Chapter 3: Movement of Substances

Define **diffusion**, **osmosis** and **active transport**.

Diffusion is the net movement of particles in solid, liquid or gaseous state, down a concentration gradient without the need of energy(passive). (*No need membrane)*

Osmosis is the net movement of water molecules from a region of higher water potential to a region of lower water potential, through a partially permeable membrane. (*No need energy)*

Active transport is a process in which energy from cellular respiration is used to move particles against a concentration gradient across a **partially permeable membrane**. (*only in living cells)*

Describe the **importance of diffusion** in nutrient uptake and gaseous exchange in plants and humans.

Nutrient uptake in Humans

Example: Diffusion allows digested food substances like glucose, amino acids to absorbed **from small intestine into blood capillaries** (*Both Active Transport and Diffusion* can occur there)

Gaseous exchange in Humans

Diffusion of oxygen from alveolar air space into blood capillaries **through** the alveolar walls allows oxygen to be transported to all parts of the body. Diffusion of carbon dioxide from respiring cells into the blood and ***through*** the alveolar walls allows removal of carbon dioxide from the body.

Gaseous exchange in Plants

Diffusion of water vapour ***out*** *of* the stomata allows transpiration to occur. Transpiration is important as it draws water and mineral salts from the roots to the stem to the leaf. Latent heat of vapourisation is removed during the evaporation of water from the cells in the leaves, cooling the plant. It also helps to keep the plant cells turgid, maintaining the shape of soft tissues in plants.

Describe the importance of **active transport** as in ion uptake by root hairs and uptake of glucose by cells in the villi.

Ion uptake by root hairs

The root hair cells absorb ions against a concentration gradient. This lowers the water potential of the sap in the root hair cell. Thus water from the soil solution enters the root hair cell by osmosis. The entry of water then dilutes the sap and the sap of the root hair cell now has a higher water potential than the inner cells. Hence water passes by osmosis from the root hair cell into the adjacent inner cell. This process continues until water enters the root xylem vessels and moves up the plant.

Glucose uptake by cells in villi

Glucose and amino acids are absorbed by active transport when there is a lower concentration of them in the lumen of the small intestine than in the blood capillaries.

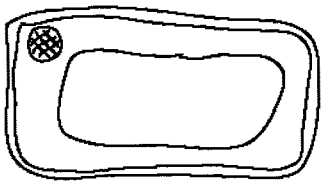
State the **similarities** and **differences** between diffusion and osmosis.	
Similarities	Differences
Both involve the movement of *molecules* down a concentration gradient Both are passive processes in which no energy is required	Diffusion is applicable to any type of particle whereas osmosis is applicable to only water molecules. Diffusion does not require a membrane whereas osmosis only takes place across a partially permeable membrane

State the **differences** between active transport and diffusion	
Active transport	Diffusion
Movement of particles against a concentration gradient. Energy is required. Occurs only in living cells Requires partially permeable membrane	Movement of particles down a concentration gradient. Energy not required. Occurs in living and non living things. Does not require partially permeable membrane

State the difference between **hypotonic**, **hypertonic** and **isotonic** solutions and use these terms in appropriate situations.Note: for ANIMAL systems only
Hypotonic solution has a lower concentration with respect to the cell. Hypertonic solution has a higher concentration with respect to the cell. Isotonic solution has the same concentration with respect to the cell.

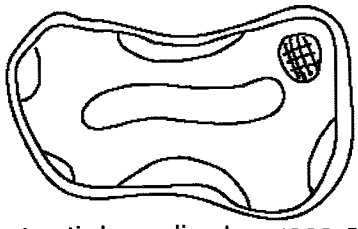
Describe fully, what happens when:

a) A plant cell is placed in a solution of **higher water potential**
Water enters the plant cell by osmosis across a partially permeable membrane as surrounding solution has a higher water potential than the cell sap of the plant.
***Vacuole** increases in size* and pushes the cell contents against the cellulose cell wall.
Water exerts a **turgor pressure** onto the cellulose cell wall preventing cell from bursting.
Plant cell enlarges and becomes turgid.
*This is important for a seedling to emerge from the soil.



b) A plant cell is placed in a solution of **lower water potential**
Water moves out of the plant cell by osmosis across a partially permeable membrane as surrounding solution has a lower water potential than the cell sap of the plant.
***Vacuole** decreases in size* and cell contents shrink away. **Cell membrane detaches** itself from the cellulose cell wall.

The plant cell decreases in size and becomes plasmolysed if the surrounding solution is highly concentrated. Plant cell/tissue turns flaccid.



c) An animal cell is placed in a **hypotonic** solution
Water enters the animal cell by osmosis down a water potential gradient across a partially permeable membrane as surrounding solution has a higher water potential.
Animal cell expands and swells up.
The cell bursts due to absence of cell wall.

d) An animal cell is placed in a **hypertonic** solution
Water moves out of the animal cell by osmosis down a water potential gradient across a partially permeable membrane as surrounding solution has a lower water potential.
Animal cell shrinks in size and **membrane** forms spikes. The cell becomes crenated.

What is **turgor pressure** and what are the advantages of it?

Turgor pressure is the water pressure that is exerted onto the cell wall which causes the cell to expand *without bursting*.

Advantages
Turgor pressure helps to keep plant cells firm and makes the plant stay upright.

Chapter 4: Nutrients

Explain the need for **food**.

- It helps to provide energy for vital activities of the body (keeping our hearts muscles contracting and skeletal muscles contracting for movement).
- It helps to synthesise new protoplasm for cell growth, repair of worn-out parts of the body and cell division.
- It helps us to stay healthy.

State the roles of **water** in animals and plants.

Animals

Water is a *medium* or substance in which chemical reactions occur in an organism.

Water helps to transport dissolved substances around the body such as *digested products* from the small intestine to other parts of the body, *excretory products* from the tissue cells to the excretory organs for removal from the body and *hormones* from the endocrine glands to the *target organs*.

Water is a key component of *protoplasm*, *lubricants* found in joints to reduce friction between joints during movement, *digestive juices*, *blood* and *tissue fluid*.

Water is needed for certain chemical reactions such as hydrolysis in digestion.

Water helps to *regulate body temperature*. When **water** from sweat evaporates from the skin surface, latent heat of vapourisation is removed and the body cools down.

Plants

Water is essential for *photosynthesis*.

Water is needed to keep plant cells *turgid* and the plant itself upright.

Water is needed to transport dissolved *mineral salts* up the xylem from the roots to the leaves.

Water is needed to transport *food substances* from the leaves to other parts of the plants. (Phloem has water)

Water is needed to *remove latent heat of vapourisation* during transpiration.

Identify the elements that carbohydrates are made up of and their relative ratio.

$C_nH_{2m}O_m$

Ratio of Hydrogen to Oxygen is always 2:1

State the **functions** of carbohydrates.

1. As a substrate for *respiration(a process that requires **enzymes**)* to provide energy for cell activities.

2. For the formation of *nucleic acids*, for example, DNA.

3. To synthesise *lubricants*, for example, mucus, which consists of a carbohydrate and a protein.

4. To be *converted* into other organic compounds such as amino acids and fats. (Happens in plants and animals)

5. To form *supporting structures* for example cell walls in plants.

6. To synthesise *nectar* in some flowers.

List and differentiate between the three main **categories** of carbohydrates.

1. Monosaccharides (Single Sugars)
   Glucose, Fructose, Galactose

2. Disaccharides (Double Sugars)
   Maltose (malt sugar), Sucrose (cane sugar – plants only), Lactose (milk sugar – found in milk of all mammals)

3. Polysaccharides (Complex Carbohydrates)
   Starch, Glycogen, Cellulose

Conclude the **amount** of reducing sugar present with respect to the **colour** of the precipitate after a Benedict's test.(Note: sucrose is **NON-reducing**)

Green – Traces of reducing sugar
Yellow or orange precipitate – Moderate amount of reducing sugar
Brick-red or orange-red precipitate – Large amount of reducing sugar
Blue – Reducing sugars absent

List the **steps** of Benedict's Test.

*If sample is a solid, mash up, add water, decant and retrieve the solution.
1. Add $2cm^3$ of Benedict's Solution to $2cm^3$ of the solution. Shake.
2. Leave the test tube in a beaker of boiling water for 5 minutes.
3. Observe for a colour change.

Identify where each polysaccharide; starch, glycogen and cellulose is found in plants and animals.

Starch –stored as starch granules in leaves and roots.
Glycogen – found in the liver and muscles of animals.
Cellulose – found in the cell wall of plant cells

List down reasons why glycogen and starch are used as ***storage materials***.
Molecules of starch and glycogen are **Compact and tightly coiled** so they occupy less space than all the individual glucose molecules that make up a glycogen or starch molecule. They can be easily **Hydrolysed** to glucose when needed for example in tissue respiration. They are **Insoluble** in water so they do not change the water potential in cells (to prevent cells from crenating) They are **Large** molecules which cannot diffuse through cell membranes so they will not be lost from the cell.

State that large molecules are synthesised from smaller basic units.
Large molecules are synthesised from smaller basic units during condensation. Condensation is a chemical reaction in which 2 smaller, simpler molecules are joined together to form a larger, *complex* molecule with the removal of *1 water molecule*. *Note: Hydrolysis is a chemical reaction in which 1 water molecule is used to break down a larger, complex molecule into 2 smaller, simpler molecules.*

Identify the elements that fats are made up of.
Carbon, Hydrogen and Oxygen, with *lesser* oxygen in proportion to hydrogen.

List the steps of **ethanol emulsion test** and state conclusions for the observations.
*If sample is a solid, mash up, decant after adding $2cm^3$ *of ethanol* and retrieve the solution. 1. Add $2cm^3$ of water and shake. Presence of fat produces a white emulsion *and heat is given off.*

State the **functions** of fats.
1. A source and store of energy when there is insufficient glycogen. Fats would be oxidised to give twice the amount of energy for metabolic reactions. 2. An insulating material in adipose tissues under the skin and around vital organs to prevent excessive heat loss. (Mammals which live in the water tend to lose heat quickly so they have a thick layer of fat beneath the skin to reduce loss of body heat). 3. Solvent for fat-soluble vitamins (A,D,E,K) 4. An essential part of protoplasm, especially in cell membranes. 5. A way to reduce water loss from the skin surface. (Glands in skin secrete an oily substance which forms a thin layer on the skin surface, reducing rate of evaporation of water and thus reducing heat loss from the skin.) 6. *Synthesis of* certain hormones e.g. sex hormones and steroids.(Note: most

hormones are made of proteins)

Identify the elements that proteins are made up of.
Carbon, Hydrogen, Oxygen, Nitrogen and (Sulfur)
Explain how the 3D shape of proteins can be destroyed by high temperatures and extreme pH.
High temperatures At high temperatures, atoms of proteins vibrate violently, breaking the weak hydrogen bonds *within protein*. Protein loses its 3D shape and is denatured. Thus the protein loses its function as the active site for enzyme is lost. **Extreme pH** Extreme pH breaks the weak hydrogen bonds *within* protein and causes a change in the 3D structure of the protein.

State the **functions** of protein.
1. Proteins are used in the synthesis of new *protoplasm*, for growth and repair of worn-out body cells. 2. In the synthesis of *enzymes* and some (*Sex hormones and steroids are not protein in nature*) *hormones like insulin, glucagon and adrenaline*. 3. Formation of *antibodies* to combat diseases.

List the steps of the **Biuret's test** and state conclusions for the observations.
*If sample is a solid, mash up, add water, decant and retrieve the solution. 1. Add $2cm^3$ of sodium hydroxide to $2cm^3$ of solution and shake. 2. Add 1% Copper (II) Sulfate solution drop by drop, shaking after every drop. Solution turns from blue to violet in the presence of protein.

List the steps of the Grease spot test.
1. Crush substance and smear onto filter paper Translucent grease spot will be observed.

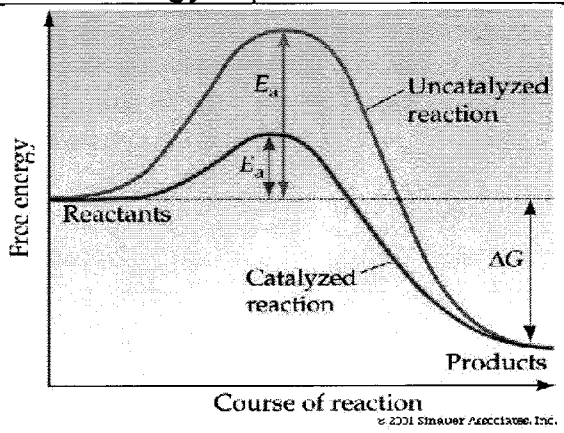
Chapter 5: Enzymes

Define enzymes.

Enzymes are biological catalysts made of protein which speed up(~~alter~~) the rate of chemical reactions by lowering the activation energy required to start the reaction without being chemically changed at the end of the reaction.
Note: Enzymes do not participate in the chemical reaction, they ACT on substrates

Define activation energy.

It is the minimum energy required for a chemical reaction to proceed/start.



List examples of hydrolases in our body.

Mouth - Salivary amylase
Stomach – Pepsin
Pancreas – Pancreatic amylase, Lipase
Small Intestine – Sucrase, Maltase, Peptidase, Lipase, Lactase

State the characteristics of enzymes.

Remains chemically unchanged
Speed up chemical reactions
Specific : lock and key hypothesis
Required in small amounts
Affected by temperature
Affected by pH

Explain enzymes' specificity in terms of lock and key hypothesis.

Enzyme reactions are specific as *enzymes act on a specific substrate.* They have a unique active site which can only *bind to a specific substrate* which has a complementary shape. The enzyme is the lock and the substrate is the key. Thus the substrate binds to the enzyme forming an enzyme-substrate complex.

Explain how enzymes speed up the rate of reaction in terms of activation energy.

Enzymes lower the activation energy required to start a reaction thus the reaction proceeds faster.

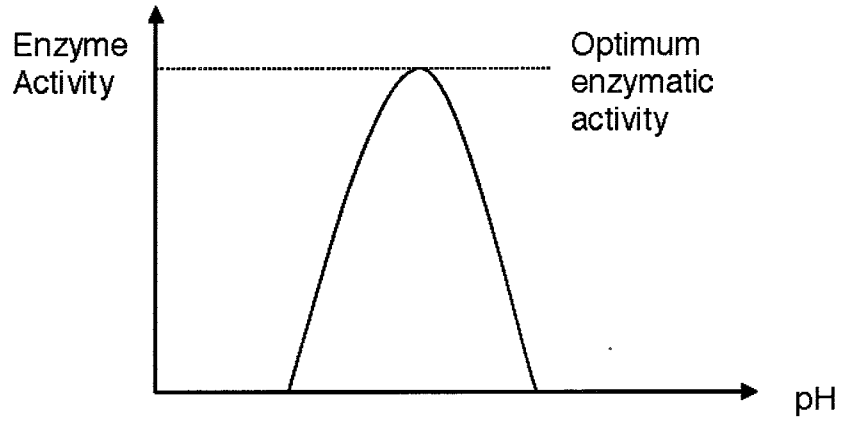
Explain how enzymes are affected by temperature in terms of **kinetic energy**.
At low temperature, enzymes are **<u>less</u>** active and both enzyme and substrate have low KE and thus less effective collisions and decrease in rate of enzyme activity/less products formed per unit time. As temperature increases, enzymatic activity doubles for every 10^0**C.** *(note: cannot be used to explain all questions on enzymes)* Enzyme and substrate have more KE therefore *effective* collisions are more frequent and rate of formation of enzyme-substrate complexes increases and thus rate of enzyme activity increases/more products formed per unit time. After optimum temperature, enzyme activity decreases. The enzyme molecule vibrates violently and hydrogen bonds within it are broken. The enzyme loses its three-dimensional shape as well as its active site. Hence, the enzyme becomes denatured.

Explain how pH affects enzymatic reactions.
Different enzymes have different optimum pH. At this pH, enzymatic reaction is at its highest rate. The enzyme will decrease in activity when the pH environment is lower or higher than the optimum pH of the enzyme. However, when the pH environment differs greatly from the enzyme's optimum pH, many weak hydrogen bonds within the enzyme are destroyed, hence the enzyme is denatured.

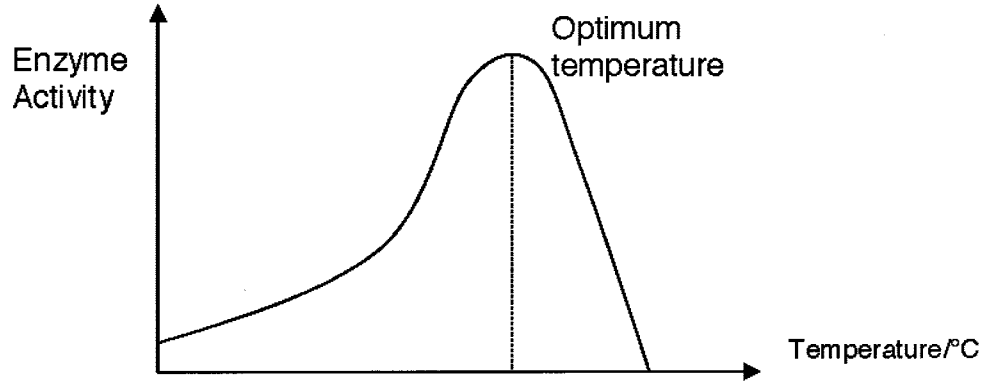
State an example of a reversible reaction catalysed by an enzyme.
1. Carbonic anhydrase catalyses the reversible reaction between water and carbon dioxide to form carbonic acid (note: this is not hydrolysis)

Sketch the graphs of:

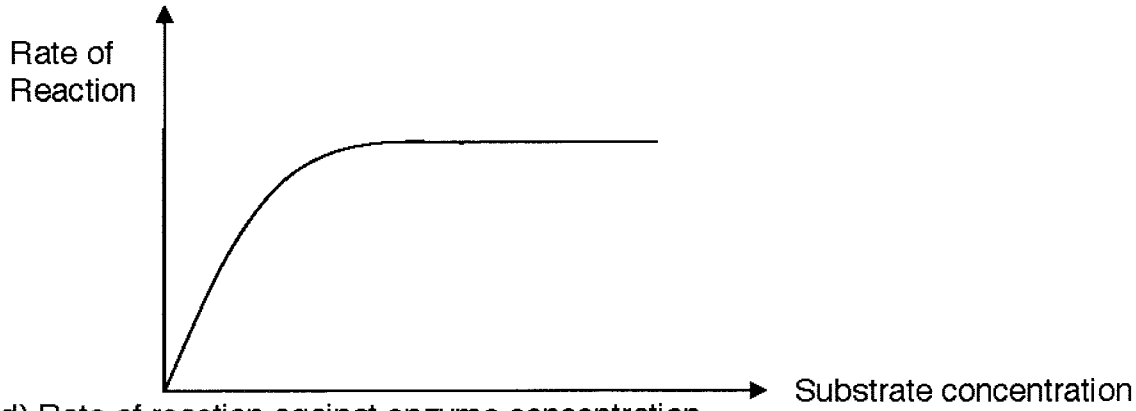
a) Enzyme activity against pH(position of curve differs for different enzymes)



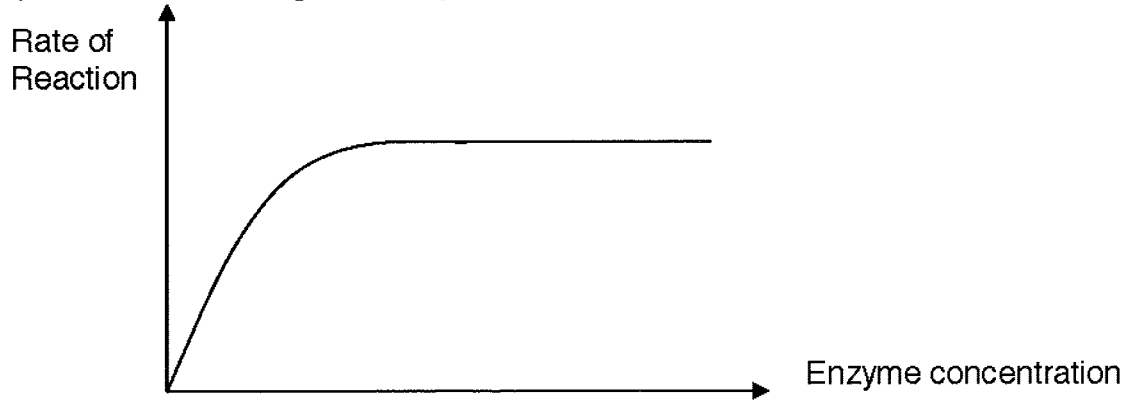
b) Enzyme activity against temperature



c) Rate of reaction against substrate concentration



d) Rate of reaction against enzyme concentration.



