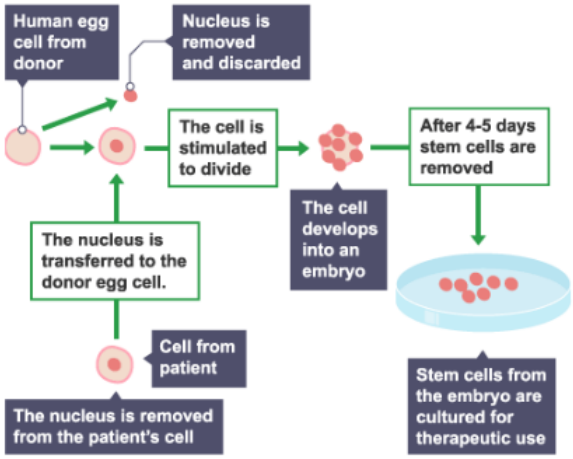
Stem cells from human embryos can be cloned and made to differentiate into **most different types**. They therefore have the potential to be transplanted into patients to treat **medical conditions** and disease. They could be used to replace cells that have been damaged or destroyed e.g.

- in type **1 diabetes**
- in cases of spinal cord or brain injury, that have led to **paralysis**

Stem cells from **adult bone marrow** can form **many types of cells** including **blood cells**.

The use of stem cells has potential risks such as **transfer of viral infection**, and some people have **ethical** or **religious** objections, the embryo **cannot give consent**.

In therapeutic cloning an embryo is produced with the same genes as the patient. Stem cells from the embryo are not rejected by the patient's body so they may be used for medical treatment.



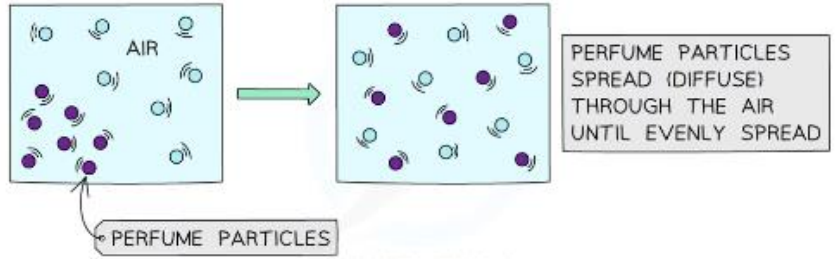
Transport in and out of cells

Cells must take in useful substances like glucose and oxygen for respiration, and remove waste substances such as carbon dioxide and urea. Cells must also control how much water they contain. The cells use three transport processes to do this: **diffusion, osmosis and active transport.**

Diffusion

Particles move around randomly. They bump into each other and this moves them all around**.**

Diffusion is the net movement of particles from an area of high concentration to an area of low concentration down a concentration gradient



Factors that affect the rate of diffusion include:

Temperature	An increase in temperature causes particles to move around more quickly and increases the rate of diffusion.
Surface Area	If the diffusion surface has folds in it then it has a larger surface area over which diffusion can take place. This increases the rate of diffusion.
The difference in concentration	The bigger the difference in concentrations, the steeper the concentration gradient. This increases the rate of diffusion.

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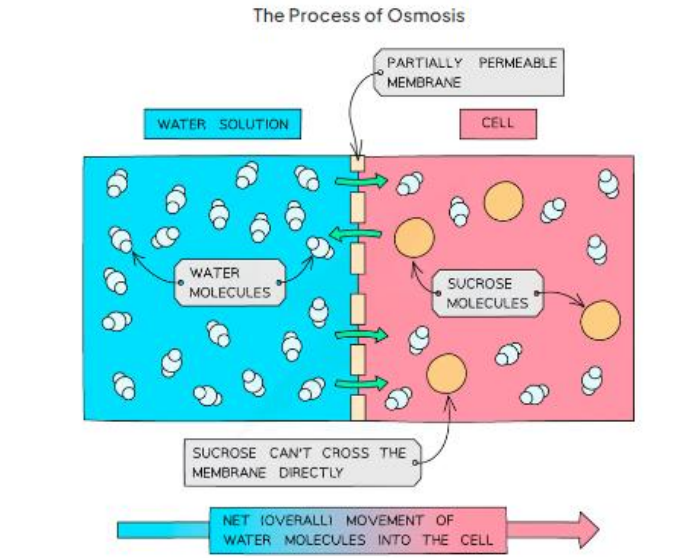
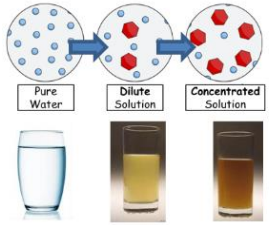
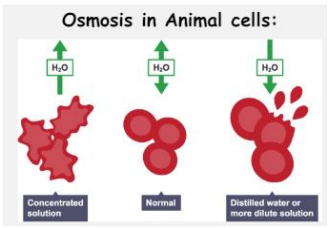
Osmosis

Osmosis, in biology, is the **diffusion** of water molecules from a **dilute** solution to a **concentrated** solution through a partially permeable membrane.

