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CELL BIOLOGY

GCSE AQA BIOLOGY: TOPIC 1

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Cells

Cells → cells are basic building blocks of all living organisms. All living organisms are made up of one or more cells

Two main types of organisms:

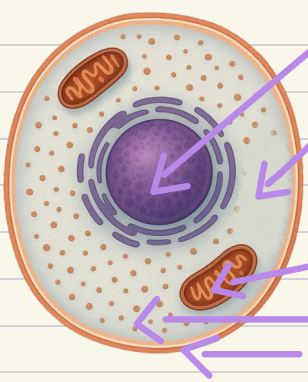
- unicellular (single-celled) e.g bacteria
- multicellular (many cells) e.g humans, plants

Two types of cells

- prokaryotic - these are simple small cells without a nucleus
- eukaryotic - these are complex cells with a nucleus

Animal cell

Animal cell is an eukaryotic cell because it's complex and contains a nucleus. An animal cell includes:



Nucleus - controls the activities of the cells, contains DNA

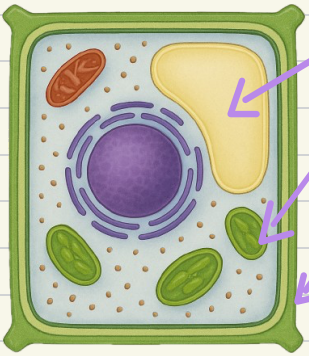
Cytoplasm - jelly -like substance that fills the inside of the cell, this is the site where chemical reactions take place

Mitochondria - site of respiration (energy release)

Cell membrane - controls movement of the cell

Plant cell

Plant cell is an eukaryotic cell because it's complex and contains a nucleus. A plant cell includes everything an animal cell has, with few more things like:



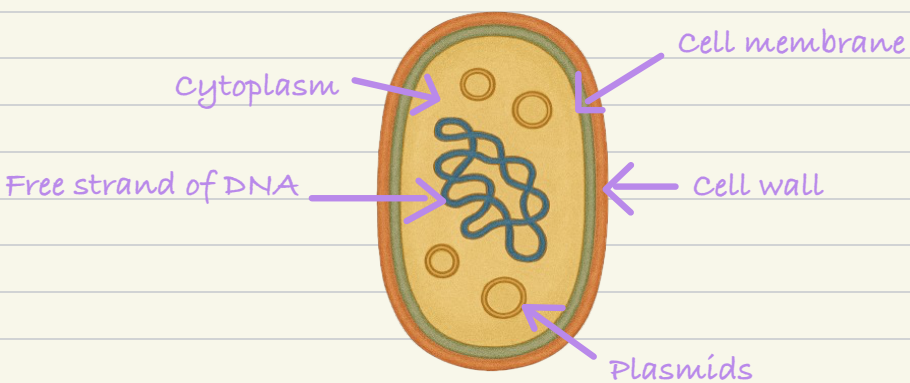
Vacuole - contains cell sap, keeps rigid

Chloroplasts - site of photosynthesis, contains chlorophyll needed to absorb light

Cell wall - strengthens and supports the cell, made out of cellulose

Bacterial cell

Bacteria cell is a prokaryotic cell because they are small, simple and don't have a nucleus. Bacteria cell includes:



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Microscopy

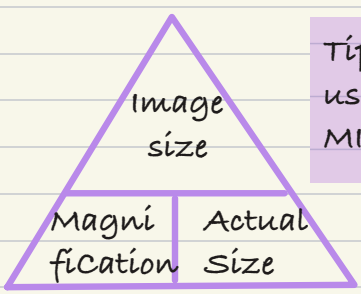
Microscopy → the use of microscopes to view objects too small to be seen with the naked eye, such as the cells. This is really important for scientists as it allows them to study cell structures and understand how organisms work.