Chapter 6: Nutrition in Humans

Describe the functions of main regions of the alimentary canal and the associated organs:

Parts	Function
Mouth	Ingestion, mastication to increase SA to V ratio and hydrolysis of starch
Salivary Glands	Secretes saliva that contains amylase, mucin and water
Oesophagus	Transport food from mouth to the stomach via peristaltic movements
Stomach	Secretes gastric juices containing enzymes (pepsinogen and prorennin) and hydrochloric acid.
Small intestine	Secrete intestinal enzymes (sucrase, maltase, enterokinase, peptidase, lactase, lipase) to hydrolyse fats, carbohydrates and proteins for absorption.
Pancreas	Secretes pancreatic juice which contains (pancreatic amylase, pancreatic trypsinogen and pancreatic lipase). Also secretes hormones insulin and glucagon.
Gall bladder	Temporarily stores bile
Liver	6 functions
Colon	Absorbs excess water and mineral salts from undigested food material. Remove bacteria periodically during egestion.
Rectum	Stores feces
Anus	Expels feces

Describe **peristalsis**.

Rhythmic wave-like antagonistic contractions and relaxations of longitudinal and circular muscles to mix and propel the contents of the alimentary canal.

Oesophagus: When circular muscles contract, longitudinal muscles relax. Size of lumen decreases and length of gut increases.

When circular muscles relax, longitudinal muscles contract. Size of lumen increases and length of gut decreases.

Define ingestion, digestion, absorption and assimilation and state the differences between them.

Ingestion: Food is taken into the alimentary canal via the **mouth** into the body.

Digestion: Process whereby **Large, Insoluble, Complex** molecules of food is broken down into **smaller, soluble, simpler** molecules to be absorbed into the *circulatory* system. Digestion takes place in the mouth stomach and small intestine.

i) Physical digestion breaks *large* food *pieces* up into smaller pieces to increase the surface area to volume ratio for digestive enzymes to work on.
ii) Chemical digestion breaks down large, complex food ***molecules*** down into smaller, simpler ***molecules*** through the action of enzymes.

Absorption: Process whereby digested food substances like simple sugars and amino acids *move* into the blood capillaries via diffusion and active transport from the lumen of the small intestine to the bloodstream ***through*** the villi of small intestine. Fatty acids and glycerol are absorbed into the lacteal.

Assimilation: Distribution and use of the products of digestion as an energy source and conversion into other nutrients needed for growth and repair of body parts.

Describe and differentiate between **physical and chemical digestion**.

Physical digestion, like mastication of food in mouth, breaks up large food pieces into smaller pieces to increase surface area to volume ratio for more rapid action of digestive enzymes to work on.

BENEFITS OF **CHEWING**

- Chewing helps to **physically digest the food into smaller pieces** so that it increases surface area to volume ratio for more rapid action of digestive enzymes and to **facilitate swallowing**, preventing choking.
- Chewing allows food to be **homogenously mixed up with saliva** to be at a **suitable pH** throughout for enzyme action.
- Through chewing, food pieces get **mixed well with enzymes** like amylase in saliva so that starch can be hydrolysed faster.
- Chewing helps to **allow mucus and water in saliva to soften as well as moisten the food** for the tongue to roll it into food boli which allows for easier swallowing down the pharynx into the rest of the alimentary canal.

Chemical digestion breaks complex food substances down into simpler molecules through the action of enzymes. Example: Hydrolysis of starch into maltose due to the action of amylase.

1. During chemical digestion, enzymes are involved but during physical digestion, enzymes are not involved.
2. During chemical digestion, new compounds are formed due to the hydrolysis of larger *molecules*, but during physical digestion, compounds of food molecules remain the same.

Describe the processes that take place in the mouth, stomach and small intestine.

Organ	pH	Processes
Mouth	7	Chewing physical digests food. (Salivary amylase) Starch → maltose.
Stomach	2	(Hydrochloric acid) 1. Creates optimum pH for proteases. 2. Activates prorennin and pepsinogen to rennin and pepsin respectively. 3. Denatures amylase. 4. Kills micro-organisms and bacteria. (pepsin) Proteins → Polypeptides. (rennin) Soluble caseinogen → Insoluble casein. (pepsin) Casein → Polypeptides.
Small Intestine	9	Bile (pH 10): Not an enzyme. Released by bile duct and stored in gall bladder, produced by liver. - Reduces surface tension of fats , causing *large fat droplets* to break into smaller fat droplets (emulsification) - Increases surface area to volume ratio for lipase to hydrolyse fats at a higher rate. - Creates an optimum pH for enzymes in small intestine Intestinal juice: (sucrase) Sucrose → glucose and fructose. (maltase) Maltose → glucose and glucose. (enterokinase) Trypsinogen → trypsin (activation) (peptidase) Polypeptide → amino acids. (lipase) Fats → fatty acids and glycerol. (lactase) Lactose → glucose and galactose. Monosaccharides and amino acids are absorbed through the villus of ileum and goes into the blood capillary and blood plasma. They are then transported via the hepatic portal vein to the liver. Pancreatic juice: (pancreatic amylase) Starch → maltose. (pancreatic lipase) Fats → fatty acids and glycerol. (pancreatic trypsin) Proteins → polypeptides.

Describe how the small intestine is adapted for absorption.

Feature	How it helps absorption
Large surface area: There are folds in inner walls; Has **villi** (singular: villus) with finger like projection and **microvilli** *on* epithelial cells.	Increases surface area to volume ratio to increase rate of diffusion and active transport.
One cell thick epithelium of villi	Digested nutrients can rapidly diffuse over a short distance into the capillaries of the villi thus increasing rate of absorption of food.
Each villus richly supplied with a **dense network of blood capillaries** to transport absorbed food substances away from the small intestine continuously. Lacteal transports fats away.	Maintains a steep concentration gradient between 2 solutions of nutrients in lumen of small intestine and blood plasma in capillaries for absorption of digested food substances to occur quickly by ensuring continual transport of nutrients (glucose, amino acids and fats) away from the small intestine.
Presence of **numerous mitochondria** in epithelial cells of villi	Increases rate of absorption by providing large amount of energy needed for higher rate of active transport.

State the importance of **active transport** during absorption and the substances involved.
It is to ensure continual absorption of products of digestion, like simple sugars and amino acids, when concentration of such substances in the lumen of small intestine is lower than the concentration in *blood capillaries of* villi.

State what happens to **undigested and unabsorbed matter**.
Undigested food and other gut content are removed as faeces, via the anus. *The process is known as egestion.*

State the function of the **hepatic portal vein** in transport of blood rich in absorbed nutrients from the small intestine to the liver.
It allows all the blood capillaries in the small intestine to merge and form the hepatic portal vein which transports sugars and amino acids dissolved in the blood from the small intestine to the liver.

Describe how fats, glucose and amino acids transported and utilized.

Nutrient	How it's transported	Utility
Fats	Lacteal	Stored under the skin in adipose tissue and around the organs as an energy source (when glucose and glycogen depletes) and *insulates against heat loss*. Also used as shock absorber.
Amino Acids	Blood Capillaries	Converted into new protoplasm for growth and repair of worn out body parts; synthesis of enzymes, hormones and antibodies; and clotting *factors*.
Glucose	Blood Capillaries	Source of energy, oxidized during aerobic respiration to release energy for cellular activities or to make DNA, RNA, mucus, etc. Excess glucose is converted to glycogen by liver and muscle cells, which is stimulated by insulin (read: homeostasis)

When blood glucose levels are higher than normal:
Pancreas secretes insulin into the bloodstream, insulin travels to the liver and STIMULATES the conversion of EXCESS glucose into glycogen. ✗ Insulin does not convert!!

When blood glucose levels are lower than normal:
Pancreas secretes glucagon into the bloodstream, glucagon travels to the liver and STIMULATES the conversion of glycogen to glucose.

State the role of liver.

1. Liver produces **Bile** (formed from breakdown of Haemoglobin too) which emulsifies fats to increase rate of digestion of fat by lipase. Fat metabolism.
large fat droplets into small fat droplets.
2. Excess amino acids brought to the liver. Amino groups are removed and converted to urea. This process is called deAmination. Urea is then excreted in urine. Remains of the deaminated amino acids (carbon residue) are converted to glucose which in excess is converted to glycogen.

3. Harmful substances may be absorbed into blood from gut. Harmful substances

made harmless in the process called **Detoxification**. Alcohol is also broken down in the liver into harmless products like water and carbon dioxide.

$$\text{Hydrogen peroxide} \xrightarrow{\text{catalase}} \text{water} + \text{oxygen}$$

4. Liver synthesizes **Plasma** proteins from amino acids, examples are fibrinogen for blood clotting.

5. Red blood cells that are worn out are destroyed in the spleen (a gland near the liver). The haemoglobin is brought to the liver. The liver breaks down the Haemoglobin and stores the **Iron** released in the process.

6. Liver plays a role in carbohydrate metabolism hence regulating blood **G**lucose levels. If *blood glucose level is lower than normal*, glycogen is converted to glucose by liver cells (stimulated by glucagon). If there is excess glucose, excess glucose converted to glycogen by liver cells (stimulated by insulin).

7. **S**tores fat soluble vitamins A & D.

Remember the acronym: **BAD PIGS**
Note: Excess Glucose is converted to fats.

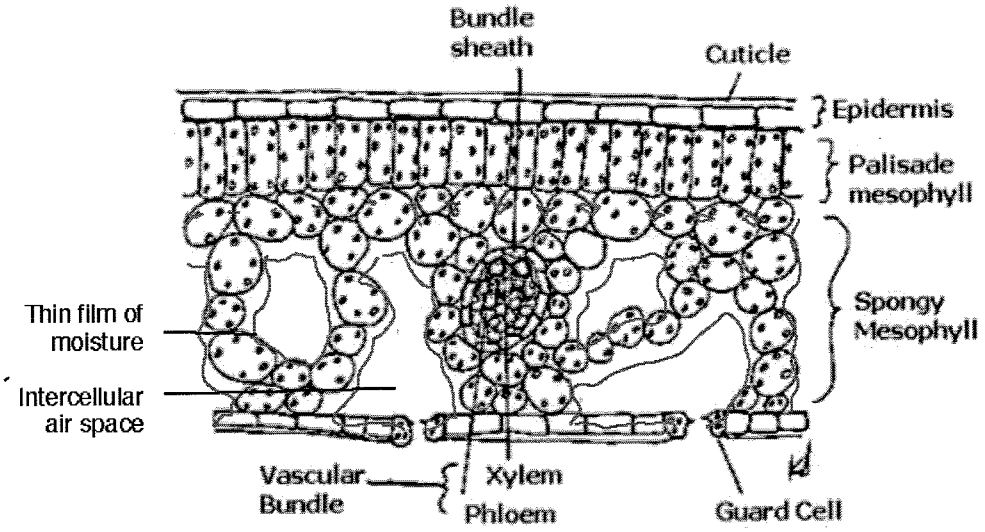
Explain detoxification of alcohol in the liver.
It is the process of converting harmful substances into harmless products. Enzyme alcohol dehydrogenase converts alcohol into acetaldehyde. Acetaldehyde is used as a source of energy in cells.

Describe the effects of excessive alcohol consumption.
Alcohol stimulates acid secretion in the stomach and excess acid increases the risk of gastric ulcers. Prolonged alcohol abuse may lead to liver cirrhosis whereby the liver cells are destroyed and replaced with fibrous tissue. Bleeding in the liver occurs for liver cirrhosis resulting in liver failure and subsequently death. Alcohol is a depressant and it slows down some brain functions. Under the influence of alcohol a person has reduction in self-control. Observable effects of intoxication are slurred speech, blurred vision and poor muscular co-ordination. Judgement deteriorates and during driving, underestimates speed, hence driving faster with slower reactions.

} immediate effects.

Chapter 7: Nutrition in Plants

Identify and label the cellular and tissue structure of a dicotyledonous leaf as seen in transverse section under the microscope.



Features of Leaf	Function of Features
Upper Epidermis	Consists of a single layer of closely packed cells that may be regularly or irregularly shaped. Waxy cuticle on the surface exposed to air to reduce water loss. Transparent to allow sunlight to penetrate the leaf, also helps to refract and focus light rays onto Palisade mesophyll.
Palisade Mesophyll (Top layer of Mesophyll Layer)	Regularly shaped columnar cells perpendicular to the upper epidermis to maximize chloroplast's exposure to sunlight incident rays. Abundance of chloroplasts to absorb maximum sunlight for photosynthesis. Main site of photosynthesis. Covered with thin film of moisture so that carbon dioxide can dissolve in it.
Spongy Mesophyll (Bottom layer of Mesophyll Layer)	Irregularly shaped cells which possess lesser number of chloroplasts than palisade cells. Numerous large intercellular air spaces among them to allow rapid diffusion of gases through the leaf. Covered with thin film of moisture so that carbon dioxide can dissolve in it.

Vascular Bundle	Xylem (top) Consists of dead cells forming vessels that contain deposits of lignin on their walls. Lignin strengthens the xylem vessels. Conducts water and mineral salts from soil to rest of plant. Flow only moves from roots to other plant parts. Phloem (bottom) Consists of living cells that conducts sucrose and amino acids from the leaves to other parts of the plant. Flow may be bidirectional but not within the same vessel.
Lower Epidermis	Similar to upper epidermis, made up of a single layer of closely packed cells that may be regularly or irregularly shaped. Has an abundance of stomata.
Stomata (singular: stoma)	Pores that control gaseous exchange. Each stoma is surrounded by a pair of guard cells. Guard cells have cell walls of uneven thickness. When guard cells photosynthesize and become turgid, stoma would open wider as swollen guard cells pull stoma open.

Describe the significance of these features in terms of their functions such as the
- Distribution of chloroplasts in photosynthesis
- Stomata and mesophyll cells in gaseous exchange
- Vascular bundles in transport

	Features	Significance
Distribution of chloroplasts in photosynthesis	Chloroplasts containing chlorophyll in all mesophyll cells	Chlorophyll absorbs and transforms light energy to chemical energy used in the manufacture of glucose.
	More chloroplasts in upper palisade mesophyll tissue	Maximize chloroplast's exposure to sunlight incident rays near the leaf near the upper epidermis.
Stomata and Mesophyll Cells in gaseous exchange	Stomatal size controlled by guard cells, able to regulate rate of diffusion of gases.	Stomata can close to reduce water loss when plant is under high light intensity on extremely hot days to prevent dehydration of plant.

		Carbon dioxide and oxygen diffuse in and out of the leaf is also regulated. Only CO2 entry directly affects the rate of photosynthesis.
	Mesophyll cells have a thin film of moisture coating it	Water is a good solvent for most gases and it allows carbon dioxide to dissolve into film of moisture so that it can diffuse into the cell more quickly.
	Surrounded by numerous interconnecting intercellular airspaces	Allows rapid diffusion of carbon dioxide into mesophyll cells, provides enough space for trapping carbon dioxide.
Vascular Bundle in Transport	Mature xylem cells have no cross walls	Allows rapid flow to water and mineral salts with little resistance. Keep up with demand for water since it's needed for photosynthesis.
	Xylem fortified with lignin	Provides mechanical support, especially during transpiration with transpiration pull exerting a suction force on stem, thus it will not collapse.

State the equation, in words and symbols for photosynthesis.

Light Dependent stage

- Light energy → Chemical Energy
- Photolysis of water. Light causes water to dissociate and release oxygen in the process.

$12H_2O \rightarrow 24H^+ + 6O_2$

Light Independent stage

- Reduction of carbon dioxide by H^+ ions generated from light stage to produce carbohydrates.
- Chemical energy harnessed from light dependent stage

Chemical energy

$6CO_2 + 24H^+$ ---------- > $C_6H_{12}O_6 + 6H_2O$

OVERALL:

Chlorophyll + Sunlight

$6CO_2 + 12H_2O$ ---------- > $C_6H_{12}O_6 + 6O_2 + 6H_2O$

Chlorophyll + Sunlight

Carbon dioxide + Water ---------- > Glucose + Oxygen

Define photosynthesis
It is a multi-step process in which light energy is absorbed by chlorophyll is transformed into chemical energy. Chemical energy is used to synthesize glucose from water and carbon dioxide with oxygen being released during the process.

Outline the intake of carbon dioxide by plants
Photosynthesis ↓ concentration of carbon dioxide in the cytoplasm of mesophyll cells Thin film of moisture surrounding mesophyll cells now has a higher concentration of dissolved carbon dioxide than the cytoplasm. Carbon dioxide diffuses into mesophyll cell cytoplasm down a concentration gradient. This ↓ concentration of carbon dioxide in the thin film of moisture with respect to carbon dioxide in the intercellular air spaces. Carbon dioxide from intercellular air spaces diffuses and dissolves into the thin film of moisture. This ↓ carbon dioxide concentration in intercellular air spaces with respect to the atmospheric carbon dioxide concentration. Atmospheric carbon dioxide ***diffuses*** into intercellular air spaces through the stomata.
State the experiments that test: - How presence of starch is tested in leaves - How to find out whether sunlight is necessary for photosynthesis - How we can find out whether chlorophyll is necessary for photosynthesis - How we can find out whether carbon dioxide is necessary for photosynthesis - How we can find out what gas is given off during photosynthesis - How we can investigate the effect of different light intensities on the rate of photosynthesis

i. How the presence of starch is tested in leaves

Remove a green leaf from a plant that has been exposed to sunlight for a few hours and place it in boiling water for 2 minutes. Remove leaf, soak in alcohol, remove and soak in water again. Spread it evenly on a white tile and add a few drops of iodine to the leaf. (Qn: Why boil? To destroy cell membrane so that alcohol can reach chloroplast and decolourise the leaf)

ii. How to find out whether sunlight is necessary for photosynthesis

De-starch a potted plant by placing it in the dark for 2 days and sandwich a leaf that's attached to the plant between two pieces of black paper. Each paper has a certain pattern cut out to allow the leaf in cut out area receive sunlight. Place plant in strong sunlight. Remove leaf and test for starch – refer to ci.

iii. How we can find out whether chlorophyll is necessary for photosynthesis

Remove a leaf from a de-starched plant that was left in the dark for 2 days with variegated leaves and make a drawing of distribution of green parts. Then expose it to strong sunlight for a few hours. Decolorize leaf and test for starch. Compare drawing of green parts on leaf and the distribution of blue-black color.

iv. How we can find out carbon dioxide is necessary for photosynthesis
De-starch 2 potted plants by placing them in the dark for 2 days. Place one pot in a bell jar with no supply of carbon dioxide by adding a beaker filled with potassium hydroxide solution. Place the other in a bell jar with carbon dioxide supply in the form of sodium carbonate. Both jars are left in strong sunlight for a few hours. Remove a leaf from each plant and test for starch.

v. How we can find out what gas is given off during photosynthesis
In a beaker full of water, place some freshwater plants in an inverted filter funnel. Place a test tube filled with water over the filter funnel. Place apparatus in strong sunlight for a few hours until the test tube is half filled with the gas produced. Remove the test tube by placing a thumb over its mouth. Test gas with a glowing splint. (Glowing splint would rekindle, gas is oxygen.)

