

Biology

**Bridging the gap from
GCSE to A Level**

Welcome to A level Biology

A Level Biology Bridging Booklet

Introduction

This booklet is designed to support the transition from GCSE to A Level Biology.

A Level Biology requires a deeper level of understanding, stronger application of knowledge, and the ability to link concepts across topics. This bridging work will help to consolidate core GCSE knowledge and introduce key ideas that form the foundation of the AQA A Level Biology course.

Completion of this booklet will allow you to:

- Identify strengths and areas for development
- Reinforce essential biological knowledge
- Develop confidence with key terminology
- Prepare for the level of challenge expected at A Level

Aims of the Booklet

- To strengthen understanding of fundamental biological concepts
- To develop accurate use of scientific terminology
- To practise applying knowledge using AQA-style command words
- To build confidence in key mathematical and analytical skills
- To prepare students for independent learning at A Level

AQA A Level Biology Specification Links

This booklet supports the following key areas of the AQA A Level Biology specification:

Year 1 Content

- Biological molecules
- Cells
- Organisms exchange substances with their environment
- Genetic information, variation and relationships between organisms.

Key Concepts Covered in this Booklet

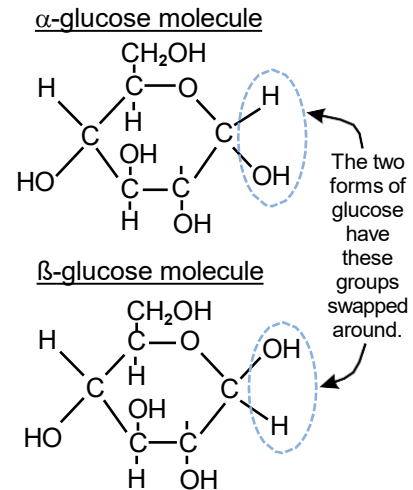
- Structure and function of carbohydrates, lipids and proteins
- Enzyme action and factors affecting enzyme activity
- Cell structure and differences between prokaryotic and eukaryotic cells
- Cell membranes and transport processes
- DNA structure and protein synthesis
- Cell division (mitosis and meiosis)
- Exchange surfaces and transport systems in animals and plants
- Immunity and disease
- Variation, evolution and classification

Carbohydrates

Carbohydrates

Carbohydrates contain **carbon, hydrogen** and **oxygen**. There are several types of carbohydrate, e.g. sugars, starch and cellulose.

- 1) Sugars are **small, water-soluble** molecules that taste sweet.
- 2) They're divided into two groups: **monosaccharides** (pronounced: mono-sack-a-rides) and **disaccharides** (die-sack-a-rides).
- 3) Monosaccharides are the single units from which all the other carbohydrates are built.
Glucose and **fructose** are both monosaccharides.
Glucose has two forms — **alpha** (α) and **beta** (β).
- 4) Disaccharides are formed when **two monosaccharides** are joined together by a chemical reaction. A molecule of **water** is also formed (so it's called a **condensation reaction**).



GLUCOSE + GLUCOSE \rightarrow MALTOSE (a disaccharide) + WATER

GLUCOSE + FRUCTOSE \rightarrow SUCROSE (a disaccharide) + WATER

Starch

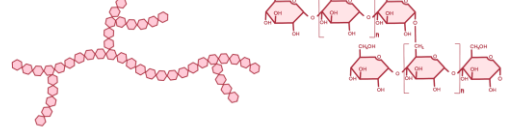
Polysaccharides are **polymers** — large molecules made up of **monomers** (smaller units). The monomers of polysaccharides are **monosaccharides**. **Starch** molecules are made up of two different polysaccharides — **amylose** and **amylopectin**, which are polymers of glucose. The insoluble, compact starch molecules are an ideal way of **storing glucose**.

Starch is **only** found in plant cells.

Amylose

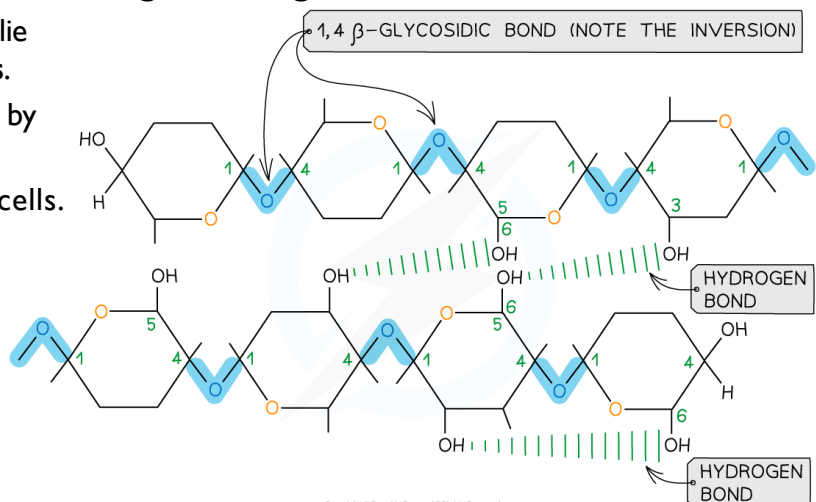


Amylopectin



Cellulose

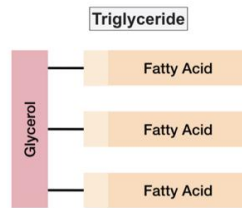
- 1) Like starch, cellulose is a polymer of glucose, but the **bonding** between the glucose units is different.
- 2) As a result, the cellulose molecules are **long and straight**.
- 3) Several cellulose molecules can lie side by side to form **microfibrils**.
- 4) The molecules are held together by many weak **hydrogen bonds**.
- 5) Cellulose is only found in plant cells.
- 6) The microfibrils **strengthen** the plant cell wall.



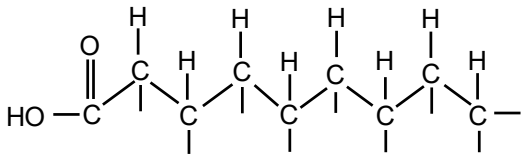
Lipids

Lipids

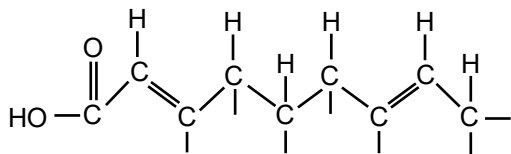
Lipids are **oils** and **fats**. Plant oils and animal fats are mostly made up of a group of lipids called **triglycerides**. A triglyceride consists of a molecule of **glycerol** with **three fatty acids** attached to it.



A fatty acid molecule is a long chain of **carbon atoms** with an **acid group** ($-\text{COOH}$) at one end. **Hydrogen atoms** are attached to the carbon atoms. If every carbon atom in the chain is joined by a **single bond**, we say that the fatty acid is **saturated**. If one or more of the bonds is a **double bond**, it's said to be **unsaturated**. A fatty acid with many double bonds is **polyunsaturated**.



Saturated fatty acid

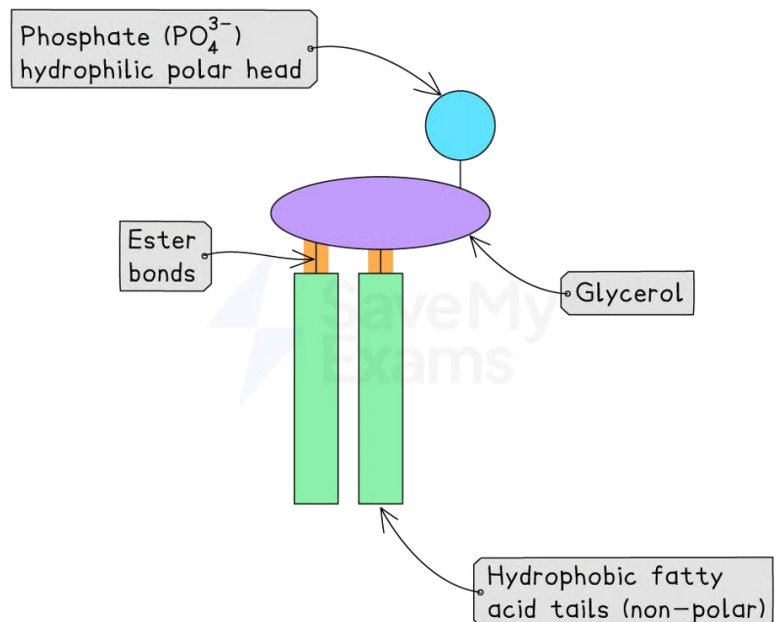


Unsaturated fatty acid

Phospholipids

Phospholipids (pronounced: foss-foe-lip-id) are like triglycerides, but instead of having three fatty acid chains, they have **two** fatty acid chains and a **phosphate** group.

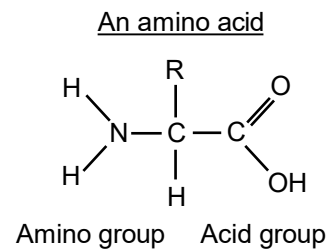
Cell membranes are made from a **double layer** of phospholipids.



Proteins

Proteins

Proteins are composed of long chains of **amino acids**. There are **twenty different** amino acids used in proteins. They all contain carbon, hydrogen, oxygen and nitrogen, and some contain sulfur. All have the **same structure** as the one in the diagram but **R** can be one of twenty different chemical groups.

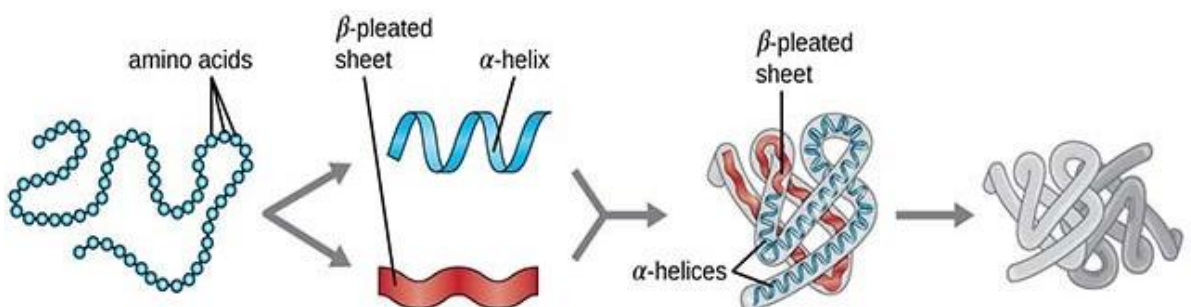


Peptide Bonds

- 1) The chains of amino acids are attached to each other by **strong peptide bonds**.
- 2) The amino acids can be arranged in any sequence and proteins can be up to **several hundred** amino acids long.
- 3) The number of different proteins that are possible is almost unimaginable. Consider that there are several thousand ways of arranging a chain of just three amino acids, with each combination forming a different protein. Add one more amino acid to the chain and the number of possibilities leaps into the hundreds of thousands.
- 4) It's the **order** of the amino acids in a protein that determines its **structure** and it's the structure of a protein that determines **how it works**.

Protein structure

- 1) The order in which the amino acids are arranged in a protein chain is called the **primary structure**.
- 2) Some chains **coil up** or **fold** into pleats that are held together by weak forces of chemical attraction called **hydrogen bonds**.
The coils and pleats are the **secondary structure** of a protein.
- 3) Some proteins (especially enzymes) have a **tertiary structure**. The coiled chain of amino acids is folded into a **ball** that's held together by a mixture of weak chemical bonds (e.g. hydrogen bonds) and stronger bonds (e.g. disulfide bonds).
- 4) If the protein has a roughly spherical shape it's called a **globular protein** (e.g. enzymes are classed as globular proteins).



Primary Protein Structure
Sequence of a chain of amino acids

Secondary Protein Structure
Local folding of the polypeptide chain into helices or sheets

Tertiary Protein Structure
three-dimensional folding pattern of a protein due to side chain interactions

Quaternary Protein Structure
protein consisting of more than one amino acid chain

Questions

Carbohydrates

- 1.State what is meant by a monosaccharide.
- 2.Describe how a disaccharide is formed.
- 3.Outline what is meant by a condensation reaction.
- 4.State the elements found in carbohydrates.
- 5.Compare α -glucose and β -glucose.
- 6.Describe the structure of cellulose.
- 7.Explain how cellulose provides strength to plant cell walls.
- 8.State the two components of starch.

Lipids

- 1.State the components of a triglyceride.
- 2.Describe the structure of a fatty acid.
- 3.Outline the difference between saturated and unsaturated fatty acids.
- 4.Define the term polyunsaturated.
- 5.State the structure of a phospholipid.
- 6.Describe the role of phospholipids in membranes.
- 7.Compare triglycerides and phospholipids.
- 8.Explain why lipids are important in cells.

Proteins

- 1.State the monomers that make up proteins.
- 2.Describe the primary structure of a protein.
- 3.Outline the secondary structure of a protein.
- 4.State the type of bond between amino acids.
- 5.Describe the tertiary structure of a protein.
- 6.Define the term globular protein.
- 7.Explain how the structure of a protein determines its function.

Enzymes

Enzymes speed up Biochemical Reactions

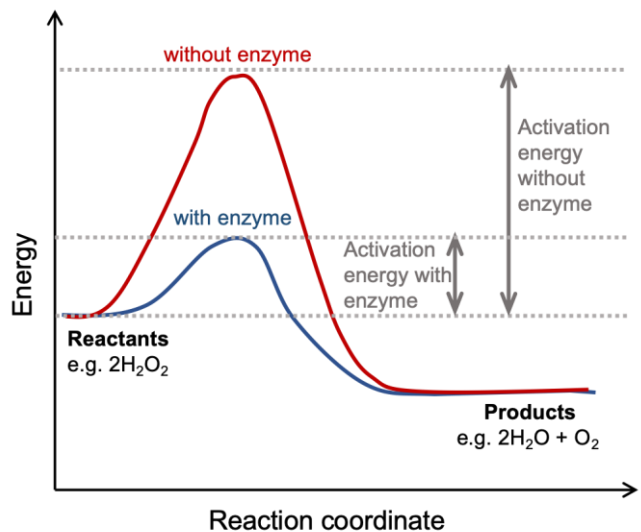
- 1) In a living cell, thousands of **biochemical reactions** take place every second. The sum of these reactions is called **metabolism**. A single chain of these reactions is called a **metabolic pathway**.
- 2) Without enzymes, these reactions would take place very **slowly** at normal body temperature.

