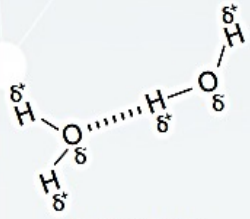
RST

Knowledge Organiser: BIOLOGICAL MOLECULES

Water - a polar molecule which allows hydrogen bonds between molecules giving water important properties.

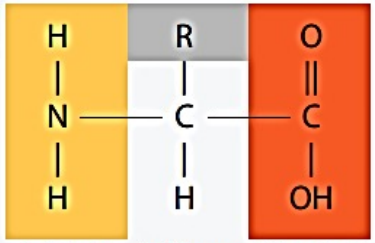
Property	Function
Solvent	Polar molecules dissolve in water and are able to be transported.
Metabolite	Water is a reactant in photosynthesis and hydrolysis, produced in aerobic respiration and condensation.
High specific heat capacity	A lot of energy is required to change the temperature of water so aquatic/cellular environments remain stable.
High latent heat of vaporisation	Evaporative cooling.
Surface tension	Support and buoyancy.



Hydrogen bonds

Proteins

Proteins are constructed from 20 types of amino acid. The general form of an amino acid is shown here. The R group is different in each of the 20. Two amino acids linked form a dipeptide. A polymer is called a polypeptide.



Amino(basic) group | Variable group | Carboxyl (acid) group

Primary Structure

The sequence of amino acids as coded by the DNA. Amino acids are linked together by condensation reactions that form peptide bonds.

Secondary Structure

Hydrogen bonds formed between the amino acids in the chain cause it to fold into an alpha helix or beta pleated sheet.

Tertiary Structure

Hydrophobic interactions between the variable groups within the secondary structure forms and disulphide and ionic bonds forms a very specific folded structure e.g. the active site of an enzyme.

Quaternary Structure

More than one polypeptide chain linked to form a molecule.

Fibrous proteins	e.g keratin- structural function
Globular proteins	e.g enzymes- metabolic function

Test for proteins

Biuret solution -blue

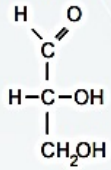
Positive reaction – A purple/violet colour is seen.

Carbohydrates

Monosaccharides

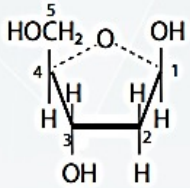
Triose

3C important in respiration and photosynthesis.



Pentose

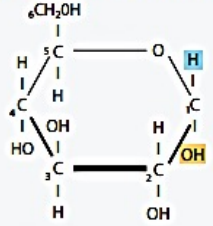
5C Important in nucleotides.



Hexose

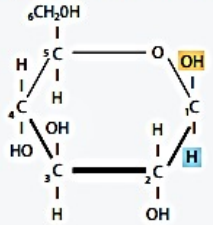
6C Glucose is a really important hexose sugar. It is used in respiration.

Monosaccharides are linked to make dimers and polymers. There are two isomers of glucose.



α glucose

or



β glucose

alpha–glucose OH group points down on carbon 1 but on beta–glucose it points up.

Disaccharides	
Sucrose	Glucose and fructose linked in a condensation reaction where one molecule of water is lost and a glycosidic bond is formed.
Maltose	As above but the monosaccharides linked are α–glucose and α– glucose.
Lactose	A dimer formed from glucose and galactose.

Polysaccharides	
Starch	A polymer of α–glucose (composed of straight-chain amylose and branched amylopectin) Compact energy storage in plants with little osmotic effect.
Glycogen	A polymer of α–glucose, energy storage in animals.
Cellulose	A polymer of β–glucose, adjacent monomers twisted through 180° to each other, allowing hydrogen bonds between chains, forming microfibrils. A strong structure for plant cell walls.
Chitin	As cellulose but with some –OH groups replaced by nitrogen-containing acetylamine groups. Strong, lightweight and waterproof for exoskeletons.

Leave blank to allow students to glue.

Knowledge Organiser: BIOLOGICAL MOLECULES

Test for starch

Iodine solution - red/brown

Positive reaction – A blue /black colour is seen.

Test for reducing sugar

Benedict's reagent- blue

Positive reaction- a semi quantitative test. The further along the colour spectrum the solution goes the more sugar is present.

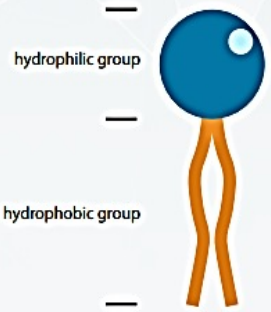
For this test to work on non-reducing sugars (those which do not reduce copper II sulphate) they must be hydrolysed by boiling in hydrochloric acid first.

Inorganic ions - An ion that contains no more than one carbon atom.

Ion	Formulae	Function
Magnesium	Mg^{2+}	Chlorophyll
Iron	Fe^{2+}	Haemoglobin
Phosphate	PO_4^{3-}	Nucleic acids and phospholipids
Calcium	Ca^{2+}	Strengthening bones and teeth in animals cell walls in plants.

Lipids

Triglyceride	Glycerol linked to 3 fatty acid chains during condensation reactions forming ester bonds.
Phospholipids	Glycerol linked to 2 fatty acid chains and a phosphate molecule. A phospholipid has a hydrophilic head and hydrophobic tail. These properties explain the plasma membrane lipid bilayer.



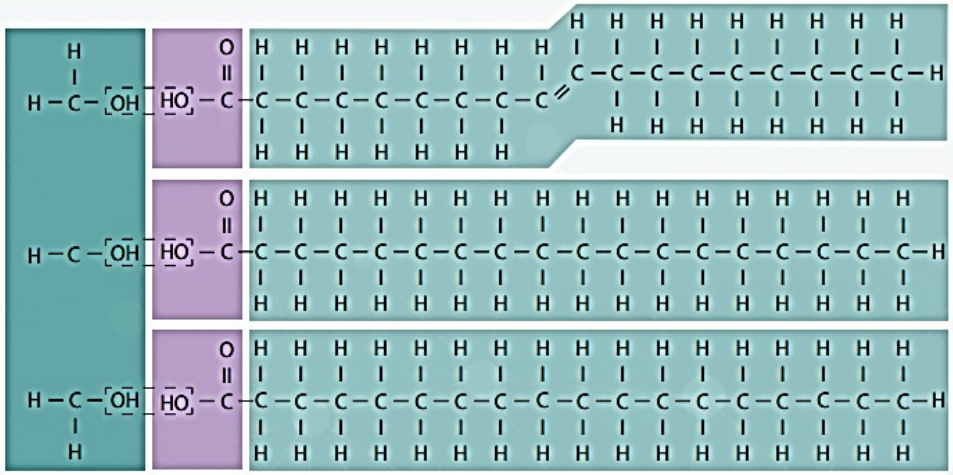
Test for lipids

Mix with absolute ethanol then add equal volumes of water.

Positive result- A cloudy emulsion is formed.

Functions of lipids include insulation, energy storage and protection.

Glycerol



glycerol

three fatty acids

Fatty acids

Unsaturated - Mono-unsaturated fatty acids have one carbon-to carbon double bond and poly-unsaturated fatty acids contain two or more carbon-to-carbon double bonds.

Saturated - have only single carbon-to-carbon bonds.

A high intake of saturated fats, is a contributory factor in heart disease as it raises the low-density lipoprotein (LDL) cholesterol level, which increases the incidence of atheroma's in coronary arteries.

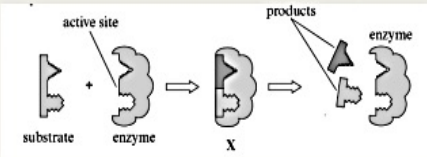
Leave blank to allow students to glue.

Knowledge Organiser: ENZYMES

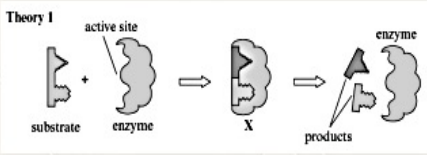
Enzymes

These are tertiary structure proteins and so they are a very specific 3D shape, which includes an active site which is held together by peptide, hydrogen, ionic and disulphide bonds.

Lock and Key Theory



In this theory of enzyme action, a **successful collision** has the **substrate** fit exactly into the **active site** of the enzyme forming an **enzyme/substrate complex**. The reaction occurs and the **products** are released. The enzyme remains unchanged at the end of the reaction.

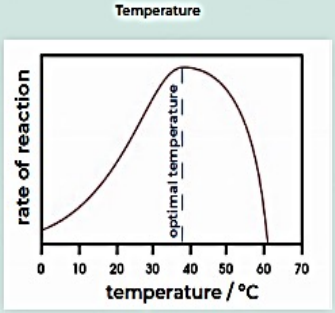


The **induced fit** theory is an alternative theory of enzyme action - **lysozyme** is proposed to function in this way. In this, the active site and substrate are **not fully complementary** in shape. Reactive groups in these areas align and the substrate forces its way into the active site. Both areas change structure slightly, the bonds in the substrate weakens and the reaction occurs at a lower **activation energy.**

Intracellular enzymes

These work **inside** cells and **extracellular enzymes** are secreted from cells for use **outside** of the cell.

Factors affecting enzymes

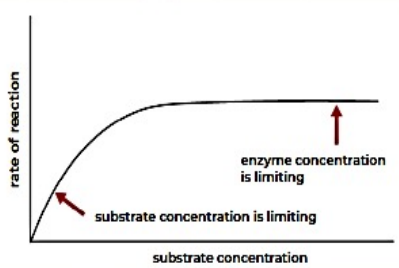


At **low temperatures** there **is low kinetic** energy and so **few successful** collisions where the substrate is able to enter the **active site** of the enzyme and form products.

As the **temperature increases**, the **kinetic energy increases** and so there are **more collisions and enzyme/substrate complexes** formed per unit time leading to increased product. This continues up to an **optimum temperature.**

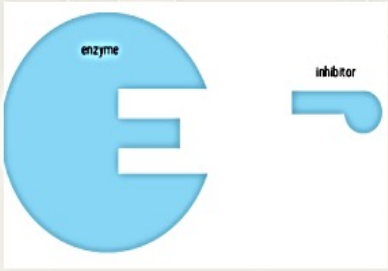
If the temperature continues to increase the kinetic energy increases to a point where **vibrations in the enzyme molecule weaken some bonds** holding the 3D tertiary structure of the **active site** together. The active site loses its shape, the substrate is no longer complementary to the active site, **no further enzyme/substrate complexes** can be made, and the enzyme is said the be **denatured**.

Substrate concentration



As enzyme reaction relies on **successful collisions** between enzymes. Any increase in the substrate concentration will increase collisions and the rate of reaction. Therefore, at low substrate concentrations it is this factor that is **limiting the rate of reaction** as increasing the substrate concentration increases the rate of reaction. At some point though, any further increase in substrate concentration has no effect on the rate of reaction. It is no longer the limiting factor. **The rate of reaction plateaus as all the enzymes have full active sites** at any one time. The enzyme concentration is the limiting factor now.

Inhibitors



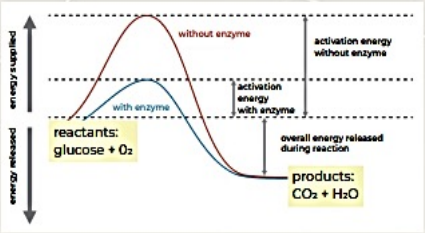
Competitive inhibitors are complementary in shape to the active site of the enzyme. They therefore prevent the formation of enzyme/ substrate complexes by blocking the active site. They do not bind permanently.

Non-competitive inhibitors bind to the enzyme away from the active site at an 'allosteric' site. This alters the shape of the active site so no enzyme/ substrate complexes can be formed. Some inhibitors bind reversibly, others irreversibly.

Leave blank to allow students to glue.