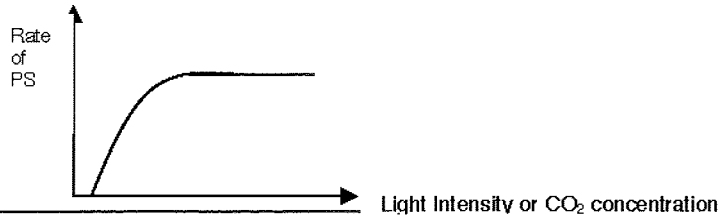
Fate of Glucose.

i) Used immediately as glucose for **cellular respiration**, or to form **cellulose cell walls**
ii) Excess glucose can also be converted to **sucrose** for transport to other storage organs so it will not diffuse out of phloem sieve tube elements to be stored as starch in stem and roots.
iii) In **daylight**, excess glucose converted to **starch** in leaves to be stored in chloroplast temporarily. At night, **starch** is **reconverted** by enzymes. First, into maltose by diatase, then to glucose. Converted sucrose for transport.
iv) Reacts with **nitrates** to form **amino acids** which condense to form proteins to build new protoplasm.
v) Excess amino acids are **transported to other parts of plant** especially growing regions for the synthesis of new protoplasm.
vi) Forms fats for **storage in seeds**, usage in **cellular respiration** and synthesis of new **protoplasm i.e cell membranes.**

~~**Why stored as sucrose?(FYI)**~~
~~**Sucrose solution with the same number of particles as glucose will have twice the number of carbon atoms and therefore twice the amount of energy. Thus for the same osmolarity, twice the energy can be transported per ml.**~~

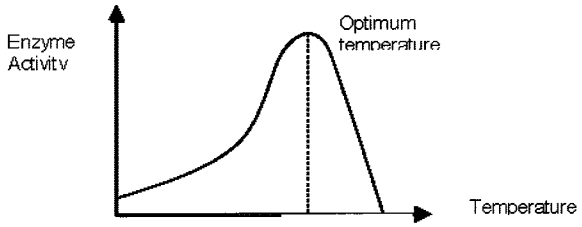
Discuss light intensity, carbon dioxide concentration and temperature as limiting factors on the rate of photosynthesis.

When it is a limiting factor, as light intensity increases, rate of photosynthesis increases. **More** light energy can be trapped and converted to chemical energy by chlorophyll. It increases until it reaches light **saturation point**, where it is no longer a **limiting factor** and increasing the light intensity would not increase rate of photosynthesis and the rate levels off. CO2 or temperature could be a limiting factor.



When carbon dioxide concentration is a limiting factor, as concentration increases rate of photosynthesis increases. More carbon dioxide can be reduced by hydrogen ions to form carbohydrates during photosynthesis i.e. more substrates (CO_2) can be converted by enzymes. When it reaches a saturation point, it is no longer a limiting factor and increasing the concentration would not increase rate of photosynthesis and the rate levels off.

When temperature is a limiting factor, rate of photosynthesis increases as temperature increases. Kinetic energy increases and there is faster molecular movement of enzymes and substrates therefore increasing no. of effective collisions. Photosynthesis is enzyme-controlled so enzymes become more active as temperature increases. More substrates (CO_2) can be converted by enzymes. Rate of photosynthesis is at maximum at optimum temperature and beyond optimum temperature, rate of photosynthesis steeply falls to zero. Extremely high temperatures denature the enzymes thus reactions cannot occur, decreasing the rate of photosynthesis.



LF: A factor that directly affects the rate at which a process (e.g. chemical reaction) occurs if its quantity is changed

Chapter 8: Transport in Humans

Describe the main functions of blood.

1. Acts as a transport medium transporting varying substances from one part of the body to another.
2. It protects the body against disease causing organisms (pathogens)
3. Blood clotting at wounds prevents excessive loss of blood. It seals the wound and prevents entry of microorganisms into the bloodstream.

Understand the importance of a double circulation.

1. Allow blood pressure in lungs (pulmonary circulation) to be low so that there is sufficient time for exchange of gases to take place in lungs.
2. Allow blood pressure going into systemic circulation (rest of body) to be high so that oxygenated blood is distributed rapidly to other organs and extremities.
3. Ensures oxygen level in blood is high enough to maintain metabolic/respiration rate.

Describe the difference between pulmonary and systemic circulation.

For pulmonary, blood leaves from the **right side of the heart** but for systemic, it leaves from the left side of the heart.
For pulmonary, blood leaving heart is **deoxygenated** but for systemic, blood leaving the heart is oxygenated.
For pulmonary, blood leaving the heart goes to the **lungs** but for systemic, blood leaving the heart goes to the rest of the body.
For pulmonary, **length of circuit** is shorter but for systemic, length of circuit is longer.
For pulmonary, **pressure** is lower but for systemic, pressure is higher.

How do humans adapt to living at high altitudes?

At high altitudes, concentration of oxygen in the atmosphere is low. Body cannot absorb sufficient oxygen to maintain its metabolic rate. Hence body needs to produce more red blood cells to compensate for lower concentration of oxygen (acclimatization). Increasing the proportion of red blood cells also increases the haemoglobin content per unit volume of blood. This means that more oxygen can be absorbed and be transported to the tissue cells per unit time. Thus having a larger number of red blood cells in their bodies over time.

Long distance runners train at high altitudes for several months as it increases the amount of haemoglobin in their blood. Hence when they run at lower altitudes, their bodies are able to transport oxygen at a higher rate, thus able to run for longer periods.

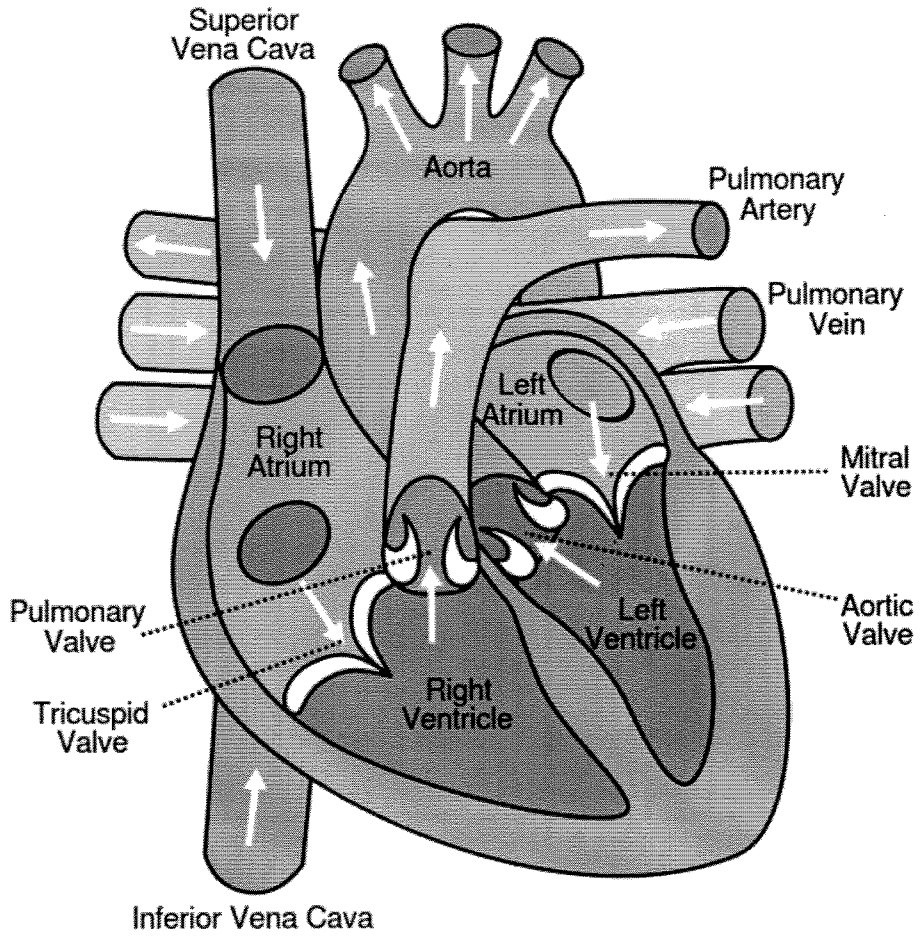
Identify the components of blood and state their structure and function

Component	Structure	Function
Plasma	Mainly water (~90%)	1. Allow blood to be pumped by heart as it is **incompressible** and hence allows transportation to occur. 2. **High heat capacity** to allow plasma to transport heat without causing a huge change to the blood temperature or composition, maintaining a constant temperature, preventing enzymes from denaturing as a lot of heat is produced from aerobic respiration of cells. 3. **Universal Solvent** allows substances to dissolve in it and hence allow them to be transported. 4. Water is needed in **chemical reactions** for example hydrolysis
	Dissolved substances	Transports: 1. **Hormones** from endocrine gland to respective target organs like insulin to liver due to high blood glucose concentration. 2. **Excretory waste products** like urea and carbon dioxide in the form of hydrogen carbonate ion. 3. **Nutrients** such as glucose and amino acids to body cells 4. Dissolved **mineral salts** like hydrogencarbonates, chlorides as ions 5. **Antibodies** made by lymphocytes to combat diseases 6. Soluble **proteins** like fibrinogen which is needed for blood clotting during wounds to prevent excessive bleeding 7. **Heat** from respiring tissues, especially muscles and liver. (Not dissolved substance)
Red Blood Cells (Erythrocytes)	Circular, Biconcave disc	Increases cell's surface area to volume ratio to absorb and release oxygen at a higher rate

	No nucleus and absence of other organelles	Contain more haemoglobin, and hence more oxygen
	Contains Haemoglobin	Binds reversibly with oxygen to enable oxygen to be transported from lungs to all cells in the body
	Elastic	Squeeze through blood vessels like capillaries, whose diameters are smaller than RBC's
White Blood Cell (Leucocytes)	Can change its shape and squeeze through capillaries walls into spaces among tissue cells to defend body tissues.	
	Lymphocytes are round in shape with a large rounded nucleus with non-granular cytoplasm	Detect **toxins** produced by disease-causing bacteria and **produce antibodies that kill bacteria and cause it to clump together** (agglutination reaction) Antibodies also neutralize toxins produced by bacteria.
	Phagocytes have a granular cytoplasm and lobed nucleus.	Detect **bacteria/foreign particles** and engulf and ingest them through phagocytosis.
Platelets	Cell fragments formed in bone marrow, have no nucleus.	Help in clotting of blood and prevent excessive loss of blood and entry of bacteria at the wound.

Describe the process of blood clotting and components involved.
Damaged tissue and platelets **release** thrombokinase. Thrombokinase, together with calcium ions, converts inactive prothrombin in the plasma to active thrombin. Thrombin then catalyses the conversion of soluble fibrinogen to insoluble fibrin threads which forms a mesh to entangle blood cells to form a clot.

Identify and label the structures of the human heart.



Describe the cardiac cycle in terms of what happened, muscular contraction and working of valves, during systole and diastole.

During atrial diastole, the right atrium relaxes & receives blood from the vena cavae (refers to bother superior vena cava and inferior vena cava) while the left atrium receives blood from the pulmonary vein.
The atria contract forcing blood into the ventricles.
After a short pause, the **ventricles contract**. The increase in **blood pressure higher than the atria** forces the **atrio-ventricular (bicuspid and tricuspid) valves to Close**, preventing a backflow of blood into the atria. This produces a loud 'lub' sound. When pressure in the contracting **ventricles is higher than pressure in the aorta and pulmonary artery**, the **semi lunar valves** in the pulmonary and aortic arches are forced **Open.** Blood flows from the left and right ventricle into the aorta and pulmonary artery respectively. As the ventricles contract the atria relax and receives blood.
The ventricles then relax. The **drop in pressure in the ventricles lower than arteries** causes the **semi lunar valves** to **Close**, producing a soft 'dub' sound. This prevents the backflow of blood into the ventricles. The drop in pressure in the ventricles causes the **bicuspid and tricuspid valves** to **Open** as **atria contracts and pressure is higher than the ventricles.**

NOTE: VENTRICLE SYSTOLE is when blood is coming out of the ventricles, not just when it contracts.

Identify the 3 main blood vessels.

1. Artery
2. Vein
3. Capillary

Compare and explain the differences in characteristics between the blood vessels.

Arteries	Veins	Capillaries
Thick muscular and elastic walls. Muscles able to contract and relax to change the size of lumen. Arteries have a smaller lumen than veins of the same cross sectional diameter.	Thinner, less muscular and elastic than arteries as blood flow is slow and smooth. Given the same cross sectional area as an artery, veins would have a larger lumen than arteries.	Single layer of greatly flattened cells, partially permeable **wall**. (not membrane)
Highest blood pressure and high velocity of blood flow.	**Lowest** blood pressure and low velocity of blood flow.	Low blood pressure and low velocity of blood flow.
Carries oxygenated blood away from heart to other parts of the body, except pulmonary artery (deoxygenated blood from heart to lungs)	Carries deoxygenated blood to the heart, except pulmonary vein (oxygenated blood from lungs to heart)	Exchange of materials occurs at the capillaries
Valves absent	Valves to prevent backflow of blood	Valves absent
	Action of skeletal muscles on veins facilitates movement of blood along the vein, allowing blood to flow more quickly back to the heart.	

State the importance of valves.

It prevents the backflow of blood.
Ensures the flow of blood is in one direction.

Be able to draw valves in veins and in the heart.

Refer to diagram above for the drawing of valves in heart.

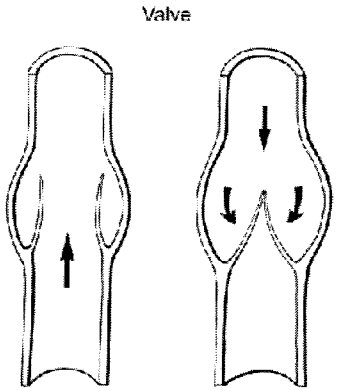


Diagram 1

Identify the main blood vessels to and from the heart, lungs, liver and kidney.

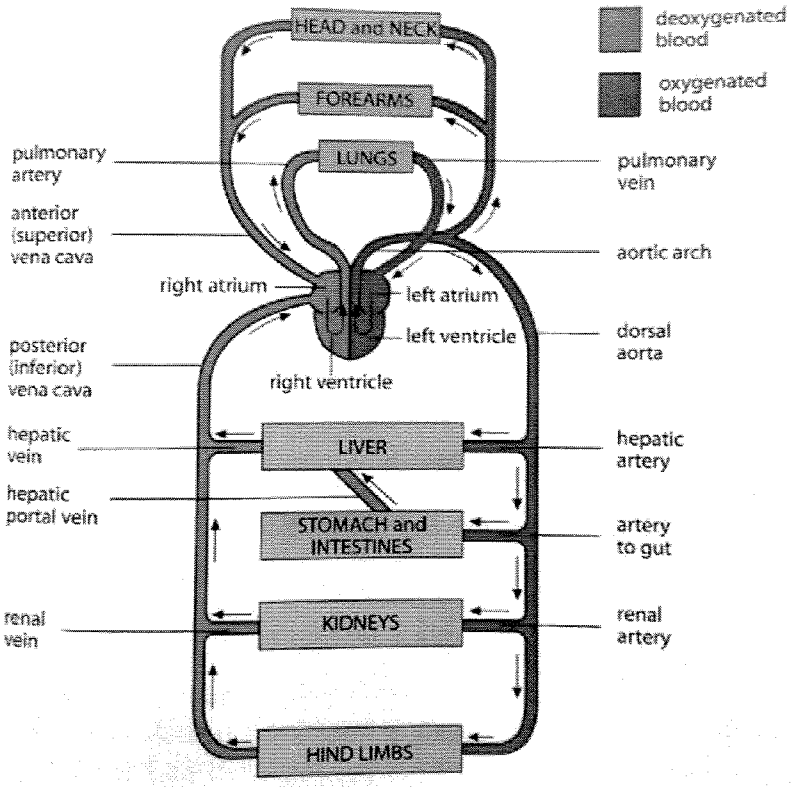


Figure 8.30 The main arteries and veins of the human circulatory system

Describe the process of the transfer of materials from blood to tissue cells.

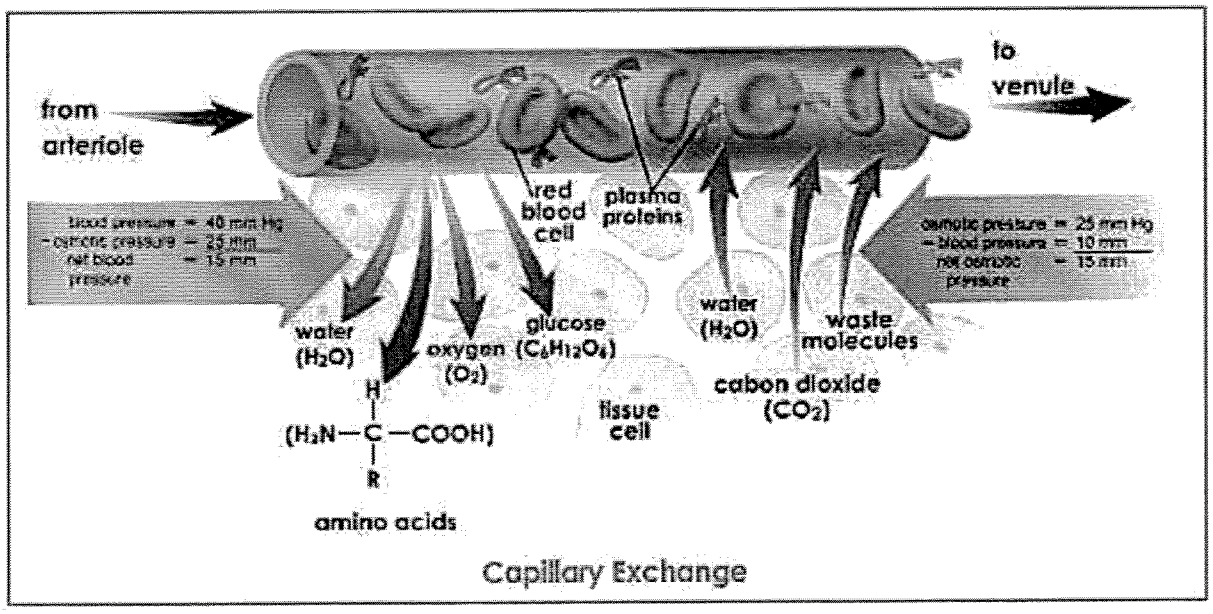
Dissolved food substances and oxygen diffuse from the blood in blood capillaries into the tissue fluid then into the cells. Tissue fluid is a colorless liquid that has lesser soluble proteins than plasma. All tissue cells are bathed with tissue fluid which carries substances in solution between the tissue cells and blood capillaries.

