Biology semester 1- Unit 2

Experimental Design

All scientific reports must include;

- TITLE: shows the relationship between the independent variable (IV) and the dependent (DV), e.g. *the effect of IV on the DV*
- AIM: describes the relationship between the IV and the DV in terms of investigation, e.g. *to see the effect of IV on the DV*
- HYPOTHESIS: specifies the relationship between IV and DV, e.g. *if the IV is *the change*, then the DV will *change**
- VARIABLES: an element that can be changed
  - → Independent- the variable that is changed
  - → Dependent- the variable that is measured
  - → Controlled-the variable that remains constant
  - → Uncontrolled-the variables that are not kept the same for both
- EXPERIMENTAL GROUP: the group given the active ingredient
- CONTROL GROUP: the group given the placebo
- EQUIPMENT: a list of all equipment and the specific quantities needed
- RISK ASSESSMENT: used to help identify possible risks and to think about the measures taken to prevent any harm, e.g. *scalpel*
- METHOD: past tense, specify equipment and amounts, stepwise(1,2,3etc), and repetition (multiple trials)
- RESULTS: organise into an easy to read format, tables and graphs etc
  - → Data type- Primary (data collected by yourself), Secondary (data collected by another)
  - → Quantitative- when recordings have numerical values
  - → Qualitative- when recordings are made as descriptions

	Independent Changed	Dependant Measured
Graph	x	y
Table	1st Column	2nd Column

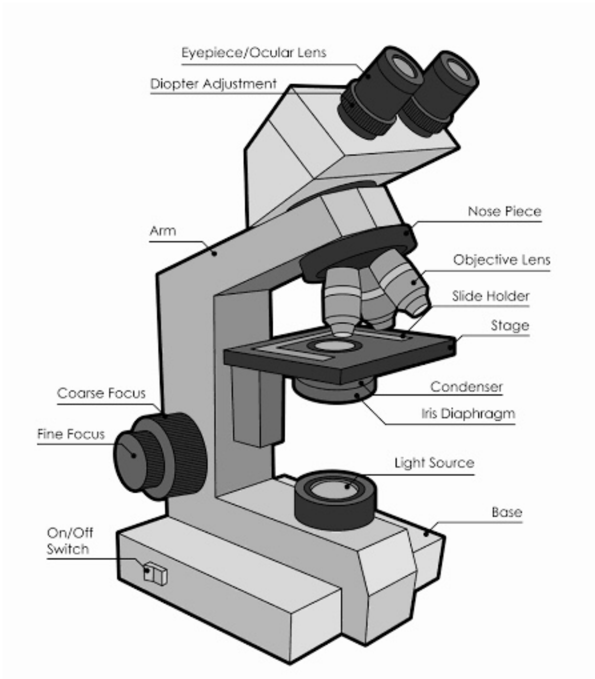
→ SOURCES OF ERROR: there are three types
  - → Human error- usually avoidable (reading the wrong scale, making a wrong calculation etc)
  - → Random error- based on the inability of humans to make measurements with absolute precision, reduced by taking averages (stopping a stopwatch as soon as a person has finished a race etc)
  - → Systematic error- difficult to detect, cannot be analysed statistically due to all the data being off in one direction (too high or too low etc)

→ CONCLUSION: brief, restate the initial hypothesis, state weather the hypothesis was supported, include final averages of results

→ GRAPH TYPES;
- → Line graph; used to track changes over short and long periods of time. When smaller changes exist, line graphs are better to use than bar graphs. Line graphs can also be used to compare changes over the same time period for more than one group
- → Bar graph; used to compare things between different groups or to track changes over time, bar graphs are best when changes are larger.
- → X-Y plot; used to determine the relationship between two different things, the x-axis is used to measure one variable and the y-axis to measure another. If both variables increase at the same time, they have a positive relationship but if they both decrease, they have a negative relationship.

Cells and Multicellular Organisms

→ Microscopes



Part	Function
Eyepiece/dioptre adjustment	Directs light from the image into the eye
Coarse Focus Knob	Changes the distance between the stage and the objective lens
Fine Focus Knob	Makes small adjustments to the focus (sharpens image)
Objective Lens	Magnify the size of the image made from the objective on the slide
Iris Diaphragm	Changes the amount of light shining through the object on the slide
Light source	Allows light to shine through the slide so you can see the magnified slide
Base	Supports the microscope

Arm	Used to support the microscope when carried
Stage	Hold the slide containing the specimen
Stage Clips	Hold the slides in place on the stage

- Total Magnification

$$Total\ magnification = \ ocular\ lens * \ objective\ lens$$

- Field of view (FOV) is the maximum area visible through the lenses of a microscope, represented by a diameter.

$$HP\ diametre = \frac{LP\ Diameter * \ LP\ Magnification}{HP\ Magnification}$$

- Estimating the size of a specimen

$$Length\ of\ one\ cell = \frac{(diameter\ of\ FOV)}{Estimated\ number\ of\ cells\ that\ cross\ diameter}$$

- **<u>Preparing a wet mount slide</u>**

→ With an onion wet mount slide;

1. Place a drop of water on the clean slide
2. Peel a thin (plastic wrap thin) piece of onion skin/membrane.
3. Place the onion membrane on the water droplet and prepare the coverslip
4. Placing the coverslip at a 45° angle in order to rid it of any air bubbles gently place and use a paper towel to dab out any possible air bubbles
5. When there are no air bubbles place a couple drops of methylene blue on the edge of the coverslip using the paper towel to evenly distribute it.

→ Multicellular organisms

2.17 Multicellular organisms have a hierarchical structural organisation of cells, tissues, organs and systems

Level of organisation	**Examples**
Multicellular organism	Plant, animal etc
Systems	Respiratory and circulatory system etc
Organs	Heart, lungs, roots, leaves etc
Tissues	Blood tissue, lung tissue etc
Cells	Nerve cell, muscle cell etc
Organelles	Nucleus, chloroplast, mitochondria etc
Molecule	Water, protein, sugar etc
Atoms	Carbon, hydrogen, oxygen etc

The term cell is used to describe the basic unit of any organism, whether it is the only unit, unicellular, or one of many units, multicellular, making up an organism. The table above shows the organisation in which cells fit into living things.

Definitions

- → Cell: basic unit of structure and function in organisms
- → Tissues: group of similar cells that work together to perform a specific function
- → Organs: structure made of different types of tissues that perform a function
- → Organ systems: group of organs that work together to perform a function
- → Organism: a complete individual living being
- → Unicellular: consisting of one cell
- → Multicellular: consisting of two or more cells

Cell theory states that; all living things are made of cells, all cells come from pre-existing cells and each organism is made of one or more cells.

- → Prokaryotic and Eukaryotic Cells

2.2 Prokaryotic and eukaryotic cells have many features in common, which is a reflection of their common evolutionary past, but prokaryotes lack internal membrane-bound organelles, do not have a nucleus, are significantly smaller than eukaryotes, usually a single circular chromosome, and exist as single cells.

2.4 Eukaryotic cells carry out specific cellular functions in specialised structures and organelles, including cell membrane, cell wall, chloroplasts, endoplasmic reticulum, Golgi apparatus, lysosomes, mitochondria, nucleus, ribosomes, vacuoles.

Prokaryotic cell	**Eukaryotic cell**
Unicellular	Usually multicellular
Small (1-10 micrometres)	Large (10+ micrometres)
No membrane-bound organelles	Has membrane-bound organelles
Circular chromosomes	DNA is linear
Asexual reproduction (binary fusion)	Mitosis and meiosis (sexual reproduction)
No cytoskeleton	
Two domains (bacteria/archaea)	

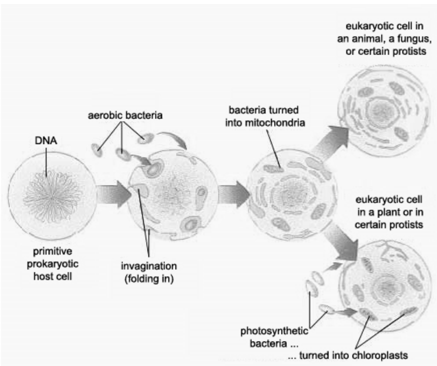
Organelle	Structure/Function
Nucleus	→ Spherical body that contains the cell's DNA. → Surrounded by double nuclear membrane, pierced by tiny pores which regulate the passage of substances between the nucleus and cytoplasm, allow communication → Controls and coordinates all cell activities
Nucleolus	→ Dense, granular region within the nucleus, containing a large amount of nucleic acid (RNA) → Responsible for the manufacture of ribosomes
Cell plasma membrane	→ Selective barrier (only allows certain molecules in or out), also known as semi-permeable → Thin, and surrounds the contents of the cell → Separates the cells internal environment from the exterior environment → Made of a double layer of phospholipids (fluid mosaic model)
Lysosome	→ Small, membrane vesicles (sacs) that contain enzymes → The enzymes break down large molecules (fats, proteins, carbohydrates) and recycle the unwanted material inside the cell
Golgi Body	→ Consist of stacks of membrane sacs and vesicles → Revive, sort, store and secrete materials → Have a large surface membrane- allows for a greater number of reactions
Mitochondria	→ Have double membrane, with cristae (folds) to increase surface area, allowing for respiration rate to increase → Amount depends on the needed energy → Responsible for producing energy needed for a cell via cellular respiration (aerobic)
Endoplasmic Reticulum	→ Large network of membranes throughout cells, responsible for the processing and the transport of proteins → Is usually continuous with outer nuclear membrane, providing pathways between the nucleus and cells environment (intracellular transport) → Immense folding of sheets of membranes, increasing surface area → If it has ribosomes attached, it is Rough ER and if not, it is Smooth ER → Smooth ER produces lipids for membranes
Ribosomes	→ Small, appearing as dense granules → Small size and round shape increase their surface area, for easy interaction with chemicals during their functioning. → Responsible for protein synthesis, necessary for the cell to function (link amino acids to make proteins) → Free in the cytoplasm or attached to the ER
Centriole	→ Cylindrical structures near nucleus → Only seen during cell division
Cytoplasm	→ Appears as thick, jelly-like clear fluid with particles → Site for chemical reactions → Cytosol makes the fluid part
Chloroplast	→ Site for photosynthesis

Cell Wall	→ Provide extra support and protection → Made of cellulose
Temporary vacuole	→ Temporary storage sac
Large permanent vacuole	→ Liquid-filled space that stores various materials

Plant cell	**Both**	**Animal cell**
Cell wall	Cell membrane	Centrioles
Chloroplasts	Mitochondria	Cytoskeleton
Large vacuole	Most organelles	Small vacuoles

- Endosymbiosis; A mutually beneficial relationship in which one organism inhabits the body of another

Endosymbiotic Theory states that eukaryotic cells were formed when a bacterial cell was ingested by another primitive prokaryote, with phagocytosis, the bacteria would have escaped being digested and would have instead form a symbiotic relationship with its host. Scientists believe that mitochondria and chloroplasts also evolved through endosymbiosis, to this day these organelles make copies of themselves like bacteria (only coming from pre-existing ones) Both have two membranes, the outer derived from the host membrane and the inner from the ingested bacteria.