- 1) Enzymes are **biological catalysts**.
- 2) They **increase** the **rate** (speed) of reactions.

Enzymes as Catalysts

- 1) Even reactions that release energy require an **input of energy** to get them going, e.g. the gas from a Bunsen burner doesn't burn until you provide heat energy from a match.
- 2) This input energy is called the **activation energy**. A reaction that needs a high activation energy can't start at a low temperature of 37 °C (i.e. body temperature).
- 3) Enzymes **reduce** the activation energy.

This graph shows the activation energies of a reaction **with** and **without** an enzyme:



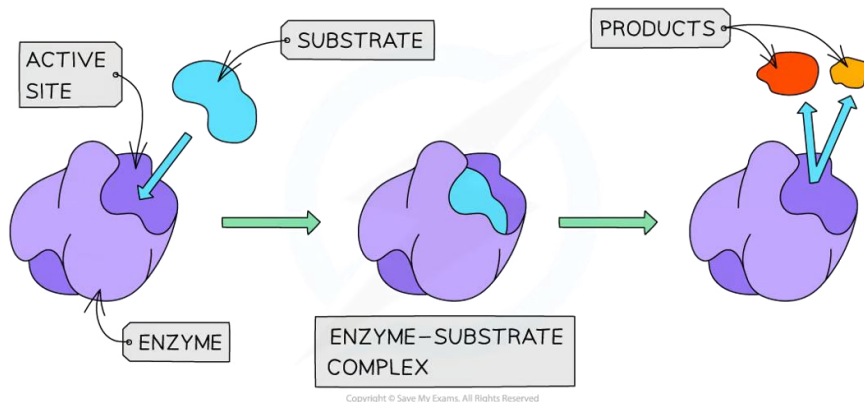
Enzymes are Proteins

- 1) All enzymes are **globular proteins** (because they're roughly spherical).
- 2) It's the order of amino acids in an enzyme that determines its **structure**, and so how it works.
- 3) Enzymes can be involved in **breaking down** molecules or **building** molecules. For example:
 - **Digestive enzymes** are important in the digestive system, where they help to break down food into smaller molecules, e.g. carbohydrases break down carbohydrates.
 - Enzymes involved in **DNA replication** help to build molecules, e.g. DNA polymerase.

Enzymes

Enzymes have an Active Site

- 1) A substance that's acted upon by an enzyme is called its **substrate**.
- 2) The **active site** is a region on the surface of the enzyme molecule where a substrate molecule can attach itself. It's where the catalysed reaction takes place.
- 3) The shape of the substrate molecule and the shape of the active site are **complementary**, i.e. they fit each other.
- 4) Almost as soon as the **enzyme-substrate complex** has formed, the products of the reaction are released and the enzyme is ready to accept another substrate molecule.



Enzymes are Specific

- 1) An enzyme usually catalyses one **specific** chemical reaction.
- 2) The substrate molecule must be the **correct shape** to fit into the active site.
- 3) **Only one substrate** will be the correct shape to fit, so each enzyme only catalyses one specific reaction.
- 4) Anything that **changes** the shape of the active site will **affect** how well the enzyme works.

The Effect of Temperature on Enzyme Activity

As temperature **increases**, enzyme reactions become **faster**, because the molecules have more **energy**. However, at high temperatures the atoms of the enzyme molecule vibrate more rapidly and **break** the weak bonds that hold the **tertiary structure** together. The **shape** of the active site **changes** and the substrate can no longer fit in. The enzyme is said to be **denatured**.

The Effect of pH on Enzyme Activity

Acids and **alkalis** can denature enzymes. Hydrogen ions (H^+) in acids and hydroxyl ions (OH^-) in alkalis disrupt the **weak bonds** and change the shape of the active site.

Questions

Enzymes (Introduction)

- 1.State what is meant by metabolism.
- 2.Define the term enzyme.
- 3.Describe the role of enzymes in reactions.
- 4.State what is meant by activation energy.
- 5.Explain how enzymes affect activation energy.
- 6.Describe why enzymes are important in living organisms.
- 7.Outline two examples of enzyme action in the body.

Enzymes (Factors & Specificity)

- 1.State what is meant by denaturation.
- 2.Describe the effect of temperature on enzyme activity.
- 3.Outline the effect of pH on enzymes.
- 4.State what is meant by a substrate.
- 5.Describe the active site of an enzyme.
- 6.Explain enzyme specificity.
- 7.Explain how changes in pH or temperature affect enzyme activity.

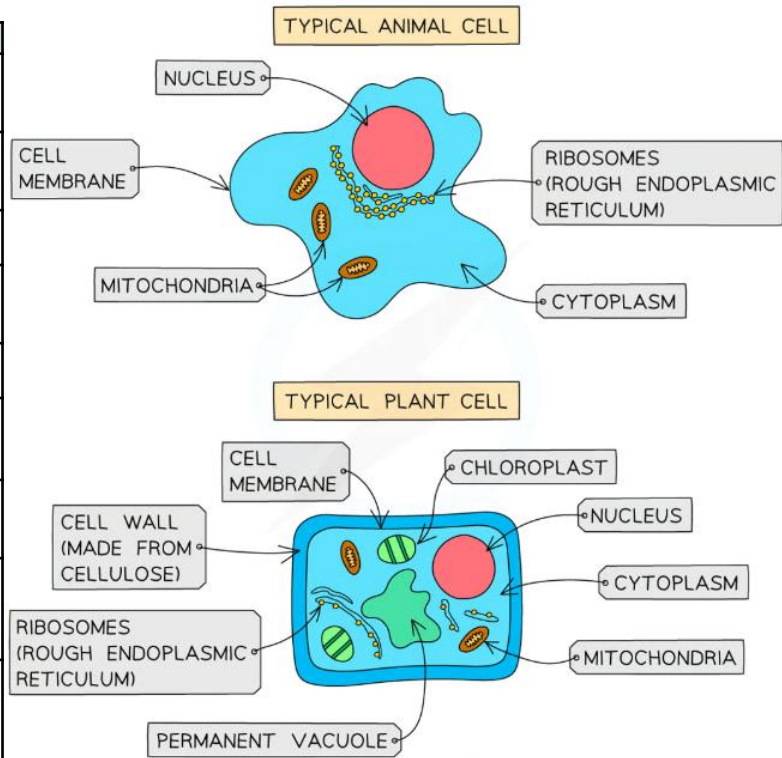
Eukaryotic and Prokaryotic Cells

Organisms can be Prokaryotes or Eukaryotes

- 1) **Prokaryotic** (pronounced like this: pro-carry-ot-ick) organisms are prokaryotic cells (i.e. they're **single-celled** organisms) and **eukaryotic** (you-carry-ot-ick) organisms are made up of eukaryotic cells.
- 2) Both types of cells contain **organelles**.
Organelles are parts of cells
— each one has a **specific function**.

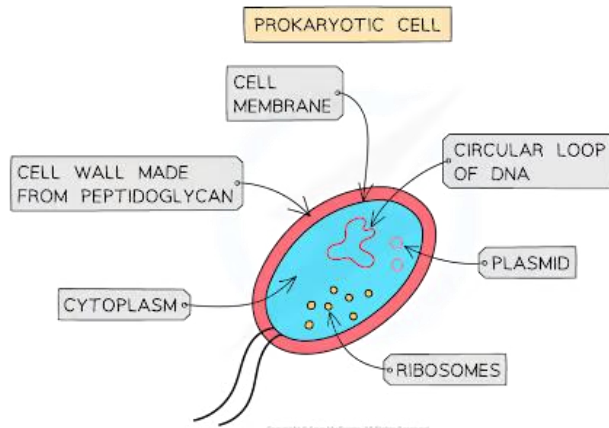
Eukaryotic cells are **complex** and include all **animal** and **plant** cells.
Prokaryotic cells are **smaller** and **simpler**, e.g. **bacteria**.

Organelle	Role
Nucleus	Contains DNA and controls cell activities
Cell membrane	Controls movement of substances in and out of the cell
Cytoplasm	Site of most chemical reactions
Mitochondria	Site of aerobic respiration (releases energy)
Ribosomes	Site of protein synthesis
Rough endoplasmic reticulum (RER)	Transports proteins made by ribosomes
Cell wall (plant only)	Strengthens and supports the cell (made of cellulose)
Chloroplast (plant only)	Site of photosynthesis (contains chlorophyll)
Permanent vacuole (plant only)	Contains cell sap and maintains pressure to keep cell rigid



Bacterial Cells are Prokaryotic

- 1) Prokaryotes like bacteria are roughly a **tenth the size** of eukaryotic cells.
- 2) Prokaryotic cells **don't contain** a nucleus, mitochondria or chloroplasts.
- 3) As they **don't** have a nucleus, their **DNA floats freely** in the **cytoplasm**. Some prokaryotes also have **rings of DNA** called **plasmids**.
- 4) Some prokaryotes have a **flagellum** which **rotates** and allows the cell to **move**.
- 5) The diagram shows a bacterial cell as seen under an **electron microscope** (see next page).

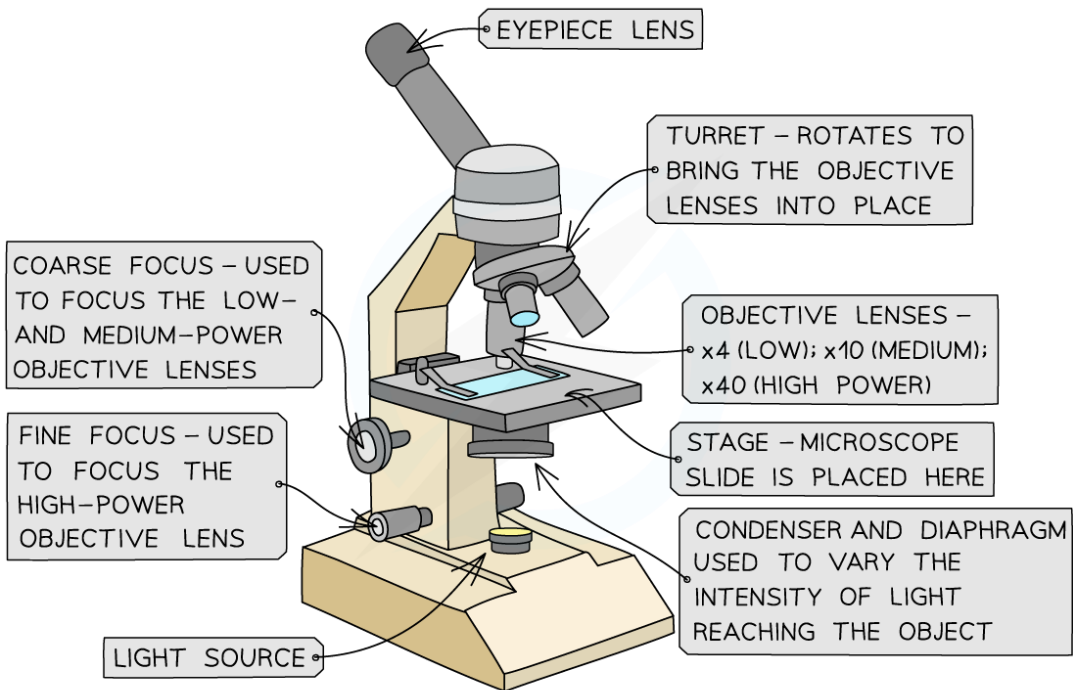


Microscopes

Light Microscope

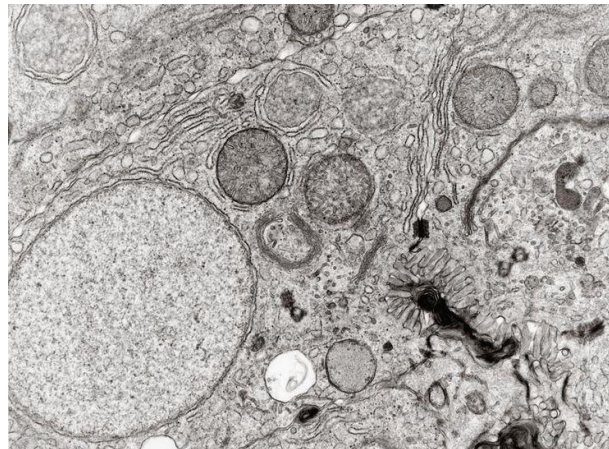
A **light microscope** can magnify up to 1500 times and allows you to see individual animal and plant cells along with the organelles inside them.

- 1) If the cells have been **stained** you can see the dark-coloured **nucleus** surrounded by lighter-coloured **cytoplasm**.
- 2) Tiny **mitochondria** and the black line of the **cell membrane** are also visible.
- 3) In plant cells, the **cell wall**, **chloroplasts** and the **vacuole** can be seen.



Electron Microscopes

- 1) The detailed **ultrastructure** of cells was revealed in the 1950s when the **electron microscope** was invented.
- 2) An electron microscope can **magnify** objects more than 500 000 times and, more importantly, it allows **greater detail** to be seen than a light microscope. For example, it allows you to see the detailed **structures inside organelles** such as mitochondria and chloroplasts.
- 3) The image that's recorded is called an **electron micrograph**.



