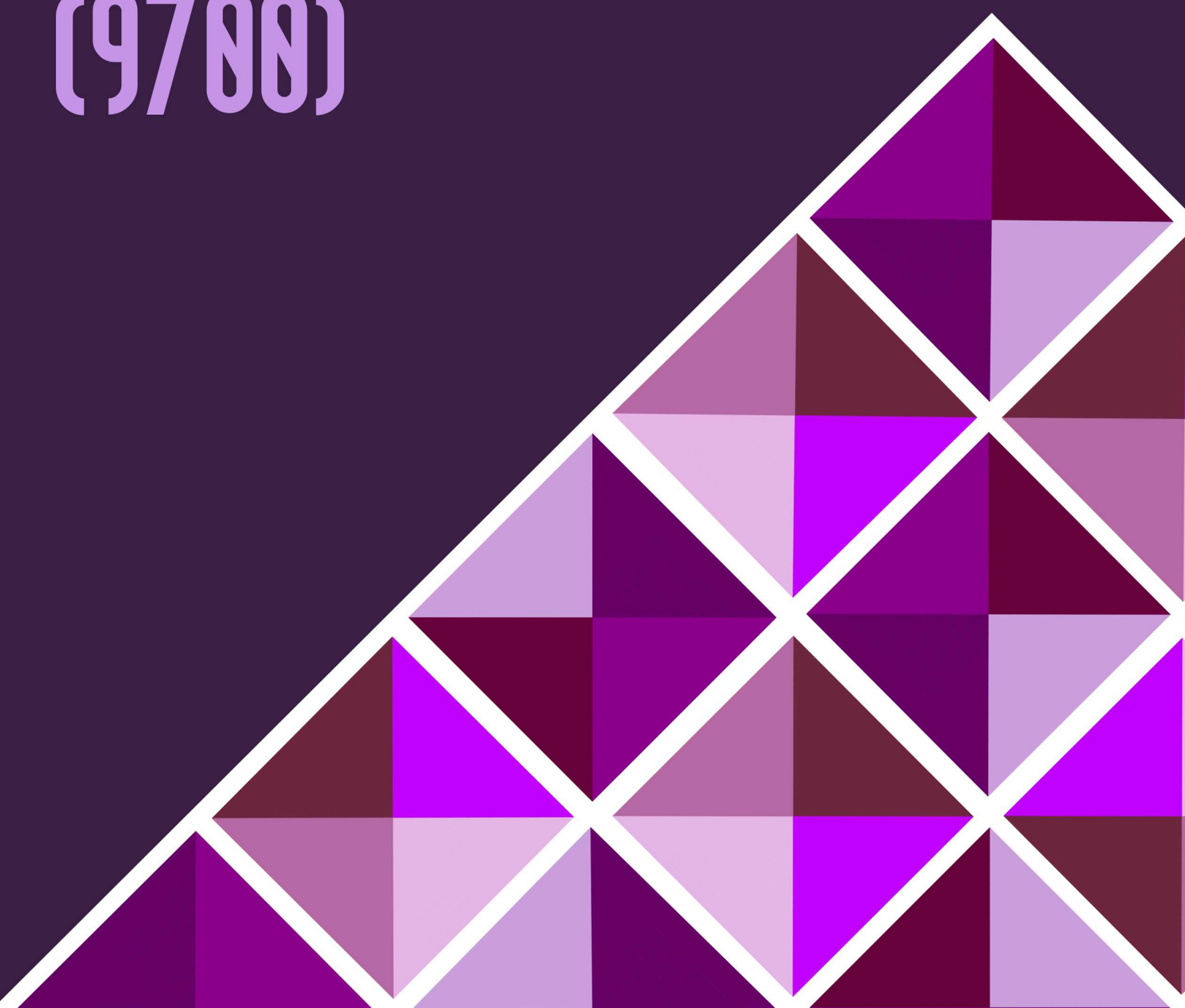
VBEST NOTES

A LEVEL CIE AS BIOLOGY (9700)



Biology

- ☐ Cell structure
- ☐ Biological molecules
- ☐ Enzymes
- ☐ Cell membranes and transport
- ☐ The mitotic cell cycle
- ☐ Nucleic acid and protein synthesis
- ☐ Transport in plants
- ☐ Transport in mammals
- ☐ Gas exchange and smoking
- ☐ Infectious disease
- ☐ Immunity

Chapter 1 : Cell structure

a) Light microscope vs Electron microscope

Light microscope	Electron microscope
Simple to use	Users require technical skills
Can view both live and dead specimens	Views only dead specimens
Poor surface view	Good surface view and internal details
Uses light rays to illuminate specimens	Uses a beam of electrons to view specimens
Lenses are made of glass	Lenses are made of electromagnets
Low resolving power, usually below 0.30µm.	High resolving power of up to 0.0001µm.
Low magnification of up to 1,500x	High magnification of up to 1,000,000x
Images are viewed by the eyes through the eyepiece	Images are viewed on a photographic plate or zinc sulphate fluorescent screen
Not used under a vacuum	Operates under a high vacuum
Cheap to buy and has low maintenance costs	Very expensive to buy and maintain

b) Magnification and resolution

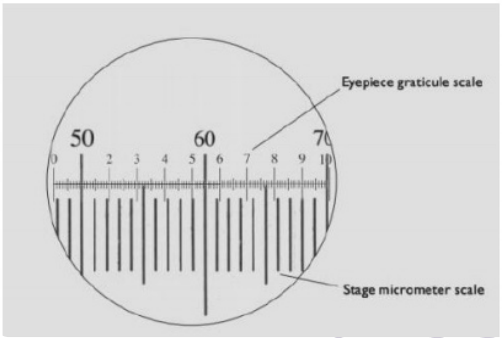
$$\text{Magnification} = \frac{\text{Image}}{\text{Actual object}}$$