Mitochondria;
→ Evolved from bacteria that carried out aerobic cellular respiration
→ Similar size to bacteria cells
→ Has own genetic material
→ Two membranes (one bacterial, one from host)

Chloroplast:
→ Once cyanobacteria (can photosynthesise)
→ Own genetic material/ribosomes
→ May explain why plant cells have cell walls (no need for nutrient engulfing

→ Cells need energy

2.1 Cells require energy inputs including light energy or chemical energy in complex molecules, and matter, including gases, simple nutrients and ions, and removal of waste to survive.

Provision of energy is vital to ensure that all essential life processes take place; making new molecules, building membrane and organelles, moving molecules in and out of the cell (homeostasis), and movement.

→ Prokaryotic processes;
  - → autotrophs (producers of energy) photosynthesis and chemosynthesis
  - → heterotrophs (consumers of energy) uses enzymes that are attached to the cell membrane to produce energy

→ Eukaryotic processes;
  - → Autotrophs, photosynthesis
  - → Heterotrophs, cellular respiration

Biomacromolecules & Transport

→ Biomacromolecules

2.1 Biological molecules are synthesised from monomers to produce complex structures, including carbohydrates, proteins and lipids.

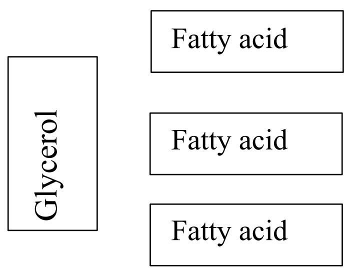
→ Every living cell is involved in synthesising complex molecules that are needed to build body parts and maintain biochemical processes (e.g. communication, transforming energy and relaying information)

→ Some organisms synthesise (produce) their own biomacromolecules from simple substances (autotrophs)

→ Other organisms synthesise from ingested organic compounds (heterotrophs)

→ Four main classes of complex molecules based on composition and structure: Carbohydrates, Lipids, Proteins and Nucleic Acids. Carbohydrates, proteins and nucleic acids are built by linking smaller repeating molecules, monomers, which then make polymers. Lipids are not polymers due to them being composed of distinct chemical groups of atoms

Molecule	**Function**	**Basic unit**	**Examples**
Carbohydrates	→ Energy source → Structural components	Glucose	→ Monosaccharides: single-sugar molecule (e.g. glucose which is the

	→ Made up of carbon, hydrogen and oxygen (ratio 1:2:1)		simplest that can be absorbed) → Disaccharide: double-sugar molecules (e.g. sucrose) → Polysaccharide: 3+ sugars combined (e.g. cellulose and starch) series of glucose molecules chemically bonded together
Proteins	→ Repair and growth → Made up of Carbon, Hydrogen, Oxygen and Nitrogen (sometimes sulphur and/or phosphorus)	Amino acids	→ 20 'standard' amino acids in eukaryotes, 9 of which are 'essential' and cannot be synthesised in the body (ingested) → 2 'non-standard' amino acids in some simple microbes → Linked with peptide to form proteins → 10+aminoacids=polypeptide → Whole set of proteins produced by a cell is called its proteome → Plants can make their own
Fats and lipids	→ Energy storage → Structural component of cell membrane → Specific biological functions (transmission of chemical signals both within and between cells)	Fatty acids and glycerol	→ Triglycerides- fats stored in body 
Nucleic acids	→ Deoxyribonucleic acid (DNA) → Ribonucleic acids (RNA)	Nucleotide	→ DNA- composed of a double helix → Nucleotide make up; sugar, phosphate and nitrogenous base → RNA is a single strand → RNA can exist as mRNA tRNA and rRNA (messenger, transfer, ribosomal

→ Cell membrane

2.5 – 2.6 The currently accepted model of the cell membrane is the fluid mosaic model, the cell membrane separates the cell from its surroundings and controls the exchange of materials, including gases, nutrients and wastes, between the cell and its environment.

- → Homeostasis; the maintenance of a constant internal environment such as temperature, water levels, carbon dioxide, despite external change.
- → Cell membranes maintain homeostasis through interacting with their surrounding environment and surrounding cells. Substances required by cells for functioning must be able to move into the cell (e.g. oxygen, carbon dioxide and nutrients such as sugars, amino acids, glycerol and water)
- → Cell membrane forms a boundary between the internal and external environment of the cell, the exchange depends on whether an organism is unicellular or multicellular, unicellular exchange takes place with outside environment, multicellular exchange takes place with extracellular fluid.
- → Internal environment is distinct from external, cells are protected by extracellular fluid (maintained by lungs, kidneys, liver etc) Plasma membrane is responsible for maintaining the differences in carbon, oxygen etc.

<u>Cell membrane structure</u>;

- → Cell membranes are semi-permeable as they only allow certain molecules to pass through them. Microscopic pores in the cell membrane determine what molecules may or may not enter
- → The pores of the cell membrane may restrict due to size, meaning large molecules (if they are to get into the cell, require special assistance)
- → Movement occurs when substances need to pass from one to another or when substances are exchanged between cells
- → The chemical structure of a cell membrane cannot be seen, even with an electron microscope, the current accepted understanding is based on the fluid mosaic model (proposed by J.Singer and G.Nicholson in 1972) The model proposes a 'lipid sea' with many and various proteins floating on it (primarily phospholipids, cholesterol and proteins)

<u>The lipid component;</u>

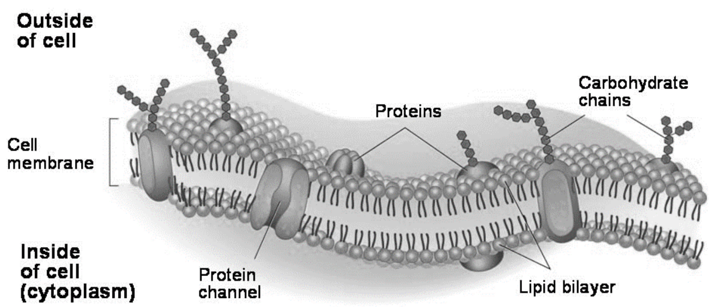
- → The 'fluid' part of the cell, which is composed of two layers of phospholipids, termed a bilayer.
- → Have hydrophobic tails, water hating, angled towards each other.
- → Have hydrophilic heads, water loving, positioned facing outwards (towards the cytoplasm and the other to the external environment)

→ Phospholipids are amphipathic, meaning they have both hydrophilic and hydrophobic regions. This structure forms the basis of the cell membrane and all other membranes within cells.
→ Allows for the membrane to be flexible and repairable, also growth and change of shape.
→ Cholesterol, a lipid embedded among the phospholipids, helps minimise the effects of temperature on fluidity. It makes sure the membrane isn't too stiff or flexible, maintains the membranes stability, phytosterol in plants/bacteria.

Protein component

→ The 'mosaic' part of the cell membrane is composed of proteins, they are suspended and scattered throughout the lipid bilayer. Some penetrate all the way through the bilayer forming channels, those allow for some material to cross through. Others are only partly embedded in the bilayer, some fixed and others who can move about freely.
→ Proteins determine most of the membrane's specific functions. Some proteins function as pores, some form active carrier systems or channels for transport, some have carbohydrates attached to form one such as a glycoprotein, this allows for cell recognition.

Protein	Roles
Adhesion	→ Link cells together
Transport	→ Act as a passageway that allow specific substance to move across the membrane → E.g. Movement of ions across membrane when the nerve is stimulated
Receptor	→ Involved in cellular communication → Bind hormones and other substances that cause change to cell activity → Different cells have different receptor proteins → Respond only to certain signals for specific functions
Recognition (glycoprotein)	→ Unique to each individual → Act as markers called antigens → Allow immune system to distinguish between 'itself' and 'foreign cells'



→ Cell Transport

2.7 Movement of materials across membranes occurs via passive processes, including diffusion, facilitated diffusion, osmosis and active processes, including active transport, endocytosis and exocytosis

→ The main inputs of a generalised human cell are oxygen, nutrients, and vitamins. The main wastes of a generalised human cell are carbon dioxide, lactic acid, and water.
→ The main inputs of a generalised plant cell are carbon dioxide, water and glucose. Its main outputs are oxygen and excess glucose.

<u>The movement of molecules across cell membranes</u>

→ The permeability of a membrane depends on the molecules size, charge (ions) and lipid solubility
→ Small molecules move across the membrane fast, these include carbon dioxide, water and oxygen.
→ Water soluble molecules have difficulty penetrating a membrane but lipid soluble don't. Molecules that have low permeability rely on the carrier proteins to transport them across the cell membrane.
→ Electrically charged molecules (ions) are not very soluble in lipids, therefore have low membrane permeability, and neutral molecules have high permeability
→ Although water is a charged molecule, the membrane is highly permeable to it. This is due to water moving by osmosis through aquaporins.