There are two types of microscopes :

Type	How it works	Magnification	Resolution
Light microscope	Uses light and glass lenses	Low	Low
Electron microscope	Uses beams of electrons	High	High

Magnification formula

$$\text{Magnification} = \frac{\text{Image size}}{\text{Actual size}}$$



Tip=remember using acronym MIA

Additional skills required :

- Use of standard form
- conversion between units (mm, nm,μm)

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Practical

Light microscope

Preparing a microscope slide

Steps on how to view an onion cell under the microscope:

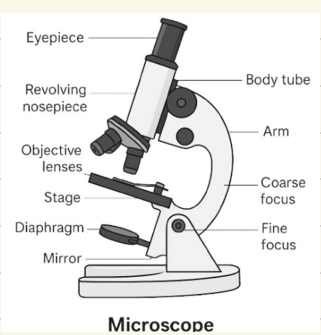
- add a drop of water to the middle of the clean slide.
- Use tweezers to gently peel a very thin and transparent layer - this is the epidermal tissue.
- place the onion tissue flat on the centre of the microscope slide.
- put iodine solution on the onion layer using the pipette -This make it easier to see as it stains the nucleus.
- place a cover slip over the onion - try not to get any air bubbles, as they can abstract the view.

Equipment needed:

- onion
- microscope slide
- cover slip
- iodine solution
- tweezers
- dropping pipette

Using the light microscope:

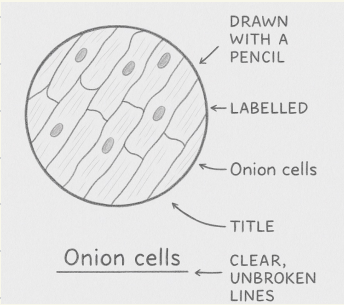
- Place your prepared slide securely on the stage using the clips.
- start by choosing the smallest objective lens.
- turn the coarse adjustment knob to lift the stage until the image appears clearer.
- look through the eyepiece and gently lower the stage until the image appears clearer.
- Sharpen the view by adjusting the focus knob.
- in order to get a closer look switch to a stronger lens.



Microscope

How to draw scientific observations from a microscope:

- use a sharp pencil - no pens, no shading
- draw what you see in clear, single lines.
- label the important features
- title your drawing
- write the magnification it was observed under



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Cell differentiation and specialisation

Cell differentiation → process by which a cell changes to become specialised for its specific function. During this process, a cell develops new structures or changes shape to perform its job better.

When does differentiation happen?

In animals → mostly happen early in development (embryo stage), after this most animal cells become specialised and can't change again. Some cells that still do differentiate are mostly involved in repairing and replacing old or damaged cells.

In plants → cells can differentiate throughout life, allowing them to grow new tissues.

Some cells haven't specialised yet, these are called stem cells, they have the potential to turn into different types of cells.

Examples of specialised cells.

Cells	Function	Special adaptions
Sperm cell	Fertilises eggs	Long tail for swimming, lot of mitochondria for energy, its head contains enzymes to break egg's membrane
Nerve cell	Carries electrical signals	Branched connections allowing connection with other nerve cells, its long length helps them cover large distances, so signals can travel more efficiently

Cells	Function	Special adaptions
Muscle cell	Contracts for movement	Long as they need to contract and it contains a lot of mitochondria to get energy
Root hair cell	Absorbs water and minerals	Long extension for large surface area to absorb water and minerals from the soil - found on the surface of plant roots
Phloem & xylem cells	Transport water and minerals in the plants	Xylem cells are hollow in the centre, allowing water to flow freely. Phloem cells have minimal subcellular structures, making it easier for sugars and other nutrients to pass through.

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Chromosomes and Mitosis

Chromosomes

Chromosomes are long, coiled molecules of DNA found in the nucleus of cells.
Each chromosome carries genes - control characteristics and activities in the cell.
Humans have 46 chromosomes (23 pairs) in each body cell/ one set from the mother, one from the father.