Knowledge Organiser: ENZYMES

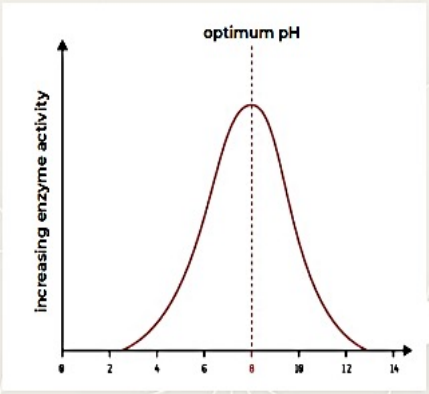
Activation energy



Enzymes are **catalysts**, this means they **lower the activation energy** of reactions, but they remain unchanged in the reaction.

pH

Most enzymes have an optimum pH. Small **changes from the optimum**, either above or below optimum pH, **make small reversible** changes in the enzyme molecule reducing its efficiency. **Large changes in pH** can **disrupt ionic and hydrogen bonds** in the enzyme causing permanent changes to the shape of the active site, **preventing the formation of enzyme/substrate complexes, denaturing the enzyme.**



Immobilised enzymes

Enzymes can be attached to an **inert matrix** such as **cellulose microfibrils** or **sodium alginate beads.**

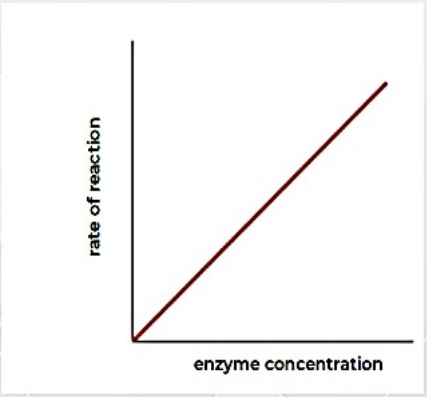
Advantages:

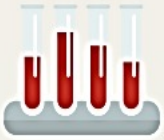
- **Increased stability** so will denature at higher temperature and can be used efficiently over a wider range of pH.
- **Products uncontaminated** with enzyme.
- Enzymes **easily added and removed** giving control over reactions or **recovered for re-use.**

Immobilised enzymes are used to create **lactose-free milk** and in **biosensors.**

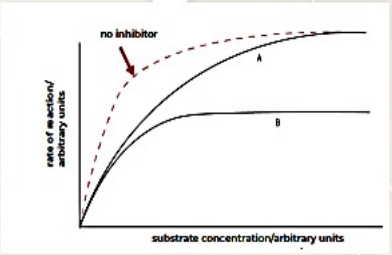
Enzyme concentration

Assuming an excess of substrate any increase in enzyme concentration increases the rate of reaction as more active sites are available for reactions.





Inhibitors



As competitive inhibitors compete with the substrate for the active site any increase in substrate concentration will decrease the effect of the inhibitor as the substrate will collide more often than the inhibitor with the active site of the enzyme. (Line A)

An increase in substrate concentration has no effect on a non-competitive inhibitor. (Line B)

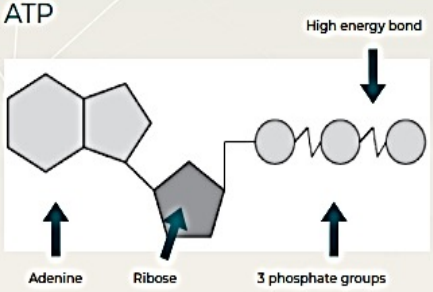
Metabolism - Anabolic reactions (building up molecules) and catabolic reactions (breaking down molecules) are catalysed by enzymes.

Leave blank to allow students to glue.

Knowledge Organiser: NUCLEIC ACIDS

The general structure of a nucleic acid consists of a pentose sugar  a phosphate group  and an organic base.  So, a generalised structure looks like: 

ATP

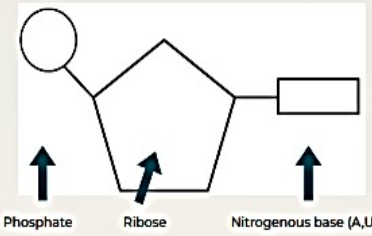


ATP is formed in an endergonic reaction (in respiration). 30.6kJ of energy is stored in this bond and released when it is hydrolysed into ADP and an inorganic phosphate (Pi).

ATP is called the 'Universal energy currency' as it is used to provide energy for all biochemical reactions in all living organisms.

- ATP releases energy in one hydrolysis reaction controlled by one enzyme.
- ATP releases energy in small usable amounts.
- ATP travels easily to where it may be used for secretion, muscle contraction, nerve transmission, active transport.

RNA



These RNA nucleotides are linked together in a single stranded polynucleotide.

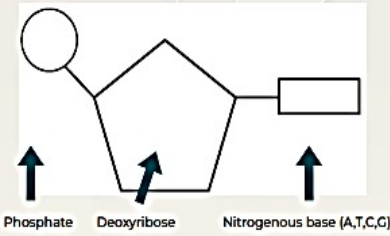
There are 3 different types of RNA with different functions.

Messenger RNA (mRNA) – made as a complementary copy of the DNA genetic code in the nucleus during transcription. The molecule length is related to the length of the gene transcribed. It attaches to a ribosome in the cytoplasm.

Ribosomal RNA (rRNA)- forms ribosomes.

Transfer RNA (tRNA)- carries an amino acid at the 3' end and an anticodon arm to attach to the mRNA.

DNA



DNA is made from one strand of nucleotides linked by hydrogen bonds between the bases to another strand that runs antiparallel to the first.

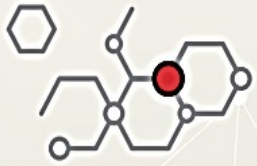
There are 2 types of bases:

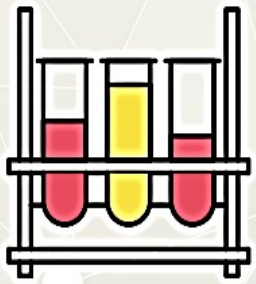
Purines: Adenine and Guanine.

Pyrimidines: Cytosine and Thymine.

They pair up with hydrogen bonds - A pairs with T, C pairs with G. This complementary base pairing links the two strands and a double helix is formed.

Differences between RNA and DNA	
RNA	**DNA**
Ribose sugar	Deoxyribose sugar
Single stranded	Double stranded
A,U,C,G bases	A,T,C,G bases
Short polynucleotides	Long polynucleotides



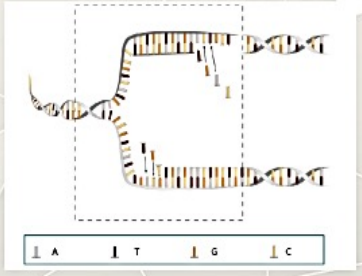


DNA Replication

When cells divide to form new cells they must receive a copy of the DNA. Therefore, chromosomes must be able to make exact copies of themselves.

The replication fork is shown here, and DNA replication occurs in the following steps:

- DNA helicase breaks the hydrogen bonds between the bases in the double helix.
- This unwinds the DNA and exposes unpaired bases.
- Free nucleotides in the nucleoplasm are bound to their complementary bases on the unzipped strand by DNA polymerase.
- Eventually, 2 new DNA molecules are formed from 1 new and 1 old strand of the DNA. This is called semi-conservative replication.

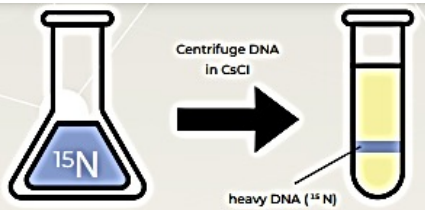


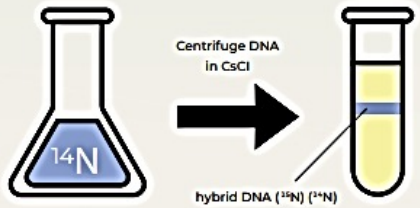
Leave blank to allow students to glue.

Knowledge Organiser: NUCLEIC ACIDS

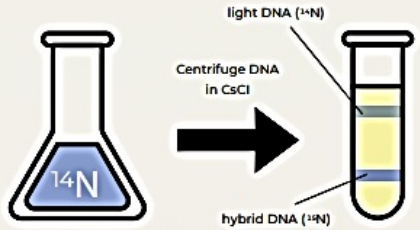
Meselson and Stahl carried out an experiment which gave evidence to the theory of semi-conservative replication of DNA.

1. Grow bacteria with a heavy isotope of nitrogen. Centrifuge a sample, a heavy band is seen.
2. Remove bacteria with heavy DNA and place into a medium with light nitrogen and allow bacteria to divide. They will synthesise DNA with the nitrogen isotope available meaning their DNA will contain 1 new and 1 old strand, making it intermediate in density when centrifuged.
3. Allow 1 more generation to grow and the hybrid strands will now be copied in a semi conservative way creating 50% hybrid and 50% light DNA.





DNA strands:
Heavy nitrogen (^{15}N) = I
Light nitrogen (^{14}N =) I

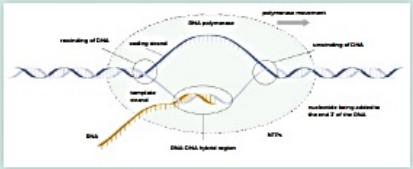


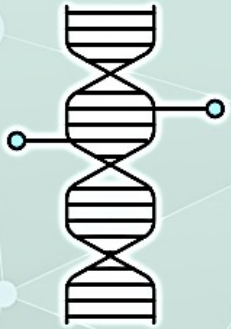
The genetic code is a linear, triplet, non-overlapping, degenerate, unambiguous, universal code for the production of polypeptides.

Protein Synthesis

Transcription → Translation

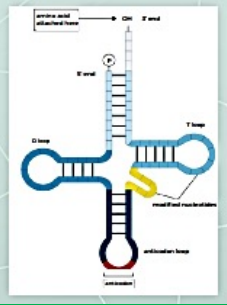
1. **DNA helicase** unzips a section (gene) of the DNA by breaking the hydrogen bonds between complementary base pairs.
2. **RNA polymerase** links to the template (coding) strand of DNA and attaches mRNA nucleotides to their complementary base pairs, e.g. Adenine in DNA now pairs with the mRNA base Uracil, Cytosine continues to pair with Guanine.
3. This copying stops at a stop sequence / codon.
4. The newly made **premRNA** then leaves the DNA.
5. Post transcriptional modification of the premRNA occurs to remove the **non-coding introns** leaving only the **coding sections, exons** in the mature mRNA that now leaves the nucleus to be translated into a protein in the cytoplasm.





1. mRNA is a linear chain of three base codons. There are complementary anticodons on tRNA molecules.
2. When the mRNA leaves the nucleus, it attaches to the small subunit of a ribosome.
3. The large subunits of a ribosome have 2 attachment sites for tRNA. The ribosome holds the mRNA and the tRNA (which have attached amino acids) in position for the amino acids to form peptide bonds and create a polypeptide chain.
4. The codon on the mRNA (3 base code) therefore chooses the tRNA as the tRNA which attaches must have a complementary 3 base code. E.g. mRNA CGA, tRNA GCU.
5. The tRNA that matches the codon on the mRNA has a specific amino acid attached to the 3' end of the tRNA molecule. The ribosome moves along the mRNA holding each tRNA in place until the amino acid attaches. The tRNA then leaves, the ribosome moves along and the next tRNA attaches to the next codon.
   In this way the mRNA (translated from a gene) carries the code for the formation of a polypeptide chain with amino acids set out in a particular order.

One gene = one polypeptide.



Modification of new polypeptides

Polypeptides can be modified by the addition of carbohydrates, lipids or phosphate or can be combined together, e.g. haemoglobin.

Leave blank to allow students to glue.

Knowledge Organiser: GAS EXCHAGE ANIMALS

Gas exchange

How much oxygen an organism needs depends on its **volume**.
The rate that oxygen is absorbed at depends on the **surface area** available for gas exchange.
Therefore, the **surface area to volume ratio** of an organism affects:

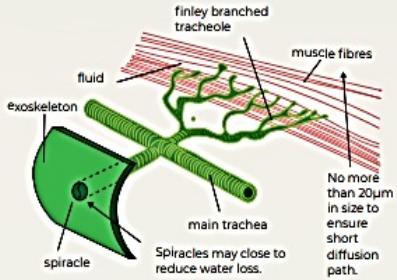
- the surface adapted for use for gas exchange
- the level of activity of the organism.

As organisms increase in size, their surface area to volume ratio decreases and so specialised respiratory surfaces are needed.