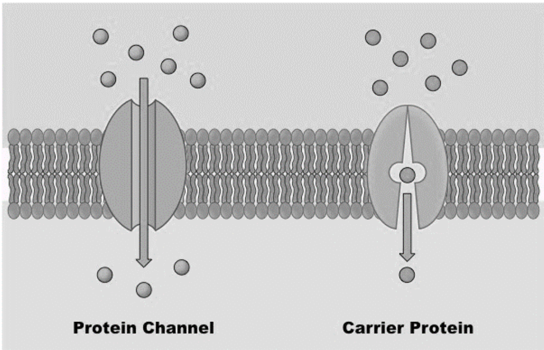
<u>Passive Transport</u>

→ Diffusion and osmosis result from random movement of particles (Brownian motion) whereby particles continually collide and move randomly.
→ When particles of higher concentration in one region than others, their constant movement slowly results in the particles spreading out to become evenly distributed in the space (reaching equilibrium)
→ Concentration gradient, high to low.

Diffusion

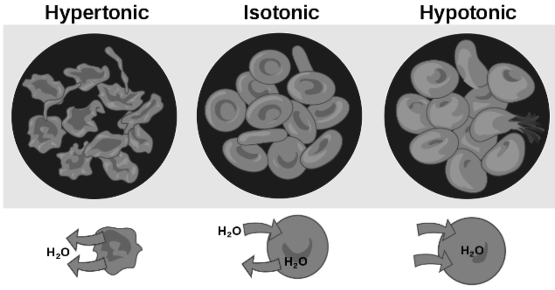
→ The movement of any molecules from a region of high concentration to a region of low concentration, until equilibrium is reached. No energy is required. May or may not be membrane-bound.
→ E.g. movement of solid, liquid or gas molecule through another medium (perfume, milk in tea, sugar in tea, ink on filter paper)
→ Described as moving along the concentration gradient, the rate of diffusion depends on the concentration gradient (the steeper it is the faster it will be)
→ Temperature effects the rate of diffusion due to as it increases the particles vibrate faster making the rate increase.

→ When equilibrium is reached the particles continue to move randomly, but not in any particular direction. (Some molecules move too slowly by simple diffusion, so proteins can act as membrane transporters, this accelerates their movement over the membrane this is called facilitated diffusion)
→ Facilitated diffusion works by the proteins providing corridors that allow a specific molecule/ion in. Ion channels are gated channels (opening and closing depending on stimulus). Carrier proteins bind to molecules and change shape to shuttle it across. Transport proteins are only used for specific molecules.



Osmosis
→ The movement of water molecules from a region of high-water concentration to a region of low water concentration through the membrane. It doesn't require energy.
→ Within cells the membrane had aquaporins making the movement of water more rapid then it should be. Tissues with high water permeability have a greater number of aquaporins in their cell membranes (e.g. kidneys)
→ Tonicity is the ability of a surrounding solution to cause a cell to lose or gain water.
→ Osmotic pressure (OP); Low OP means lots of water and little solute, High OP means little water and high solute. Water will move from high to low OP until equilibrium is reached.

Cells	Environment
Hypotonic	Solute concentration is less than that inside the cell (gains water)
Hypertonic	Solute concentration is greater than that inside the cell (loses water)
Isotonic	Solute concentration is at equilibrium (no movement across the membrane needed)

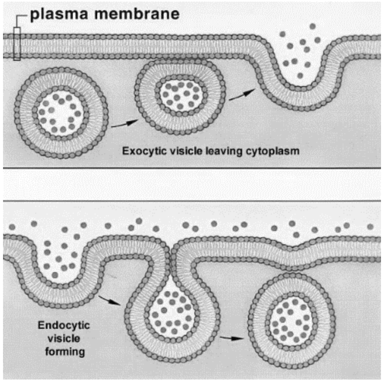


Active transport

→ Movement of molecules from low concentration to high concentration, energy is required as molecules must be pumped against the concentration gradient. These cells will have many mitochondria

Vesicular transport

→ Active process where materials are moved in vesicles.
→ Also known as 'bulk' transport due to large quantities of materials being able to be transported this way.
→ Exocytosis; Transport vesicles migrate to the membrane, fuse with it, and release their contents. Many secretory cells use exocytosis to export their products (e.g. hormones and waste)
→ Endocytosis; The cell takes in macromolecules by forming vesicles from the plasma membrane, reversal of exocytosis involving different proteins (e.g. blood cells) There is two forms of endocytosis; Phagocytosis (engulfing solid particles, digested by lysosomes) and Pinocytosis (ingestion of liquids)



Feature	Diffusion	Osmosis	Active Transport
Types of substances	Any molecule as long as it is small	Water only	Selected ions and molecules
Concentration gradient	High to low	High to low	Low to high
Energy requirement	None	None	ATP
Membrane need	None	Yes	Yes
Examples in organisms	Oxygen, salts into roots, glucose and amino acids from digestive tract to blood stream	Water into plant root, out of plant leaves, out of living things through breathing	Endocytosis, exocytosis and sodium potassium pump

Factors Affecting Exchange Rate or Materials & Enzymes

→ Factors affecting exchange

2.8 Factors that affect exchange of materials across membranes include the surface area to volume ratio of the cell, concentration gradients, and the physical and chemical nature of the materials being exchanged

1. SA: V
   - The greater the the ratio the greater the rate of diffusion

- Diffusion surfaces frequently have structure for increasing their surface area and hence the rate at which they exchange materials (e.g. villi and microvilli)

2. Concentration Gradient
   - The greater the difference in concentrations the steeper the diffusion gradient and the faster the diffusion rate.
3. Physical and chemical nature of molecules
   - Smaller molecules diffuse faster than large ones
   - Lipid soluble molecules diffuse more rapidly than water soluble molecules when passing through the cell membrane
   - Charged particles have low permeability and rely on carrier proteins

→ Enzymes

2.10-2.12 Biochemical processes in the cell are controlled by factors, including the nature and arrangement of internal membranes, and the presence of specific enzymes. Two models that are used to explain enzyme action are the lock and key model and the induced fit model. Enzymes have specific functions which can be affected by factors, including temperature, pH, presence of inhibitors and concentrations of reactants and products.

→ Metabolism; the chemical processes that occur within a living organism in order to maintain life. The metabolism of cells is carried out and controlled by enzymes.

→ Enzymes; are proteins (made of carbon, hydrogen, oxygen and nitrogen), they are an organic catalyst that controls the rate of reactions in the body by reducing the activation energy (the energy needed to start a chemical reaction). Each enzyme is specific, made for a specific reaction and remains unchanged at the end of the reaction.

Catabolic

→ A reaction in which molecules are broken down into smaller molecules or atoms

→ No energy required, but energy is released when bonds are broken (exergonic)

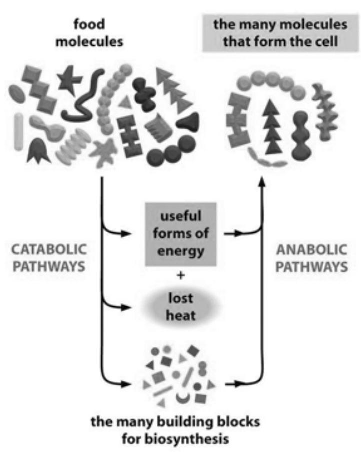
→ E.g. proteins into amino acids

Anabolic

→ A reaction which smaller molecules or atoms are combined to form a larger molecule

→ Energy is required to create a bond (endergonic)

→ E.g. amino acids into proteins



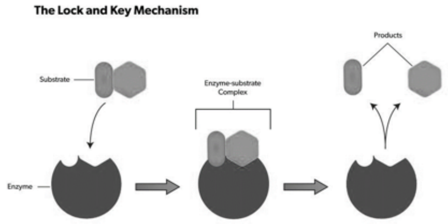
→ Substrate; molecule on which an enzyme acts, as it needs to undergo a chemical reaction

→ Active site; enzyme's catalytic site, substrate fits into active site
→ Enzyme-substrate complex; when the enzyme and substrate are combined

How enzymes work;

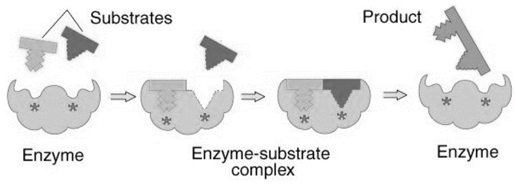
→ There are catabolic enzymes, they cleave larger molecules into smaller ones
→ There are also anabolic enzymes, those that assemble smaller molecules into larger ones
→ Enzymes are named after the reaction the catalyse (all except for pepsin have an ASE ending) e.g. Sucrase breaks down sucrose
→ *Lock and key model;*

- The enzyme is the lock and the substrate are the key
- The shape of the enzyme and the active site for that enzyme have a specific shape which fits onto the substrate forming the enzyme-substrate complex.
- Absolute specificity comes from the active site, only the correct key will fit the lock.
- The reaction occurs and the enzyme breaks away from the product/s
- The enzymes shape remains unchanged and is then ready to start the process again



→ *Induced fit model*

- The enzyme structure is flexible, not rigid
- Substrate is drawn into the active site on the enzyme
- This causes the enzyme to change shape slightly to enable the reaction to occur
- The products are released, and the enzyme returns to its original shape and ready to start the process again with another substrate



→ Optimal/Optimum; best, most favourable conditions
→ Denatured protein; protein changes shape and loses their function making the substrate unable to bind to the active site

5 factors that affect enzyme activity

1. pH;
   - optimal range for most enzymes is 6-8, but some operate best at extremities for example pepsin (in the stomach) works best at pH 2.
2. Temperature;
   - Enzymes are very sensitive to temperature
   - As the temperature increases the reaction rate also increases
   - If the temperature is too high the enzyme denatures
   - The optimal range for human enzymes is 30-40°C
   - At low temperature enzymes show little activity, which means there is not enough energy for the catalysed reaction to happen

3. Presence of inhibitors;
    - Are molecules that cause a loss of enzyme activity by preventing the substrate from fitting into the active site.
    - Competitive inhibitors are chemicals that resemble an enzyme's normal substrate and compete with it for the active site (e.g. penicillin)
    - Non-competitive inhibitors do not enter the active site but bind to another part of the enzyme molecule which causes the enzyme to change its shape so its active site cannot bind to the substrate. May act as metabolic poisons (e.g. some antibiotics)
4. Co-enzymes and co-factors
    - Change the shape of the active site so that the enzyme can combine with the substrate
5. Concentration of the reactants and products
    - The higher the substrate concentration the faster the reaction rate (beyond a certain concentration, the substrate will cease to have an effect because all the enzyme molecules will be fully occupied)
    - The higher the enzyme concentration, the faster the reaction rate.