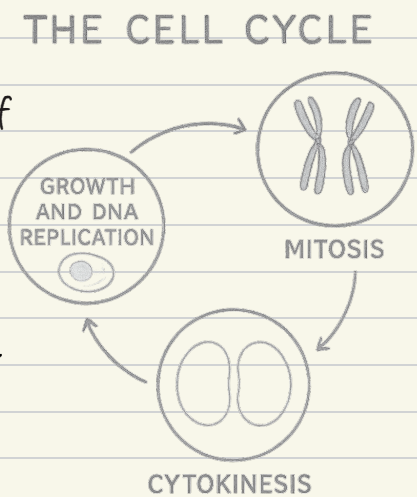
Chromosomes are important because they ensure that genetic information is passed on correctly when cells divide

The cell cycle

Cell cycle is the process by which body cells grow and divide. There are 3 main stages:

Growth & DNA replication

- cell grows and increases sub-cellular structures
- DNA replicates to form 2 identical copies of each chromosome
- chromosomes become x-shaped (2 arms Called chromatids)



Mitosis (division stage)

- chromosomes line up in the centre of the cell
- chromatids are pulled apart to opposite ends
- the nucleus divides

Cytokinesis

- the cell fully splits into identical daughter cells
- each daughter cell has exactly the same chromosomes (46 in humans)

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Stem cells

Stem cells → undifferentiated cells that can divide to produce more stem cells or become other type of cells. There are three types of stem cells: embryonic, adult and plant.

Embryonic stem cells

Embryonic stem cells are cells taken from early stage embryos (usually 4-5 days old). They can turn into any type of cells. Embryonic stem cells are useful for regrowing damaged tissues or treating diseases.

Adult stem cells

Adult stem cells are cells found in fully developed bodies. They can become certain types of cells, not all types like embryonic stem cells. Adult stem cells are found in the bone marrow.

Plant stem cells (meristems)

Meristem cells are unspecialised and can divide to produce any type of plant cell. They remain active throughout the plant's life, allowing continuous growth. They are found in the growing tips of roots and shoots. Plant stem cells can be used to clone rare plant species.

Medical uses of stem cells

- Medicine uses adult stem cells to cure diseases for example leukaemia.
- Embryonic stem cells could potentially treat diseases by replacing damaged cells like producing insulin for people with diabetes.
- Therapeutic Cloning produces embryo with the same DNA as the patient therefore stem cells are less likely to be rejected by the parent's body.

Plant uses of stemcells

Meristem stem cell allow plants to grow new roots, leaves and flowers. Used for cloning plants quickly and cheaply, preserving rare species, or produce crops with desired features.

Objections towards stem cells

- Involves destruction of embryos which can be seen as a potential life
- Risk of infection if stem cells are contaminated

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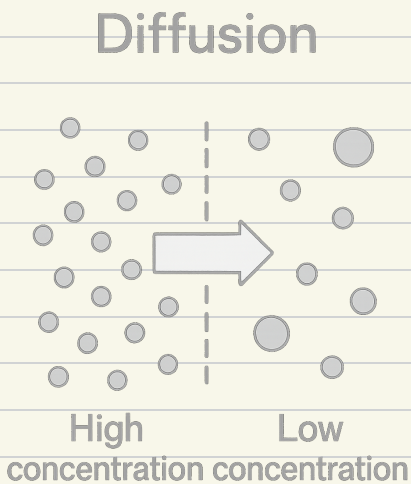
Diffusion

Diffusion → movement of particles from an area of higher concentration to an area of lower concentration (movement from where there is lots to fewer)
Diffusion happens in both solutions and gases, because the particles are free to move randomly.
For example oxygen moving from air lungs to blood for respiration. This is a passive process (No need of energy)



Factors effecting diffusion

- Bigger concentration gradient, the faster diffusion
- higher temperature, the fester diffusion
- larger surface area, the faster diffusion
- smaller particle size, the faster diffusion

