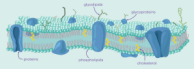
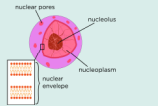
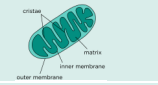
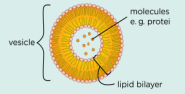
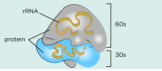
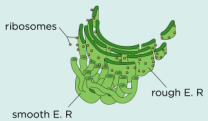
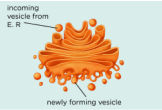
CELL STRUCTURE & WATER
CHEAT SHEET

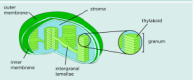
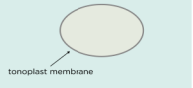
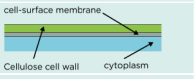
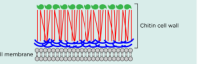
SNAPREVISE

Eukaryotic Cells

- Eukaryotes include animal, plant & fungal cells.
- The following organelles are presents in eukaryotic cells:

Organelle	Structure	Function
Cell surface membrane		• Controls passage of entry of substance into the cell • Site of cell communication via receptors
Nucleus		• Stores DNA • Nuclear pores allow mRNA & ribosomes to pass through
Mitochondria		• Carry out aerobic respiration to produce ATP
Lysosomes		• Contains digestive enzymes to break down pathogens, old organelles, cells & food molecules
Ribosomes		• Site of protein synthesis
Rough endoplasmic reticulum		• Provide a large surface area for protein synthesis
Smooth endoplasmic reticulum		• Synthesise, store and transport lipids and carbohydrates.
Golgi Apparatus		• Modifies proteins • Sort, package, and transport molecules around the cell

- There are additional organelles in plants, algae & fungi:

Organelle	Structure	Function	Present in which organism
Chloroplasts		• Site of photosynthesis	Plants & algae
Cell vacuole		• Maintains cell structure • Act as a tempo-rary energy store	Plants
Cell wall		• Provides support & mechanical strength	Plants & algae
			Fungi

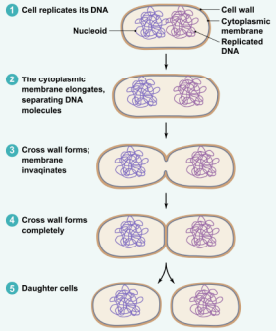
- In complex multicellular organisms, eukaryotic cells become
- Specialised for specific functions.
- Specialised cells are organised into tissues, tissues into organs and organs into systems.

Prokaryotic Cells

- Prokaryotes are smaller and simpler than eukaryotes.

Feature	Eukaryotic Cell	Prokaryotic Cell
Nucleus	Present	Absent
DNA	Linear and packaged into chromosomes in nucleus	Circular and freely floating in cytoplasm
Cell Membrane	Present	Present
Membrane-bound organelles	Present	Absent
Ribosomes	Present (80S)	Present (70S)
Cell Wall	Sometimes (cellulose or chitin)	Present (peptidoglycan)
Chloroplasts	Sometimes	Absent
Flagellum	Absent	Sometimes
Capsule	Absent	Sometimes
Plasmid	Absent	Sometimes

- Bacteria replicate by binary fission.



Methods of Studying Cells

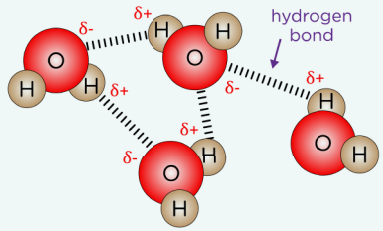
- There are 3 main types of microscopes used to observe cells:

	Light Microscope	Scanning Electron Microscope	Transmission Electron Microscope
Medium	Light Beam	Electron Beam	Electron Beam
Dimensions	2D	3D	2D
Max Magnification	X1,500	X200,000	X2,000,000
Max Resolution	200 nm	20 nm	0.1 nm

- Magnification is how much bigger the image is compared to the original object viewed with the naked eye
- Magnification = (size of image)/(size of object)
- Resolution is how well a microscope distinguishes between two points that are close together.
- Cell fractionation can be used to separate organelles.
  - Homogenisation - grinding cells release the organelles into solution
  - Filtration - separates organelles & debris
  - Ultracentrifugation - using a centrifuge the organelles are separated out in order of mass

Water

- Water molecules consist of 2 hydrogen molecules covalently to an oxygen molecule.



- The molecules are slightly polar because the oxygen nucleus pulls the shared electrons away from the hydrogen nuclei. Giving the oxygen nuclei a δ- charge, and the hydrogen nuclei a δ+ charge.
- The polarity of water causes attraction between water molecules. This force of attraction is called a hydrogen bond.

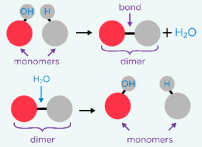
Property of water	Why it is useful
Liquid medium	Provides habitats for aquatic organisms, medium for chemical reactions & used for transport
Important metabolite	Used in hydrolysis & condensation reactions
High specific heat capacity	Keeps aquatic & cellular environments stable
High latent heat of vaporisation	Evaporation has a cooling effect on organisms
Cohesion of molecules	Water is drawn up the xylem
Surface tension	Allows pond-skaters to walk on the surface
Good solvent and transport medium	Dissolves ionic and polar molecules, allowing them to easily be transported
Good reaction medium	The cytoplasm in cells is an aqueous solution where many chemical reactions happen
Incompressible	Can prevent plants from wilting & act as a hydrostatic skeleton for invertebrates

CARBOHYDRATES, LIPIDS & PROTEINS
CHEAT SHEET

SNAPREVISE

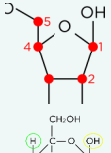
Monomers & Polymers

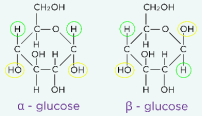
- Monomers are individual molecules that make up a polymer.
- Polymers are long chains that are composed of many individual monomers that have been bonded together in a repeating pattern.
- Condensation Reactions occurs when two molecules combine to form a more complex molecule with the removal of water.
- Hydrolysis Reactions occurs when larger molecules are broken down into smaller molecules with the addition of water.



Carbohydrates

- Monosaccharides are the simplest carbohydrates, consisting of only one sugar molecule (e.g. Glucose, Fructose & Galactose).
- Ribose sugars (pentose) are found in many important biological molecules such as ribonucleic acid (RNA), ATP, NAD
- Glucose is a hexose sugar with 2 isomers
- Disaccharides are sugars that are composed of two monosaccharides joined together in a condensation reaction, forming a glycosidic bond.