Gas exchange in insects

Insects cannot use their external surface for gas exchange as they are covered in an impermeable cuticle to reduce water loss by evaporation.

1. Pairs of spiracles on segments of the thorax and abdomen.
2. These holes lead to tubes called tracheae leading to tracheoles.
3. Tracheoles enter muscle cells directly. They have fluid at the end for dissolving and diffusion of oxygen.
4. During flight, when oxygen requirements increase, fluid in tracheoles decreases to shorten diffusion path and whole-body contractions ventilate by speeding up air flow through spiracles.



Gas exchange in fish

Fish require a specialised gas exchange surface as:

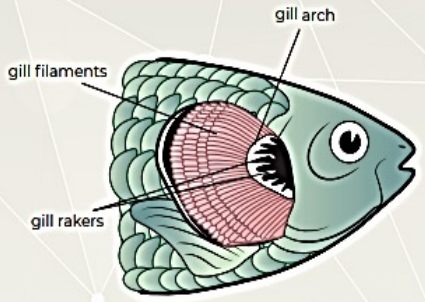
- they have a smaller surface area to volume ratio
- they are relatively active and so have high metabolic rates making oxygen requirements high
- they require a ventilation mechanism to maintain concentration gradients for gas exchange.

Ventilation in fish

Fish require a ventilation mechanism to push water, a dense medium with low oxygen content, over the high surface area gill filaments. Removal from water causes these gill filaments to collapse, stick together and the gas exchange surface becomes too small for survival.

1. Mouth opens, floor of buccal cavity lowers so volume increases, and pressure decreases and water rushes in.
2. Mouth closes, floor of buccal cavity raises, increasing pressure pushing water over the gills.
3. Pressure in gill cavity increases and water forces operculum open and leaves through it.

The gills have gill filaments made of gill plates/ lamellae, the gas exchange surface across which the water flows.
Gill rakers prevent large particulates entering and blocking the gills.

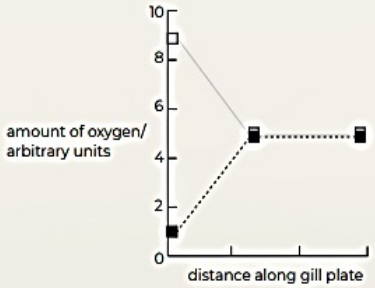


Gas exchange surfaces must:

- be moist
- be thin (short diffusion pathway)
- have a large surface area
- be permeable to gases
- in larger organisms they must have a good blood supply to maintain concentration gradients.

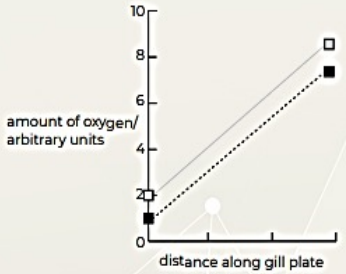
Continuous flow

If water and blood flow in the same direction equilibrium is reached and oxygen diffusion stops halfway across the gill plate.



Counter current flow

If water and blood flow in opposite directions across the gill plate the concentration gradient is maintained, and oxygen diffuses into the blood across the entire gill plate.



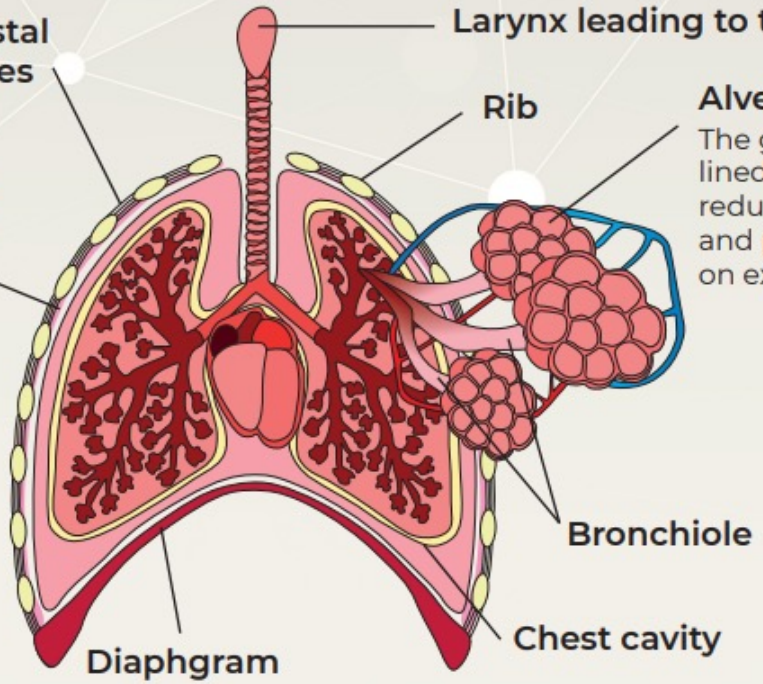
How some organisms adapt to the challenge of gas exchange:

Amoeba	Flatworm	Earthworm
*Single cell *Large surface area to volume ratio *Rate of oxygen diffusion through cell membrane meets demand.	*Multicellular *Smaller surface area to volume ratio *Flattened body to reduce diffusion distance so rate of oxygen diffusion through body surface meets demand.	* Multicellular, even smaller surface area to volume ratio. * Body surface still used for gas exchange, but circulatory system needed to distribute oxygen, mucus secreted to moisten surface and slow moving to reduce oxygen demand.

Leave blank to allow students to glue.

Knowledge Organiser: GAS EXCHAGE ANIMALS

Gas exchange in humans



Ventilation in humans - Inspiration

1. External intercostal muscles contract and pull the rib cage up and out.
2. Outer pleural membrane is pulled out. This reduces pressure in the pleural cavity and the inner pleural membrane is pulled outward.
3. This pulls on the surface of the lungs and causes an increase in the volume of the alveoli.
4. Alveolar pressure decreases to below atmospheric pressure and air is drawn into the lungs.

Leave blank to allow students to glue.

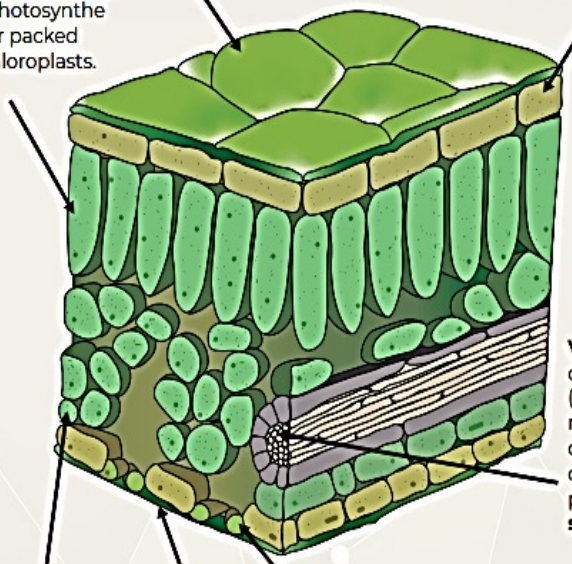
Knowledge Organiser: GAS EXCHAGE PLANTS

The Structure of the Angiosperm Leaf

Cuticle - A waxy transparent layer. It allows light to pass through to the photosynthetic palisade mesophyll below but reduces water lost by evaporation through the top surface of the leaf.

Upper epidermis - Transparent for light to easily penetrate to photosynthetic layers.

Palisade mesophyll – main photosynthetic layer packed with chloroplasts.



Vascular bundle containing **xylem** (carrying water from roots), **phloem** (to carry sucrose to other parts of the plant) and **bundle sheath parenchyma.**

Spongy mesophyll surrounded by air spaces for easy diffusion of gases.

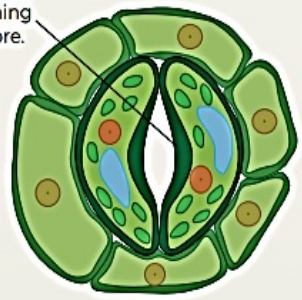
Lower epidermis

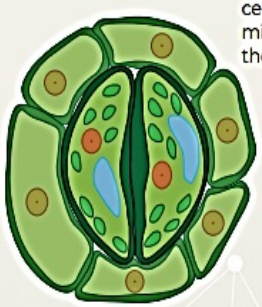
Stomata - The stomatal pores allow the exchange of gases down a concentration gradient. The gases diffuse through intracellular spaces to and from the photosynthetic cells where they dissolve in the moist lining and diffuse into the cells. Guard cells open and close the stomata. The closing of the stomata during the night reduces water loss.

Leaves are adapted for photosynthesis by:

- **Large surface area** and orientate perpendicular to the sun for maximum light absorption.
- **Thin** with a **transparent cuticle and upper epidermis** for light to penetrate into the leaf and also for efficient diffusion of gases from the stomata, up through the gas spaces to the photosynthetic layers.
- **Palisade cells packed with chloroplasts;** cells are densely stacked with long axes perpendicular to leaf surface.

Open
Turgid guard cells bend due to thickened inner walls - opening stomatal pore.





Closed
Flaccid guard cells meet in the middle, closing the stomatal pore.

Opening and closing stomata for gas exchange

1. In light, chloroplasts in guard cells photosynthesise and produce ATP.
2. ATP used for the active transport of potassium ions into guard cells.
3. Starch is converted to malate.
4. Malate and potassium ions lower water potential of guard cells and water is drawn in by osmosis.
5. Uneven thickening of guard cell inner walls causes them to bend as they swell, opening the stomatal pore.
6. The opposite occurs when there is no light closing the pore.

Leave blank to allow students to glue.

Knowledge Organiser: DIGESTION

During digestion, large biological molecules are hydrolysed to smaller molecules that can be absorbed across cell membranes

- Large biological molecules in food e.g. starch / proteins too big to be absorbed across cell membranes
- Digestion breaks them into smaller molecules e.g. glucose / amino acids → absorbed from the gut to the blood

Digestion in mammals of carbohydrates by amylases and membrane-bound disaccharidases

Digestion of starch (polysaccharide)

- Amylase hydrolyses starch to maltose (polysaccharide to disaccharide)
  - Amylase produced by salivary glands, released into mouth
  - Amylase produced by pancreas, released into small intestine
- Membrane bound maltase (attached to epithelial cells lining the ileum of the small intestine) → hydrolyse maltose to glucose (disaccharide to monosaccharide)
- Hydrolysis of glycosidic bond

Digestion of disaccharides

- Membrane bound disaccharidases, e.g. maltase, sucrose, lactase (attached to epithelial cells lining the ileum of the small intestine) → hydrolyse disaccharide to x2 named monosaccharides
  - E.g. maltase – maltose → glucose + glucose
  - E.g. sucrase – sucrose → fructose + glucose
  - E.g. lactase – lactose → galactase + glucose
- Hydrolysis of glycosidic bond

Digestion in mammals of lipids by lipase, including the action of bile salts

- Bile salts produced by the liver
- Bile salts emulsify lipid to smaller lipid droplets
  - Increasing surface area (to volume ratio) of lipids speeds up action of lipases
- Lipase made in the pancreas, released to small intestine
- Lipase hydrolyses lipids → monoglycerides + fatty acids
- Breaking ester bond
- Monoglycerides, fatty acids and bile salts stick together to form micelles

Digestion in mammals of proteins by endopeptidases, exopeptidases and membrane-bound dipeptidases

- Endopeptidases
  - Hydrolyse peptide bonds within a protein / between amino acids in the central region
  - Breaking protein into two or more smaller peptides
- Exopeptidases
  - Hydrolyse peptide bonds at the ends of protein molecules
  - Removing a single amino acid
- Dipeptidases (type of exopeptidase)
  - Often membrane bound in ileum
  - Hydrolyse peptide bond between a dipeptide
  - = 2 amino acids

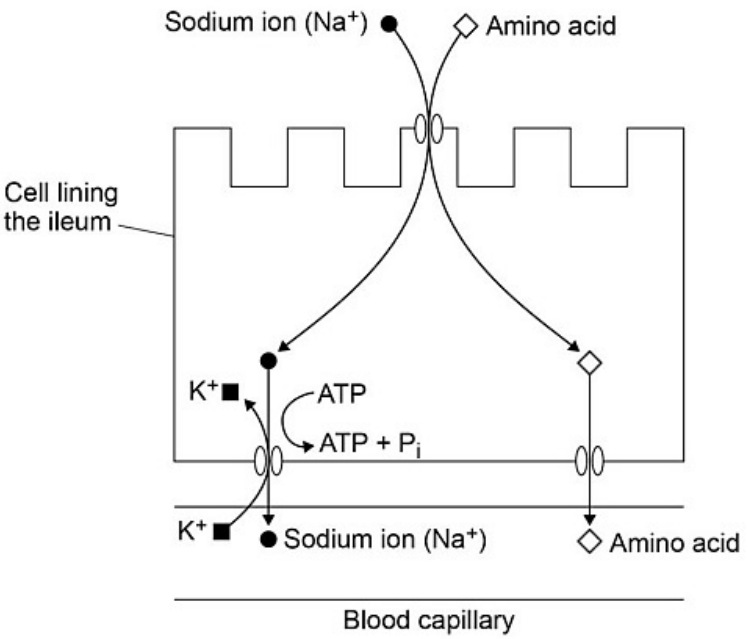
Leave blank to allow students to glue.

