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Updated to 2016-18 Syllabus

CIE AS-LEVEL BIOLOGY 9700

SUMMARIZED NOTES ON THE SYLLABUS

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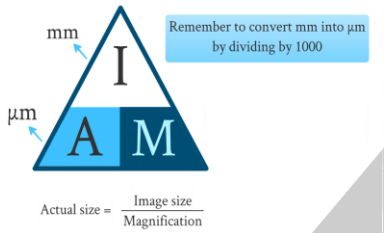
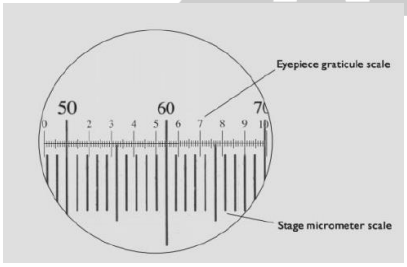
1. Cell Structure

1.1 Microscopy in the Cell

- Photomicrographs of plant and animal cells are created using:
  - Light Microscope: This is the most widely-used microscope wherein a specimen is dyed and illuminated with light which is focused using a glass lens.
    - It has a resolution of approximately 200nm which is lower than the resolution of an electron microscope.
  - Electron microscope: This type of microscope uses a beam of electrons to create an image of the specimen. The electron beams have a much shorter wavelength than light and therefore provide higher resolution. The electron micrograph can only display dead specimens as they need to be placed in a vacuum.
    - Electron micrograph has a higher resolution of 0.5nm.
- Magnification can be calculated using:



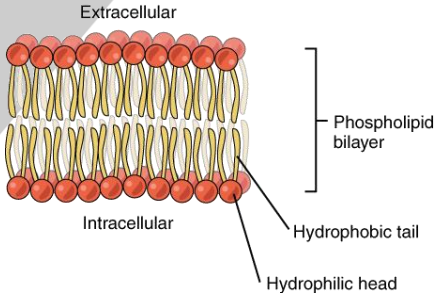
- The eyepiece graticule is fitted into the eyepiece of the microscope and is used to measure objects. However, the eyepiece itself has no units and is therefore calibrated by the stage micrometer. The stage micrometer has an accurate scale and provides refrence dimentions.



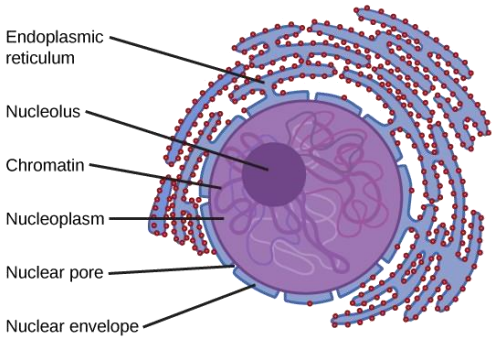
- Magnification is the number of times larger an image is compared to the real size of the object and depends on the power of the objective lens and eyepiece lens used. Resolution, however, is the degree to which detail can be seen. The limit of resolution is the minimum distance between which two points can be seperated. The resolution of a microscope depends on the wavelenght of radiation being used.

1.2 Cells as the Basic Unit of Living Organism

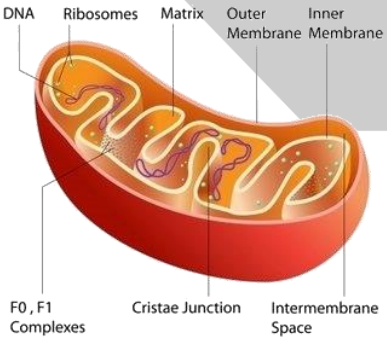
- In an electron micrograph, very small particles can be observed as the electrons are easily absorbed. The parts of the specimen that appear darker in the final image are denser and absorb more electrons. Due to higher resolution, the electron micrographs of plant and animal cells show must organelles. The structure that is revealed by the electron micrograph is known as an ultrastructure.
- Cell structures can show how different cells function. These cell structures include:
  - **Cell surface membrane**: It is a selectively permeable membrane present in both plant and animal cells that allows for the exchange of certain biological molecules and ions. It is comprised of two phospholipid bilayers which are assembled with the hydrophilic phosphate heads facing the aqueous environment (inside and outside the cell) and the hydrophobic tails facing each other.



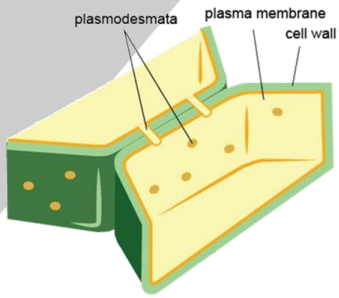
  - **Nucleus:** This structure is surrounded by 2 membranes called the nuclear envelope. The nuclear envelope contains gaps called pores which allow mRNA to move out of the nucleus and allow nutrients and enzymes to enter. The nucleus contains hereditary material known as DNA which are contained within chromosomes. DNA is organized into units called genes. Genes control activity of the cell and inheritance. The nucleolus is the region of the nucleus which contains large amounts of DNA and RNA, its function is to make ribosomes.



- **Rough endoplasmic reticulum**: Ribosomes of the rough endoplasmic reticulum are sites for protein synthesis and produce the rough appearance. The R.E.R provides a pathway for transport of materials through cell.
- **Smooth Endoplasmic reticulum:** This is a site for lipid synthesis and chemical modification of proteins. It also destroys toxic substances.
- **Golgi apparatus:** It transports and chemically modifies the materials contained within it. It is also involved in the formation of lysosome.
- **Mitochondria:** It is surrounded by a double layer and has a matrix that contains 70S ribosomes and circular DNA which is used to make some of the mitochondrion's own proteins.

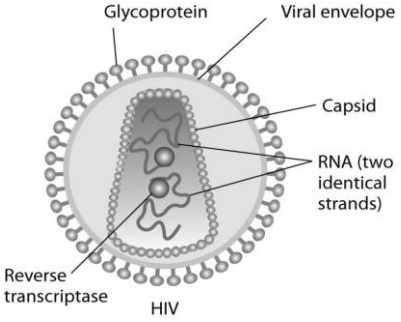


- **Ribosomes:** There are two different types. 80S ribosomes are present in the cytoplasm and R.E.R of plant and animal cells. 70S ribosomes are found Chloroplast and Mitochondria. It is the site at which mRNA (transcribed from the nucleus) is translated into polypeptides with the help of tRNA.
- **Lysosomes:** It is contained within vacuoles of animal cells and produces hydrolytic enzymes to digest materials that the cells consume from the environment. E.g.: engulfed bacteria and old organelles.
- **Centrioles:** There are 2 centrioles arranged at right angles to form the centrosome. They are only found in animal cells. During cell division, they separate and move to opposite ends of the cell to organize spindle fibers.
- **Microtubules:** This provides an internal skeleton for cells and determine cell shape. It provides transport routes within cells and supports the cell.
- **Chloroplast:** This cell structure is only found in plant cells in the palisade mesophyll, spongy mesophyll and surface of stem. It also has 2 membranes. It contains flattened sacs known as thylakoids. Chlorophyll is embedded in thylakoid membranes. Thylakoids stacked on top of each other to form grana. Grana are linked by lamella. These structures are present in a matrix called the stroma. Chloroplast contains starch grains, circular DNA and 70S ribosomes and are used in photosynthesis.
- **Cell wall:** The cell wall of a prokaryotic cell is made of polysaccharides called peptidoglycan which prevents cell from bursting and provides cell with protection from viruses. In plant cells, call wall is made from cellulose which provides strength for the cell.
- **Plasmodesmata:** This is a gap in the cell wall which runs through the walls of two adjacent cells. It allows for the transport of lager substances between cells.



- **Large vacuole and tonoplast:** The tonoplast in the membrane of the large permanent vacuole present in plant calls. The vacuole contains cell sap (solutes, e.g.: sugar and enzymes)

- Adenosine triphosphate (ATP) is the energy molecule used by cells. It is made up 3 phosphate groups, a nitrogeneous base and a ribose sugar. It is produced in the chloroplast and mitochondria.
- A typical prokaryote is approximately 1 to 5 micrometers where as a typical eukaryotic cells is approximately 10 to 100 micrometers.
- Viruses hijack cells by making viral proteins through the protein synthesis mechanism within the cell. The capsid is attached to protein molecules and contain strands of genetic material.



2. Biological Molecules

2.1 Testing for Biological Molecules

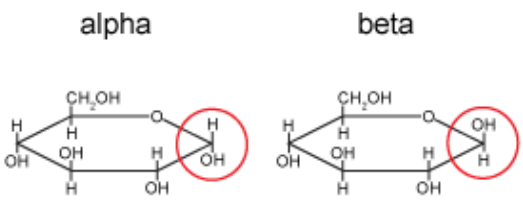
The tests carried out to identify biological molecules:

- **Benedict's test for reducing sugars**- Equal volume of sample being tested and Benedict's solution are mixed and heated.
- **Acid or enzyme hydrolyis followed by benedict's test for non-reducing sugars**- Hydrochloric acid is added to a the sample being tested in th ration of 1:2 respectively and heated in a water bath for approximetly 2 minutes. A pinch of sodium hydrogencarbonate is added to make the solution alkaline. After this, benedicts solution is added in the same amount as the sample being tested.
- **Buiret's test used to detect the presence of protiens**- Equal amounts of the sample and buirets solution are added together.
- **Emulsion test for lipids**- The sample is added to 2cm3 of ethanol and mixed well until it dissolves (lipids are soluble in ethanol). This mixture is then placed into a test tube containing the same amount of water. A milky white emulsion will appear if lipids are present and remain clear if not.
- **Iodine test for the presence of starch**- Iodine in potasium iodide (IKI) is added to sample being test in 1:1 ratio and colour change is observed.