Photosynthesis & Cellular Respiration

→ Photosynthesis

2.13 Photosynthesis is a biochemical process that uses light energy to synthesise organic compounds; light dependent and light independent reactions occur at different sites in the chloroplast; and make up separate parts of the overall process that can be represented as a balanced chemical equation.
2.14 The rate of photosynthesis can be affected by the availability of light and carbon dioxide, and temperature.

Define;

→ Adenine triphosphate (ATP); the energy currency of life. ATP is a high-energy molecule found in every cell, its job is to store and supply the cell with needed energy.

→ Anabolic reaction; a constructive process, simple molecules that combine to form complex molecules. Usually requires energy. Produces molecules that can store energy such as ATP.

→ By-product; an incidental or secondary product made in the manufacture of synthesis or another process

→ Aerobic; relating to, involving, or requiring free oxygen

→ Anaerobic; relating to or requiring an absence of free oxygen

→ Catabolic reaction; a destructive process which breaks down complex molecules and formation of simple molecules take place. The released energy acts as a driving force for the reaction (catalysed by enzymes)

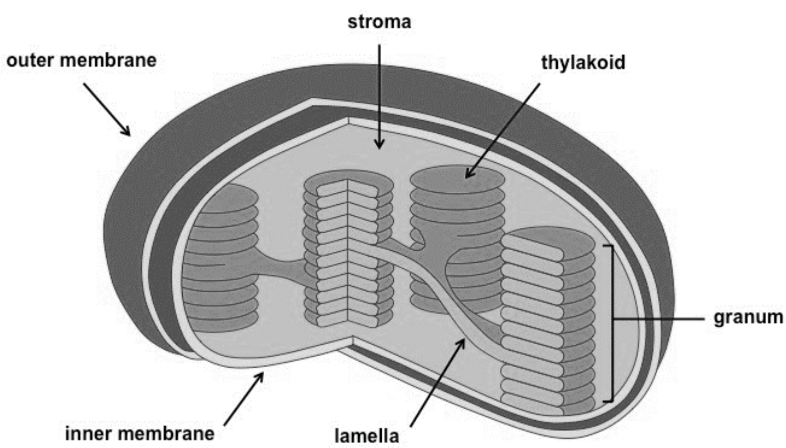
→ Chloroplast; A plastid in green plant cells which contain chlorophyll and in which photosynthesis takes place
→ Cytosol; The aqueous component of the cytoplasm of a cell within which various organelles and particles are suspended.
→ Glycolysis; the breakdown of glucose by enzymes, releasing energy and pyruvic acid.
→ Granum/ Grana; the stacks of thylakoids embedded in the stroma of a chloroplast; granum is its single form.
→ Lamella; a membranous fold in a chloroplast
→ Limiting factor; an environmental factor that limits the growth or activities of an organism or restricts the size of a population in geographical range.
→ Organic compound; a compound that contains carbon covalently bound to other atoms, especially another carbon or a hydrogen atom (hydrocarbon)
→ Stroma; the colourless fluid surrounding the grana within the chloroplast, contains grana (thylakoid), sub-organelles and daughter cells
→ Thylakoid; membrane-bound sack which has chlorophyll and other photosynthetic pigments

Photosynthesis

$$6CO_2 + 6H_2O \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} C_6H_{12}O_6 + 6O_2$$

$$\text{Carbon Dioxide} + \text{Water} \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} \text{Glucose} + \text{Oxygen}$$

→ Apart from the necessary reactants a suitable temperature and particular enzymes are needed for photosynthesis.
→ Photosynthesis is an anabolic reaction due to it absorbing sunlight
→ Takes place in the chloroplast



Light dependent stage

→ Occurs in the thylakoid membrane of the chloroplast
→ Light energy is absorbed by different pigments within the thylakoid membranes
→ Chlorophyll(green), Carotenoid (orange), Xanthophyll (yellow)
→ Chlorophyll reflects green pigments, making it look green.
→ When sunlight is absorbed, electrons in the water molecule become energised and split into a hydrogen ion and oxygen
→ Some ATP molecules are formed.

Light independent stage

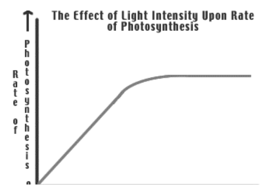
→ Occurs in the stoma of the chloroplast
→ Glucose molecules are produced from carbon dioxide, hydrogen ions, and ATP, ATP then becomes ADP.
→ Sometimes called the Calvin Cycle

Reactions of photosynthesis	**Light dependent**	**Light independent**
Where it occurs	Thylakoid membrane (grana/lamella)	Stroma
Requirements	→ Sunlight → Water → ADP	→ Chemical energy (ATP) → Carbon dioxide → Hydrogen ions
Products	→ Oxygen → Hydrogen ions → ATP	→ Glucose (ATP)

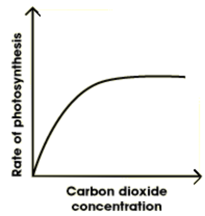
→ During the day chloroplasts convert glucose into sucrose or starch. Sucrose is the most easily transposed and starch is the most common storage form (stored during the day, at night turned into sucrose, moved to other cells that lack chloroplasts)

Factors affecting photosynthesis

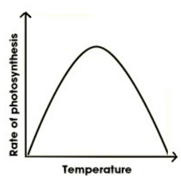
→ Light intensity; The rate of photosynthesis increases exponentially with light intensity until a maximum is reached and it plateaus, if intensity is too high there's a possibility of damaging the chloroplasts.



→ Level of carbon dioxide; the rate of photosynthesis increases as the carbon dioxide levels do but it eventually slows down once it reaches higher concentration.



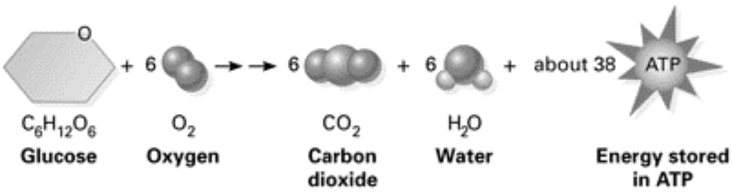
→ Temperature; affects enzymes, increasing photosynthesis, temperatures above optimum will decrease rate due to possible denatured enzymes.



- Cellular Respiration

2.15 Cellular respiration is a biochemical process that occurs in different locations in the cytosol and mitochondria, and metabolises organic compounds, aerobically or anaerobically, to release useable energy in the form of ATP; products of anaerobic respiration vary between organisms (plants, yeast, bacteria, animals); the overall process of aerobic respiration can be represented as a balanced chemical equation.
2.16 Rate of respiration can be affected by the availability of oxygen and glucose, and temperature.

→ Most important reaction is cellular respiration, it occurs inside cells to provide ATP/energy
→ Cellular respiration is a metabolic pathway that breaks down glucose and extracts the energy to produce energy that is useful to the cell.
→ Through enzymes, cells can carry out anabolic and catabolic reactions and end up with a net profit of energy.



<u>Anaerobic respiration</u>
→ Without oxygen
→ Occurs in the cytoplasm
→ Glucose is broken down into 2 pyruvic acid molecules (pyruvate) and releases 2 ATP molecules (glycosis) in animals
→ If there is no oxygen available, the pyruvate is converted to lactic acid, which then exits the cell and travels through the blood stream to the liver. Later it is recombined with oxygen and turned back into glucose/glycogen.
→ When you create energy via anaerobic respiration, you incur an oxygen debt, this would also make that when you breathe heavily after exercising your body is trying to speed up the process to get to restore energy.

Anaerobic respiration in yeast
→ Manipulated in alcohol fermentation and bread making
→ Conditions left anaerobic so ethanol can build up

$$\text{glucose} \longrightarrow \text{ethanol} + \text{carbon dioxide} + \text{energy}$$

$$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2 + \text{energy}$$

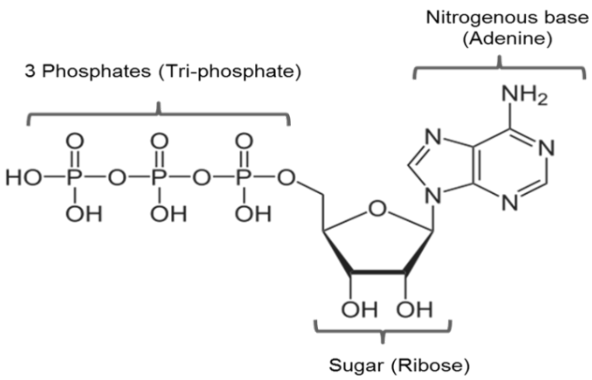
Aerobic respiration

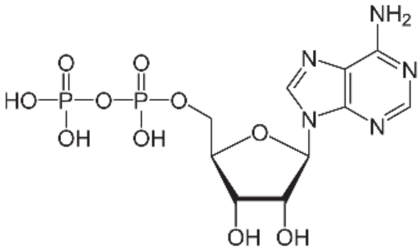
→ Oxygen is required
→ Occurs in the mitochondria, the inner membrane of a mitochondrion is highly folded to make more surface area for reactions to occur.
→ 2 pyruvate molecules move into the mitochondrion, there the Krebs cycle and ETC (Electron Transport Chain) make a series of reactions. There the Krebs cycle makes 2 ATP and the ETC makes 34 ATP, making 36 ATP.
→ The total amount of ATP produced from one glucose molecule is 38 including the 2 from the anaerobic respiration.

