CHAPTER 1 – CELL STRUCTURE AND ORGANISATION

(a) Identify cell structures (including organelles) of typical plant and animal cells from diagrams, photomicrographs and as seen under light microscope: chloroplasts, cell membrane, cell wall, cytoplasm, cell vacuoles, nucleus.
(b) Identify the following organelles from diagrams and electron-micrographs: mitochondria, ribosome.
(c) State the functions of the above organelles.

Protoplasm
= Nucleus + Cytoplasm + Cell Membrane

Parts of a Typical ANIMAL Cell

Structure:
- Only one per cell (except RBC)
- Contains chromosomes

Function:
- Controls cell activities (Eg. growth and repair)
- Required for cell division

Too small to be seen in **light** microscope:

RIBOSOME, MITOCHONDRIA

Can only be seen using more powerful **electron** microscope

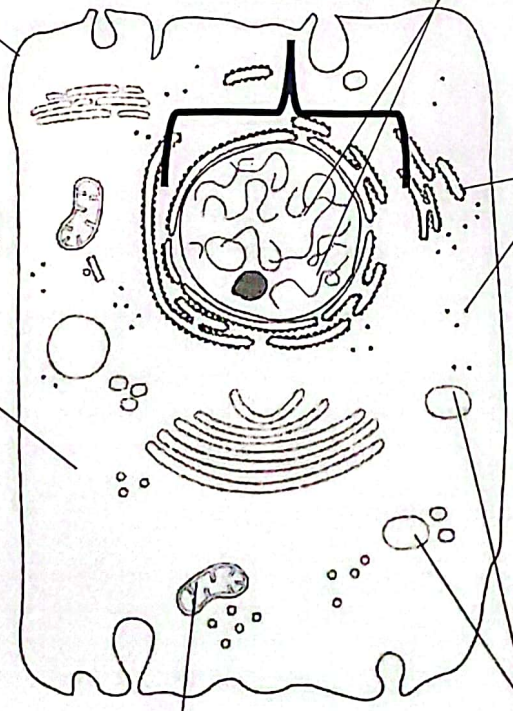
CELL MEMBRANE

Structure:
- Partially-permeable

Function:
- Controls the substances entering and leaving cell
- By allowing only substances that are small enough to pass through it

NUCLEUS

Chromosomes



RIBOSOMES

Structure:
- Round, very small (cannot be seen with light microscope)
- Located freely in cytoplasm OR attached to ER

Function:
- Protein synthesis

CYTOPLASM

Structure:
- Jelly-like substance
- Fills up the remaining space of the cell

Function:
- Site where most cell activities occur
- Contains specialised organelles

VACUOLES

Structure:
- Fluid-filled space enclosed by a membrane

Function:
- Store water and food substances for use by cell

Note:
- Animal cells have <u>many</u>, <u>small</u> vacuoles

MITOCHONDRIA

Structure:
- Oval-shaped
- Small (cannot be seen with light microscope)

Function:
- Site of <u>aerobic respiration</u> to <u>release energy</u> for the cell (used for cellular activities like growth and repair)

Note:
- Aerobic Respiration
  → process when glucose is oxidised to release energy stored inside
- Specialised cells (eg. sperms) which require more energy will need to contain more mitochondria

Parts of a Typical PLANT Cell

Protoplasm
= Nucleus + Cytoplasm + Cell Membrane

CELL WALL

Structure:
- Fully-permeable
- Made of cellulose (a rigid, carbohydrate)

Function:
- Protects the cell from injury
- Gives the plant cell shape

Note:
- Absent in animal cells

CELL MEMBRANE

Structure:
- Partially-permeable

Function:
- Controls the substances entering and leaving cell
- By allowing only substances that are small enough to pass through it

CYTOPLASM

Structure:
- Jelly-like substance
- Fills up the remaining space of the cell

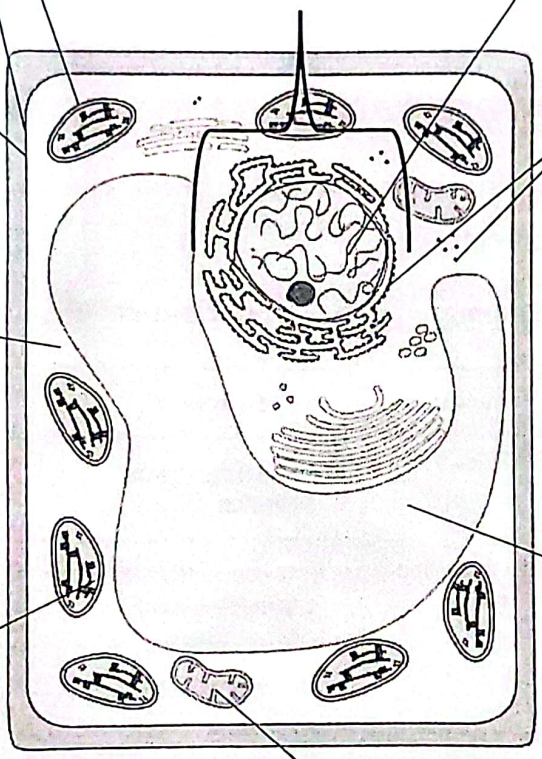
Function:
- Site where most cell activities occur
- Contains specialised organelles

NUCLEUS

Structure:
- Only one per cell (except RBC)
- Contains chromosomes

Function:
- Controls cell activities (Eg. growth and repair)
- Required for cell division

Chromosomes



RIBOSOMES

Structure:
- Round, very small (cannot be seen with light microscope)
- Located freely in cytoplasm OR attached to ER

Function:
- Needed for protein synthesis

VACUOLE

Structure:
- Filled with a fluid – cell sap

Function:
- Store water and food substances (eg. dissolved mineral salts, amino acids, sugars) for use by cell

Note:
- Plant cells have <u>one, large, central</u> vacuole

CHLOROPLAST

Structure:
- Oval-shaped
- Contains chlorophyll (green pigment)

Function:
- Site of photosynthesis
- Traps light energy and converts it to potential energy during photosynthesis

Note:
- Size is bigger than mitochondria
- Absent in animal cells
- Present only in photosynthesising plant cells (more chloroplasts = more photosynthesis)

MITOCHONDRIA

Structure:
- Oval-shaped
- Small (cannot be seen with light microscope)

Function:
- Site of aerobic respiration to <u>release energy</u> for the cell (used for cellular activities like growth and repair)

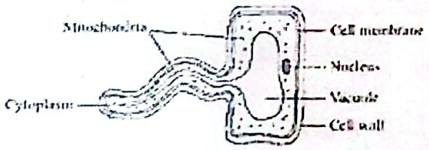
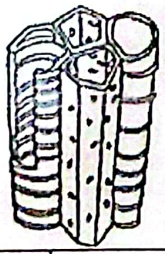
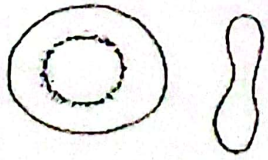
Note:
- Aerobic Respiration → process when glucose is oxidised to release energy stored inside
- Specialised cells which require more energy will need to contain more mitochondria

(d) Compare the structure of typical animal and plant cells.

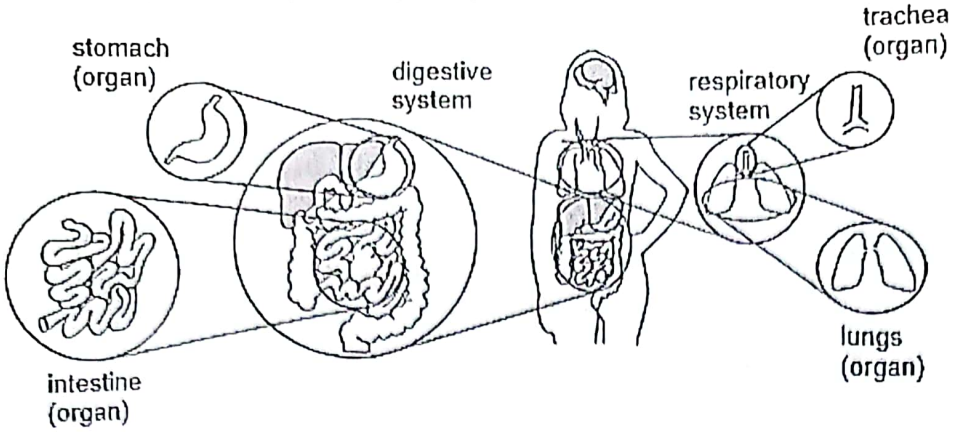
With respect to...	Typical **ANIMAL** cell	Typical **PLANT** cell
Cell wall	absent	present
Chloroplast	absent	present
Vacuole (number & size)	Has many (number), small (size) vacuoles	Has one (number), large (size), central (location) vacuole
Some key **similarities**	Both have: nucleus, cytoplasm, cell membrane	

(e) State simply, the relationship between structure and function for:
(i) absorption – root hair cells
(ii) conduction & support – xylem
(iii) oxygen transport – red blood cells

Summary Table - 3 Specialised Cells

Specialised Cell	Function	Structure	How does the structure help the cell to perform its function?
Root Hair Cell 	Absorbs water and mineral salts	• Has a long, narrow extension	• Increases surface area to volume ratio → to allow faster absorption of water (by osmosis) and mineral salts (by diffusion)
		• Has concentrated cell sap inside vacuole	• Increases concentration gradient (steeper) → to allow faster absorption of water (by osmosis) and mineral salts (by diffusion)
		• Has a large vacuole	• To store more water inside vacuole → so that more water can be absorbed.
Xylem 	1) Transports/ Conducts water and mineral salts from roots to leaves	• Does not have protoplasm (no nucleus, cytoplasm, and cell membrane)	• So that xylem is a hollow, continuous tube → allows water and minerals to be transported without obstruction
	2) Provides mechanical support	• Has lignin deposited on walls / has lignified walls	• Strengthens xylem walls → to provide more mechanical support
Red Blood Cell 	Transports oxygen from lungs to all cells of the body	• Has biconcave shape	• Increases surface area to volume ratio → to allow faster diffusion of oxygen from lungs into RBC, and from RBCs to cells around the body
		• Contains haemoglobin	• To bind oxygen
		• Does not have a nucleus	• To increase space in RBC to contain more haemoglobin to bind more oxygen for transport

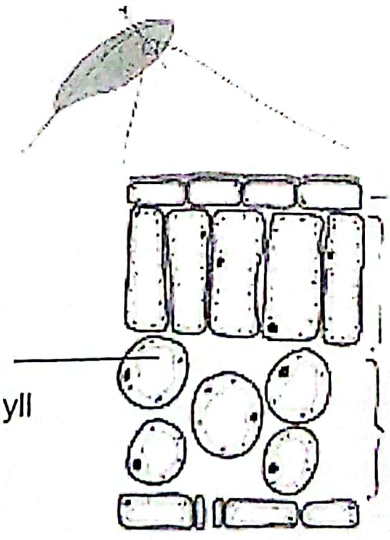
(f) Differentiate cell, tissue, organ, organ system.



How do cells work together in a multicellular organism?

Cells	Specialised for a particular function
↓	
Tissue	A group of similar cells which work together to perform a specific function
↓	
Organ	Different tissues working together to carry out a specific function
↓	
Organ system	Several related organs working together to carry out a particular function
↓	
Organism	

Example:



One spongy mesophyll **CELL**

This layer consisting of many spongy mesophyll cells is a tissue. Spongy mesophyll **TISSUE**.

All together, this is an **ORGAN** – the leaf.

Many different layers of tissue make up the organ.

CHAPTER 2 – MOVEMENT OF SUBSTANCES

Summary Table: Diffusion vs Osmosis

Differences in...	DIFFUSION	OSMOSIS
type of particle	Gas or liquid particles, except water	Water molecules only
**Partially-permeable membrane	Not required (but can have)	Required
definition	Net movement of particles down a concentration gradient	Net movement of water molecules down a water potential gradient through a partially permeable membrane

The rate of diffusion is affected by 3 factors:

Factor 1: Concentration Gradient	Factor 2: Surface Area	Factor 3: Temperature
the steeper the concentration gradient, the faster the rate of diffusion	the larger the surface area, the faster the rate of diffusion.	the higher the temperature, the faster the rate of diffusion.

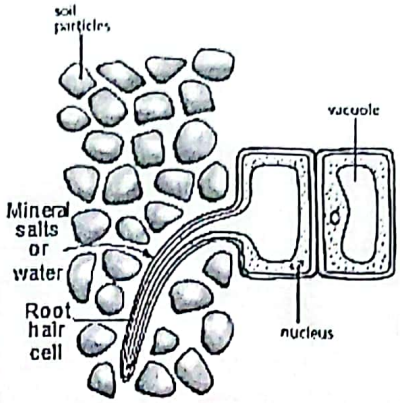
(a) Define diffusion and describe its role in nutrient uptake and gaseous exchange in plants and humans

NUTRIENT UPTAKE

Nutrient Uptake in Plants (Absorption of water and minerals)

NUTRIENT UPTAKE
By diffusion

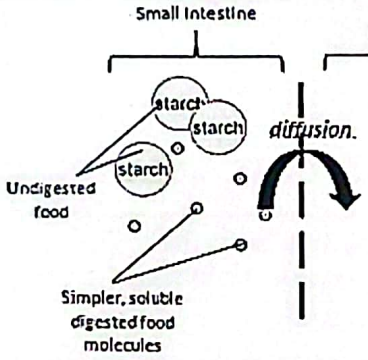
- Mineral salts move from
- A region of higher concentration (soil) to a region of lower concentration (root hair cell)
- down a concentration gradient
- By diffusion.



WATER UPTAKE
By osmosis

- Water molecules move from
- A region of higher water potential (soil) to a region of lower water potential (root hair cell)
- down a water potential gradient
- By osmosis.

Nutrient Uptake in Animals (Absorption of digested food in ileum)

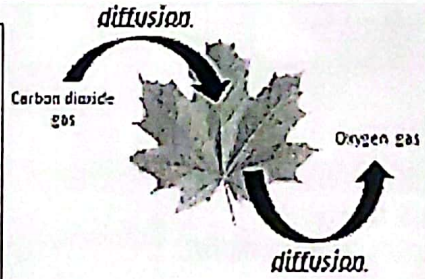


- Digested food molecules move from
- A region of higher concentration (small intestine) to a region of lower concentration (blood)
- down a concentration gradient
- By diffusion.

GAS EXCHANGE

Gas Exchange in Plants (for photosynthe-sis and respiration)

- Carbon dioxide molecules move
- From a region of higher concentration (surrounding air) to a region of lower concentration (leaf)
- down a concentration gradient
- By diffusion.



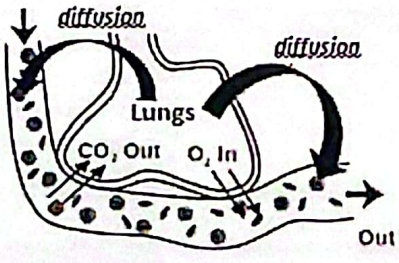
GAS EXCHANGE

- Oxygen molecules move
- From a region of higher concentration (leaf) to a region of lower concentration (surrounding air)
- down a concentration gradient
- By diffusion.

Gas Exchange in Animals (in alveolus)

Giving out of carbon dioxide
By diffusion

- Carbon dioxide molecules move from
- A region of higher concentration (blood) to a region of lower concentration (lungs)
- down a concentration gradient
- By diffusion.