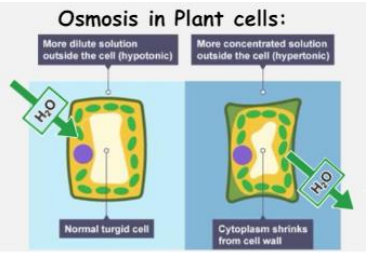


Water will always move from a more **dilute** solution to a more (solute) **concentrated** solution to even up the concentration of water molecules on each side of the membrane.





Osmosis



This is what happens at the microscopic level of the cells, but you can do lab experiments with whole tissues, such as in this topic's osmosis required practical involving whole potato chips.

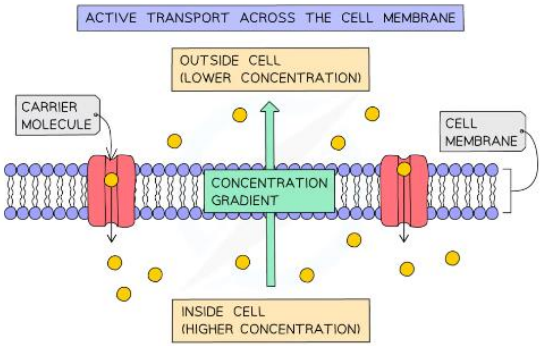
Active Transport

Unlike diffusion and osmosis (passive processes), active transport **requires energy.** Active transport moves substances from an area of low concentration to an area of high concentration against a concentration gradient. It requires energy from respiration

Active transport allows:

- mineral ions to be absorbed into plant root hairs from very dilute (low concentration) solutions in the soil. Plants require ions for healthy growth.
- glucose molecules to be absorbed from the lower concentrations in the gut into the blood which has a higher glucose concentration.

This is achieved by special 'protein pumps' found in the cell membranes.



Exchanging substances if your big

Large multicellular organisms (anything bigger than a worm) aren't able to get the nutrients they need just by diffusion from their surroundings because they have a small **surface area to volume ratio**. Instead, they have adaptations to increase the rate of diffusion. Exchange surfaces (like the lungs, the intestines and gills in fish) have adaptations to increase diffusion. They normally have:

- A **large surface area**
- A **thin membrane** (to provide a short diffusion path)
- Having an **efficient blood supply**
- Are well **ventilated** (animal lungs)

Big and round = small SA:V ratio

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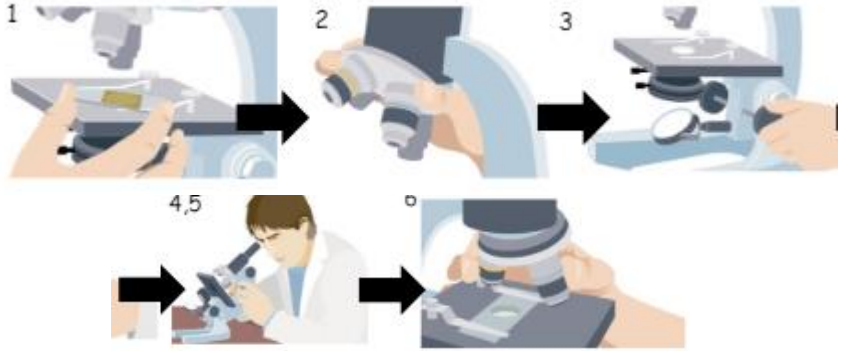
Cells

How to prepare a stained slide of onion (plant) cells

- Use a dropping pipette to put one drop of water onto a microscope slide.
- Peel off a thin layer of tissue from a piece of onion and place on the slide.
- Put a drop of iodine stain onto the onion tissue.
- Lower a cover slip on top trying not to get any air bubbles.

How to view your slide under the microscope

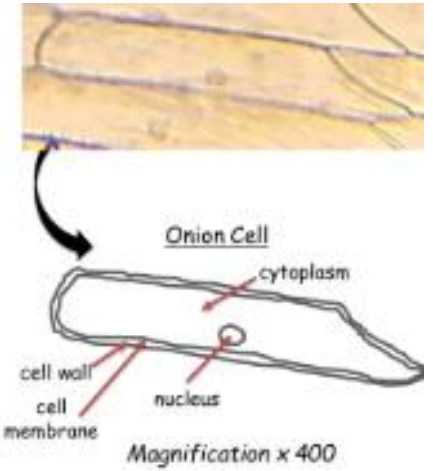
1. Put the slide on the **microscope stage**.
2. Use **the lowest power objective lens**
3. Turn the **coarse adjustment knob** to move the stage up to just below the objective.
4. Now looking through the eyepiece, use the coarse adjustment knob to move the stage downwards until the image is roughly **in focus.**
5. Adjust the focus with the **fine adjustment** until you get a clear image.
6. Now rotate the nosepiece to use a **higher power objective lens**.
7. **Draw what you see** using a pencil and label your biological drawing. Include a title and the magnification. Remember to multiply the objective magnification by the eyepiece magnification.