Disaccharide	Constituent monosaccharides
Maltose	2 × α-glucose
Sucrose	α-glucose and fructose
Lactose	β-glucose and galactose

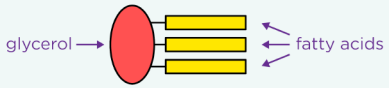
- Polysaccharides are formed by many monosaccharides joined together.
  - Amylose, amylopectin (starch) is the main polysaccharide energy store in plants, is composed of α-glucose.
  - In animals, the polysaccharide energy store is called glycogen, composed of α-glucose.
  - Cellulose is a structural component of plant cell walls, composed of long unbranched chains of β-glucose.

Biochemical Tests

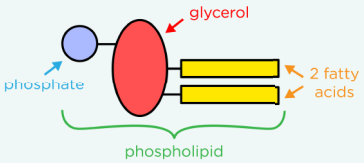
Molecule	Reagent	Positive Result
Reducing sugars	Benedict's reagent → Heat	Red/orange precipitate
	Reagent test strip	Compare with calibration card
Non-reducing sugars	Hydrochloric acid → Heat Sodium hydrogencarbonate Benedict's reagent → Heat	Red/orange precipitate
Starch	Iodine in potassium iodide solution	Blue/black
Proteins	Sodium hydroxide Copper (II) sulphate	Purple
Lipids	Ethanol Water → Shake	Cloudy white

Lipids

- Fatty acids can be:
  - Saturated – there are no C=C bonds and the molecule has as many hydrogen atoms as possible.
  - Unsaturated – there is at least one C=C bond, therefore the molecule contains fewer hydrogen atoms than is maximally possible.
- A triglyceride molecule is formed by joining one molecule of glycerol to three fatty acids through three condensation reactions, forming ester bonds.
- Triglycerides have key roles in respiration and energy storage due to its insolubility and high carbon to hydrogen ratio.

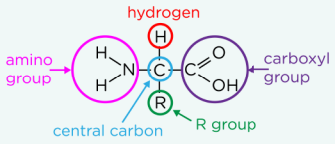


- Phospholipids replace one of the fatty acid chains in triglycerides with a phosphate molecule.
- The hydrophobic tails and hydrophilic heads of phospholipids allow them to form phospholipid bilayers.



Proteins

- Amino acids are the monomer units used to make proteins.
- The 20 naturally occurring amino acids only differ in their R groups.
- Dipeptides are formed when two amino acids are joined together by a condensation reaction, forming a peptide bond.
- A polypeptide is a polymer made of many amino acids joined together by peptide bonds.



- A protein may contain one or more polypeptide chains.
- There are four structural levels:

Level	Definition	Bond type
Primary	The specific sequence of amino acids in a polypeptide chain	Peptide bonds
Secondary	The curling or folding of the polypeptide chain into α-helices and β-pleated sheets due to the formation of hydrogen bonds	Hydrogen bonds
Tertiary	The overall specific 3-D shape of a protein, which is determined by interactions between R groups and the properties of R groups	Hydrogen bonds Ionic bonds Disulphide bridges
Quaternary	The specific 3-D shape of a protein that is determined by the multiple polypeptide chains and/or prosthetic groups bonded together	Hydrogen bonds Ionic bonds Disulphide bridges

Inorganic Ions

- Inorganic ions are atoms or molecules with an electric charge, containing no carbon.
- Cations are positively charged ions
- Anions are negatively charged ions
- Inorganic ions occur in solution in the cytoplasm and body fluids of organisms, some in high concentrations and others in very low concentrations
- Each type of ion has a specific role, depending on its properties
  - Hydrogen ions determine the pH of bodily fluids. The higher the concentration, the lower the pH
  - Sodium ions are used in the co-transport of glucose and amino acids across cell membranes and transmission of nervous impulses
  - Phosphate ions are essential components of DNA, RNA, nucleotides & ATP
  - Calcium ions regulate protein channels, impulse transmission and harden body parts like teeth.
  - Potassium ions play a role in muscle contraction, nervous transmission. active transport and maintaining turgidity in plant cells.
  - Ammonium ions and Nitrate ions are part of the nitrogen cycle and a source of nitrogen for biological molecules
  - Hydrogencarbonate ions are formed when carbon dioxide dissolves in blood. They are important in the transport of carbon dioxide in the blood and the regulation of blood pH

$$CO_2 + H_2O \rightleftharpoons HCO_3^- + H^+$$

Globular Proteins

- A globular protein is protein with a spherical shape that is soluble in water; they typically have metabolic roles
- Globular proteins have a few important properties:
  - They are roughly spherical in shape, with hydrophobic R groups on the inside and hydrophilic R groups on the outside. They are therefore soluble in water
  - They have very specific shapes; this allows them to carry out very specific functions
- Haemoglobin is a conjugated globular protein, made of 4 polypeptide chains and 4 haem prosthetic groups which contain Fe^{2+}.
- Insulin is composed of two polypeptide chains, joined together by disulphide links. The specificity of the shape allows binding to cell membrane receptors.
- Pepsin has hydrogen bonds, disulphide link and few basic R groups to keep it functional in low pH stomach acid.

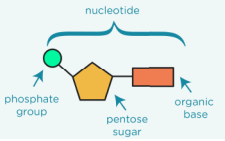
Fibrous Proteins

- Fibrous proteins have some similar properties to each other:
  - They contain long polypeptide chains with repeating sequences of amino acids
  - The amino acids have non-polar R groups, so the proteins are insoluble in water
  - The polypeptide chains are able to form fibres which make the proteins stronger
- Collagen is used to make bones, tendons and are found in artery walls to help resist the high pressure
- Keratin contains high amounts of cysteine, resulting in disulphide links forming between the two polypeptide chains, which makes the molecule very hard and strong. It is found in fingernails, hooves and horns.
- Elastin has the ability to stretch and recoil. Elastin is stretchy due to coiling of the elastin molecules and cross-links that keep the molecules together. It is found in the lungs, bladder and blood vessel walls.