Uptake of Oxygen
By diffusion

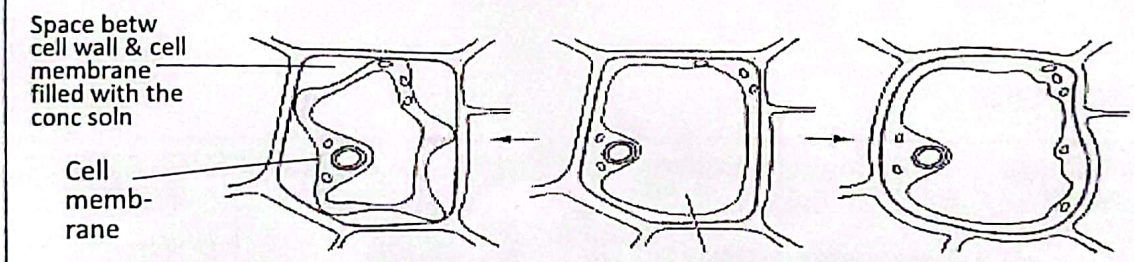
- oxygen molecules move from
- A region of higher concentration (lungs) to a region of lower concentration (blood)
- down a concentration gradient
- By diffusion.

(b) Define osmosis and describe the effects of osmosis on plant and animal tissues

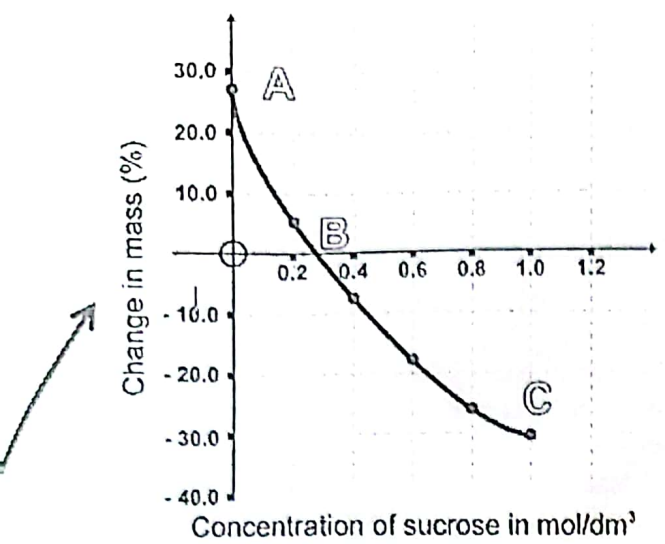
EFFECT OF OSMOSIS ON ANIMAL CELLS

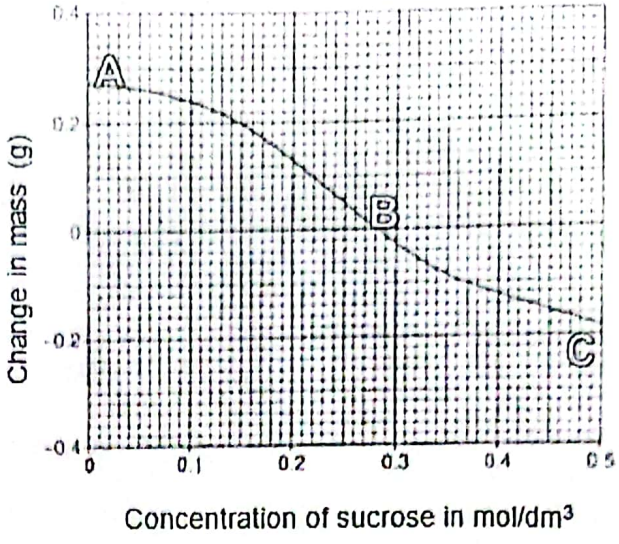
ANIMAL CELL placed in...	Concentrated solution (lower water potential)	Solution with the same water potential	Distilled water (higher water potential)
			
Describe the Appearance	Derease in size/shrunken, then become crenated	normal (no change)	Increase in size/ expanded, then burst
Explain	• Water molecules move • From a region of higher water potential (rbc) to a region of lower water potential (salt solution) • Through the partially-permeable cell membrane	• There is no net movement of water molecules as.. • the water potential of the RBC and the salt solution is the same. → there is no/zero water potential gradient	• Water molecules move • From a region of higher water potential (water) to a region of lower water potential (rbc) • Through the partially-permeable cell membrane

EFFECT OF OSMOSIS ON PLANT CELLS

PLANT CELL placed in...	Concentrated solution (lower water potential)	Solution with the same water potential	Distilled water (higher water potential)
			
Describe the Appearance	• Plant cell decreases in size • Vacuole becomes smaller • Cell membrane pulls away from cell wall	normal (no change)	• Plant cell increases in size • Vacuole becomes bigger
	Becomes flaccid and plasmolysed		Turgid (but does not burst)
Explain	• Water molecules move • From a region of higher water potential (plant cell) to a region of lower water potential (salt solution) • Through the partially-permeable cell membrane	• There is no net movement of water molecules • The water potential of the plant cell sap and the salt solution is the same. → there is no/zero water potential gradient	• Water molecules move • From a region of higher water potential (water) to a region of lower water potential (plant cell) • Through the partially-permeable cell membrane

Describing & Explaining Osmosis Graphs from Experiments





Graph	Describe the result shown...	Explain the result...
..at **point A**	Potato strip increased in mass by 28% when soaked in 0 mol/dm³ solution (distilled water).	➢ The water potential in the distilled water is higher than cell sap of potato cells. ➢ Water molecules enter the potato cells via osmosis through the partially-permeable membrane
..at **point B**	Potato strip had no change in mass when soaked in 0.3 mol/dm³	➢ **Water potential of sucrose solution is the same as water potential in cell sap of potato cells.** i.e. the potato cell sap concentration = 0.3 mol/dm³ ➢ There is no net movement of water. → Mass of potato strip remains the same.
..at **point C**	Potato strip decreased in mass by 30% when soaked in 1 mol/dm³ solution	➢ The water potential in the potato cells is higher than solution. ➢ Water molecules leave the potato cells via osmosis through the partially-permeable membrane.

Example Qn:

Outline how you can conduct an experiment to determine the cell sap concentration of potato.

- Prepare three known different concentrations of starch solution in three test tubes.
- Into each test tube, place one potato strip of the same dimensions for the same duration of time at the same temperature.
- Measure the initial and final lengths of the potato strips to calculate the change in length.
- Plot a graph where horizontal axis is the solution concentration and vertical axis is the change in length.
- The concentration where change is length is zero is equal to the concentration of potato cell sap. (see point B in above graphs)

Osmosis Experiment:
How to cut potato strips

https://tinyurl.com/CutPotatoOsmosis

CHAPTER 3a – BIOLOGICAL MOLECULES (NUTRIENTS)

(a) State the roles of water in living organisms

In humans only	In both plants and animals	In plants only
• **Water (in the form of sweat) helps to control body temperature.** When water in sweat evaporates from the skin surface, heat is removed to cool the body down. • **Water is a key component of blood which helps in transporting dissolved substances** Eg. Blood	• **Water is needed as a solvent for chemical reactions.** Eg. digestion, photosynthesis, respiration • **Water is needed as a key component of tissues.** Eg. as part of cytoplasm	• **Water is required for photosynthesis.** • Water is needed to **keep plant cells turgid and firm.** If plant cells lose/lack too much water, they become **plasmolysed.** • **Water in the xylem transports dissolved mineral salts** from roots to all parts of the plant. **Water in the phloem helps to dissolve sugars** manufactured from photosynthesis and transport them from the leaves to all parts of the plant.

(b) State that large molecules are synthesised from smaller basic units: glycogen and starch from glucose, polypeptides and proteins from amino acids, fats (lipids) from glycerol and fatty acids.

Summary: 3 Key Nutrients

	CARBOHYDRATES	PROTEINS	FATS
Elements	Carbon, Hydrogen, Oxygen	Carbon, Hydrogen, Oxygen, Nitrogen	➢ Carbon, Hydrogen, Oxygen
Single basic unit	Glucose	Amino Acids (20 different types in nature)	➢ 1 Glycerol + 3 Fatty Acids
Functions	➢ Starch is a relatively immediate source of energy. ➢ Glucose is oxidised/utilised during respiration to release energy for all cellular activities.	➢ Repair and build new cells and tissues ➢ Build muscles ➢ Synthesise other substances like enzymes, hormones	➢ Keep warm / heat insulation to prevent excessive heat loss in winter ➢ Secondary source of energy ➢ Store energy (more compact form of storing energy as compared to starch) ➢ To make cell membranes
Sources	➢ Starch: Bread, rice, pasta, bananas, potato, yam ➢ Sugars: fruits, candy	Lean meat, fish Tofu, beans, Egg white	Oil, cheese, butter
Examples and different forms	➢ single sugar: glucose ➢ double sugars: maltose, sucrose *Note: sucrose is not a reducing sugar. ➢ complex carbohydrates: in plants → starch, cellulose (cell walls) in animals → glycogen (stored in liver, muscles)	Examples of substances which are proteins include enzymes, hormones, etc.	Diet high in fats and cholesterol can lead to coronary heart disease.

(c) Describe and carry out tests for starch (Iodine test), reducing sugars (Benedict's test), protein (biuret test), fats (ethanol emulsion test)

Scan the QR codes to watch Youtube videos of how to **perform FOOD TESTS**:

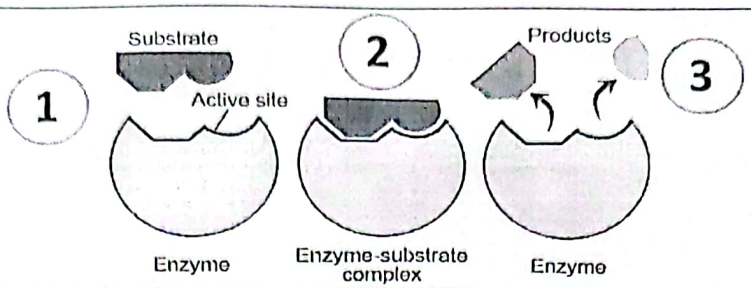
Test for Starch (Iodine Test)	Test for Reducing Sugar (Benedict's Test)	Test for Protein (Biuret Test)	Test for Fats (Ethanol Emulsion Test)

Summary Table – Food Tests

Nutrient tested	Starch	Reducing Sugar (eg. glucose, not sucrose)	Protein (not amino acids/ polypeptides)	Fats
Food Test	Name: Iodine Test Reagent: Iodine solution	Name: Benedict's Test Reagent: Benedict's solution	Name: biuret Test Reagent: sodium hydroxide solution + copper sulfate solution / biuret solution	Name: Ethanol emulsion Test Reagent: Ethanol, distilled water
Procedure	1. Add 2 drops of iodine solution to solid sample. OR 1. Add $2cm^3$ of liquid sample into a test tube. 2. Add 2 drops of iodine solution and shake.	1. Add $2cm^3$ of sample into a test tube. 2. Add $2cm^3$ of Benedict's solution. Shake to mix. 3. Place the test tube in a boiling water bath for 3 minutes. Refer to the diagram drawn.	1. Add $2cm^3$ sample into a test tube. 2. Add $2cm^3$ sodium hydroxide solution. Shake to mix. 3. Add copper sulfate solution drop by drop, shaking after each drop. OR replace steps 2 and 3 with this step 2: 2. Add $2cm^3$ of biuret solution. Shake well and allow to stand for 5 min.	1. Add $2cm^3$ of sample into a test tube. 2. Add $2cm^3$ of ethanol. Shake to mix. 3. Add $2cm^3$ of water. Shake to mix.
Results / Observations	Observation → Conclusion Iodine solution remains brown → Starch is absent. Iodine solution turns blue-black. → Starch is present	Observation → Conclusion Solution remains blue → Reducing sugar absent Brick-red ppt formed → Large amount of reducing sugar present. Orange / yellow ppt formed → Moderate amount of reducing sugar present Green ppt formed → Little amount of reducing sugar present	Observation → Conclusion Solution remains blue → Protein is absent. biuret solution turns violet → Protein is present	Observation → Conclusion Solution remains clear → Fat is absent. White emulsion formed → Fat is present

CHAPTER 3b – BIOLOGICAL MOLECULES (ENZYMES)

(c) Explain enzyme action in terms of the "lock and key" hypothesis (explain the mode of action of enzymes in terms of an active site, enzyme-substrate complex, and enzyme specificity).

<table>
<tr><th colspan="4">How do enzymes work?</th></tr>
<tr><td>Labelled diagram to show how enzymes work:</td><td colspan="3"> 
</td></tr>
<tr><td>Describe the mode of action of an enzyme.</td><td>Step 1:
• The enzyme binds the substrate at the enzyme's active site.</td><td>Step 2:
• Enzyme-substrate complex is formed.
• Chemical reaction occurs.</td><td>Step 3:
• Enzyme releases products.</td></tr>
<tr><td>Using the lock-and-key hypothesis, describe the mode of action of an enzyme.
S is the K
E is the L</td><td>Step 1:
• The Substrate is like the Key.
The Enzyme is like the Lock.
The active site is like the keyhole.
• Shape of the active site is <u>complementary</u> to shape of substrate.
• Enzyme binds substrate at active site.</td><td>Step 2:
• Enzyme-substrate complex is formed.
• Chemical reaction occurs.</td><td>Step 3:
• Enzyme releases products.
Enzyme remains chemically unchanged and can be reused for the next reaction.</td></tr>
</table>

Example Qn testing on Specificity of Enzyme:

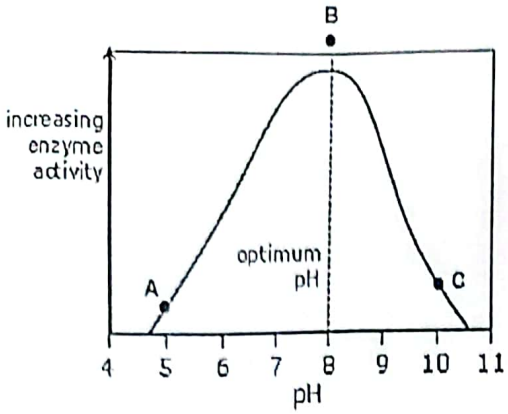
With reference to the lock-and-key hypothesis, explain why amylase can only digest starch and not fats.

- The <u>substrate (starch) is like the key</u>. The <u>enzyme (amylase) is like the lock</u>. The active site is like the keyhole.
- <u>3D Shape of Enzyme's active site is complementary to 3D shape of substrate</u>. So, amylase can bind starch and digest it.
- But the shape of fats is <u>not complementary</u> to the shape of active site of amylase.
  Thus, amylase <u>cannot bind</u> fats to form Enzyme-Substrate complex. <u>No chemical reaction</u> occurs.
  So amylase cannot digest fats.

Enzymes Revision Video 1: Mode of Action, Lock & Key	Enzymes Revision Video 2: Enzyme Graphs
<u>https://tinyurl.com/MsYTMLEnzymes1</u>	<u>https://tinyurl.com/MsYTMLEnzymes2</u>

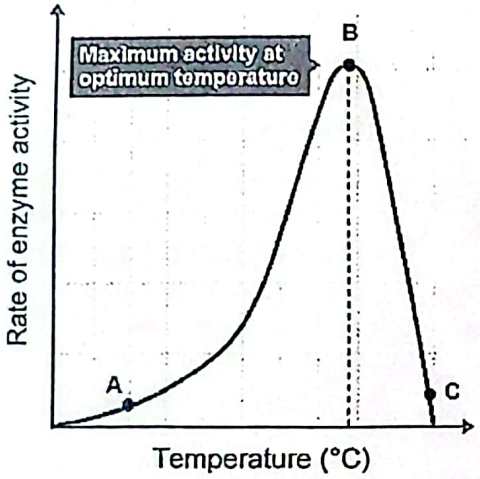
(d) Investigate and explain the effects of temperature and pH on the rate of enzyme-catalysed reactions.