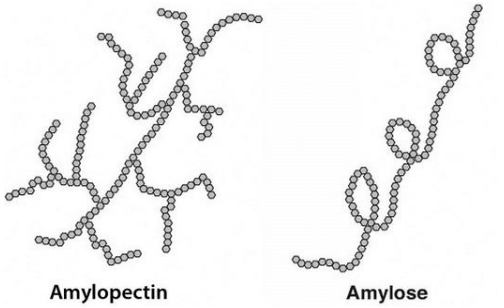
INDICATOR	MACRO-MOLECULE	NEGATIVE TEST	POSITIVE TEST
Benedict's solution	simple carbohydrate	blue	orange
IKI solution	complex carbohydrate	dark red	black
Biuret solution	protein	blue	violet, black

2.2 Carbohydrates and Lipids

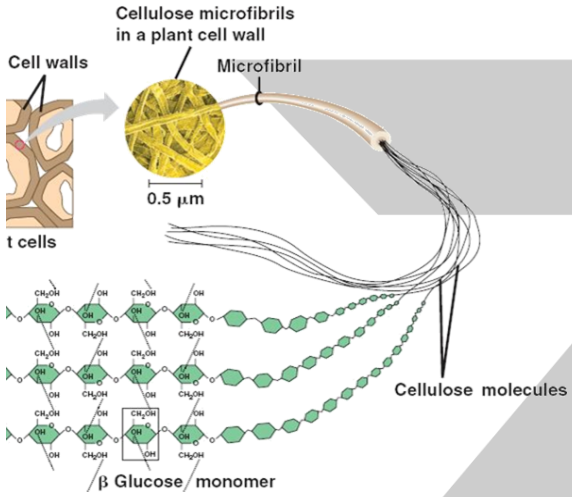
- Glucose has the molecular formula C6H12O6. It is an energy source which is broken down during respiration. It is also the monomer from which Starch and Cellulose are made. There are two different kinds of glucose monomers known as α- glucose and β - glucose and their difference lies between the position of an –OH group in their ring structures.



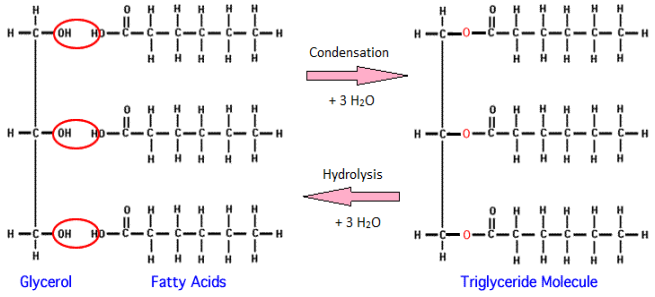
- Monomer: The simplest repeating unit of a polymer, eg: glucose. It is
- Polymer: This is made from monomers joined together by glycosdic bonds, eg: starch,
- Macromolecule: These are large and complex molecules that are formed due to polymerisation of smaller subunits, eg:
- Monosaccharide:This is a molecule consisting a single sugar unit, the simplest form of carbohydrate and cannot be hydrolised further. It has a general formuala of $(CH_2O)_n$.
- Disaccharide: This is a non- reducing sugar that is formed when two monosaccharides joined together by glycosidic bonds.
- Polysaccharide: This is a carbohydrate which contains large number of glucose units bonded together by glycosidic bonds.
- Glycosidic bonds are covalant bonds that occur between constituent monomers and are formed due to a condesation reaction which involves the removal of a water molecule in order to form polysaccharides and disaccharides such as sucrose.
- These constituent molecules can also be sepreated by hydrolysis which breaks the glycosodic bond between monomers, eg: Acid hydrolysis of non-reducing sugars which breaks glycosidic bond in order to retrieve contituent monomers eg: Sucrose.
- Starch is a macromolecule that is found in plant cells and is made up of two components known as amylose and amylopectin. These components are polysaccharides that are made from a glucose molecules and contain a 1,4 glycosidic bonds. Amylpectin is branched in structure and therefore also contains a- 1,6 glycosidic bonds as bonds form between adjacent a- glucose molecules. Amylose is helical in shape while amylopectin in branched. Starch is higly compact and stores energy.



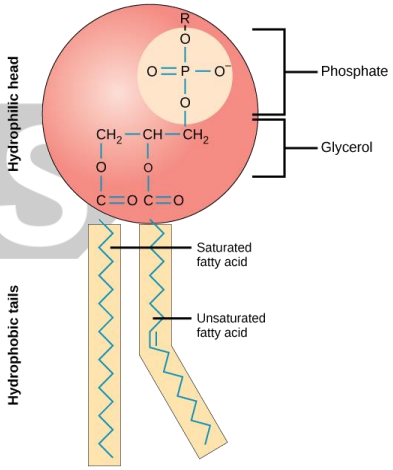
- Glycogen is a macromolecule that is used for the storage of energy is animal cells and is also made from a- glucose molecules. The structure of glycogen is very similar to that of amylopictin, however, it is more branched and therefore contains more a- 1,6 glycosidic bonds.
- Cellulose is found in the cell wall of plant cells and is made from b- glucose units that form b-1,4 glycosic bonds. Alternate b- glucose molecules are rotated 180 degrees in order to form these bonds. Hydrogen bonds are also formed between parrallel cellulose molecules.
- A- glucose molecules are used in macromolecules that store energy, eg: glucose and starch whereas b- glucose molecules are used for structural puposes, eg: cell walls.



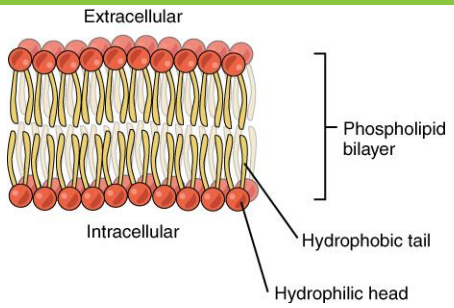
- A triglyceride contains 3 fatty acid chains and a glycerol molecule. Fatty acid chains are long hydrocarbon chains with a carboxylic group (-COOH) at one end. The glycerol is an alcohol containing 3 carbon atoms wherein each carbon atom is attached to a hydroxyl (-OH) group. A triglyceride molecule is formed when the 3 fatty acid chains formed ester bonds with a glycerol molecule. The ester bond is formed between the (-COOH) groups of fatty acids and the (-OH) groups of the glycerol molecule.



- Triglyceride molecules have several uses and can have unsaturated and saturated fatty acids. All carbon-carbon bonds in saturated fatty acids are single bonds. Triglyceride molecules that contain saturated fatty acids are called fats and are more likely to be solids at room tempratures. Triglycerides molecules that contain nsaturated fatty acids contain a carbon to carbon bond that is also a double bond. Double bonds are easier to break and therefore make the lipids melt easily.
- Triglycerides function as storage for energy due to the relatively in globules of fat and oils are and do not dissolve in water due to the non-polar hydrocarbon tails. They contain more energy per gram than polysaccharides. Oil droplets made of triglycerides are present in cells of the adipose tissue in mammals. The adipose tissue helps insulate the body against heat loss and acts as a protective layer around some organs. A triglyceride molecule is also a source of metabolic water as water is released when triglycerides are oxidized during respirations.
- A phospholipid molecule in made up of three components. The polar <u>head</u> contains a phosphate group and glycerol while the non- polar <u>tail</u> contains 2 fatty acid chains. The phosphate group dissolves in water whereas the fatty acid chains are repelled by water molecules and avoid them. This is due to the partial negative charge on the phosphate group that gets attracted to the partial positive charge on the hydrogen atom of the water molecule.

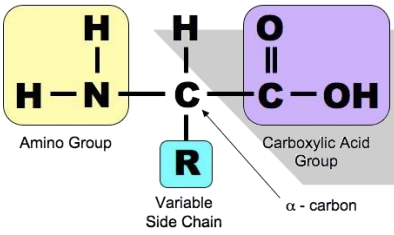


- The phospholipid molecules form a double layer (bilayer) to form membrane structures. This is known as the phospholipid bilayer and is arranged so that the hydrophilic heads are facing outwards and in contact with the aqueous environment inside and outside of a cell while the hydrophobic tails face each other, forming the core. This makes a stable boundary between two aqueous compartments and allows for a selectively permeable membrane.



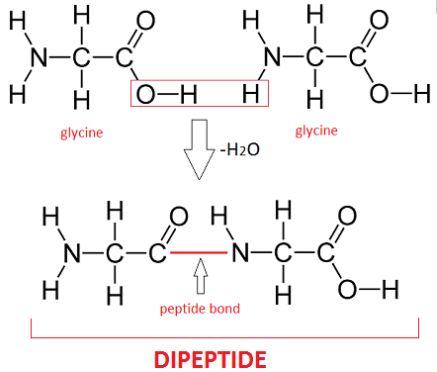
2.3 Proteins

- Proteins are made of amino acids. Amino acids are amphoteric molecules as they contains both an acidic and a basic group. There are 20 different kinds of amino acid and this is the general formula:



Amino acids only differ in the R- groups or variable side chains and will always contain an amine group (basic), carboxyl group (acidic) and a hydrogen atom attached to the central carbon atom.

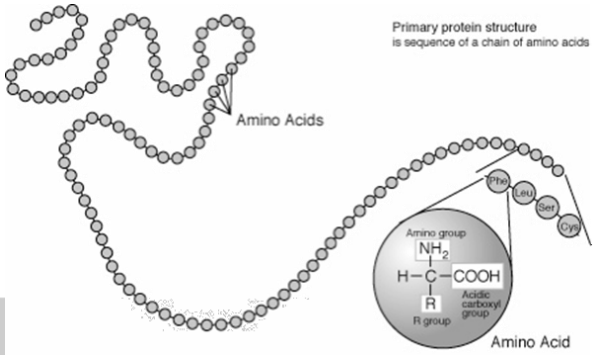
- A peptide bond is formed when 2 amino acids join together. One amino acid will lose the (-OH) from its carboxyl group while the other loses an (-H) from its amine group. The formation of a peptide bond is a condensation reaction as it results in the release of a water molecule. The new molecule formed is called dipeptide. Many amino acids that join together by peptide bonds form a polypeptide.