Functions of the Nucleus, Mitochondria and Cell Wall

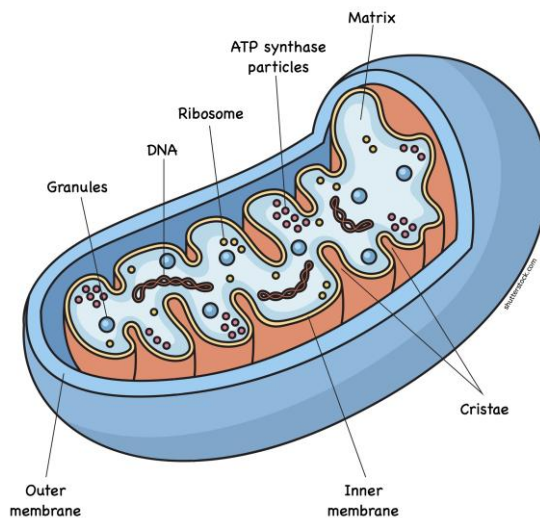
Nucleus

- 1) The **nucleus** is the control centre of the cell.
- 2) It contains **DNA** (deoxyribonucleic acid): the coded information needed for **making proteins**.
- 3) During **cell division** the chromosomes carrying the long DNA molecules coil up, becoming shorter and thicker and visible with a light microscope.
- 4) Electron micrographs show that there's a **double membrane** around the nucleus.

Mitochondria

Mitochondria are about the size of bacteria, so they can be seen with a light microscope, but you need an electron microscope to see any of the detail.

Each mitochondrion has a **smooth outer membrane** and a **folded inner membrane**:



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Their job is to capture the energy in glucose in a form that the cell can use. To do this **aerobic respiration** takes place inside the mitochondria.

Word equation: **GLUCOSE + OXYGEN → CARBON DIOXIDE + WATER + (ENERGY)**

The energy released by respiration ends up in molecules of **ATP** (adenosine triphosphate). ATP is used in the cell to provide the energy for **muscle contraction, active transport** (called active uptake in some text books) and **building large molecules** from small ones, as well as many other processes.

Cell Wall — Plants

- 1) The plant cell wall is relatively rigid and provides **support** for the cell.
- 2) It mainly consists of bundles of long, straight **cellulose molecules**.
- 3) The cellulose molecules lay side by side to form **microfibrils**.

Questions

Eukaryotic vs Prokaryotic Cells

- 1.State what is meant by a prokaryotic cell.
- 2.State what is meant by a eukaryotic cell.
- 3.Describe two differences between prokaryotic and eukaryotic cells.
- 4.State where DNA is found in prokaryotic cells.
- 5.Outline the function of ribosomes.
- 6.Describe the role of mitochondria.
- 7.Explain why prokaryotic cells are considered simpler.

Microscopes

- 1.State the maximum magnification of a light microscope.
- 2.State one advantage of an electron microscope.
- 3.Describe what is meant by magnification.
- 4.Outline the difference between light and electron microscopes.
- 5.State the term used for images from electron microscopes.
- 6.Explain why electron microscopes provide more detail.

Cell Structures (Nucleus, Mitochondria, Cell Wall)

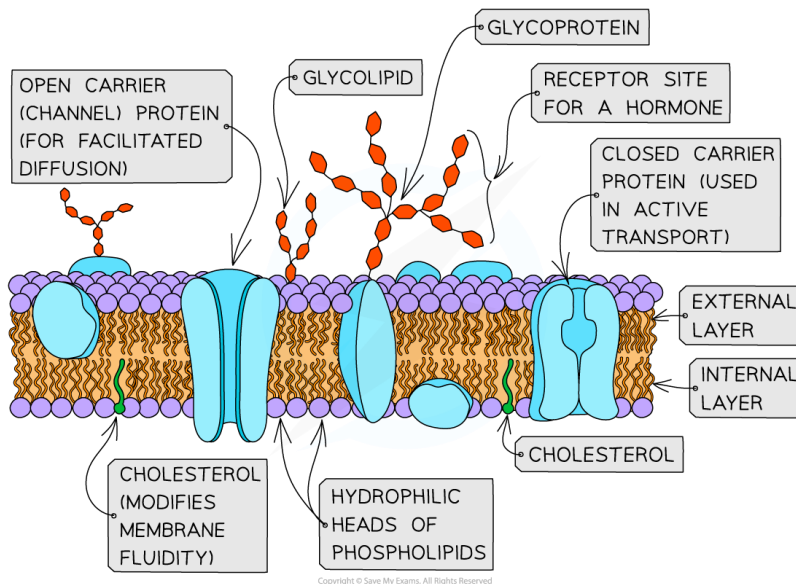
- 1.State the function of the nucleus.
- 2.Describe the role of DNA in the cell.
- 3.Outline the function of mitochondria.
- 4.State the word equation for aerobic respiration.
- 5.Describe the structure of the cell wall.
- 6.Explain how the cell wall provides support.

Cell Membranes

Structure of the Cell-Surface Membrane

The **cell-surface membrane** is the very thin structure around an individual cell.

- 1) Electron micrographs show that the cell-surface membrane consists of a double layer of **phospholipid** molecules tightly packed together.
- 2) Bigger **protein molecules** are embedded in the phospholipid molecules.
- 3) Some proteins go **all the way through** the membrane and some only go **halfway**.
- 4) Membranes surrounding the **organelles** inside cells have the **same** structure.



Substances Pass Through Membranes by Four Methods

1 Diffusion

- 1) The particles of liquids and gases are constantly **moving about**. This movement causes the particles to spread from an area of **higher** concentration to an area of **lower** concentration.
- 2) Particles will **diffuse** through the cell membrane as long as they are small enough to pass through the very small gaps **between** the phospholipid molecules. Water, oxygen and **carbon dioxide** molecules can do this.
- 3) The cell **doesn't** need to provide any energy for this process.

The difference in concentration is sometimes called a **concentration gradient**, e.g. a big difference in concentration is a big concentration gradient.

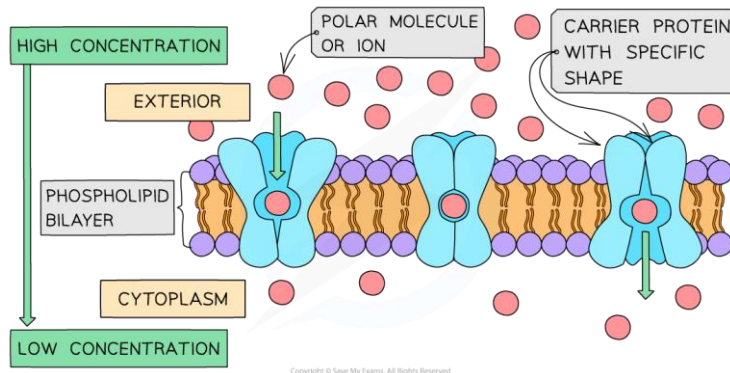
2 Osmosis

- 1) **Osmosis** is the diffusion of **water** molecules across a partially permeable membrane from a region of **higher concentration** of water molecules to a region of **lower concentration** of water molecules. The cell **doesn't** need to provide energy.
- 2) The concentration of water molecules is also referred to as the **water potential**. At AS and A-level, you tend to talk about water moving from a region of **higher water potential** to a region of **lower water potential**.

Cell Membranes

3 Facilitated Diffusion

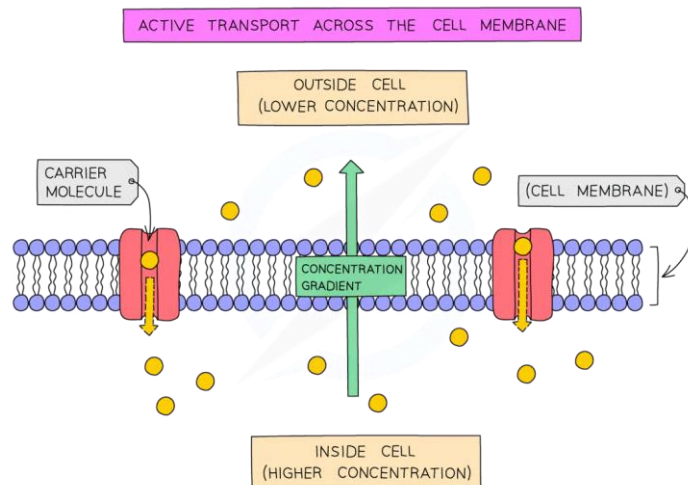
- 1) Glucose and many other water soluble molecules are **too big** to diffuse across the membrane by themselves. They must be helped across by **carrier proteins**.
- 2) Each substance has its **own specific** carrier protein.
- 3) For example, a molecule of glucose fits onto the outside end of a **glucose carrier protein**.
- 4) This causes the protein to **change shape**, allowing the glucose molecule to diffuse through it into the cytoplasm of the cell. The cell **doesn't** need to provide any energy.



Mineral ions like sodium (Na^+) and potassium (K^+) have electrical charges on them, so they also need help to cross the membrane. Specific **channel proteins** in the membrane allow them to diffuse through.

4 Active Transport (or Active Uptake)

- 1) When a cell needs to move substances across the membrane from a region of **low** concentration to a region of **higher** concentration, it must provide **energy**.
- 2) The substance fits into a **specific carrier protein**, then molecules of **ATP** (see page 8) provide the energy to change the shape of the protein.
- 3) As it changes shape the protein **actively transports** the substance across the membrane.
- 4) These special **carrier proteins** are sometimes called “**pumps**” because they’re moving substances **against** a concentration gradient.



Questions

Cell Membranes (Part 1)

1. Define diffusion.
2. Define osmosis.
3. State the direction of water movement in osmosis.
4. Describe the structure of the cell membrane.
5. Outline what is meant by a concentration gradient.
6. Explain how substances move by diffusion.
7. Explain why osmosis does not require energy.

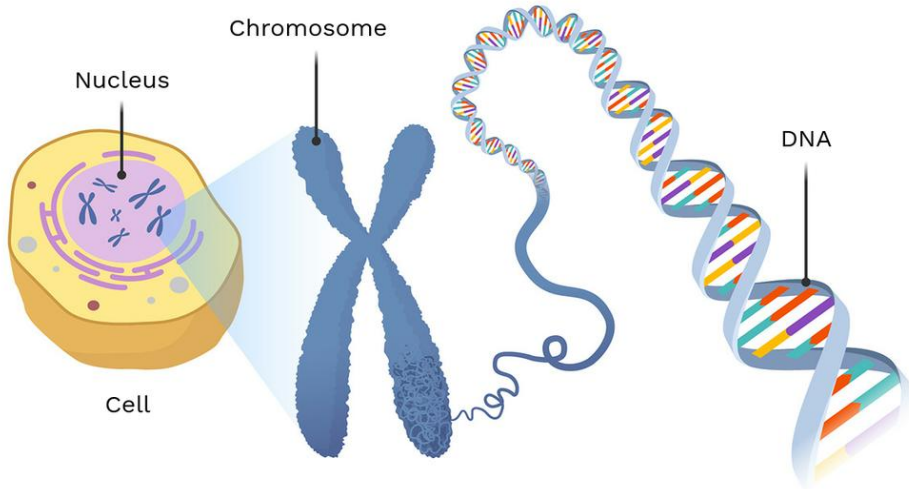
Cell Membranes (Part 2)

1. State what is meant by active transport.
2. Describe the role of carrier proteins.
3. Outline facilitated diffusion.
4. State the role of ATP in active transport.
5. Compare active transport and diffusion.
6. Explain why ions require transport proteins.

Chromosomes

DNA is Found on Chromosomes

DNA is found in the **nucleus** of **eukaryotic cells**. It has to be **wound up** into chromosomes to fit in. Each human chromosome contains between a couple of hundred and a few thousand genes.

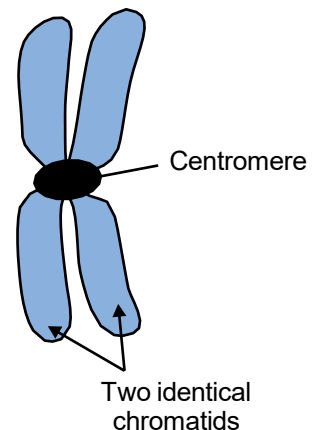


Homologous Pairs

Humans have **23 homologous pairs** of chromosomes (46 in total), e.g. two number 1s, two number 2s, two number 3s, etc. One from each pair comes from your mother and one comes from your father. Both chromosomes in a pair are the **same size** and carry the **same genes** (which is why they're called **homologous pairs**). But they usually have **different alleles** (different versions of the genes).

Chromosomes are Often Shown as X-Shaped

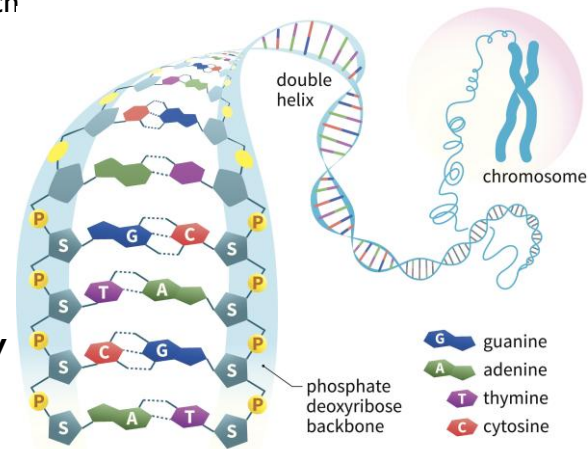
In loads of books chromosomes are shown as **X-shaped**. An X-shaped chromosome is actually **one chromosome** attached to an **identical copy** of itself. Don't get it confused with a homologous pair of chromosomes. They're only X-shaped just after the DNA has been **replicated** (e.g. in cell division). Each side of the X is referred to as a **chromatid** and the bit in the middle where they're attached is called the **centromere**.



DNA and Protein Synthesis

DNA is Made Up of Nucleotides Containing Bases

- 1) **DNA** is a **double helix** (a double-stranded spiral). Each of the two DNA strands is made up of lots of small molecules called **nucleotides**.
- 2) Each **nucleotide** contains a part called a **base**. DNA has just **four** different bases.
- 3) These bases are: **adenine (A)**, **cytosine (C)**, **guanine (G)** and **thymine (T)**.
- 4) Each base forms **hydrogen bonds** to a base **on the other strand**. This keeps the two DNA strands **tightly wound** together.
- 5) The bases **always** join up in the **same way**.



Adenine (A) always joins up with **thymine (T)**, and **cytosine (C)** always joins up with **guanine (G)**.

These pairs of bases are called **complementary bases**. They join together because they **complement** each other in shape — this is called **complementary base pairing**.