NUCLEIC ACIDS, ATP, GENETIC INFORMATION, PROTEIN SYNTHESIS & ENZYMES
CHEAT SHEET

SNAPREVISE

DNA & RNA

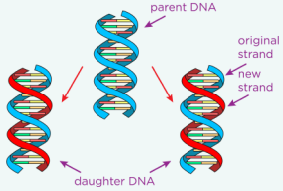


- DNA & RNA are both polynucleotides.
- The basic structure of a nucleotide is:

	DNA	RNA
Number of Strands	Two antiparallel strands	One strand
Length	Very long	Relatively short
Pentose Sugar	Deoxyribose	Ribose
Nitrogenous Bases	Adenine, Cytosine, Guanine & Thymine	Adenine, Cytosine, Guanine & Uracil
Function	Store genetic information	Transfer genetic information & forms ribosomes with proteins

DNA Double Helix & Replication

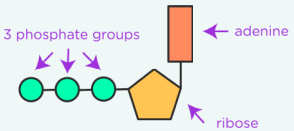
- Polynucleotides are polymers made up of many nucleotide monomers joined together by a series of condensation reactions, forming phosphodiester bonds.
- The DNA double helix is held together by hydrogen (H) bonds between complementary base pairs.
  - 2 H bonds between Adenine & Thymine
  - 3 H bonds between Cysteine and Guanine
- Semi conservative replication is the method in which DNA replicates, creating two molecules of DNA that consist of one original DNA strand and one newly synthesised DNA strand.
  - DNA helicase breaks H bonds between the two strands
  - Free nucleotides complementary base pair to the exposed strands
  - DNA polymerase catalyses condensation reactions to join adjacent nucleotides, forming phosphodiester bonds.



Genetic Information

- In prokaryotic cells, DNA molecules are short, circular and not associated with proteins.
- In eukaryotes, the nucleus contains very long, linear DNA molecules associated with proteins, called histones. Together a DNA molecule and its associated proteins form a chromosome.
- The mitochondria and chloroplasts of eukaryotic cells also contain DNA which, like the DNA of prokaryotes, is short, circular and not associated with protein.
- The genome is the full set of DNA found in an organism.
- The proteasome is the full range of proteins that can be synthesised from the genome.
- A gene is a section of DNA that code for polypeptides and functional RNA and are located at a fixed locus on a DNA molecule.
- A sequence of three DNA bases, called a codon, codes for a specific amino acid. The genetic code is universal, non-overlapping and degenerate.
- In eukaryotes, sections of the nuclear DNA do not code for polypeptides (introns). Exons are sections of DNA that code for amino acid sequences.

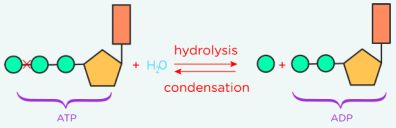
ATP



- The structure of ATP is:

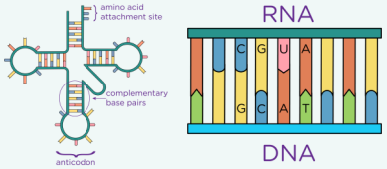
	ATP → ADP	ADP → ATP
Reaction type	Hydrolysis	Condensation
Enzyme involved	ATP hydrolase	ATP synthase
Energy profile of reaction	Releases energy	Requires energy

- The hydrolysis of ATP can be coupled to energy-requiring reaction and used to phosphorylate compounds.
- The condensation of ADP to form ATP can occur during respiration and photosynthesis.

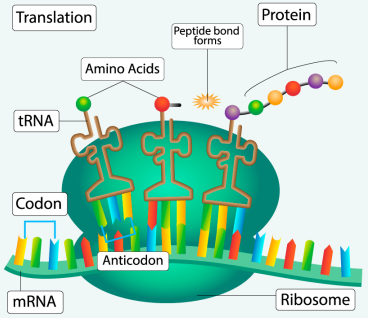


Protein Synthesis

- Structure of tRNA & mRNA:
- Transcription is the process of making messenger RNA from a DNA template.
- DNA helicase breaks the hydrogen bonds between the DNA helix, free RNA nucleotides base pair with the exposed DNA template strand.

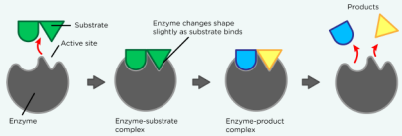


- In prokaryotes, transcription results directly in the production of mRNA from DNA.
- In eukaryotes, transcription results in the production of pre-mRNA; this is then spliced to form mRNA.
- Translation is the process of making proteins by forming a specific sequence of amino acids based on coded instructions in mRNA. RNA polymerase catalyses phosphodiester bonds between adjacent RNA nucleotides and the mRNA strand detaches, allowing the DNA helix to reform.
- mRNA attaches to a ribosome on the rough endoplasmic reticulum, tRNA carries the corresponding amino acid to each codon on the mRNA one at a time, with an enzyme catalysing the formation of a peptide bond between amino acids using ATP, until a stop codon is reached and the peptide is released, folding into its tertiary structure.



Enzymes

- Enzymes are biological catalysts that speeds up the rate of reaction and remains unchanged and reusable at the end of the reaction.
- They lower the activation energy of the reaction.
- The lock and key model proposed that each substrate is a key that only fits a specific lock or enzyme. The alternative induced fit model has been proposed (below)

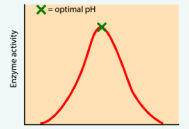


- The specificity of enzymes is due to the tertiary structure of its active site, allowing complementary binding to substrates.
- Enzymes catalyse both intracellular and extracellular reactions that determine structures and functions from cellular to whole organism level.
  - Catalase intracellularly breaks down hydrogen peroxide into water and oxygen
  - Amylase is secreted from the salivary glands and pancreas to extracellularly break down starch. Requires Cl^- cofactor
  - Trypsin is secreted from the pancreas to extracellularly break down proteins
- Some enzymes are synthesised in an inactive precursor form and need to be activated e.g. another enzyme removes part of the molecule in trypsin, forming the correct active site shape
- Some enzymes require a cofactor, which is a substance which must be present to enable an enzyme to catalyse a reaction at the appropriate rate.
  - A prosthetic group is permanently bound e.g. Zn^{2+} bound to carbonic anhydrase

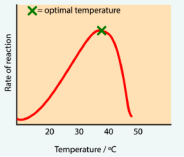
$$CO_2 + H_2O \longleftrightarrow H_2CO_3 \longleftrightarrow H^+ + HCO_3^-$$

  - A coenzyme forms temporary associations and are derived from vitamins.
- Factors affecting enzyme activity include:

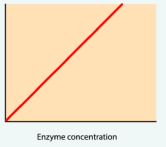
pH:



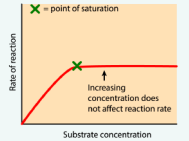
Temperature



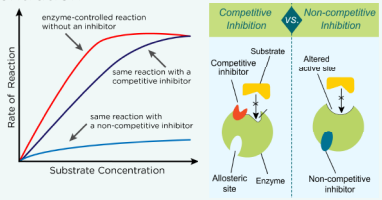
Enzyme concentration



Substrate concentration



Competitive & non-competitive inhibitor concentration



- The temperature coefficient (Q_{10}) for a specific reaction is the effect of a 10°C rise in temperature on the rate of the reaction

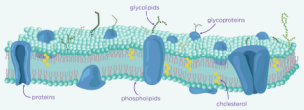
$$Q_{10} = \frac{rate\ of\ reaction\ at\ (T+10)°C}{rate\ of\ reaction\ at\ T°C}$$

CELL TRANSPORT & CELL DIVISION
CHEAT SHEET

SNAPREVISE

Cell Membranes

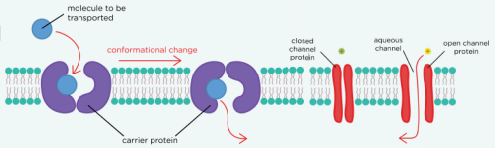
- Cell membranes act as barriers and can control what passes into and out of cells and organelles
- The cell membrane is composed of phospholipids, proteins, glycoproteins, glycolipids and cholesterol.