Resolution : the shortest distance between two points on the specimen that can still be distinguished as separate objects

c) Units

µm $\underset{\div 1000}{\overset{\times 1000}{\rightleftharpoons}}$ nm $\underset{\div 1000}{\overset{\times 1000}{\rightleftharpoons}}$ mm

d) Calibration



- Line up one of the divisions of the eyepiece graticule with a fixed point on the stage micrometer.
- Count the number of divisions on the eyepiece graticule that corresponds with a set measurement on the stage micrometer.
- Calculate the distance in micrometers of one division on the eyepiece graticule .

e) Functions of membrane systems and organelles

- Plasma membrane : Controls what enters and leaves the cell
- Nucleus : Directs cell activities and contains genetic material called chromosomes made of DNA
- Ribosomes : Found free in the cytoplasm and attached to RER
  Ribosomes on the RER produce proteins by linking amino acids
- Mitochondria : Generate ATP from substrates in presence of oxygen
- Golgi Apparatus : Modify packages and transports proteins
- Lysosome : Contains digestive enzymes
- Vacuole : Surrounded by a membrane and filled with fluid.
- Smooth ER : Involved in synthesis of lipids and carbohydrates.
- Rough ER : Site of attachment for ribosomes
- Chloroplast : Contains pigment chlorophyll that captures energy from sunlight for photosynthesis

f) Prokaryotes and eukaryotes

There are only two basic types of cells prokaryotes and eukaryotes

- All bacteria and bacteria-like Archaea are prokaryotic organisms.
- Eukaryotes can be single cell or multicellular organisms.
- They are more complex having evolved from prokaryotic-like predecessor.

EUKARYOTIC Cells vs PROKARYOTIC Cells

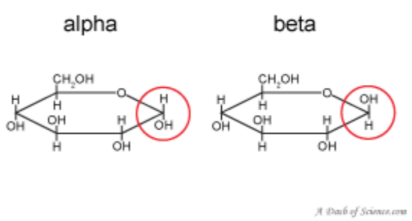
CHARACTERISTIC	PROKARYOTES	EUKARYOTES
Size	0.2-2.0μm in diameter	10-100μm
Nucleus	x	ALL
Organelles with Phospholipid membrane	x	**ER, Golgi bodies, Lysosome mitochondrial, chloroplasts**
Glycocalyx	**capsule** (organize) **slime layer** (unorganize)	Surround some animal cells
Motility	*rotating* **Flagella** (some)	*undulated* Flagella & Cilia ("9+"2 arrangement microtubles others by *amboid action*
Flagella	some	some
Cilia	x	some
Fimbriae & Pili	some	x
Cell Wall	most, bacteria (peptidoglycan)	most: protein, cellulose, algin agar, carrageenan, silicate, glucomanna, chitin
Plasma membrane	Lacking carbs and sterols	has: glycoproteins, glycolipids, sterols
Cytosol	ALL	ALL
Inclusions	ALL	ALL
Endospores	some	x
Ribosomes	Cytoplasm (70s)	Cytoplasm (80s) Mitochondria & Chloroplast (70s)
Chromosomes	single, circular, lack **histones**	More than one, linear, contain **histones**

Chapter 2 : Biological Molecules

a) Carbohydrates $C_6H_{12}O_6$

i) Monosaccharides : The simplest carbohydrates

Glucose molecules has 2 forms: α-glucose and β-glucose.



ii) Disaccharides

Disaccharides are formed in a condensation reaction between two monosaccharides.

The bond that joins them together = glycosidic bond.

Glucose + Glucose —> Maltose

Glucose + Fructose —> Sucrose

Glucose + Galactose —> Lactose

Disaccharides are split back into monosaccharides by hydrolysis reaction (addition of water)

iii) Polysaccharides

Polysaccharides form from linking many monosaccharides into long chains.

There are structural polysaccharides and storage polysaccharides

- Structural polysaccharides : Cellulose

  Cellulose is made out of beta glucose molecules and linked by 1,4 glycosidic bonds

  The chain is straight and not branched.

  Cellulose chains join together by hydrogen bonds to form microfibrils.

  Microfibrils are what provides structure to plant cells.

- Storage polysaccharides: Starch and Glycogen

Starch is the storage polysaccharide for plants.

It is a mixture of amylose and amylopectin. Both are polymers of alpha glucose.

Amylose is a molecule with very long chain, linked by 1,4 glycosidic bonds.

The chain coils up into a spiral and is held in shape by hydrogen bonds

Amylopectin is highly branched and is linked by 1,4 and 1,6 glycosidic bonds.

Glycogen is the storage polysaccharide for animals and fungi

It is made out of alpha glucose molecules linked together by 1,4 and 1,6 glycosidic bonds.

It is highly branched and releases more energy than amylopectin

b) Lipids

- Triglycerides are made of glycerol 'backbone', attached to 3 fatty acids by ester bonds.

Unsaturated fatty acids has C-C double bonds and saturated fatty acids has no double bonds.

Unsaturated lipids tend to have lower melting points than saturated lipids.

Triglycerides are insoluble in water, making them energy storages in plants, animals and fungi.

In mammals : Helps to insulate body against heat loss.

Have relatively low density which increases buoyancy

↳ useful for aquatic mammals living in cold water (whales, seals).

Forms a protective layer around organs (e.g. kidneys).

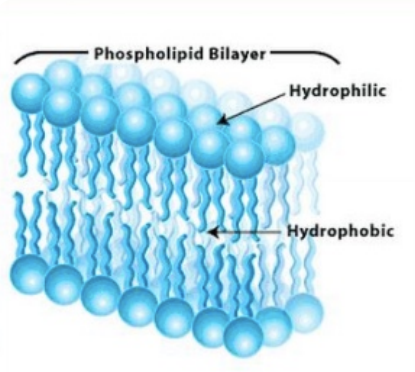
In plants : Triglycerides are major part of energy stores in seeds : Endosperm and cotyledons

- Phospholipids :

Tails are hydrophobic: no electrical charge —> not attracted to H2O molecules.

Heads are hydrophilic: has electrical charge —> attracted to H2O molecules.