Proteins are Made by Reading the Code in DNA

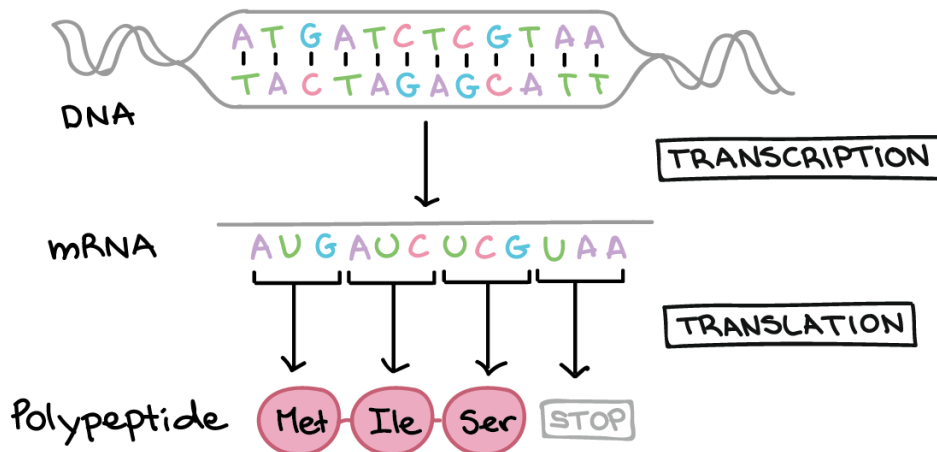
- 1) **DNA** controls the production of **proteins** (**protein synthesis**) in a cell.
- 2) A **section of DNA** that codes for a particular **protein** is called a **gene**.
- 3) Proteins are made up of **chains** of **amino acids**. Each different protein has its own particular **number** and **order** of amino acids.
- 4) This gives each protein a different **shape**, which means each protein can have a different **function**.
- 5) It's the **order** of the **bases** in a **gene** that decides the order of **amino acids** in a **protein**.
- 6) Each gene contains a **different sequence** of **bases** — which is what allows it to code for a **unique protein**.

'Codes for' just means 'contains the instructions for'.

RNA and Protein Synthesis

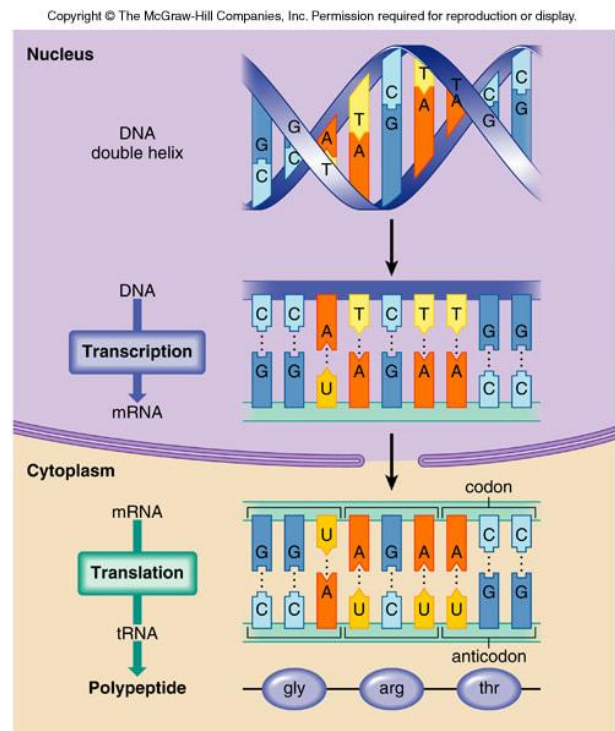
RNA is Needed to Make Proteins

- 1) DNA molecules (and so genes) are found in the **nucleus** of a cell, but they can't move out of the nucleus because they're very **large**.
- 2) Protein synthesis happens in the **cytoplasm** at organelles called **ribosomes**.
- 3) So when a cell **needs** a particular protein, a **copy** of the gene that codes for it is made in the nucleus. This copy is **smaller** than DNA so it can move in to the cytoplasm, where it can be used to make the protein.
- 4) The copy of the gene is made from a molecule called **messenger RNA (mRNA)**.



DNA is Used as a Template to Make an mRNA Molecule

- 1) The DNA in the gene acts as a **template**.
- 2) RNA, like DNA, is made up of **nucleotides**, which each have a **base**.
- 3) The bases on RNA nucleotides line up next to their **complementary** bases on the DNA template.
 - In RNA, there's **no thymine (T)**, so the base **uracil (U)** binds to any **adenine (A)** in the DNA instead.
 - Once the bases on the **RNA** nucleotides have **paired up** with the bases on the **DNA** strand, the RNA nucleotides join together to make an **mRNA molecule**.
- 4) Eventually, a **whole copy** of the gene is made and the **sequence (order)** of **bases** in the mRNA copy is complementary to the sequence of bases in the DNA template.



Mutations

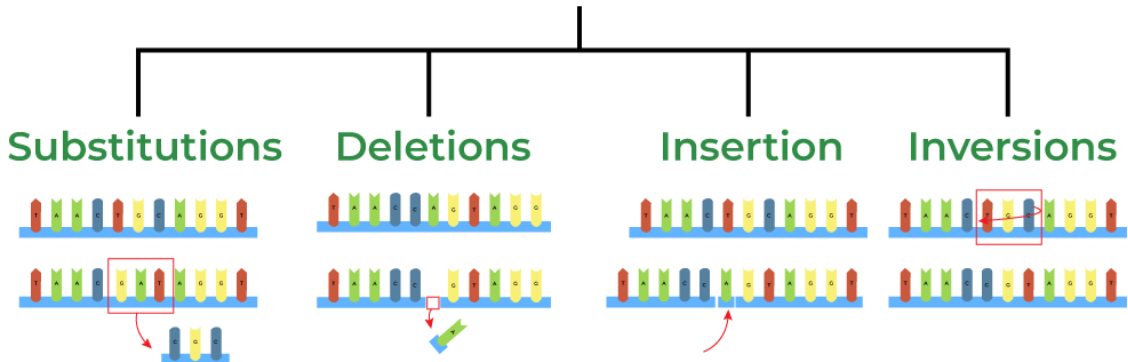
The Order of Bases Determines the Order of Amino Acids

Three bases in a row (a **triplet**, e.g. GCT) codes for **one amino acid** — this is called the **genetic code**. **Different amino acids** are coded for by **different triplets**, e.g. TAT = tyrosine, AGT = serine. The **order of the bases** (and so triplets) in the DNA of a gene determines the order of bases in its mRNA copy, and that determines the **order of amino acids** in a protein:

Mutations Change the Order of Bases in DNA

- 1) **Mutations** are changes to the **base** sequence (order) of DNA.
- 2) For example, one base can be **substituted** (swapped) for another one. This can cause the base triplet to **change**. E.g. if C is substituted for A, GCT becomes GAT.
- 3) So mutations can change the **amino acids** in the protein that the gene codes for.
- 4) A change in the amino acids can cause a **different protein** to be produced. Sometimes the different protein can be **harmful** (see below).

Types of Mutations (At the DNA level)



Mutations happen **spontaneously** (randomly), but how **frequently** they happen can be increased by **mutagenic agents** — factors that increase mutations, e.g. UV radiation in sunlight.

Mutations can be Harmful

- 1) Mutations can cause **cancer** because **cell division** is controlled by **proteins**. If mutations occur in the **genes** for these proteins, they can **alter** the proteins so they **no longer work**. This can lead to **uncontrolled cell division**, and the development of a **tumour** (cancer).
- 2) Mutations also cause **genetic disorders** — mutations that result in **altered** genes and proteins can be **inherited** (passed on from your parents), e.g. cystic fibrosis.

Questions

Chromosomes

- 1.State what a chromatid is.
- 2.Define the term centromere.
- 3.State the number of chromosomes in a human body cell.
- 4.Describe what is meant by homologous chromosomes.
- 5.Outline where DNA is found in a cell.
- 6.Explain why chromosomes become visible during cell division.

DNA

- 1.State the structure of DNA.
- 2.Define the term nucleotide.
- 3.State the four bases found in DNA.
- 4.Describe complementary base pairing.
- 5.Define the term gene.
- 6.Explain how DNA controls protein synthesis.
- 7.Explain how the sequence of bases affects proteins.

RNA and Protein Synthesis

- 1.State the role of mRNA.
- 2.Describe where mRNA is produced.
- 3.Outline how mRNA is formed.
- 4.State one difference between DNA and RNA.
- 5.Describe complementary base pairing in RNA.
- 6.Explain why mRNA is needed for protein synthesis.

Mutations

- 1.Define the term mutation.
- 2.Describe what happens in a substitution mutation.
- 3.State what is meant by a triplet.
- 4.Outline how mutations affect proteins.
- 5.Explain how mutations can cause disease.
- 6.Describe what is meant by a mutagen.

Cell Division — Mitosis

Mitosis is Needed for Growth and Repair

- 1) If you have **damaged** tissue, the cells around the damaged area divide by **mitosis** to replace the damaged cells.
- 2) Cells **also** divide by mitosis to produce new tissue for **growth**.

Asexual Reproduction Involves Mitosis

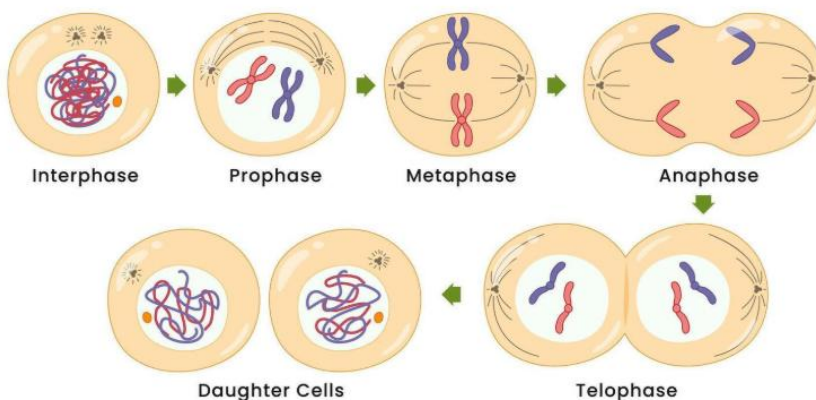
- 1) In **asexual reproduction**, a single organism produces offspring by dividing into two organisms or by splitting off a piece of itself.
- 2) All the offspring are **genetically identical** to each other and to the parent.
- 3) The cells divide by **mitosis** (like most cells).

Bacteria and many plants reproduce asexually.

In Mitosis the DNA Copies Itself, Then the Cell Divides Once

Mitosis is split up into **four** stages: **prophase**, **metaphase**, **anaphase** and **telophase**. **Before** mitosis starts, there's a period called **interphase**.

- 1) **Interphase** — Before the cell starts to divide, every DNA molecule (each chromosome) must **replicate** so that each new cell has a full copy of DNA. The new molecule remains attached to the original one at the **centromere**.
- 2) **Prophase** — Mitosis can now begin. Each DNA molecule becomes **supercoiled** and **compact**. Each chromosome can now be seen with a light microscope and appears as two **chromatids** lying side by side, joined by the centromere (i.e. X-shaped).
- 3) **Metaphase** — The **nuclear membrane** breaks down and the chromosomes **line up** along the **equator** (middle) of the cell.
- 4) **Anaphase** — The centromeres split and the **chromatids separate** and are dragged to opposite ends of the cell.
- 5) **Telophase** — A **nuclear membrane** forms around each set of chromatids (exact copies of the original chromosomes) and the **cytoplasm divides**.



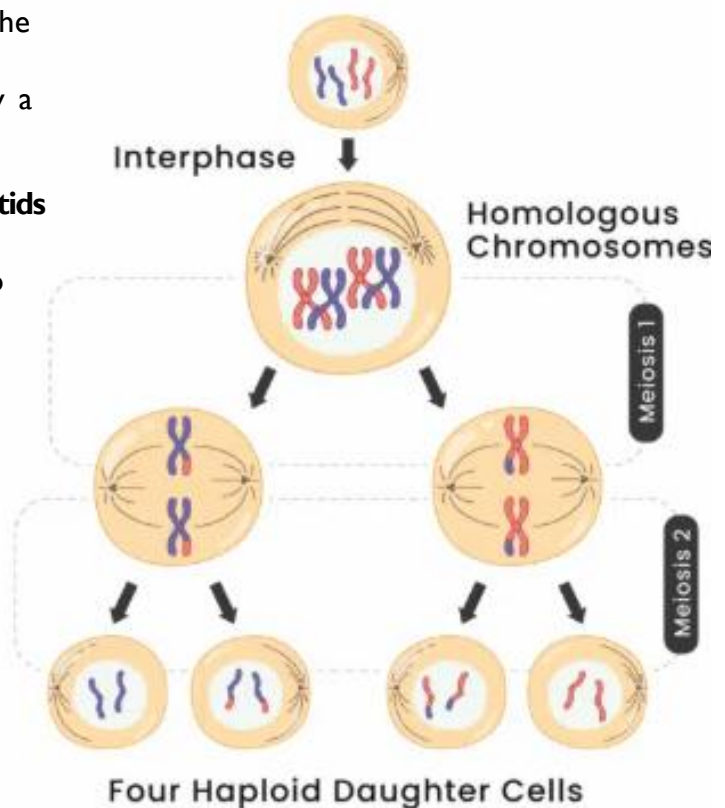
Cell Division — Meiosis

Sexual Reproduction Involves Meiosis

- 1) In **sexual reproduction**, the offspring are genetically different from their parents and from each other. This produces variation in a population.
- 2) Each parent produces sex cells (**gametes**) containing just **one set** of genetic material. This involves a special kind of cell division, called **meiosis**, and the gametes are described as being **haploid**.
- 3) During **fertilisation** the nuclei of the gametes join together to form a **zygote**. The zygote has **two complete sets** of genetic material, and is said to be **diploid**.
- 4) The zygote grows by simple cell division (**mitosis**) to form the **embryo**.