- Glycolipids and glycoproteins allow cell adherence, stability and act as recognition sites
- Cholesterol has a hydrophilic end and a hydrophobic end & regulates membrane fluidity by intercalating between the phospholipids.
- At high temperatures the phospholipid bilayer increases its fluidity and permeability, increasing the risk of the proteins becoming denatured. At low temperatures, the phospholipids are compressed, making the membrane stiff
- Organic solvents disrupt the bilayer and dissolve the membrane

Passive Transport

- Passive transport involves exchange of substances without requiring metabolic energy from the cell
- Diffusion is the net movement of particles from an area of higher concentration to an area of lower concentration (down their concentration gradient).
- Facilitated diffusion is the net movement of particles down their concentration gradient across a partially permeable cell membrane via carrier or channel proteins.



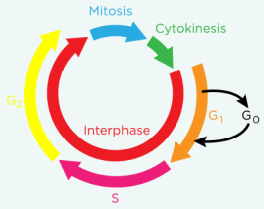
- Water potential is a measure of the tendency of water molecules to move from one area to another area and describes the pressure created by these water molecules; the more dilute a solution, the higher (less negative) the water potential (Ψ).
- Osmosis is the net movement of water from an area of higher water potential to an area of lower water potential across a partially permeable membrane.
- The rate of diffusion can be increased by increasing the number of channel & carrier proteins, the surface area of the cell membrane, reducing the diffusion distance and creating a steeper concentration gradient.

Active Transport

- Active transport is the movement of particles from an area of low concentration to an area of high concentration (against their concentration gradient) across a cell membrane, using ATP and carrier proteins.
- Bulk transport transports large substances across the cell membrane
- Endocytosis is the bulk transport of large molecules into a cell. The membrane invaginates and encloses the material being taken up into a vesicle, which pinches off.
- Exocytosis is the bulk transport of large molecules out of a cell. A vesicle fuses with the cell membrane, releasing its material.

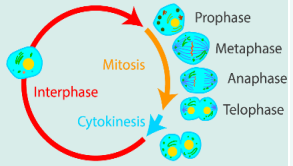
Mitosis

- Within multicellular organisms, not all cells retain the ability to divide
- Mitosis produces genetically identical daughter cells, which is useful for growth, repair and asexual reproduction
- The eukaryotic cell cycle has three main stages:
- Interphase consists of two growth phases (G_1&G_2) and a DNA synthesis stage (S). The cell may exit the cell cycle at G0



- Mitosis is the nuclear division
- Cytokinesis is when the cell splits in two, forming two identical daughter cells.
  - In animal cells, the plasma membrane folds inwards until the two dents meet to separate the two daughter cells
  - In plant cells, cellulose starts to build up at the equator (the end plate). Plasma membrane forms in the middle of the end plate resulting in two fully separated plant cells

Stage	Description
Prophase	DNA condenses & coils, nuclear envelope breaks down, centrioles move to opposite poles
Metaphase	Spindle fibres attach to centromeres & chromosomes line at the equator
Anaphase	Centromeres divides, chromatids move to opposite poles
Telophase	Chromosomes uncoil, nuclear envelope reforms

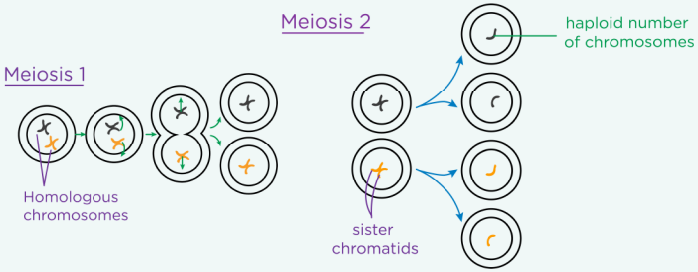


- Cell cycle checkpoints ensure the cell only divide at the appropriate time when ready and helps detect DNA damage.

	Checkpoint Location	Function
Restriction Point or G_1/S Checkpoint	Between G_1 and S	Decides whether cell proceeds to S-Phase..
G_1 Checkpoint	End of G_1	Checks cell is ready for S-Phase
G_2/M Checkpoint	Between G_2 and mitosis	Checks and repairs all of the DNA before the cell enters mitosis.
Mitosis Checkpoint	In the middle of mitosis	Checks cell is ready to proceed in mitosis. Ensures that the cell doesn't proceed to the next stage before it's ready.

Meiosis

- Meiosis produces 4 haploid daughter cells (gametes) that are genetically different from each other.



- In meiosis 1, homologous chromosomes are separated from each other, with one chromosome from each pair going into one of the two daughter cells. In the second meiotic division, the sister chromatids from each chromosome are separated

Stage	Description
Prophase 1	Chromatin condenses & coils, nuclear envelope breaks down, centrioles move to opposite poles. Crossing over occurs between homologous chromosomes
Metaphase 1	Spindle fibres attach to centromeres & chromosomes line at the equator
Anaphase 1	Homologous chromosomes move to opposite poles
Telophase 1 and cytokinesis	Chromosomes uncoil, nuclear envelope reforms. Animal cells divide by cytokinesis
Prophase 2	Chromatin condenses & coils, nuclear envelope breaks down, centrioles move to opposite poles.
Metaphase 2	Spindle fibres attach to the centromeres & chromosomes lines up at the equator
Anaphase 2	The centromeres divide and the chromatids are pulled to opposite poles
Telophase 2 and cytokinesis	Chromosomes uncoil, nuclear envelope reforms. Cells divide to form 4 haploid cells.

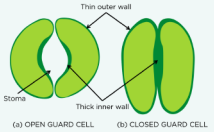
- Variation results from independent assortment of chromosomes and crossing over during meiosis 1. Also, random fertilisation of the gametes.