In H2O, phospholipid molecules are arranged into a bilayer: hydrophilic heads facing outwards into the water + hydrophobic tails facing inwards, avoiding water.



c) Proteins

Proteins are large molecules made of long chains of amino acids formed by condensation reaction. Amino acids are held together by peptide bonds. Two amino acids joined together make a dipeptide.

- Structure:

Primary structure : The linear sequence of amino acids in a polypeptide or protein molecule.

Secondary structure : The way in which the primary structure of a polypeptide chain folds.
After synthesis, polypeptide chains are folded or pleated into different shapes:
Alpha helix (regular 3D shape) and Beta-pleated sheet (twisted, pleated sheet)
They are held together by strong H-bonds giving them great stability.

Tertiary structure : The final 3D structure of a protein, involving coiling or pleating of the secondary structure. They are held by: Hydrogen Bonds, Disulphide Bonds, Ionic Bonds and Hydrophobic and Hydrophilic Interactions.

Quaternary structure : Consist of more than 2 polypeptide chains join together to form a protein.
Sometimes contain an inorganic component = prosthetic group.
The polypeptide chains are held by the same bonds as in the tertiary structure.

- Globular and fibrous proteins

Haemoglobin is a water soluble globular protein that consist of 2 beta polypeptide chains and 1 haem group. It carries oxygen in the blood as oxygen binds to the iron in the haem group.

Collagen is fibrous protein that is held together by strong hydrogen and covalent bonds.
Collagen molecules wrap around each other forming fibrils and subsequently strong collagen fibres.
Collagen formed the structure of bones, connective tissues, tendons and cartilages.

d) Water

- A H2O molecule has a negative charge on the O atom and a positive charge on both H atoms, causing it to be a polar molecule thus making water an excellent solvent.
  Being a solvent it helps to transport substances around the bodies of organisms.
- It has a high specific heat capacity (a lot of energy is required to increase temperature of water) and large latent heat of vaporisation (evaporation of water provides cooling effect with little water loss)
- H2O freezes from the top down and is less dense in its solid state making it float. (due to crystal structure of ice)
- Water molecules have strong cohesion bonds between them, this enables them to travel in mass flow.

Chapter 3 : Enzymes

Enzymes are biological catalyst that speed up or slow down metabolic reaction while remaining unchanged.
They may facilitate the breaking of an existing bond or the formation of a new bond.
Substrates = the molecules that bind to the enzyme
Products = new substances formed.

Enzymes are a globular protein

a) Active site

Active site is a binding site in the enzymes molecules where the substrate attaches to the enzyme, creating an enzyme substrate complex.
Enzyme binding sites are highly specific.

- Lock and Key hypothesis

The shape of the active site of the enzyme and the substrate molecules are complementary.
Like a key into a lock, only the correct size and shape of the substrate would fit into the active site of the enzyme.

- Induced fit hypothesis

The shape of the active site of the enzyme and the substrate molecules are not complementary.
In the presence of the substrate, the active site changes its shape and molds to completely fit the substrate.

b) Activation energy

Activation energy = minimal amount of energy that is needed for a reaction between enzyme and substrate to start.
Enzymes reduce activation energy needed so that reaction take place at a lower temperature.

c) Factors affecting the rate of enzyme catalysed reactions

- Temperature

As temperature increases, kinetic energy of reacting molecules increases. This increases successful collision thus increasing ROR
At optimal temp enzyme's activity and ROR is maximal
Above this temperature, H bonds holding enzyme molecule in shape begin to break, causing enzyme to denature, distorting it's active site. This makes the substrate unable to bind to it, decreasing ROR.

- pH

Optimum pH - is the pH at which an enzyme has maximum activity.
Extreme changes in pH breaks the bonds holding enzyme in shape, causing enzyme to denature, distorting it's active site. This makes the substrate unable to bind to it, decreasing ROR.

- Enzyme concentration

More concentration of enzyme leads to more collisions between enzyme and substrate and increases the ROR
However this is only true until substrate concentration becomes the limiting factor. Increasing enzyme concentration will do nothing if there is no substrate to bind to active site.

- Substrate concentration

Increasing concentration of substrate will increase collisions between enzyme and substrate leading to higher ROR.
However this is only true until enzyme concentration becomes the limiting factor. Increasing substrate concentration will have no effect if there is no enzyme active site to bind to.

- Inhibitor concentration

Inhibitor is a substance that slows down the rate at which an enzyme works.

—> Competitive inhibitors

Have similar shape to the enzyme's normal substrate and can fit into the enzyme's active site, preventing the substrate from binding.
This reaction is reversible by increasing concentration of substrate.

—> Non-competitive inhibitors

Have different shape than the substrate therefore can ot bind to the active site.
Instead they bind to the allosteric site.
Binding to the allosteric site changes the shape of the enzyme and subsequently its active site.
Thus substrate cannot bind to active site of enzyme
Increasing concentration of substrate will not have any affect on non competitive inhibitors.

d) Michaelis Menten Constant

Michaelis-Menten equation measures the velocity of enzymatic reactions
Vmax represents the maximum rate achieved by the reaction at maximum substrate concentrations.
Km is the substrate concentration at which the reaction rate is half of Vmax.
Km is a measure of the affinity of an enzyme to its substrate. The lower the Km, the greater the affinity.

e) Immobilized enzymes

When enzymes are in solution, they can only be used once as it is very difficult and time consuming to separate them from the product. Therefore to allow for their re-use, enzymes have to be immobilised.
Enzymes are immobilised by attaching them to an insoluble material such as calcium alginate.
This process enables enzymes to be reused as they can be easily separated from the products.
Immobilising the enzyme also enables them to be more stable at high temperatures.