Diffusion in cells

Cell membranes hold the cell together and it allows diffusion as smaller molecules move in and out, big molecules can't fit through the cell membrane

Examples of molecules that can diffuse:

- Oxygen
- glucose
- amino aids
- water

Examples of molecules that can't diffuse:

- Protein
- starch

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Osmosis

Osmosis → diffusion of water molecules across a partially permeable membrane (contains small holes in it). Water moves from dilute solution (high water concentration) to concentrated solution (low water concentration). Water moves both ways as they travel randomly. Osmosis is important because it regulates water content in cells and helps control internal conditions. This is a passive process (no need of energy)

Practical

Osmosis in potatoes

Investigating effect of different sugar concentrations on potato chips:

- Cut potato cylinders of equal si ze
- measure and record starting mass
- place the potato in different beakers of different concentrations of sugar solution
- leave for a set time (for example 5 hours)
- take the potato out, dry it and re-measure the mass
- calculate percentage change in mass

Analysis

- if the potato gains mass, water entered
- if the potato loses mass, water left

Variables:

- independent - concentration of sugar solution
- dependent -change in mass of potato
- control - volume of solution & size of potato

Percentage change = (final mass - starting mass) / starting mass x 100

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Active transport

Active transport → movement of substances against a concentration gradient - from low concentration to a high concentration. This is an active process (requires energy from respiration). Absorbs substances that are in lower concentration outside the cell. Examples of active transport include root hair cells and gut.

Root hair cell -In plants

The surface of roots is covered with root hair. Each root hair increases surface areas for absorbing water and minerals. The concentration of minerals is higher inside the root hair cell than the surrounding soil.

Glucose absorption in the gut -In humans

After digestion, glucose is absorbed from the gut into the blood. Sometimes there is more glucose in the blood than in the gut, so active transport is used to make sure all glucose is absorbed. This ensures no energy is wasted and your body gets all the fuel it can.

Diffusion vs Osmosis vs Active transport

	Diffusion	Osmosis	Active transport
Requires energy?	No	No	Yes
Movement	High to low concentration	High to low concentration	Low to high concentration
Type of substance	Gases or dissolved substances	Only water molecules	Ions and molecules

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Exchange surfaces

Exchange surfaces → specialised areas in the body or organism where substances are exchanged between internal and external environments. They allow essential materials (like gases and nutrients) to move in and out of cells efficiently.

Importance of exchanging substances

Every living organism needs to exchange substances with the environment to stay alive.

For example these vital substances:

- oxygen for respiration
- carbon dioxide as waste
- nutrients and water from food or surroundings

Surface area to volume ratio

These substances must enter and exit cells efficiently. But how fast they do this depends on surface area to volume ratio (SA:V)

- smaller organisms have a high SA:V ratio; diffusion is enough.
- larger organisms have a low SA:V ratio; need specialised exchange surfaces.
- therefore, as an organism gets bigger, its volume increases faster than its surface area.
- In unicellular organisms, gases can diffuse directly into the cell across the cell membrane, as they have a large surface area compared to their volume.

Formula we can use: SA:V= surface area / volume

Good exchange surfaces have these adaptions:

- Large surface area (more particles can diffuse at once)
- thin membrane (short diffusion distance)
- good blood supply (maintains steep concentration gradient)

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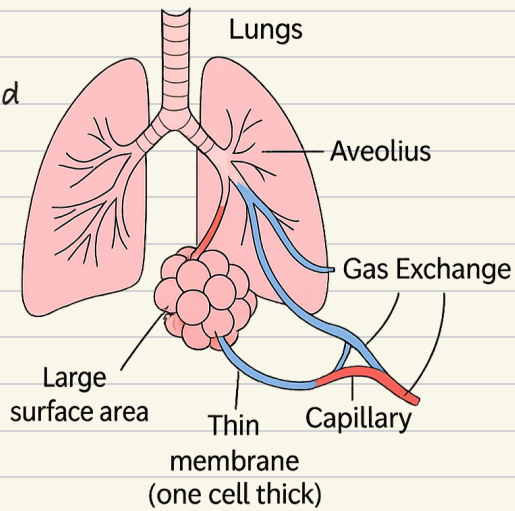
Exchanging substances

Exchanging substances → essential materials like gases, nutrients, and waste are transported into and out of the cells and organisms, to support processes like respiration, photosynthesis, and excretion.