In Meiosis, DNA Copies Itself Then the Cell Divides Twice

- 1) The **only cells** in the human body that divide by meiosis are special cells in the **testes** and **ovaries**.
- 2) These cells divide to produce **gametes** (sperm and eggs).
- 3) The DNA **replicates**, so each of the 46 chromosomes become two chromatids joined by a centromere.
- 4) The 46 chromosomes sort themselves into the **23 homologous pairs**, then the **pairs separate**. One of each pair goes to one side of the cell and one goes to the other.
- 5) The cytoplasm now divides. Each of the new cells **contains 23 chromosomes** (consisting of two chromatids joined by a centromere).
- 6) In both of these new cells the **chromatids separate** and the cytoplasm divides to form two cells.
- 7) At the end of meiosis, **four haploid cells** have been produced from every original diploid cell.



Questions

Mitosis

- 1.State the purpose of mitosis.
- 2.Define asexual reproduction.
- 3.Describe what happens in interphase.
- 4.Outline the stages of mitosis.
- 5.State what happens in anaphase.
- 6.Explain why mitosis produces identical cells.

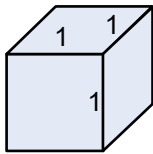
Meiosis

- 1.Define meiosis.
- 2.State what is meant by haploid.
- 3.State what is meant by diploid.
- 4.Describe the role of gametes.
- 5.Outline what happens during meiosis.
- 6.Explain why meiosis produces variation.

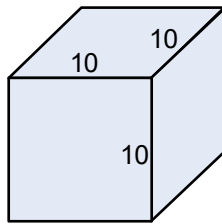
Size and Surface Area to Volume Ratio

Small Objects have Relatively Large Surface Areas

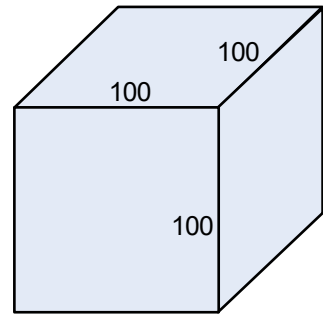
- 1) Have you ever wondered **why** there are no large single-celled organisms or why big animals are made up of **millions** of tiny cells instead of a few large ones?
- 2) The main reason relates to the changes in the **surface area to volume ratio** of an object as it increases in size.
- 3) Look at the three cubes in the diagram below. The **smallest cube** has the **biggest** surface area to volume ratio and the **biggest cube** has the **smallest** surface area to volume ratio.



Surface area = 6 cm^2
Volume = 1 cm^3
Surface area : Volume
6 : 1



Surface area = 600 cm^2
Volume = 1000 cm^3
Surface area : Volume
0.6 : 1



Surface area = $60,000 \text{ cm}^2$
Volume = $1,000,000 \text{ cm}^3$
Surface area : Volume
0.06 : 1

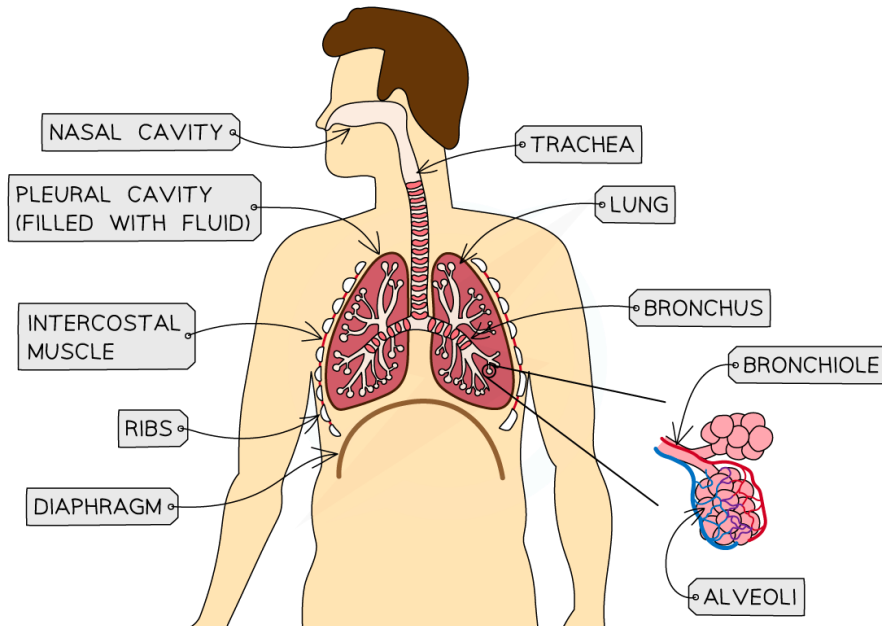
Surface Area is Important for Exchange

- 1) Cells or organisms need to **exchange materials** and **heat** with their environment.
- 2) **More** chemical reactions happen every second in organisms with a **larger volume** than in ones with smaller volumes.
- 3) Therefore **more** oxygen, nutrients, waste products and heat need to be exchanged across the membrane of cells of larger organisms.
- 4) With increasing volume this becomes an **ever-increasing problem**.

Structure of the Thorax

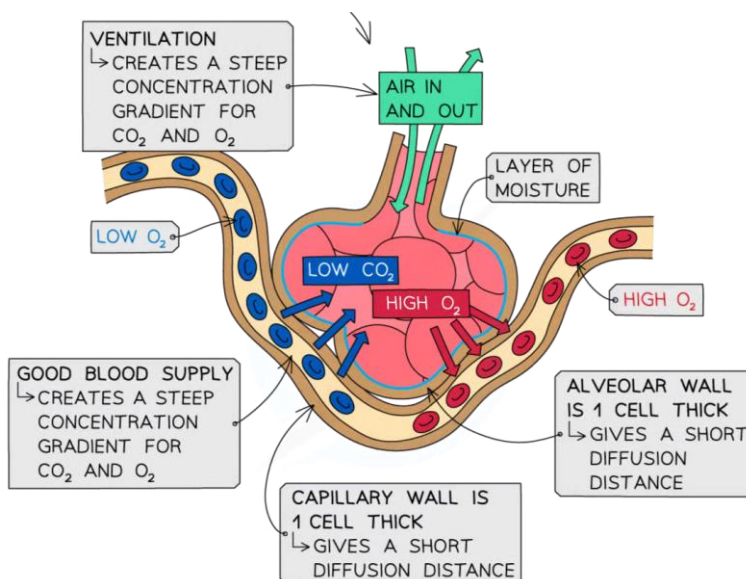
Lungs have a Very Large Gas Exchange Surface

Large, active animals, like mammals, have evolved complex **blood systems** and **lungs** to provide a **large surface area** for the efficient diffusion of oxygen and carbon dioxide.



Alveoli have Adaptations that Increase the Diffusion Rate

- 1) The walls of the alveoli consist of a **single layer** of thin, flattened, epithelial cells. Diffusion happens **faster** when molecules only have to travel **short** distances.
- 2) Diffusion is faster when there's a **bigger difference** in concentrations between two regions. The blood flowing through the rich network of capillaries around the alveoli **carries away** the oxygen that has diffused through the alveolar walls. This ensures that there's always a **higher concentration of oxygen** inside the alveoli than in the blood. The reverse is true for **carbon dioxide**.
- 3) The alveolar walls are **fully permeable** to dissolved gases. Oxygen and carbon dioxide can pass easily through the cell membranes of the epithelial cells.



Breathing In and Breathing Out

Why do We Need to Breathe?

Ventilation (breathing) ensures that air with a **high concentration of oxygen** is taken into the lungs, and air with a **high concentration of carbon dioxide** is removed from the lungs. This maintains high **concentration gradients** between air (inside your alveoli) and blood, **increasing** the rate of diffusion of oxygen and carbon dioxide.

If Volume Increases, Air Pressure Decreases

If the **volume** of an enclosed space is **increased**, the **pressure** inside it will **decrease**.

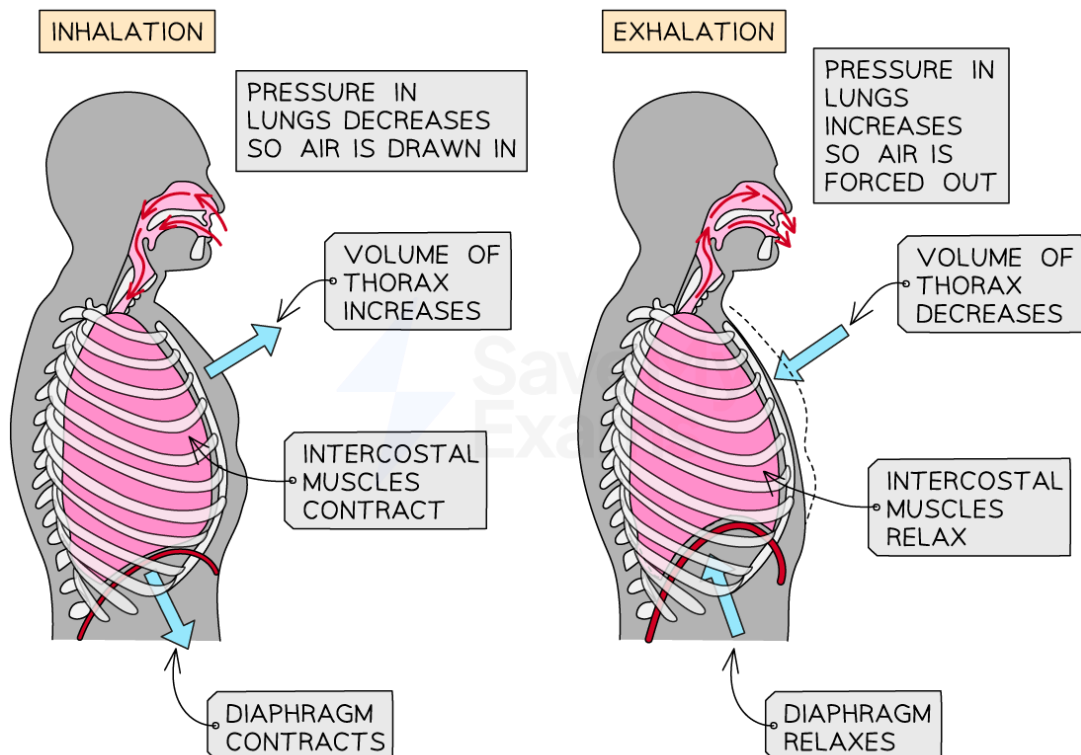
- 1) The lungs are suspended in the **airtight thorax**.
- 2) Increasing the volume of the thorax decreases the air pressure in the lungs to below atmospheric pressure. Air flows **into** the lungs, inflating them until the pressure in the alveoli equals that of the atmosphere.
- 3) Decreasing the volume of the thorax increases the pressure in the lungs and air **flows out** until the pressure in the alveoli drops to atmospheric pressure.

Breathing In...

- 1) **Intercostal muscles** and **diaphragm** (a muscular sheet) **contract**.
- 2) Thorax volume **increases**.
- 3) This decreases the pressure, so air **flows in**.

...and Breathing Out

- 1) **Intercostal muscles** and **diaphragm** **relax**.
- 2) Thorax volume **decreases**.
- 3) This increases the pressure, so air **flows out**.



Questions

Surface Area to Volume

1. Define surface area to volume ratio.
2. Describe how SA:V changes with size.
3. State why large organisms need exchange systems.
4. Outline why small organisms are more efficient at diffusion.
5. Explain why cells are small.

Gas Exchange (Thorax & Alveoli)

1. State the function of alveoli.
2. Describe the structure of alveoli.
3. Outline how diffusion occurs in the lungs.
4. State two adaptations of alveoli.
5. Explain how blood supply affects diffusion rate.

Breathing

1. Define ventilation.
2. Describe what happens during inhalation.
3. Describe what happens during exhalation.
4. State the relationship between pressure and volume.
5. Explain how breathing maintains concentration gradients.

Disease

Disease can be Caused by Many Things

- 1) **Pathogens** — these are organisms that can cause disease, e.g. bacteria and viruses. **Infectious diseases** are caused by pathogens and can be passed from person to person, e.g. TB, malaria and HIV.
- 2) **Genetic defects** — some diseases are caused by **mutations** in a person's genes, e.g. cystic fibrosis is caused by a mutation in a gene for a protein.
- 3) **Lifestyle** — certain lifestyles **increase the risk** of getting some diseases, e.g. smokers are more likely to get lung cancer.

Risk Factors for Disease

- 1) A risk factor is something that **increases the chances** of something bad happening. For example, smoking is a risk factor for heart disease — if you smoke you're **more likely** to get heart disease.
- 2) Risk factors **don't always** lead to disease though. For example, using sunbeds is a risk factor for skin cancer — if you use sunbeds you increase your risk of skin cancer, but you won't necessarily get the disease.
- 3) Some risk factors are **unavoidable** because they're **inherited**, e.g. certain versions of genes increase your risk of getting breast cancer.
- 4) Some risk factors are **avoidable** because they're associated with your **lifestyle**. For example, a diet high in salt is a risk factor for high blood pressure — if you change your lifestyle to reduce your salt intake you reduce the risk.

Risk factor	Diseases
Smoking	Mouth, lung and throat cancer; emphysema and other lung diseases; cardiovascular disease
Drinking too much alcohol	Mouth, stomach, liver and breast cancer; possibly many other cancers; cardiovascular disease
High blood pressure	Cardiovascular disease; diabetes
Overweight/obese	Various cancers; cardiovascular disease; diabetes
Unbalanced diet	Various cancers; cardiovascular disease; diabetes
Using sun beds too much	Skin cancer

Immunity

Phagocytes Engulf Pathogens

- 1) If a pathogen gets into the body it's detected by a type of white blood cell called a **phagocyte**
- 2) It's actually the **molecules** on the **surface** of the pathogen that the phagocytes detect. These molecules are called **antigens**.
- 3) Human cells have antigens on their surface too, but phagocytes can tell the difference between '**self**' (your own) and '**foreign**' antigens.
- 4) Phagocytes **engulf** pathogens that are carrying foreign antigens and destroy them.