Chapter 4 : Cell membrane and transport

All cells and organelles are surrounded by a partially permeable membrane. The membrane has 2 layers of phospholipids (phospholipid bilayer) and in between those layers are protein molecules.
This is called the fluid mosaic model of membrane structure:
- Fluid because molecules within the membrane can move around within their own layers)
- Mosaic because the protein molecules are mosaically arranged

a) Structure and functions of the cell membrane

- Phospholipids- Have a hydrophobic head and a hydrophilic tail. They are permeable too small and nonpolar molecules and impermeable to large molecules and ions.
- Glycoproteins- Act as cell-surface receptors and are responsible for the binding of extracellular signalling molecules. Their binding sites are highly specific.
- Cholesterol- Mantains the fluidity of the membrane. It is also waterproof and helps increase stability of the membrane.
- Channel proteins- Facilitates the movement of large molecules in and out of the cell.
- Carrier proteins- Actively move substances across the cell surface membrane using energy from ATP.
- Glycolipids- Help cells attach to one another (cell adhesion), cell signalling and act as cell-surface antigens

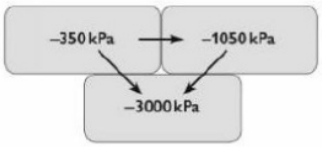
b) Passive and active transport across cell membranes

Passive and Active
→ Simple Diffusion
→ Facilitated Diffusion
→ Osmosis (water only)

- Diffusion is a net movement of molecules from a region of its higher concentration to a region of its lower concentration down a concentration gradient

- Facilitated diffusion is the movement of specific molecules from a region of high concentration to a region of low concentration down a concentration gradient with using channel protein or carrier protein. Usually ions or large molecules.

- Osmosis is the diffusion of water molecules from a region high water potential to a region of lower water potential across a partially permeable membrane down a water potential gradient
  More negative kPa, more concentrated, lower water potential.



- Active transport is the movement of specific molecules from a low concentration to high concentration against the concentration gradient using carrier protein using ATP.

c) Endocytosis and exocytosis

Macromolecules are too large to move with membrane proteins and must be transported across membranes in vesicles.

- Exocytosis is the transport of macromolecules out of a cell in a vesicle. The membrane of the vesicle fuses with the cell membrane, expelling its contents outside the cell.
- Endocytosis is the transport of macromolecules into a cell in a vesicle. The cell puts out extensions around the object to be engulfed and the membrane fuses together around the object, forming a vesicle. (Eg : phagocytosis (cell eating) and pinocytosis (cell drinking))

d) Surface area to volume ratios

- As a cell increases in size, there is less surface area in proportion to its volume.
- The volume ↑ faster than the surface area, therefore the surface area to volume (SA/V) ratio ↓.
- Cells cannot continue growing larger, indefinitely. When a maximum size is reached, cell growth stops.
- As cells are surrounded by a semi permeable membrane, solutions can diffuse in and out of the cell.

- In dilute solutions as water moves into the cytoplasm,

Animal cells - expand and burst (lysis)

Plant cells - expand and becomes turgid (cell wall prevents it from bursting)

- In concentrated solutions as water moves out of the cytoplasm,

Animal cells - the cell shrinks

Plant cell - protoplast shrinks away from cell wall (plasmolysis)

Chapter 5 : The mitotic cell cycle

Mitosis is a nuclear division giving rise to genetically identical cells in which the chromosome number is maintained by the exact duplication of chromosome.

a) Significance of mitosis

- Production of genetically identical cells: It keeps the chromosomal number the same in every generation.
- Growth: a single cell divides repeatedly to produce all the cells in the adult organism in repair of a tissue (not organ)
- Cell replacement: produce new cells to replace ones that have been damaged (repair and generation of lost parts) or worn out (healing of wounds).
- Asexual reproduction: a single parent gives rise to genetically identical offspring

b) Cell cycle

The cell cycle is the continuous cycle of growth and mitotic division.
It has 3 major phases: Interphase and mitotic phase and cytokinesis
The period from one cell division to the next is called the cell cycle.
Interphase : G1, S and G2
Mitosis : Prophase, Metaphase, Anaphase and Telophase
Cytokinesis

- Interphase :

  G1 —> Cells synthesize RNA and proteins to induce growth.

  S-phase —> Replication of DNA.

  G2- phase —> Organelles (mitochondria and chloroplasts) are replicated and DNA is checked

- Mitosis :

Prophase —> Chromosomes condense and become more coiled.
The nuclear membrane breaks down and the nucleolus disappears.
Centrosomes move to opposite ends of the pole and forms spindle fibres

Metaphase —> The chromosomes align themselves along the metaphase plate
Spindle fibres attached to kinetochores of the chromosomes.

Anaphase —> The centromeres divide, and the sister chromatids of each chromosome are pulled apart and move to the opposite ends of the cell, pulled by spindle fibres attached to the kinetochore regions.
The separated sister chromatids are now referred to as daughter chromosomes.

Telophase —> The nuclear membrane reforms around the chromosomes grouped at either pole of the cell.
The chromosomes uncoil and become diffuse.
The spindle fibres disappear.

- Cytokinesis

In animals : A cleavage furrow forms at the equator of the cells and will eventually pinch off the two cells to separate them. The cell membranes of each cell will undergo fission to separate the two daughter cells completely.

In plants. : A new cell plate is formed in between the 2 cells. After the plate divides the plant cells into two daughter cells, the plasma membrane seals off and fully separates the two new cells.

c) Haploid and diploid cell

- Haploid cells
  Cells that contain only 1 complete set of chromosomes.
  They are gametes and are produced from diploid cells by meiosis. (reduction division)
  In human, when the sperm and egg (haploid cells with 1 set of 23 chromosomes) fused together, this produced a diploid zygote with 2 sets of chromosomes (46 chromosomes).
  As this cell divided by mitosis, each daughter cell obtained a complete copy of each set.
- Diploid cells
  Most of the cells in the body are diploid cells, they contain 2 complete sets of chromosomes, 1 from mother and one from father. (Total 46 sets)
  Diploid cells reproduce using mitosis, which creates a completely identical copy of the cell.

d) Control of cell division

Cancer and uncontrolled cell division

In cancer : genes that control cell division mutate and cell divides over and over again, forming an irregular mass of cells.

In malignant tumour: some of cancer cells may break off and start to form new tumours elsewhere in the body.

Several genes must mutate before a cell becomes cancerous. This can happen just by chance.