Effect of pH:



Describe how **enzyme activity** is affected…		Explain why.
At a particular **point** in the graph *(eg. At point A…)*	(a) At point A (pH 5), enzyme activity is low. (b) At point B (pH 8), enzyme activity is maximum. (c) At point C (pH 10), enzyme activity is low.	(a) Because enzymes are denatured. (b) Because enzymes are most active at optimum pH 8. (c) Because enzymes are denatured.
From **one point to another point** in the graph *(eg. as pH increases from 5 to 9…)*	(a) From A to B (pH 5 to pH 8), enzyme activity is increasing (b) until at Point B (pH 8), where enzyme activtiy is maximum. (c) From point B to C (pH 8 to pH 10, enzyme activity is decreasing.	(a) Because enzymes are more active nearer optimum pH. (b) Because enzymes are most active at optimum pH 8. (c) Because enzymes are denatured above optimum pH.

Effect of temperature:



Describe how **enzyme activity** is affected…		Explain why.
At a particular **point** in the graph *(eg. At point A…)*	(a) At point A , enzyme activity is low. (b) At point B, enzyme activity is maximum. (c) At point C, enzyme activity is low.	(a) Because enzymes are denatured. (b) Because enzymes are most active at optimum temperature. (c) Because enzymes are denatured.
From **one point to another point** in the graph *(eg. as pH increases from 5 to 9…)*	(a) From A to B (approaching optimum temperature), enzyme activity is increasing (b) until at Point B, where enzyme activtiy is maximum. (c) From point B to C, enzyme activity is decreasing.	(a) Because when temperature increases, particles move faster and there are more effective collisions. (b) Because enzymes are most active at optimum temperature. (c) Because enzymes are denatured above optimum temperature.

Common digestive enzymes:

Enzymes	Substrates to Products	Optimum pH level
****PEPSIN (in gastric juice in stomach)**	**Proteins to Polypeptides**	**2-3 (acidic)**
Lipase (in pancreatic and intestinal juice in small intestine)	Fats to Fatty acids & Glycerol	**7-8** (slightly alkaline)
Salivary amylase (in saliva secreted into mouth)	Starch to maltose	**6-7** (slightly acidic)
Amylase (in pancreatic juice secreted into duodenum)	Starch to Maltose	**7-8** (slightly alkaline)
Proteases (in pancreatic juice secreted into duodenum)	Proteins to Polypeptides	**7-8** (slightly alkaline)
Proteases (in intestinal juice secreted into ileum)	Polypeptides to Amino acids	**7-8** (slightly alkaline)
Maltase (in pancreatic and intestinal juice in small intestine)	Maltose to Glucose	**7-8** (slightly alkaline)

CHAPTER 4 – ANIMAL NUTRITION

Why is Digestion important?

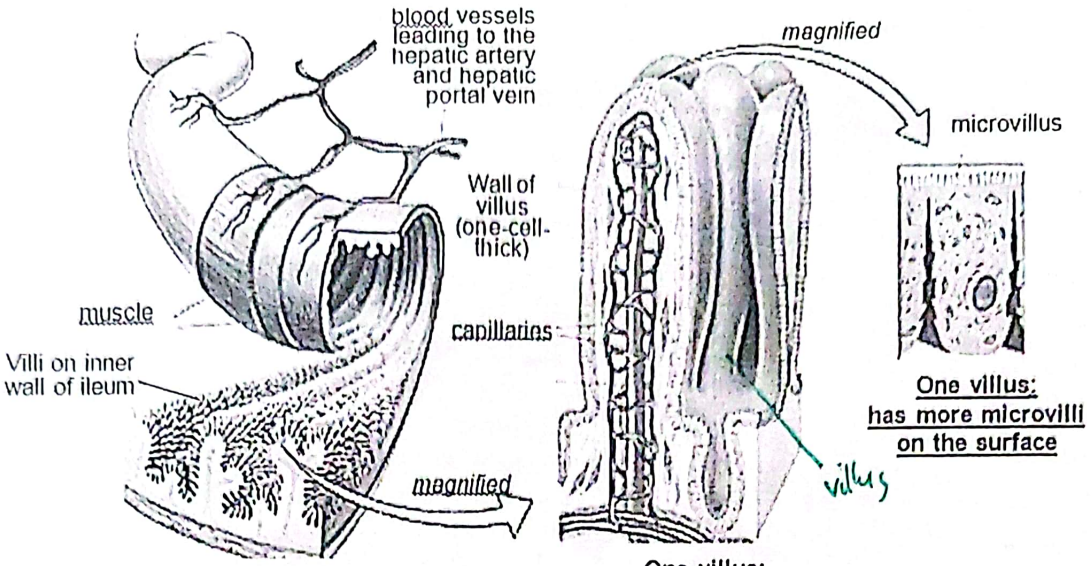
- Digestion breaks down large food substances into smaller, simpler and soluble molecules
- These can then be absorbed from the ileum into the blood down a concentration gradient by diffusion

(c) Describe functions of enzymes (amylase, maltase, protease, lipase) in digestion, listing the substrates and end-products.

	STARCH (complex carbohydrate)	PROTEIN	FATS	To note / Physical Digestion
MOUTH Secretion: Saliva	Starch is digested by salivary amylase into maltose. (optimum pH: 6-7)	No protein digested.	No fats digested.	Physical Digestion: Chewing (increases SA:vol for faster digestion by enzymes)
OESOPHAGUS	No starch digested, although some may continue here from digestion in mouth.	No protein digested.	No fats digested.	No digestive enzymes in oesophagus, thus so digestion.
STOMACH Secretion: Gastric Juice	No starch/carbohydrate digested.	Protein is digested by pepsin into polypeptides. (optimum pH: 2-3)	No fats digested.	Physical Digestion: Churning (mixes food with enzymes)
DUODENUM (optimum pH: 7-8) Secretion: Pancreatic Juice	- Starch is digested by (pancreatic) amylase into maltose. - Maltose is digested by (pancreatic) maltase into glucose.	- Protein is digested by (pancreatic) proteases into polypeptides. - Polypeptides are further digested by (pancreatic) proteases into amino acids.	Emulsified fats are digested by (pancreatic) lipase into glycerol and fatty acids.	- Bile produced by liver is secreted from gall bladder into duodenum and ileum - to emulsify fats for faster fat digestion by lipase.
ILEUM (optimum pH: 7-8) Secretion: Intestinal Juice	- Starch is digested by (intestinal) amylase into maltose. - Maltose is digested by (intestinal) maltase into glucose.	- Protein is digested by (Intestinal) proteases into polypeptides. - Polypeptides are further digested by (intestinal) proteases into amino acids.	Emulsified fats are digested by (intestinal) lipase into glycerol and fatty acids.	Digestion is completed here. Absorption of digested food occurs.
COLON	No digestion occurs. Water and minerals are absorbed, leading to formation of faeces.			
RECTUM	Storage of faeces			
ANUS	Removal of faeces from body			

How is the ILEUM adapted for its function of ABSORPTION OF DIGESTED FOOD?

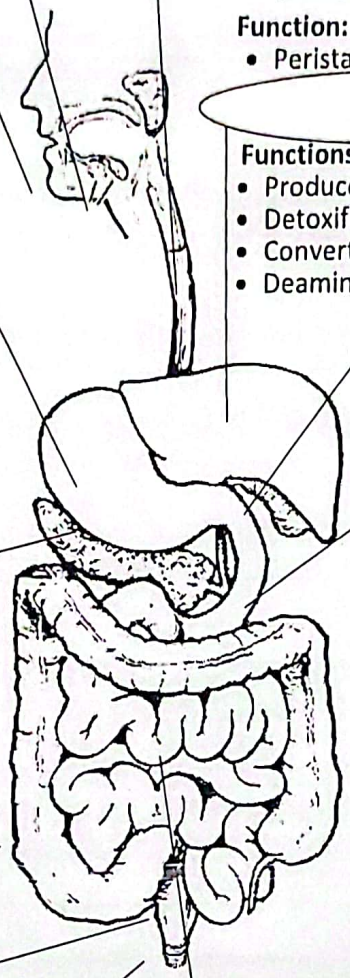
ABSORPTION IN ILEUM: VILLUS & MICROVILLUS



	4 Adaptations of ileum	Explain how it enables efficient absorption (link to diffusion rate)
1	Small intestine is very long	• To allow sufficient time for more digested nutrients to be absorbed
2	Inner surface of ileum wall is lined with villi, and each villi has microvilli	• This increases the surface area to volume ratio of the inner ileum wall • Hence increasing rate of diffusion of digested food substances
3	Wall of villi is one-cell thick, and membrane of microvilli is very thin	• This reduces distance that digested food diffuses across • Hence increasing rate of diffusion
4	Each villus is surrounded by a rich network of blood capillaries	• This allows digested nutrients like glucose and amino acids to be quickly transported away in the blood capillaries • So as to maintain a steep concentration gradient for efficient diffusion of digested food into blood.

(a) Describe functions of main regions of alimentary canal and associated organs (mouth, salivary glands, oesophagus, stomach, duodenum, pancreas, gall bladder, liver, ileum, colon, rectum anus) in relation to ingestion, digestion, absorption, assimilation and egestion

DIGESTIVE SYSTEM: STRUCTURE & FUNCTION



MOUTH (pH: 6-7)

Function - Physical Digestion:
- Teeth chews food into smaller pieces (higher SA)
- Tongue rolls food into boli and mixes it with saliva

Function- Chemical Digestion:
- Starch is digested by

SALIVARY GLANDS

Function:
- Secretes saliva containing salivary amylase
- Into the mouth via salivary ducts

OESOPHAGUS

Structure:
- Long tube with circular and longitudinal muscles (antagonistic muscles)

Function:
- Peristalsis – to push food down towards stomach.

STOMACH (pH: 2-3)

Structure:
- Distensible, muscular bag
- Walls secrete gastric juice (containing pepsin and HCl)

Function – Physical Digestion:
- Stomach churns to mix the partially-digested food with gastric juice.

Function- Chemical Digestion:
- Proteins are digested by pepsin (from gastric juice) into polypeptides.
- HCl provides optimum pH for pepsin activity.

LIVER

Functions:
- Produce & secrete bile to emulsify fat
- Detoxifies alcohol into harmless substances
- Converts excess glucose into glycogen for storage
- Deaminates excess amino acids into urea for removal

GALL BLADDER

Function:
- Stores bile
- Secretes bile into duodenum via bile duct

DUODENUM (pH: 7-8)

Structure:
- Pancreatic juice containing pancreatic enzymes secreted into duodenum.
- Bile is secreted into duodenum.

Function – Physical Digestion:
- Fats are emulsified by bile into smaller emulsified fat droplets (higher SA).

Function - Chemical Digestion:
- Pancreatic amylase digests starch into malto Maltase digests maltose into glucose.
- Pancreatic protease digests proteins into polypeptides. Peptidases digest polypeptide into amino acids
- Pancreatic lipase digests emulsified fats into fatty acids + glycerol.

PANCREAS

Structure:
- Feather-shaped
- Accessory organ

Function:
- Produces and secretes pancreatic juice (containing digestive enzymes) into the duodenum

COLON

Function:
- Absorbs water and mineral salts from undigested waste materials that pass through it

RECTUM

Function:
- Stores faeces (undigested waste materials)

ANUS

Function:
- Egestion of faeces from body

ILEUM (pH: 7-8)

Structure:
- Intestinal juice containing intestinal enzymes secreted. Bile is also secreted into ileum.
- Inner walls have numerous villi for higher SA to volume ratio.
- Each villus in turn has microvilli to further increase SA to volume ratio for faster absorption of digested food.

Function – Chemical Digestion:
- Pancreatic amylase digests starch into maltose. Maltase digests maltose into glucose.
- Pancreatic protease digests proteins into polypeptides. Peptidases digest polypeptides into amino acids
- Pancreatic lipase digests emulsified fats into fatty acids + glycerol.

Function – Absorption of digested food:
- Products of digestion are absorbed through the villi into the blood down a concentration gradient by diffusion.

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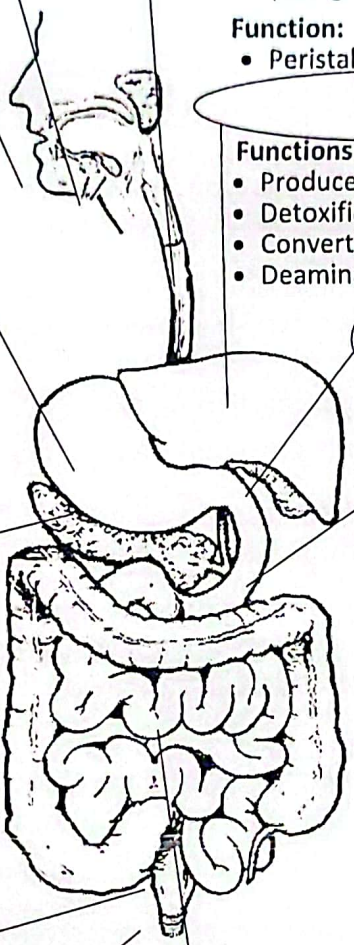

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- Egestion of faeces from body

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- Inner walls have numerous villi for higher SA to volume ratio.
- Each villus in turn has microvilli to further increase SA to volume ratio for faster absorption of digested food.

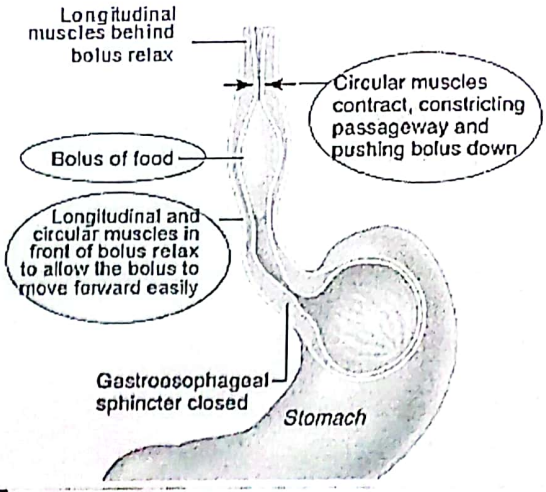
Function – Chemical Digestion:
- Pancreatic amylase digests starch into maltose. Maltase digests maltose into glucose.
- Pancreatic protease digests proteins into polypeptides. Peptidases digest polypeptides into amino acids
- Pancreatic lipase digests emulsified fats into fatty acids + glycerol.

Function – Absorption of digested food:
- Products of digestion are absorbed through the villi into the blood down a concentration gradient by diffusion.

