Brilliant Tutoring Programme Training - Science

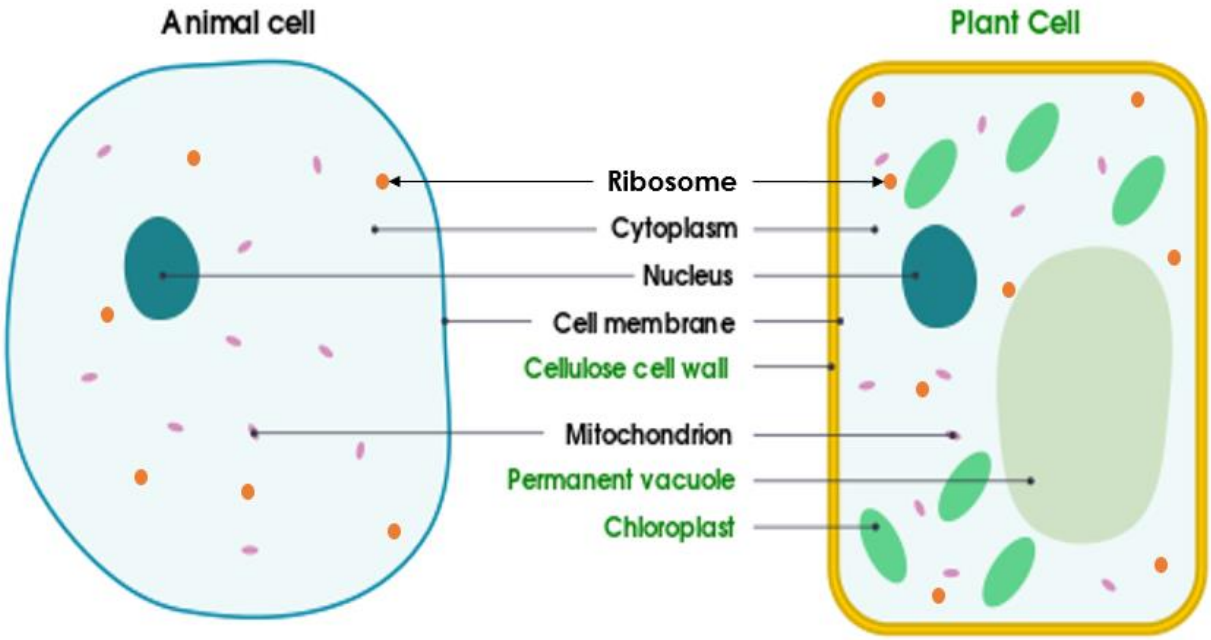
Cell Structure

Learning Outcomes:

- To know the structures in animal, plant, and bacteria cells
- To understand how cells are viewed under light microscopes, and how to calculate magnification
- To be able to explain the differences between three types of cell transport

All living organisms are made of cells. Humans, animals, and plants are multicellular organisms meaning they are made of more than one cell, while bacteria are unicellular organisms and exist as single cells.

Animal and plant cells are eukaryotes – this means their cells contain a nucleus. Most animal and plant cells are between 0.01 and 0.1mm in size. The diagrams below show the components of each cell type.



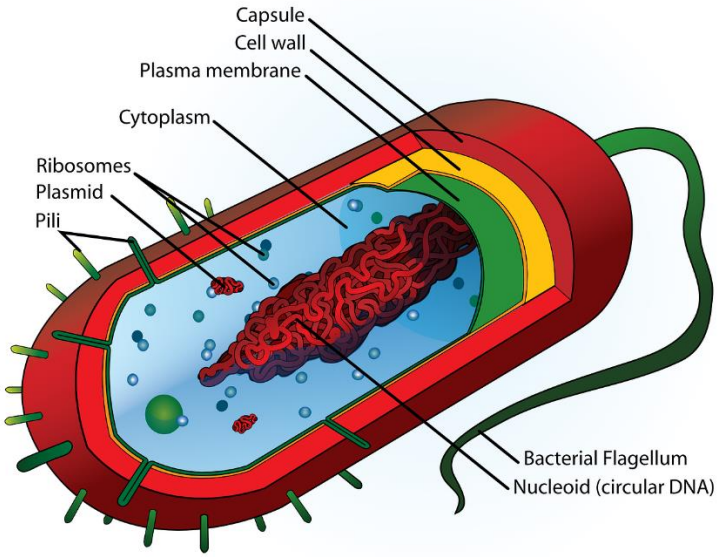
The organelles shown above can all be seen when using an electron microscope. If you were using a light microscope at school, you would not be able to see the ribosomes or mitochondria as they are too small to be seen with these microscopes.