CELL SPECALISATION & GAS EXCHANGE
CHEAT SHEET

SNAPREVISE

Specialised Cells

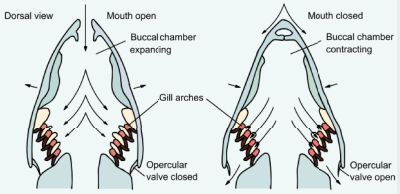
- Erythrocytes have a large SA:V, with their biconcave shape. They lack a nucleus, so more haemoglobin can be stored
- Neutrophils have a multilobed nucleus allowing them to move and engulf material more easily
- Sperm cells have a tail to allow movement. There is a high density of mitochondria to provide ATP to the tail. Sperm cells have a streamline shape and a specialised lysosome (acrosome) that contains digestive enzymes to enter an egg cell
- Squamous epithelial cells are thin and flat to reduce the diffusion distance for gas exchange.
- Ciliated epithelial cells in the trachea have cilia to move mucus along the trachea
- Palisade cells contain lots of chloroplasts, are long and cylindrical allowing close packing. The chloroplast can be moved by the cytoskeleton to maximise light absorption
- Guard cells control the opening and closing of the stomata. ATP is used to pump K^+ ions into the cell, making water move in by osmosis in order to open the stomata for gas exchange.

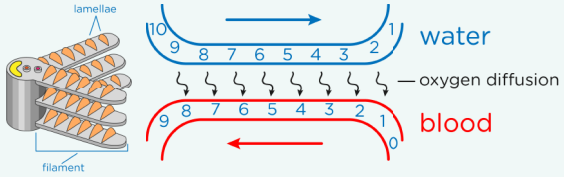


- Root hair cells have protrusion to increase their surface area for water absorption. They also have protein pumps and lots of mitochondria to transport minerals into the cell in order to lower the cells water potential

Gas Exchange

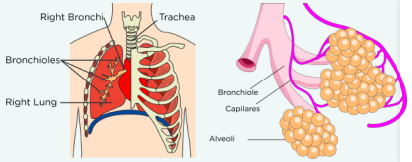
- Single celled organisms can exchange oxygen and carbon dioxide directly through their plasma membrane via diffusion.
- Insects exchange gas in their tracheal system. Air enters via spiracles, travels through trachea and tracheoles, delivering oxygen directly to every tissue. Tracheal fluid limits diffusion to cells. Larger insects can also ventilate by movement of the abdomen, flight muscles changing the volume of the thorax and the presence of air sacs.
- Gas exchange in fish occur via gills.
  - They ventilate their gills by a buccal-opercular pump
  - The orientation of the gill filaments and lamellae ensures that the water flowing over them moves in the opposite direction to the flow of blood through the capillaries (countercurrent flow), maintaining a diffusion gradient.



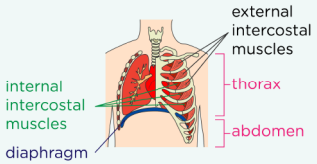


Human Gas Exchange System

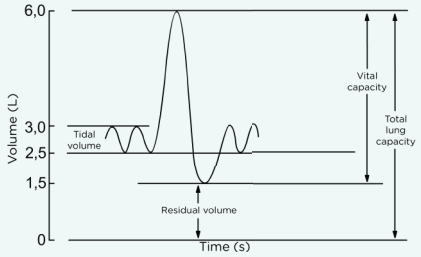
- In humans, gas exchange occurs via the lungs
- The alveolar epithelium is adapted for gas exchange by having a large surface area, good blood supply, thin walls & elastic fibres which help recoil



- Ventilation is the process of breathing in (inspiration) and out (expiration).
- Inspiration: external intercostal muscles contract, rib cage moves up & out, diaphragm contracts, volume of the thorax is increased, atmospheric pressure is greater than pulmonary pressure and air is forced into the lungs.

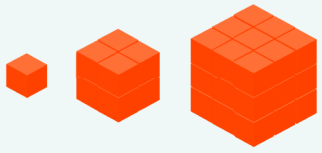


- Expiration: internal intercostal muscles contract, ribs move down and inwards, diaphragm relaxes, volume of the thorax is decreased, pulmonary pressure is greater than atmospheric pressure, air is forced out of the lungs
- Spirometers measure the volume and function of the lungs. Inhalation and expiration moves the lid of the spirometer which is recorded by the datalogger. Carbon dioxide is absorbed by soda lime in the chamber.
- Vital capacity is the maximum amount of air that can be moved by the lungs in one breath
- Residual volume is the volume of air left in the lungs after a forced expiration
- Tidal volume is the volume of air moved in and out of the lungs with a normal breath.



Surface Area to Volume Ratio

- The greater the size of an organism, the smaller its surface area: volume ratio
- Larger organisms therefore require specialised exchange surfaces and transport mechanisms to meet their metabolic requirements

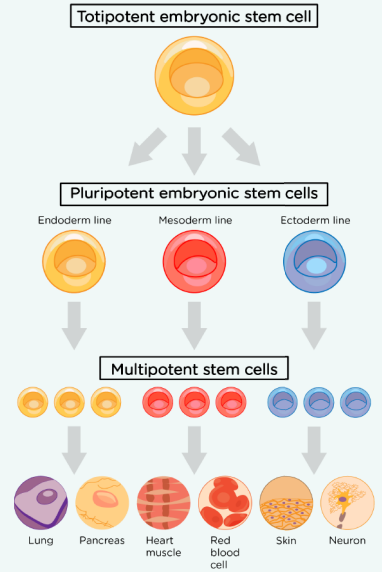


- Specalised exchange surface have: a large surface area, thin barriers and associated transport systems to maintain a steep diffusion gradient.
- Also, organisms with a higher metabolic rate require more nutrients and produce more waste, therefore require a specialised exchange surface

Stem Cells

- Stem cells are undifferentiated cells that are able to express all of their genes and divide by mitosis.
- During development, the stem cells undergo cell differentiation. This is the process by which cells become specialised for different functions.
- Fully developed cells are unable to divide by mitosis.

Stem Cell	Ability
Totipotent	Can divide and differentiate into any type of cell.
Pluripotent	Can self-renew and differentiate into any type of cell except the cells that make up the placenta.
Multipotent	Can only differentiate and divide into a limited number of cell types
Unipotent	Can only differentiate into a single type of cell e.g. cardiomyoblasts can only differentiate into cardiomyocytes.