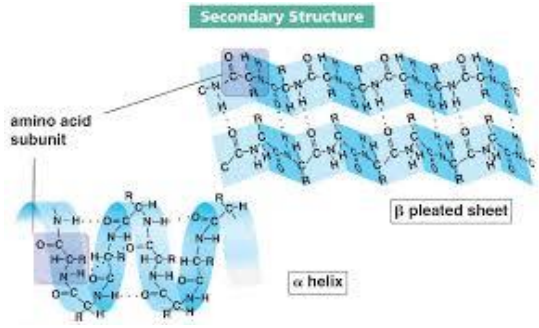
- Polypeptides are broken down to amino acids by breaking peptide bonds. Peptide bonds are broken when hydrolysed (water molecule is added). This often occurs in the small intestine.

2.4 Protein Structure

- The primary (1°) structure of proteins determines the number and linear sequence of amino acids in a polypeptide. A slight change in the sequence of amino acids can affect the protein's structure and function. Only covalent bonds such as peptide bonds are involved in this level of protein structure.

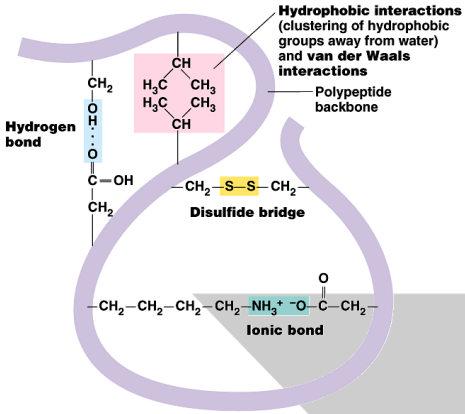


- The secondary (2°) structure of proteins is classified into 2 types: α- helix and β- pleated sheets. The chain of amino acids which makes a polypeptide does not remain straight, it twist into 2 different shapes to form the secondary structure. In α- helix the polypeptide chain twist into a regular spiral and is maintained by regularly spaced hydrogen bonds. Each hydrogen bond forms between the (-NH) group of one amino acid and the (CO-) group of another amino acid in the polypeptide chain. In a β- strand, the chain is not tightly coiled and lies almost straight. Often, several β strands lie side by side and form adjacent hydrogen bonds. Each hydrogen bond forms between the (-NH) group of one amino acid and the (CO-) group of another amino acid in the polypeptide chain. A single polypeptide may have regions that are a-helix and β- sheets. Hydrogen bonds can be easily broken down due to temperature and pH changes.

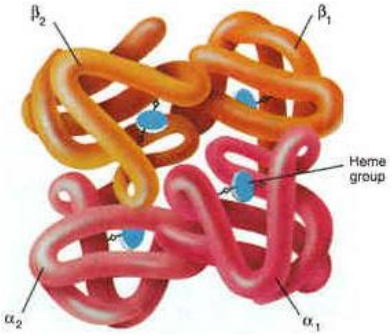


- The tertiary (3°) structure of proteins is achieved when the polypeptide is permanently folded into a complex shape. This shape is maintained by 4 types of bonds. These bonds are:
- Hydrogen bonds between wide varieties of R- groups.

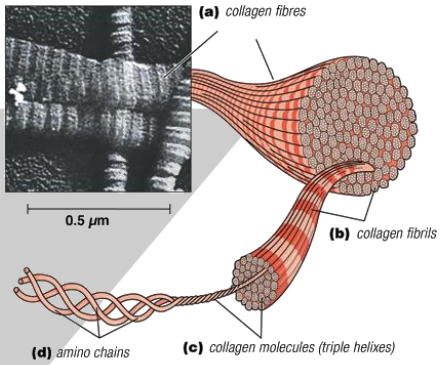
- Disulphide bridges between two cysteine molecules (amino acids).
- Ionic bonds between R groups containing amine and carboxyl groups.
- Hydrophobic interactions between R groups which are non- polar or hydrophobic.
- Van der Waals forces between individual molecules.



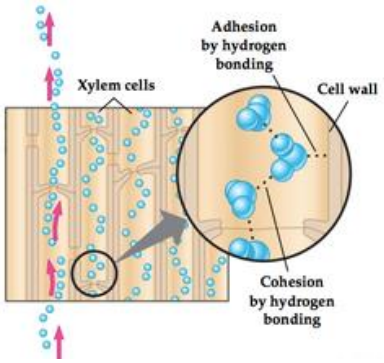
- Quaternary (4°) structure of proteins involves more than one polypeptide. Two or more polypeptide chains curl together to form the complete protein molecule. Many complex proteins exist as clusters of polypeptide chains. This is known as the quaternary structure and is held together by the same bond found in the tertiary structure.
- In the protein haemoglobin, amino acids with R- groups that are hydrophilic are present on the outside while amino acids with R- groups that are hydrophobic are present on the inside. This makes the protein soluble in water. The tertiary structure of haemoglobin is 3-D and spherical. It's spherical and soluble characteristics make haemoglobin a globular protein. A haemoglobin molecule is composed of 2 a-chains and 2 b-chains. It also has 4 haem groups which contain an Fe^{2+}each. These are non-amino acid components that are also known as prosthetic groups. They are necessary for the transport of oxygen through the blood as each molecule of oxygen binds to each binds to a haem group.



- Collagen is a fibrous protein that is present in the skin, bones, teeth, cartilage and walls of blood vessels. It is an important structural protein. A collagen molecule has 3 polypeptide chains that are coiled in the shape of a helix. The molecule has a compact structure and almost every 3rd amino acid is glycine. The 3 polypeptide strands are held together by hydrogen bonds. Each 3- stranded molecule of collagen interacts with another by forming covalent bonds. Collagen molecules are too large to be able to dissolve in water. Due to the hydrogen bonds that hold the 3 polypeptides in a collagen molecule, the protein has high tensile strength.



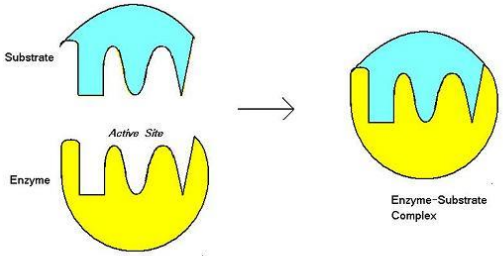
- A water molecule contains two hydrogen atoms and one oxygen atom held together by hydrogen bonds. It is a medium for metabolic reaction in the cells of plants and animals. Water is an effective solvent because of its polarity which means that water can form electrostatic interactions (charge-based attractions) with other polar molecules and ions. Water molecules also have cohesive and adhesive properties. Cohesion refers to the attraction of one water molecule to the other and water molecules have strong cohesive forces due to their ability to form hydrogen bonds with one another. Adhesion is the attraction of molecules of one kind to molecules of a different kind, and it can be quite strong for water, especially with other molecules bearing positive or negative charges.
- It takes a lot of heat to increase the temperature of liquid water because some of the heat must be used to break hydrogen bonds between the molecules. In other words, water has a high specific heat capacity.
- Just as it takes a lot of heat to increase the temperature of liquid water, it also takes a large amount of heat to vaporize a given amount of water, because hydrogen bonds must be broken in order for the molecules to fly off as gas. That is means that water has a high latent heat of vaporization.



3. ENZYMES

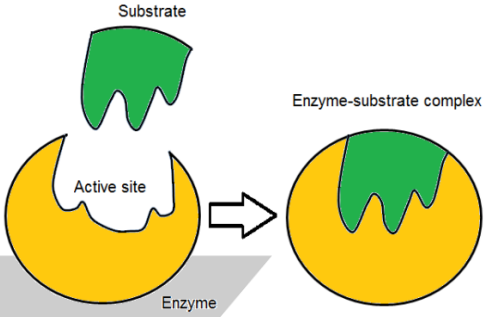
3.1 Mode of Action of Enzymes

- An enzyme is a biological molecule that accelerates metabolic reactions. Enzymes are globular proteins as they have a roughly spherical shape and are water soluble. The hydrophilic R- groups of amino acids are present on the outside of enzyme molecules while the hydrophobic R- groups of amino acids are present on the inside to ensure solubility. Different enzymes can function inside and outside the cell.
- Enzymes have specific active sites that are complementary to the shape of the substrate. The substrate is held in place at the active site by weak hydrogen and ionic bonds. The combined structure is called the enzyme-substrate complex.
- Activation energy is the energy required in any chemical reaction to break the bonds in reactant molecules so that new bonds are formed to make the product. An enzyme lowers the activation energy required for the reaction. However, overall energy released during reaction is maintained.
- Enzymes has two proposed modes of action known as lock-and-key theory and induced-fit theory.
- In the lock-and-key theory, the shape of the active site is very precise and substrates that are not complementary to the shape of the active site cannot bind. The enzyme-substrate complexes forms enable the reaction to take place more easily.



Lock-and-key Model.- The substrate and enzyme active site have complementary shapes

- In induced fit theory, the enzyme's active site is not initially an exact fit to the substrate molecule. However, the enzyme molecules are more flexible and can change shape slightly as the substrate enters the enzyme. This means that the enzyme molecule will undergo conformational changes as the substrate combines with enzyme's active site, forming the enzyme-substrate complex.

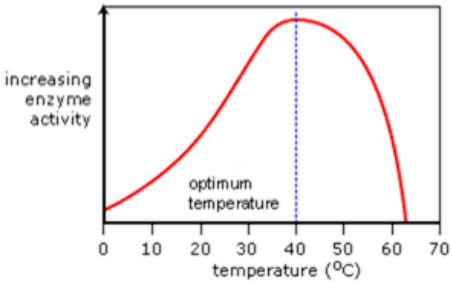


- Enzymes speed up the rate of a reaction by lowering the activation energy of a reaction. The effect that enzymes have on the rate of reactions can be measured in two ways: 1) measuring rates of formation of products. 2) Measuring rates of decrease of substrate.
- By measuring the amount of product accumulated in a period of time, the rate of the reaction can be determined. Rate of reaction= volume of product produced/ time. This method of measuring the effect of an enzyme on the rate of reaction can be used with the enzyme catalase.
- By measuring the rate at which the reactants disappear from the reaction mixture, the effect of the enzyme on the rate of reaction can be determined. Eg: measuring the rate at which starch disappears when the enzyme amylase is added.