The risk is increased by factors that cause mutation (carcinogenic factors):

- ionising radiation
- ultraviolet radiation
- chemicals
- viruses

Chapter 6 : Nucleic acid and protein synthesis

a) DNA

Nucleotides consist of a 5C sugar, a phosphate group and a nitrogen base

A and G = purine bases (double ring)

C, T and U = pyrimidine bases (single ring)

Nucleotides are bonded together by phosphodiester bonds between the phosphate group of one nucleotide and the sugar of another to make nucleic acids. (by condensation)

- Difference between DNA and RNA

  DNA is a double stranded helix polynucleotide with a deoxyribose sugar

  RNA is a single-stranded polynucleotide chain with ribose sugar

b) DNA replication

The semi-conservative replication of DNA ensures genetic continuity between generations of cells.

DNA replication occurs during interphase.

Steps :

- The double helix unwinds and the hydrogen bonds between the complementary bases break using DNA helicase thus separating the two strands of DNA.
- One of the strands is used as the template and complementary base pairing occurs between the template strand and free nucleotides. (A with T and C with G)
- DNA polymerase links together the phosphate and deoxyribose groups of adjacent nucleotides.

c) Protein synthesis

- Transcription

  Using one strand of DNA as a template, mRNA is transcribed by RNA polymerase.

  It contains a complementary copy of the base sequence on the template strand of part of a DNA molecule. mRNA leaves nucleus and into cytoplasm.

- Translation

  mRNA attaches to ribosome.

  tRNA is a type of RNA. It has an anticodon on one end and an amino acid bonded to the other, which it carries to the ribosome.

  The anticodon of the tRNA binds itself to the first codon on the mRNA by complementary base pairing

  Another tRNA molecule binds to the second codon of the mRNA.

  The amino acids attached to the tRNA molecules join by a peptide bond and then tRNA molecules detach themselves from the amino acids, leaving them behind.

  This process is repeated thus leading to the formation of a polypeptide chain until a stop codon is reached on mRNA and ends the process of protein synthesis.

d) Gene mutation

A gene mutation is a random change in the sequence of nucleotides that may result in an altered polypeptide. A change in the sequence of bases in DNA may result in a change in the sequence of amino acids in a protein. This in turn may result in a change in the 3-D structure of the protein and therefore the way that it behaves.

> This does not always happen, because there is more than one triplet that codes for each amino acid, so a change in a triplet may not change the amino acid that is coded for.

Sickle cell anaemia

The mutation is a change in the gene that codes for β polypeptide in a Hb molecule.

The abnormal β polypeptide has the amino acid valine where it should have the amino acid glutamic acid.

The normal form of Hb is called HbA, the abnormal Hb is called sickle cell Hb (HbS)

These amino acids are on the outside of the Hb molecule when it takes up its tertiary and quaternary shapes.

When the abnormal Hb is in an area of low oxygen concentration, the Hb molecules stick to one another, forming a big chain of molecules that is not soluble and therefore forms long fibres.

This pulls the red blood cells out of shape, making them sickle-shaped instead of round.

They are no longer able to move easily through the blood system and may get stuck in capillaries.

Chapter 7 : Transport in Plants

a) Transport system

- In a single-celled organism, transport of O2, CO2 and nutrients can happen by diffusion alone. Because no point in the cell is very far from the surface, so it does not take long for gases to diffuse from the cell surface membrane to the centre of the cell,
- In a large organism, diffusion is no longer sufficient. This is because: the centre of the organism may be a long way from the surface, so it would take too long for substances to diffuse all that way; the surface area to volume ratio is much smaller.

Large organisms solve these difficulties in two ways: transport system and increase surface area.

b) Structure of transport tissues

Xylem : transports water and inorganic ions from the roots to the leaves.
Xylem tissue contains dead, empty cells with no end walls and are arranged in long lines to form xylem vessels. These are long, hollow tubes through which water moves by mass flow from the roots to all other parts of the plant.

Phloem : transports food made in the plant (sucrose and amino acids) from the leaves to the rest of the plant.
Phloem tissue contains cells called sieve tube elements and each sieve tube element has a companion cell. They are living cells.

c) Pathways

Two routes by which the water travels from the root hair cells to the xylem of the root.

- Symplast : Water moves from cell to cell through plasmodesmata
- Apoplast : Water moves through the cell walls and intracellular spaces

d) Movement of water

<u>Soil to root</u>

It can occur via symplast or apoplast pathway
Water can only travel through apoplast pathway up to the endodermis.
This is because at the endodermis there is the Casparian strip, which is impermeable to water.
In order for the water to cross the endodermis the water that has been moving through the cell walls must now enter symplast pathway.

Up the xylem

Water moves up the xylem vessels by mass flow. The water molecules are held together by hydrogen bonds between them (cohesion), keeping the water column unbroken.

There is a relatively low hydrostatic pressure at the top of the column, produced by the loss of water by transpiration. This lowering of hydrostatic pressure causes a pressure gradient from the base to the top of the xylem vessel.

The push of water upwards is aided by the root pressure which is where the action of the endodermis moving minerals into the xylem by active transport, drives water into the xylem by osmosis, thus pushing it upwards.

Transpiration

Water is released into the atmosphere as water vapour to the atmosphere via stomata.

Transpiration involves osmosis, where water moves from the xylem to the mesophyll cells. Water from the surface of mesophyll cells evaporate into intercellular spaces and diffusion as water vapour down a water vapour potential gradient out of the stomata.

Transpiration is and inevitable consequence of photosynthesis.

During photosynthesis, the guard cells change shape to open the stomata to allow CO_2 to diffuse into the leaf. When the stomata opens, water vapour diffuses out.

e) Movement of assimilates

Source and sink

A source where assimilates enter the phloem.

A sink is where assimilates leave the phloem.

Translocation

- From companion cells to sieve tube element

H^+ is actively pumped out of the cytoplasm of the companion cells into its cell wall. As H^+ concentration increases, it diffuses back into the cytoplasm together with sucrose via H^+ sucrose co transporter. This increases the concentration of sucrose in the companion cell, so it diffuses down the concentration gradient and into the sieve tube element through the plasmodesmata.