(Phagocytes often move out of blood vessels as they can change their shape to squeeze through capillary walls)

At arterial end of the capillaries where blood pressure is higher, blood plasma is forced out (without its proteins) through the capillary walls into intercellular spaces as tissue fluid. Body cells would absorb oxygen and nutrients from tissue fluid.

At venous end, blood pressure is lower, tissue fluid enters the blood capillary along with waste products.

**Red blood cells change shape as they flow through narrow blood capillaries: Rate of blood flow is reduced, giving more time for and thus increasing rate of exchange of materials between blood and tissue cells.*



Capillary Exchange

Identify the ABO blood groups and discuss the results when different blood groups are mixed together.

Blood Group	Antigen on RBC	Antibody in Plasma
A	A	B
B	B	A
O	None	A & B
AB	A & B	None

Agglutination would occur when blood containing red blood cells with a certain antigen is injected into an individual with the antibody that can recognize it in plasma. For example, when blood group A's blood (red blood cell only) is donated, transfused into an individual with blood group B, agglutination reaction occurs as blood group A has Antigen A on the red blood cells which would be detected by Antibody A in the blood of a person with blood type B.

Describe coronary heart disease.

It occurs when coronary arteries become narrowed, thus oxygen and nutrients is supplied to the heart muscles at a lower rate. Coronary arteries are narrowed by lipids (fat and cholesterol) carried by the blood which get deposited on the **inner** walls of coronary arteries, making them narrower (atherosclerosis). When blood pressure gets too high and plaque rupture, blood clots and arteries are completely blocked, supply of blood to heart muscles is stopped (coronary occlusion). Atherosclerosis would cause angina, continuous pain in the chest. Coronary occlusion causes heart attacks, which can occur without pain.

Explain the cause of coronary heart disease and describe the preventive measures.

Causes	Preventive Measures
Fatty diet, high in sodium, cholesterol and saturated fats	Healthy diet, unsaturated fats
Lack of exercise	Regular exercise
Smoking	Not smoking
Stress	Reducing stress
Obesity	

Why doctors advice patients with atrial septal defect to not engage in vigorous exercise

The hole in the septum of the heart allows oxygenated blood from the left atrium and deoxygenated blood in the right atrium to **mix**. This **lowers the concentration of oxygen carried by the blood pumped out by the left side** of the heart and subsequently pumped to the rest of the body via the aorta. With less oxygen carried by the blood to the rest of the body, the heart will have to work harder to supply the body oxygen it needs when it engages in vigorous sports. This will strain the heart and cause it to fail.

Chapter 9: Transport in Plants

State the structure and functions of xylem and phloem.

Xylem
1. Dead cells with no protoplasm which reduces resistance to flow of water(faster).
2. Long and hollow tubes without cross walls that transport water from roots to leaves faster.
3. Vessel wall fortified with lignin which provides mechanical support to plant, preventing collapse during uptake of water.

Functions
1.Conduct water and dissolved mineral salts from roots to stems and leaves
2.Provide mechanical support for plant

Phloem
1. Cross-walls have sieve pores which to allow rapid flow of sucrose & amino acids
2. Degenerate protoplasm which reduce resistance to flow of sucrose & amino acids
3. Have companion cells with numerous mitochondria which carry out respiration to release large amounts of energy for a higher rate of active transport.

Compare and contrast the vascular tissues organized in the stems, roots and in the leaves.

In stems,
Xylem and phloem are grouped to form the vascular bundle.
Vascular bundle are arranged in a ring around a central region called the pith
Phloem lies outside the xylem with a tissue, cambium, between them
Cambium can divide and differentiate to form new xylem and phloem tissues, giving rise to a thickening of the stem
Region between vascular bundles and epidermis is the cortex.
Both the cortex and pith store up food substances such as starch
Stem is covered by a layer of cells called epidermis.
Epidermal cells are protected by a waxy, waterproof cuticle which reduces evaporation of water from the stem.

In roots,
Xylem and phloem alternate with each other
Cortex of root is also a storage tissue
Epidermis of root is the outermost layer of cells also called the piliferous layer. It bears root hairs.

In leaves,
Xylem lies above the phloem.

Describe the process of the entry of water, in terms of water potential from the soil to xylem.
The thin film of liquid surrounding each soil particle is a dilute solution of mineral salts. The sap in the root hair cell is relatively concentrated solution of sugars and various salts. Thus the sap has a lower water potential than the soil solution. The 2 solutions are separated by a partially permeable cell membrane of the root hair cell. Water enters the root by osmosis. The entry of water dilutes the sap The sap of the root hair cell now has a higher water potential than that of the inner cell. Hence water passes by osmosis from the root hair cell into the inner cell. Similarly water is continuously passed into the next cell until the water enters the root xylem vessel (*lateral movement*) and moves up the plant (*vertical movement*).

Importance of root pressure.
The living cells around the xylem vessels in the root use active transport to pump ions into the xylem vessel. This lowers water potential in the xylem vessels. Water then move by osmosis from the living cells into the xylem vessels and flow upwards.

Define transpiration.
Transpiration is the loss of water vapour from aerial parts of a plant, especially through the stomata of the leaves.

Describe the movement of water from the leaf to the air outside.
Water moves out of the mesophyll cells via osmosis to form a thin film of moisture over the surface. Water evaporates from the thin film of moisture and moves into the intercellular air spaces Water vapour accumulates in the large air spaces near the stomata. Water vapour then diffuses through the stomata to the drier air outside the leaf. As water moves out of the mesophyll cells and evaporates from the thin film of moisture, water potential of the cell sap decreases. The mesophyll cells begin to absorb water by osmosis from the cells deeper inside the leaf. The cells in turn remove water from the xylem vessels. This suction force pulls the whole column of water up the xylem vessels.

Describe the movement of carbon dioxide from the atmospheric air to the leaf.
Photosynthesis ↓ concentration of carbon dioxide in the cytoplasm of mesophyll cells Thin film of moisture surrounding mesophyll cells now has a higher concentration of dissolved carbon dioxide than the cytoplasm. Carbon dioxide diffuses into mesophyll cell cytoplasm. This ↓ concentration of carbon dioxide in the thin film of moisture with respect to carbon dioxide in the intercellular air spaces Carbon dioxide from intercellular air spaces diffuses and dissolves into the thin film of moisture. This ↓ carbon dioxide concentration in intercellular air spaces with respect to the atmospheric carbon dioxide concentration. Atmospheric carbon dioxide ***diffuses*** into intercellular air spaces through the stomata.

Identify and explain the factors affecting the rate of transpiration.
Humidity of air Intercellular air spaces in leaf are usually saturated with water vapour. The less humid the air outside the leaf, the steeper the concentration gradient of water vapour *between* the atmosphere and within leaf. Thus rate of transpiration will be higher. Air movement Wind blows away the water vapour accumulated outside the stomata. This maintains concentration gradient of water vapour *between* atmosphere and within leaf. The stronger the air movement, higher the rate of transpiration. Temperature of air A rise in temperature increases the rate of evaporation of water, increasing the concentration of water vapour in the air spaces. Hence, a steep concentration gradient of water vapour *between* the atmosphere and within leaf. Thus rate of transpiration higher at higher temperatures. Light intensity In sunlight, guard cells photosynthesize and become turgid. Stomata become wider. This increases the rate of transpiration.

State the importance of transpiration in plants.
1. Transpiration pull draws water and mineral salts from roots to stems and leaves 2. Evaporation of water from cells in leaves removes latent heat of vapourisation. This cools the plant, preventing it from being scorched by the hot sun. 3. Water transported to the leaves can be used in photosynthesis 4. Keep cells turgid and to replace water lost by cells. Turgid cells keep the leaves spread out widely to trap sunlight for photosynthesis.

State the advantages and disadvantages of wilting.
Advantages When the leaf folds up, SA that is exposed to sunlight is reduced. This causes the guard cells to become flaccid and stomata to close. Thus rate of transpiration is reduced. Disadvantages Rate of photosynthesis is reduced because water becomes a limiting factor. As the stomata are closed, the amount of carbon dioxide diffusing into the leaf reduces. Carbon dioxide becomes a limiting factor, thereby decreasing the rate of photosynthesis.

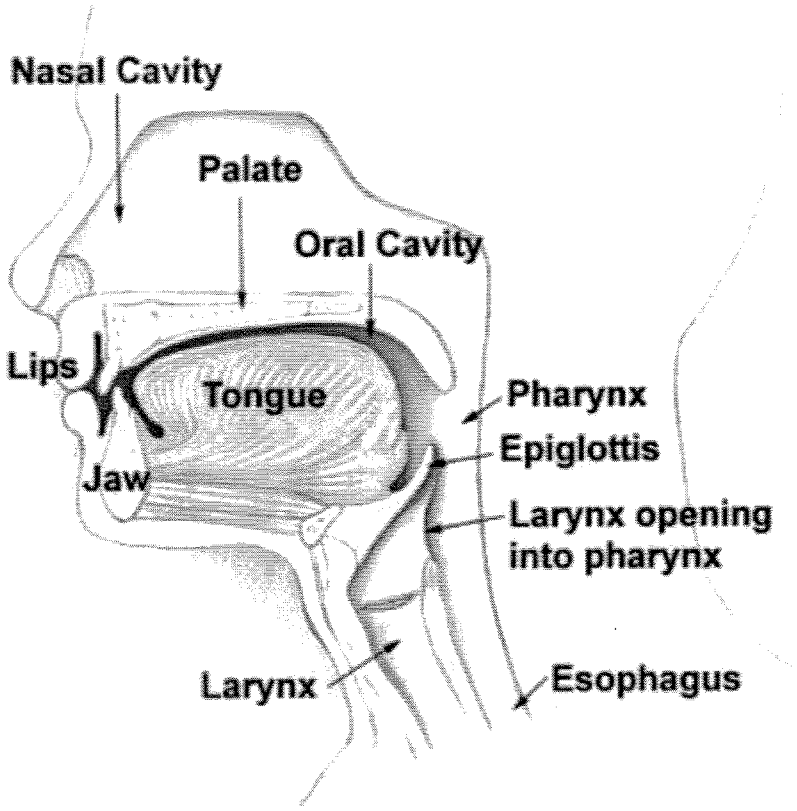
Describe the experiments used to study the rate of transpiration.
The shoot to be used in a potometer is cut underwater and the cut end is immersed in water for few hours before use. This allows the shoot to adjust to conditions in the potometer. A potometer is used to **directly measure the rate of absorption** of water by the plant and not the rate of transpiration. The amount of water lost is less than the amount of water absorbed because some water is used for photosynthesis. Measuring the distance moved by the air bubble or volume of water taken up in a fixed amount of time will indicate the rate of water absorption. We **assume** that the rate of water absorption is **proportional** to the rate of transpiration, thus the distance moved by the air bubble or volume of water taken up in a fixed amount of time is the rate of water loss in the shoot.

Define translocation.
It is the transport of manufactured food substances such as **sucrose** and **amino** acids in the **phloem** from **leaves to other parts** of the plant.

Describe at least one experiment used to study translocation.
Using aphids, the long mouthpart of the aphids penetrate the leaf or stem. The body of the aphid is then cut off, leaving the mouthpart in the plant. The liquid that exudes from the cut end of the mouthpart is analysed and found to contain sucrose and amino acids. The proboscis of the aphid is actually inserted into the phloem sieve tube. This shows that translocation of sucrose and amino acids occurs in plants.

Chapter 10: Respiration

Identify on diagrams and name the larynx, trachea, bronchi, bronchioles, alveoli and associated capillaries.



State the characteristics of and describe the role of the exchange surface of the alveoli in gaseous exchange.

- Numerous alveoli to **increase surface area to volume ratio** to increase rate of gaseous exchange (N/A if the diagram in question, if any, only shows 1 alveolus)
- Alveolus surrounded by rich network of blood capillaries for **continuous** blood flow to maintain a **steep** concentration gradient between alveolar air space and blood to increase rate of gaseous exchange. (N/A if diagram in question, if any, only shows a single capillary)
- Blood capillaries are one cell thick for **higher rate** of diffusion of gases over a **short distance**.
- Thin film of moisture on **inner** surface of alveolus to allow oxygen to **dissolve** and **diffuse** across alveolar wall.
- Wall of alveolus is one cell thick for oxygen and carbon dioxide to diffuse across a short distance for higher rate of gaseous exchange.
- Air spaces **continuously** filled with air from inhalation to maintain **steep** concentration gradient between alveolar air space and blood for higher rate of gaseous exchange.

Describe the removal of carbon dioxide from the lungs including the role of the carbonic anhydrase enzyme.
Carbon dioxide produced by cells during **cellular respiration**. Most carbon dioxide **diffuses into red blood cell** Carbon dioxide reacts with water **in the red blood cell** to form **carbonic acid**, a reaction catalyzed by **carbonic anhydrase** contained within the red blood cell. Carbonic acid **dissociates** into bicarbonate ion and hydrogen ion. Haemoglobin binds reversibly with most of hydrogen ions to preventing it from acidifying the blood. Most of the **bicarbonate ion diffuses out** of the red blood cell and **into the plasma** to be carried in bloodstream to lungs. In the lungs, bicarbonate ion **diffuses from plasma to red blood cell** combining with hydrogen ion released from the haemoglobin to form carbonic acid. **Carbonic acid is then converted back to carbon dioxide and water** with the help of carbonic anhydrase. Carbon dioxide diffuses to plasma and interstitial fluid. Carbon dioxide diffuses from the interstitial fluid, through the alveolar wall and **dissolves in the thin film of moisture** on the **inner** surface of the alveolar wall. The carbon dioxide then diffuses from the thin film of moisture to the alveolar space to be **expelled during exhalation**.

Describe the transport of oxygen from the lungs to tissue cells.
Oxygen from the inhaled air present in the lungs, **dissolves** in the thin film of moisture on the **inner** surfaces of the alveolar walls. Then oxygen then **diffuses** through the alveolar walls into the interstitial fluid surrounding the alveolar walls. Then oxygen then **diffuses** through the endothelium into the red blood cells and combine with haemoglobin reversibly to form oxyhaemoglobin. Capillaries containing oxygenated blood merge to form the pulmonary vein. Pulmonary vein → Left atrium → Left ventricle → Aorta → Arteries → Arterioles → Capillaries surrounding tissue cells Oxygen then diffuses out of blood capillaries → tissue fluid → tissue cells.

Describe the role of cilia, gland cells (in the epithelium of the trachea), diaphragm, ribs and intercostals muscles in breathing.
Gland cells/ Goblet cells in epithelium of trachea secrete mucus to trap dust and bacteria. **Cilia on epithelial cells of trachea** sweep mucus containing trapped dust and bacteria, up the trachea towards the pharynx to be swallowed into the esophagus or coughed out. (Note: *CILIA DO NOT TRAP*) During **inhalation**, Internal intercostal muscles relax **External intercostal** muscles **contract** **Rib**cage and sternum swing **outwards and upwards** **Diaphragm contracts and flattens** **Volume of thoracic cavity** increases **Atmospheric pressure is higher than pressure in lungs, causing air to rush**

into lungs.

.....

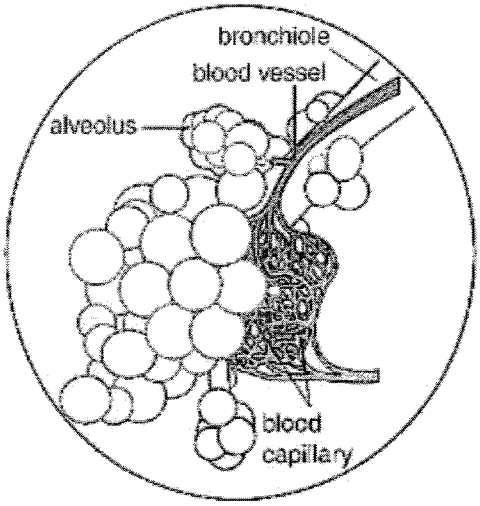
During **exhalation**,
Diaphragm relaxes and arches upwards
Internal intercostal muscles contract
External intercostal muscles relax
Ribcage and sternum swing inwards and downwards.

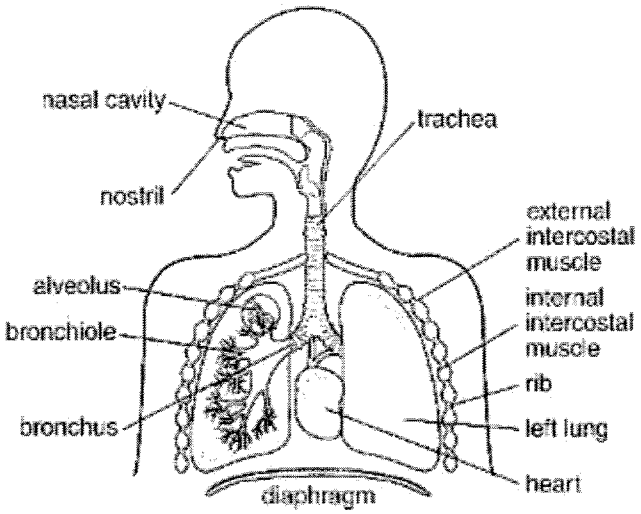
Volume of thoracic cavity decreases

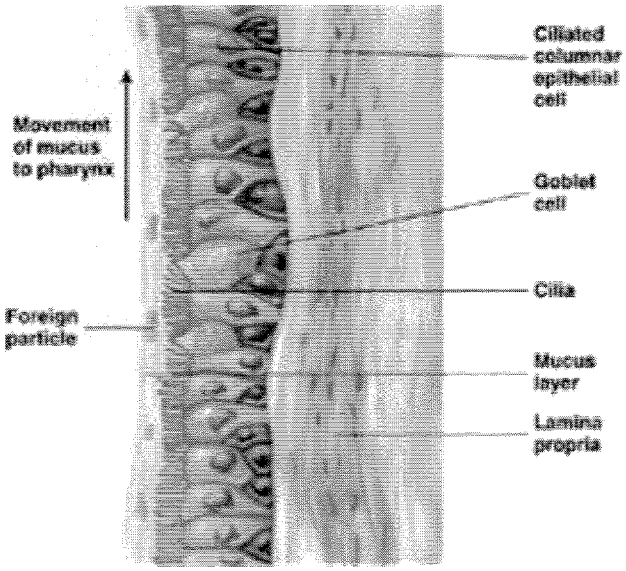
Air pressure in lungs now higher than atmospheric pressure, forcing air out of lungs into the atmosphere.

Identify the parts of the respiratory system.