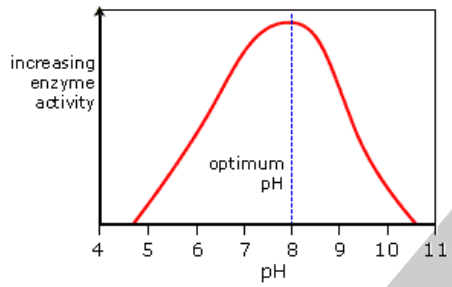
3.2 Factors that affect Enzyme Action

- Factors that affect the rate of an enzyme-catalysed reaction include:
- Temperature: As the temperature increase, the kinetic energy and the enzyme activity increase as well until optimal temperature is reached (usually 40 degrees). At optimal temperature, maximum rate of reaction is achieved. If the temperature continues to increase beyond optimal temperature, the rate of the reaction begins to decrease as more kinetic energy breaks the hydrogen bonds in the secondary and tertiary structure of enzyme. This changes the shape of the enzyme and its

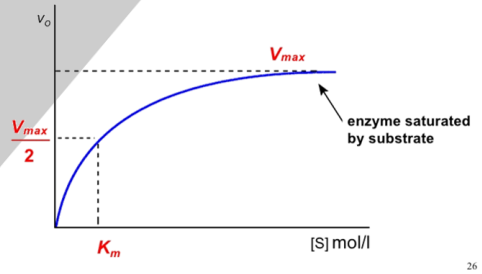
active site and causes the substrate to no longer fit. The enzyme is denatured.



- pH: Any change in the pH value of the medium around the enzyme will cause ionic and hydrogen bonds to be damaged, this will change the 3-D shape of the enzyme and deform the active site. The substrate will therefore not be able to fit into active site so the reaction slows down or stops. The effects of pH is reversible within certain limits but if the pH is far from optimal value, the enzyme gets denatured.



- Enzyme concentration: As the concentration of enzymes is increased, there are more available active sites for substrates to fit into. More enzyme-substrate complexes are formed, more products are formed and the rate of reaction is increased. The limiting factor is the enzyme concentration. Once all substrates have formed enzyme-substrate complexes, a further increase in concentration will have no effect on the rate of reaction. At this point, the limiting factor is the substrate concentration.
- Substrate concentration: As the concentration of the substrates increases, here are greater chances of collision with enzyme. More enzyme-substrate complexes are formed, more products are formed and the rate of reaction is increased. The limiting factor is the substrate concentration. Once all enzymes are occupied and working at maximum turnover rate, a further increase in concentration will have no effect on the rate of reaction. At this point, the limiting factor is the enzyme concentration.
- Inhibitor concentration: Inhibitors interfere with enzyme activity and reduce the rate of an enzyme catalysed reaction. Therefore, as the concentration of inhibitors increases, the rate of reaction decreases.
- Inhibitors are classified into two ways depending on their mode of action. Whether the competition is for the active site and whether the inhibitory effect is temporary or permanent. Reversible inhibitors have temporary inhibitory affects and can be either competitive or non-competitive inhibitors.
- The reversible competitive inhibitor has a similar shape to the substrate and fits into the active site. This prevents enzyme-substrate complexes from being formed, the rate of reaction decreases. The reversible non-competitive inhibitor has a different shape to the substrate and fits into a site other than the active site. This distorts the whole enzyme including the active site, preventing the formation of enzyme-substrate complexes and decreasing the rate of reaction.



- The substrate concentration that corresponds to half of Vmax is Km. An enzyme with a high Km has low affinity for its substrate and requires a greater concentration of substrate to achieve Vmax.
- When an enzyme is immobilized, less product is formed. This is due to the decrease in free movement of the enzyme which results in less enzyme-substrate complexes being formed. The rate of reaction decreases. Free enzymes are less stable and can only be used once. Immobilized enzymes can be re-used several times and are lass effected by high temperatures.

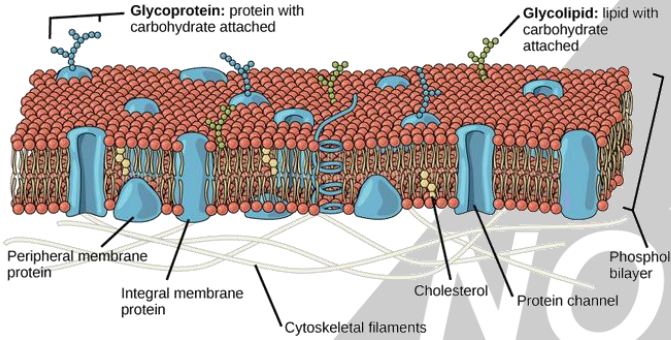
4. Cell Membrane and Transport

4.1 Fluid Mosaic Model

- The membrane structure has two phospholipid layers (phospholipid bilayer) and also contains proteins, glycolipids, glycoproteins and cholesterol. The word 'fluid' refers to the fact that individual phospholipid and protein molecules move around within their own layer. The word 'mosaic' describes the pattern produced by

scattered protein molecule when the surface of the membrane is viewed from above.

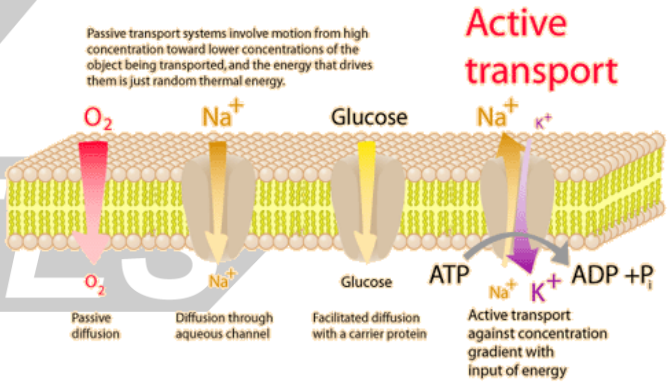
- The molecules present in the membrane include:
- Phospholipid bilayer: This provides the basic structure of membranes, it is selectively permeable and acts as a barrier to most water soluble substances.
- Cholesterol: regulates the fluidity of a membrane. It increases flexibility and stability. Its hydrophobic region prevents polar molecules from passing through the membrane.
- Glycolipids and glycoproteins: Carbohydrate chains that are attached to membrane protein and phospholipids project out into the watery fluids surrounding the cell where they form hydrogen bonds to stabilize the membrane structure.
- Proteins: Transport proteins provide hydrophilic channels for ions and polar molecules. Enzymes catalyse the hydrolysis of molecules. Some proteins also take part in energy transfer systems.
- Channel proteins and carrier proteins: There are many kind of protein channels each specific for a different kind of ion or molecule. They can control the substances that enter and leave the cell.



- Cell surface receptors: These are present in membranes and bind with particular substances, eg: hormones which are chemical messengers which circulate in the blood but only bind to specific target cells.
- Cell surface antigen: These act as cell identity markers. Each type of cell has its own antigen. This enables cells to recognise other cells and behave in an organised way.
- Cell signalling: Cells communicate by sending and receiving signals. For example: when a specific hormone binds to receptor molecules on the call surface membrane of a cell, it triggers a series of chemical reactions in the cell. Other cells that do not have receptors for that particular hormone are not affected by it.

4.2 Movement of Substances into & out of Cells

- Diffusion: This is the net movement of molecules or ions from a region of high concentration to a region of low concentration. It is a passive process (molecules have natural kinetic energy). As a result of diffusion, molecules reach an equilibrium.
- Facilitated diffusion: Movement of molecules from a region of high concentration to a region of low concentration down a concentration gradient. The movement is passive, however, molecules go through protein channels instead of passing through phospholipids. This allows for the passage of large polar ions and molecules.
- Osmosis: This is the diffusion of water molecules from a region of higher water potential to a region of lower water potential through a selectively permeable membrane. Water molecules are small and can therefore pass through phospholipids despite their polarity.
- Active transport: Movement of substances from a region of low concentration to a region of high concentration against a concentration gradient. This occurs via transport proteins that use energy from ATP.

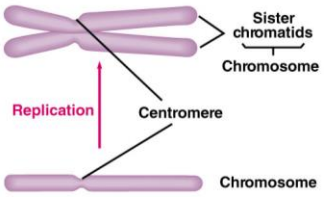


- Exocytosis: This is the movement of substances out of the cell. A vesicle containing the substance moves towards the cell surface membrane with the help of microtubules, using energy from ATP. The vesicles fuse with the cell surface membrane releasing the contents to the outside.
- Endocytosis: This process brings substances into the cell. The cell surface membrane engulfs the material to be taken in, forming an endocytotic vesicle.