- From source to sink

At the source, concentration of sucrose in sieve tube elements increases, water potential decreases.
Water diffuses in down concentration gradient, creating an increase in hydrostatic pressure.
At the sink, sucrose diffuses out of sieve tube element down the concentration gradient.
This produces a water potential gradient so water also diffuses out of the phloem, decreasing the hydrostatic pressure.
Phloem sap moves by mass flow down this pressure gradient.

f) Factors affecting rate of transpiration

- High temperature : It increases the rate of transpiration. Evaporation from the cell walls inside the leaf therefore happens more rapidly, and diffusion also happens more rapidly.

- High humidity : It decreases the rate of transpiration. This is because the water potential gradient between the air spaces inside the leaf and the air outside is less steep, so diffusion of water vapour out of the leaf happens more slowly.

- High wind speed : It increases rate of transpiration. This is because the moving air carries away water vapour from the surface of the leaf, helping to maintain a water potential gradient between the air spaces inside the leaf and the air outside.

- High light intensity : It increases the rate of transpiration. This is because the plant may be photosynthesising rapidly, requiring a rapid supply of CO_2. This means that more stomata are likely to be open, through which water vapour can diffuse out of the leaf.

g) Xerophytes

A xerophyte is a plant that is adapted to live in an environment where water is in short supply.
The adaptations may include:

- Leaves with small surface area to volume ratio : This reduces the amount of surface area from which water vapour can diffuse.
- Leaves with a thick, waxy cuticle : This reduces the quantity of water that can diffuse through the surface of the leaf into the air.
- Stomatal pits : This produces a layer of high water potential around the stomata, reducing the water potential gradient and therefore reducing the rate of diffusion of water vapour from inside the leaf to outside.

Chapter 8 : Transport in mammals

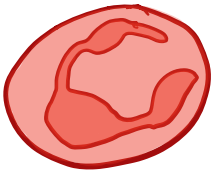
a) The circulatory system structures and their functions

The mammalian circulatory system is called a closed double circulation because blood flows through the heart twice in one circulation and it travels in the vessels

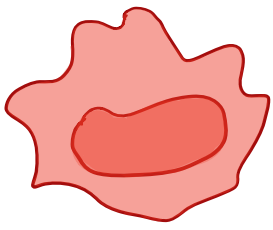
- Arteries : Carries blood away from the heart. Has thick elastic walls to withstand high pressure which can expand and recoil as blood passes through. It is line with smooth endothelium to reduce friction and ease flow of blood.
- Arterioles : Branched off arteries that feed blood into capillaries. Contains smooth muscle which can contract and make the lumen smaller to control flow of blood in different parts of the body.
- Capillaries – They have a narrow lumen, a large surface area, and a slow blood flow to allow for efficient diffusion. Also have one cell thick walls which have tiny gaps that allow plasma to leak out.
- Venules – They are small blood vessel is that connect capillaries to the veins.
- Veins – Carries low pressure blood from the body into the heart. They contain valves to prevent backflow of blood.

Blood components

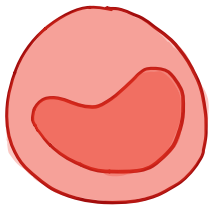
- RBC : Transports O2 to respiring tissues and carries CO2 away from cells. It has a bioconcave shape to increase surface area to volume ratio is allowing rapid diffusion of O2. Has no nucleus or mitochondria to allow more surface area to carry haemoglobin.
- WBC : There are two types of WBC - lymphocytes and phagocytes. Lymphocytes make antibodies and phagocytes destroy unwanted cells by engulfing them (phagocytosis)
- Platelets : Helps blood to clot by clumping together. They protect the body by stopping bleeding.
- Tissue fluid and lymph : When plasma leaks through capillaries called tissue fluid. Some tissue fluid collect at the lymphatic vessels.



Neutrophil



Monocytes

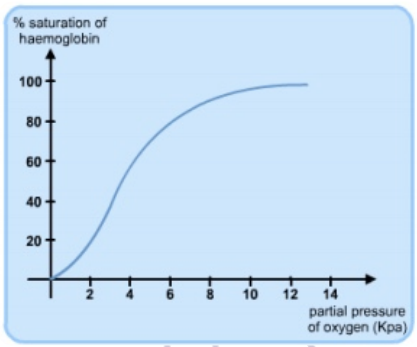


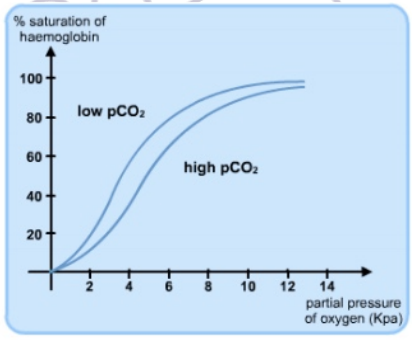
Lymphocyte

b) Haemoglobin and O2 transport

Haemoglobin is made up of four polypeptide chains, each of which has a haem group. Each haem group contains an iron ion which combines with O2. Each iron ion can combine with 2 oxygen atoms so 1 haemoglobin molecule can combine with 8 oxygen atoms.
Haemoglobin combines with oxygen to form oxyhaemoglobin.
At high partial pressure of O2, haemoglobin will be highly saturated with O2.

Dissociation curve
It's a graph showing the relationship between pO2 and the % saturation of Hb with O2.
In areas of high CO2 concentration, Hb is less saturated with O2 than it would be if there was no CO2 present.
This release of O2 is called the Bohr effect.
It enables Hb to unload more of its O2 in tissues where respiration is taking place.
The Bohr effect causing a shift to the right in the dissociation curve.





c) CO2 transport

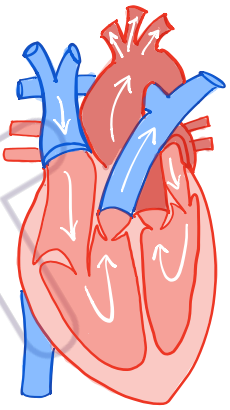
Some of the CO2 produced by respiration diffuses into the red blood cells and forms carbonic acid.
The HCO3 diffuses out of the red blood cell into the plasma, decreasing the concentration of negatively charged ions inside the red blood cells. To counteract this, chloride ions move from the plasma into the red blood cells. (Chloride shift)

Some CO2 diffuses into the red blood cells but instead of forming carbonic acid, it attaches directly onto the Hb molecules to form carbaminohaemoglobin. CO2 does not bind to the haem group, therefore oxygen can still bind to form oxyhaemoglobin.