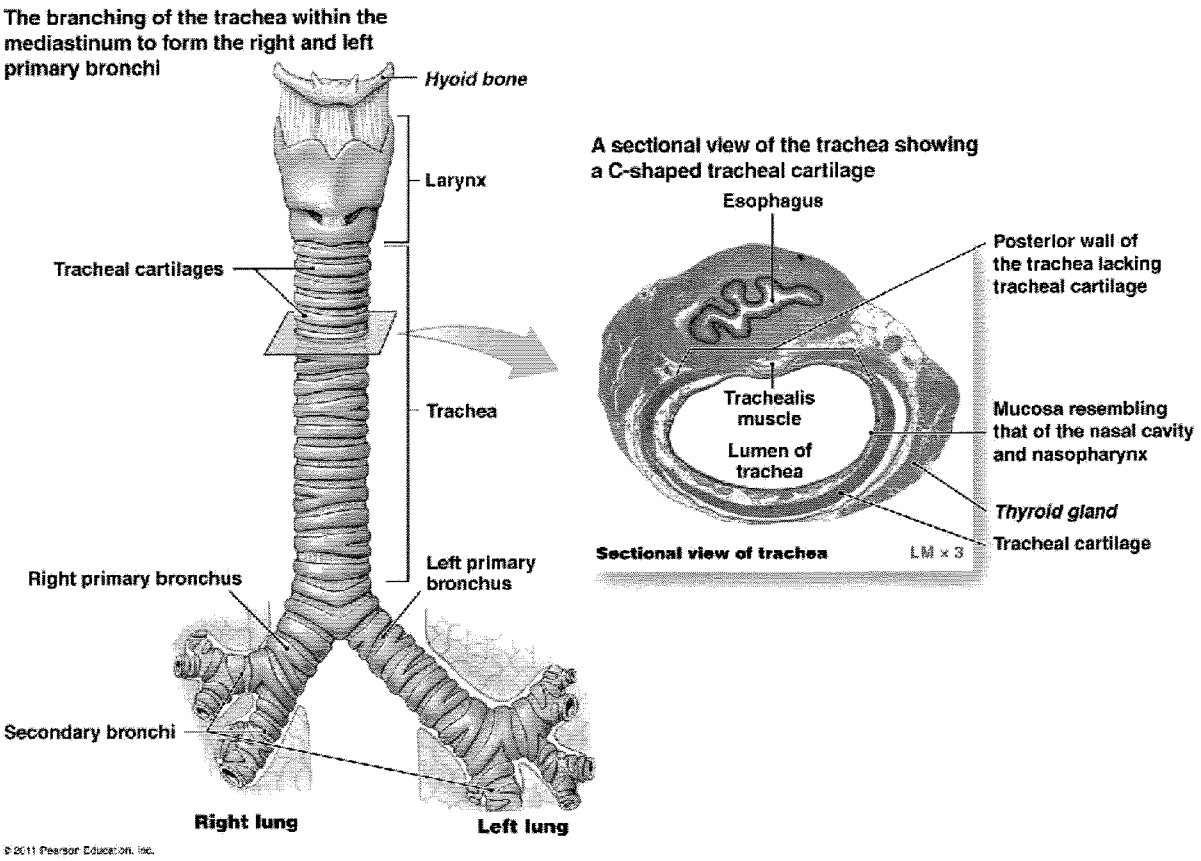
- Nasal cavity
- Pharynx
- Larynx
- Trachea
- C-shaped cartilage
- Ciliated cell
- Gland cell (in the epithelium of the trachea)
- Bronchus
- Bronchiole
- Alveolus
- (External and internal) intercostals muscles
- Rib cage
- Diaphragm


bronchiole
blood vessel
alveolus
blood capillary


nasal cavity
trachea
nostril
external intercostal muscle
alveolus
internal intercostal muscle
bronchiole
rib
bronchus
left lung
heart
diaphragm


Movement of mucus to pharynx
Ciliated columnar epithelial cell
Goblet cell
Cilia
Foreign particle
Mucus layer
Lamina propria

The structure of the trachea and primary bronchi



Define and state the equation in words and symbols for aerobic respiration in humans.
Aerobic respiration is the oxidation of organic food substances (glucose), releasing a **large amount of energy**, **carbon dioxide** and **water** within the cells or tissues of an organism in the presence of **oxygen**. Glucose + Oxygen → Large amount of energy + Carbon Dioxide + Water $C_6H_{12}O_6 + \quad O_2 \quad \rightarrow CO_2 + H_2O$ + Large amount of energy

Describe and state the equation in words only for anaerobic respiration in humans.
Anaerobic respiration is the **breakdown of food substances (glucose)** in the absence of oxygen, **releasing less energy** than aerobic respiration. Glucose → Lactic acid + Small amount of energy

Define and state the equation, in words only, for anaerobic respiration in yeast cell.
Glucose → Ethanol + Carbon dioxide + Small amount of energy

Describe the effects of tobacco smoke and its major toxic components – nicotine, tar and carbon monoxide on health.

Tobacco **smoke** contains:

Nicotine

1. **Addictive** drug
2. Causes the release of **adrenaline** which increases heart rate and blood pressure
3. Makes blood **clot** easily hence blocking the coronary artery and leading to heart attack.

Tar

1. **Accumulates** in lungs
2. Contains cancer-causing (carcinogenic) chemicals which induce **uncontrolled cell division** of epithelium thus blocking the air sacs and reducing rate of gaseous exchange.
3. **Paralyses** cilia lining the air passages hence dust particles and bacteria trapped in the mucus lining the trachea cannot be removed.

Carbon Monoxide

1. Combines irreversibly with greater affinity to haemoglobin to form carboxyhaemoglobin which reduces capacity of red blood cells to transport oxygen. Hence concentration of oxygen carried in blood is decreased.
2. Increases the rate of **fatty deposits** on **inner** arterial wall which increases risk of atherosclerosis.
3. **Damages lining** of blood vessels thus increasing risk of blood clotting in arteries.

Irritants

1. **Paralyses** cilia lining the air passages hence dust particles and bacteria trapped in the mucus lining the trachea cannot be removed, increasing risk of chronic bronchitis and emphysema.

.....

Chronic Bronchitis

Cilia are paralyzed (due to the tar/irritants in cigarette smoke) and mucus containing dust particles and bacteria cannot be removed.
The epithelium lining the airways for example bronchi becomes inflamed due to bacterial infection.
Excessive mucus is secreted by glands (in attempt to remove the dust and bacteria).
Airways become narrow making breathing difficult
Person has to cough persistently to clear airways to breathe. This increases risk of emphysema.

Emphysema

Persistent and **violent** coughing to remove excess mucus destroys the partition walls between alveoli.
SA to V ratio for gaseous exchange decreases
Lungs become inflated with air, loses elasticity
Breathing becomes difficult and the person wheezes and suffers severe breathlessness
Concentration of oxygen in blood decreases as rate of oxygen diffusion decreases

If person has both chronic bronchitis and emphysema, he suffers from chronic obstructive lung diseases.

Describe the effect of lactic acid in muscles during exercise.
Since there is insufficient oxygen taken in to meet **energy** demands of vigorous muscular contractions, muscles incur an oxygen debt. Lactic acid concentration builds up slowly in muscles, eventually becoming high enough to cause fatigue. During period of rest, breathing rate is still high to provide sufficient oxygen to repay oxygen debt. Lactic acid is removed from muscles and **transported to liver** to be oxidized to **release** energy. The energy is then used to **convert remaining lactic acid** into glucose. When lactic acid is used up, oxygen debt is repaid.

Why oxygen used increases as level of exercise increases?
Muscular contraction increases and becomes more vigorous Muscles use up energy and raise demand for more energy to sustain vigorous muscular contractions **More** oxygen is required and in the presence of **more** glucose will release **more** energy to meet demands by **higher rate** of respiration. Rate and depth of ventilation increases and volume of air intake per unit time increases. [2012 TYS 8d] Volume of blood delivered to tissues per unit time increases as heart beats faster to allow **more** oxygen and glucose to be supplied to muscles to undergo **higher rate** of aerobic respiration to release **more** energy for vigorous muscle contractions. [2010 TYS 1cii]

How exercise & breathing rate affects one another.
More oxygen used for respiration and carbon dioxide released in the blood. Carbon dioxide concentration increases and stimulates breathing rate to increase.

Chapter 11: Excretion

Define excretion and explain the importance of removing nitrogenous and other compounds from the body.

Excretion is the removal of metabolic waste products and toxic materials such as urea, uric acids and creatinine from the body.

Metabolism includes anabolic (building up) and catabolic (breaking down) reactions. Metabolic reactions produce waste products, which may be harmful if they accumulate in the body. They must either be removed or deposited as harmless insoluble substances.

Excretory products	Excretory organ	Excreted as
Carbon dioxide	Lungs	Gas in expired air
Excess mineral salts	Kidneys	Constituents of urine
Nitrogenous waste products (e.g Urea and Uric acid)	Skin	Constituents of sweat, but only small quantities
Excess water	Kidneys	Main constituent of urine
	Skin	Main constituent of sweat
	Lungs	Water vapor in expired air
Bile pigments (Breakdown of haemoglobin)	Intestine	Constituents of feces

Note: Main purpose of sweating is to regulate body temperature, excretion is secondary.
Other constituents of feces, mainly undigested food material will be egested.

Describe the structure of nephrons.

Afferent Arteriole: A branch of the renal artery leading to the glomerulus, with a larger lumen diameter than efferent arteriole.

Efferent Arteriole: Smaller in diameter than afferent arteriole to create a high hydrostatic blood pressure and force the filtrate out.

Glomerular Capillaries (Glomerulus): Highly coiled Glomerular capillaries to increase SA to V ratio to have more filtrate formed per unit time. Glomerular capillaries more porous than normal capillaries to allow greater permeability for small ions and molecules to pass through faster.

☆ Basement membrane : partially permeable.

Bowman's Capsule: A cup-like structure in the cortex

Proximal Convoluted Tubule: Highly coiled to increase SA to V ratio to reabsorb

most mineral salts and all glucose, amino acids and vitamins (via active transport and diffusion) Most water absorbed back by osmosis.
Epithelium made up of cells that resemble that of the intestinal villi.

Loop of Henle: The U-shaped portion of the tubule in the medulla.

Distal Convoluted Tubule: The coiled tubule which comes after the Loop of Henle

Collecting Duct: A duct that runs straight through the medulla and eventually opens into the renal pelvis

some water & mineral salts.

Outline the function of kidney tubules with reference to ultra filtration and selective reabsorption in the production of urine.

Ultrafiltration:

1. Efferent arteriole smaller in diameter than afferent arteriole: High hydrostatic blood pressure to force the filtrate out of blood into Bowman's capsule.
2. Highly coiled glomerular capillaries: Large surface area to volume ratio, to increase rate of ultrafiltration, allowing more filtrate to be formed per unit time.
3. Glomerular capillaries more porous than normal capillaries: Greater permeability for very smaller molecules and ions to pass through faster.

After ultrafiltration: ALL small molecules filtered, including useful substances (glucose, amino acids, water and mineral salts) and waste products (urea, uric acid and other nitrogenous wastes)

Selective Reabsorption

Proximal convoluted tubule reabsorbs most of the mineral salts, all of glucose, amino acids and vitamins (diffusion but mostly active transport); and most of the water (osmosis) back into the bloodstream.
Wall of nephron is one cell thick but has an abundance of mitochondria for active transport, also bears microvilli to increase surface area to volume ratio for higher rate of absorption of substances.

Loop of Henle: Osmosis of water and active transport of mineral salts.

Distal convoluted tubule: Active transport of mineral salts, little osmosis.

Collecting duct: Osmosis.

Outline the role of anti-diuretic hormone in the regulation of osmotic concentration.

When water potential of blood increases, hypothalamus is stimulated and causes pituitary gland to release less anti-diuretic hormones (ADH) which makes the cells of collecting tubules less permeable to water. Hence less water is reabsorbed by collecting tubules back into bloodstream and more water remains in the urine. (vice versa)

Explain why the volume of urine decreases as external temperature increases?
As external temperature increases, thermoreceptors in the skin are stimulated and nerve impulses are transmitted to the hypothalamus. The hypothalamus then sends nerve impulses to the sweat glands in the skin to release more sweat which contains water. Latent heat is lost through evaporation of water from sweat. Water potential of blood is reduced. This stimulates hypothalamus and hence, more ADH is released by pituitary gland which results in more water reabsorbed at the collecting duct as the cells become more permeable to water, therefore lesser volume of urine produced(more concentrated).

Note: ADH is produced by hypothalamus and released from pituitary gland

Outline the mechanism of dialysis in the case of kidney failure.

1. Blood is drawn from a vein (connected to an artery via a fistula) in the patient's arm
2. Blood is pumped through a tubing to the dialysis machine
3. Tubing is bathed in a special dialysis fluid(same as body temperature) and the tubing is partially permeable
4. Small molecules like urea and metabolic waste products diffuse out of the tubing
5. Larger molecules like platelets and blood cells remain in the tubing
6. The filtered blood is returned to vein in the patient's arm

Part		Feature	Effect
Basement membrane of Bowman's capsule	Dialysis tubing	Partially permeable	Allows small molecules like urea and water to pass through but not large molecules like proteins (note: blood cells are not molecules!)
PCT and DCT	Dialysis tubing	Long, coiled and narrow	Increases SA to V ratio, during filtration
Continuous blood flow from afferent arteriole to efferent arteriole	Continuous flow of dialysis fluid against flow of blood (Counter current flow)	Continuous blood flow	Maintains steep concentration gradient between blood and kidney tubules/dialysis fluid for filtration
Carries out selective reabsorption	Dialysis fluid has similar concentration of essential substances as blood plasma		Prevents useful substances from being excreted
Blood taken from renal artery into kidney	Blood taken from vein joined to artery in arm		Provides natural force provided directly from the heart into artery to allow forceful flow of blood. Concentration of urea is high.

Account for differences in mechanism of healthy kidney and dialysis machine.

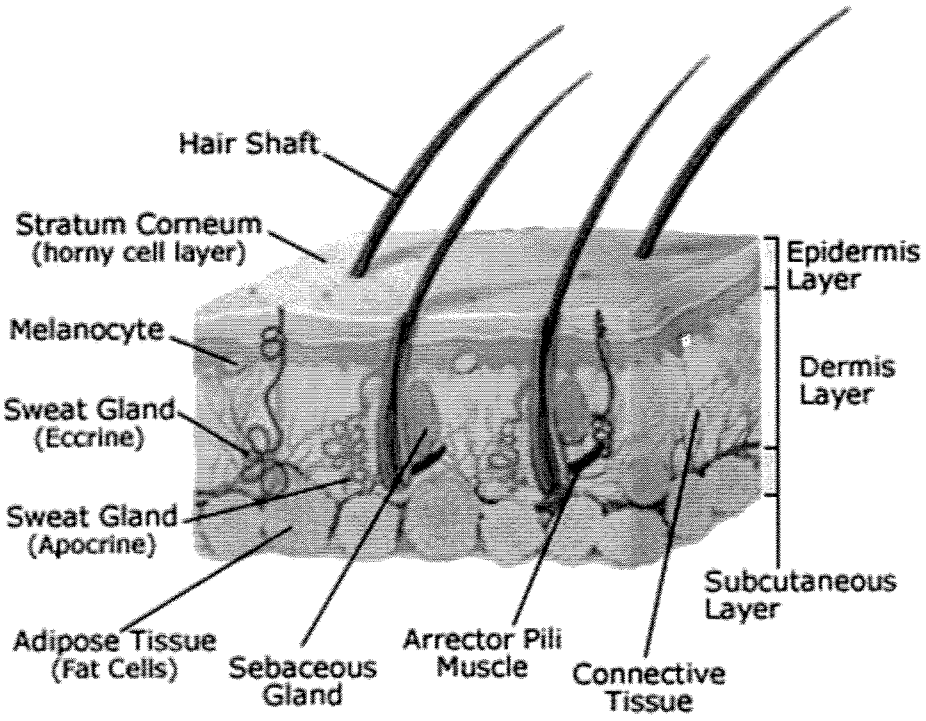
Healthy Kidney	Dialysis Machine
Excretion - **Ultra-filtration** to remove metabolic wastes and toxins from blood - Waste and toxins not **selectively reabsorbed**, only useful substances are - Waste end up in urine Blood water potential - Selective reabsorption - Mainly at proximal convoluted tubule - Anti-diuretic hormones involve when blood water potential is low or high (e.g. when water potential of blood is low, more ADH is released for more reabsorption of water)	Excretion - **Diffusion** of metabolic wastes and toxins - **No waste and toxins** in dialysis fluid - Wastes end up in dialysis fluid Blood water potential - Osmosis of water molecules - Dialysis tubing is partially permeable - Water potential of dialysis fluid kept at optimal level (e.g. when water potential is low, water molecules from the dialysis fluid will move into blood by osmosis)

Chapter 12: Homeostasis

Define homeostasis.
Homeostasis is the maintenance of a constant internal environment, keeping it within a narrow range such as blood glucose concentration, body temperature, water potential of blood.

Explain the basic principles of homeostasis in terms of stimulus resulting from a change in the internal environment, a corrective mechanism and a negative feedback.
There must first be a stimulus, a change in the internal or external environment. The receptor detects the stimulus and brings about a self corrective mechanism which reverses the effect of the stimulus. *Negative feedback, the reverse effect of a stimulus caused by corrective mechanisms that took place, allows the receptors to receive signals and ensure corrective mechanisms proceed until normal conditions in the internal environment are restored.*

Identify on a diagram of the skin: hairs, sweat glands, temperature receptors, blood vessels and fatty tissue.



Describe the maintenance of a constant temperature in humans in terms of insulations and the role of temperature receptors in the skin, sweating, shivering, blood vessels near the skin surface and the co-ordinating role of the brain.

Stimulus	Rise in Temperature	Drop in Temperature
Receptor/Hypothalamus	The thermoreceptors in skin detect the stimulus of the (increase/decrease) in ***EXTERNAL*** temperature and sends nerve impulses to the hypothalamus in the brain which regulates the body temperature by sending out nerve impulses to relevant body parts.	
Sweat Glands	More active, produce more sweat. **More** water from sweat evaporates from skin, removing **more** latent heat of vaporization.	Less active, produce less sweat. **Less** water from sweat evaporates from skin, removing **less** latent heat of vaporization.
Arterioles	Vaso-dilate to allow **more** blood to flow through blood capillaries near the surface of the skin, increasing heat loss via conduction, convection and radiation.	Vaso-constrict to allow **lesser** blood to flow through blood capillaries near the surface of the skin, reducing heat loss by conduction, convection and radiation.
Metabolic Rates	N.A.	**Increase**, to increase the amount of heat released by respiration
Breathing	**Rapid breathing** to remove more latent heat of vaporization from evaporation of thin film of moisture on inner walls of alveoli.	N.A.
Shivering	N.A.	Shivering is the **spasmodic contractions** of skeletal muscles to increase metabolic rate of the body, thus increasing the amount of heat released by respiration.

	This changes the body temperature which serves as a negative feedback. Corrective mechanisms continue until body temperature (increases/decreases) to normal.

- Able to **remain active** throughout the day and also throughout the year, irrespective of the environmental temperature.
- **Enzymes** work best at a constant optimum temperature, which is around body temperature.
- Can continue to feed throughout the year, do not need to **hibernate**.
- Able to live in areas with **different climatic conditions**

Outline the role of hypothalamus in coordinating temperature regulation.
The hypothalamus receives stimuli about temperature changes in our external environment from the thermoreceptors in the skin. It also monitors the temperature of blood passing through it and receives stimuli about temperature changes in our internal environment.