- Totipotent stem cells are only present in mammals in the first few cell divisions of an embryo. During development, totipotent cells become specialised by expressing different genes and producing different proteins.
- Induced pluripotent stem cells are unipotent stem cells that have been reprogrammed to become pluripotent by using protein transcription factors to express genes associated with pluripotency.
- Pluripotent stem cells can be used to replace cells and treat human disorders like leukaemia and diabetes.
- Bone marrow stem cells can differentiate into any type of blood cell
- Meristem cells in plants are involved in the production of new xylem and phloem tissue

MASS TRANSPORT & THE HEART
CHEAT SHEET

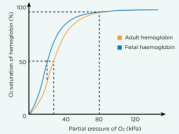
SNAPREVISE

Mass Transport in Animals

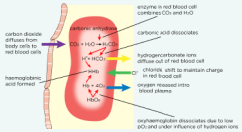
- Red blood cells transport oxygen using the protein haemoglobin

$$\text{oxygen} + \text{haemoglobin} \underset{\text{DISSOCIATION}}{\overset{\text{ASSOCIATION}}{\rightleftharpoons}} \text{oxyhaemoglobin}$$

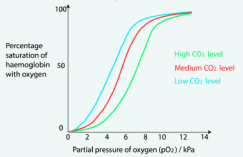
- Haemoglobin is made up of four polypeptide chains, each containing a prosthetic haem group. Each haem group binds one oxygen molecule
- Haemoglobin saturation depends on the partial pressure of oxygen (pO_2). Binding of the first O_2 molecule causes a conformational change in the haemoglobin, making the haem groups more accessible to oxygen.
- Fetal haemoglobin has a higher oxygen affinity than adult haemoglobin because fetal haemoglobin must be able to bind oxygen from adult haemoglobin in the placenta.



- Carbon dioxide is transported in the blood for release from the lungs.
  - 5% of the carbon dioxide transported is dissolved in the blood plasma
  - 10% of the carbon dioxide transported is combined with haemoglobin to form carbaminohaemoglobin
  - 85% is transported as hydrogencarbonate ions (HCO_3^-) dissolved in blood plasma

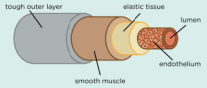


- Bohr affect — haemoglobin's oxygen binding affinity is inversely related to the concentration of carbon dioxide, causing the oxygen dissociation curve to shift



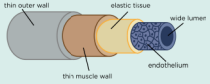
- A good transport system has
  - A fluid medium to transport substances
  - A pump to create pressure for the circulation of the transport fluid
  - Exchange surfaces
- An open circulatory system is one in which the blood is not held in vessels e.g. in insects.
- A close circulatory system the blood is contained within vessels.
- A single circulatory system the blood flows through the heart once for each circuit of the body.
- A double circulatory system blood within double circulatory systems flows through the heart twice for each circuit of the body
- Circulatory system:

Arteries & Arterioles
transports blood away from the heart

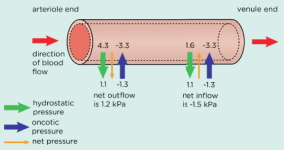


Capillaries — area of metabolic substance exchange

Veins and Venules
transports blood towards from the heart

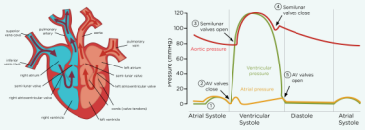


Tissue fluid

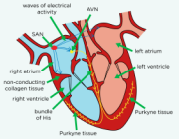


Tissue fluid formation:
Arteriole: Hydrostatic pressure > oncotic pressure, so fluid moves out
Venule: Hydrostatic pressure < oncotic pressure, so fluid moves in
Remaining fluid returns to circulation via the lymphatics system

The Heart



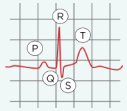
- The cardiac cycle is the sequence of events that occur within one full beat of the heart.
- Systole is the contraction stage and diastole is the relaxation stage
- Cardiac muscle is myogenic, meaning it can contract and relax without receiving signals from the nervous system
- The sinoatrial node (SAN) sends out regular waves of electrical activity to the left & right atrial wall causing contraction. The electrical waves are then passed onto the atrioventricular node (AVN), then to the bundle of His, with a slight delay. The bundle of His splits into the Purkynge tissue, causing contraction of the left & right ventricles from the bottom up.



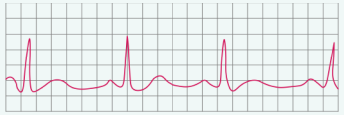
- The rate at which the SAN fires is controlled unconsciously by the medulla oblongata in the autonomic nervous system

Stimulus	Receptor	Effect
High blood pressure	Baroreceptors in the aorta & carotid arteries	Medulla sends impulses along parasympathetic neurones, using acetylcholine to reduce the heart rate
Low blood pressure		Medulla sends impulses along sympathetic neurones, using noradrenaline to increase the heart rate
High blood O_2, pH or low CO_2	Chemoreceptors in the aorta, carotid arteries & medulla	Medulla sends impulses along parasympathetic neurones, using acetylcholine to reduce the heart rate
Low blood O_2, pH or high CO_2		Medulla sends impulses along sympathetic neurones, using noradrenaline to increase the heart rate

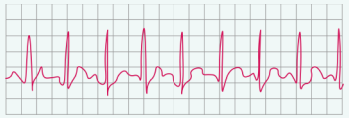
- ECGs can detect the electrical signals through the skin
  - P wave shows atrial systole
  - QRS complex shows ventricular contraction
  - T wave shows diastole



- Bradycardia — slow heart rate:

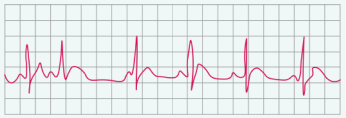


- Tachycardia — fast heart rate:



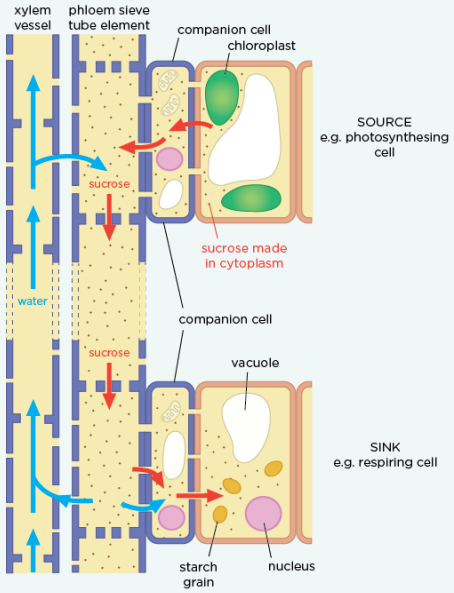
- Atrial fibrillation — atria beats more rapidly than the ventricles:

- Ectopia — irregular heartbeat:



The Phloem

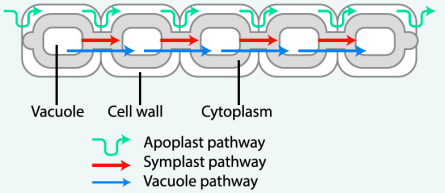
- The phloem transports assimilates from sources to sinks via translocation



- Sucrose is actively transported into the companion cells and moves via diffusion into the sieve tube followed by water. Assimilates move from area of high to low pressure (mass flow). At the sink the solutes are removed, water leaving by osmosis.