Knowledge Organiser: DIGESTION

Mechanisms for the absorption of the products of digestion by cells lining the ileum of mammals, to include co-transport mechanisms for the absorption of amino acids and of monosaccharides

1. Sodium ions actively transported out of epithelial cells lining the ileum, into the blood, by the sodium-potassium pump. Creating a concentration gradient of sodium (higher conc. of sodium in lumen than epithelial cell)
2. Sodium ions and glucose move by facilitated diffusion into the epithelial cell from the lumen, via a co-transporter protein
3. Creating a concentration gradient of glucose – higher conc. of glucose in epithelial cell than blood
4. Glucose moves out of cell into blood by facilitated diffusion through a protein channel

Figure 1 shows the co-transport mechanism for the absorption of amino acids into the blood by a cell lining the ileum.



Mechanisms for the absorption of the products of digestion by cells lining the ileum of mammals, to include the role of micelles in the absorption of lipids

- Monoglycerides and fatty acids diffuse out of micelles (in lumen) into epithelial cell
  - Because lipid soluble
- Monoglycerides and triglycerides recombine to triglycerides which aggregate into globules
- Globules coated with proteins to form chylomicrons
- Leave via exocytosis and enter lymphatic vessels
- Return to blood circulation

Leave blank to allow students to glue.

Knowledge Organiser: CIRCULATORY SYSTEM

Types of circulatory systems

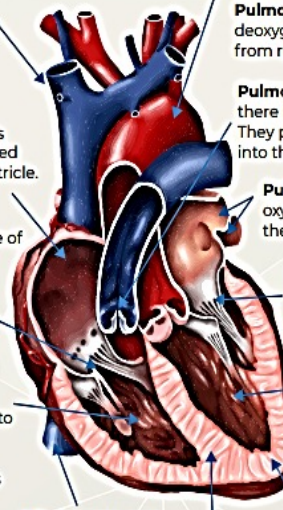
Open	Blood is pumped into a haemocoel, bathes organs and returns slowly to heart with little control over direction of flow.
Closed	Blood is pumped into a series of vessels; blood flow is rapid, and direction is controlled. Organs are not bathed by blood but by tissue fluid that leaks from capillaries.
Single	Blood passes through the heart once in each circulation.
Double	Blood passes through the heart twice in each circulation - once in the pulmonary (lung) circulation and then again pumping blood through the systemic (body) circulation.

Comparison of circulatory systems

Circulatory systems may have: · transport medium · a system of vessels · a pump · valves · a respiratory pigment to carry oxygen.

Insects	Earthworms	Fish	Mammals
Open circulatory system. Dorsal tube-shaped heart. No respiratory pigment in blood as lack of respiratory gases in blood due to tracheal gas exchange system.	Closed circulatory. 5 pseudohearts. Respiratory pigment haemoglobin carries respiratory gases in blood.	Closed, single circulatory system. Blood pumped to and oxygenated in the gills continues around body tissues. This means a lower pressure and slower flow around the body.	Closed, double circulatory system. High blood pressure to body delivers oxygen quickly. Lower pressure to lungs prevents hydrostatic pressure forcing tissue fluid into and reducing efficiency of alveoli.

The mammalian heart



Superior vena cava - returns deoxygenated blood to the heart.

Aorta - carries oxygenated blood from the left ventricle to the body.

Pulmonary artery - takes deoxygenated blood to lungs from right ventricle.

Pulmonary (semilunar) valve - there is a similar valve in the aorta. They prevent blood flowing back into the heart between heart beats.

Right atrium - contracts and pumps deoxygenated blood into the right ventricle.

Pulmonary Veins - return oxygenated blood from lungs to the right atrium.

Tricuspid valve - pressure of the contraction of the atrium opens this valve which then closes, preventing backflow.

Bicuspid (mitral) valve - behind which is the left atrium - it prevents backflow of blood into the atrium.

Left ventricle - Comparatively thicker muscular wall to produce a higher pressure to push oxygenated blood rapidly around the body.

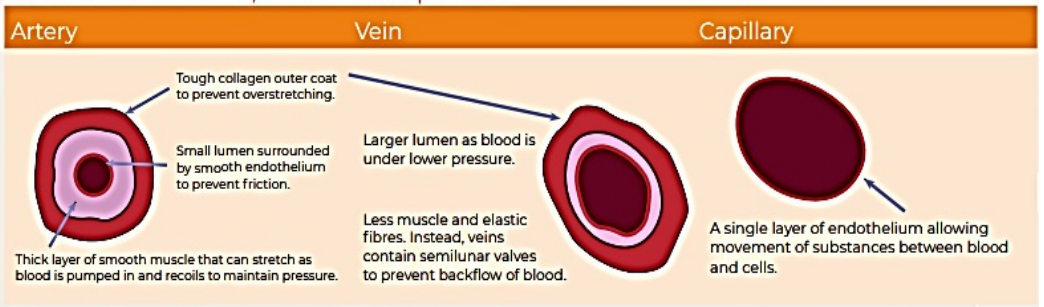
Right ventricle - thinner muscular wall compared to the left ventricle as less pressure is produced on contraction. This prevents of blood into the left ventricle after it contracts.

Inferior vena cava

Apex

Septum - wall dividing oxygenated blood (left) and deoxygenated blood (right) side of the heart.

Structure of arteries, veins and capillaries



The cardiac cycle

Atrial systole	Atrial contract. Pressure opens atrio-ventricular valves. Blood flows into ventricles.
Ventricular systole	Ventricles contract. Atrio-ventricular valves close due to pressure in ventricles. Semilunar valves in aorta and pulmonary artery open. Blood flows into arteries.
Ventricular Diastole	Ventricle muscle relaxes. Semilunar valves close to prevent backflow of blood.
Diastole	Heart muscle relaxes and atria begin to fill from vena cava and pulmonary veins.

Initiating the heartbeat

- The heartbeat is myogenic; initiation comes from the heart itself.
- The Sino-atrial node acts as a pacemaker sending waves of excitation across the atria causing them to contract simultaneously.
- A layer of connective tissue prevents the wave of excitation passing down to the ventricles.
- The atrio-ventricular node transmits impulses down the bundle of His to the apex of the heart.
- The impulse then travels up the branched Purkinje fibres simulating ventricles to contract from the bottom up ensuring all the blood is pumped out.

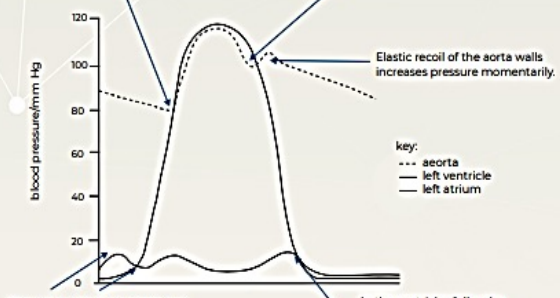
Leave blank to allow students to glue.

Knowledge Organiser: CIRCULATORY SYSTEM

Pressure changes in the heart

Contraction of the thick muscular wall (systole) increases the pressure in the ventricle. At a certain level the semilunar valve leading to the aorta is forced open and blood enters the aorta, increasing the pressure.

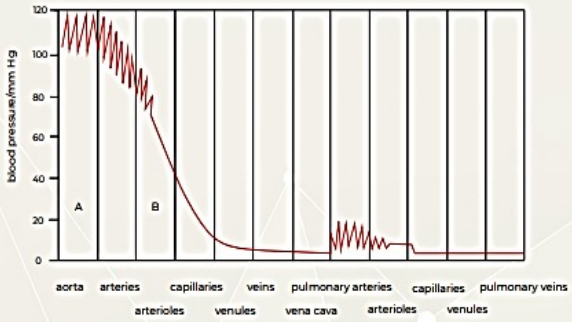
As the ventricle wall relaxes (diastole) the pressure drops in both the ventricle and aorta. The semilunar valve closes, preventing blood flowing back into the ventricle.



Pressure in atrium increases as it contracts, forcing blood through the atrio-ventricular valves into the ventricles. As the atria empty, the valves snap shut.

As the ventricles fully relax, contraction in the atria walls causes the atrio-ventricular valves to open and the ventricle to refill with blood.

Pressure changes in the vessels

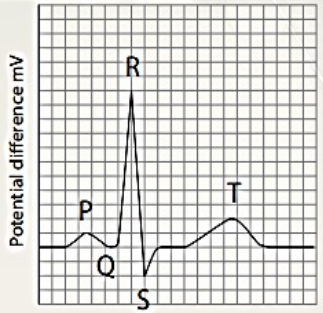


A - Pressure in the aorta is high due to contraction of the powerful left ventricle forcing blood into the vessel. It falls only slightly during ventricular diastole due to the elastic recoil of the arteries. Arterioles are further away from the heart, have a large surface area and are narrow, leading to a substantial drop in pressure. However, arterioles can adjust their diameter to control blood flow.

B - The huge cross-sectional surface area covered by the capillaries causes a dramatic decline in pressure. Slow moving blood is essential for effective exchange between blood and cells. Low pressure requires valves and massaging effect of muscles to aid the transport of blood through the veins back to the heart.

ECG

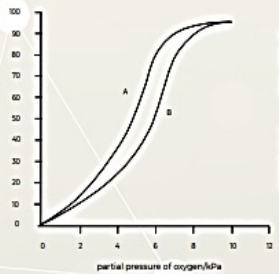
The electrical activity that spreads through the heart during the cardiac cycle can be detected using electrodes placed on the skin and shown on a cathode ray oscilloscope. This is called an electrocardiogram (ECG).



P wave	Depolarisation of the atria corresponding to atrial systole.
QRS wave	Spread of depolarisation through the ventricles resulting in ventricular systole.
T wave	Repolarisation of the ventricles resulting in ventricular diastole.

Oxygen dissociation curves

- Red blood cells transport oxygen.

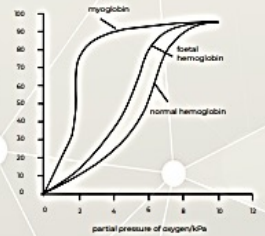


B – Where CO_2 is present the Bohr shift occurs and the curve moves to the right, meaning haemoglobin has a lower affinity for oxygen, releasing it more readily. This is helpful in respiring tissues.

A – a sigmoid curve that shows haemoglobin has a high affinity for oxygen at high partial pressures of oxygen (the lungs) but releases it readily at lower partial pressures (respiring tissues).

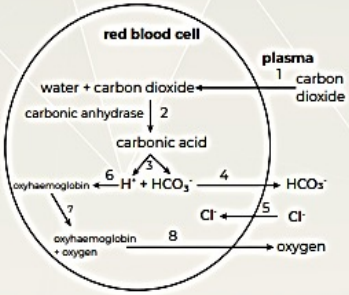
Myoglobin - curve shifts to the left. It has a high affinity for O_2 and holds on to it until partial pressures of O_2 are really low, it then releases it rapidly. It acts as a store of O_2 in muscle.

Foetal haemoglobin - curve just to the left, a higher affinity for O_2 than haemoglobin at all partial pressures so foetus can take O_2 from the mothers blood.