Adaptation to high altitude

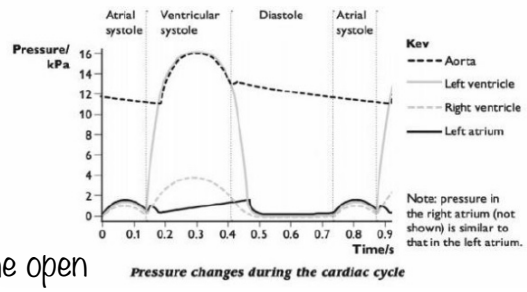
- At high altitudes, pO2 is lower than at sea level, therefore haemoglobin is less saturated with O2 in the lungs and delivers less O2 to body tissues.
- The body increases number of red blood cells in blood to maintain amount of oxygenated blood delivered to cells.
- Even though each Hb molecule carries less O2, the increased number of red blood cells helps to supply the same amount of O2 to respiring tissues.

d) Heart



- The mammalian heart is a double pump where the right side pumps deoxygenated blood to the lungs and the left side pumps oxygenated blood to the rest of the body. The blood is then returned to the heart through the vena cava.
- The ventricle walls are thicker than the atrial walls to withstand the high-pressure of pumping blood out of the heart.
- The left ventricle wall is thicker than the right ventricle wall as it has to produce a high enough pressure to move blood to the whole body.
- The tricuspid (right), bicuspid (left) and semilunar valves work to prevent back flow of blood.

e) Cardiac cycle



Pressure changes during the cardiac cycle

- Both sides of the heart contract and relax together.
- The sequence of one heart beat is called the cardiac cycle.
- During atrial systole, the muscles in the walls of the atria contracts, pushing more blood into the ventricles through the open atrioventricular valves.
- During ventricular systole, the muscles in the walls of the ventricles contract. This causes the pressure of the blood inside the ventricles to become greater than in the atria, forcing the atrioventricular valves shut. The blood is forced out through the aorta and pulmonary artery.
- During diastole, the heart muscles relax. The pressure inside the ventricles becomes less than that inside the aorta and pulmonary artery, so the blood inside theses vessels pushes the semilunar valves shut.
- Blood flows into the atria from the veins, so the cycle is ready to begin again.

Initiation and control of cardiac cycle

Heart has the ability to initiate its own contraction : myogenic.

- In the wall of the right atrium, SAN acts as the pacemaker of the heart, as it initiates a wave of electrical impulses across both atrias which causes the atria to contract.
- The electrical wave eventually reaches the AVN. It delays the impulses briefly before it passes on the excitation to ventricles, down the bundle of His to the apex of the heart.
- The bundle of His branches into Purkyne fibres which carry the wave upwards. This causes the ventricles to contract, thus emptying them.

Chapter 9 : Gas exchange and smoking

a) Gas exchange system

	Cartilage	Elastic fibres	Ciliated & Goblet cells + Smooth muscle
Trachea	present	present	present
Bronchi	present	present	not present
Bronchiole	not present	present	present

Cartilage : provide support and prevents tubes from collapsing
Ciliated epithelium : it is covered with many cilia that sweep mucus up towards the mouth
Goblet cells : secrete mucus that traps dust particles and bacteria.
Smooth muscle : contract and relax to reduce and increase the diameter of the tubes, controlling air flow.
Elastic fibres : stretch to allow alveoli and airways to expand during inhalation and recoils to allow alveoli to expel air out of lungs.
*Trachea has C shaped rings of cartilage and bronchus has irregularly shaped blocks of cartilage

b) Gas exchange at alveolus

There is a higher concentration of O_2 and a lower concentration of CO_2 inside the alveolus. Blood blood to the lungs has a low concentration of O_2 and high CO_2, this creates a concentration gradient. O_2 diffuses down the concentration gradient from the alveolus to the blood capillary and CO_2 diffuses from the blood capillary into the alveolus.

The volume of air that is moved into or out of the lungs during one breath is called the tidal volume. The maximum amount of air that can be moved in or out during the deepest possible breath is called the vital capacity

c) Smoking

The components of tobacco smoke include tar, carbon dioxide and nicotine.

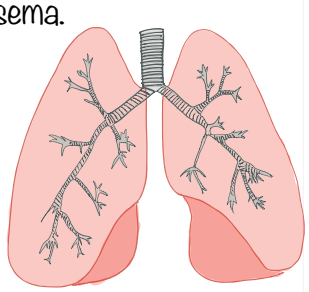
- Tar is a mixture of substances including chemicals that act as carcinogens (cause cancer). It also settles on epithelial lining leading to inflammation.
- Nicotine is the addictive substance that increases the release of dopamine and adrenaline in the blood. Increased dopamine gives feelings of pleasure. Increased adrenaline increases breathing and heart rate.
- Carbon monoxide binds irreversibly with haemoglobin forming carboxyhaemoglobin. This reduces the amount of haemoglobin available to combine with oxygen.

Effects of smoking on gas exchange system

- Chronic Bronchitis : Tar on epithelial lining causes goblet cells to increase mucus production. Excess mucus production prevent cilia from beating efficiently causing mucus to build up. Excess mucus is a breeding ground for bacteria, increasing chances of infection.

- Emphysema : Infection in the lungs increases the number of white blood cells secreted by the immune system. WBC secrete elastase that damages the elastin of the alveolus. This decreases its ability to expand and recoil. Alveolus may burst and reduce the surface area available for gaseous exchange.

- COPD : It is a condition where the person has both chronic bronchitis and emphysema.