5. The Mitotic Cell Cycle

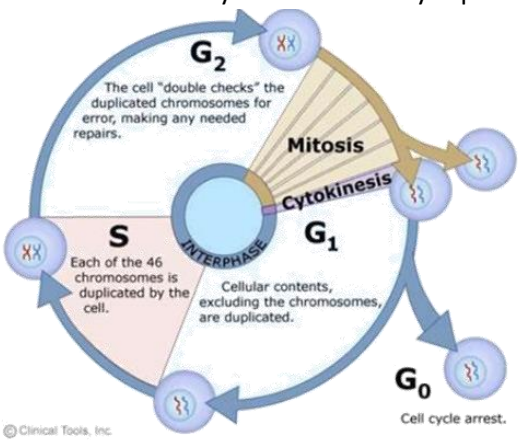
5.1 Replication & Division of Nuclei & Cells

- A chromosome is a structure made of DNA and histones, found in the nucleus of a eukaryotic cell. Bacterial chromosome refers to circular strand of DNA present in a prokaryotic cell. Chromosomes are individual DNA molecules coiled and twisted around histone proteins.
- A chromatid is one-half of two identical copies of a replicated chromosome. During cell division, the identical copies are joined together at the region of the chromosome called the centromere. Joined chromatids are known as sister chromatids. Once the joined sister chromatids separate from one another in anaphase of mitosis, each is known as a daughter chromosome.
- Telomeres are structures found at the end of chromosomes. They consist of a short DNA sequences that repeats over and over again and protects genes from the chromosome shortening that happens at each cell division.
- Mitosis: Mitosis is a way of making more cells that are genetically the same as the parent cell. It plays an important part in the development of embryos, and it is important for the growth and development of our bodies as well. Mitosis produces new cells, and replaces cells that are old, lost or damaged. In mitosis a cell divides to form two identical daughter cells. It is important that the daughter cells have a copy of every chromosome, so the process involves copying the chromosomes first and then carefully separating the copies to give each new cell a full set.

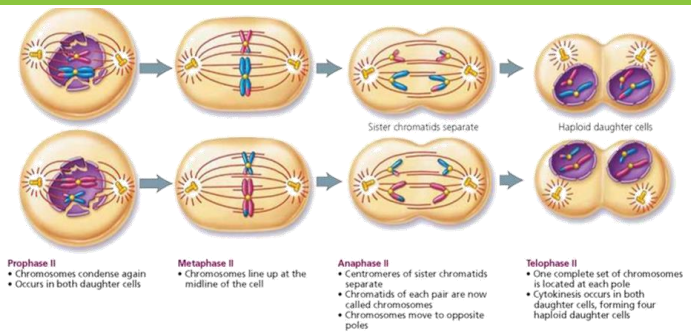


Chromosome replication

- **The cell cycle includes three stages:**
  - **Interphase**: Prior to the mitosis phase of the cycle, the cell undergoes a period of growth where it replicates its DNA and organelles. This is further divided into three stages:
  - G1: cellular contents excluding the chromosomes are duplicated.
  - S (synthesis): Each of the 46 chromosomes is duplicated by the cell.
  - G2: The cell makes any other necessary repairs.



- **Mitosis** is the next phase of the cell cycle wherein the cell separates the copied chromosomes to form two full sets. This stage is divides into 4 stages:
- Prophase: In this stage, the nuclear membrane and nucleolus breaks down. Chromosomes condense and become visible. Each chromosome is seen as two chromatids. Centrioles in the centrosomes move to opposite poles. Spindle fibres emerge from the centrioles.
- Metaphase: Chromosomes continue to condense in this stage and kinetochores appear at the centromeres. The mitotic spindle attach to kinetochores. Chromosomes are arranged at the equator of the cell and each sister chromatid is attached to spindle fibres.
- Anaphase: Each centromere divides into two and the sister chromatids (now chromosomes) are pulled towards opposite poles of the cell. For every chromosome, two chromatids separate and reach opposite poles, so the two new cells to be formed will be genetically identical.
- Telophase: Chromosomes arrive at opposite poles and begin to decondense. Nuclear membrane surrounds each set of chromosomes and the nucleolus reappears. The mitotic spindle breaks down and cell reproduction is now complete resulting in two new cells that are genetically identical.



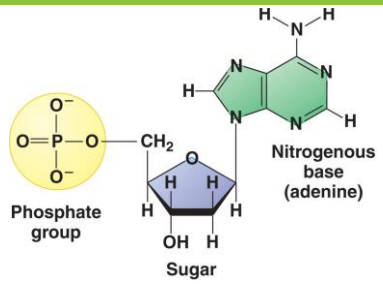
- **Cytokinesis** is the next phase of the cell cycle and is different for plant and animal cells. In animal cells, a cleavage furrow separates the daughter cells. In plant cells, a cell plate (the precursor to a new cell wall) separates the daughter cells.

- Stem cells: Cells that divide repeatedly by mitosis, all other cells arrive from stem cells. There are three different kinds:
- Totipotent: cells that can divide repeatedly to form any other cell in the body, eg: zygote
- Pluripotent: Once specialisation of totipotent cells. They can only form certain cells.
- Multipotent: These are stem cells that have specialised further and can form even fewer cells. They are found in the bone marrow. Thus, mitosis plays a significant role in cell replacement and tissue repair.
- Tumours are formed by unchecked cell division.

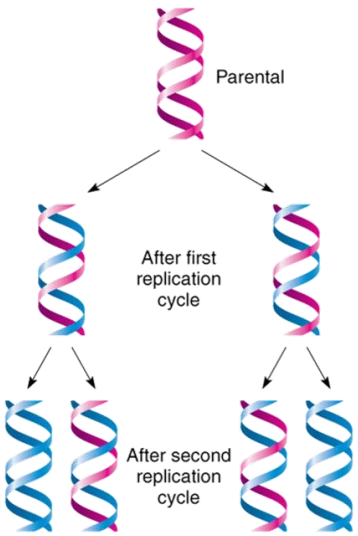
6. Nucleic Acid & Protein Sythesis

6.1 Structure & Replication of DNA

- Nucleotides are the basic building block of nucleic acids, such as DNA and RNA. It is an organic compound made up of nitrogenous base, a pentose sugar (deoxyribose), and a phosphate group. A phosphate group links the sugar on one nucleotide onto the phosphate of the next nucleotide to make a polynucleotide.
- DNA is double-stranded, so there are two polypeptide strands alongside each other. These strands are arranged into a ladder-lie structure called a double helix. Each molecule of DNA is made of small subunits called nucleotides. The phosphate and the sugar form the back bone of the DNA molecule while the base pairs form the 'rungs". It has 4 nitrogenous bases: Adenine, thymine, guanine and cytosine.

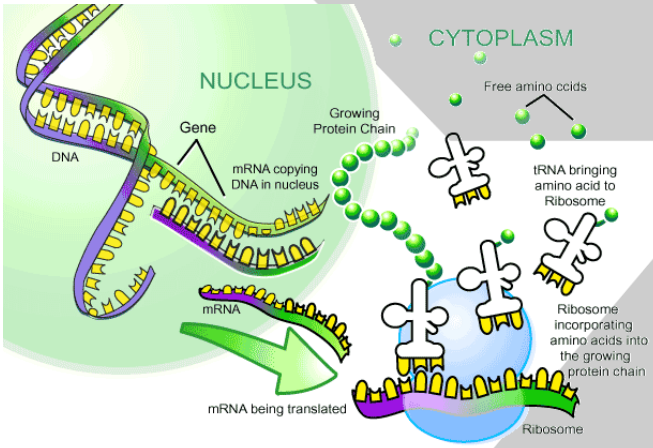


- A Gene is a sequence of nucleotides that forms part of a DNA molecule.
- RNA is a nucleic acid present in the nucleus, cytoplasm and ribosome. It is a single stranded polynucleotide chain of small subunits called nucleotides. It contains a pentose sugar (ribose) and has 4 nitrogenous bases: Adenine, uracil, guanine and cytosine. There are different types of RNA which include:
- mRNA (messenger RNA) carries the genetic in the form of a template from the nucleus to the ribosome for translation.
- tRNA (transfer RNA) has a specific amino acid at one end and an anticodon at the other end. It fits onto the mRNA at ribosomes at complementary mRNA codon for protein synthesis.
- In DNA contemporary base pairing occurs adenine between adenine and thymine (or adenine and uracil in RNA) and also occurs between guanine and cytosine. Because of complementary base pairing, the order of the bases in one strand determines the order of the bases in the other strand and therefore the strands are complementary to each other as well. Purines are nitrogenous bases with double ring structures (Guanine and adenine). Pyrimidines are nitrogenous bases with single ring structures (Adenine, uracil and cytosine).
- Semi-conservative replication of DNA replication occurs during interphase. The DNA separates into two strands and each strand acts as a template. Each new DNA molecule consists of one old strand and a complementary new strand.



6.2 Protein Synthesis

- The synthesis of proteins is directed by an mRNA template. The information contained in the nucleotide sequence of the mRNA is read as three letter words (triplets), called codons. The anticodon on one end of tRNA fits into the complementary mRNA codon at the ribosome for protein synthesis.
- An alteration in the DNA sequence is known as a gene mutation. Therefore the nucleotides that determine the sequence of amino acids in a polypeptide is altered and this changes the resulting polypeptide.
- Sickle cell haemoglobin and normal haemoglobin differ in only a single amino acid out of more than a 100 amino acids in the complete haemoglobin protein. This causes difference in solubility of haemoglobin and inherited.



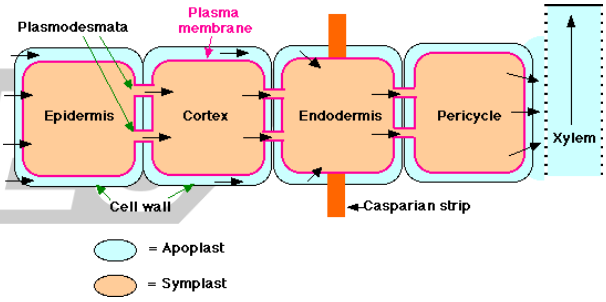
7. TRANSPORT IN PLANTS

7.1 Structure of Transport Tissue

- Xylem vessels: These are dead cells which from a long, narrow and hollow tube to increase capillarity. The vessels are hollow to reduce resistance to water flow and allow a continuous stream. The walls of xylem vessels are lined with lignin which has high tensile strength and provides mechanical support and prevents collapse of vessels. There are pits that are found on xylem vessel element and tracheids which allow lateral transfer of water between xylem vessels.
- Phloem tissue- there are two cell type that are present next to each other:
- Sieve tube element: There are sieve plates with sieve pores that allow rapid flow of sucrose. It does not contains many organelles (no vacuole and nucleus)to decrease resistance to phloem sap.
- Companion cells: Have more organelles (nucleus, mitochondrion, etc.) It contains transport proteins and coordinates cellular activity.