	Anaerobic	**Aerobic**
Location in cell	Cytoplasm	Mitochondrion
Inputs	1 Glucose	1 Glucose and 6 oxygen
Outputs in animals	2 lactic acid+ 2 ATP	6 carbon dioxide + 6 water + 36 ATP
Outputs in Plants	Carbon dioxide + alcohol	Carbon dioxide + water + ATP
Outputs in Bacteria	Methane +hydrogen + sulphide	Carbon dioxide + water + ATP
Oxygen Required	no	yes
N. of ATP produced	2	36
Other differences	→ Lactic acid if no oxygen is available for aerobic → Glucose is not completely broken down → Oxygen debt	→ Krebs cycle (2 ATP) → ETC (34 ATP) → Glucose is completely broken down and fully used

Factors Affecting cellular respiration

→ Oxygen; If levels of oxygen are reduced in the atmosphere, then the respiration rate decreases.
→ Glucose; If levels of glucose are increased, then the respiration rate increases.
→ Temperature; At very high temperatures the rate of respiration decreases with time, at very low temperatures the respiration rate is insignificant. The ideal temperature is 20-30°C.
→ A high SA: V will allow the cell to have the potential to respire rapidly.

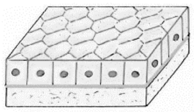
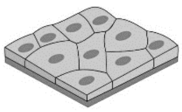
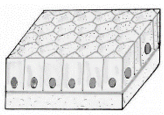
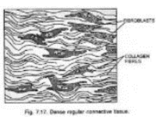
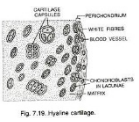
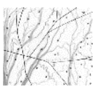


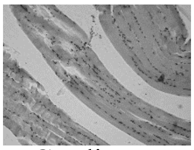
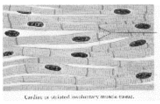
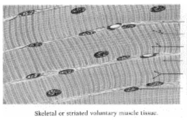
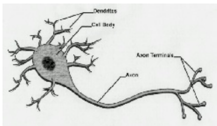


Tissues

- Tissues

2.17 Multicellular organisms have a hierarchal structural orginisation of cells, tissues, organs and systems.

Tissue	**Diagrams**	**Structure**	**Function**	**Location**
Epithelial	→ Cuboidal  → Squamous  → Columnar 	→ Cells grouped closely together → No intercellular matrix → They can be in one layer, called simple, or multiple, stratified. → 3 shapes; squamous (flattened like fish scales), cuboidal (cube-shaped), and columnar (column-like)	→ Covering and protection. → Outer body covering. → Body linings → Glandular tissue → Blood vessels	→ Lining of the heart → Blood vessels → Alimentary canal → Gall bladder → Trachea → lungs
Connective	→ Dense  → Cartilage  → Ligament 	→ Made up of cells and intercellular substances called the matrix → Often fibres are found between the cells → Different types; Areolar, dense, connective, bone, and blood	→ Binds and supports. → The most abundant tissue in the human body → Binds and supports other tissues in the body	→ Tendons → Ligaments → Fibrous membranes

Muscular	→ Smooth  → Cardiac  → Skeletal 	→ Skeletal; striated and voluntary → Smooth; unstriated and involuntary → Cardiac; branched and involuntary	→ Movement → Elongated cells capable of contraction → Rhythmic contraction → Movement of the bones → Movement of internal organs	→ Attached to skeleton → Wall of heart → Blood vessels
Nervous		→ Control and communication → Made up of neurons which have long extensions of the cytoplasm which carry nerve impulses	n/a	→ Brain → Spinal cord → nerves

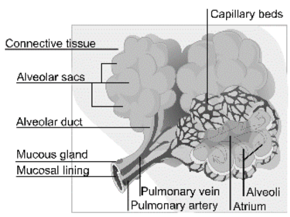
Gas Exchange in Animals

- Gas Exchange

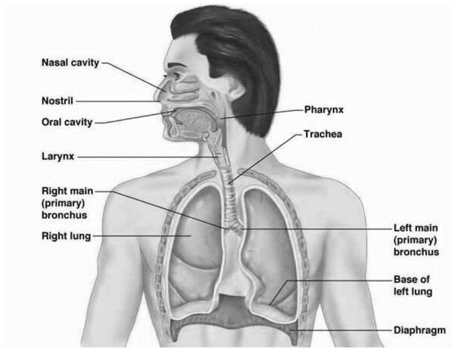
2.18 In animals, the exchange of gases between the internal and external environments of the organisms is facilitated by the structure of the exchange surface/s, including spiracles, gills and alveoli and skin.

Efficient gas exchange needs;

1. Moisture; as the gases dissolve on the water and diffuse from one side of the membrane to the other
2. To be thin & permeable; so, the gas molecules can move across it easily and quickly.
3. A large surface area; in relation to the volume of the organism, so as to adequately provide the gaseous requirements.
4. A greater concentration of required gas on one side of the membrane than the other; this allows the concentration gradient to be maintained.



Gas exchange in mammals



- → Blood arriving at the alveoli are rich in carbon dioxide and the air inhaled is low in oxygen. This maintains the concentration gradient.
- → Air inhaled is rich in oxygen and the blood in capillaries is low in oxygen, this allows for the concentration gradient to be maintained fully.
- → This is through the process of diffusion.
- → Oxygen moves from the alveolus into the erythrocytes due to a higher concentration of oxygen in the air inhaled than in the plasma and RBCs.
- → Carbon dioxide moves the opposite way due to a higher concentration of carbon dioxide in the plasma and the RBCs than in the alveoli
- → The concentration gradient between the alveoli and the capillaries is maintained through constant aeration of the lungs (this ensures that high levels of oxygen are maintained in the alveoli) and the constant flow of blood in the capillaries which surround the alveoli removing oxygen. There should always be a higher level of oxygen in the alveoli to the capillary and vice versa with carbon dioxide.

Name	**Structure**	**Function**
Nasal Cavity	→ Part of the face which protrudes → Nostrils allow air to enter and leave → Highly vascular	→ Warms, filters and humidifies incoming air → Contains smell receptors (olfactory) → Cells have cilia and hairs
Pharynx	→ Muscular, tubular structure	→ Carries air from the nasal cavity to the lungs (plus food to the oesophagus) → Epiglottis; prevents food entering the trachea
Larynx	→ A short tubular structure reinforced with cartilage (Adam's Apple), which contains vocal cords	→ Air forced over the vocal cords causing them to vibrate and produce sounds
Trachea	→ Windpipe, supported by horseshoe shaped cartilage rings	→ Carries air to the lungs. → Ciliated mucus membrane filters the air by moving the debris upward to be swallowed
Bronchi	→ Two tubes at the end of trachea which branch into the right and left lung	→ Carry air to the lungs → Filters air (ciliated mucus membrane trap dust and other foreign

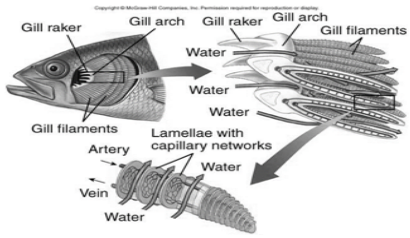
		particles which would not be beneficial)
Bronchiole	→ Very fine branches of the bronchi → No cilia → No cartilage	→ Carry air from the bronchi into the lungs
Lungs	→ Two large spongy organs which contain millions of alveoli that are highly vascular	→ Provides the large surface area necessary for the blood to exchange carbon dioxide for oxygen
Alveoli	→ Tiny air sacs which are enclosed in capillaries → Cells are one cell thick and moist	→ Site for gaseous exchange between internal and external environments → Provides moist surface that contains surfactants which prevent it from collapsing, allowing for the oxygen to dissolve
Diaphragm	→ Dome shaped muscle separating the abdominal and thoracic cavities	→ When this muscle contracts it flattens and pulls lungs down increasing volume

Feature of respiratory surface	**Importance**
Large surface area	Provides increased places for diffusion and molecules can move across the membrane faster during gas exchange
Rich blood supply	Helps maintain the concentration gradient
Thin wall	Make diffusion faster and easier, minimal distance for gas to travel to get in or out of alveoli/capillary
Deep positioning of lungs	Prevents excessive evaporation of fluid so gases are able to dissolve first then diffuse
Volume of lungs changes	Air can be pulled in or out of the lungs to maintain the concentration gradient

Gas exchange in fish

→ Fish have gills which water continually flows
→ Gills are supported by water flowing over them to maintain the concentration gradient (maintain flow by forcing water out of gills or swimming with mouth open)
→ The water has oxygen dissolved in it, more oxygen less carbon dioxide which makes diffusion occur
→ As the water flowing over the gills has a higher concentration of oxygen and lower carbon dioxide concentration, oxygen diffuses into the blood and carbon dioxide diffuses out.

→ Countercurrent flow; the blood flow in capillaries is opposite to the flow of water over the gills, this means that the blood in the capillary is meeting new water with a full load of oxygen. Maintains the concentration gradient, allowing gills to take up to 80% of oxygen from water passing over.