Chloride shift

Some CO_2 is carried in the blood dissolved in plasma, some as carbaminohaemoglobin but most is carried as hydrogen carbonate ions as shown below:



1	CO_2 diffuses into a red blood cell (RBC)
2	CO_2 combines with H_2O catalysed by the enzyme, carbonic anhydrase, forming carbonic acid.
3	Carbonic acid dissociates into hydrogen ions (H^+) and hydrogen carbonate ions (HCO_3^-) diffuse out of the RBC.
4	Hydrogen carbonate ions diffuse out of the RBC.
5	Chloride ions (Cl^-) diffuse (facilitated diffusion) into the RBC to maintain electrochemical neutrality - **the chloride shift**.
6	H^+ bind to oxyhaemoglobin, reducing its affinity for oxygen. **This is the Bohr effect.**
7	Oxygen is released from the haemoglobin.
8	Oxygen diffused from the RBC into the plasma and body cells.

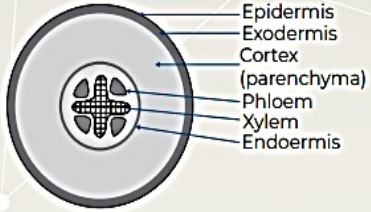
Formation of tissue fluid – a link between blood and cells. Important as plasma transports nutrients, hormones, excretory products and distributes heat.

1. At the arterial end of the capillary bed, hydrostatic pressure is higher than osmotic pressure.
2. Water and small soluble molecules are forced through the capillary walls, forming tissue fluid between the cells.
3. Proteins and cells in the plasma are too large to be forced out.
4. Due to reduced volume of blood and friction, blood pressure falls and it moves through the capillary.
5. At the venous end of the capillary bed osmotic pressure of the blood is higher than the hydrostatic pressure.
6. Most of the water from tissue fluid moves back into blood capillaries (down its water potential gradient). The remainder of the tissue fluid is returned to the blood, via lymph vessels.

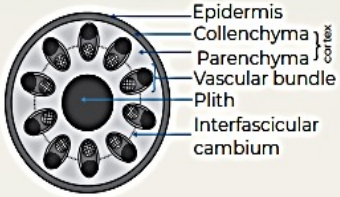
Leave blank to allow students to glue.

Knowledge Organiser: TRANSPORT IN PLANTS

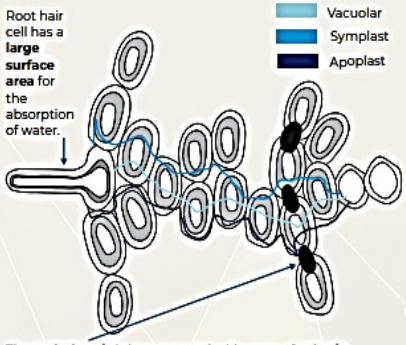
Structure of the root



Structure of a stem



Apoplast, symplast and vacuolar pathways



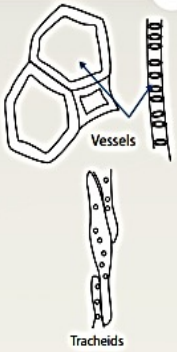
The **endodermis** is impregnated with areas of **suberin** called the **casparian strip**. This blocks the apoplast pathway, forcing water into the symplast pathway. Minerals are selected to move into the symplast by **active transport**. This sets up a water potential gradient, lower in the xylem so water moves in by osmosis resulting in a force called **root pressure**.

Pathway	Movement of water across the root cortex
Apoplast	From cell wall to cell wall.
Symplast	From cytoplasm to cytoplasm through plasmodesmata.
Vacuolar	From vacuole to vacuole.

Xylem

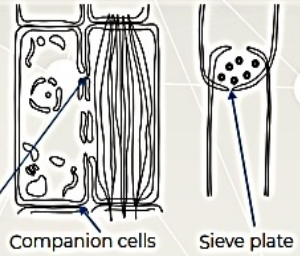
- Vessels
- Tracheids
- Fibres
- Parenchyma

Xylem are dead cells that transport water and minerals up the plant and provide mechanical strength and support as it is strengthened by waterproof lignin.



Phloem

Phloem sieve tubes carry **sucrose and amino acids.** Sieve elements end in **sieve plates** containing **pores** through which **cytoplasmic filaments** extend linking cells. No other organelles are in the sieve elements. **Companion cells** contain many **mitochondria for ATP** and the organelles for **protein synthesis** which are passed to the sieve elements through **plasmodesmata**.



- Sieve tubes
- Fibres
- Parenchyma

Transpiration is the loss of water, as water vapour from the leaves of plants. It leads to the transpiration stream.

Transpiration stream– water moves into the root and enters the xylem (root pressure). Cohesive forces between water molecules and adhesive forces between water molecules and the hydrophilic lining of the xylem creates a transpiration pull as the water leaving the xylem into the leave pulls on molecules below. This is cohesion–tension theory.

Factors increasing transpiration

Lower humidity	Higher temperature
Higher light intensity	Higher air movement (wind speed)

Adaptations to environment

Plant	Adaptations
Hydrophyte- Water plants, e.g Water Lily	Little/no waxy cuticle as no need to conserve water. Stomata on upper surface as lower surface submerged. Poorly developed xylem as no need to transport water. Large air spaces reservoirs of gas and for buoyancy.
Mesophyte- Live with adequate water	Close stomata at night to decrease water loss. Shed leaves in unfavourable conditions, e.g. Winter. Underground organs and dormant seeds survive winter.
Xerophyte- Water is scarce, e.g Marram grass	Thick waxy cuticle reducing water loss by evaporation from epidermal tissue. Sunken stomata increasing humidity in an air chamber above the stomata, reducing transpiration. Rolled leaves - reduces area of leaf exposed directly to air. Stiff interlocking hairs trap water vapour inside rolled leaf, reducing water potential gradient and therefore water loss.

Translocation

The phloem transports the products of photosynthesis from source (the leaf) to sink (area of use or storage). This is called translocation and there is evidence to show this is bidirectional through the phloem.

Evidence for bidirectional flow in the phloem

1. Ringing experiments (removal of phloem) show accumulation of sucrose products on leaf side of the ring but none on root side. Movement of sucrose was blocked by removal of phloem...phloem is the route of transport.
2. Using Aphids to sample sap from the phloem. An aphid stylus extends into sieve tube elements. If a laser is used to remove the stylus from the body, the stylus then becomes a micropipette and sap drips out which can be analysed to show sucrose and amino acids are carried in the phloem, both above and below leaves.
3. Radioactive labelling of carbon dioxide which will become incorporated into sucrose can be used in conjunction with the above technique. Sap sampled can be analysed using autoradiography.

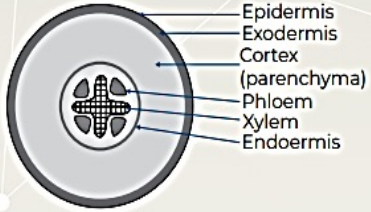
Theory of Mass Flow

For	Against
Sucrose made at source lowers water potential. Water enters cells and sucrose is forced into phloem (loading) increasing hydrostatic pressure so mass flow occurs along the phloem to the root where sucrose is stored as starch, water potential is less negative and water moves into the xylem.	Sieve plates impede flow.
	Translocation is faster than expected with diffusion.
	This theory does not explain bidirectional flow or different rates of flow of sucrose and amino acids.
	Does not explain companion cell mitochondria, high O_2 intake or stopping of translocation by cyanide.

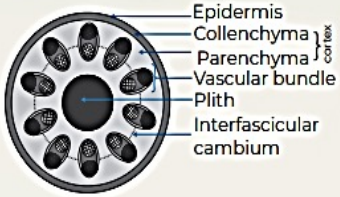
Leave blank to allow students to glue.

Knowledge Organiser: TRANSPORT IN PLANTS

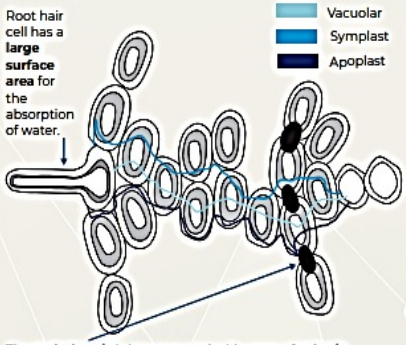
Structure of the root



Structure of a stem



Apoplast, symplast and vacuolar pathways



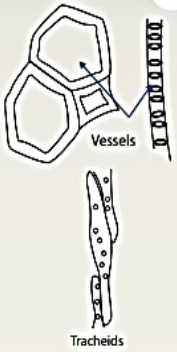
The **endodermis** is impregnated with areas of **suberin** called the **casparian strip**. This blocks the apoplast pathway, forcing water into the symplast pathway. Minerals are selected to move into the symplast by **active transport**. This sets up a water potential gradient, lower in the xylem so water moves in by osmosis resulting in a force called **root pressure**.

Pathway	Movement of water across the root cortex
Apoplast	From cell wall to cell wall.
Symplast	From cytoplasm to cytoplasm through plasmodesmata.
Vacuolar	From vacuole to vacuole.

Xylem

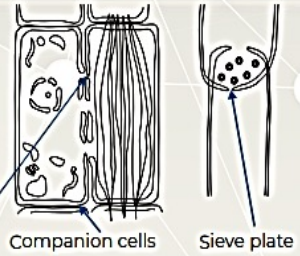
- Vessels
- Tracheids
- Fibres
- Parenchyma

Xylem are dead cells that transport water and minerals up the plant and provide mechanical strength and support as it is strengthened by waterproof lignin.



Phloem

Phloem sieve tubes carry **sucrose and amino acids.** Sieve elements end in **sieve plates** containing **pores** through which **cytoplasmic filaments** extend linking cells. No other organelles are in the sieve elements. **Companion cells** contain many **mitochondria for ATP** and the organelles for **protein synthesis** which are passed to the sieve elements through **plasmodesmata**.



- Sieve tubes
- Fibres
- Parenchyma

Transpiration is the loss of water, as water vapour from the leaves of plants. It leads to the transpiration stream.

Transpiration stream– water moves into the root and enters the xylem (root pressure). Cohesive forces between water molecules and adhesive forces between water molecules and the hydrophilic lining of the xylem creates a transpiration pull as the water leaving the xylem into the leave pulls on molecules below. This is cohesion–tension theory.

Factors increasing transpiration

Lower humidity	Higher temperature
Higher light intensity	Higher air movement (wind speed)

Adaptations to environment

Plant	Adaptations
Hydrophyte- Water plants, e.g Water Lily	Little/no waxy cuticle as no need to conserve water. Stomata on upper surface as lower surface submerged. Poorly developed xylem as no need to transport water. Large air spaces reservoirs of gas and for buoyancy.
Mesophyte- Live with adequate water	Close stomata at night to decrease water loss. Shed leaves in unfavourable conditions, e.g. Winter. Underground organs and dormant seeds survive winter.
Xerophyte- Water is scarce, e.g Marram grass	Thick waxy cuticle reducing water loss by evaporation from epidermal tissue. Sunken stomata increasing humidity in an air chamber above the stomata, reducing transpiration. Rolled leaves - reduces area of leaf exposed directly to air. Stiff interlocking hairs trap water vapour inside rolled leaf, reducing water potential gradient and therefore water loss.

Translocation

The phloem transports the products of photosynthesis from source (the leaf) to sink (area of use or storage). This is called translocation and there is evidence to show this is bidirectional through the phloem.

Evidence for bidirectional flow in the phloem

1. Ringing experiments (removal of phloem) show accumulation of sucrose products on leaf side of the ring but none on root side. Movement of sucrose was blocked by removal of phloem...phloem is the route of transport.
2. Using Aphids to sample sap from the phloem. An aphid stylus extends into sieve tube elements. If a laser is used to remove the stylus from the body, the stylus then becomes a micropipette and sap drips out which can be analysed to show sucrose and amino acids are carried in the phloem, both above and below leaves.
3. Radioactive labelling of carbon dioxide which will become incorporated into sucrose can be used in conjunction with the above technique. Sap sampled can be analysed using autoradiography.

Theory of Mass Flow

For	Against
Sucrose made at source lowers water potential. Water enters cells and sucrose is forced into phloem (loading) increasing hydrostatic pressure so mass flow occurs along the phloem to the root where sucrose is stored as starch, water potential is less negative and water moves into the xylem.	Sieve plates impede flow.
	Translocation is faster than expected with diffusion.
	This theory does not explain bidirectional flow or different rates of flow of sucrose and amino acids.
	Does not explain companion cell mitochondria, high O_2 intake or stopping of translocation by cyanide.