(b) Understand what peristalsis is and where it occurs to propel food along the alimentary canal

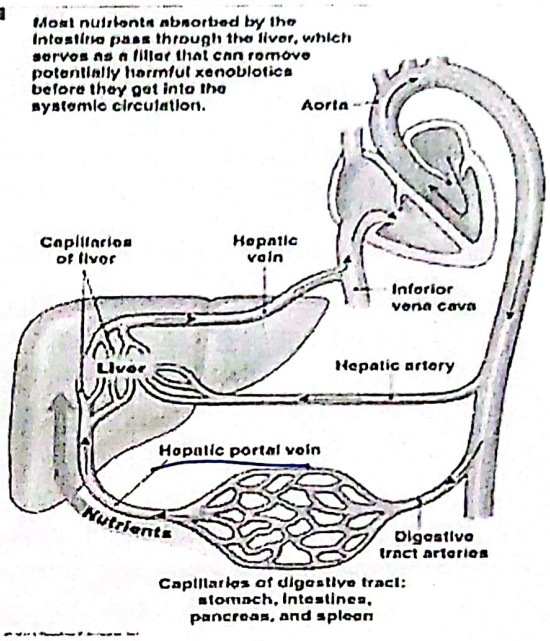
PERISTALSIS is the rhythmic, wave-like muscular contractions and relaxations of the muscles in the walls of the alimentary canal, and mainly the **oesophagus**

- Peristalsis occurs mainly in the oesophagus, and
- also occurs in **other parts of the alimentary canal** to propel food down the alimentary canal from one organ to the next + to mix food with digestive juices



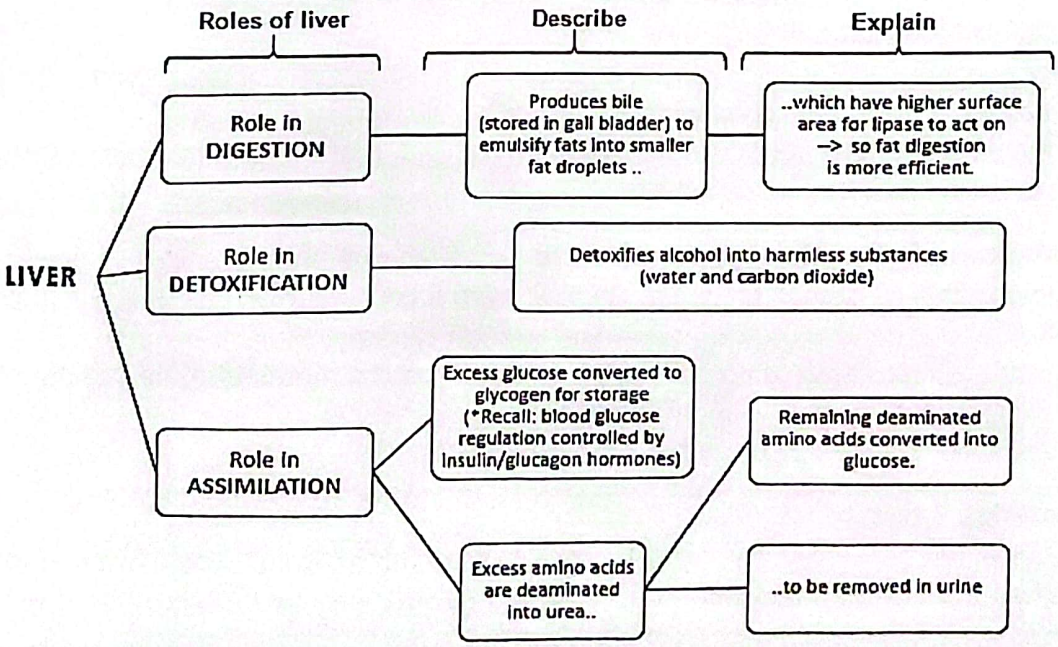
(d) State function of hepatic portal vein in the transport of blood rich in absorbed nutrients from the small intestine to liver

- Hepatic portal vein transports blood containing the absorbed digested food (glucose and amino acids) from the ileum directly to the liver.



(e) State the role of liver in metabolism of glucose, metabolism of amino acids and formation of urea (deamination), breakdown of alcohol (detoxification), production of bile to aid in fat digestion.

The 4 key roles of liver in human nutrition



CHAPTER 5 – PLANT NUTRITION

(b) State the word equation for photosynthesis.

- The site of photosynthesis is the leaf (specifically, the palisade and spongy mesophyll cells).

$$\text{carbon dioxide + water} \xrightarrow[\text{chlorophyll}]{\text{light}} \text{glucose + oxygen}$$

(d) State that chlorophyll traps light energy and converts it into chemical energy for the formation c carbohydrates and their subsequent uses and storage of starch

- What is the fate of the products of photosynthesis?
  - Some glucose is converted into sucrose to be transported from the leaf to other parts via the phloem by translocation.
  - Excess glucose is converted into starch and stored in the leaf or in storage organs.
  - Oxygen gas and glucose produced from photosynthesis is used to carry out respiration to release energy for growth and repair.

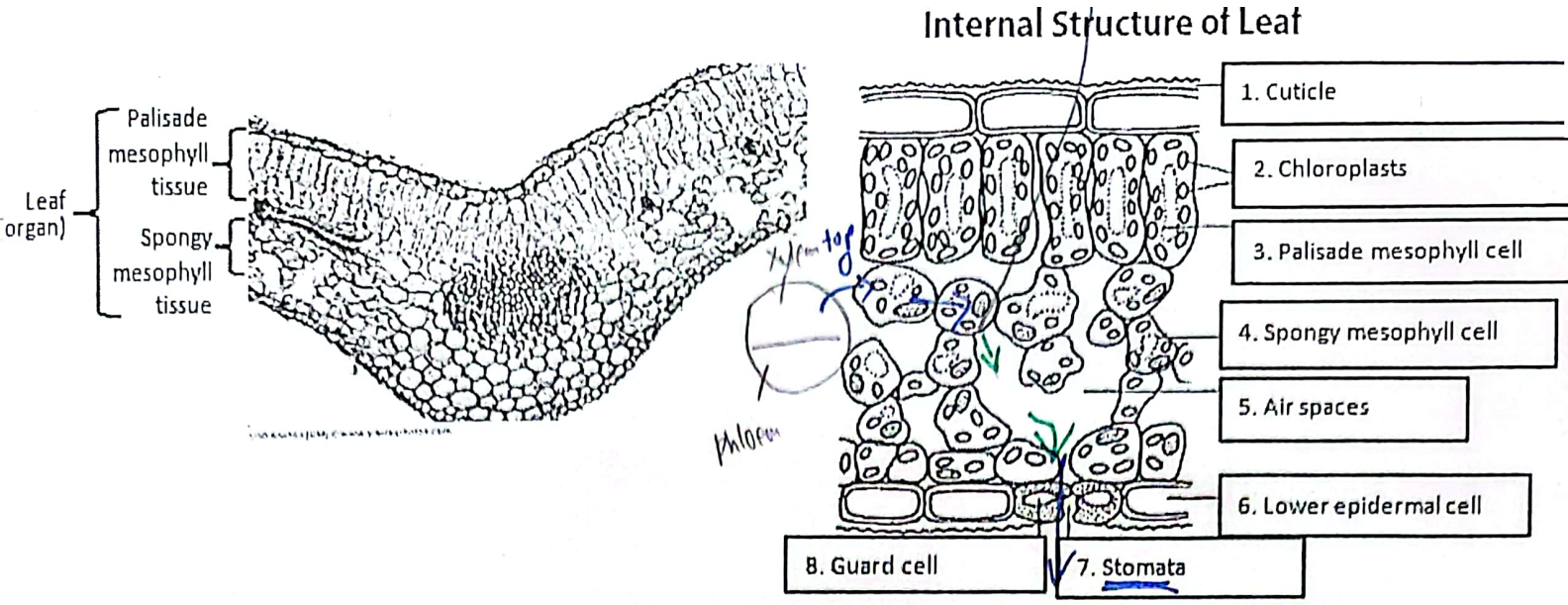
(f) Briefly explain why most life forms are completely dependent on photosynthesis.

Photosynthesis is important for the survival of all living organisms because...

1. Green plants are producers which can carry out photosynthesis because they contain chloroplasts to trap light energy.
   Through photosynthesis, they convert light energy into chemical energy stored in glucose.
   Other organisms do not have chloroplasts and have to obtain chemical energy from plants indirectly or directly by consuming them.
2. Photosynthesis removes carbon dioxide from the air and releases oxygen that is needed for respiration carried out by all organisms for energy.

(a) Identify the cellular and tissue structure of a dicot leaf, as seen in cross-section under the microscope and state their functions:

- **distribution of chloroplasts – photosynthesis**
  - The highest concentration of chloroplasts, and hence the highest rate of photosynthesis occurs the palisade mesophyll cells, then spongy mesophyll cells, followed by guard cells.
  - Because the palisade mesophyll cells receive the most light, so they have the most number of chloroplasts to trap light for photosynthesis.
- **stomata and mesophyll cells – gas exchange**
  - During photosynthesis, oxygen produced diffuses down a concentration gradient from the mesophyll cells, into air spaces, then out of leaf through stomata.
    Carbon dioxide diffuses down a concentration gradient from the surrounding air into the stomata, then into air spaces, then into mesophyll cells.
  - During respiration, the reverse occurs.
- **vascular bundles – transport**
  - Xylem vessels transport water and minerals from roots to the leaves (mesophyll cells) for use in photosynthesis, by transpiration pull.
  - Phloem transports sugars (sucrose) manufactured in the leaves (mesophyll cells) to all parts of the plant for respiration or storage, by translocation.

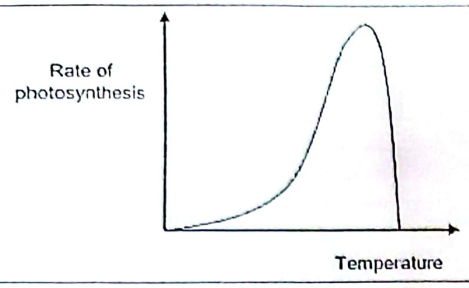


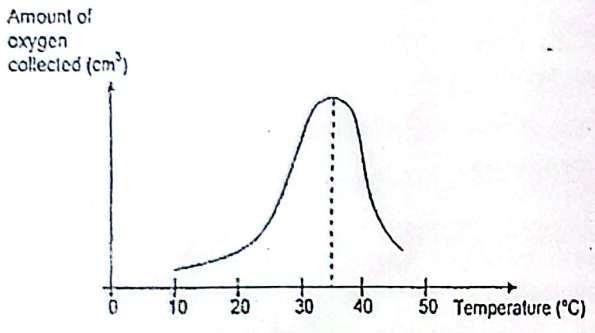
	Part	Structure	Function
1	Cuticle	• Waxy, waterproof • Transparent	• Prevents evaporation of water • Allows light to pass into the leaf
2	Chloroplasts	• Contains chlorophyll • Found in palisade and spongy mesophyll cells and less in guard cells	• Chlorophyll is needed to absorb light for photosynthesis
3	Palisade mesophyll	• Elongated, cylindrical shape • Closely-packed • Contains the highest number of chloroplasts	• Receives the most light and has most chloroplasts → Main site of photosynthesis in the leaf
4	Spongy mesophyll	• Irregularly-shaped • Has large inter-cellular air spaces among cells • Contains some chloroplasts • Cells covered with thin film of moisture • Contains vascular bundle (xylem + phloem)	• Can carry out some photosynthesis • Moisture →for gases to dissolve in for faster diffusion • Xylem transports water (needed for photosynthesis) and minerals to mesophyll cells • Phloem transports sugars produced during photosynthesis away from leaf
5	Air spaces	• System of interconnecting air spaces among spongy mesophyll cells	• Allows gases* to diffuse quickly into and out of mesophyll cells
6	Lower epidermis	• Single layer of epidermal cells (also found in upper epidermis) • Covered by outer layer of cuticle to reduce water loss through stomata	
7	Stoma (sing.) Stomata (pl.)	• An opening in between 2 guard cells	• Allows gases to diffuse in and out of leaf
8	Guard cell	• Occurs in pairs that surround a stoma	• Control the rate of gases* diffusing in and out of leaf by controlling the size of stomata • Turgid guard cells → stomata open wider • Flaccid guard cells → stomata closes more

(e) Investigate and state the effect of varying light intensity, carbon dioxide concentration and temperature on the rate of photosynthesis (eg. in submerged aquatic plants)

TEMPERATURE

Photosynthesis involves enzymes. Therefore, rate of photosynthesis is affected by temperature because enzyme activity is affected by temperature.





Describe the effect of temperature on photosynthesis.

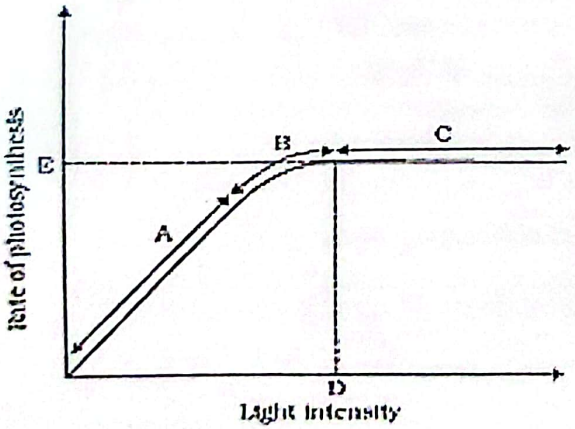
1) As temperature increases up to optimum temperature of 35°C, rate of photosynthesis also increases.
2) At optimum temperature of 35°C, rate of photosynthesis is maximum / highest.
3) When temperature increases further above 35°C, rate of photosynthesis decreases.

Explain.

1) Enzymes are becoming more active → Chance of effective collisions increases.
2) Enzymes are most active → highest chance of effective collusions
3) Enzymes are becoming denatured due to high temperatures.

LIGHT INTENSITY

Light energy is required for photosynthesis, where light energy is converted to chemical energy. Therefore, rate of photosynthesis is affected by light intensity (or distance between lamp and the plant).



Describe the effect of light intensity on photosynthesis.

A. As light intensity increases, rate of photosynthesis also increases. Limiting factor is light intensity.
B. As light intensity increases, rate of photosynthesis also increases to maximum rate (point **E**). Limiting factor is light intensity.
C. As light intensity increases further, rate of photosynthesis remains the same. The limiting factor is no longer light intensity.

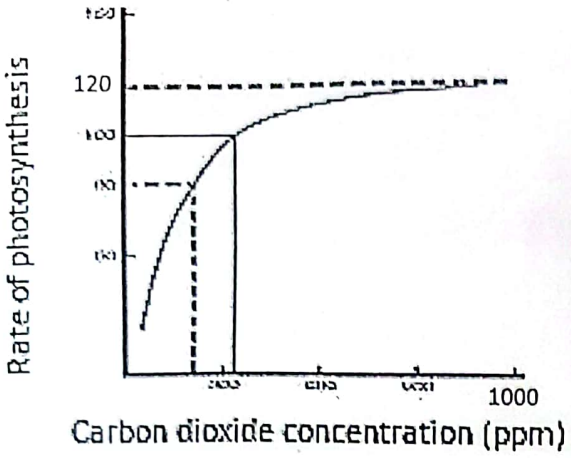
Explain.

A. and B. More light intensity is being supplied for photosynthesis. Light is required for photosynthesis.

C. Although more light is supplied (in excess), rate of photosynthesis is limited by non-optimum temperature or insufficient CO_2 concentration.