Chapter 10 : Infectious diseases

a) Virus and bacteria

- Bacteria : has peptidoglycan cell wall and ribosome, DNA and RNA floating freely in cytoplasm
- Virus : has a protein coat, DNA or RNA enclosed in protein coat, has no ribosomes
- Bacteria do not require a host to survive where as viruses are entirely dependent on the hosts.

b) Diseases

Diseases can be infectious or non-infectious. Infectious diseases are caused by pathogens. Non-infectious diseases cannot be spread between organisms.

Disease	Pathogen	Transmitted by	Prevent transmission by	Type
Cholera	Vibrio Cholerae	Contaminated water and food	Boil water before drinking, wash hands before eating	B
Tuberculosis	Mycobacterium Tuberculosis	Airborne water droplets	TB vaccine	B
HIV/AIDS	HIV	Bodily fluids	Take HIV medication, use protection during sexual intercourse	V
Malaria	Plasmodium vivax	Infected by a female mosquito vector	Reduce number of mosquitoes in surrounding area and use repellant	P
Measles	Morbillivirus	Airborne water droplets	Use measles vaccine	V
Smallpox	Variola	Contact with contaminated items or person	Use smallpox vaccine	V

c) Antibiotics

Antibiotics are selective toxins, killing or disabling the pathogen without harming the host.
They do not work on viruses. (virus has no cell wall)

Penicillin on bacteria

Penicillin interferes with the synthesis of peptidoglycan in bacterial cell walls. Penicillin prevents peptidoglycan from forming cross-links. This greatly weakens the cell wall and causes the bacterium to lyse because of osmotic pressure.
Penicillin does not harm human cells as we do not have peptidoglycan.

Resistance

Some bacteria become resistant due to natural selection. As they reproduce, they pass down their antibiotic resistance to their offspring, this creates a resistance strain.
Antibiotics should only be used when needed and patient should always finish full course of antibiotics to prevent resistant strains from forming.

Chapter 11 : Immunity

The first line of defence is made up of physical and chemical barriers.

These types of barriers are non-specific

- Physical Barriers : Skim, nose, throat and digestive tract
- Chemical Barriers : Tears, earwax, stomach acid and sweat

a) Self and non self antigen

On the surface of every cell there are chemical markers call antigens. Your immune system recognises antigens on your own self as self-antigens. Any cells with different antigen (non self) will stimulate an immune response.

b) Phagocytes

Phagocytes are produced in the bone marrow and develop into neutrophils or monocytes/macrophages. They both work by phagocytosis.

Monocyte are in active cells that circulate in the blood. As they mature and leave the blood, they become macrophages.

Macrophages are antigen-presenting cells as they display antigen of pathogens they have encountered on their cell surface membrane is where the B or T lymphocytes may encounter them.

Phagocytes produced in the bone marrow. They then develop into neutrophils or monocytes/macrophages.
They both destroy bacteria and viruses by phagocytosis.
Mono are in active cells that circulate in the blood

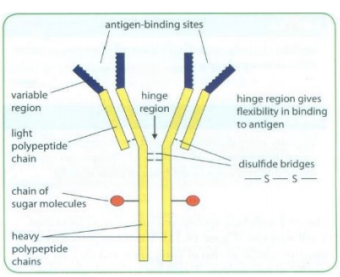
c) Lymphocytes

Both B-lymphocytes and T-lymphocytes are made in bone marrow. B lymphocytes continue to mature at bone marrow, while T lymphocytes mature at the thymus.
Each lymphocyte is specific to only one antigen.

B lymphocyte

When it encounters an antigen that binds to its receptors, the B-lymphocyte is activated and undergoes clonal selection and expansion.
It then divides repeatedly by mitosis to produce a clone of genetically identical plasma cells or memory cells. Plasma cells then secrete antibodies that destroy or a neutralise the antigens.

Clonal selection and expansion can produce plasma cells or memory cells. Plasma cells only last for a short while while memory cells will remain in the blood for a long period of time. Memory cells help create a faster secondary immune response.



Antibodies

Antibodies are immunoglobins. The variable region of the antibody is specific to the antigen and identical to that of the B-lymphocyte it was secreted from.

They work by

- Sticking bacteria together making it easier for phagocytes to destroy them
- Neutralising the toxins produced by pathogens
- Punching holes in bacterial walls to cause them to lyse due to osmotic pressure
- Binding to viruses to prevent them from infecting cells.

T-lymphocytes

On encountering specific antigen T-lymphocyte are activated and undergo clonal expansion to produce T-helper cells, T-killer cells and their specific memory cells.

- T-helper cells secrete cytokines that stimulate B-cells to divide and form plasma cells and memory cells.
- T killer cells attach to the cells displaying antigens matching their receptor and destroys the infected body cells.

d) Immunity

Active immunity gives permanent immunity while passive immunity gives temporary immunity.

Natural active : Previously having the disease

Natural passive : Young infant with mother's antibodies through placenta/breast milk

Artificial active : Vaccination

Artificial passive : Antibody injection

Vaccine

- A vaccine contains a killed or weakened part of a pathogen that is responsible for infection.
- Pathogen still has antigen on its cell-surface membrane.
- When immune system and counters this antigen is it stimulates clonal expansions of B-lymphocyte and T-lymphocytes.
- Memory cells produced from this immune response will help secondary response when body encounters live pathogen in the future.

e) Monoclonal antibodies

Monoclonal antibody is are produced via the hybridoma method
Antigen are injected into a mouse to stimulate immune response .
After a few days, plasma cells are isolated from the spleen of the mouse and fused with myeloma cells to form hybridoma cells.
They are then grown in a culture to produce genetically identical cells.

f) Autoimmune diseases

An auto immune disease is when body's immune system fails to recognize the own body's cells are self antigens and attacks them.

Myasthenia gravis

Immune system releases antibodies that block receptors for acetylcholine at the neuromuscular junction which prevents the muscle from contracting.
MG can be treated by anticholinesterase medication and thymectomy.

1st Edition : Zhi Yee
Producer : Mr. Sai Mun