Leave blank to allow students to glue.

Knowledge Organiser: DNA AND CHROMOSOMES

DNA is stored differently in eukaryotes vs. prokaryotes

- Eukaryotic DNA: Long, linear, associated with proteins called histones, tightly coiled into chromosomes (DNA molecule + its associated proteins)
- Prokaryotic DNA: Short, circular, not associated with proteins/histones

Mitochondria and chloroplasts in eukaryotic cells have their own DNA

- Similar to prokaryotic DNA – short, circular, not associated with proteins/histones

Genes

- Sequence of DNA bases that codes for:
  - The amino acid sequence of a polypeptide
  - A functional RNA e.g. ribosomal RNA and tRNAs
- A gene occupies a fixed position, called a locus, on a particular DNA molecules

The nature of the genetic code

- Sequence of DNA triplets (or mRNA codons) codes for sequence of amino acids
  - DNA triplet: sequence of 3 bases coding for specific amino acid
    - e.g. UAU codes for tyrosine
- Universal
  - The same specific DNA base triplets code for the same amino acids in all living organisms
    - e.g. UAU codes for tyrosine in all organisms
- Non-overlapping
  - Discrete, each base can only be used once and in only one triplet
- Degenerate
  - The same amino acid can be coded for by more than one base triplet
    - e.g. tyrosine can be coded for by UAU or UAC

In eukaryotes, much of the DNA doesn't code for polypeptides

- Between genes…
  - Non-coding multiple repeats (or Variable Number Tandem Repeats (VNTRs) in second year)
- Within genes
  - Only exons code for amino acid sequences, which are separated by one or more non-coding sequences, called introns

More important definitions

- Genome: the complete set of genes in a cell, including those in mitochondria and/or chloroplasts
- Proteome: The full range of proteins that a cell/genome is able to produce
- Alleles: different version (sequence of bases / triplets) of the same gene
- Homologous pair of chromosomes: same size chromosomes with same genes, but different alleles

Leave blank to allow students to glue.

Knowledge Organiser: DNA AND CHROMOSOMES

Protein synthesis overview

- 2 stages:
  1. Transcription
     - Production of mRNA from DNA
     - Nucleus
  2. Translation
     - Production of polypeptides from the sequence of codons carried by mRNA
     - Cytoplasm on ribosomes

Messenger RNA (mRNA)

- Made by transcription in the nucleus
- Acts as a template for translation in the cytoplasm
- Sequence of bases on RNA determines sequence of amino acids in polypeptide chain
- Straight chain molecule
- Sequence of bases on RNA determined by sequence of bases on DNA
  - Triplet code = codon
- Chemically unstable
  - So breaks down after a few days

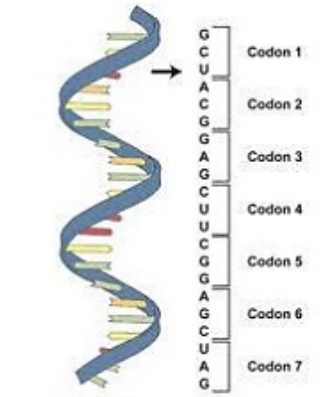
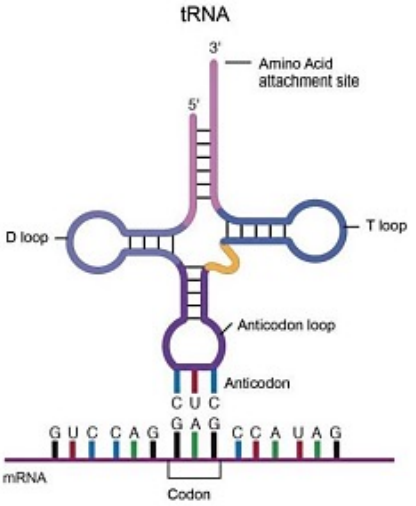


Image adapted from: National Human Genome Research Institute. Talking Glossary of Genetic Terms. Available at: www.genome.gov/Pages/Hyperion/DOE/VIP/Glossary/Illustration/codon.shtml.

Transfer RNA (tRNA)

- Carries an amino acid
  - Amino acid binding site
- Anticodon = 3 bases
  - Anticodon bases complementary to mRNA codon
- Each tRNA specific to one amino acid, in relation to its anticodon
- Single polynucleotide strand
  - Folded – 3 hairpin loops = three-leafed clover shape
  - Held together by hydrogen bonds



Similarities / differences between structure of mRNA and tRNA molecules

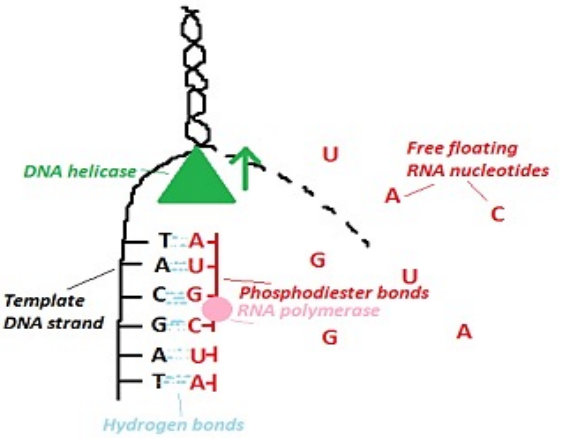
- Similarities
  - Both single polynucleotide strand
- Differences
  - mRNA single helix / straight, whereas tRNA folded into clover shape
  - mRNA is a longer, variable length, whereas tRNA is shorter
  - mRNA contains no paired bases or hydrogen bonds, whereas tRNA has some paired bases and hydrogen bonds

Leave blank to allow students to glue.

Knowledge Organiser: DNA AND CHROMOSOMES

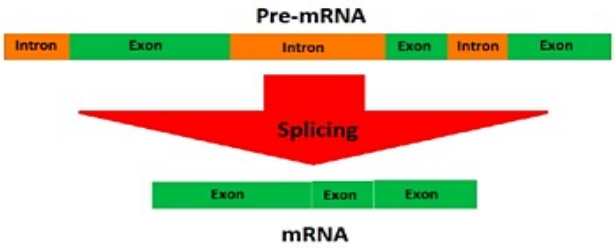
Transcription

- In nucleus
- DNA double helix unzipped / unwound by helicase
  - Hydrogen bonds broken
- RNA nucleotides align next to their complementary bases on the template strand
  - Forming (temporary) hydrogen bonds
  - Uracil replaces thymine in RNA
- RNA polymerase joins adjacent nucleotides - condensation reaction
- Forming phosphodiester bonds
- When RNA polymerase reaches stop codon, mRNA (prokaryotes) or pre-mRNA (eukaryotes) detaches from DNA
- mRNA leaves nucleus via nuclear pore



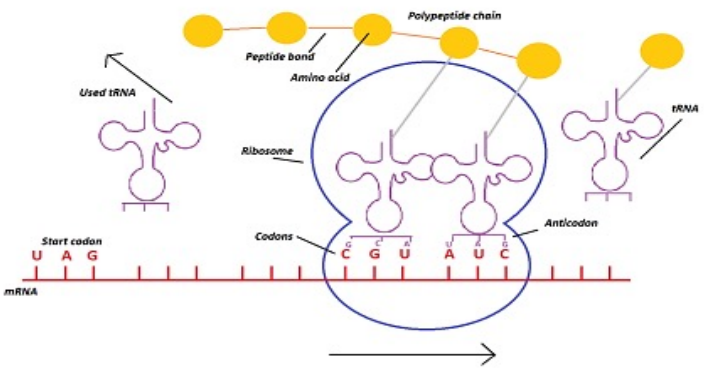
Post transcriptional modification

- Eukaryotic genes contain
  - Exons – coding regions
  - Introns – non-coding regions
- Whole gene transcribed to pre-mRNA
  - Pre-mRNA contains introns & exons
- Splicing
  - Introns removed
  - Exons spliced together
  - Spliced together in different combos for different proteins
- Prokaryotic DNA doesn't contain introns
  - mRNA produced directly from DNA
  - No splicing



Translation

- Sequence of mRNA codons determines sequence of amino acids
- tRNAs carry specific amino acids, in relation to their anticodon
- At the ribosome, tRNA codon binds to mRNA codon
  - tRNA anticodon complementary to mRNA codon
  - Hydrogen bonds formed
  - First codon = start codon
- Two amino acids joined by condensation, forming a peptide bond
  - Using energy from ATP
- tRNA detaches (without its amino acid), ribosome moves along mRNA to next codon
- Continues until stop codon (polypeptide released)



Leave blank to allow students to glue.

ABO

Knowledge Organiser: CELL STRUCTURES

Ribosomes

Ribosomes are involved in protein synthesis. They are made of a large and a small subunit constructed from rRNA and protein.

They occur in 2 different sizes - the smaller 70s in prokaryotes and 80s in eukaryotes.

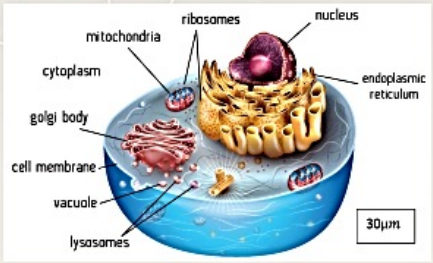
Endoplasmic reticulum

These are a series of flattened sacs - double membraned cisterna leading on from the nuclear envelope.

1 Rough Endoplasmin Reticulum - Covered in ribosomes for protein synthesis, cisterna then transport the protein.

2 Smooth Endoplasmin Reticulum - Synthesis and transport of lipids.

Animal cell



Vacuole

Contains cell sap, surrounded by the tonoplast membrane.

Cell Wall

A structure made from cellulose microfibrils and pectin.

- Is fully permeable for transport of substances.
- Provides strength to the plant.
- Communication through the cell wall via plasmodesmata.

Golgi body

The golgi body modifies and packages proteins.

- **Produces secreting enzymes**
- **Secreting carbohydrates**
- **Produces glycoproteins**
- **Transporting-storing lipids**
- **Forms lysosomes and digestive enzymes.**

Centrioles

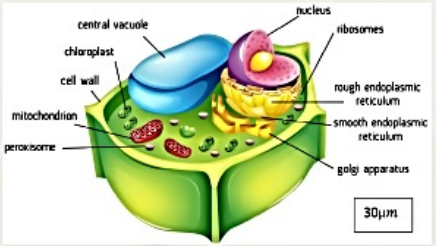
Found in animal cells. They are 2 rings of microtubules that form the spindle in cell division.

Cell Theory

Cell theory states that new cells are formed from other existing cells and that the cell is a fundamental unit of structure, function and organisation in all living organisms.

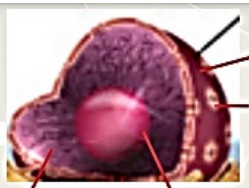
Animal and plant cells are **eukaryotic**. They contain membrane-bound organelles, DNA is found within a nucleus, **cell walls are made of cellulose, ribosomes are 80s** and aerobic respiration occurs within mitochondria.

Plant cell



Endosymbiotic theory

The presence of 70s ribosomes and DNA in both mitochondria and chloroplasts suggests they were once free-living cells engulfed by ancient bacteria and developed a symbiotic relationship with them.



Nucleus

Nuclear envelope

A double membrane with pores that allows mRNA and ribosomes out of the nucleus.

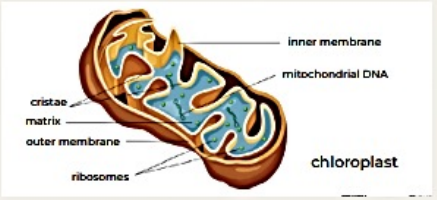
Chromatin

DNA coils bound to protein- codes for protein synthesis.

Nucleolus

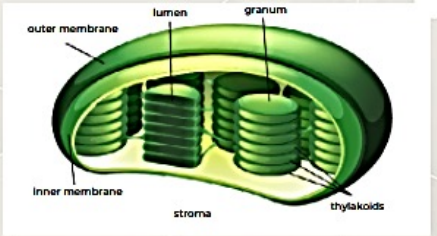
rRNA and ribosomes made here.