White Blood Cells Produce Antibodies

- 1) Some white blood cells produce **antibodies** that **bind to** antigens.
- 2) The ones that produce antibodies are called **B-cells** (they're sometimes called B-lymphocytes — pronounced: lim-fo-sites).
- 3) When the antibody binds to the antigen it brings about the **death** of the pathogen carrying it.

Another Type of White Blood Cell is Involved

- 1) **T-cells** (or T-lymphocytes) are a type of white blood cell that are involved in **communication** between phagocytes and B-cells.
- 2) When a phagocyte has engulfed a pathogen it signals to the T-cell that it's found something. The T-cell then **activates** the B-cells to produce antibodies.

Vaccination Gives You Immunity

- 1) If you're **vaccinated** against a pathogen you can't get that disease (you're **immune**).
- 2) Vaccines **contain antigens** from a pathogen in a form that can't harm you, e.g. attached to dead bacteria.
- 3) Your body produces **antibodies** against the antigens so, if the same pathogen (carrying the same antigens) tries to invade again, the immune system can respond **really quickly** and you won't suffer from any **symptoms**.
- 4) Vaccines don't stop the pathogen getting **into** the body, they just **get rid of it** really quickly when it does.

Questions

Disease

1. Define the term pathogen.
2. State two types of disease.
3. Describe what is meant by a risk factor.
4. Outline the difference between genetic and lifestyle factors.
5. State one disease linked to smoking.
6. Explain why risk factors do not always lead to disease.

Immunity

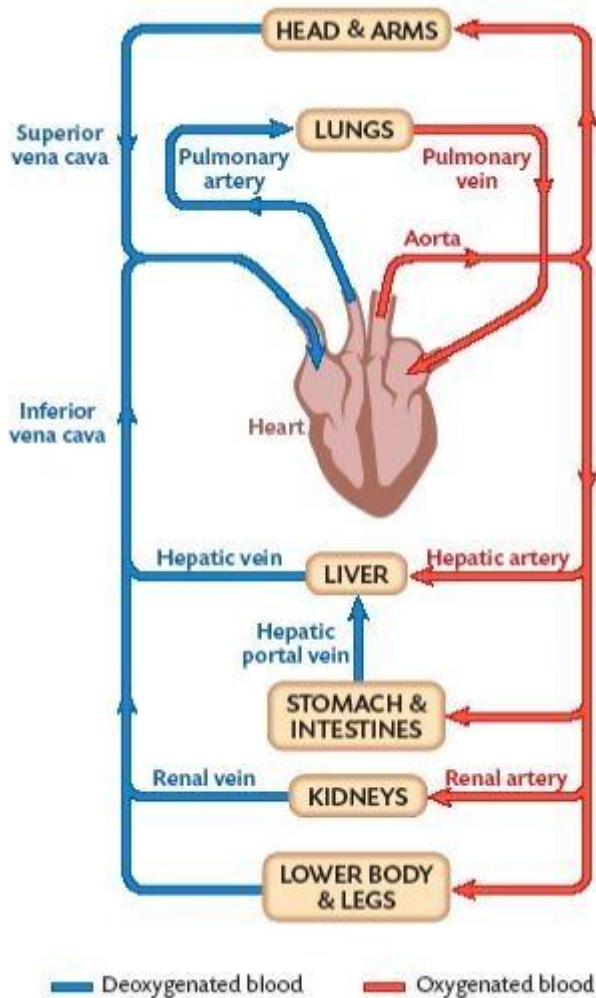
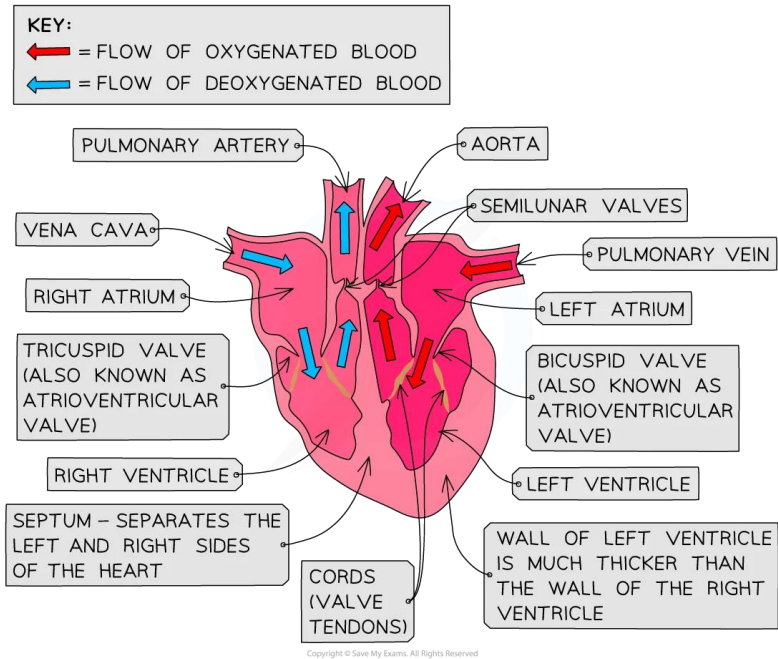
1. State the role of phagocytes.
2. Define the term antigen.
3. Describe the role of B-cells.
4. Outline the function of T-cells.
5. Explain how vaccination works.
6. Explain how antibodies help destroy pathogens.

The Circulatory System

Large Animals Need a Circulatory System

- 1) Diffusion is only efficient over **short distances**, so any animal bigger than a simple worm needs a system that will bring glucose and oxygen into close contact with individual cells.
- 2) In humans, the **heart** pumps blood around the body through **blood vessels**.

The heart has **four chambers** — two **atria** and two **ventricles**.



- 3) The blood vessels carry blood around the **entire body** and go to **every organ** before returning the blood to the heart.
- 4) There are **three** main types of blood vessel:
 - **Arteries** carry blood **away** from the heart.
 - **Veins** carry blood **to** the heart.
 - **Capillaries** are where the exchange between the blood and the cells takes place.
- 5) As the blood flows through the **tissues**, dissolved substances such as glucose, oxygen and carbon dioxide are **exchanged** between the blood and the cells.

The main artery in the human body is the **aorta**. It carries oxygenated blood **from the heart** to the rest of the body.

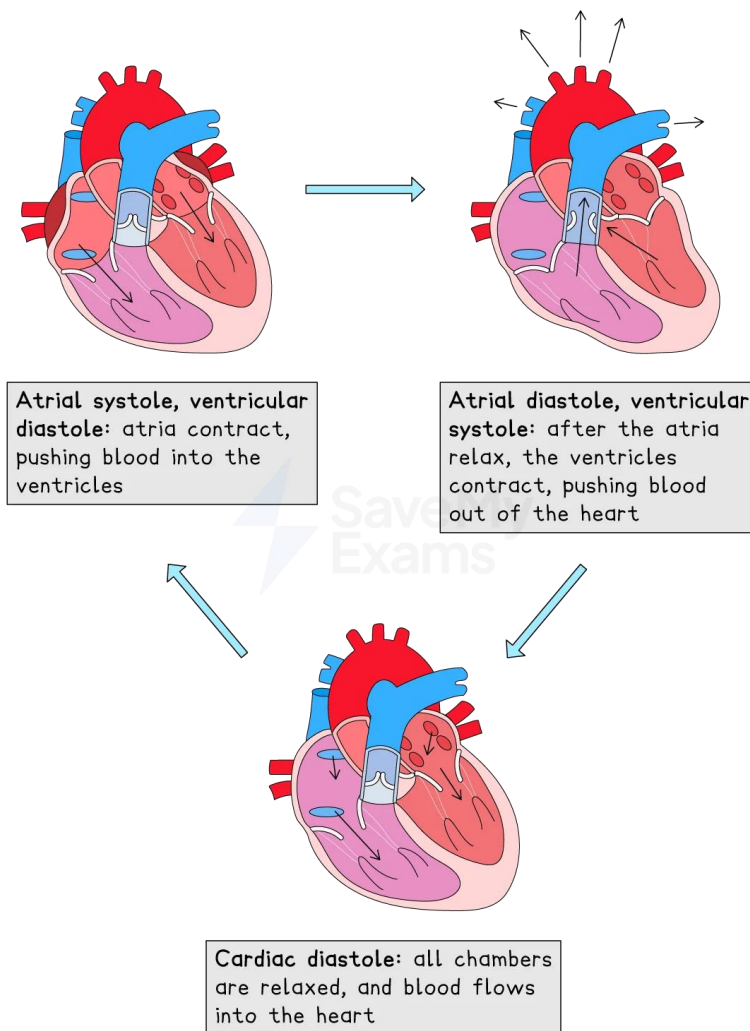
The Heart

Important Facts to Remember

- 1) The heart acts like two separate **pumps**. The **right side** sends blood to the **lungs** and the **left side** pumps blood around the rest of the **body**.
- 2) Blood always flows from a region of **higher pressure** to a region of **lower pressure**.
- 3) **Valves** in the heart prevent the blood from flowing backwards.
- 4) **No energy** is required to make the valves work — it's the **blood pressing** on the valves that makes them **open and close**.

The Cardiac Cycle

The **cardiac cycle** is the sequence of events that occurs during **one heartbeat**.



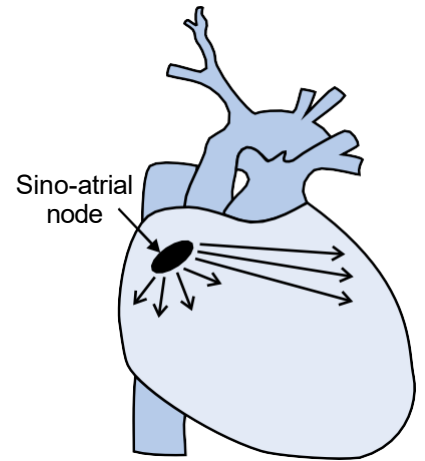
The **ventricles** are much more **powerful** than the atria and, when they contract, the **heart valve** pop shut automatically to prevent **backflow** into the atria. The ventricle walls are **thicker** because they need to push the blood further (e.g. the **left ventricle** has to push blood all the way round the body).

As soon as the ventricles relax, the valves at the top of the heart **pop shut** to prevent backflow of blood (back into the ventricles) as the blood in the arteries is now under a **fair bit of pressure**.

The Heart

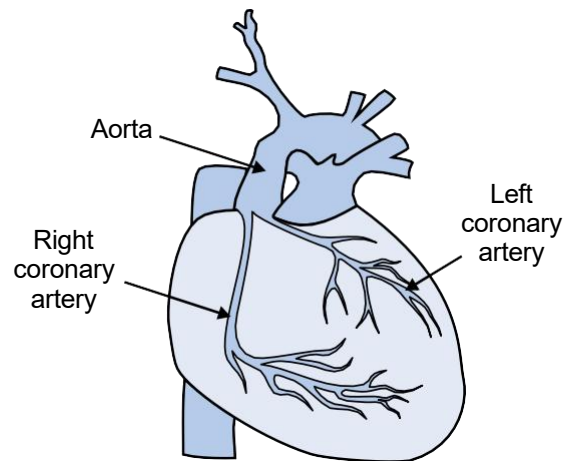
The Heart has its Own Pacemaker

- 1) **Most muscles** require **nerve impulses** from the central nervous system to make them **contract**.
- 2) The heart **produces** its own **electrical impulses**.
- 3) A group of specialised cells called the **sino-atrial node**, in the wall of the right atrium, sends out **regular impulses**.
- 4) These spread across the atria, making them **contract**.



Arteries Supply The Heart Muscle with Blood

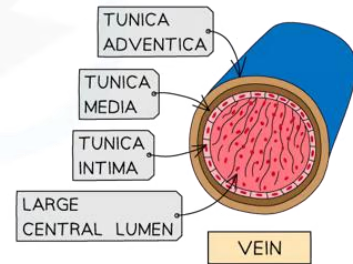
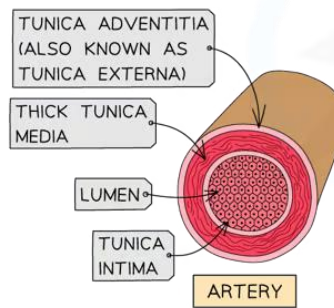
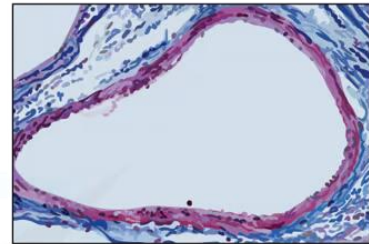
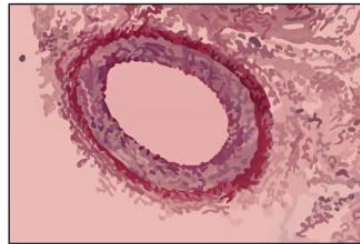
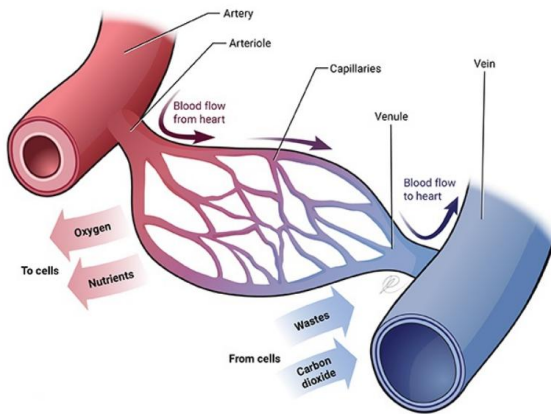
- 1) Heart muscle, like all tissue, needs **oxygen** and **glucose** so it can respire and release the energy it needs to function.
- 2) It gets these things from the **blood**.
- 3) The heart muscle is supplied with blood by the **coronary arteries** (the word coronary is used to refer to the heart).
- 4) The two main coronary arteries come off the **aorta**.
- 5) The coronary arteries are quite **thin** (especially compared to the aorta).