The cell components listed in green are only found in plant cells. Use your prior knowledge to match the cell component with their function below:

Mitochondria	Semi-permeable structure that controls the movement of substance in and out of the cell
Nucleus	Made from Cellulose; acts to strengthen the cell and support the plant
Cell Membrane	Jelly-like substance containing cell organelles. Where chemical reactions take place
Chloroplast	Where protein synthesis takes place
Cell Wall	The site of respiration in the cell
Ribosome	Contains the genetic material (DNA) of the cell and controls the cell's activities
Permanent Vacuole	Filled with cell sap to maintain cell turgor (pressure)
Cytoplasm	Contains chlorophyll which absorbs light energy for use in photosynthesis

Quick note: animal cells can contain vacuoles, but these are very small and temporary structures. Vacuoles are used to store or transport substances in animal cells.

Bacteria cells are prokaryotes: this means they do not contain a nucleus, so all their chromosomal DNA is loose in the cytoplasm. This DNA is wound up tightly and called the Nucleoid; but they can have extra loops of DNA called Plasmids as well.



The functions of the structures that bacteria have in common with eukaryotes (cell wall, ribosomes etc) are the same, but bacteria have some extra components too.

- Pili – help bacteria stick to surfaces so they can survive and reproduce
- Plasmid – carries extra genes which give the bacteria a survival advantage e.g. antibiotic resistance genes are often found on plasmids. Plasmids can also be used to transport genes between different cells.
- Capsule – helps bacterial cells stick together to form a colony, and prevents the cells from dehydrating
- Flagellum – helps bacteria swim (acts like a tail)

Thinking question: bacteria are unicellular, so the cell above is one whole organism. Why might it be useful for a bacterium not to have a nucleus, but to have their DNA free in the cytoplasm?