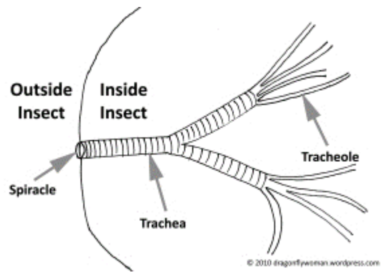
Name	Function
Operculum	Only bony fish have one, protects the gills and pushes water over the gills
Gill arch	Supports the gills, contains an artery that transports deoxygenated blood
Gill	Made of numerous thin filaments
Gill Filament	Makes large, thin surface for gas exchange. Each filament is made of thin delicate plates (lamellae)
Lamella	Increases surface area, contains many capillaries so they appear dark red, and thin permeable walls increase diffusion rate

Gas Exchange in Insects

→ Has its respiratory system separate to it circulatory system

→ Insects are composed of a tracheal system that supply muscles with oxygen directly, the tracheoles deliver and extract gas from the bodies system (via simple diffusion)

→ Spiracles are small pore-like structures in the insect's skin which take the oxygen in and release the carbon dioxide. This gives the insects cells a continuous airline to the atmosphere.



→ Pumping the abdomen draws air in and out of the trachea

→ Air moves into the thin, moist tracheoles and arrives directly at the muscle tissue, the ends of the tracheoles are lined with a thin, moist surface where the exchange of gases can occur

→ The fluid gets drawn into the muscle tissue during contractions and released back into the tracheole when the muscle rests.

→ To limit water loss they close their spiracles, have hairs around the spiracles to trap humid air, some insects have air sacs along the trachea that allows them to store small amounts of oxygen if they have no way to ventilate.

Gas exchange in earthworms

→ No specialised respiratory organs

→ Use their entire skin as a gas exchange given

→ Gas exchange only happens when the skin is moist (secretes mucus)

Circulatory system

2.20 In animals, the transport of materials within the internal environment for exchange with cells is facilitated by the structure of open and closed circulatory systems according to the different metabolic requirements of organisms and differing environments

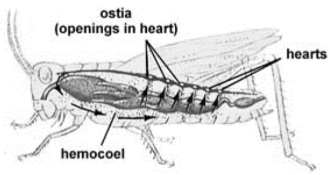
Three general components

- → A fluid in which materials are transported, such as blood or hemolymph
- → A system of blood vessels or spaces throughout the body in which the fluid moves
- → A pump, such as the heart that pushes the fluid through the blood vessels or spaces

- → Ostium; a small opening or orifice, as in a body organ or passage
- → Hemolymph; a circulating fluid in the bodies of some invertebrates that is the equivalent of blood (blood + interstitial fluid), helps to remove waste, transport nutrients, clean the system of pathogens and debris
- → Hemocoel; the system of cavities between the organs of Arthropods and molluscs through which the blood circulates.

Open circulatory system	Closed circulatory system
Hemolymph flows out of vessels (open chambers)	Blood is completely confined to vessels and connected to the heart
Hemolymph travels at low pressure	Blood travels at high pressure
No distinction between blood and interstitial fluid	Distinction between blood and interstitial fluid
Insects have a muscular tube that serves as heart to pump the hemolymph through a network of open-ended channels	Heart pumps blood through vessels
Organs don't have direct contact with hemolymph	Organs don't have direct contact with blood
Exchange of gases/nutrients occurs between hemocoel and cells	Exchange between gases/nutrients occur between blood vessels and cells
Uses less energy to operate and maintain	Uses more energy to operate and maintain
Most invertebrates (insects, Arthropods, and most molluscs)	Most vertebrates and some invertebrates (such as the annelid earthworm)

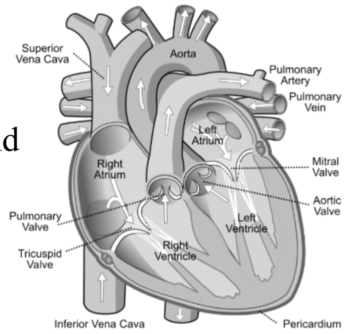
Open circulatory system



- → In insects and other Arthropods, the heart is an elongated dorsal tube
- → Pumps hemolymph through vessels out into the sinuses
- → When heart relaxes it draws hemolymph in through the Ostia (pores)
- → Body movements squeeze the sinuses and help circulate the hemolymph
- → Instead of lungs the tracheal system helps the air directly to the cells.

Closed circulatory system

→ Four principal functions; Transport of water, oxygen and carbon dioxide, Distribution of nutrients and removal, Maintains body temperature, and Circulation of hormones.
→ Essential features of transport; Ability to reach every cell, Distributing the necessary requirements in a usable form, and Not distributing the functioning of other systems in the body.
→ Oxygenated; with oxygen
→ Deoxygenated; without oxygen
→ Systemic; transports nutrients/oxygen to body cells and rids waste
→ Pulmonary; Transports deoxygenated blood to lungs where oxygenation takes place, then the oxygenated blood returns to the heart.



Part	Function
Heart	→ The heart is a hollow organ that pumps blood through the body → Driven by muscles → Your heart is about the size of clenched fist and made of cardiac muscle tissue → Has four main chambers → A double pump; pushes blood around the body, pushes blood to the lungs
Pericardium	→ Encloses and holds heart in place → Prevents heart from overstretching → Allows for friction to be reduced when beating
Superior vena cava	→ Conducts deoxygenated blood from the upper parts of the body into the right atrium
Inferior vena cava	→ Conducts deoxygenated blood from the lower parts of the body to the right atrium
Right atrium	→ Receives deoxygenated blood from the body and pumps it into the right ventricle
Tricuspid valve	→ Prevents back-flow of blood from the right ventricle during ventricular contraction
Right ventricle	→ Pumps deoxygenated blood to the lungs via the pulmonary arteries
Pulmonary artery	→ Transports deoxygenated blood from the right ventricle to the lungs
Pulmonary semi-lunar valve	→ Prevents back-flow of blood from the pulmonary artery during ventricle diastole
Pulmonary veins	→ Transports oxygenated blood from the lungs to the left atrium
Left atrium	→ Receives oxygenated blood from the lungs and pumps it into the left ventricle

Bicuspid valve	→ Prevents back-flow of blood from left ventricle during ventricular contractions
Left ventricle	→ Pumps oxygenated blood to the body via the aorta
Aorta	→ Transports oxygenated blood from the left ventricle to the body
Aortic semi-lunar valve	→ Prevents back-flow of blood from the aorta
Chordae tendineae	→ Prevents atrioventricular valves from turning inside out during ventricular contraction
Pupillary muscle	→ Joins chordae tendineae to heart wall
Apex	→ Non-functional
Septum	→ Separates left and right sides of heart and blood flow (prevents oxygenated and deoxygenated blood from mixing)

<u>Blood Vessels</u>

Arteries

→ Carry oxygenated blood away from the heart (exception is pulmonary artery)
→ Blood flowing through arteries is bright red due to being enriched in oxygen
→ Large arteries branch into narrower arteries (arterioles), which spread out through our bodies and supply blood to the capillaries.
→ Have thick, smooth muscular walls for strength, and elastic tissue to allow recoil
→ They expand and contract as blood surges through them under pressure each time the heart pumps giving us our pulse.
→ The diameter of the lumen can be changed to control blood flow; vasoconstriction and vasodilation.

Capillaries

→ Tiny blood vessels that create a network around body cells
→ They connect the smallest arteries and veins (arterioles and venules)
→ The walls of capillaries are only one cell thick, so that dissolved food, oxygen, carbon dioxide and waste can diffuse easily between cells and the blood. Makes it a site of exchange for nutrients and gases
→ They carry blood between the cells and supply our body cells with materials needed
→ Blood pressure in capillaries varies depending on whether they are close to arteries or veins

Veins

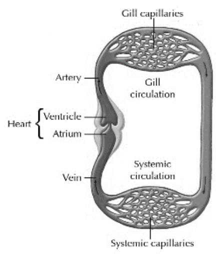
→ After flowing through capillaries, our blood flows into the smallest veins (venules)
→ These come together to form larger veins until the largest ones, the vena cava
→ Wider than arteries but have thinner walls and aren't as elastic or muscular
→ Diameter of the lumen is unchangeable, blood flow is slower, have valves
→ Carry dark red blood (deoxygenated)

Blood

→ Divided into plasma and formed elements. The plasma is the liquid portion of blood and make up 55% of the overall volume of blood, mostly water which suspends dissolved substances (ions, gases, nutrients, waste products, hormones, and proteins)
→ Red Blood Cells (Erythrocytes); responsible for transporting oxygen to the cells. The RBCs enter the capillary network to enable the oxygen to be transferred from the blood to the other cells. Have a biconcave disc shape which creates a large surface area allowing the oxygen to enter and exit the RBC quickly when required. Made in the red bone marrow and do not contain a nucleus but have haemoglobin to which oxygen molecules attach.
→ White Blood Cells (Leucocytes); function to protect the body from disease and infection. These cells can be subdivided into granulocytes, monocytes and lymphocyte. All of which are produced in the red bone marrow and have a short lifespan (hours/days)
→ Platelets (Thrombocytes); fragments of cells, do not contain a nucleus. Made in the red bone marrow and their main function is to help clot the blood.