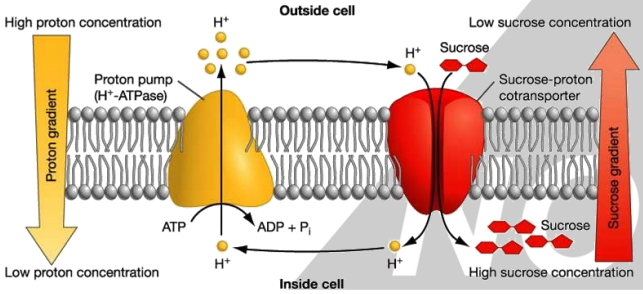
7.2 Transport Mechanisms

- Water is taken up by the root hairs from the soil. The soil water has a relatively high water potential while the cytoplasm of the root hair cell has a relatively low water potential as it contains many more inorganic and organic substances. Therefore, water moves into the root hair cells as water flows from a region of high water potential to a region of low water potential.
- Water then moves from root hairs to xylem in the roots by passing across parenchyma cells to the xylem in roots. The water passes through the root in three way:
- The Apoplast pathway: This is pathway involves the movement of water through cell wall to cell wall by mass flow. Water can pass through via apopolast pathway until it reaches the casparian strip as it is impermeable to water due to thick suberin. Water must now pass through cytoplasm.
- The Symplast pathway: This pathway involves the movement of water through the cytoplasm. Firstly, water passes through the partially permeable membrane. Then, the water passes through cytoplasm and vacuole before moving from one cell to another through the plasmodesmata.



- The vascular pathway: In this pathway, water enters the vacuole by osmosis from higher water potential in the soil. Water moves from vacuole to vacuole through the plasmodesmata.
- After passing through xylem in roots, water moves up the xylem vessels in a continuous stream until it reaches the xylem of the leaves. Water moves out into the atmosphere from the leaves through the stomata. The loss of water to the atmosphere is the direct consequence of gas exchange.

- Transpiration is a process involving the loss of water in the form of water vapour from the leaves through the stomata.
- Cohesion: Hydrogen bonds are formed between individual water molecules. Therefore, as one water molecule moves up the xylem, it pulls the other molecule along with it. This allows for water molecules to move up as a continuous stream.
- Adhesion: Hydrogen bonds are formed between a water molecule and cell walls of xylem temporarily. This allows water molecules to continue moving upwards against gravity.
- Sucrose is loaded into the phloem tubes by companion cells. This is made possible due to the transport proteins present in the cell surface membrane of companion cells. The two transport proteins are:
- The proton pump driven by ATP, pumps H+ ions (protons) out of the cell into the cell wall (apoplast pathway), creating a high concentration of H+ ions in the cell wall.
- The H+ ion-sucrose co-transporter then drives the movement of H+ ions from a region of high concentration (cell wall of companion cells) to a region of low concentration (cytoplasm of companion cell) along with sucrose.

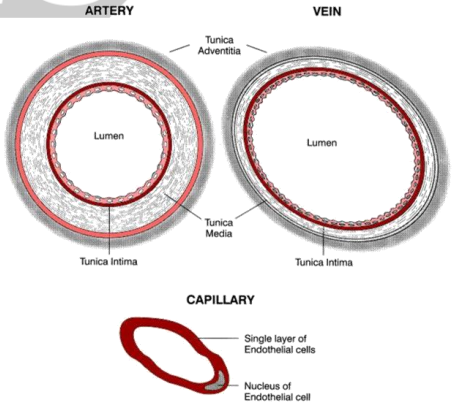


- Translocation is transport of soluble organic substances within a plant. This substances are called assimilates and they include sucrose and amino acids. Sugars are transported as sucrose instead of glucose as glucose is more reactive. Assimilates are transported in large quantities by mass flow and from a region of high hydrostatic pressure to a region of low hydrostatic pressure.

8. Transport in Mammals

8.1 The Circulatory System

- The mammalian circulatory system is a closed double circulation. This means that mammals have two loops in our body in which blood circulates. The circulatory system also includes a heart and blood vessels (arteries, capillaries and veins).
- Arteries: These blood vessels transport blood swiftly to the tissues at high pressures. Arteries have walls made of three layers known as: Tunica intima, Tunica media and Tunica externa. Artery walls are thick and the middle layer contains elastic fibres so that they can stretch to accommodate the greater volume and high pressure without being damaged. The elastic fibres recoil and contract, squeezing the blood and so moving it along in a continuous flow. As arteries reach tissues they branch into smaller vessels called arterioles which have more smooth muscle fibres. The muscles constrict and dilate to regulate blood flow.
- Capillaries: Arterioles continue to branch into capillaries. These are the smallest blood vessels and they take the blood as close as possible to the cells. This allows for rapid transfer of substances between cells and the blood. Due to the very small diameter of these blood vessels, blood travels very slowly. This increases the opportunity for diffusion to occur. Walls of capillaries are made of a single layer of endothelial cells with pores between individual cells present to allow some components of blood to pass through into the cells and tissues of the body.
- Veins: These blood vessels carry deoxygenated blood back to the heart. The exception is pulmonary vein. The walls of veins are the same as arteries but the middle layer (tunica media) has less elastic fibres as the blood that flows through veins has low in pressure.
- **Comparison of Blood Vessels:**

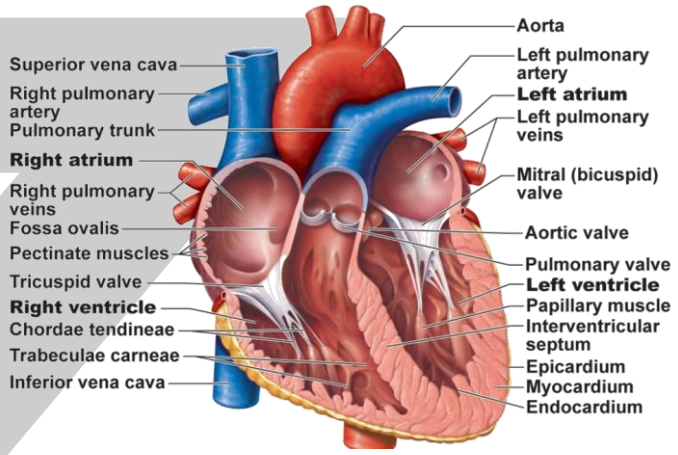


- **Blood** is composed of 4 components:
- Plasma: This is the liquid part of the blood. It is a dilute solution of salts, glucose, amino acids, vitamins, urea, protein and fats.

- Leukocytes (white blood cells): Involved in the immune system.
- Platelets: Involved in blood clotting.
- Red blood cells: Involved in carrying oxygen.
- **Tissue fluid:** This fluid surrounds all the cells. Substances move from the blood to the tissue fluid and from the tissue fluid they diffuse into the cells.
- **Lymph:** About 90% of fluid that leaks from capillaries at the arterial end into tissue spaces eventually returns to the capillaries at the venous end. The remaining 10% is returned back to the lymphatic. Fluid inside the lymphatic is called lymph. Lymph is very similar to tissue fluid but has a different name as it is in a different place.
- Haemoglobin (Hb) transports oxygen and carbon dioxide:
- In the lungs: The pO_2 is high and the pCO_2 low therefore CO2 in plasma diffuses from the blood into the alveoli and oxygen diffuses into the blood from the alveoli. Carbaminohaemoglobin dissociates to form CO_2 and haemoglobin. Haemoglobin then picks up O_2 and HHb (haemoglobinic acid) dissociates to form H+ ad Hb. The H+ ions combine with HCO3- to form carbonic acid which dissociates to form CO_2 and water. CO_2 diffuses into alveoli.
- In respiring tissues: The pCO_2 is high and the pO_2 is low. CO2 from the cells diffuses into the plasma. Hb in the plasma combines with CO_2 to form carbaminohaemoglobin. Some CO2 combines with water to form carbonic acid which then dissociates into H+ and HCO3- ions. H+ ions combine with Hb to form Haemoglobinic acid (HHb).
- The presence of a high pCO2 causes Hb to release oxygen. This is called the Bohr Effect. High pCO2 are found in actively respiring tissues which need oxygen. This causes Hb to release oxygen even more readily than it would otherwise.
  (insert graphs of dis. Curves with high conc co2 and low conc.)
- In high altitudes, the pO_2 is low. In order to increase oxygen intake, populations that live in high altitude areas have adapted by developing higher haemoglobin count, larger lung cavity, increased red blood cell count and greater number of mitochondria to increase the efficiency of oxygen transport from lung to tissue.

8.2 The Heart

- **External structure of the heart:** Blood vessels that leave the heart are the Aortic arch and pulmonary artery. Blood vessels that enter the heart are the superior vena cava, the inferior vena cava and the pulmonary vein. The left and right side of the heart are separated by the septum.
- **Internal structure of the heart-** The human heart has four chambers:
- Atria: 2 upper chamber are known as atria. They are thin walled and receive blood at low pressure.
- Ventricles: 2 lower chambers are known as ventricles. They are thick walled, receive blood from atria and pump it out through arteries.