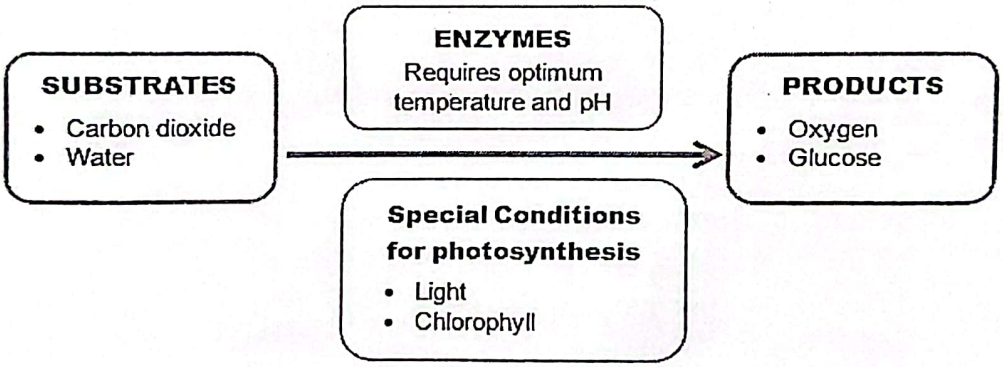
CARBON DIOXIDE CONCENTRATION

Carbon dioxide is a substrate required for photosynthesis. Carbon in carbon dioxide will be converted to carbon in glucose. Hence, rate of photosynthesis is affected by concentration of carbon dioxide substrate.



Describe the effect of CO_2 concentration on photosynthesis.	**Explain.**
• As CO_2 concentration increases from 0 to 1000ppm, o Rate of photosynthesis also increases up to 120 units. o the limiting factor is <u>CO_2 concentration</u>	• More CO_2 substrate (reactants) present for photosynthesis chemical reaction.
• As CO_2 concentration increases further above 1000ppm, o Rate of photosynthesis remains the same (and does not increase any more). o The limiting factor is <u>no longer CO_2 concentration</u>	• Although more CO_2 substrate is supplied (in excess), the rate of photosynthesis is limited by other conditions like non-optimum temperature or insufficient light intensity.

EXPERIMENTS INVESTIGATING PHOTOSYNTHESIS



- **DESTARCHING BEFORE** experiment

Method 1	Method 2
Place the plant in a dark room for 48 hours.	Cover the <u>leaves</u> with <u>black paper</u> for <u>48 hours</u>.

How does this help to destarch the plant?

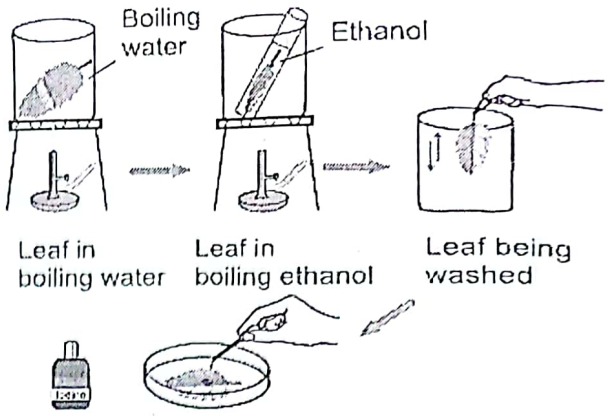
In the dark...
- o Photosynthesis stops → no new starch is produced.
- o Plants use up starch reserves to carry out respiration to release energy.

Why need to destarch the plant before experiment?

Rationale:
- remove all the existing starch present in the leaves before using it for an experiment
- so that any starch found present is produced due to the leaf photosynthesising during the experiment

- **PREPARING A LEAF FOR STARCH TEST**

Step	Procedure	Rationale
1	Put leaf in boiling water for 2 min	Kill leaf cells and break open cell wall
2	Immerse boiled leaf in a boiling tube containing alcohol/ethanol. Place the boiling tube in a boiling water bath for 10 min.	Decolourise leaf by removing chlorophyll from leaf cells.
3	Gently remove leaf and dip it in hot water to rinse it.	Soften the brittle leaf and make it more permeable to iodine solution.
4	Remove leaf and spread evenly on a white tile. Add a few drops of iodine solution.	Performing iodine test to test for presence of starch.

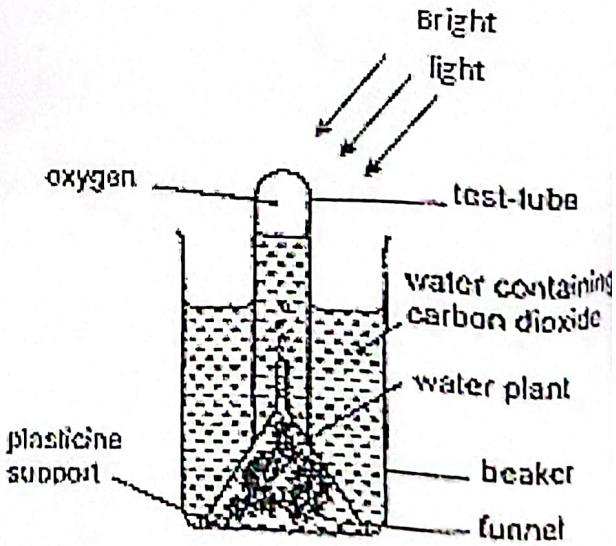


Results:

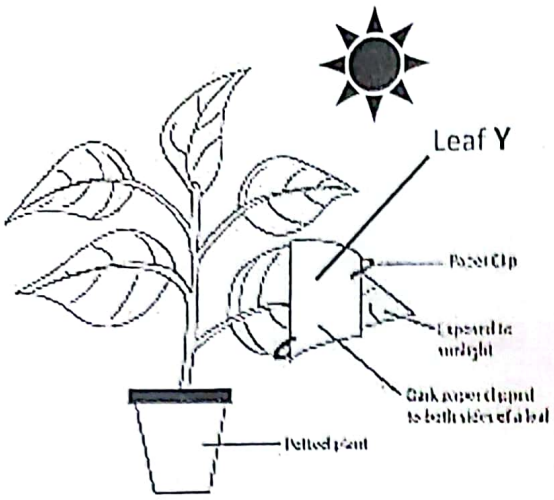
Observation *(What was seen?)*	**Conclusion** *(Link to food test)*	**Implication** *(This shows/means…)*
Iodine solution turns blue-black.	Starch is present in leaf.	• The leaf carried out photosynthesis. • Glucose produced was converted to starch and stored in leaf.
Iodine solution remains brown.	Starch is absent.	The leaf did not photosynthesise.

- **INVESTIGATING IF PHOTOSYNTHESIS HAS OCCURRED BY DETERMINING IF O_2 IS PRODUCED**

Observation	Conclusion	Implication
Gas bubbles produced from underside of leaves and rise upwards.	Oxygen is produced and photosynth-esis had taken place.	• Assumption: gas produced is oxygen o To test for O_2: glowing splint relights. • The leaf had carried out photosynthesis and produced oxygen, • which was released through stomata that are mostly on the underside of the leaves.
No. of gas bubbles counted per min is _____ .		
Length of column of gas collected at the top of test tube is _____ cm.		



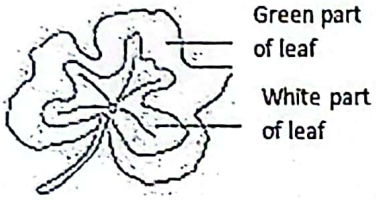
EXPERIMENT – LIGHT IS REQUIRED FOR PHOTOSYNTHESIS



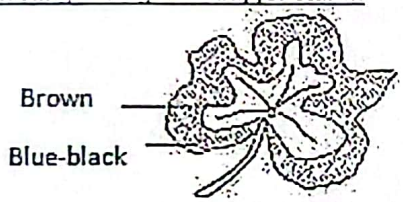
Starch Test	On parts exposed to sunlight	On parts covered by dark paper
Describe your observation/ results.	Iodine solution turned blue-black as Starch was produced.	Iodine solution remained brown as Starch was not produced.
Explain your observation/ results.	- This part of the leaf was able to carry out photosynthesis - as the leaf was able to trap light.	- This part of the leaf was **not** able to carry out photosynthesis - the leaf did not receive and absorb any light.
Only parts which absorbed light were able to photosynthesise to produce glucose, later stored as starch in the leaves.		

• EXPERIMENT – CHLOROPHYLL IS REQUIRED FOR PHOTOSYNTHESIS

Variegated leaf at the start

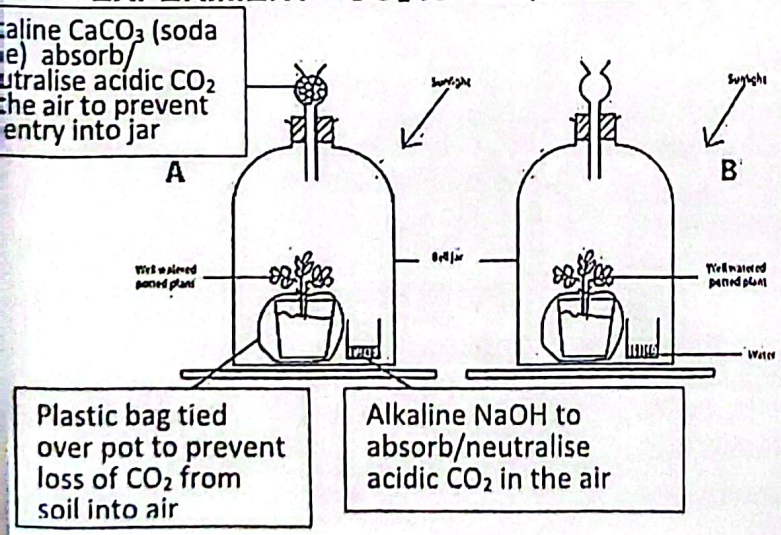


After testing variegated leaf for starch



Starch Test	On green parts	On white parts
Describe your observation/ results.	Iodine solution turned blue-black as starch was produced.	Iodine solution remained brown as starch was not produced.
Explain your observation/ results.	- This part of the leaf was able to carry out photosynthesis - as the leaf contained chlorophyll that can trap light.	- This part of the leaf was **not** able to carry out photosynthesis - as the leaf did not contain any chlorophyll needed to trap light
Only parts which contained chlorophyll were able to photosynthesise to produce glucose, later stored as starch in the leaves.		

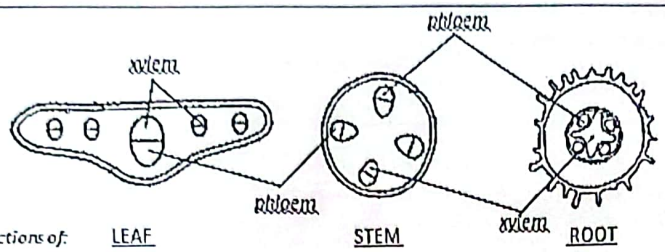
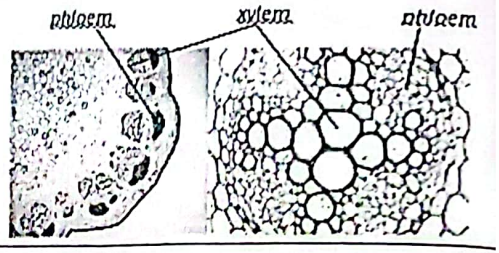
• EXPERIMENT –CO_2 IS REQUIRED FOR PHOTOSYNTEHSIS



Starch Test	**Plant A** (CO_2 absent)	**Plant B** (CO_2 present)
Describe observation/ results.	Iodine solution remained brown as starch was not produced.	Iodine solution turned blue-black as starch was produced.
Explain observation/ results.	- Leaf from A was **not** able to carry out photosynthesis - as there was **no** CO_2 substrate	- Leaf from B was able to carry out photosynthesis as there was CO_2 substrate for photosynthesis

CHAPTER 6 – PLANT TRANSPORT

(a) Identify the positions of xylem vessels and phloem in sections of a typical dicot leaf under the light microscope, and state their functions

	XYLEM	PHLOEM
What it transports (function)	Transports water and mineral salts from the roots to leaves by the process of transpiration pull.	Transports sugars (in the form of sucrose) from the leaves/storage organs to all parts of the plant by the process of translocation.
Diagrams/labels of xylem & phloem in different parts of the plant		Electronmicrograph photos of vascular bundles: 

(b) Relate structure and function of root hair to their surface area, and to uptake of water and ions

**Refer to Chapter 1, Learning Outcome (e) –*

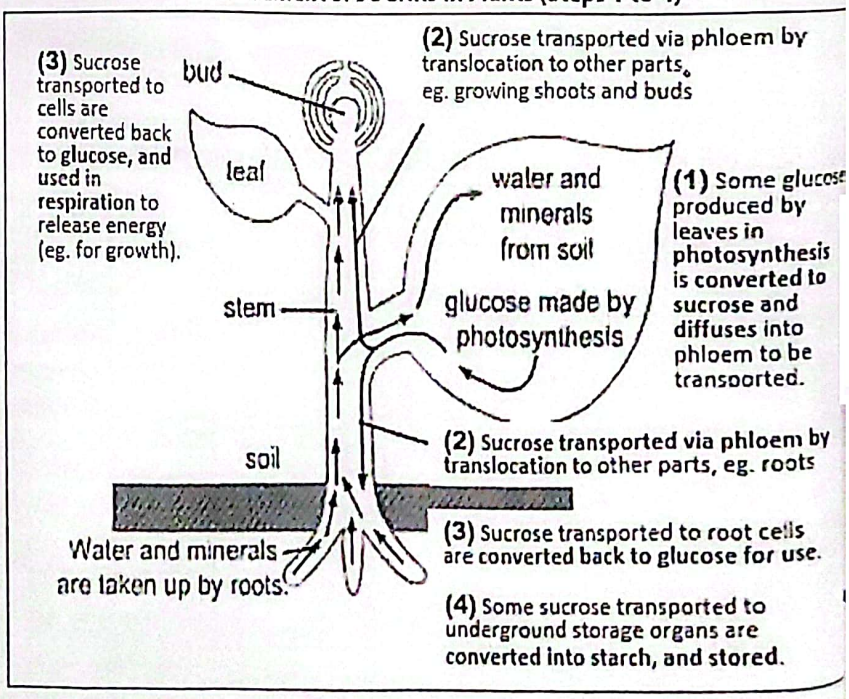
- Specialized cell – structure and function of Root Hair Cell In absorption of water and minerals

(c) State that transpiration is the loss of water vapour from stomata

(g) Define the term *translocation* as the transport of food in the phloem tissue.
(Pathway of Movement of Sugars)

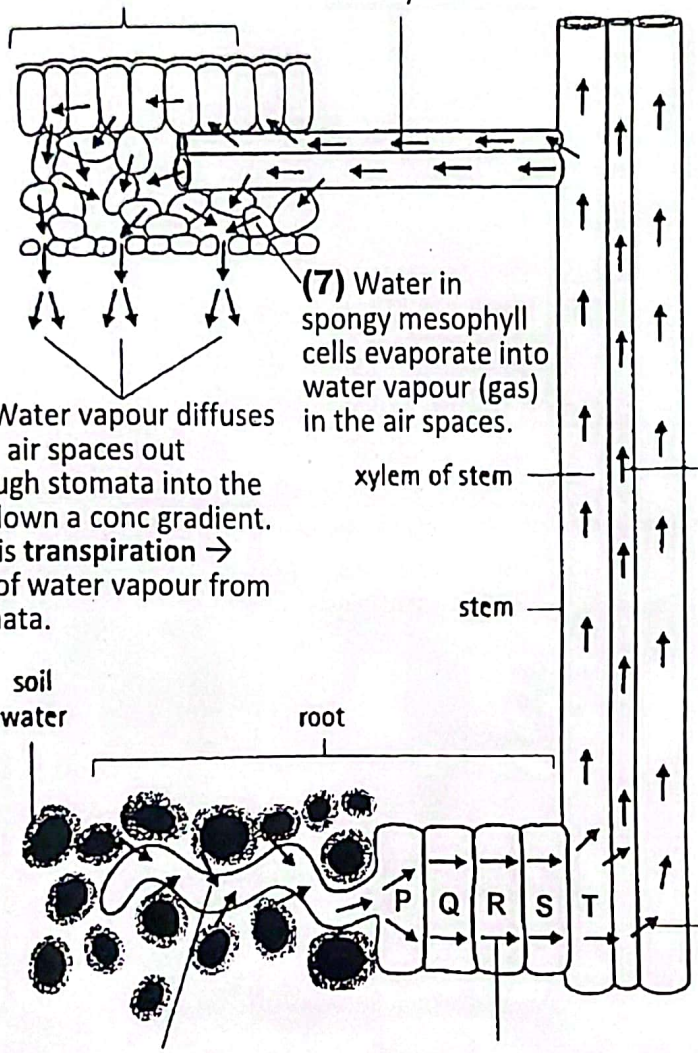
Process	Definition
Transpiration	• loss of water *vapour* from stomata • Location: Stomata
Transpiration Pull	• A suction force generated by transpiration • which draws water up from the roots to the leaves through the xylem. • Location: xylem
Translocation	• Process by which sucrose (food) is transported in the phloem to all parts of the plant. • Location: phloem

Movement of SUGARS In Plants (Steps 1 to 4)



(d) Explain briefly the movement of water through the stem in terms of transpiration pull. (Pathway of water)

Movement of WATER in Plants (Steps 1 to 8)



(4) Water moves up the xylem from roots to leaves, by transpiration pull.