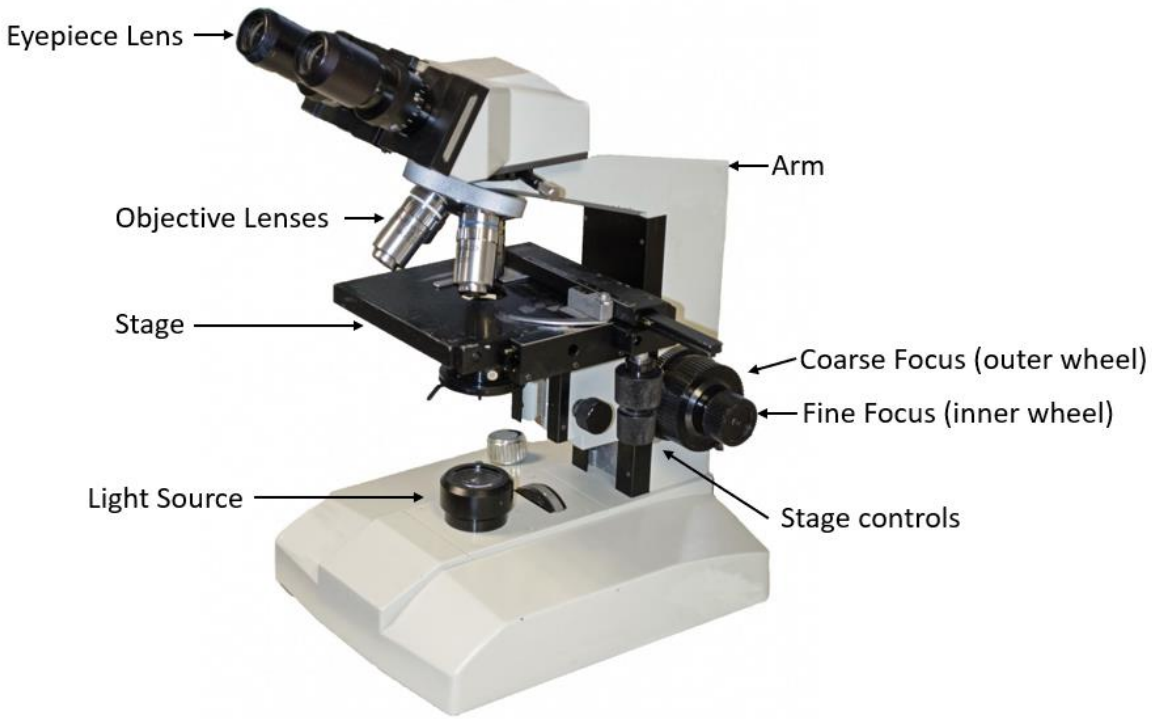
Microscopy

Cells cannot be seen by the naked eye, so to view them we use microscopes. There are several stages required to prepare biological samples for viewing under the microscope.

1. Water droplets are added to slides first to ensure cells stay hydrated and keep their shape.
2. Cells are then added to the slide.
3. Most cells are colourless, so we stain them with dyes to observe their shape and organelles.
4. Coverslips are placed over the top of the cell sample to protect the microscope and prevent the cell from drying out. Coverslips must be added carefully to prevent ait bubbles getting trapped: most scientists use mounted needles to lower the coverslip gently over their samples.

Risks of microscopy experiments:

- Light levels can be too high and damage the eyes
- Microscope stains can be damaging (or can stain your skin for extended periods)
- Coverslips, slides and mounted needles are all sharp and can cut skin



The eyepiece and objective lenses both act to magnify a sample, so we use the magnification on both lenses to work out exactly how many times bigger we view a sample compared to the actual size

- e.g. If the eyepiece lens has a magnification of 10x and the objective lens has a magnification of 40x, the overall magnification of the microscope is 10 x 40 = 400x.

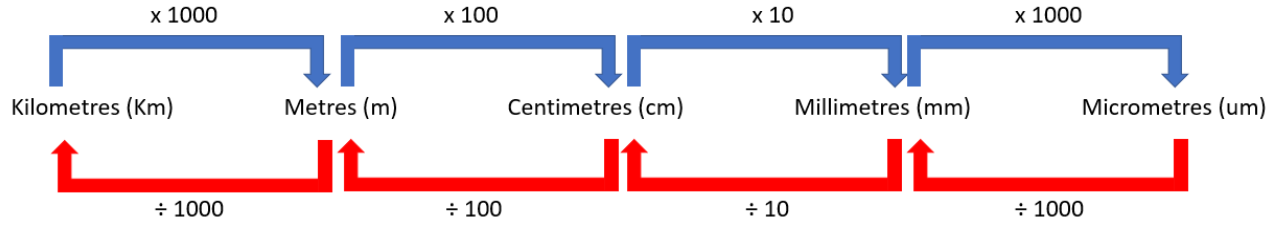
When completing microscope calculations, we use the equation:

- **Magnification = Image size ÷ Actual size**

An animal cell was viewed under a light microscope and found to be 1.5cm in length. The magnification of the eyepiece lens was 10x and the magnification of the objective lens was 100x. Work out the actual size of the animal cell.