Water Transport in Plants

- Water moves through plant tissue via 3 pathways:



- The xylem transports water & mineral ions up the plant against gravity. It is made of dead cells and lignified.
- Water evaporates from the leaves creating tension (transpiration), and the cohesive nature of water moves the whole column of water up the xylem (cohesion-tension theory)
- Water moves up the xylem due to capillary actin, root pressure and transpiration pull
- The rate of transpiration is affected by: light, temperature, humidity & wind.
- Xerophytes are plants adapted to living in dry conditions. They can reduce water loss by having: hairs, waxy cuticle, small leaves, sunken stomata, rolled leaves.
- Hydrophytes are plants adapted to living in water. Their adaptations include: stomata on the upper epidermis, using hydathodes, large air spaces for buoyancy and oxygen diffusion.

DISEASE & IMMUNITY
CHEAT SHEET

SNAPREVISE

Disease

- Communicable disease are caused by pathogens (viruses, bacteria, fungi & protoctista) and can be transmitted from one person to another. They are infectious.
- Pathogens can be transmitted directly (e.g. physical contact, ingestion, droplet infection) or indirectly (e.g. via vectors)
- Bacteria are prokaryotes that can usually damage cells directly or release toxins
- Protoctists are unicellular eukaryotic organisms, which can produce sexually and asexually
- Fungi are eukaryotic organism which cannot photosynthesis therefore are parasties
- Viruses are acellular, non-living particles, they can only replicate inside living host cells where they hijack the host machinery to replicate and then burst the cell to be released.

Disease	Pathogen	Description
HIV/AIDs	Virus	Attacks immune cells
Influenza	Virus	Attack mucous membrane in the respiratory system
Tobacco mosaic virus	Virus	Moult and discolour leaves on tobacco and tomato plants
Ringworm	Fungi	Causes a skin rash in cattle
Athletes foot	Fungi	Causes a rash on the foot of humans
Black Sigatoka	Fungi	Causes leaf spots in banana plants
Blight	Protoctista	Affects potato tubers and tomato and potatoes leaves
Malaria	Protoctista	Blood parasite Plasmodium spread by mosquitos
Tuberculosis	Bacteria	Kills cells and tissues, mainly in the lungs
Bacterial meningitis	Bacteria	Causes swelling of the meninges damaging the brain and nerves
Ring rot	Bacteria	Decays vascular tissue in tomato and potato plants

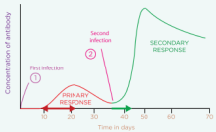
- Autoimmune diseases occur when the immune system mistakenly attacks its own antigens
  - In Arthritis, antibodies attack membranes around the joints
  - In Lupus antibodies attack proteins in the nucleus of cells.

Cell-mediated Immunity

- Antigen from the pathogen is displayed on the cell surface of body cells or phagocytes after phagocytosis
- T cells with the correct specific receptor bind with the antigen and are activated
- They divide by mitosis (clonal expansion) and differentiate into T helper, cytotoxic and memory cells.

Primary & Secondary Response

- The primary immune response is when a pathogen infects the body for the first time the initial immune response is slow
- The secondary immune response is a more rapid and vigorous response caused by a second or subsequent infection by the same pathogens. This is due to the presence of memory cells.

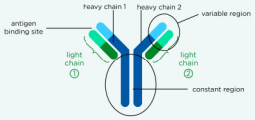


Components of the Immune System

- Antigens are any part of an organism/substance which is recognised as foreign by the immune system and goes on to trigger an immune response.

Cell		Function
Phagocytes	Macrophages	Engulfs and digests pathogens by fusion of the phagosome with lysosomes
	Neutrophils	
T cells	T helper cells	Stimulates B cells to divide and secrete antibodies
	Cytotoxic T cells	kill abnormal cells and infected body cells via perforin
	T memory cell	Remain in the blood for years and provide long term protection
B cells	Plasma cell	Secrete antibodies
	B memory cell	Remain in the blood for years and provide long term protection

- Antibodies are a protein produced by lymphocytes in response to the presence of the corresponding antigen.
- Antibodies agglutinate pathogens by forming antigen-antibody complexes, leading to phagocytosis & neutralise toxins.



Defences

- Human primary defences include:
  - The skin acting as a barrier
  - Blood clotting and skin repair
  - Mucous membranes
  - Coughing and sneezing
  - inflammation
- Plant passive defences include:
  - Cellulose barrier
  - Lignin
  - Waxy cuticle
  - Bark
  - Callose blocking flow in sieve tubes
- Plant active defences include:
  - Deposit callose
  - Close stomata
  - Add cellulose
  - Induce cell necrosis
  - Increase the number of oxidative bursts
  - Produce chemical defences

Chemical	Action
Phenols	Antibiotic and antifungal proteins. One example is the tannins present in tree bark
Alkaloids	Compounds containing nitrogen (e.g. caffeine, nicotine, cocaine and morphine) are bitter to stop herbivores feeding on them and affect enzyme action.
Defensins	These cysteine-rich, defensive proteins have anti-microbial activity. They appear to affect the functioning of ion transport channels in the plasma membrane.
Hydrolytic enzymes	Present in the spaces between cells, they can have a variety of effects. Chitinases break down the chitin in fungal cell walls, glucanases hydrolyse the glycosidic bonds in glucans, and lysozymes destroy bacterial cell walls.

Humoral immunity

- The humoral response is best at fighting pathogens which are free in the bodily fluids
- Free antigen binds to a complementary B cell receptor, activating the B cell (clonal selection)
- The pathogen is endocytosed, and the antigen presented on the plasma membrane
- T helper cell binds to the presented antigen and stimulates the B cell to divide by mitosis (clonal expansion)
- The B cell differentiates to plasma and memory cells

Vaccination & Medicines

- Vaccination is the introduction into the body of a vaccine containing disease antigens, by injection or mouth, in order to induce artificial immunity
- Vaccines work by injecting weakened/dead pathogens into the body to stimulate an immune response, to form memory cells against the specific antigen, which destroy the pathogen quickly upon infection.
- Herd immunity is when the vaccination of a significant proportion of the population provides protection for individuals who have not developed immunity
- Pathogen may mutate so that its antigens change suddenly (antigenic variability) So the vaccine is now ineffective to the new antigens.
- Ethical considerations: side effects, financial cost, right to choose, animal testing of vaccines, human trials
- Active immunity occurs when specific antibodies are produced by the individual's own immune system
- Passive immunity occurs when specific antibodies are introduced to the individual from an outside source.