Blood Vessels

Arteries, Arterioles, Capillaries and Veins

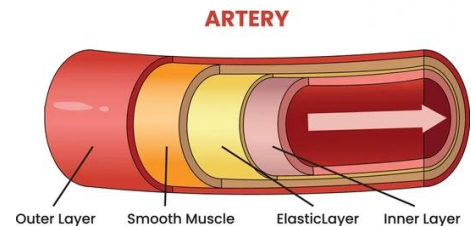
- 1) **Arteries** carry blood away from the heart.
- 2) They subdivide into smaller vessels called **arterioles**.
- 3) Arterioles subdivide into microscopic vessels called **capillaries**.
- 4) Capillaries join up to form **veins**.
- 5) Veins **return** blood to the **heart**.



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Arteries

- 1) Arteries have a **thick wall** compared to the diameter of the lumen. There's an outer layer of **fibrous tissue**, then a thick layer of **elastic tissue** and **smooth muscle**, then a very thin inner layer of folded **endothelial tissue**.
- 2) When the ventricles contract, blood enters the arteries at **high pressure**. This **stretches** the folded endothelium and elastic walls. When the ventricles relax, it's the elastic recoil of the artery wall (when the wall shrinks back to its original size) that keeps the blood pressure up. Important organs, like the kidneys, wouldn't be able to function if the blood pressure dropped too far between heartbeats.



Arterioles

- 1) Arterioles are **narrower** than arteries and they have a higher proportion of **smooth muscle fibres** and a lower proportion of **elastic tissue**.
- 2) When the circular muscle fibres of an arteriole contract, the diameter of the lumen is reduced, so **less blood flows** through that vessel. This means that arterioles can **control** the amount of blood flowing to a particular organ.

Blood Vessels

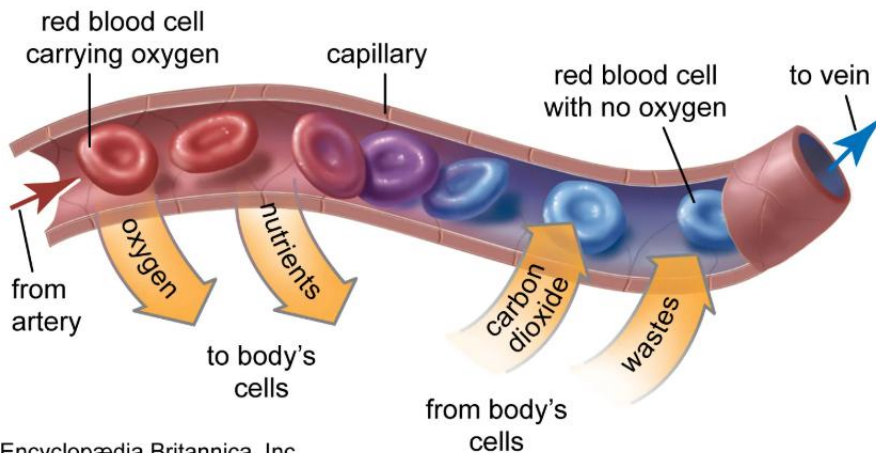
Capillaries can Only be Seen With a Microscope

Capillary walls consist of a single layer of **endothelial cells** (cells that line the blood vessels). Some capillaries have **tiny gaps** between the endothelial cells.



Capillaries are Well Suited to Their Job

- 1) The **very thin walls** and the **gaps** between the cells allow water and substances like glucose and oxygen to **diffuse quickly** from the blood into the cells. Waste products, such as carbon dioxide and urea, diffuse from the cells into the blood.
- 2) Organs contain thousands of capillaries, so altogether there's a **huge surface area** for the exchange of substances.
- 3) Blood flows quite **slowly** through capillaries. This allows **more time** for diffusion to occur.

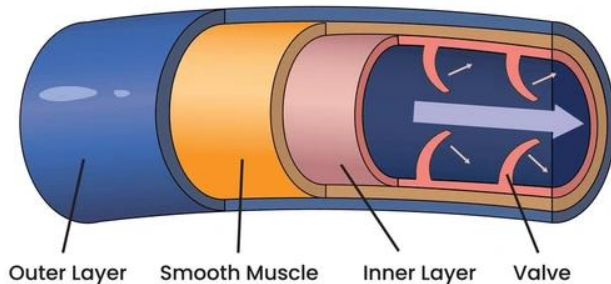


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VEIN

Veins Have Valves

- 1) A vein has a **large lumen** and a relatively thin wall containing some elastic tissue and smooth muscle. Veins also have **valves** that prevent the blood flowing backwards.
- 2) When the **leg muscles** contract they bulge and press on the walls of the veins, pushing the blood up the veins. When the muscles relax, the valves close. This action helps the blood **return** to the heart.

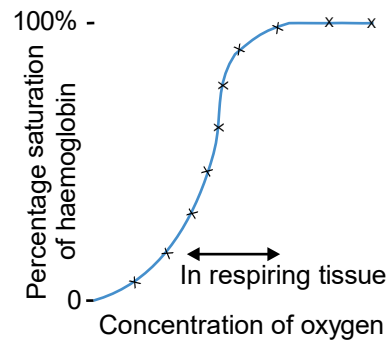


Blood

Haemoglobin has Special Properties

- 1) The blood's main function is to **transport** materials to and from cells.
- 2) So the blood can do this, red blood cells are packed with **haemoglobin**, a protein that contains iron and can **carry oxygen**.
- 3) When oxygen combines with haemoglobin it forms **oxyhaemoglobin**.
- 4) When there's a lot of oxygen present, one molecule of haemoglobin can combine with **four** molecules of oxygen — the haemoglobin is **100% saturated**.
- 5) When less oxygen is present, fewer molecules of oxygen combine and the haemoglobin is **less than 100% saturated**.

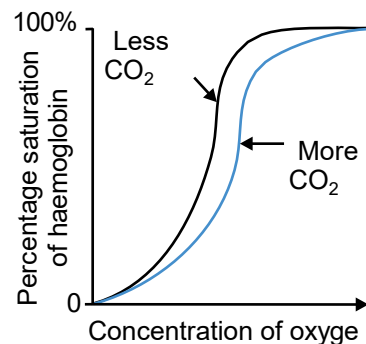
It would be reasonable to expect that a graph of '% saturation of haemoglobin' against 'concentration of oxygen' would be a straight line (i.e. that the two would be proportional). However, when experiments are carried out and the results plotted, the line of best fit is **S-shaped**.



- 6) Haemoglobin has special properties that allow it to become fully saturated with oxygen in the capillaries around the **alveoli** of the lungs, where there's a **high concentration of oxygen**
- 7) Then when it reaches respiring tissue, where there's **less oxygen**, it can give up almost all of its oxygen immediately — so the rate of respiration in the tissues isn't slowed down because of an oxygen shortage.

Carbon Dioxide Changes the Properties of Haemoglobin

- 1) Respiring tissues produce **carbon dioxide**.
- 2) If there's not a lot of carbon dioxide present, the haemoglobin is **less efficient at taking up** oxygen (i.e. it needs to be exposed to more oxygen before it becomes fully saturated).
- 3) But, when there's a lot of carbon dioxide present, the haemoglobin becomes **more efficient at releasing** oxygen (i.e. it can release more oxygen molecules in areas of fairly high oxygen demand).
- 4) This is good because it means that **rapidly respiring tissues**, e.g. contracting leg muscles and brain cells, get **more oxygen**.
- 5) This effect of carbon dioxide concentration on the oxygen-binding properties of haemoglobin is known as the **Bohr effect**.



Questions

Circulatory System

- 1.State the function of the circulatory system.
- 2.Name the three types of blood vessel.
- 3.Describe the role of arteries.
- 4.Describe the role of veins.
- 5.Outline the function of capillaries.
- 6.Explain why large organisms need a circulatory system.

Heart

- 1.State the function of the heart.
- 2.Describe the role of valves.
- 3.Outline the cardiac cycle.
- 4.State why ventricles have thick walls.
- 5.Explain how pressure differences move blood.

Pacemaker & Coronary Arteries

- 1.State the role of the sinoatrial node.
- 2.Describe how the heart controls its own rhythm.
- 3.State the function of coronary arteries.
- 4.Explain why heart muscle needs oxygen.

Blood Vessels

- 1.Describe the structure of arteries.
- 2.Describe the structure of veins.
- 3.State the function of arterioles.
- 4.Explain how arterioles control blood flow.
- 5.Compare arteries and veins.

Capillaries

- 1.State the function of capillaries.
- 2.Describe the structure of capillaries.
- 3.Explain how capillaries are adapted for exchange.
- 4.Explain why blood flows slowly in capillaries.

Blood

- 1.State the function of haemoglobin.
- 2.Define oxyhaemoglobin.
- 3.Describe what is meant by saturation.
- 4.Outline the Bohr effect.
- 5.Explain how haemoglobin releases oxygen.

Xylem and Phloem

Xylem Tissue Transports Water and Minerals from Roots

Water from the soil **enters** the roots by **osmosis**. Then it travels through the root to the **xylem** — this is the tissue that **transports water** through the plant and up to the leaves.

Water can travel through the roots in **two** ways:

The **symplast** system:

- Some water moves through the root via the **cytoplasm** of the root cells. The water has to cross the **cell membrane**, which regulates the passage of the water and dissolved minerals.

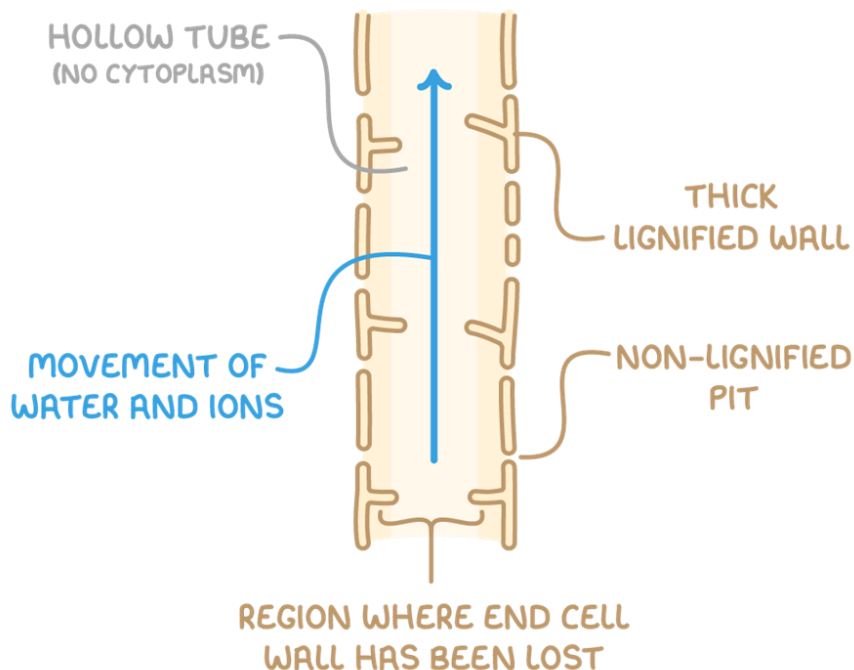
The **apoplast** system:

- The water moves through the **cell walls** and the **spaces between the cells**.
- There are **no membranes** to regulate the passage.

Water Travels Up the Plant Through the Xylem Tissue

The cells that make up the tubes (vessels) of **xylem tissue** are dead, waterproof and hollow. This means water can **move** through them easily. Water is **pulled up** through the xylem tissue by a combination of factors: **cohesion**, **tension** and **adhesion**:

- 1) Water **evaporates** from inside the leaf leaving a higher concentration of solutes.
- 2) Water from the nearest xylem vessel enters by **osmosis**.
- 3) Water molecules stick together because of weak hydrogen bonds between them — this is called **cohesion**.
- 4) As water molecules leave the xylem vessel they **pull up** further molecules, so the whole column of water is pulled up.
- 5) Evaporation pulls the water column upwards and gravity pulls it down, so the water column is under **tension**.
- 6) The **adhesion** of water molecules to the sides of the xylem vessels stops the column breaking.

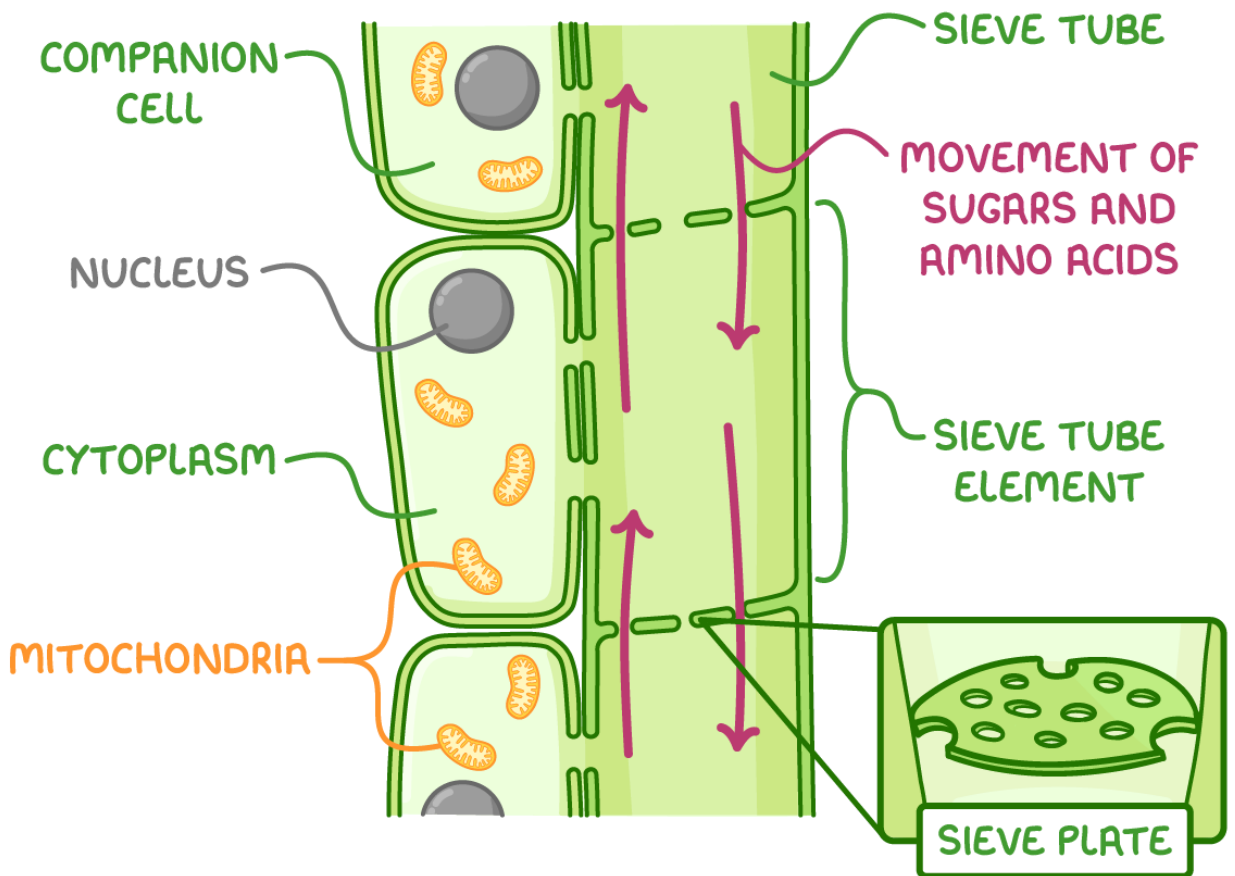


Xylem and Phloem

Phloem Transports Organic Compounds

Sugars and other organic compounds are **transported** through plants in **phloem tissue**. Phloem tissue is also arranged in **tubes** so the solutions of sugar, etc. can **move** through them easily.