1. Write out your equation: Magnification = Image size ÷ Actual Size
2. Combine the magnifications of the lenses by multiplying them together: 10 x 100 = 1000x – this means the cell appeared 1000x bigger than it actually is.
3. Convert your units to mm – this is the easiest unit to work with! 1.5 cm = 15mm
4. Replace the words in your equation with values you know:
   1000 = 15mm ÷ Actual Size
5. Rearrange the equation to find the Actual size:
   Actual size = 15mm ÷ 1000 = **0.015mm**

Hint: when working out cell sizes, always double check your units. You can use the flow chart below to double check your maths!



Try this question:

- **A liver cell is 0.075mm long. When observed down the microscope, the image appears to be 5.1cm. What is the magnification of this microscope?**

Light microscopes have a maximum magnification of 1500x so several organelles and cell structures cannot be seen using this tool. Electron microscopes can be used to see cells at a higher magnification – up to 1,000,000x!

There are two types of electron microscopes:

1. Scanning Electron Microscopes (SEM) which are often used to view the surface of structures
2. Transmission Electron Microscope (TEM) which are used to examine cells and tissues (these can be used in hospitals to help diagnose patient conditions)

Electron Microscopes are expensive to run and easily damaged, so schools do not have these to use. You will always use light microscopes, but you can be asked about Electron microscopes in your exams so make a note of the key facts!

Discussion question: light microscopes use a light source to illuminate a sample for observation. How might an electron microscope work? Discuss with your tutor.

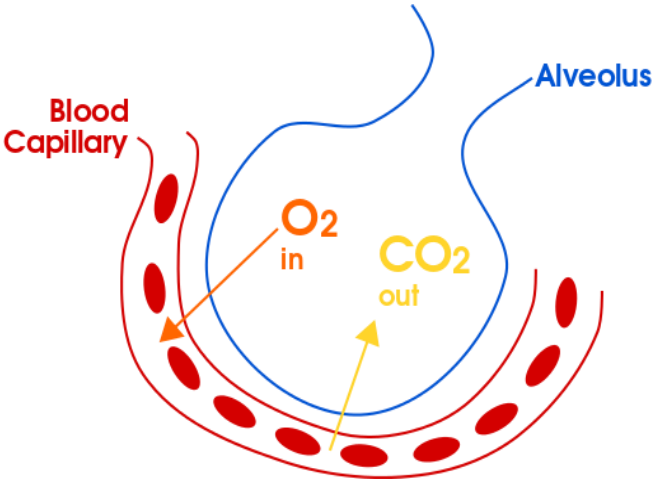
Cell Transport

There are three different methods by which substances can enter or leave cells:

1. Diffusion
2. Osmosis
3. Active Transport

Diffusion is the movement of molecules from a high concentration to a low concentration. We say this movement is "down" the concentration gradient. One example is when Oxygen diffuses from a high concentration in the lungs to a low concentration in the blood during gas exchange. Diffusion is a passive process; this means it does not require energy.

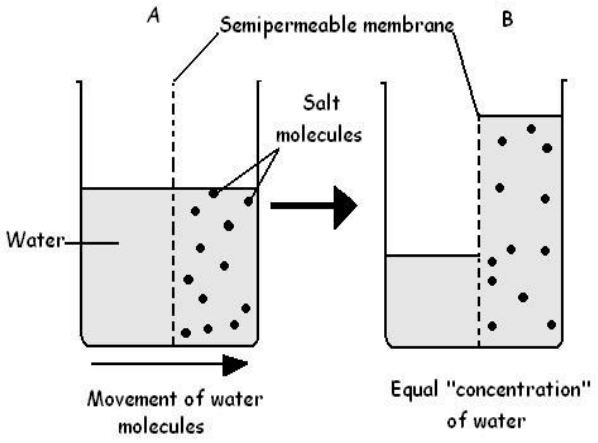
Here the alveolus has a high concentration of Oxygen, and the blood has a low concentration of Oxygen, so the Oxygen diffuses from the alveolus into the blood and is carried to body cells for respiration.



Carbon Dioxide is at a high concentration in the blood (having been made in respiration and picked up from body cells) and a low concentration in the alveolus, so CO_2 diffuses from the blood into the alveolus and is breathed out.