Recall:
- Adaptations of xylem
- How to get transpiration pull?

(3) Water then moves from root cell into xylem by osmosis, down a water potential gradient.

Example:
Water potential of S > T.
So water moves from root cells into xylem.

(1) Root hair cells absorb water by osmosis (and minerals by diffusion).

Recall:
- Adaptations of RHC
- WP gradient for osmosis

(2) Water moves from root hair cell to surrounding root cells by osmosis, down a water potential gradient.

Example:
Water potential of P > Q > R > S.
So...
Water moves by osmosis from P to Q to R to S from a region of higher to lower water potential in a direction towards xylem.

(e) Describe the effects of variation of air movement, temperature, humidity and light intensity on transpiration rate

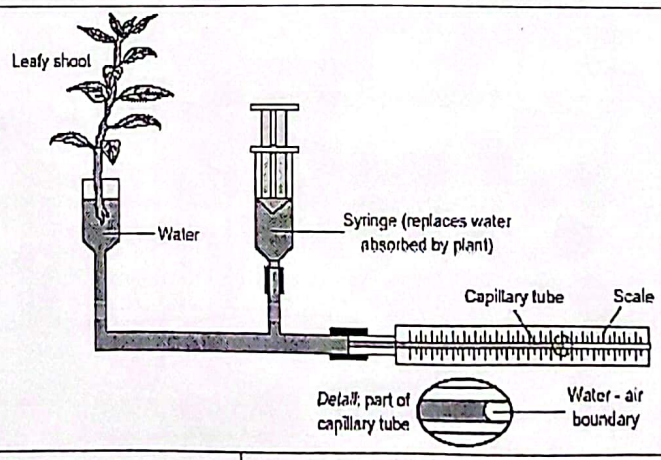
SUMMARY TABLE – Factors Affecting Rate of Transpiration

Factor	Describe how rate of transpiration is affected	Explain why or how come the transpiration rate is affected in this way	
WIND	▪ When wind **increases**, rate of transpiration increases.	▪ Wind blows away water vapour surrounding the leaf. ▪ So concentration of water vapour surrounding the leaf is lower	So concentration gradient is steeper → water vapour diffuses out of stomata faster
TEMPERATURE	▪ When temperature **increases**, rate of transpiration increases.	▪ Rate of evaporation of water into water vapour increases at hotter temperatures. ▪ So concentration of water vapour inside leaf is higher	
HUMIDITY	▪ When humidity **decreases**, rate of transpiration increases.	▪ concentration of water vapour surrounding the leaf is lower	
LIGHT INTENSITY	▪ When light intensity **increases**, rate of transpiration increases.	▪ Stomata opens wider (due to an increase in photosynthesis rate) ▪ So more water vapour can diffuse out of stomata	

3 Experiments to Investigate Rate of Transpiration

(1) Using a Potometer

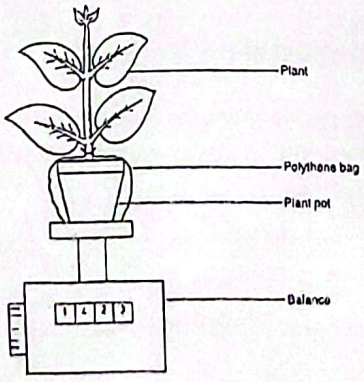
When the plant transpires…
→ it loses water, and
→ then absorb more water from the roots/cut end of stem,
→ causing meniscus to move towards the plant.



(2) Measuring Mass of Water Vapour lost

The more the mass lost → the greater the transpiration

But note: some water could also be absorbed for photosynthesis.



(3) Using Cobalt Chloride Paper

Presence of water vapour will cause cobalt chloride paper to turn from blue to pink.

The shorter the time taken
→ means more water vapour lost
→ means the higher the rate of transpiration

(f) Describe how wilting occurs.

Wilting occurs if... rate of water absorbed is less than rate of water lost by plant.

rate of water absorbed

Can be affected by:
- Rate of osmosis/water absorbed
- Adaptation of root hair cells to absorb water

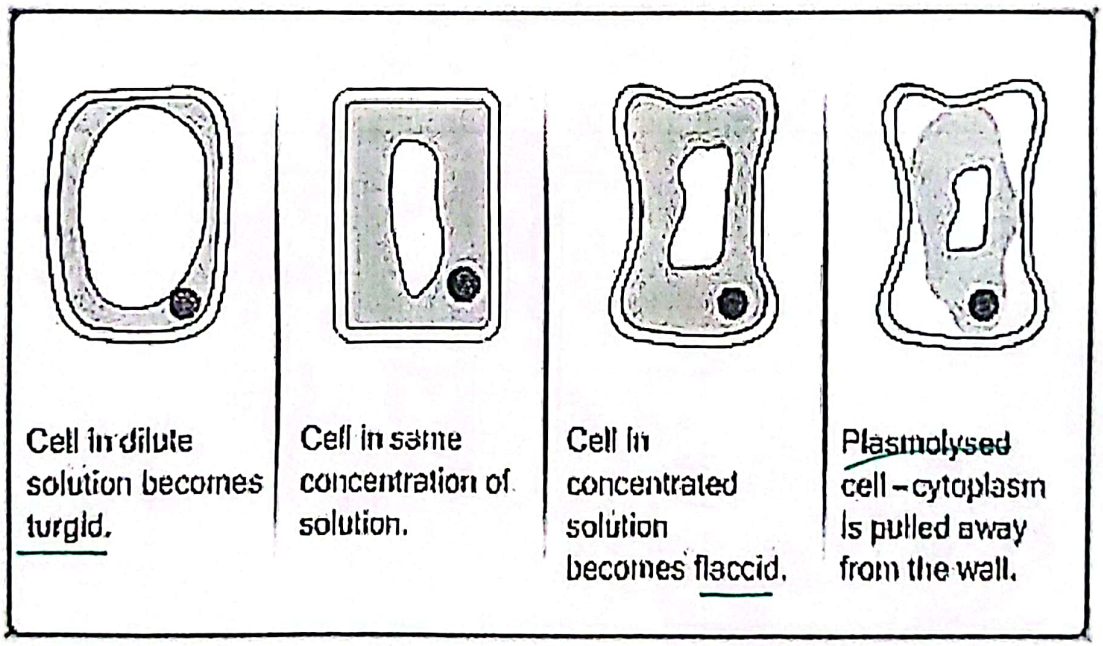
rate of water lost

Can be affected by:
- Transpiration rate (Wind, Temperature, Humidity, Light Intensity)
- Stomata (size, distribution)

Consequence: In a wilting plant...

- Leaf cells **lose water** by osmosis
- Leaf cells become **less turgid/more flaccid,** and eventually becomes **plasmolysed.**
- This causes the leaves to be flaccid/droop, reducing surface area of leaves exposed to light.
  → Less light absorbed, less water absorbed leads to lower rate of photosynthesis
  → plant cannot grow, and dies.

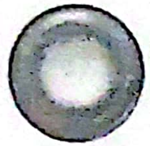
Recall:



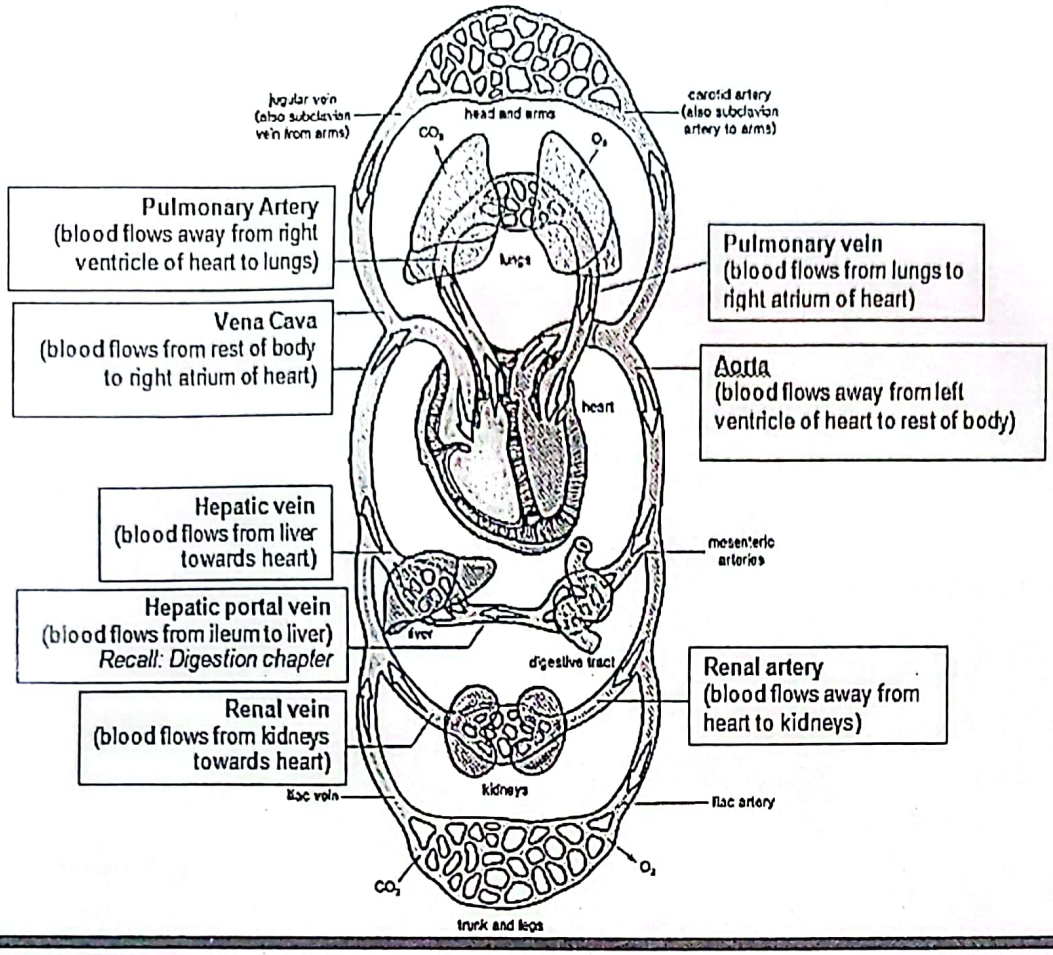
CHAPTER 7 – TRANSPORT IN MAN

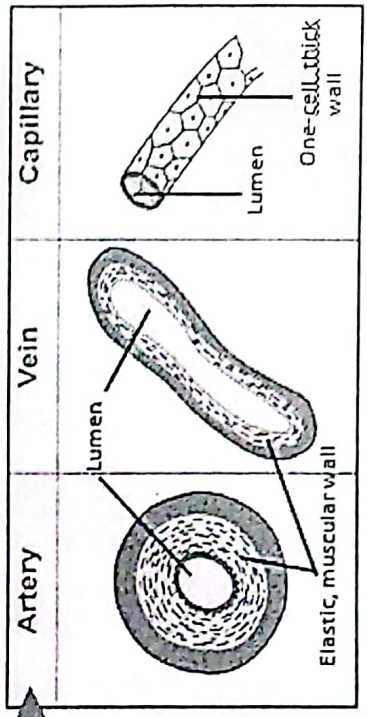
(b) State and explain the role of blood in transport and defence:

- Red Blood Cells – haemoglobin and oxygen transport
- Plasma – transport of blood cells, ions, soluble food substances, hormones, urea, vitamins, plasma proteins, carbon dioxide
- White Blood Cells – Phagocytosis, antibody formation and tissue rejection
- Platelets – fibrinogen to fibrin, causing clotting

Component	RED BLOOD CELL	WHITE BLOOD CELL	PLASMA	PLATELETS
Function	Transport oxygen from lungs to all cells 	Protect against diseases and infections 1st type: Lymphocytes  2nd Type: Phagocytes 	Transport medium • transporting blood cells, and essential substances like glucose, and • wastes like carbon dioxide and urea. Also transports other substances like hormones, enzymes, vitamins, plasma proteins, ions, etc.	Clots blood when there is an open wound to prevent: 1) prevent excessive blood loss, and 2) prevent foreign bodies like bacteria and viruses from entering and infecting wound 
How structure aids its function	*Recall Ch. 1: Specialised cells* 1) greater surface area to volume ratio to increase rate of diffusion of oxygen into and out of RBC 2) Haemoglobin binds oxygen in RBC 3) More space to contain more haemoglobin to bind more oxygen to be transported	Lymphocytes: • Produces antibodies that binds to toxins to neutralise them Phagoctyes: • Carry out phagocytosis (ingest and engulf) to break down foreign particles like bacteria and viruses.	• Plasma is a fluid → allows blood to flow (fluidity) • Contains mostly water → Allows substances like carbon dioxide and glucose to dissolve in it to be transported.	Steps for **blood-clotting process:** 1. At the wound, platelets release enzymes. 2. Enzymes convert soluble fibrinogen into insoluble fibrin threads. 3. Fibrin threads form a fibrin net over the wound. 4. Fibrin net traps RBCs to form a blood clot.

(a) Name the main blood vessels to and from the heart, lungs, liver, and kidney.