Describe the maintenance of a constant blood glucose concentration.
When blood glucose concentration rises above normal, the Islets of Langerhans in the pancreas is stimulated and secretes insulin. Insulin stimulates the liver and muscles to convert excess glucose to glycogen. Permeability of cell surface membrane to glucose increases. Blood glucose concentration decreases until normal. Insulin secretion stops. When blood glucose concentration drops below normal, the Islets of Langerhans in pancreas is stimulated and secretes glucagon. Glucagon stimulates liver and muscle cells to convert glycogen to glucose. Blood glucose concentration increases until normal. Glucagon secretion stops.

Describe the maintenance of a constant osmotic pressure in the body.
When water potential of the blood increases, the hypothalamus is stimulated and the pituitary gland releases less anti-diuretic hormone (ADH). Lesser ADH decreases permeability of the collecting duct to water for kidney to reabsorb more water into the blood, resulting in more water being excreted in urine. This happens until water potential of blood returns to normal. When water potential of blood decrease (below normal), the hypothalamus is stimulated and the pituitary gland releases more ADH. More ADH increases permeability of the collecting duct to water for kidney to reabsorb more water into the blood, resulting in less water being excreted in urine. This happens until water potential of blood returns to normal.

Chapter 13: The Nervous System

State the components of the nervous system.

Central Nervous System (CNS) consisting of the brain and the spinal cord.
Peripheral Nervous System (PNS) consisting of cranial nerves from brain and spinal nerves from spinal cord and sense organs

State the relationship between receptors, the central nervous system and the effectors.

Stimulus is gathered by the receptors. The stimulus is converted into electrical signals called nerve impulses. The nerve impulses are then transmitted by peripheral nerves to the central nervous system – brain and spinal cord. Brain interprets the nerve impulses and initiates nerve impulses that are transmitted to effectors to carry out the intended actions.

Outline the functions of sensory neurones, relay neurones, and motor neurones.

Sensory neurones are neurones that transmit nerve impulse from the sense organs or receptors to the central nervous system.
Motor neurones are neurones that transmit nerve impulses from the central nervous system to the effectors.
Relay neurones are neurones that transmit nerve impulse from the sensory neurone to the motor neurones.

Describe the following reflex actions:

- Sudden withdrawal of hand on touching a hot object
- Knee-jerk reflex
- Pupil Reflex

Sudden withdrawal of hand on touching a hot object
The heat on the object stimulates the thermoreceptor and pain receptors in the skin. Electrical impulses are produced and travels along the sensory neurone to the spinal cord. In the spinal cord, impulses are transmitted across a synapse to the relay neurone and then across another synapse to the motor neurone. Electrical impulses leave the spinal cord along the motor neurone to the effector. The effector is the biceps muscle which then contracts causing the sudden withdrawal of the hand.

Knee-jerk
Stretch receptors are stimulated and nerve impulses are produced and travels along the sensory neurone to the spinal cord. In the spinal cord, impulses are transmitted directly to the motor neurone across a synapse and electrical impulses leave the spinal cord along the motor neurone to the effector. The effector is the thigh muscles which then contracts, causing the lower leg to kick up.

Pupil reflex
As light intensity increases, photoreceptors in retina are stimulated. Nerve impulses are sent via sensory neurone in optic nerve to brain. Sensory neurone connects via synapse to relay neurone which connects to motor neurone via another synapse. Electrical impulses leave the brain along the motor neurone in optic nerve to the iris muscles. Circular muscle of iris contracts and radial muscle of iris relaxes to constrict pupil to prevent too much light from entering eye.

Compare and contrast voluntary action and reflex action.

Similarities:

- Both involve nerve impulses transmitted along neurons.
- Both involved the brain.
- In both cases, nerve impulses are transmitted along the relay and motor neurons to effectors.

Differences:

- A reflex action is not controlled by the conscious will but a voluntary action is controlled by conscious will.
- A stimulus (usually external) is needed for a reflex action to occur, but it is not required for a voluntary action AS it is initiated in the brain.
- Nerve impulses are produced at the receptor for a reflex action, but produced in the brain for a voluntary action.
- Nerve impulses travel along the sensory neurone to the central nervous system in a reflex action, but in a voluntary action, sensory neurone is not involved, the impulses travel within the CNS to the effector.

Chapter 15: Hormones

Define a hormone.

It is a chemical substance produced by endocrine glands, carried by the blood which alters the activity of one or more specific target organs and is then broken down by the liver.

Explain what is meant by an endocrine gland, with reference to the islets of Langerhans in the pancreas.

Endocrine glands are ductless and secrete hormones directly into the bloodstream, which then distributes the hormone around the body for them to reach the target organs. The Islets of Langerhans secretes insulin or glucagon directly into the bloodstream which travels to the liver and muscle cells to stimulate conversion of excess glucose to glycogen or glycogen to glucose respectively.

State the role of the hormone adrenaline in boosting blood glucose levels and give examples of situations in which this may occur.

Adrenaline is produced and released by the adrenal gland, which is stimulated when an individual is afraid, angry, anxious or stressed. Adrenaline prepares the body for 'fight or flight' or for states of emergency.

Adrenaline:

- Increases **blood glucose levels** by stimulating the conversion of glycogen to glucose in liver and muscles. The glucose produced is carried by blood to all the vital organs especially the heart and skeletal muscles, leading to increased respiration.
- Increases **metabolic rate** for more energy to be released during tissue respiration.
- Increases the **rate of heartbeat** and causes a rise in blood pressure so that oxygen and glucose are carried faster to the muscles.
- Constricts **arterioles** in skin and digestive system. This causes paleness, thus channeling more blood to the muscles eg. In limbs
- Increases rate and depth of **ventilation** for more oxygen to be available for respiration.
- Contracts **hair erector muscles**, producing 'goose pimples'
- Increases rate of **blood coagulation**
- Causes **pupils** to dilate to enhance vision

Describe the signs, such as an increased blood glucose level and glucose in urine, and the treatment of diabetes mellitus using insulin.

Signs of diabetes

- Persistently high blood glucose level
- Presence of glucose in urine after a meal
- Healing of wounds is slow or difficult

Types of diabetes

a. Type 1, developed early in a person's life. Juvenile/Early-onset diabetes. Islets of Langerhans unable to produce sufficient insulin.
b. Type 2, developed later in a person's life. Late on-set diabetes, target cells (eg. muscle cells) do not respond well to insulin. Overweight people are more likely to develop type 2 diabetes.

Treatment

i. Type 1: Insulin injected into bodies daily.
ii. Type 1: Have to ensure supply of sugary foods such as glucose sweets as their blood glucose concentration may drop too low if used too much insulin
iii. Type 2: Control blood sugar level (regulate carbohydrate content in diet, exercise)

List the differences between endocrine and nervous control.

Endocrine	Nervous
Both are coordinate systems that cause changes in response to a stimulus	
Chemical signals	Electrical signals
When blood glucose level increases, HS will send chemical substances (insulin) to liver and muscle cells	When hand touches hot object, NS will send electrical impulses to brain
Gives a slow response to bring blood glucose level back to normal	Gives a quick response when hand is retracted
May affect more than one target organ like liver and muscles	Usually localized and affects only 1 target organ or specific muscle
Hormones transported by blood	Electrical impulses transmitted by neurones
Responses are short or long lived.	Responses are short lived.
Always involuntary	Voluntary or involuntary

List the differences between a hormone and an enzyme.

Hormone	Enzyme
Mostly Protein	All made of proteins
Released directly into bloodstream	Released via duct or gland cells with pits
Found in blood stream	May be found in or outside bloodstream like in alimentary canal
Alter activity of organ	Acts to speed up rate of any chemical reaction

How nervous system and endocrine system acts

Independently:

- NS: Receptors in skin detect the stimulus, impulses produced from the sensory neurone goes to spinal cord then motor neurone to the effector (muscle)
- HS: Regulation of blood glucose level work independently from nervous system. Endocrine gland detects an increase in blood glucose level and secretes insulin into the bloodstream which is brought to liver and muscle cells.

Nervous system can stimulate endocrine gland to release hormones into bloodstream.

-Fear, anxiety or stress stimulates the hypothalamus.

-Nerve impulses are produced and they travel along the sensory neurone to the spinal cord.

-The motor neurone leaves the spinal cord carrying the nerve impulses to the adrenal gland, stimulating it to release adrenaline.

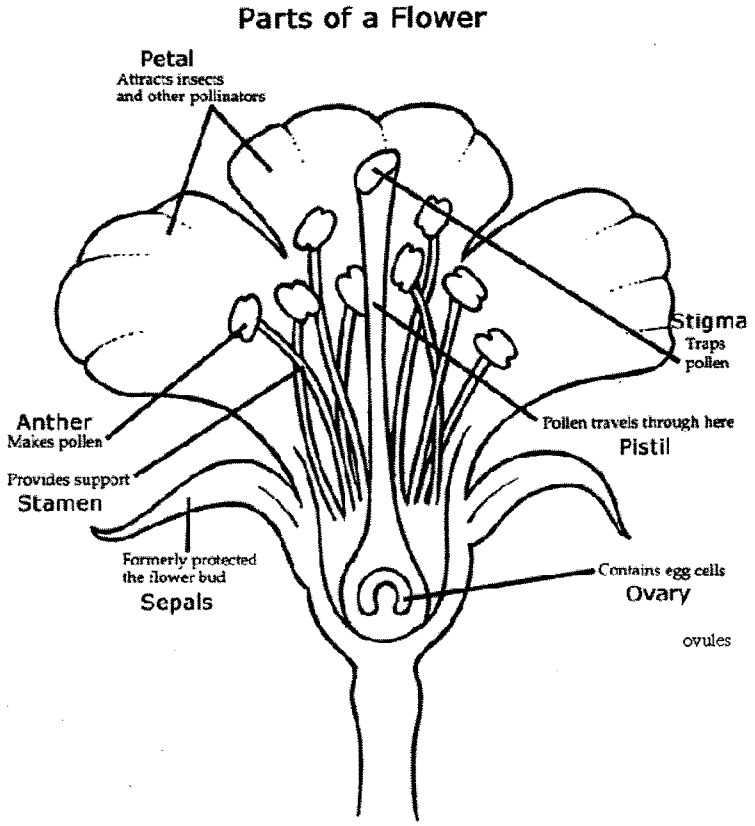
-Adrenaline is carried in the blood to the heart and lungs, increasing breathing and heart rate to cope with the situation.

Chapter 16: Reproduction in Plants

Define sexual and asexual reproduction.

Sexual reproduction requires the fusion of nuclei of one male and one female gamete produced by meiosis. Genetic variation occurs amongst the offspring and with parents. However asexual reproduction does not involve the fusion of nuclei of gametes. Offspring are genetically identical to parents and to each other and are produced by mitosis.

Identify, know how to label and state the functions of sepals, petals, carpel, stamen.



Functions

Sepal (All: calyx): They are modified leaves which encloses and protects other parts of the flower during the bud stage

Petals (All: corolla): They are modified leaves. In insect pollinated flowers, petals are brightly coloured to attract insects for pollination and a platform for insects to land on.

Carpel (All: pistil/gynoecium): The carpel is the female part of the flower which consists of an ovary, a style above the ovary and one or more stigmas.

Stamen (All: androecia): The stamen is the male part of the flower consists of an anther and a filament.

Define pollination, self pollination and cross-pollination
Pollination is the transfer of pollen grains from an anther to a receptive stigma to bring male and female gametes together. Self pollination is the transfer of pollen grains from anther to stigma of a same flower or to stigma of another flower in the **same plant** Cross pollination is the transfer of pollen grains from anther of one flower to stigma of flower in another plant of the **same species**

State the advantages and disadvantages of self pollination and cross pollination.

SELF	CROSS
+ Only 1 parent plant required	- 2 parent plants required
+ Beneficial qualities more likely to pass down to offspring	- Lower probability of pollen grains reaching stigma of other plants (compared to self)
+ Does not depend on external factors like wind or insects for pollination	- Depends on external factors like wind or insects for pollination
+ Less pollen and energy wasted	- More pollen and energy wasted (compared to self)
+Offspring inherit beneficial qualities from one parent plant	
- Offspring's genes inherited from one parent plant which leads to **less** genetic **variation** and hence being less adaptable to environmental changes.	+ Offspring **inherit beneficial qualities** from both parents hence being more adaptable.
- Inbreeding occurs and offspring become weaker, smaller and less disease resistant	+ More genetically varied than self-p thus increasing adaptability of plants to environmental changes
	+ More **viable seeds** produced thus capable of surviving longer before germination

won't rot so fast

Describe the pollination of insect pollinated and wind pollinated flower. (Clitoria and ischaemum muticum)

Insect pollinated flower (Clitoria)

- Insect lands on petal
- Follows nectar guide into base of flower to collect nectar
- Insect forces its way between 2 wing petal and move in to collect nectar
- Insect's back forces open the keel petal to expose stigma and anther
- Stigma and anther brush against hairy back of insect and pollen grains from anther stick onto the insect's hairy back
- At the same time pollen grains on the back of the insect from the anther of another flower which the insect had landed on previously are transferred to the sticky stigma
- When insect leaves, keel petal spring back to original position and enclose stamen and stigma

Wind pollinated flower (Ischaemum Muticum)

- The mature stamens have long pendulous filaments that hang downwards and can swing freely
- Filaments hang out of bracts exposing mature anthers to the wind
- Dust-like pollen grain is shaken free in the wind and carried by wind
- Mature stigmas project out of the bracts. They are long, extended and feathery to provide a large SA to receive any floating pollen.

Compare and contrast between insect pollinated and wind pollinated flowers.

	INSECT	WIND
PETALS	Large	Small / Absent
	Brightly coloured	Dull coloured
	With scent, nectar and nectar guides to attract insects	Without scent and nectar
STIGMA	Not feathery	Feathery - easier to trap pollen grains
	Small and compact with sticky surface	Large and protruding
STAMEN	Non-pendulous filament	Long slender and pendulous filaments the hang outside flower
	Anthers are small and firmly attached to filament and enclosed in petals	Anthers are large and flexible
POLLEN GRAINS	Produced in comparatively small quantities as it relies on insects for pollination	Produced in large quantities as there is high wastage
	Large, sticky and heavy with rough surface to adhere to insects	Small, dry, smooth and light (Has air sacs for buoyancy)

Nectar Guide present absent

Compare and contrast between self pollinated and cross pollinated flowers.

SELF	CROSS
Bisexual flowers with carpel and stamen maturing at the same time	Anther and stigma maturing at different times
Stigma situated directly below stamen	Stigmas of plants with bisexual flowers to be situated some distance away from anther
Bisexual flowers present in the same plant but never open (Cleistogamous)	Dioecious plants: Flowers of plants that have one reproductive organ i.e stamen/stigma
Stigmas are receptive to allow germination of pollen grain of the same plant.	Stigma of plants can secrete an inhibiting secretion to inhibit germination of pollen grain of the same plant even if it reaches stigma of flower.

Describe the process of fertilization in flowering plants.

1. Pollen grain lands on stigma
2. Germinates in response to sugary fluid secreted by stigma
3. Pollen tube grows out from each pollen grain
4. Cytoplasm and 2 nuclei (Generative nucleus + Vegetative nucleus) of each pollen grain passes into pollen tube
5. As it grows, pollen tube secretes enzymes to penetrate surrounding tissue of stigma and right through the style
6. Along the way,
Generative nucleus: Divides mitotically into 2 male gametes
Vegetative nucleus: Controls growth of tube towards ovule and degenerates when it reaches ovule.
7. Pollen tube enters ovule through micropyle (Ovule wall)
8. Upon reaching ovule, tip of tube absorbs sap in ovule and burst to release 2 male gametes
9. Fertilization occurs when one male nucleus fuses with ovum to form the zygote.
Other male nucleus fuses with definitive nucleus to form endosperm nucleus.
This results in double fertilization.
10. Zygote will divide and develop into embryo in seed
Endosperm will divide and give rise to food storage tissue (endosperm)

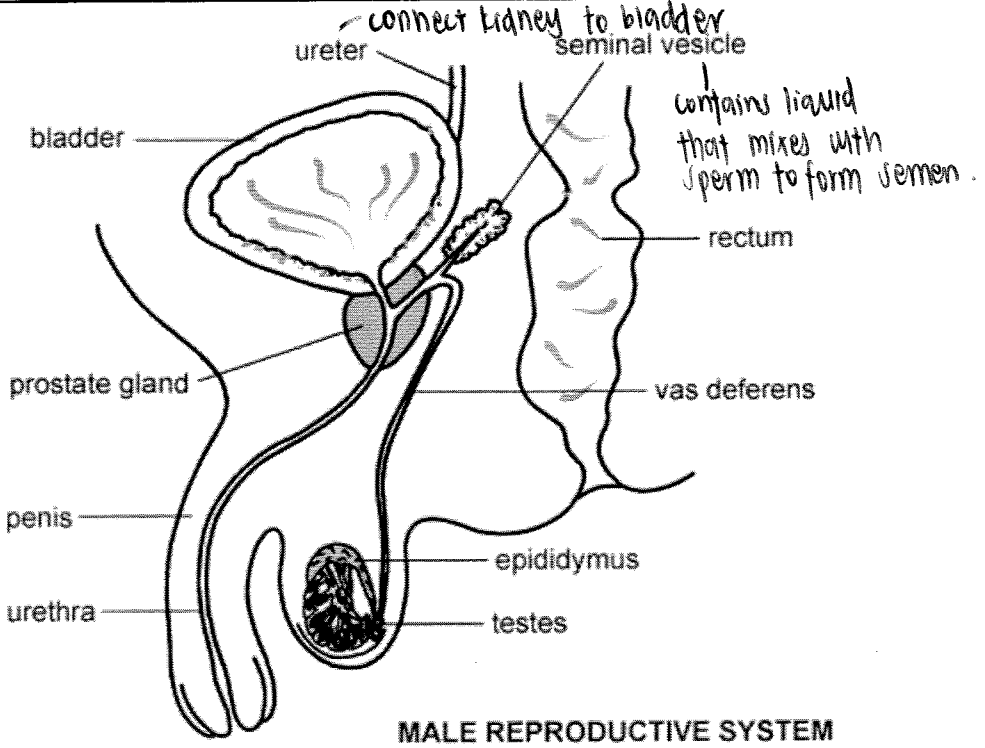
Asexual and Sexual Reproduction

Asexual: Offspring genetically identical as parent
Limited

Self & Cross pollination LEAD TO sexual reproduction. As a result, there is genetic variation.

Chapter 17: Reproduction in Humans

Identify on diagrams (side and frontal view) the male reproductive system and give the functions of testes, scrotum, sperm ducts, prostate gland, urethra and penis.



MALE REPRODUCTIVE SYSTEM

Functions

Testes: Male sex organs which produce sperms (haploid sex cells for reproduction) testosterone (sex hormones)

Scrotum: Sac that holds testis outside body to keep sperms cooler for optimum temperature for sperms (production and to keep them healthy).