How to prepare a stained slide of cheek (animal) cells

- Use a dropping pipette to put one drop of water onto a microscope slide.
- Swab the inside of your mouth with a clean cotton bud.
- Rub the cotton bud in the drop of water to transfer the animal cells to the slide.
- Put a drop of methylene blue stain onto the animal cells.
- Lower a cover slip on top trying not to get any air bubbles.

Biological drawing



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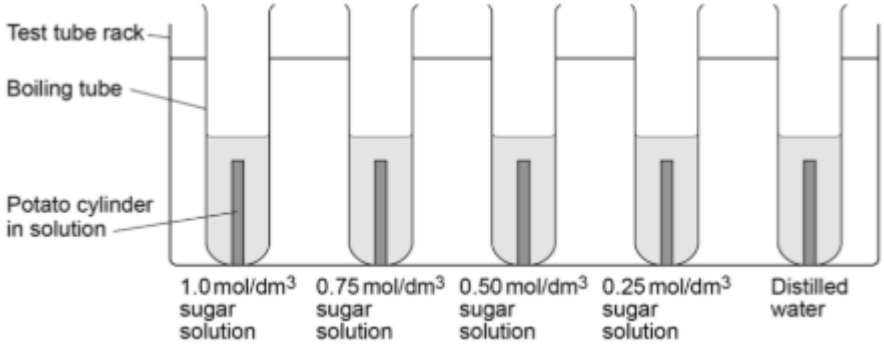
Required practical: Investigate the effect of a range of concentrations of salt or sugar solutions on the mass of plant tissue.

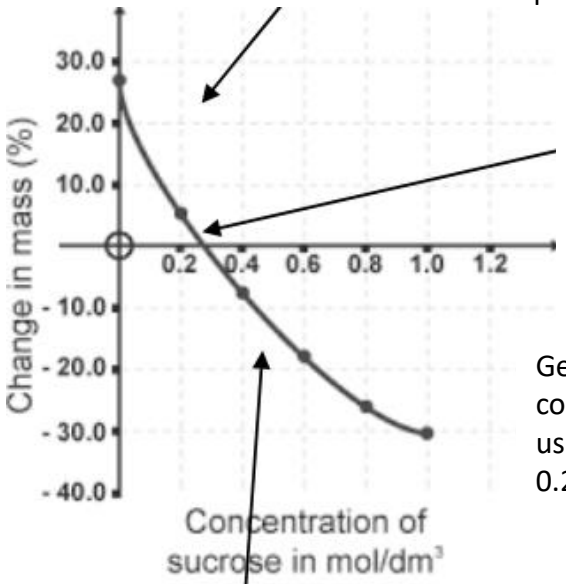
Independent variable: Concentration of the solution
Dependent variable: Change in mass
Control variables: • Same diameter/length cylinder
• Trim off skin on all cylinders
• Cylinders taken from the same potato
• Same temperature (water bath)
Improve by repeating and calculating a **mean** for each concentration

Method
• Use a cork borer to cut five potato cylinders of the same diameter. Trim off any skin and trim them to the same length.
• Blot with tissue paper and measure the mass of each potato cylinder. (Note that you could also measure length.)
• Place each chip into a different concentration of salt (or sugar) solution.
• Leave the chips for one hour.
• Remove the potato cylinders from the boiling tubes, blot them dry and measure the end mass of each potato cylinder.
• Calculate the percentage change in mass = They have difference starting masses, percentage change allows results to be compared.
• Plot a graph showing concentration of solution on the x-axis and percentage change in mass on the y-axis.



Results

Where potato cylinders have gained in mass, the change will be positive. Water has moved into potato cells by osmosis from a dilute solution in the boiling tube to a more concentrated solution in the potato cells.



Where the line crosses the x-axis at 0% change in mass, the sucrose concentration of the solution is equal to the concentration of the contents of the potato cells. There is no net movement of water by osmosis.

Get a more accurate estimate of the concentration of potato cell contents by using smaller intervals between 0.2 mol/dm³ and 0.4 mol/dm³

Where potato cylinders have decreased in mass, the change will be negative. Water has moved out of potato cells by osmosis from a more dilute solution in the potato cells to a more concentrated solution in the boiling tube.