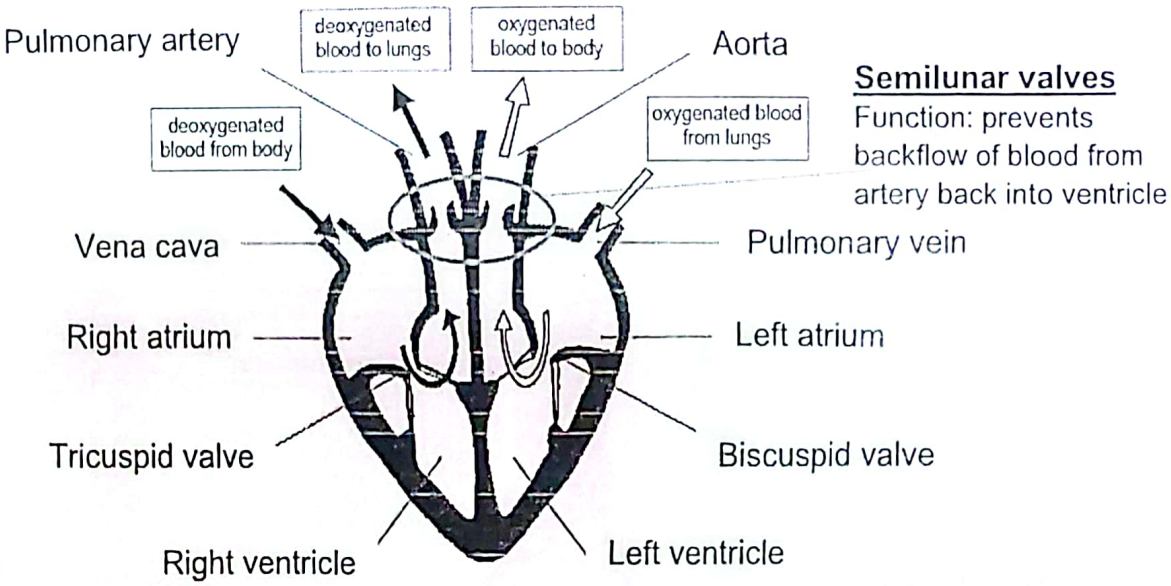


(c) Relate the structure of arteries, veins and capillaries to their functions.

Summary: Artery vs Vein vs Capillary

		ARTERY	VEIN	CAPILLARY
Features of **blood vessel**	Muscular wall	*Thick, elastic muscular wall	Thin muscular wall	No muscular wall. Instead, has a <u>one-cell thick wall</u> → shorter distance for substances to diffuse faster across
	Lumen	Small lumen	Large lumen	Small lumen
	Valve	None	*Has valves (function: prevent backflow of blood)	None
	Size	Large	Large	Small
Features of **blood carried** by blood vessel	Direction of blood	Away from heart to all parts of the body	Towards heart	N/A Substances diffuse between blood and tissues/body cells.
	Oxygen content	High (except Pulmonary Artery)	Low (except Pulmonary Vein)	More than veins, less than arteries
	Carbon dioxide content	Low (except Pulmonary Artery)	High (except Pulmonary Vein)	Less than veins, more than arteries
	Blood pressure	*High	*Low	More than veins, less than arteries

(d) Describe the structure and function of heart in terms of muscular contraction and working of valves.



Blood flow in right side of heart (deoxygenated)	Blood flow in left side of heart (oxygenated)
• **Deoxygenated blood** flows from body into RA via vena cava. • RA fills with deoxygenated blood, increasing pressure in RA. • Build-up of pressure in RA causes the tricuspid valve to open. • Deoxygenated blood flows from RA into RV, aided by contraction of RA. • RV fills with deoxygenated blood, increasing pressure in RV. • Build-up of pressure in RV + strong contraction of RV muscular walls pushes oxygenated blood up the pulmonary artery, causing semi-lunar valve to open. • **Deoxygenated blood** flows from RV to lungs via **pulmonary artery**.	• **Oxygenated blood** flows from lungs into LA via pulmonary vein. • LA fills with oxygenated blood, increasing pressure in LA. • Build-up of pressure in LA causes the bicuspid valve to open. • Oxygenated blood flows from LA into LV, aided by contraction of LA. • LV fills with oxygenated blood, increasing pressure in LV. • Build-up of pressure in LV + strong contraction of LV muscular walls pushes oxygenated blood up the aorta, causing semi-lunar valve to open. • **Oxygenated blood** flows from LV to other parts of body via **aorta.**
In the lungs, Oxygen diffuses into the blood, carbon dioxide out into lungs. Oxygen is replenished.	**In the body cells,** Oxygen (and glucose) diffuses from blood to cells for use in respiration. Carbon dioxide diffuses from cells into blood.

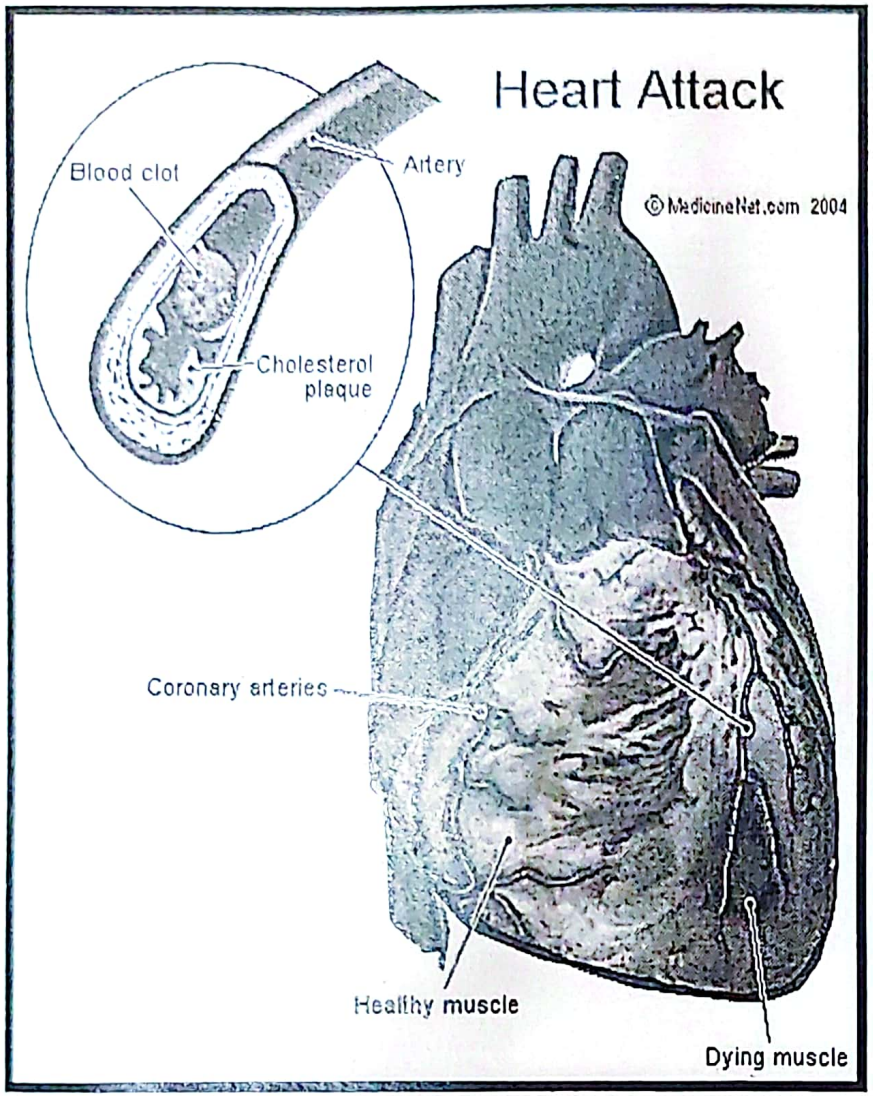
Also view for extra/related info – but pls refer to notes for most accurate info!

Blood Flow in heart	How platelets clot blood	Circulatory System
https://youtu.be/BEWjOCVEN7M	https://youtu.be/gExUCrpAKyQ	https://youtu.be/CWFyxn0qDEU

(e) Describe coronary heart disease in terms of the occlusion of coronary arteries and list the possible causes, such as diet, stress, smoking, and possible preventive measures.

- **Coronary arteries** are the blood vessels that transport blood rich in oxygen and nutrients like glucose to the heart muscles for respiration.

How is Coronary Heart Disease caused?

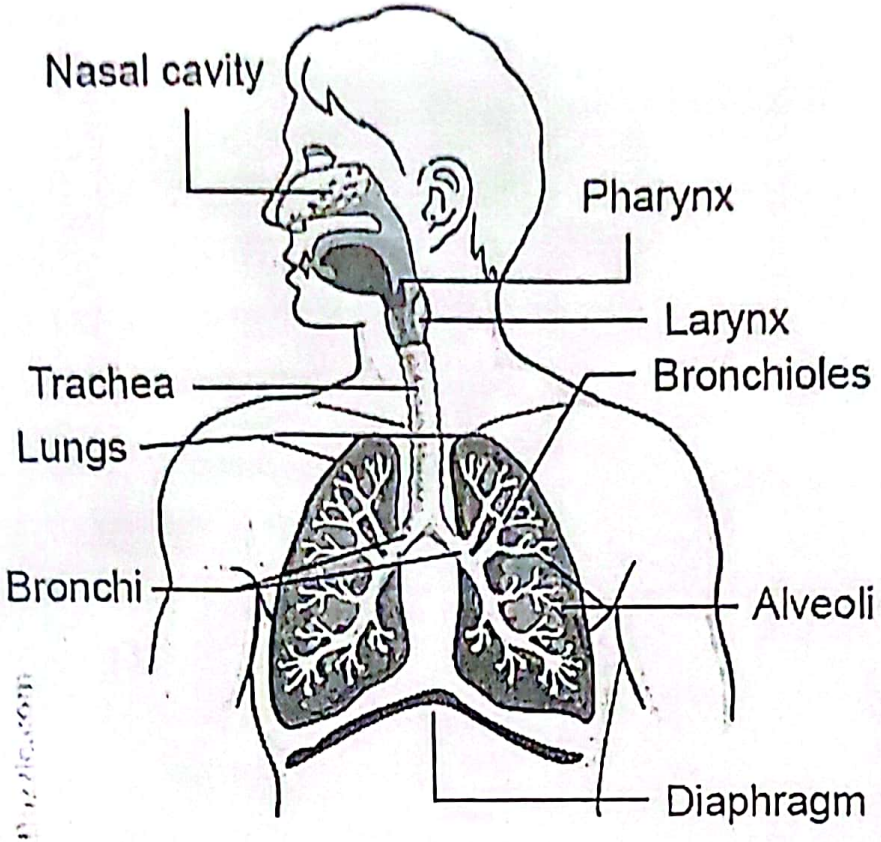


- **Smoking**
- **Diet high in fat and/or cholesterol**
- **Lack of regular exercise**
- Prolonged stress / stressful lifestyle
- Genetic predisposition

1. Cholesterol and fats are accumulated and deposited on **inner walls** of the **coronary arteries**, forming **plaque.**
2. Coronary arteries become narrower and become blocked (occlusion).
3. Blood containing glucose and oxygen cannot be transported to the heart muscles.
4. Heart muscles cannot carry out respiration to release enough energy.
   → heart muscles cannot contract, causing heart attack.
   → Heart muscle cells die.

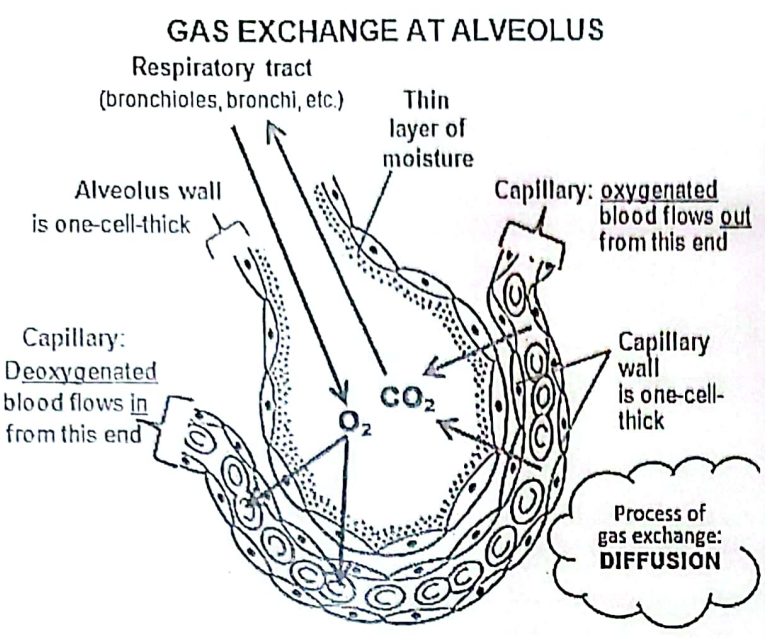
CHAPTER 8– RESPIRATION

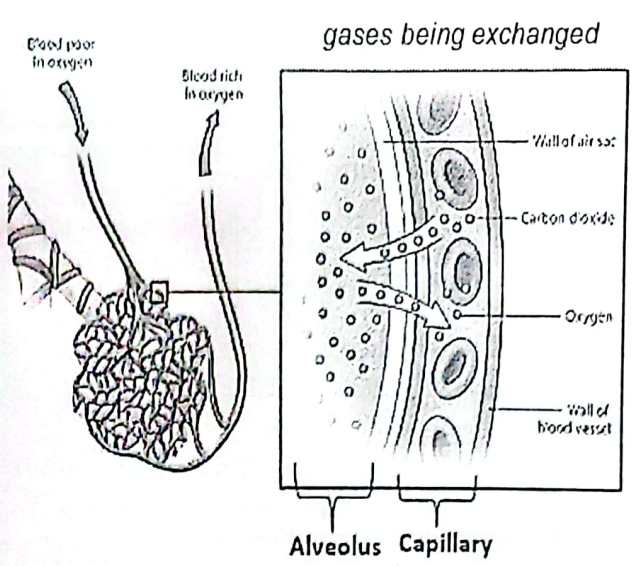
(a) Identify on diagrams and name the larynx, trachea, bronchi, bronchioles, alveoli, and associated capillaries and state their functions in human gas exchange.



**Revision Video (Respiratory System): https://tinyurl.com/MsYTMLRespiration3

b) State the characteristics of, and describe the role of, the exchange surface of the alveoli and associated capillaries and state their functions in human gas exchange.





Part	Structure	Function
Nasal Cavity (nose)	• contains mucous-producing cells and small hairs lining the inner walls	• space where air enters and exits body when inhaling and exhaling respectively • Mucus to trap dust and dirt in inhaled air • Small hairs to sweep mucus and foreign particles out of nose or towards larynx to be swallowed
Trachea	• Lined with c-shaped cartilage rings on one side contains mucous-producing cells and cilia lining the inner walls	• C-shaped cartilage allow one side of the trachea to be able to expand/contract next to the oesophagus through which big pieces of food may go down • Cilia to sweep mucus, foreign particles to be expelled out or to larynx to be swallowed
Bronchus (left & right)	• contains mucous-producing cells and cilia lining the inner walls	• Filters and allows air containing oxygen to pass into the left and right lungs and carbon dioxide to pass from trachea out to nose
Bronchiole	• Smaller airways branching out from bronchi	• Allows containing oxygen to pass into the alveoli and carbon dioxide to pass from alveoli out to the nose to be exhaled
Alveolus (site of gas exchange)	• Numerous air sacs • Wall is one-cell thick • Inner wall has a film of moisture • Surrounded by numerous blood capillaries	• Adaptations enable alveoli to carry out gas exchange by diffusion, efficiently

	DESCRIBE adaptation	EXPLAIN how it helps	Link to diffusion and gas exchange
1	Alveolus wall is one-cell thick	Shorter distance for gases to diffuse across	For faster diffusion of gases (increase rate of diffusion).
2	Thin film of moisture on inner wall of alveolus	Allows gases to dissolve in the film of moisture	For faster diffusion of gases across alveolus wall
3	Alveoli are surrounded by numerous blood capillaries.	Blood capillaries transport oxygenated blood away from alveoli quickly (and to other parts of the body)	To maintain steep concentration gradient for faster diffusion of gases
4	numerous alveoli.	Increases surface area to volume ratio	For faster diffusion of gases across alveolus wall

**Revision Video (Alveolus & Gas Exchange): https://tinyurl.com/MsYTMLRespiration2

(c) Describe the effect of tobacco smoke and its major toxic components – nicotine, tar, carbon monoxide, on health.