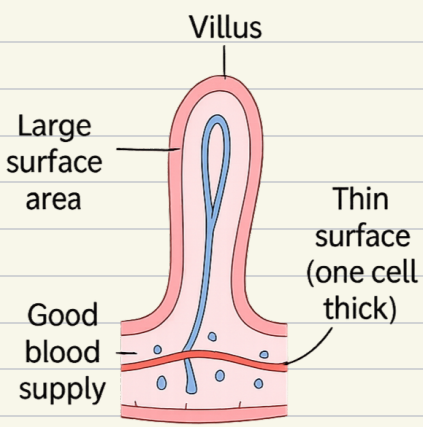
Gas exchange in the lungs (alveoli)

- oxygen diffuses from alveoli to blood
- carbon dioxide diffuses from blood into the alveoli



Alveoli's are adapted:

- large surface area
- very thin walls
- good blood supply



- Large surface area
- Thin surface (one cell thick)
- Good blood supply

Villi in the small intestine

Small intestine contains a bunch of villi's. Nutrients like glucose and amino acids absorbed into the bloodstream by the villis.

Villis are adapted:

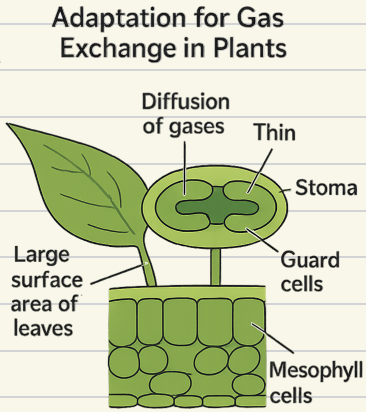
- large surface area
- rich supply of blood
- thin walls

Gas exchange in plants

In plants, carbon dioxide diffuses in, and oxygen diffuses out.

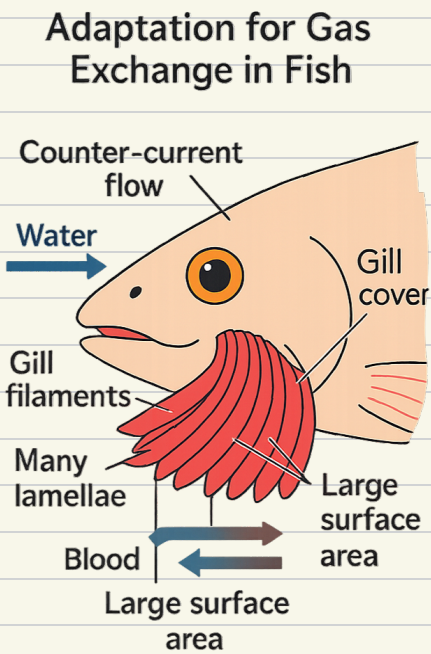
Roots are adapted:

- has stomata which lets carbon dioxide diffuse in, oxygen and water vapour diffuse out
- flattened shape and air spaces inside the leaf give a big surface area
- has guard cells that control opening of stomata to reduce water loss



Gas exchange in fish

Fish rely on their gills to take in oxygen from the water and get rid of carbon dioxide. Water enters the mouth and flows across the gills, and oxygen moves from water into the bloodstream while carbon dioxide moves out.



Gills are adapted:

- gill filaments provide a large surface area
- lamellae (tiny plates on filaments) increase surface area further
- lamellae have a rich blood supply
- are one cell thick
- counter- current flow (water and blood flow in opposite directions) keeps oxygen moving by maintaining a steep concentration gradient