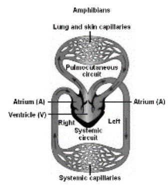
Other animals

Fish



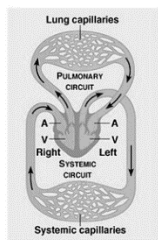
→ Simplest vertebrate heart
→ 2 chambers (1 atrium, 1 ventricle)
→ Oxygenated blood travels directly from gills to tissues
→ The atrium receives blood from the body cells
→ The ventricle sends blood to the gills to collect oxygen

Amphibians



→ 2 atria, 1 ventricle
→ Separate atria allow some separation of oxygenated and deoxygenated blood
→ Though blood can mix in the ventricle mixing is minimal
→ Some reptiles have partial separation of the ventricle

Mammals and birds

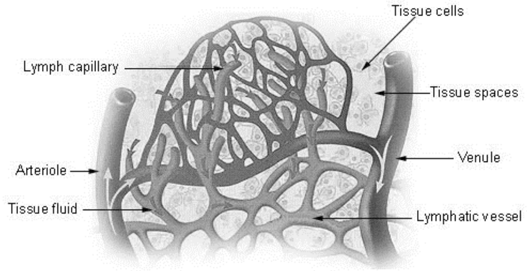


→ 4 chambered hearts
→ Allow complete separation of oxygenated and deoxygenated blood
→ Complete separation is needed to support a fast metabolism

Lymphatic Systems

→ Two main functions; To collect some of the interstitial fluid that escapes blood capillaries and return them to the circulatory system, and Defend against disease-causing organisms
→ Composed of lymphatic vessels, glands scattered along the length of the vessels, and fluid (lymph)

→ Fluid which is forced out at the arterial end of the blood capillary network due to high blood pressure does not all return to the venous end
→ The fluid can't remain in the tissue as it would cause swelling. Instead it moves into the lymph capillaries.
→ Lymphatic Vessels/capillaries differ to blood vessels/capillaries because; they are open/blind-ended tubes, they are larger, more permeable and all larger vessels contain valves
→ Lymph contains; water, proteins, cell debris, micro-organisms and foreign substances.
→ Lymph flows in one direction only (away from tissues), contracting skeletal muscles squeeze lymphatic vessels, forcing lymph away from tissues and valves to prevent backflow.



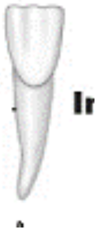
Digestive Systems

- Digestive system

2.19 In animals, the acquisition and processing of nutrients is facilitated by the structure of the digestive system; animals may have a gastrovascular cavity with one opening or a specialized alimentary canal with two openings; specialisation of alimentary canals is related to diet, for example herbivores and carnivores.

→ Mechanical digestion; Food broken up into smaller pieces (increase surface area) by the mouth (teeth, tongue, lips) and the churning action of the alimentary canal.
→ Chemical digestion; Chemically breaking down molecules into smaller ones by digestive juices and enzymes.

Dentition
→ The type of diet an animal eats determines the features that the animal possesses in order to obtain its food
→ Vertebrates have dentition that suites their diet
→ Carnivore; have large pointed incisors and canines that can be used to kill prey and rip/cut away pieces of flesh. The jagged premolars and molars crush and shred food
→ Herbivore; have premolars and molars with broad ridged surfaces that grind tough plant material. The incisors and canines are generally modified for biting off pieces of vegetation, some have no canines.
→ Omnivore; have adaptions for the breakdown of both plants and meat (see table for human dentition)

Type	**Diagram**	**Position**	**Number**	**Function**
Incisor		Front of mouth	8	Cutting
Canine		Each side of incisor	4	tearing
Premolar		Back of the mouth	8	Crushing & grinding
Molar		Back of the mouth	12	Crushing & grinding

→ Alimentary Canal; continuous tube from mouth to anus
→ Accessory Organs; assist the breakdown of food but aren't part of the alimentary canal
→ Defaecation; the expulsion from the alimentary canal made up of waste products that weren't digested (faeces)
→ Secretion; the release of substrate (juices/enzymes) from a cell or gland into the alimentary canal

<u>Four main functions of the digestive system</u>
1. Ingestion; taking in of nutrients
2. Digestion; breakdown of organic molecules by mechanical and chemical digestion
3. Absorption; taking of digested molecules into tract
4. Egestion; removal of waste food material from the body

Human Digestive System

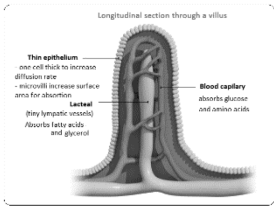
Part	Function
Mouth	→ Ingests food
Teeth	→ Mechanically breaks down food by mastication
Saliva	→ Contain enzymes; salivary amylase, which chemically breakdown starch → Secretes mucus → Alkaline environment → Forms a bolus (food + saliva)
Tongue	→ Helps mash and push the bolus into the oesophagus
Oesophagus	→ Transport the bolus into the stomach → Salivary amylase is still active and works all the way town → Peristalsis (muscle contractions) helps transport of the bolus → Secretes mucus
Epiglottis	→ A flap of tissue which close off the trachea so there is no food into the lungs
Stomach	→ Three layers of muscle churns the food increasing the surface area (mechanical digestion) → Stores, churns and chemically breaks down food → Coats the bolus with gastric juices (hydrochloric acid, mucus and enzymes) making it into chyme → Acidic environment helps sterilise and assist pepsin breakdown of proteins. → Lining of the stomach is coated with mucosa to protect from friction and the action of the HCl → Cardiac and pyloric sphincters regulate movement of food in and out of the stomach as well as preventing HCl from leaving the stomach
Duodenum	→ The start of the small intestine (25cm long) → Location where the chyme is neutralised (Acid + Base = Salt + Water)
Pancreas	→ Accessory organ → Secretes alkaline pancreatic juice via the pancreatic duct into the duodenum to neutralise the chyme → Contains Pancreatic Protease, Pancreatic amylase, lipase, ribonuclease, and deoxyribonuclease
Liver	→ Accessory organ → Secretes bile (alkaline fluid no enzymes but Bile Salts) into the gall bladder → Bile emulsifies lipids
Gall bladder	→ Accessor organ → Stores the bile → Releases the bile into the duodenum
Small intestine	→ 6 metres long → Connects to the stomach through the pyloric sphincter → Connects to large intestine via the caecum → Three regions; duodenum, jejunum, and ileum → Inner lining is called the mucosa and contains villi → Peristalsis and secretion of digestive juices help in the digestive activity

Large intestine	→ Absorption of water, salts, vitamins and any remaining sugars are absorbed into the bloodstream → Peristalsis helps transport to the rectum → Secretion of mucus → No villi → No secretion of digestive juices → Contains bacteria; break down organic molecules and produce vitamins
Rectum	→ Where the faeces are stored
Anus	→ The sphincter at the end of the alimentary canal → Voluntarily controlled → Location where faeces exit the body

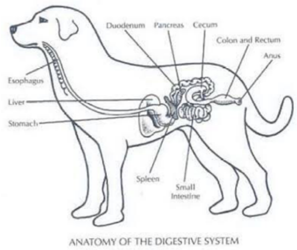
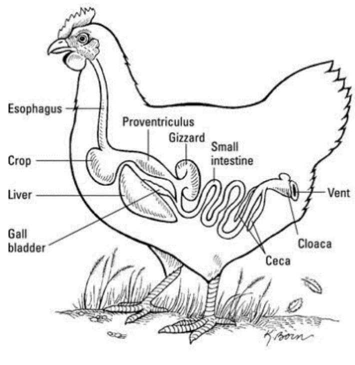
Villi

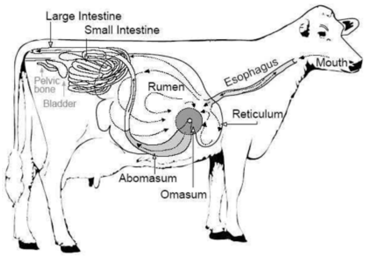
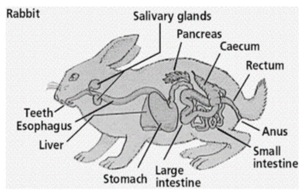
→ Fatty acids and glycerol are done using passive transport

→ Amino acids and glucose are done via active transport



<u>Other digestive systems</u>

Types of digestive systems	Make-up of the system	Diagram/ Examples
Monogastric System	→ One simple stomach → Their stomach secretes acid (pH 1.5 to 2.5) this breaks down feed materials and destroys most bacteria → Adapted to eat rations high in concentrate (highly digestible, high energy and low fibre. Typically, 80% to 90% digestible) → Common concentrates are cereal grains and oil meats	• Hogs, cats, dogs and humans 
Avian System	→ No chewing (no teeth), break down substances by using their beak to peck or scratching with their feet → Feed travels down their oesophagus and empties into their crop(where food is stored and soaked) from the crop it goes into their proventriculus(the birds stomach, gastric acids and HCl are secreted) then goes to the gizzard(muscular organ contains grit/stones function like teeth) then small intestine to large, the non-digestible travel to the cloaca	• Poultry 

Ruminant System	→ Large stomach divided into four compartments → Rumen; solid feed is mixed and partially broken down, contains millions of bacteria and microbes promoting fermentation (which breaks down roughages, high fibre low energy, 50-65% digestible), synthesise amino acids → Reticulum; small pouch on side of the rumen, traps foreign materials (wire, nails etc) → Omasum; produces grinding action separates feed and some water → Abomasum; 'true stomach'	• Cattle, sheep, goats and deer 
Pseudo-Ruminant System	→ Eats large amount of roughage but doesn't have several compartments, does most of the same functions of a ruminant System. → Sometimes eat forages as well as grains and other concentrated feeds	→ Horses, rabbits, hamsters 

Vascular Plants Exchange & Terrestrial Plants

- Vascular Plants and Non-Vascular Plants

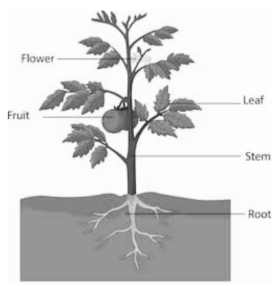
2.21 In Vascular plants, gases are exchanged via stomata and the plant surface and does not involve the plant transport system
2.22 In vascular plants, transport of water and mineral nutrients from the roots occurs via xylem through root pressure, capillary action (adhesion &cohesion of water molecules), transpiration; transport of the products of photosynthesis and some mineral nutrients occurs by translocation in the phloem