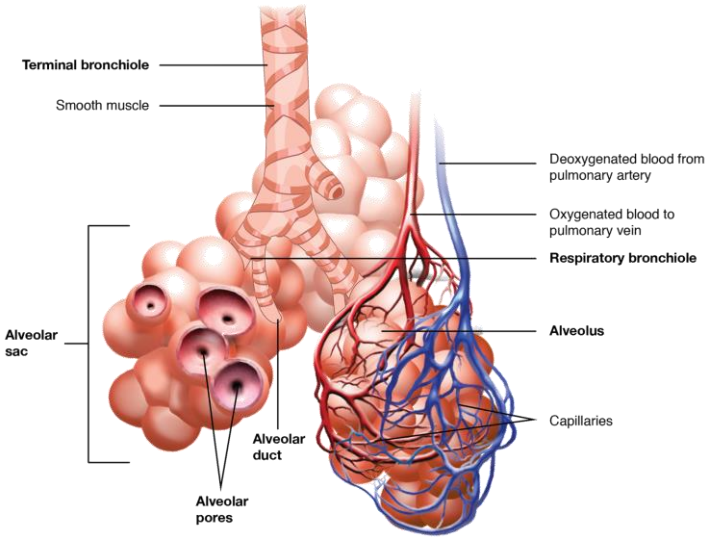
- The cardiac cycle is divided into 2 stages, systole and diastole:
- Atrial systole: This occurs when muscles in the atrial walls contract and blood passes on to the ventricles. 70% of the blood flows passively down to the ventricles.
- Ventricular systole: After 0.13 seconds after the atria contracts, the ventricle walls contract as well increasing the blood pressure and pushing it out of the heart. The blood passes through the aorta and pulmonary arteries.
- Ventricular diastole: This lasts for about 0.3 seconds, the ventricles relax and the pressure falls below that in the arteries. The higher pressure in the arteries pushes against the semilunar valves, shutting them.
- Diastole: All muscles of the heart relax and the pressure inside ventricals gets lower than in the atria. When this happens most of the blood starts to flow from the atria to the ventricles even though the atria is not contracting. However, the atria contracts towards the end to push out the last bit of blood into the ventricles and the cycle begins all over again.

- Control of the heart beat: The cardiac cycle begins in the right atrium. There is a specialised patch of muscles in the wall of the right atrium known as the Sino-Atrial node. Cells at the SAN set the rhythm for all of the cardiac muscle cells to beat as they send out electrical impulses to the rest of the atria.
- The electrical impulses do not pass down to the ventricles. Instead, a second node (Atrio-ventricular node picks up the electrical impulses from the atria.
- The impulse swiftly moves down to the septum of the heart, along fibres called Purkyne tissue. Once the impulse arrive at the base of the ventricles, it moves outwards and upwards through ventricular walls. This causes the ventricle to contract.

9. Gas Exchange and Smoking

9.1 The Gas Exchange System

- **Cartilage:** It is a connective tissue. Cartilage strengthens airways and keeps them open. It also prevents airways from collapsing or bursting due to changes in air pressure.
- **Epithelium:** Air flows down lungs through trachea and bronchi which are lined by cells adapted to remove particles from air before it reaches the lungs. These cells make up a tissue called epithelium. There are two main kinds:
- Ciliated cells: These epithelium cells are lined with tiny cytoplasmic extensions known as cilia. They are responsible for the continual beating of mucus towards the larynx.
- Goblet cells: These epithelium cells are found in between ciliated cells in large amounts. The upper part of a goblet cell is swollen with mucin droplets that are secret by the cell.
- The lungs are the site for gas exchange between air and blood. Large number of alveoli are present to increase surface area. The wall of alveolus is very thin (made up of squamous epithelium) to decrease the diffusion distance for efficient exchange of gases. Outside the alveolus are capillaries. The steep concentration gradient of CO2 and O2 is maintained by breathing and movement. Elastic fibres of allow the alveoli to stretch during inhalation. This increase surface area available for diffusion of air.



9.2 Smoking

- The three components of cigarette smoke are tar, carbon monoxide and nicotine. Tar inhibits the cleaning action of the ciliated epithelium that line the airways. Therefore, mucus accumulates in bronchioles which get obstructed. The trapped dirt particles cause irritation and cause chronic bronchitis.
- Oxidants in cigarettes inactivate a protein inhibitor which is necessary for the maintenance of elastin. Therefore, elastic fibres are permanently stretched causing bronchioles to collapse during exhalation. Alveoli also burst in the process and this leads to breathlessness, fatigue and wheezing. This condition is known as Emphysema. When chronic bronchitis and emphysema occur with each other, the complex disease is referred to as chronic obstructive pulmonary diseases.
- Tar also contains several carcinogens. These affect cell division. Tar is often deposited where trachea branches into 2 bronchi. This leads to a development of malignant tumours. Cancourous cells break away from primary tumours and begin to form tumours in other parts of body.

10. Infectious Diseases

10.1 Infectious Diseases

- Disease: An abnormal condition of an organism which interrupts the normal bodily functions that often leads to feeling of pain and weakness, and usually associated with symptoms and signs.
- Infectious diseases: An infectious disease is a disease resulting from the presence of pathogens including

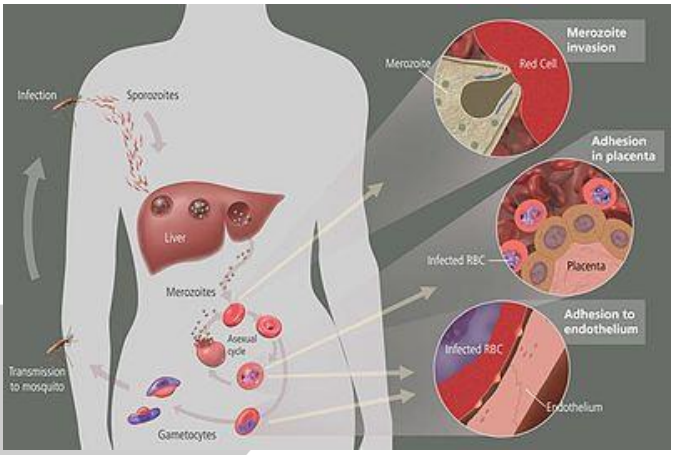
viruses, bacteria, fungi, protozoa and multicellular parasites. These pathogens are able to cause disease in animals and/or plants. Infectious pathologies are usually contagious diseases due to their potentiality of transmission from one person or specie to another. Diseases can be transmitted in a variety of ways, from drinking contaminated water to sexual contact.

- Non-infectious disease: medical condition or disease that is not caused by infectious agents. NIDs can refer to chronic diseases which last for long periods of time and progress slowly. Sometimes, NCDs result in rapid deaths such as seen in certain diseases such as autoimmune diseases, heart diseases, stroke, sickle cell anaemia and others.
- Name and type of causative pathogen for following infectious diseases:
- Cholera: As Cholera is a water-borne disease, it occurs where people do not have access to proper sanitation, a clean water supply or uncontaminated food.

PATHOGEN	Vibrio cholerae (bacterium)
TRANSMISSION METHOD	Food and water borne
SYMPTOMS	Severe diarrhoea, loss of water and salts, dehydration.

- Malaria: Malaria is caused by Plasmodium parasites. The parasites are spread to people through the bites of infected female Anopheles mosquitoes. When a female mosquito stings a human (to take a blood meal), either of the following event may occur:
- In case of an infected person, the mosquito obtains both male and female gametes of Plasmodium along the blood it sucks up. Then, the gametes fuse in the mosquito's stomach, forming thousands of immature malarial parasites which invade the mosquito's salivary glands.
- The other event that could occur is that an already infected mosquito with immature malarial parasites, injects them into a healthy person. The immature malarial parasites then undergo maturation in the person's liver. The 2nd event then returns to the 1st event and eventually results in a transmission cycle.

PATHOGEN	Plasmodium
TRANSMISSION METHOD	Insect vector
INCUBATION	1 week - 1 year
SYMPTOMS	Fever, nausea, headaches, sweating, spleen enlargement, muscle pain



- Acquired Immune Deficiency Syndrome: is a syndrome caused by the retrovirus Human Immunodeficiency Virus (HIV). HIV pathogens infect and destroy the T helper cells of the immune system and without these, the immune system does not respond adequately to infection. When T-Cell numbers are low, the body is particularly vulnerable to infection by anything from the common cold to tuberculosis. Thus, AIDS is not a disease, HIV is the virus that causes AIDS which is a syndrome.

PATHOGEN	Human immunodeficiency virus (retrovirus)
TRANSMISSION METHOD	Exchange of body fluids (sexual intercourse, intravenous needle sharing, blood transfusions)
SYMPTOMS	HIV - fever and then none AIDs - hugely increased susceptibility to disease, such as pneumonia and TB.

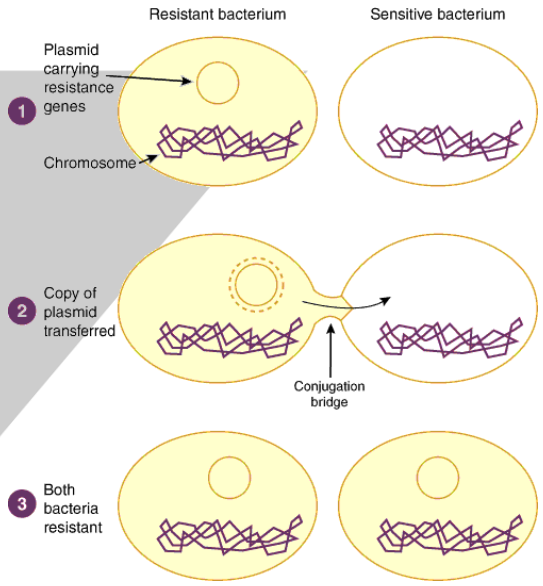
- Tubercolosis (TB): Tuberculosis is an incredibly invasive disease - it starts with a primary infection in the lungs and quickly spreads to the lymph nodes, bones and gut. It often strikes HIV-positive people when their immune system begins to weaken. It spreads via aerosol droplets and unpasteurised milk and is particularly prevalent in overcrowded areas. People suffering malnutrition are more susceptible.