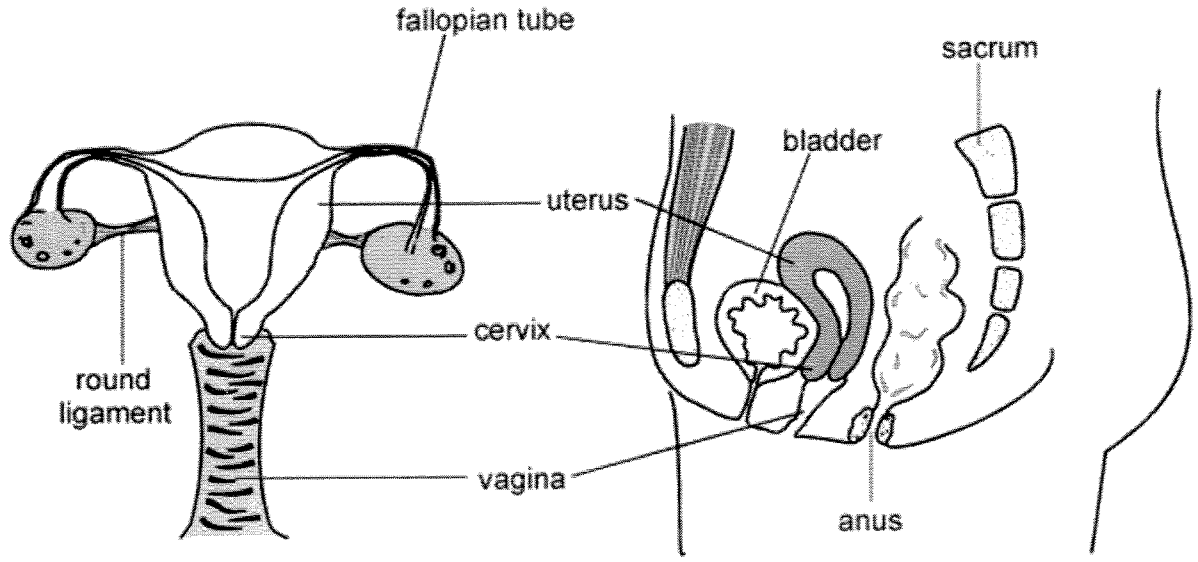
Sperm ducts: Connects and transports sperms from testis to urethra

Prostate gland: Secretes seminal fluid which contains enzymes and nutrients to nourish and activate sperms to form semen (seminal fluid+ sperms)

Urethra: Passes through penis (passageway for urine and sperms out of the body)

Penis: Has numerous blood capillaries that fill up blood spaces during erection so as to become erect to be able to ejaculate and deposit sperms into vagina.

Identify on diagrams (side and frontal view) the female reproductive system and give the functions of ovaries, oviducts, uterus, cervix and vagina



FEMALE REPRODUCTIVE SYSTEM

Functions

Ovaries: Releases an ovum every 28 days into the fallopian tube. It produces the female sex hormones, estrogen and progesterone.

Oviducts: Mature egg is released into an oviduct. Muscles in the walls of fallopian tube contract and cilia to help push the ovum along the oviduct via peristalsis.

Uterus: Site where fetus develops during pregnancy with a central cavity and thick elastic muscular walls. It receives, nourishes and protects fetus during pregnancy. Has smooth muscles in uterus wall which contract to expel baby during birth, causing labour pain.

Cervix: Keeps fetus in uterus until it is ready to be born

Vagina: Opening for penis during copulation and passageway for birth of baby.

Briefly describe the menstrual cycle with reference to the alternation of menstruation and ovulation, the natural variation in its length, and the fertile and infertile phases of the cycle with reference to the effects of progesterone and oestrogen only.
Day 1 Uterine lining breaks down and lining flows out together with a small amount of blood and unfertilized egg/ova through the vagina -Menstruation Day 6 Follicles are stimulated to secrete estrogen which rebuild and repairs lining of uterus to make it spongy, full of capillaries and thick Day 14 Ovulation occurs due to high level of estrogen and corpus luteum forms from empty follicle. Corpus luteum secretes progesterone and estrogen. Estrogen further thickens the uterine lining, making it spongy and full of capillaries. **Progesterone** maintain the thickened uterine lining for implantation. If Fertilization Occurs... The fertilized egg becomes a zygote and the zygote develops into an embryo through mitosis. The Embryo embeds itself in the uterine lining and secretes a hormone (Human Chorionic Gonadotropin) which prevents Corpus luteum from breaking down. Corpus luteum secretes progesterone and estrogen until placenta is completely formed(to take over the secretion) and sufficient progesterone and estrogen is produced If Fertilization Does not Occur... The egg breaks down. Subsequently, the corpus luteum breaks down and progesterone is not secreted. The uterine lining is not maintained and breaks down. Return to Day 1.

Describe fertilization and early development of the zygote simply in terms of the formation of a ball of cells which becomes implanted in the wall of the uterus.
Cilia lining the oviduct sweep the zygote along the oviduct. Peristaltic movements also help to move the zygote to the uterus. The zygote divides by mitosis to form a hollow ball of cells called the embryo. It takes about 5 days for the embryo to reach the uterus. Eventually the embryo embeds in the uterine lining. This is called implantation which usually occurs 7 days after fertilization.

* Oestrogen thickens, Progesterone maintain

State the functions of the amniotic sac and amniotic fluid.
Amniotic sac: 1. Encloses the fetus in the amniotic cavity which contains the amniotic fluid Amniotic fluid: 1. Liquid ~~shock absorber~~ (to distribute any force that may push mother's uterus) to ~~protect embryo from mechanical injury~~ and ~~unequal pressures from mother's organs~~. 2. ~~Supports and cushions~~ fetus. 3. Cannot be compressed therefore protecting fetus from physical injury. 4. Allows embryo to move freely as it grows 5. ~~Lubricates and reduces friction in vagina during birth~~.

State the functions of the placenta and umbilical cord in relation to exchange of dissolved nutrients, gases and excretory products. (Structural details not required)
Placenta 1. Allows nutrients, oxygen and protective antibodies to diffuse from mother's blood to fetal blood. 2. Allows metabolic wastes like urea and carbon dioxide to diffuse from fetal blood into mother's blood stream 3. Produces progesterone and estrogen to maintain uterine lining during pregnancy Umbilical cord 1. 2 umbilical arteries that transport deoxygenated blood and metabolic waste products away from fetus to placenta 2. 1 umbilical vein that transports oxygenated blood and nutrients from placenta to fetus.

Discuss the spread of human immunodeficiency virus (HIV) and methods by which it may be controlled.
Spread of HIV is caused by: 1. Unprotected Sex 2. Sharing of hypodermic needles with infected person 3. Transmission from mother to fetus as small weight substances can pass through placenta ~~into fetus~~ from maternal blood to fetal blood 4. Infection from blood products HIV attacks lymphocytes and prevents body from protecting against infection.

Reasons why mother's blood and fetus' blood is not continuous.
1. Higher blood pressure of mother's system may kill fetus 2. Fetus and mother may have different blood groups thus resulting in agglutination.

Similarities and differences in events leading to fertilization (inc. meiosis and pollination etc) between human and plants.	
SIMILARITIES	
Many sperms released at each ejaculation	Many pollen grains released for pollination
Formation of Haploid sperms	Formation of Haploid male gametes
Enzymes to digest ovum coating	Enzymes to digest stigma and style tissue
DIFFERENCES	
Sperms use flagellum as they are motile	Growth of pollen tube as gametes are non motile
Sperms nourished by semen	Pollen grain nourished by digested style tissue

Compare and contrast **sperm** and **ovum**	
SPERM	OVUM
23 chromosomes	23 chromosomes
Smaller than ovum – 50 micrometres	**Larger than sperm – 120 micrometres**
Small Nucleus	Large Nucleus
Little Cytoplasm	Abundant cytoplasm
Tadpole shaped (bullet like shaped head with membrane, nucleus and enzyme; Mitochondria in middle; flagellum at end)	Spherical shape (Outer protein coat, inner cell surface membrane and nucleus)
Motile: Flagellum capable of violent swimming motions which propels it forward	**Immotile: Unable to move on its own. Aid of cilia and muscles along the oviduct**
Male gametes receive nutrients from semen	**Carries own food stored in yolk sac**

In terms of frequency, numbers and time of production....

Sperms are released only when needed	**Ovum is released during ovulation every 28 days on average**
Mature sperms released in millions with 200-500 million sperms released per seminal discharge	**One egg released at a time**
Male gametes are produced after puberty	Female gametes produced in the fetal stage

1. Uterine lining breaks down and is removed through the vagina with a small amount of blood and an unfertilised egg.

Chapter 19: Heredity

Define a gene as a unit of inheritance and distinguish clearly between the terms gene and allele.

A Gene is a fragment of a DNA molecule which contains genetic information, a unit of inheritance, which codes for a specific polypeptide which determines a physical characteristic of an organism.

Alleles are alternative forms of the same gene which occupy the same relative locus on a pair of homologous chromosomes.

Explain the terms dominant, recessive, co-dominant, homozygous, heterozygous, phenotype and genotype.

A dominant allele expresses itself and gives the same phenotype in both the homozygous and heterozygous conditions.

A recessive allele does not express itself in the phenotype of an organism in the heterozygous condition but only in the homozygous condition.

Co-dominance is when both alleles express themselves equally in the phenotype of an organism in the hybrid.

Incomplete dominance is when neither allele is completely dominant over the other. Hybrid expresses a phenotype that is intermediate between that of both homozygous conditions.

Complete dominance is when one allele is completely dominant over the other. Hybrid expresses a phenotype in which the dominant trait masks the expression of the recessive trait.

Homozygous is when the 2 alleles controlling a trait are the same.

Heterozygous is when the alleles controlling a trait are different.

Phenotype: The observable trait of an individual.

Genotype: The genetic make-up of an individual.

Define Gene mutation and Chromosomal mutation.

Gene mutation is the sudden change in sequence of bases in a DNA molecule which results in new alleles of genes in the nucleus

Chromosomal mutation is the sudden change in chromosome number. in the nucleus

Explain why observed ratios often differ from expected ratios, especially when there are small numbers of progeny.
Animals normally produce a small number of progeny compared to plants. Using gender in humans as an example, and given that there is 50% chance for the offspring to be male or female when the male parent has one X and one Y chromosome and the female parent has two X chromosomes, it means there is a chance of either gamete containing X chromosome from the female nucleus to meet and fuse with the nucleus of the sperm containing either X or Y chromosome since fertilization is random. This is merely a percentage probability of the gender of the child and there are cases with all male offspring in the family. Each time the mother conceives, there is a 50% chance for the child's gender. *Do **not** write "XX chromosomes" or "XY chromosomes"!*

Explain co-dominance and multiple alleles with reference to the inheritance of the ABO blood group phenotypes – A, B, AB, O gene alleles I^A, I^B and I^O.
Alleles I^A and I^B are dominant over I^O. I^A and I^B are codominant. Therefore individuals with alleles I^A and I^B will have blood group AB as both alleles express themselves equally in the phenotype of an organism in the individual.

Describe the determination of sex in humans – XX and XY chromosomes.
Sex chromosomes determine the sex of the individual. Females would have two X chromosomes, while males would have one X and one Y chromosome. During gamete production, the female gamete contains an X chromosome each. However males produce 2 types of sperm one containing and X, the other the Y chromosome.

Explain a Test cross.
Test cross involves crossing an organism of unknown genotype with a homozygous recessive organism to determine the dominant trait.

Describe mutation.
It is the sudden or spontaneous change in structure of a gene such as in sickle cell anemia and albinism; or chromosome number, such as the 47 chromosomes in the condition known as Down Syndrome in the nucleus which affects the phenotype of the person. It can arise due to exposure to mutagens like gamma rays or X rays or chemicals like bromine, mustard gas or formaldehyde.

Differentiate between gene mutation and chromosome mutation.

Gene mutation results in new alleles of genes while chromosome mutation results in a difference in chromosome number in the nucleus compared to normal conditions.

Gene mutation: Albinism

Mutation of a recessive allele.
Absence of pigments in the skin, hair and eyes of animals and humans.
Requires both parents to pass down the recessive allele *for the offspring* to be albino.
- Has reddish-white skin (easily sunburnt)
- Iris does not have any pigment, Choroid does not have black pigments (sensitive to sunlight)

Gene mutation: Sickle-cell anemia

Change in 1 amino acid that causes the change in the 3D shape of haemoglobin molecule
Haemoglobin S (HbS) is produced, making red blood cell sickle-shaped.
Normal haemoglobin is Haemoglobin A (HbA).

Homozygous recessive have abnormal haemoglobin in blood.

Inflexible haemoglobin becomes insoluble

- HbS molecules *in rbcs makes rbcs* clump together, restricting flow of blood as it is inflexible.
- Increases blood viscosity and blocks blood vessels. This retards bloodflow to tissues and promotes coagulation causing tissue and organ damage, pain and stroke as they cannot respire without enough oxygen.

Fragile, prone to rupture

- Haemolytic anaemia (premature destruction of red blood cells)
- Interferes with rbc ability to *transport* sufficient oxygen to cells
- People with this disease usually die at a young age.

Heterozygous

- People who are heterozygous for the sickle cell trait are more resistant to the malaria pathogen as a small percentage of *rbcs* are sickle-shaped and the sickle cell rbc cannot contain enough oxygen for malaria respiration, making them more resistant to malaria.
- Hence these individuals are most adapted, have better chances of survival and reproduction as compared to normal individuals with 2 normal haemoglobin alleles that code for normal haemoglobin, particularly in malaria prone areas.
- Due to this heterozygote advantage that causes them to be naturally selected for, the sickle cell allele continues to occur at high frequency in malaria-stricken populations.

Chromosome mutation: Down's Syndrome

- Zygote has extra chromosome 21, making the total chromosome count to be 47, unlike the usual 46 chromosomes.
- As the copies of chromosome 21 did not split during gamete formation, there is an additional chromosome (the older the mother, the higher the chance).

Name radiation and chemicals as factors (mutagens) which may increase rate of mutation.
Ultraviolet light; Mustard gas; Alpha, beta and gamma radiation; Formaldehyde

Describe the difference between continuous and discontinuous variation and give examples of each.	
CONTINUOUS	DISCONTINUOUS
1. Deals with a wide **range** of phenotypes. 2. Phenotypes are controlled by **many genes**. 3. Phenotypes are determined by genes which show **additive effect** 4. Expression of phenotypes is affected by **environmental condition** 5. Height, Weight, Intelligence, Skin colour	1. Phenotypes have distinct, clear cut differences 2. Phenotypes are controlled by one gene only *(sometimes it states a few genes in MCQ)* 3. Phenotypes are determined by genes which do not show additive effect 4. Expression of phenotypes is not affected by environmental conditions 5. Eye colour, Gender, Blood group

State that variation and competition lead to **differential survival of and reproduction** by, those organism best fitted to the environment.

Give examples of environmental factors that act as forces of natural selection.
Competition for food and space, predation.

Explain the role of natural selection as a possible mechanism for evolution.
Sexual reproduction, as well as, spontaneous mutation which may cause the phenotype of the organisms to change, produce varieties within the species. Competition (for food and space etc) occurs among different varieties of organisms resulting in the survival of the fittest. **Natural Selection:** Nature selects those varieties with favourable alleles, which are best adapted under the prevailing conditions. Others die or decrease in number due to predation or lack of food. Those that survive past reproductive age, **reproduce** and pass down favourable alleles to offspring. + **Evolution (if needed in question):** After many generations, frequency of favourable alleles increase Resulting in a new breed of organisms which are very different from the original stock, hence we say that a new species has evolved.

Give examples of natural selection (Darwin's Finches)

Darwin Finches

Ancestral finches have short, straight beaks to crush seeds.
Those present in Galapagos Islands have 6 major types of beaks to suit their particular diet.

3 examples:
Cactus ground finch: Long slender beak for collecting nectar from cactus flower.
Vegetarian tree finch: Curved parrot-like beak to feed on buds and fruits
Woodpecker finch: Large, straight beak to bore holes in tree trunks and uses a stick to poke insects out of holes in woody tree trunk as they feed on insect larvae.

Rabbits

Mutation occurs and nature selects the variation that is best suited to the environment.
Forest: Dark coloured rabbits are selected for as they camouflage well with dark forest, has a small size and crouching position to hide from predators.

Open plain: Light colored fur coat rabbits are selected for as they camouflage well in open plains. Larger in size, longer hind legs to run and escape from predators. Longer ears to have keener sense of hearing to detect predators.

Give examples of artificial selection such as in the production of economically important plant and animals.

Hybridization: Cross breeding different varieties of plants to produce a new and better variety.

(eg.) Cultivated sugarcane in Java that's rich in sugar that is susceptible to disease and to insect pests is cross-bred with a wild sugarcane that has low sugar content but resistant to disease. Breeders managed to produce plants both high in sugar content and resistant to diseases.

(eg.) Jersey cows known to produce a lot of good milk, but it does not thrive well in warm climates. Brahman breed thrives well in warm climates but are not good producers of milk. Hybridization produced breeds that produce good milk and thrive in warm climates.

Compare and contrast natural selection and artificial selection.	
NATURAL SELECTION	ARTIFICIAL SELECTION
1. Process which a population struggles to survive and organisms best adapted to the environment survive and reproduce. 2. Occurs when natural environment conditions change and organisms compete 3. Varieties produced by natural mutation, sexual reproduction 4. Eg. Industrial Revolution of Moths	1. Process of man choosing or isolating desired traits among a natural population of organisms and selectively breed them. 2. Occurs when humans choose the varieties of organisms to our needs. 3. Varieties produced by selective breeding or genetic engineering. 4. Eg. Increased cow milk produced, Sweeter fruits, Disease resistant plants.

Chapter 20: Molecular Genetics

Explain DNA, chromosomes and genes.

A gene is a segment of a DNA molecule which codes for formation of one type of polypeptide. ~~Many polypeptid~~ 1 codon codes for 1 amino acid

DNA (deoxyribonucleic acid) is a molecule that carries genetic information which consists of 2 strands of polynucleotides twisted around to form a double helix structure. A molecule of DNA has many genes along its length.

A DNA *molecule* is wrapped around proteins to form a single chromatin thread. Chromatin is shortened, condensed and tightly coiled to form chromosomes *during cell division.*

Outline the relationships between DNA, chromosomes and gene.

Gene is a segment of a **DNA** molecule.

Chromosomes are highly coiled condensed form of **DNA**.

Gene occupies a specific locus on a **chromosome**.

State the function of DNA.

DNA is found in the nucleus of the cell and carries genetic information that determines characteristics of a person.

State the structure of DNA in terms of bases, sugar and phosphate groups found in each of their nucleotides.

A DNA consists of 2 polynucleotide strands twisted around each other to form a double helix.
Each polynucleotide strand formed by basic units (nucleotide).
One nucleotide contains 1 nitrogenous base, 1 phosphate group and 1 deoxyribose sugar.
Nitrogenous bases are cytosine, thymine, adenine and guanine which show complementary base pairing.
A pairs with T and C with G in the ratio A:T=1:1 and C:G=1:1 joined by hydrogen bonds
Nucleotides join to form a sugar-phosphate backbone with nitrogenous bases projecting into the double helix.

State the rule of complementary base pairing.

Adenine and Thymine are complementary *base* pairs while Guanine and Cytosine are complementary *base* pairs. The percentage of Adenine is equal to the percentage of Thymine in a single molecule of DNA (which is double-stranded), which also applies for Guanine and Cytosine.

Significance of order of bases in a DNA molecule.
A gene is a segment of DNA molecule. A gene codes for formation of one type of polypeptide and has a specific sequence of nucleotides which results in a specific sequence of bases. The order of bases determines the sequence of amino acids in a polypeptide which affects the folding of the polypeptide. Polypeptides are combined to form proteins. The 3D structure of the polypeptide is important as enzyme or protein function is closely linked to its structure. These proteins determine the characteristics of an individual.

Explain the process of genetic engineering.
Genetic engineering is the process of transferring genes from one organism to another. Individual genes are cut off from chromosomes of the cells of one organism and inserted into the cells of another organism of the same or different species. A vector is a DNA molecule used to carry genes of one organism to another. Plasmids from bacteria can be used to transfer genes.