Mitochondria



Aerobic respiration occurs in the mitochondria. They are cylindrical in shape for a large surface area and reduced diffusion distance.

Chloroplasts



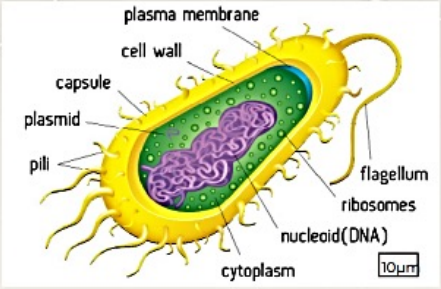
The thylakoids of the chloroplasts contain chlorophyll, a pigment that traps light

1 kilometre (km) = 1000 meters (m)	1 metre(m) = 1000 millimetres (mm)	1 millimetre (mm) = 1000 micrometres (µm)	1 micrometre (µm)= 1000 nanometres (nm)

Leave blank to allow students to glue.

Knowledge Organiser: CELL STRUCTURES

Prokaryotes



Bacteria are prokaryotic cells. They contain no membrane bound organelles and this gives some essential differences between prokaryotes and eukaryotes.

Prokaryotes	Eukaryotes
DNA free in cytoplasm	DNA in nucleus
Ribosomes 70s	Ribosomes 80s
Peptidoglycan cell wall	Cellulose cell wall
Mesosome for aerobic respiration	Mitochondria for aerobic respiration

Viruses

Nucleic acids inside DNA or RNA

Capsid, a protein coat.

A virus is not a living thing, it is not a cell. It has no cytoplasm or organelles. It injects its genetic material into a living cell which then creates more virus particles.

Microscopy

Viruses are too small to be seen under a light microscope. A light microscope can be used to view eukaryotic and prokaryotic cells.

Light microscopes can magnify up to x2000 however the ones in school are likely to have a maximum magnification of x400 or x1000.

Electron microscopes have a much higher magnification of over x100,000. They also have a better resolution - the ability to distinguish between different structures.

Magnification of microscope drawings

A - Actual size (measured using the eyepiece graticule)

I - Image size measured using a ruler

M - Magnification. How many times bigger the drawn image is than the actual size

Calibrating the microscope

1. Under a particular magnification, line up the smaller eyepiece graticule and larger stage micrometre.

2. Count how many eyepiece units (epu) fit into the stage units. In this example, the scales clearly line up. 80 epu fit into 20 stage units.

3. The size of each stage micrometre unit is known (shown on the slide), e.g. 0.1mm

4. Calculate using the data the size of each epu.

$\frac{20}{80}$ x 0.1 = 0.025mm

5. Convert 0.025mm into µm. E.g. 0.025mm x1000 = 25µm

6. Remove the stage micrometre slide and replace with a slide you want to observe. You can now measure the specimen on your slide as you know under this magnification each eyepiece unit is 25µm in length.

7. Draw an image of your specimen, use clear lines, no shading and label structures clearly.

Organisation of eukaryotes

Cell	Cells are the basic unit of life.
Tissue	A group of cells with the same structure and function working together.
Organ	A group of tissues working together to perform a particular function.
Organ system	A system of organs working together with a particular role.
Organism	All the systems working together forming a discrete individual.

Tissue

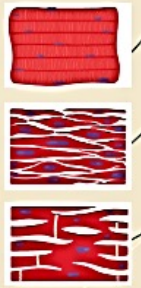
Epithelial tissue - continuous layers of cells on internal and external surfaces.

Cuboidal - simplest, one cell thick, e.g. PCT kidney

Columnar - elongated, have cilia e.g. trachea

Squamous - flattened e.g. alveolar walls

Muscle tissue - tissue able to contract



Skeletal - striated (striped), voluntary, attached to bones for locomotion.

Smooth - spindle shaped cells, no stripes, involuntary e.g. skin and digestive tract.

Cardiac - heart mus-cle, striated, short fibres, contracts with-out nerve stimulation. Does not tire.

Connective tissue - separates tissues and organs

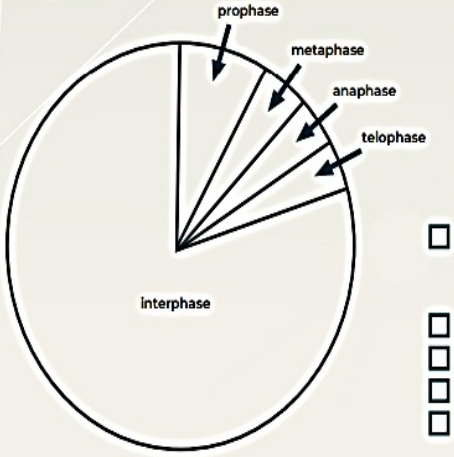
Elastic and collagen

Blood bone and carti-lage

Leave blank to allow students to glue.

Knowledge Organiser: CELL DIVISION

Cell cycle



The cell cycle is a natural cycle of events that occur in the life of a cell.

During most of the cell cycle the cell remains in a phase called **interphase**.

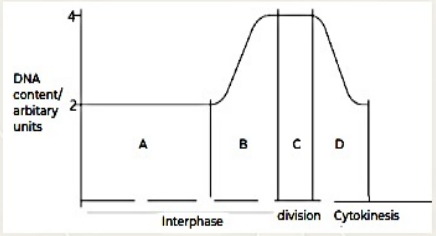
Interphase is a time of high metabolic activity for the cell:

During section A of the graph below, the following occur:

- ☐ **Replication** organelles like mitochondria and chloroplasts which have their own DNA.
- ☐ **Making** new organelles.
- ☐ **Synthesis** of ATP.
- ☐ Synthesis of proteins.
- ☐ Increase in cell size.

During section B:

- ☐ **Replication** of DNA.



IPMAT-can be used to remember the order of the phases in mitosis:

Cytokinesis

Where telophase is the division of the chromosomes, cytokinesis is the division of the cytoplasm to create the 2 new genetically identical cells.

In plant cells there are some differences:

- There are **no centrioles** in plant cells.
- In cytokinesis, **a cell plate** (droplets of cell wall material) develops **from the centre out** instead of cleavage from the outside in as in animal cells.

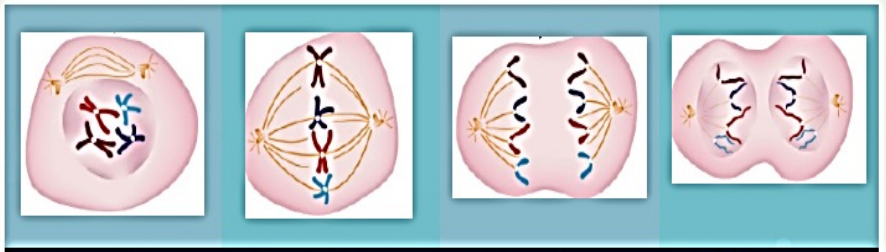
Mitosis

The significance of mitosis is that it produces cells which are genetically identical to the parent cell, giving genetic stability.

This is cell division for:

- growth
- repairing damaged cells
- replacement of old, worn out cells
- asexual reproduction.

The cell cycle is controlled by genes. If the genes that regulate the cell cycle are damaged, uncontrolled mitosis can occur. This rapid replication of cells can form tumours, leading to a disease called cancer. These genes that cause cancer are called **oncogenes**.



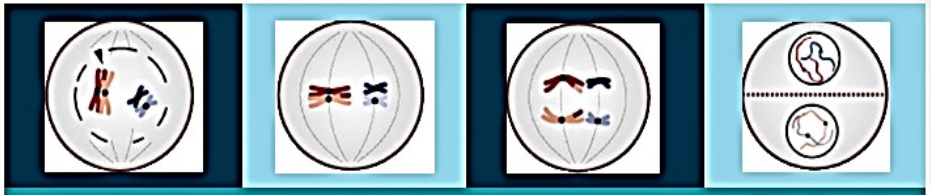
Prophase	Metaphase	Anaphase	Telophase
• Chromosomes condense and become visible • Centrioles move to opposite sides of cell • Spindle forms from microtubules • Nuclear envelope disintegrates.	• Centromeres of chromosomes attach to spindle and line up on the equator.	• Spindle fibres shorten • Centromere separates and individual chromatids are pulled to the poles centromere first.	• Spindle breaks down • Chromosomes uncoil • Nuclear envelope reforms.

Leave blank to allow students to glue.

Meiosis

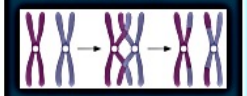
This takes place in reproductive organs and the significance of this process is that it produces cells which are haploid for sexual reproduction.

Meiosis occurs in 2 different cell division events following interphase. The first division is different to the phases in mitosis.



Prophase I

- Differs from prophase in mitosis as chromosomes form **bivalents**, pairs of homologous chromosomes.



- Arms of the chromatids may cross over forming **chiasmata** where genetic material can be exchanged between homologous chromosomes increasing the variation in inherited genomes.

Metaphase I

- **Homologous chromosomes** arrange themselves in pairs along the equator.
- **Independent assortment** occurs here where the homologous chromosomes from parent 1 and parent 2 arrange themselves randomly along the spindle facing each pole.

Anaphase I

- The chromosome bivalents separate as each chromosome is pulled by its centromere (which does not split) towards the opposite pole.

Telophase I

- Nuclear envelopes reform around the chromosomes at the poles.
- In meiosis prophase II occurs after telophase I.

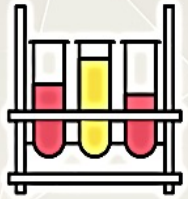
Prophase II

Metaphase II

Anaphase II

Telophase II

Events occur in each new nucleus in the second phase of meiosis exactly as they do in mitosis. Finally, cytokinesis occurs resulting in 4 genetically varied cells.



Comparing mitosis and meiosis

	Mitosis	Meiosis
number of nuclear divisions in the process	1	2
number of cells formed	2	4
ploidy of parental cells/nuclei	2n- Diploid	2n- Diploid
ploidy of daughter cells/nuclei	2n- Diploid	n- Haploid
genetic nature of daughter cells/nuclei	Genetically identical	Genetically different
pairing of homologous chromosomes	No	Yes - to form bivalents
crossing over	No	Yes - Chiasmata formed
segregation of homologous chromosomes.	No	Yes - bivalents separate.

Knowledge Organiser: CELL DIVISION

Leave blank to allow students to glue.

Knowledge Organiser: MEMBRANES AND TRANSPORT

Fluid mosaic model

Singer and Nicholson proposed this model for the structure of the cell membrane in 1972.

Fluid - because the phospholipid molecules within a layer can move relative to each other.

Mosaic- because the proteins within the phospholipid layer are of different sizes and shapes and form different patterns.

Phospholipid bilayer

The **hydrophilic phosphate heads** of the phospholipids form the outer and inner surface of the cell membrane.

The **hydrophobic fatty acid tails** of the phospholipids point towards each other.

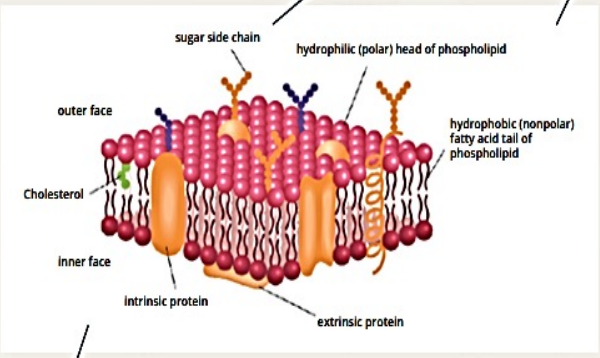
Extrinsic proteins

Found on **either outer surface** of the bilayer.

Those with sugars attached **(glycoproteins)** form the glycocalyx layer of the membrane which has a role in **cell to cell recognition** or **hormone receptor sites.**

Cholesterol

Found between the phospholipids making it more rigid and stable.



Permeability

Cell membranes are **selectively permeable**. They only allow certain molecules through.

Permeability can be increased by:

- **Temperature** - increases above 40°C increase vibrations of phospholipids, moving them further apart.
- **Organic solvents** - dissolve phospholipids.