The definition for Osmosis is:
"The movement of water molecules from a dilute to a concentrated solution across a partially permeable membrane".

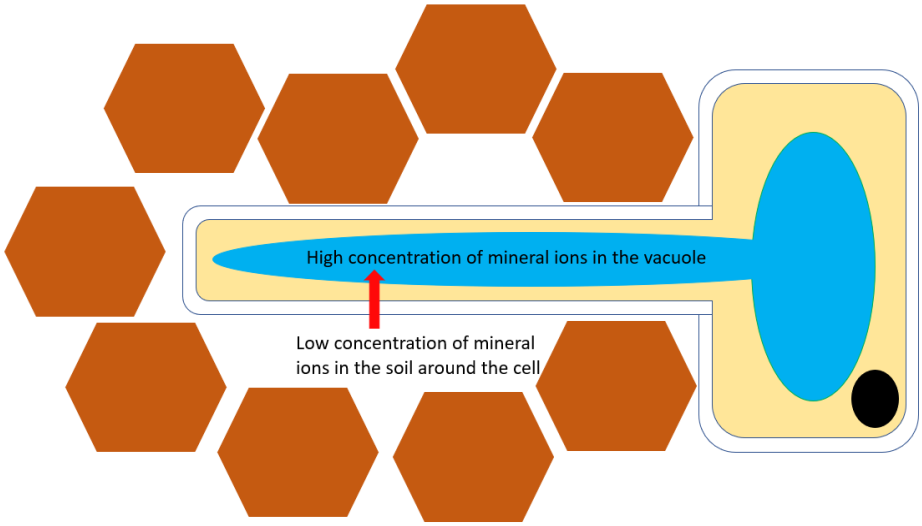
A dilute solution means a solution with a high concentration of water molecules, while a concentrated solution has a low concentration of water molecules. The key points about osmosis are that only water can move by osmosis, and this movement occurs across a partially permeable (semi-permeable) membrane.



Here you can see that in the image A, one side of the membrane is dilute, while the other is a concentrated solution. Image B shows that osmosis has taken place, with water molecules moving from the dilute to the concentrated solution until both sides of the membrane have the same concentration of water.

One example of Osmosis is water moving into potato cells (as seen in your core practical). Osmosis is also a passive process and does not need energy.

Active Transport is the movement of molecules from a low concentration to a high concentration. This goes against the concentration gradient, so this does require energy. One example of active transport is the movement of minerals into root hair cells of plants.



Answer the questions below about cell transport mechanisms:

1. Glucose passes from the blood into body cells by diffusion. What does this mean about the concentration of glucose in the blood and in the body cells? (1)

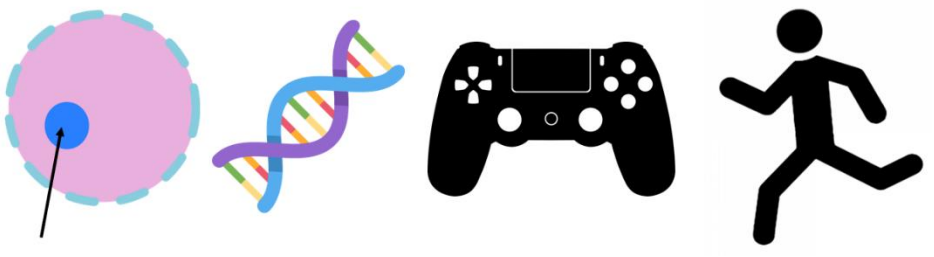
2. An onion cell was submerged in pure water. Explain why the onion cell expanded in size and burst open (3)

3. Suggest why root hair cells have a high number of mitochondria (3)

Consolidate: Dual Coding

Convert the written definitions for the three types of cell transport into images. An example could be:

The Nucleus of a cell contains the DNA and controls the cell activities.



Diffusion	
Osmosis	
Active Transport	