State a specific example of genetic engineering – insulin production in medical biotechnology.
Obtain a human chromosome containing the insulin gene. Cut 2 ends of the gene using a restriction enzyme to produce 2 'sticky ends' Each sticky end is a single strand of DNA bases. Obtain a plasmid from bacterium and cut it with the same restriction enzyme to produce complementary sticky ends. Insulin gene and plasmid is mixed and attached by complementary base pairing, DNA ligase is added to join the ends forming a recombinant plasmid. Recombinant plasmid is mixed with E coli bacteria. Temporary heat or electric shock is applied to open up pores in the cell surface membrane of each bacterium for recombinant plasmid to enter. Transgenic bacterium is placed within nutrient broth in fermenter with optimum temperature, pH, oxygen supply to multiply rapidly. The gene duplicates and during cell division, each new bacterium receives a copy of the insulin gene to make insulin.

Compare between selective breeding and genetic engineering.	
SELECTIVE BREEDING	GENETIC ENGINEERING
1. Plants and animals used for breeding must be closely related or belong to the same species.	1. Genes from any plant or animal can be inserted into non-related species or different species.
2. Defective genes may be transmitted along with healthy genes to the offspring.	2. Genes are carefully selected before transferring into the organism, reducing risk of genetic defects being passed on to offspring.
3. Slow process involving breeding over several generations. Requires a large amount of land for raising large number of organisms.	3. Fast process as individual cells are used which reproduce rapidly in the laboratory in a small container.
4. Less efficient. Organisms grow more slowly and require more food.	4. More efficient. Transgenic salmon grows faster and requires less food than ordinary salmon.
5. More expensive (due to 3 & 4)	5. Cheaper (due to 3 & 4)

Benefits of genetic engineering.

Low cost production of medicine
-GE of important drugs like human insulin has reduced the cost of medicine. Thus more patients can afford them and get treated.

Production of crops that grow in **extreme conditions** (eg. High salt environments)
- Drought resistant crops/Salt tolerant crops/ Crops that make more efficient use of nitrogen and other nutrients.
-Allows farmers to grow crops even when soil conditions are not suitable for cultivating crops.

Development of crops that produce toxins that kill **pest**-resistant crops
- Use of costly pesticides that damage the environment is reduced
- Bt (Bacillus thurigensis) gene from a certain bacterium can be inserted into plant cells to produce toxins that can kill insect/pests.

Development of food designed to meet **specific nutritional goals**
- Improved nutritional quality of food. For example rice with high vitamin A content.

Discuss the social and ethical implications/issues of genetic engineering with reference to a named example.

Environmental Hazards

- Crops that have been genetically engineered to produce insect toxins result in **death of insects** feeding on GM crops – loss of biodiversity in long term. (Ch22)
- Natural selection takes place when varieties (referring to insects) which are resistant to toxins survive and reproduce and pass down favourable alleles to offsprings. Resulting in more insects attacking crops.
- Herbicide-resistant plants may **cross breed** with weeds to create 'superweeds' *when pollen grains of the crops land on the stigma of the weeds.*

Economic Hazards

- Biotechnology companies use **terminator technology** and engineer crop plants such that the plants produce seeds which cannot germinate. Farmers are therefore forced to buy special seeds after each harvest from these companies posing as a serious problem to poorer societies.

Health Hazards

- Genetic Engineering could **introduce allergens** into food, causing a reaction from our immune system to the body. Eg. Lectin found in beans is an effective pest control against aphids thus the gene for lectin is transferred to potatoes. People who are allergic to lectin may unknowingly eat the transgenic potatoes and react badly to the lectin present.
- Modifying a single gene in plant cells may alter some metabolic processes within the plant, resulting in **production of toxins** which were not initially found in the plant. Consumption of these plants or products by the plants by humans can pose serious health problems. Consumption by insects can lead to loss of biodiversity.
- Genes that code for antibiotic resistance may be **accidentally incorporated into bacteria** that cause diseases to humans. Thus rendering antibiotics ineffective in killing the bacteria.

Social Hazards

- Genetic engineering may result in **class distinctions**. Individuals with the financial means can afford certain gene technologies while the poorer communities suffer.

Ethical Hazards

- Some **religion** do not approve of GE as it may not be appropriate to alter the natural genetic make-up of organisms.
-There are objections to consuming animal genes in plants and vice versa. For example, vegetarians may object to the transfer of animal genes into crop plants.

Chapter 21: Ecology

Describe the non-cyclical nature of energy flow.

The ultimate source of energy is the Sun, producers convert light energy into chemical energy via photosynthesis. Energy in the producers is passed from one trophic level to another by feeding.
Energy lost as heat to the environment cannot be recycled and there is a progressive loss of energy by Heat during respiration, *Excretory waste products like urea, Uneaten body parts like bones left to be decomposed, Undigested matter (faeces) – loss of energy in the form of organic matter along* food chains. Hence light energy from the Sun has to be constantly supplied to the ecosystem as organisms cannot use heat energy to do work, they can only use light and chemical energy.

Explain the terms producer, consumer in the context of food chains and food webs.

Producers are organisms which utilize chlorophyll (or other photosynthetic pigments) to **trap and convert** light energy to chemical energy to manufacture **glucose** during photosynthesis.
*Significance: Producers provide a continuous flow of energy into the food chain which can be passed through each trophic level through conversion of light energy to chemical energy.

Consumers are organisms which obtains chemical energy directly or indirectly by **feeding** on plants or other organisms and they **cannot make their own food** by photosynthesis.

Explain the term trophic level in the context of food chains and food webs.

A food chain is a series of organisms through which energy is transferred in the form of food. Each trophic level is a stage in a food chain.

Describe the role of decomposers in an ecosystem.

Decomposers **obtain some energy** by **breaking down dead organisms, faeces and excretory products**, releasing the rest of the energy to the environment. When the dead organisms and waste matter are broken down, inorganic nutrients, carbon and nitrogen compounds, return to the physical environment and are used again by green plants.

Explain how energy losses occur along food chains and discuss the efficiency of energy transfer between trophic levels.

Only 10% of energy is transferred from one trophic level to another as energy is lost as …
Heat during respiration
Excretory waste products excreted by consumers like urea
Uneaten body parts like bones and left to be decomposed
Undigested matter, as in faeces, loses energy in the form of organic matter.

Therefore energy available for 4^{th} or 5^{th} stage of the food chain is insufficient to sustain organisms *for survival*.

Understand how pyramids of numbers, biomass and energy are constructed.

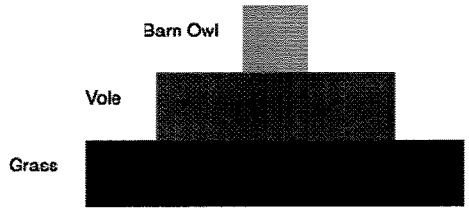
Numbers

Graphical representation of the number of organisms present in each trophic level at a particular time.

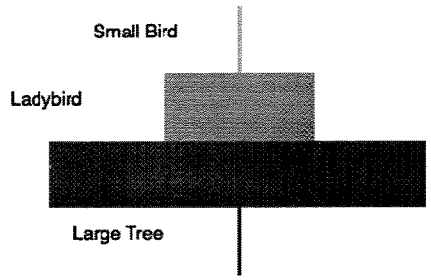
Most are upright pyramid-shaped with 2 exceptions:

a. A lot of small animals feeding on a large plant

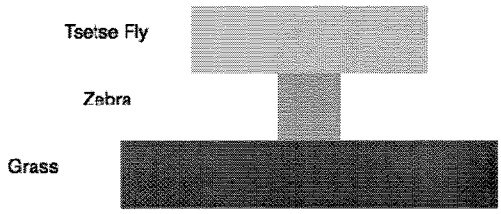
b. An animal has a large number of small parasites feeding on it



Usual case, upright.



Exception 1



Exception 2

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Biomass

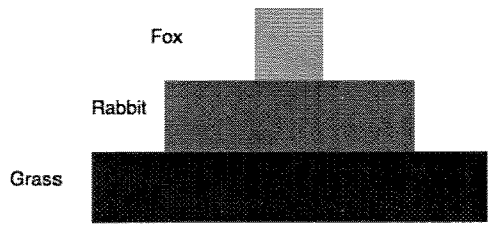
Graphical representation of the total amount of living material present by comparing the dry mass of organisms present in each trophic level at a particular time.

- Pyramid of biomass is in dynamic state. When organisms die, food value on that trophic level can still be maintained by rapid replacement of newborn organisms.

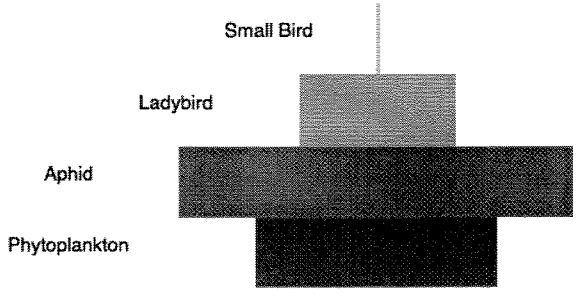
Most are pyramid shaped and upright except:

a. When producer is a small organism that multiplies very rapidly.

In that case, total biomass of producers present at any one time may be less than total biomass of primary consumers, this making the pyramid inverted.



Usual case, upright.



Exception

Energy

Pyramids of energy tell us how much energy is contained in the tissue of organisms at each trophic level in a food chain, allowing us to compare the total energy in each trophic level over a period of time.

Takes account the inedible part of organisms, which is not reflected in pyramids of biomass.

The ultimate source of energy is the sun and energy lost as heat to the environment does not return to the same system or organisms that produced it. It can't be recycled, unlike materials like nutrients. Approximately 10% of energy is transferred from one trophic to another.

Always pyramid-shaped, with no exceptions to this rule.

Describe how carbon is cycled within an ecosystem.
Carbon is constantly removed from and released into the environment in the form of carbon dioxide, thus CO_2 concentration remains relatively constant at 0.03%. 1. During photosynthesis, green plants absorb carbon dioxide from the atmosphere and use it to manufacture carbohydrates, such as glucose. 2. Glucose is changed into other organic compounds such as fats, amino acids and proteins. 3. Carbon can either become part of the bodies of animals that feed on green plants, or are preserved in fossil fuels such as coal, natural gas and oil. 4. The carbon dioxide released when organisms decompose or when organisms respire is then absorbed back into plants during photosynthesis.

Describe how carbon in a glucose molecule is recycled in the carbon cycle.
Glucose releases its carbon to the environment when it is oxidized during **respiration** to become carbon dioxide gas. The carbon dioxide gas becomes incorporated into plants as starch during **photosynthesis,** when consumed by animals becomes glucose again upon **hydrolysis** of the carbohydrates or even absorbed and assimilated and stored as glycogen in the liver and muscle cells. **Decomposers** helps to release the remaining trapped carbon in a dead animal by feeding on them and breaking them down and releases carbon dioxide into the environment.

Understand and appreciate the importance of the carbon cycle.
It ensures a **continuous supply of inorganic CO_2** for plants to photosynthesize, an important process that converts solar energy to chemical energy, which other non-photosynthetic organisms can use to stay alive. It enables a **one-way flow of energy through ecosystem** in the form of food along food chains. Carbon compounds carry the trapped solar energy from organism to organism in the food chains of an ecosystem.

Define a carbon sink.
A carbon sink is an area that stores carbon compounds for an indefinite period. It stores more carbon than it releases.

Describe oceans as carbon sinks
Oceans are the **largest** carbon sinks on Earth. The carbon dioxide that dissolves in the ocean's water is absorbed and used by **phytoplankton** and **algae** in photosynthesis. A portion of the carbon compounds found in oceans is buried in the seabed and is in the form of fossil fuels such as **natural gas** and **oil**.

Describe forests as carbon sinks
Forests are also important carbon sinks. Atmospheric carbon dioxide is absorbed by the plants and used in **photosynthesis**. A large amount of carbon compounds is stored in **trees**. Remains of dead trees form **coal** – a fossil fuel.

Chapter 22: Our impact on the Ecosystem

Describe the causes and effects of deforestation.

Causes

To meet the increasing demands for land and materials such as wood.

Effects

1. Soil erosion. Leaf canopy in rainforests protects the soil from impact of falling rain. Without trees, soil is exposed directly to force of rain. Topsoil, the most fertile layer, gets washed away or eroded during heavy rain especially when rain falls on steep slopes.

2. Flooding. Eroded soil is deposited in streams and rivers blocking flow of water. Water levels in river rise rapidly causing floods.

3. Desertification. Sunlight falls directly on the soil. Water evaporates rapidly from soil and hardens. With topsoil eroded, land becomes barren and plants cannot grow. Organisms which depend directly or indirectly on plants for food also die. The destruction of land to desert-like conditions is desertification.
Habitats are also destroyed and species of animals become extinct.
*Overgrazing also leads to desertification as plants cannot regenerate fast enough.

4. Climate changes. Rainwater retained and absorbed by roots is lost as water vapour during transpiration. Water vapour condenses and falls as rain. Since trees are cut down, area becomes dry and warm, annual rainfall decreases.

Describe the causes and effects of overfishing.

Causes

Demand for fish increases thus they are caught in large numbers.
Modern fishing gear in commercial fishing catches marine life indiscriminately.

Effects

1. Many unwanted species are trapped in the process of dragging large fishing nets along the bottom of the sea during **trawling**. Similarly, giant drift nets trap everything in their path like turtles and dolphins. These accidental catches are then dumped back into the sea but often die.

2. Coral reefs and organisms on the sea bed are destroyed during **dredging**.

3. In **cyanide fishing**, cyanide is squirted into the water around coral reefs, stunning reef fish and making them unable to swim properly. Explosives such as dynamite are also used to stun and catch reef fish, killing corals and many other reef organisms.

4. Species of fish are caught faster than they are replaced. Young fish caught will not be able to grow and reproduce thus decreasing the fish population.

Evaluate the effects of water pollution by sewage.

- Sewage contains **organic wastes** which are a good source of food for bacteria.
- Organic matter may **contain** nitrates and phosphates which are nutrients for water plants and algae.
- **Aerobic bacteria** grow and multiply rapidly and deplete oxygen in the water during respiration.
- **Anaerobic bacteria** also break down organic wastes and release bad smelling gases such as hydrogen sulfide and ammonia.

- **Bacteria decompose** the organic wastes and also release phosphates and nitrates.
- This leads to profuse growth and multiplication of algae. (**Eutrophication**)

- **Submerged** water plants die due to lack of sunlight. Do not release **oxygen** into water.
- Bacteria grow and multiply rapidly by **decomposing on dead plants**, using up even more oxygen.
- **Marine life,** like fish, dies due to lack of oxygen for respiration.

Evaluate the effects of pollution by inorganic waste.

Inorganic wastes contain **poisonous metals** like mercury, lead, zinc, arsenic and cadmium.

Chemicals will be absorbed by plants which are then eaten by fish, leading to bioaccumulation in one trophic level, and thus bioamplification up the food chain. Top consumers suffer from toxic effects due to high concentrations of those poisonous substances.

Evaluate the effects of water pollution due to insecticide including bioaccumulation within food chains and bioamplification up food chains and its impact on top consumers.

Insecticides such as DDT are non-biodegradable, meaning they cannot be broken down into simpler harmless substances by microorganisms like bacteria. They are insoluble and remain in soil for many years and may be washed in streams and rivers. In high concentrations, they may poison fish or animals that take in the polluted water or feed on contaminated fish.

Insecticides such as DDT (dichlorodiphenyltrichloroethane) are toxic and non bio-degradable and cannot be excreted by consumers and is stored in the consumer's adipose tissue. ***("The organic waste is thus accumulated in the body of the consumer throughout its lifetime." – Write only when question asks what is bioaccumulation)*** DDT is accumulated in the body of the consumer throughout its lifetime which is known as bioaccumulation and is passed along the food chain leading to biomagnification/amplification. DDT reaches fatal concentrations in bodies of the final consumer.

Outline the roles of microbes in sewage disposal as an example of environmental biotechnology.

Environmental biotechnology makes use of 'green' solutions to reduce pollution and keep the environment clean.

Water reclamation plants reduce water pollution by using bacteria to digest organic pollutants in sewage and convert it into harmless soluble substances.

1. Used water is channeled into water reclamation plants and first enters the **primary settling tank**. Heavy solids in the used water settle to the bottom of the tank and is removed as sludge (compact form).

2. Partially treated water drained into **aeration tank** and mixed with bacteria. The bacteria secretes enzymes to digest **organic pollutants** in the used water into harmless soluble substances and carbon dioxide.

3. Liquid from the aeration tank sent to **final settling tank** where microorganisms are removed from the water before being discharged into the sea.

4. Sludge is treated in **anaerobic digesters**. (Breaking down the organic pollutants releases methane and methane is used as a fuel to provide electricity.)

5. Treated sludge is dewatered and disposed of as a soil container.

Discuss the reasons for conservation of species in the management of fisheries and management of timber production.

<u>Reasons for Conservation in Management of Fisheries</u>
It is to eliminate the pollution of rivers and seas. Fishing grounds and fisheries must be managed to prevent over-fishing and indiscriminate fishing.

Methods:
- Banning the use of drift nets which indiscriminately trap all forms of marine life.
- Using nets with certain mesh size so that young fish are not caught.
- Regulating entry of ships into fishing grounds
- Limiting the period of fishing in fishing grounds

<u>Reasons for Conservation in Management of Timber Production</u>
Forests are a major source of oxygen, they help moderate the weather, provide shade and protection for the soil. Must be managed to conserve forests and reduce pollution ('Slash and burn' practices release large amounts of carbon dioxide, contributing to global warming).

Methods:
- Reforestation
- Ensures that young trees are not felled
- Trees felled for timber are cut down at a regulated rate
- Designated land as forest reserves

Discuss the reasons for conservation of species with reference to the **maintenance of biodiversity.**

Tropical plants are of great economic importance as they are a source of raw material for industries, medicinal drugs, insecticides and food.

Industries
Rattan → make furniture
Rubber from latex of rubber trees → make tires
Fibres from cotton plants → make cloth
Fibre from coconut husks → make ropes

Medicinal drugs
Quinine, an anti malarial drug from bark of Cinchona.
Morphine, a pain suppressing drug derived from the sap of poppy plant.
Chemicals in the Madagascar rosy periwinkle is used to treat leukemia.

Insecticide
Pyrethrum in chrysanthemum used in insecticide industry.

Food
Tropical rainforests provide food like rice, pineapple, banana

Suggest reasons for conservation.

1. To **maintain a large gene pool** as many wild plants and animals possess favourable genes that can be used for cross-breeding so as to improve agricultural produce. We can have plants with resistance to bacteria or drought by doing cross breeding.

2. To **maintain biodiversity** as many tropical plants are of great economic importance as they are a source of raw material for industries, medicinal drugs, insecticides and food.

3. For **scientific value** as the study of wildlife provides useful information to humans eg. Study of evolution

4. To maintain a **stable and balanced ecosystem** to prevent disruption of natural cycles such as water and carbon cycles and prevents global warming.

5. To prevent **extinction** of plant and animal species

6. To ensure conservation of marine life as they are a **major source of food** for humans.

7. Preserve **natural scenery** and wildlife for people to appreciate and to maintain natural resources for outdoor recreational activities like fishing, hiking.