PATHOGEN	Mycobacterium tuberculosis, Mycobacterium bovis (bacterium)
TRANSMISSION METHOD	Airborne droplets
SYMPTOMS	Coughing up blood, shortness of breath, fever, chest pain & sweating

- Smollpox: Smallpox is characterised by red spots containing fluid appearing all over the body. infectious disease caused by the variola virus. It spreads from one person to another. People who had smallpox had a fever and a distinctive, progressive skin rash. Many smallpox survivors have permanent scars over large areas of their body, especially their faces. Some are left blind.
- Measels: easles is a disease that causes a rash and fever, with potentially fatal complications. Measles is no longer common in the UK or most developed countries since most children are vaccinated. It and most commonly affects developing countries in places where conditions are overcrowded and insanitary. It can cause childhood blindness and severe brain damage, and is the ninth leading cause of death worldwide.
- Unlike smallpox, measles requires several booster shots to develop full immunity, and in large cities with high birth rates, it can be difficult to give boosters or even follow up cases of measles. Refugees from these areas can spread the disease around, which makes it much more difficult to treat than smallpox. Measles is highly infectious.
- These diseases are relevant because they are the ones of current concern they are all in epidemic or pandemic status. Due to international travel, infectious diseases can be spread round the entire world very quickly.

10.2 Antibiotics

- Antibiotics such as penicillin are chemical substances made by microorganism which will inhibit the growth or replication of other microorganism without harming the infected organism. There are a wide range used to treat bacterial and fungal infection. Antibiotics used to destroy bacteria are called bactericidal antibiotics and antibiotics that inhibit the growth and reproduction bacteria are known as bacteriostatic antibiotics. Penicillin interferes with the synthesis of bacterial cell walls. When a newly formed bacterial cell grows, it secretes enzymes called autolysins which makes little holes in bacterial cell walls to allow for expansion and stretching. Penicillin inhibits the enzyme glycoprotein peptidase, which links together the peptidoglycan chains that make up bacterial cell walls. Therefore, peptidoglycan chains will not be able to close those holes and cells walls will burst due to weakness.
- Antibiotics are ineffective against viruses. Viruses do not have any form of cell structure or metabolism. These viruses replicate only within living hosts.
- Antibiotic resistance: Bacteria can become resistant to antibiotics if they gain a gene that codes for proteins that protect them from antibiotics. This is mutation. They can acquire these genes by mutation or transfer of resistance.



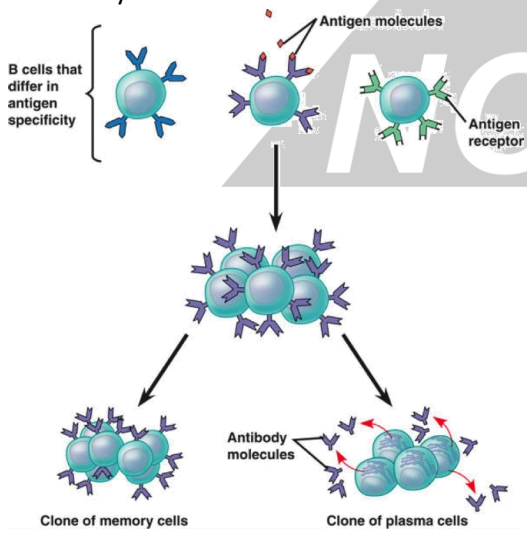
11. IMMUNITY

11.1 The Immune System

- Immune response: This is the body's response to the non-self antigens such as the antigens of pathogens. It involves the production of antibodies in response to antigens.
- Phagocytes (macrophages and neutrophils) are produced throughout life by bone marrow and are stored there before they are distributed around the body by blood. They remove dead cells as well as invasive microorganisms.
- Neutrophils: These make up 60% of white blood cells. They leave the blood through capillary walls to enter tissues. They are short lived and often die after ingesting and destroying bacteria.
- Macrophages: These are present in the passage through which lymph flows into lymph nodes and also found on

the inside surfaces of alveolar walls. They are long lived and they engulf foreign particles and microorganism. Macrophages are also known as antigen presenting cells (APC's). This is they present the antigens of pathogens (foreign particles) on their cell surface membrane. This signals the lymphocytes to destroy the pathogens.

- Phagosytosis: When bathogens attack the body, the cells under attack release chemiclas like histamine. These chemicals attract neutrophils to site. The plasma membra of neutrophils engulfs the pathogen and traps it within a vacule. Lysosomes join this vacule, releasing hydrolytic digestive enzymes that kill the pathogens. Dead neutrophils collect at the site of infection forming pus.
- There are two types of lymphoctes:
- B- lymphocytes: This type of lymphocyte is produced and developed in the bone marrow. When mature, each b-cell makes on type of antibody molecule. Antibody molecules stay within the plasma membrane of b-cells. Part of the antibody molecules form a protien receptor that combines with specifically with one type of antigen. Each antigen with combine with a specifc antibody on B-cell. Once they have combined, the B-cell will undergo mitosis repeatly to form clone cells. As only the B-lymphcytes with antibodies complementary to antigens divide like this, it is known as clonal selection. Some become plasma cells (produce antibodies) and others become memory cells.

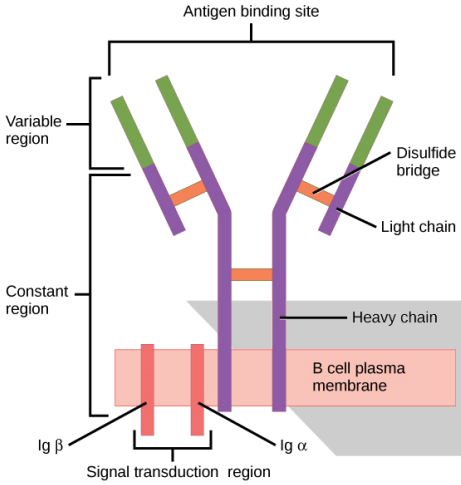


- T- lymphocytes: These cells are produced at the bone marrow but collect in the thymus till maturiy. Matute T-cells have T- cell receptors that are complementary antigens of pathogens. T- cells only respond when they encounter this antigen on the cell surface membrane of a host cell such as a macrophage (APC). A particular T-cells with complementary receptor will binds to antigen found on the surface of APC. This T-cell clones into two types of cells:
- T helper cells: They secrete chemicals known as cytokines which stimulate other cells (macrophages and B-cells) to fight against the invaders.
- T killer cells/ T cytotoxic cells: These T-cells destroy the cell to which they are bound. They search the body for cells that have become invaded by pathogens and are displaying the pathogens antigen on their plasma membranes. When T-killer cells recognize the antigens, they attach themselves to the surface of infected cells and secrete toxic substances that kill the cells and pathogens within them.
- Memory cells: These form the basis for immunological memory and can last many years, often a lifetime. During a primary response, there are very few B-cells specific to the antigen and so the production of antibodies is low. However, during the secondary response, there are many more antibodies produced as many memory cells divide quickly and differentiate into plasma cells.
- The immune systen can sometimes fails to distinguish between self and non self antigens. Myasthenia gravis is one of those cases. In this condition, your own body produces antibodies that target an individual's own body, organs, cells, and receptors for destruction or inactivation. Normally, antibodies are supposed to target foreign invaders such as bacteria and viruses for destruction or inactivation. But in an autoimmune condition such as myasthenia gravis, the antibodies become directed against self antigens. Specifically, these antibodies attach themselves to the receptors on the skeletal muscles of your body. By doing so, the antibodies prohibit the receptors on the muscles from receiving a specific signal or destroy the receptors outright. This causes difficulty in walking, eating and in some cases respiratory faliure as the muscles of respiration can no longer work.

11.2 Antibodies & Vaccination

- Antibodies: These are globular glycoproteins with 4 polypeptide chains, 2 heavy chains and 2 light chains. The chains are held together by disulphide bridges and for a Y-shaped structure. The lower part of the 'Y' is called the constant region as it has the same amino acid

sequence in all antibodies. The upper part of the 'Y' is called the variable region of the molecule and has a different amino acid sequence in different antibodies. Antibodies have 2 identical binding sites formed by both light and heavy chains. The sequence of amino acids in this region make the specific 3-D shape which binds to just one type of antigen.



- Monoclonal antibodies: These are pure and highly specific antibody. In theory, a particular plasma cell can be isolated and cultured to produce large amounts pure antibodies. However, plasma cells were unable to divide until 1975 when Georges Kohler and Cesar Milstein discovered a new way of culturing plasma cells.
- Monoclonal antibody formation: A mouse is injected with relevant antigen. The resulting plasma cells are then fused with myeloma (cancer) cells from a mouse. These myeloma cells are immortal and can multiply. The resulting cell is called a hybridoma which produces large quantities of identical antibody molecules. This is useful in administering artificial passive immunity.
- **Immunity:** There are two types of immunity, active and passive. Both may be acquired naturally or artificially. Providing immunity artificially is called immunization.
- **Active immunity:** This is occurs when antigens are received. There are two types:
- Natural active immunity: This is obtained as a result of an infection where the body has manufactured its own antibodies.
- Artficial active immunity: This is achieved by injecting small amounts of antigens or attenuated pathogen called vaccines. The process is called vaccinations. This stimulates the production of antibodies against the antigen.
- **Passive immunity:** Antibodies are taken into the body and only remain in the system for a short time as they are then converted and excreted. This type of immunity is short term however it acts to clear the infection immediately. No immunological memory is created. Naturally this type of immunity comes from breast milk.
- Vaccination: A vaccine is antigenic material, which could be a live, dead or harmless micro-organism, or perhaps a harmless form of a toxic or simply surface antigens. This allows our immune system to produce the requisite B and T cells without actually suffering the disease, mimicking natural immunity.
- Viruses are constantly mutating and changing - the reason we cannot create a vaccine against the common cold or influenza is because it mutates very frequently and the vaccine will not be effective. These mutations are known as antigenic shift or drift. Diseases like malaria are eukaroytic in nature and have far more genes and thus antigens on their cell surfaces.
- People sometimes do not respond well to vaccinations, maybe because their immune system cannot handle it, or they do not have enough protein to make antibodies - and thus the vaccination attempt may infect them. People may also be infected with a live virus and could potentially pass it out in their faeces during the primary response, infecting others. This is why we vaccinate everyone at the same time, known as herd immunity.

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