Immunity	Example
Natural Active	Direct contact with pathogen
Natural Passive	Antibodies through breastmilk
Artificial Active	Vaccination
Artificial Passive	Injection of antibodies

- Antibiotics prevent the growth of bacteria. They are effective because they show specificity in killing bacteria without harming human cells. However, overuse has led to the spread of resistance in bacteria e.g. MRSA. To reduce spread prescription of antibiotics is controlled, patients must finish their course and prevent spread by control measures
- New medicines can be discovered from plant compounds using DNA sequencing to screen plants and organisms for potential medical compounds. DNA sequencing can also be used to develop a specific drug suited to persons genome.

BIODIVERSITY, CLASSIFICATION & NATURAL SELECTION
CHEAT SHEET

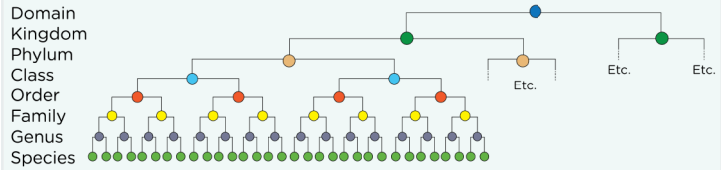
SNAPREVISE

Biodiversity

- Biodiversity is the variety of organisms in an area. It can be considered on different levels including habitat, species and genetic diversity of an area
- Habitat diversity refers to the range of habitats present in a region
- Species diversity is the number of species and the number of individuals within each species in a specified area. It takes into account species richness and species evenness.
- Species richness is a measure of the number of different species in a community.
- Species evenness is a measure of the relative abundances of different species in an area.
- Genetic diversity is the variety of all the genes (number of different alleles of genes) possessed by the individuals in a population or whole species
- Alleles are different forms of the same gene
- The greater the genetic diversity, the greater the ability of the species to adapt to a changing environment.
- Genetic diversity can be estimated by comparing physical characteristics or by analysing genomes.
- Species with a greater number of polymorphic genes tend to have greater genetic diversity
- $\textbf{Genetic Diversity} = \frac{\textbf{no.of loci with more than one allele}}{\textbf{total no.of loci}} \times 100$
- Simpson's diversity index (D) measure biodiversity taking into account species richness and evenness .
- $D = 1 - \left(\sum \left(\frac{n}{N}\right)^2\right)$
  - N = total number of organisms of all species
  - n = total number of organisms of each species
- Factors affecting biodiversity include:
  - Human population growth increases the demand for resources from the environment
  - Agriculture reduces biodiversity by monoculture, use of herbicide & pesticides, hedgerow removal and woodland clearance
  - Climate change is causing animals to migrate or die
- Reasons for maintaining biodiversity can be:
  - Ecological — ecosystems are more stable when biodiversity is high. Keystone species are a species which has a disproportionate effect on its environment relative to its abundance, their removal will greatly reduce the ability of an ecosystem to function
  - Economical — provides resources
  - Aesthetic
  - Ethical
- Conservationists protect biodiversity with methods such as: giving endangered species legal protection, creating protected area & The Environmental Stewardship Scheme.
- A balance between conservation and agriculture is needed.

Classification

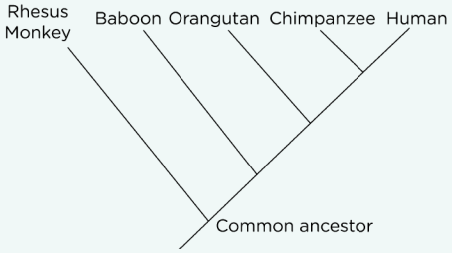
- The Biological Species Concept- a species contains all organisms that are capable of breeding together to produce living, fertile offspring.
- Classification is the process of sorting living things into groups.
- Classification hierarchy comprises the taxa: domain, kingdom, phylum, class, order, family, genus and species.



- Classifications are constantly updated as new methods are discovered to infer relationships e.g. physical characteristics to DNA sequencing, amino acid sequencing or cytochrome C comparisons.

Animalia	Animals are eukaryotic, multicellular, heterotrophic and usually able to move around
Plantae	Plants are eukaryotic, autotrophic, multicellular, have a cellulose cell wall, and contain chlorophyll
Fungi	Fungi are eukaryotic, single-celled or multicellular, saprophytic, have a chitin cell wall and a multinucleate cytoplasm
Protoctista	Protoctists are eukaryotic, mostly free living, single-celled or multicellular, autotrophic or heterotrophic,
Prokaryotae	Prokaryotes have smaller ribosomes, a naked loop of DNA, free living or parasitic, no nucleus or no other membrane bound organelles,

- The binomial naming system names species by their genus and species name.
- Phylogeny is the study of evolutionary relationships between organisms.
- In a phylogenetic diagram, branch tips represent species at the end of their specific lineage, branching points represent common ancestors & The closer the branches, the closer the evolutionary relationship.



Natural Selection

- Predation, disease and competition means that not all individuals within a population survive to get a chance to reproduce. This differential survival and reproduction is the process by which natural selection acts.
  Genetic variation within a population creates intraspecific competition. The organisms with phenotypes that provides a selective advantage are more likely to survive and reproduce and thus pass on their favourable alleles to the next generation. This means that the proportional of individuals with the favourable allele will increase in the next generation (increase the allele frequency) within the population. This is evolution by natural selection.
- Evolution is the change in allele frequencies in a population over time.
- An adaptation is a trait that enhances survival in a habitat
  - Anatomical adaptations are structural features e.g. roots with a large surface area
  - Behavioural adaptations e.g. hibernation
  - Physiological adaptations are changes to cellular processes e.g. fight or flight adrenaline response
- Convergent evolution occurs when organisms that live in similar conditions are subject to the same selection pressures, resulting in similar adaptations
- Evidence for the theory of natural selection comes from the fossil record and biological molecules, including mDNA
- Evolution by natural selection has resulted in antibiotic resistance bacteria and pesticide resistance in insects

Variation

- Interspecific variation is the differences between any two species
- Intraspecific variation is the differences between members of the same species
- Characteristics that show continuous variation are normally polygenic (determined by many gene loci that have additive effects on each other).
- Characteristics that show discontinuous variation are usually monogenic (determined by a single gene loci).
- Variation is due to genetic and environmental factors.
- The main source of genetic variation is mutations, which can produce different alleles of genes.
- Further sources of genetic variation include meiosis (independent assortment and crossing over) and the random fertilisation of gametes during sexual reproduction to create new allele combinations.
- The environment can influence the way an organism's genes are expressed. This can be because of biological factors such as predators or non-biological factors such as sunlight.