Lipid soluble substances (vit A) and small molecules (O^2 and CO^2) can dissolve and move **directly through the phospholipid bilayer.**

Water soluble substances (glucose, ions, all polar molecules) cannot pass through the hydrophobic fatty acid tails and so **must use intrinsic proteins to pass though.**

Intrinsic proteins

These proteins span the whole phospholipid bilayer and can form:

Channel proteins - pores lined with polar (hydrophilic) groups that allow charged ions through, e.g. Na+

Carrier proteins - allow larger polar molecules through, such as water-soluble **sugars** and **amino acids**. Binding of the molecules changes the shape of the protein moving the substance into or out of **the cell.**

The polarity of proteins determines if they sit on the membrane (extrinsic) or through it (intrinsic).

Water potential (ψ)

0 Pure water

-300

Some dissolved solutes

-800

The more solute in solution the more negative the water potential

Osmosis

The diffusion of water from a region of high water potential to low water potential across a selectively permeable membrane.

Water potential (ψ) is the tendency of water molecules to move. The solute potential is the osmotic strength of the solution. As shown to the left, the water potential of pure water is 0 and becomes more negative as the concentration of the solution increases.

In plant cells: $\psi = \psi p + \psi s$

Turgid(firm) cells - in **a hypotonic** (less concentrated solution) cells take up water by osmosis. The pressure potential of the cell increases as the cytoplasm pushes on the cell wall.

Incipient plasmolysis - A cell in this state has lost enough water for the cell membrane to start being drawn away from the cell wall. This lowers the pressure potential to 0.

Plasmolysed - Cells in hypertonic (more concentrated) solutions become **flaccid** (floppy).

In animal cells: It is important animal cells are in an **isotonic** solution (same concentration of dissolved solutes inside and outside cell) as they lack a cell wall. Cells can **burst** in hypotonic and **shrink** in hypertonic solutions due to osmosis.

Leave blank to allow students to glue.

Knowledge Organiser: MEMBRANES AND TRANSPORT

Diffusion

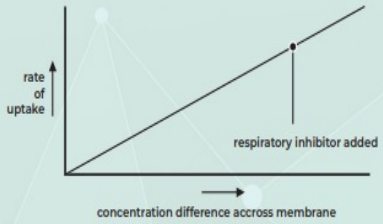
Simple diffusion

Diffusion is the movement of molecules from a region of high concentration to a region of low concentration down a concentration gradient. It is a **passive process** and so requires no energy. **Simple diffusion occurs through the phospholipid bilayer.**

Diffusion rate is increased by:

- higher concentration gradient
- thinner membrane/shorter diffusion distance
- larger surface area
- smaller molecules
- being non-polar or fat soluble
- increased temperature.

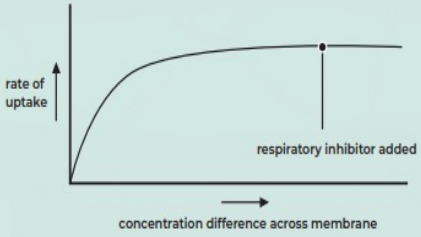
The graph shows that as the concentration on one side of the membrane increases there is a directly proportional increase in the rate of diffusion. Respiratory inhibitors like cyanide (leading to lack of energy) has no effect on the rate of diffusion.



Facilitated diffusion

This is the process of diffusion but for polar molecules or ions that cannot pass directly though the phospholipid bilayer.

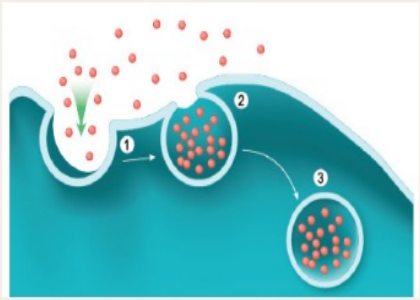
All of the **same rules apply as for diffusion**, the only difference is that substances enter the cell through **protein channels.** The effect of this is shown in the graph below. A continuing increase in the concentration will eventually lead to a maximum rate being reached due to the limiting effect of the number of channels available. This is a **passive process, therefore**, the **respiratory inhibitor has no effect.**



Co-transport

This is a type of facilitated diffusion where two different substances use the same carrier protein at the same time.

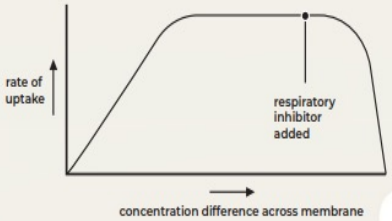
E.g. a molecule of glucose and 2 sodium ions attach to a carrier protein on the outer side of the membrane. This changes the shape of the protein sufficiently to flip them to the inside of the membrane. They can then diffuse separately through the cell.



Active transport

This moves molecules against a concentration gradient, i.e. from where they are in lower concentration to where they are already at a higher concentration. This process requires energy in the form of ATP from respiration. The ATP activates carrier proteins to move molecules across the cell membrane.

As this relies on ATP the addition of a respiratory inhibitor or lack of oxygen will also prevent transport as there will be no ATP available.



Bulk transport

Endocytosis - 2 main types

- **Phagocytosis** - solids enter the cell.
- **Pinocytosis** - liquids enter the cell.

1 Plasma membrane folds inwards

2 Plasma membrane engulfs the material.

3 Vesicle formed from plasma membrane enters the cell.

Exocytosis

3 Vesicle formed from the golgi moves towards the plasma membrane.

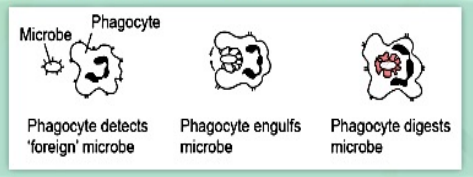
2 Vesicle fuses with plasma membrane

1 Vesicle contents empty out of cell.

Leave blank to allow students to glue.

Knowledge Organiser: IMMUNITY

Body defences

Body part	Defence mechanism
Skin	A tough barrier. Strong connective tissue maintained by vitamin C that prevents microbes entering the body. Skin flora competes with pathogenic bacteria to avoid infection.
Lysozyme	An enzyme in tears, saliva and stomach acid that kills bacteria.
Ciliated mucous membranes	Traps microbes in inhaled air. Passes up the trachea for swallowing and destruction in the stomach.
Blood clotting	Seals wounds in skin quickly to prevent infection.
Inflammation	Raised temperature is unfavourable to microbes and increase in blood flow delivers phagocytes to the area.
Blood - white blood cells called phagocytes kill invading microbes in a process called phagocytosis.	

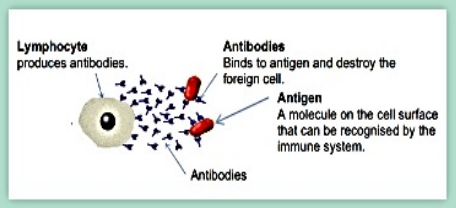
Antibodies

These are produced by white blood cells called lymphocytes.

Antibodies are proteins (globulins). They are Y shaped and formed from four polypeptide chains with two binding sites.

They are specific to the antigen and they bind to form an antigen-antibody complex. This renders the antigen inactive by:

1. agglutination
2. marking for phagocytosis.



Antibiotics

These drugs don't affect the host cells but disrupt bacterial metabolism. They work in two ways:

Bacteriostatic: prevents the growth of bacteria.

Bactericidal: kills bacteria.

Penicillin

- Peptidoglycan bacterial cell walls are strengthened by polysaccharide cross-linked by amino acids. This stops osmotic lysis.
- Penicillin affects the formation of the cross links by inhibiting the enzyme that makes them. The wall is weakened and osmotic changes can cause cells to burst.
- Gram negative bacteria have an outer lipopolysaccharide layer that protects the cells from penicillin.

Tetracycline

Tetracycline acts as a competitive inhibitor of the second anticodon-binding site on the 30S subunit of bacterial ribosomes. It prevents the binding of a tRNA molecule to its complementary codon.

This prevents protein synthesis common to all bacteria.

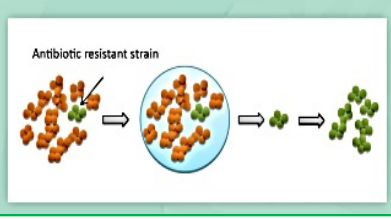
Tetracycline is a broader spectrum antibiotic.

As viruses have no metabolic pathways, they are unaffected by antibiotics.

Antibiotic resistance

Overuse of antibiotics has led to the development of antibiotic resistance.

1. Bacteria divide rapidly and have a high mutation rate.
2. Some mutations confer resistance to antibiotics. Overuse of these antibiotics gives the resistant strain a selective advantage.
3. Numbers of the resistant strain increase, making infections more difficult to treat with the usual antibiotics.



Leave blank to allow students to glue.

Knowledge Organiser: IMMUNITY

Humoral immune response

1. Stem cells in the bone marrow make **B lymphocytes** that mature in the spleen and lymph nodes and have receptors for the detection of specific antigens on the surface of foreign cells.
2. When the B lymphocytes are activated by a corresponding antigen, they divide rapidly forming **antibody secreting plasma cells**. This **clonal expansion** is increased by the cytokines from the cell mediated response.
3. B lymphocytes also make **memory cells** that remain in the bloodstream and divide rapidly if the antigen is encountered again.

Cell mediated immune response

1. Stem cells in the bone marrow make **T lymphocytes**, which are activated in the **thymus gland**.
2. Detecting a foreign antigen causes proliferation of T lymphocytes as:

T killer cells
Cause lysis of target cells.

T memory cells
Remain in bloodstream.

T helper cells
Release **cytokines.**

Cytokines stimulate the clonal expansion of B cells and to produce antibodies. Cytokines activate phagocytes to engulf and digest the foreign cells.

Immunity

Active: individual produces antibodies.

Protection is long lasting due to production of antigen specific memory cells.

Natural	**Artificial**
Following an infection.	Following vaccination.

Passive: Individual receives antibodies from someone else.

Protection is short lived as no memory cells are produced and the antibodies themselves identified as foreign and destroyed.

Natural	**Artificial**
Antibodies are transferred to the foetus via the placenta, or to the baby in breast milk.	Pre-synthesised antibodies are injected into an individual, e.g. tetanus antitoxin.

Vaccinations

- A vaccination stimulates artificial active immunity in an individual.
- A vaccine must contain an immunogenic antigen that stimulates a strong immune response.
- Vaccinations for pathogens that exhibit low levels of antigenic variation can protect an organism after one immunisation, e.g. Rubella.
- Some pathogens have many antigenic types and mutate frequently. These require seasonally repeated immunisations.

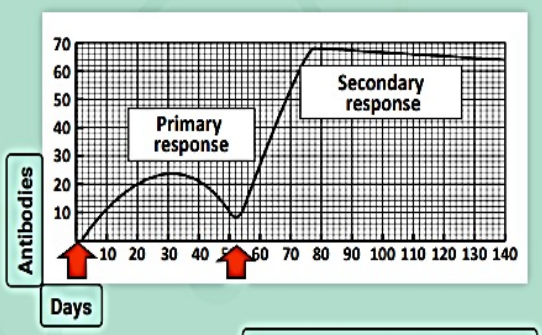
Immunisation programmes require consideration of the following:

- cost vs effectiveness of the vaccine
- protection of the individual compared to protection of the community
- the rights of the individual when considering mandatory compared or voluntary programmes
- side effects.

Primary and secondary immune responses

Primary response

1. On first exposure to the antigen, there is a latent period when antigen presenting cells (including macrophages) carry out phagocytosis and incorporate foreign antigen into their cell membranes.
2. T helper cells detect these antigens and secrete cytokines that stimulate B cells to undergo clonal expansion and stimulate macrophages to carry out phagocytosis.
3. Some B cells then differentiate to become antibody-secreting plasma cells with short lives. Others become long-lived memory cells that retain the ability to undergo mitosis in case of secondary infection.



Low level of antibody is secreted, which clears the infection and symptoms over a period of 2 – 3 weeks.

Antibody levels increase to between **10** and **100 times greater** than the initial response in a **very short time frame**. **Antibody levels stay high for longer** and **no symptoms** develop.

Secondary response

Following re-exposure to the same antigen, there is a very short latent period due to the presence of memory cells.

Only a very small amount of antigen is required to stimulate rapid production of plasma cells.

Leave blank to allow students to glue.