- 1) The movement of carbohydrates and other organic compounds in plants is known as **translocation**.
- 2) It occurs in the **sieve tubes** of the **phloem tissue**.
- 3) **Companion cells** next to the sieve tubes are believed to **actively transport** sugar into the sieve tubes, and then water follows by **osmosis**.



Questions

Xylem

- 1.State the function of xylem.
- 2.Describe the structure of xylem vessels.
- 3.Define cohesion.
- 4.Define adhesion.
- 5.Explain how water moves up the plant.

Phloem

- 1.State the function of phloem.
- 2.Define translocation.
- 3.Describe the role of companion cells.
- 4.Explain how sugars move in plants.

Variation and Evolution

We all Vary

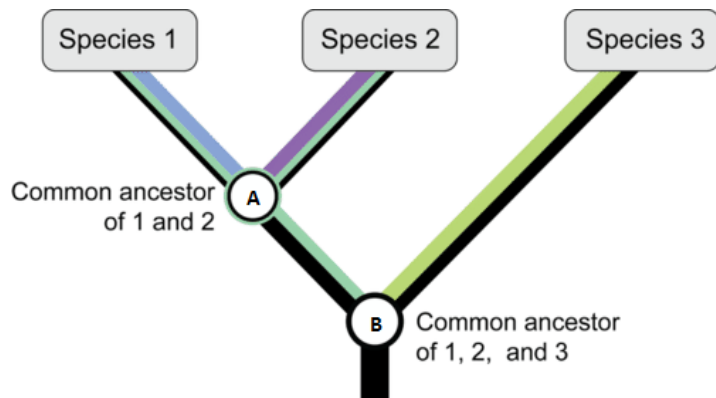
- 1) All organisms are **different** from each other, e.g. giraffes are loads different from zebras, which are different from lions and tigers and bears...
- 2) Organisms of the **same species** also show **some variation**, e.g. humans show variation in height, weight, favourite colour of shoe polish...
- 3) Organisms of the **same species** are similar because they all have the **same genes** but they vary because they have **different versions** of those genes (called **alleles**). E.g. humans all have a gene for blood type, but they can have A, B or O alleles.

Variation Means Some Organisms are Better Adapted

- 1) An adaptation is a **characteristic** that helps an organism to **survive** and **have children**, e.g. polar bears have **thick, white fur** to stay warm and camouflaged in the snow.
- 2) **Characteristics vary** in a population so some organisms are **better adapted** for certain conditions than others, e.g. polar bears with thicker fur are better adapted to survive in a cold environment than polar bears with thinner fur. The slightly different adaptations you get **within species** (e.g. slightly thicker fur on one polar bear compared to another) are coded for by **different alleles**.

Evolution

Evolution is the **gradual change** in the **characteristics** of a population from one generation to the next. The theory of evolution is that all organisms evolved from a **common ancestor** (organism) over **millions of years**.



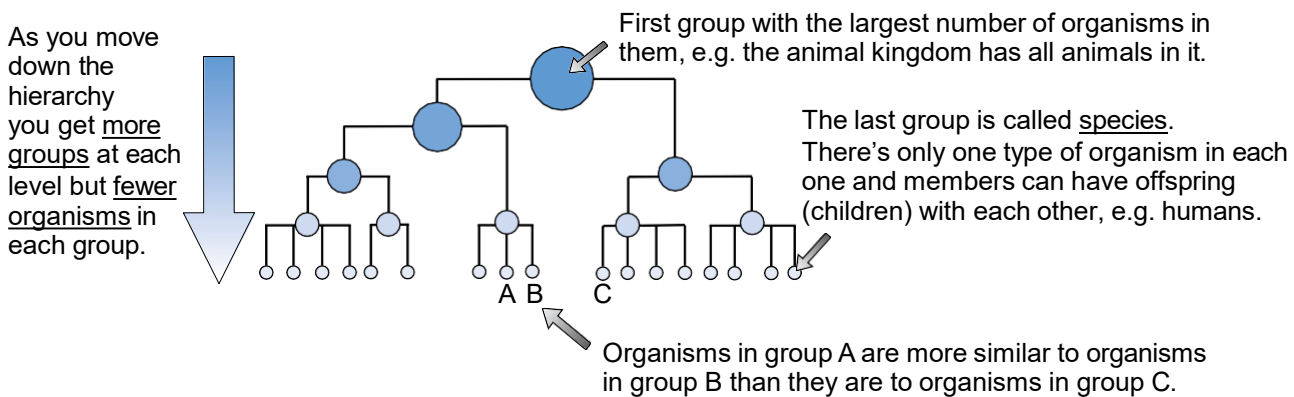
Natural Selection

- 1) Organisms from the **same population** all **vary** (e.g. different length of fur).
- 2) Organisms **compete** with each other for food, shelter, water, etc.
- 3) Those with **better adaptations** (caused by different **alleles**) are more likely to find food, shelter, water, etc., **survive** and have little **kiddies**. So they **pass on** the alleles for their better adaptations. E.g. bears with longer fur will stay warmer and be more likely to survive, and so have kids with longer fur.
- 4) Over time, the **number** of organisms with the better adaptations (alleles) **increases**.
- 5) The **whole population** of organisms **evolves** to have the better adaptations (alleles).

Classification

Classification Systems

- 1) Classification is just **sorting** organisms into different **groups** and **naming them**.
- 2) It makes it **easier** for scientists to **study** organisms without getting **confused**, because every type of organism has a different name, e.g. *Homo sapien* (humans) or *Ursus maritimus* (polar bears).
- 3) Organisms are arranged into different groups depending on their **similarities** and **differences**, e.g. all animals are grouped together, and all plants are grouped together in a separate group because they're different to animals.
- 4) Organisms are placed in groups in **classification hierarchies** (pronounced: hire-arc-ees) — the biggest groups (e.g. animals, plants) are **split** into **smaller groups** (e.g. animals with a backbone in one group and animals without a backbone in another). These groups are **split again** into more smaller groups, and so on.



A **species** is a group of organisms that **look similar** and can reproduce to give **fertile offspring** (their children can also reproduce).

Classification Systems are Based on Lots of Things

- 1) **Older** classification systems grouped organisms based only on how they look, e.g. four limbs, six eyes, bum chin...
- 2) **Newer systems** use looks and lots of other things:
 - **DNA** — how similar and different the base sequence is (e.g. ATTTAC vs. ATTTAT).
 - **Other molecules** — e.g. proteins and enzymes.
 - **Early development** — how they grow from an embryo to a baby.

Questions

Variation and Evolution

1. Define variation.
2. Describe what is meant by an allele.
3. Define adaptation.
4. Outline natural selection.
5. Explain how evolution occurs over time.

Classification

1. Define classification.
2. Describe modern classification systems.
3. State what a species is.
4. Outline what is meant by a hierarchy.
5. Explain why classification is important.

Case study

Case Study: Cystic Fibrosis

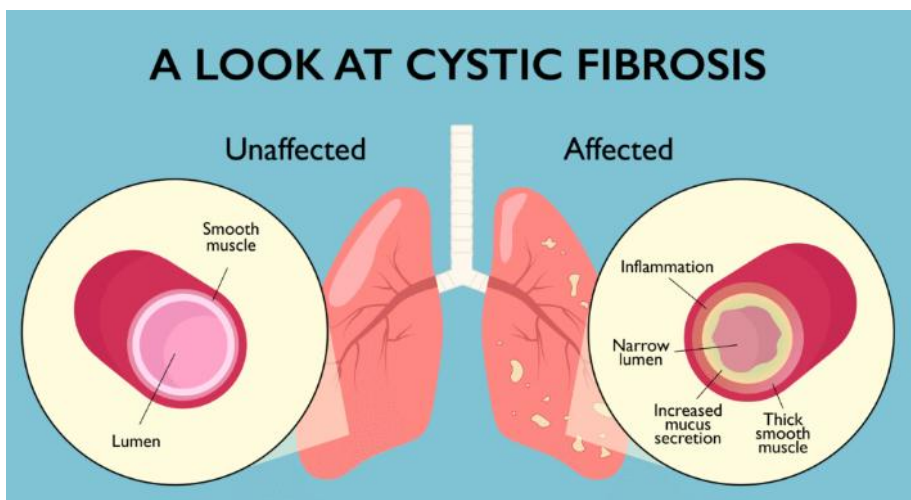
Scenario

Cystic fibrosis (CF) is a genetic disorder caused by a mutation in a gene that codes for a protein involved in the transport of chloride ions across cell membranes.

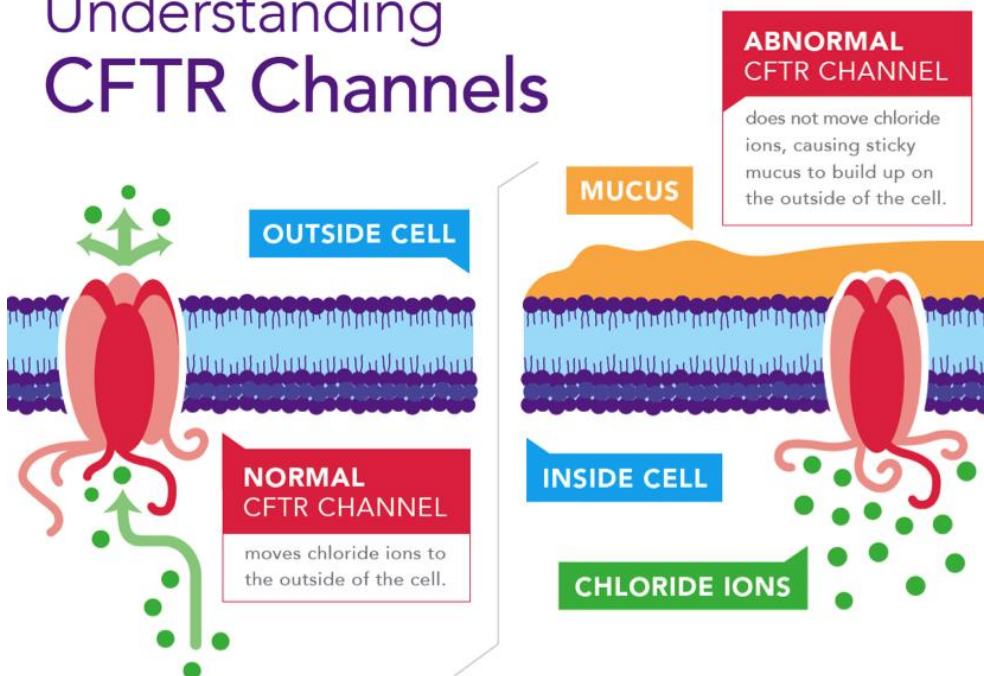
In healthy cells, this protein allows chloride ions to move out of cells. This helps water to follow by osmosis, keeping mucus **thin and runny**.

In people with cystic fibrosis:

- The protein is **faulty** and does not function correctly
- Chloride ion transport is reduced
- Less water moves out of cells by osmosis
- Mucus becomes **thick and sticky**
- This thick mucus:
 - Blocks airways in the lungs
 - Makes gas exchange less efficient
 - Traps bacteria, leading to frequent infections



Understanding CFTR Channels



Case study

Questions

Core Knowledge (AO1)

1. Define the term mutation.
2. State what is meant by a gene.
3. State the function of proteins in the cell membrane.
4. Describe the structure of the cell membrane.

Application (AO2)

1. Explain how a mutation can affect the structure of a protein.
2. Explain how a change in protein structure can affect its function.
3. Describe how chloride ions normally move across cell membranes.
4. Explain the role of osmosis in mucus production.

Linking Ideas (AO2 → AO3)

1. Explain why mucus becomes thick and sticky in individuals with cystic fibrosis.
2. Analyse how thick mucus affects gas exchange in the lungs.
3. Explain why individuals with cystic fibrosis are more likely to develop infections.

Higher Level Thinking (AO3)

1. Evaluate how a single gene mutation can have wide-ranging effects on the body.
2. Explain how cystic fibrosis demonstrates the relationship between DNA, proteins and phenotype.
3. Suggest why cystic fibrosis is considered both a genetic and physiological disease.

Extension – Data Interpretation

A scientist measures the rate of gas exchange in healthy individuals and in individuals with cystic fibrosis.

1. Calculate the percentage decrease in gas exchange in individuals with cystic fibrosis.
2. Suggest one reason for this difference using your biological knowledge.

Group	Rate of Gas Exchange (arbitrary units)
Healthy individuals	100
Individuals with CF	65