→ Plant organisation and function; Specialised cells, tissues, organs to systems
→ Functions include; Obtaining energy, producing organic compounds, distributing materials, removing wastes, and exchanging gases

Vascular Plants

Plant structure and function

Structure	Function
Root	→ Anchors plant → Transports and collects water and minerals → Stores excess food



Stem	→ Main support of the plant → Contains tubing for material transport
Leaf	→ Packed with chloroplasts → Main site of photosynthesis
Flower	→ Reproductive organs
Fruit	→ Mature or ripened ovaries that contain seeds

Stomata
→ Tiny pores on the surface of the leaves
→ Each stoma is bordered by guard cells (two bean shaped cells joint at the ends)
→ Regulate moisture, gas exchange and temperature
→ Stoma opens when guard cells absorb water (become turgid and push out)
→ Pores close when guard cells lose water (become flaccid and turn in)

Gaseous exchange
→ Carbon dioxide and oxygen don't need to be transported because they are exchanged locally through stomatal pores
→ Exchange occurs entirely via diffusion
→ Structure of leaves adaption for exchange; always flat (maximum SA), and contain open air spaces (maximum SA: easier movement)

Transpiration
→ The loss of water from the leaves of plants, through the stomata
→ Transpiration rates will be higher when stomatal pores are open than when they are closed

→ Stomata are open at day and close at night; they are driven by sunlight, during the day more oxygen is produced and during the night more carbon dioxide is produced
→ When too hot, water vapour lost through transpiration is greater than water taken up from soil. Guard cells lose water and close. Photosynthesis decreases restricting the overall growth. Carbon dioxide in plant increases which causes closing of stomata.
→ When too humid, the rate of water loss decreases, and stomata can stay open. This then encourages water loss (plants need to maintain a balance of water and gases)
→ Stomatal Adaptions; stomata can open and close. Found on lower epidermis limiting exposure to direct sun, many stomata found in pits limiting exposure to winds which increase evaporation

Two types of systems
1. *Shoot system*
   → Comprised of all of the parts of the plants found above ground (e.g. stem, leaves, reproductive organs)
   → Responsible for; transportation of nutrients, absorption of oxygen and carbon dioxide, reproduction, and carrying out photosynthesis

2. *Root system*
   → Below the ground generally, includes root and root hairs
   → Responsible for absorption of water and nutrients from the soil

Two types of tissues

1. *Xylem*
   → Carries water and dissolved nutrients from roots to rest of plant
   → Made up of two cell types; Tracheids and vessel elements
   → Xylem cells die when mature, leaving hollow cells and cell walls, ideal for water flow. Turns into bark.
   → One way transport only
   → Thick walls, stiff, and have no end walls
2. *Phloem*
   → Transports sucrose and other products from where they are produced/stored to rest of plant
   → Two cell types; sieve tube cells (long, no organelles, arranged in tubes) and companion cells (controls activity of sieve tube)
   → Two-way transport
   → End walls with perforations

Non Vascular Plants

→ First plants to colonise land, small plants, restricted to moist environments, no true roots, stems or leaves, may have adaptions such as rhizoids and cuticle. E.g. Mosses and liverworts

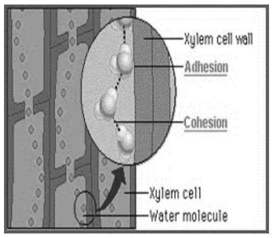
Transporting water

Root system; absorbs water and minerals from soil, supports and anchors the plant, and storage.

1. *Taproots*
   - Large main roots and short side branches
   - Can push vertically through soil to reach aquifers
2. *Fibrous roots*
   - Many smaller roots of roughly equal sizes
   - Do not grow deep but hold soil in place and prevent erosion
   - Colonising plants e.g. grasses

→ Root surface area; Roots are covered in hairs, expansions of epidermal cells, increases for water absorption. Thin walls and penetrate soil well.
→ Movement of Water (Root system);
   - Water and minerals enter root via osmosis and diffusion or active transport
   - Water → Parenchyma cells (ground tissue) → xylem cells (via pits)
   - Form of water entering root and pushing into cells creates pressure (root pressure) ensures water and minerals reach vascular tissue

→ Movement of water (Shoot system);
   - Xylem and phloem tissue grouped into vascular bundles



- One in xylem, other forces combine with root pressure to help water move against gravity.
- Adhesion (hetero); attraction between water molecules and side of the xylem
- Cohesion (homo); attraction between water molecules and themselves

→ Transpiration;
- Continuous column of water in plant, transpiration stream.
- Loss of water through evaporation; occurs through stomata, drives constant upwards motion of water, and requires energy from the sun, cohesive forces and root pressure

→ Transpirational pull; The entire force where water is pulled up large vertical distances through xylem

Water Loss

→ When plants lose more water through transpiration than it takes up through roots;
- Raises tension of water column and water gradient from soil to xylem
- Roots remove more water from soil
- Flow of water to roots eventually slows down
- Stomata close
- Water loss is minimised

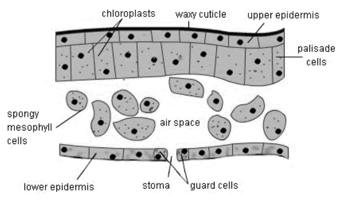
Obtaining nutrients

→ Minerals obtained from surrounding water or soil (aquatic or terrestrial) as ions
→ Actively pumped into root hairs
→ Ions move between cells through junctions
→ Can then be carried up stem in transpirational pull once in xylem
→ In Leaf;
- Ions used to produce chlorophyll, proteins, carbohydrates etc.
- Without ions plants suffer from deficiencies

→ Food vs Nutrients;
- Food: molecules processed through digestion and respiration to provide energy
- Nutrients: other substances such as minerals and vitamins
- Plant nutrients: soluble materials and salts (e.g. sodium, potassium and phosphorus). Required for complex chemistry, don't provide energy to cell.

Leaf structure and function

→ Perfectly designed to capture light energy;
- Thin, flat; large SA exposed to sunlight
- Shape held by turgor (stiffness) plus veins which are supplied with strengthening and vascular tissue
- Photosynthetic cells sit close to vascular tissue, meaning close to water
- Photosynthetic cells surrounded by air spaces, meaning close to gases



Chloroplast Cells

→ Palisade cells; Separated by narrow air spaces. Densely packed with chloroplasts to maximise light absorption

→ Mesophyll cells; Surrounded by air spaces. Contains fewer chloroplasts (underside of leaf is paler)

Leaves and Photosynthesis

→ Location; Sunlight hits upper epidermis where palisade cells lie

→ Shape; Broad leaves allow more SA for light, water, and gas absorption

→ Stomata; Allow diffusion of gases

→ Vascular Tissue; Transports water, minerals, and compounds

Distributing Products

→ Photosynthesis packages energy into neat packages of sugar for respiration

→ Moves to where there is demand

→ Storage; When more sugars are produced than used plants may form tubers, bulbs, or corms. Store sugar as starch until it is needed

Phloem & Translocation

→ Translocation;

- Movement of sugars in solution through the plant.
- Sugars actively transported into sieve cells
- Energy comes from respiration occurring in mitochondria of companion cells.
- Sugar concentration increases → Volume of liquid increases allowing sugary solution to be transported where needed → Water moves by osmosis

Waste Removal

→ Plants (deciduous) can;

- Store wastes in leaves which drop off in autumn
- Store wastes in bark and shed
- Stored as crystals or dissolved in vacuoles
- Can be removed as resins, fats, waxes etc.

▪ Terrestrial plants

2.23 Terrestrial Australian plants are adapted to minimise water loss in an arid environment

Plant adaptions that enable them to reduce water loss

→ Due to their adaptability, plants live in almost every conceivable environment. Many times plants evolve to live in situations where little moisture is present.

→ These plant structures can receive the maximum amount of food with the lowest rate of water evaporation. Conserving water, as a valuable resource, saves plants and allows them to survive in harsh environments.

Xerophytes

→ Plants that have adaptions that allow them to survive in habitats where transpiration rates are very high.
→ They can tolerate dry conditions (desert etc.) due to the presence of multiple adaptions.

Xerophytes structural adaptions to reduce transpiration rate

Structural adaptions	How it reduces
Leaves have reduced amount of stomata	→ Having fewer stomata on top surface and more on the bottom epidermis → Reduced gas exchange
Leaves have thick, waxy cuticle	→ Acting as a barrier to evaporation → Reflects light away from the leaf reducing its amount of collected heat
Leaves can be rolled and/or hairy	→ Trapping cool air in the central part of the leaf → Reducing the surface area exposed to wind evaporation
Leaves have sunken stomata in pits	→ Traps water vapour
Leaves small and circular & reduced to spines	→ Reduces total surface area of the leaf causing less evaporation due to combination of less heat being absorbed by individual leaves → Reduces total surface area exposed to sun
Leaves which hang vertically	→ Reducing total surface area exposed to sun
Low growth	→ Reducing exposure to wind → More likely to be shaded

Xerophytes adaptions to resist drought

Structural adaptions	How it reduces
Deep tap-roots	→ Tapping into the water table (aquifers)
Extensive system of superficial roots (shallow root system)	→ Soaking up infrequent rains on the surface
Storing water in succulent tissues	→ Storing water in fleshy leaves, stems or roots
Folded stems	→ Contract in periods of extreme hot weather or climate, acting as shield in order to protect the stomata

Xerophytes physiological adaptions to resist water loss

Physiological adaption	How it resists
CAM physiology (reversed stomatal rhythm)	→ Closing their stomata during the day and opening at night → Take in carbon dioxide during the night and store it for use in photosynthesis during the day
Ceasing vegetative activity (dormancy)	→ Existing in desiccated state, and only germinating when water is available

Note; Finished booklet 11,000 words