	Nicotine	Tar	Carbon Monoxide
Effect on health	1. Coronary heart disease 2. Causes addiction	1. Emphysema, bronchitis 2. Lung cancer	1. reduces efficiency of oxygen transported in blood to all cells
How is it caused?	1. Increases blood pressure and narrowing of coronary arteries	1. Paralyses cilia lining the airways → cannot sweep out dust and dirt → prolonged coughing → breaking down of alveoli walls → reduces efficiency of gas exchange 2. Tar causes cells to multiply uncontrollably	1. Binds irreversibly to haemoglobin in red blood cell → RBC cannot bind oxygen

**Revision Video (Smoking): https://tinyurl.com/MsYTMLRespiration1

(d) Define and state the word equation for *aerobic respiration* in humans.
(e) Define and state the word equation for *anaerobic respiration* in humans.

Organisms require energy to support life processes such as: synthesis of new protoplasm for growth and repair, muscular contractions, function of key processes etc.

Word Equation: Aerobic Respiration

glucose + oxygen → carbon dioxide + water (+ energy)

Word Equation: Anaerobic Respiration

glucose → lactic acid (+ energy)

**Revision Video (Smoking): https://tinyurl.com/MsYTMLRespiration4

	Breathing	Respiration	
		1st type: Aerobic	**2nd type: Anaerobic**
Definition of the process	Muscular contractions and movement of the ribs to cause air to move into and out of the lungs **to allow gas exchange** at the alveoli	o Breakdown of glucose in the presence of oxygen, o to release a large amount of energy, o with carbon dioxide and water as waste products.	o Breakdown of glucose in the absence of oxygen, o To release a small amount of energy, o with lactic acid as waste products.
Type	Physical process	Chemical process	Chemical process
When?	All the time	All the time	Only when large amount of energy required and oxygen intake is insufficient to support rate of aerobic respiration
Where?	• Site of breathing: nose/ respiratory tract • Site of gas exchange: alveoli in the lungs	All cells (in the mitochondria)	All cells (in the cytoplasm)

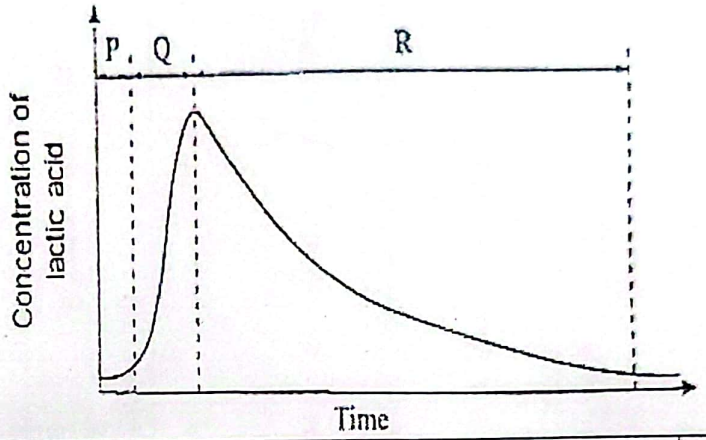
(f) Describe the effect of lactic acid in muscles during exercise.

Aerobic and Anaerobic Respiration during Exercise

Example:

An athlete runs a 400m race.

The graph below shows how the concentration of lactic acid in his leg muscles changes with time after he starts the race.



- When lactic acid accumulates in the muscle it causes muscle pain/ache called muscle fatigue.
- The amount of time needed for the muscle fatigue to dissipate/ breathing rate to go back to normal is the time needed to take in enough oxygen for aerobic respiration to repay the oxygen debt incurred during anaerobic respiration.

	P	Q	R
Respiration	Aerobic	Aerobic + Anaerobic	Aerobic
Describe the graph.	• As time increases, the concentration of lactic acid in muscles remains constant.	• As time increases, the concentration of lactic acid in muscles increases	• As time increases, the concentration of lactic acid in muscles decreases
Explain the graph.	• Aerobic respiration is occurring. • Oxygen intake is sufficient for respiration at the start of the race. • So, there is no anaerobic respiration yet. • So, there is no increase in lactic acid concentration in muscles.	• Anaerobic respiration is ALSO occurring because • oxygen intake is insufficient for respiration • So, there is lactic acid produced as waste product from anaerobic respiration • Leading to an increase in lactic acid concentration in muscles.	• Aerobic respiration is occurring • Oxygen taken in is used to repay the oxygen debt incurred during anaerobic respiration. • Lactic acid broken down in the liver • Leading to a decrease in lactic acid concentration in muscles.
Relate the info in the graph to the athlete and the race.	➢ The race has just started. ➢ Normal breathing rate, breathing volume and heart rate	➢ Race is ongoing. ➢ Breathing rate, breathing volume increases to take in more oxygen ➢ Heart rate increases to transport oxygen faster to respiring muscle cells ➢ Muscle fatigue due to lactic acid	➢ Race has ended ➢ Breathing rate, breathing volume, heart rate decreases during recovery ➢ Recovery from muscle fatigue

**Revision Video (Lactic Acid & Oxygen Debt):
https://tinyurl.com/MsYTMLRespiration5

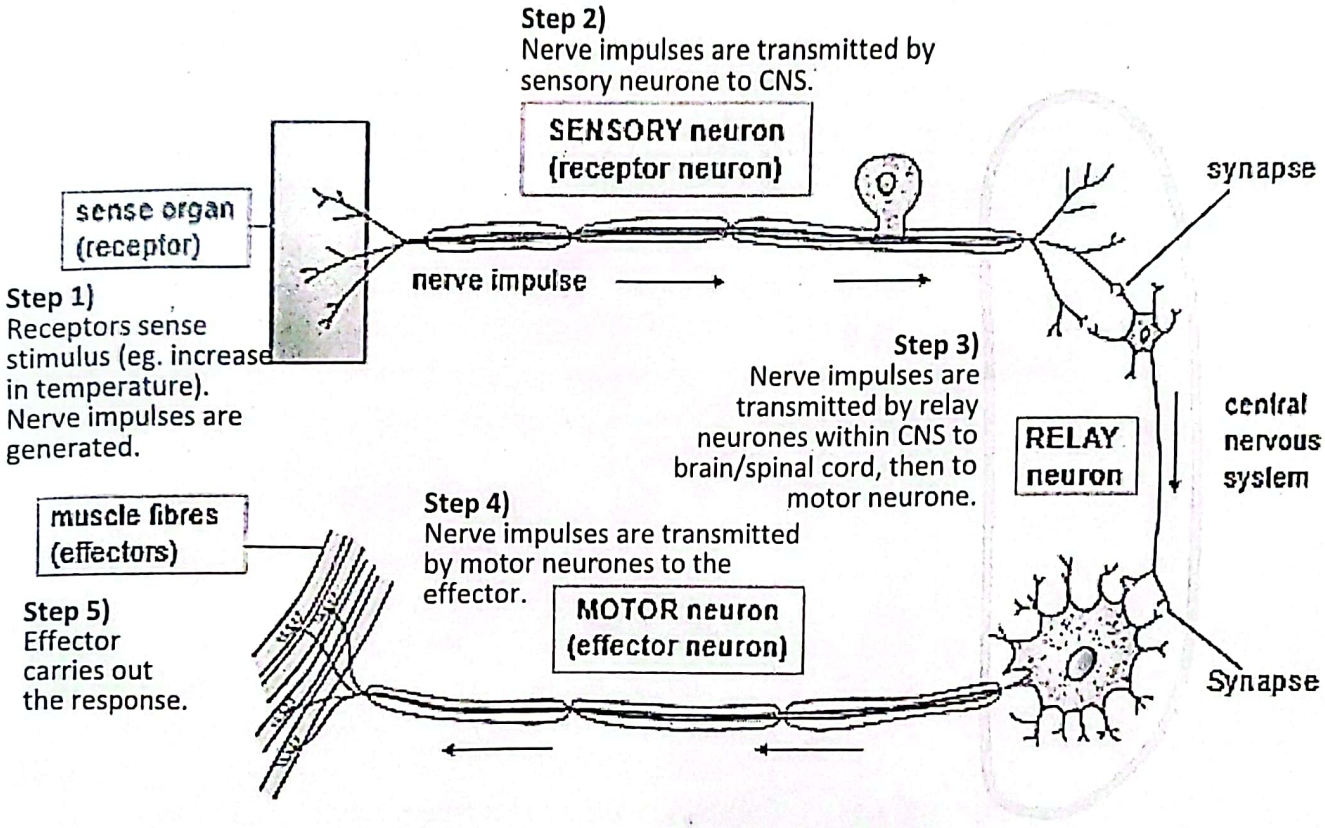
CHAPTER 9 – CO-ORDINATION & RESPONSE (Nervous System, Eye, Hormones)

(a) State the relationship between receptors, the central nervous system, and the effectors.
(b) State that the nervous system – brain, spinal cord and nerves, serves to co-ordinate and regulate bodily functions

Receptors (in sense organ)	CNS	Effector
• Senses/ detects stimulus (eg. increase in temperature)	• Brain/spinal cord processes information • Coordinate and regulate responses to stimuli	• Carries out the response

(f) Discuss the function of the brain and spinal cord in producing a co-ordinated response as a result of a specific stimulus in a reflex action (involuntary responses).

Reflex / Response Arc:

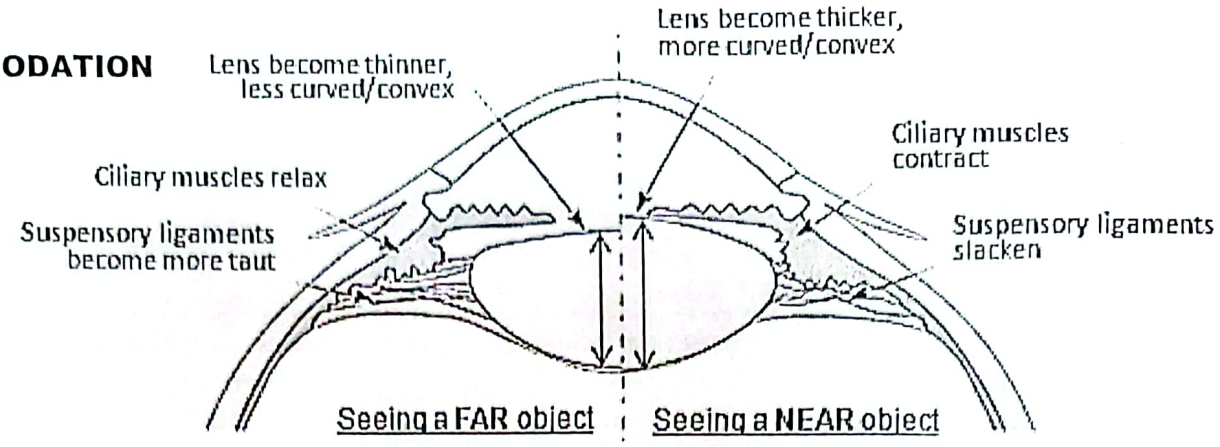


(e) Outline the functions of sensory neurones, relay neurones and motor neurones.

Sensory Neurone	Relay Neurone	Motor Neurone
Transmits nerve impulses from sense organ towards CNS	Transmits nerve impulses within CNS and from CNS to motor neurone	Transmits nerve impulses away from CNS towards effectors

(c) State the principal functions of component parts of the eye in producing a focused image of distant objects on the retina. (Accommodation/Focusing)

ACCOMMODATION



Accommodation	Looking at a NEAR object (Distance Decreases)	Looking at a FAR object (Distance Increases)
Example of situations	Looking from the bird in the sky to checking your watch	Looking up from your book to the clock across the hall
Causes: Ciliary muscles in ciliary body	Contract	Relax
Causes: Suspensory ligaments	become more slack	Become more taut
Causes: Lens	Becomes thicker/ more convex	Becomes thinner/ less convex
Effect of the response	Forms a clear, focused image of a near object	Forms a clear, focused image of a far object

(d) Describe the pupil reflex in response to bright and dim light. (Pupil Reflex)

Parts involved in Pupil Reflex	Light Intensity INCREASES / Brighter	Light Intensity DECREASES / Dimmer
Example of situations	Switching on lights in a dark room	Going into a dark room from outdoors
Circular muscles in iris	Contract	Relax
Radial muscles in iris	Relax	Contract
Pupil	Constricts / becomes smaller	Dilates / becomes bigger
Effect of the response	To reduce the amount of light entering eye	To increase the amount of light entering eye

Occurs simultaneously

Reflex Arc for Pupil Reflex (Bright):

1) Increase in light stimulates the photoreceptors on the retina of the eye (sense organ). Nerve impulses are produced.
2) Sensory neurone transmits nerve impulses to brain.
3) Nerve impulses are transmitted by relay neurones within the CNS to the motor neurone
4) Motor neurone transmits nerve impulses to the circular and radial muscles in the iris (effector).
5) The circular muscles of the iris contract while the radial muscles relax.
6) Pupil constricts / becomes smaller to reduce the light entering eye.

**too much light entering the eye can damage the retina.*
**too little light entering will not be sufficient to see*

(g) Define a *hormone* as a chemical substance, produced by a gland, carried by blood, which alters the activity of one or more specific target organs and destroyed by the liver.

Definition: Hormones are...

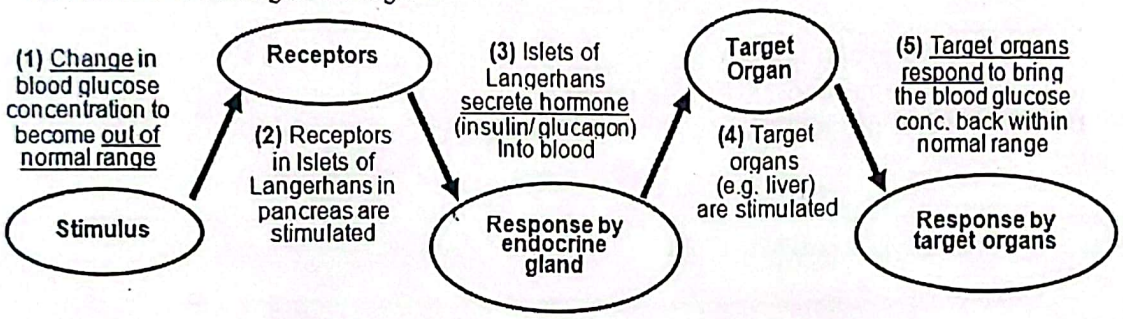
• chemical substances • produced by endocrine glands • in minute quantities	→ • transported in the bloodstream to target organs	→ • and are eventually destroyed in the liver after performing their functions

(h) State what is meant by an endocrine gland, with reference to the islets of Langerhans in the pancreas.

	Secretion of hormone	Implications	Examples
Endocrine Gland	• Ductless glands, • Hormones secreted directly into bloodstream	• Can be more than 1 target organ • takes longer time to reach target organ and for target organs to respond	• Pancreas (Islets of Langerhans secrete insulin & glucagon) • Ovary (secrete oestrogen, progesterone)

(i) Outline how blood glucose concentration is regulated by insulin and glucagon.

An overview of blood glucose regulation:



	Blood Glucose Rises > normal levels	Blood Glucose Falls < normal levels
Examples of situations	• Just after a meal • Uncontrolled diabetes type 1 or 2	• Fasting for some time • Over-secretion of insulin
Why it is dangerous	• Develop **diabetes mellitus** • Body **can't store or utilise glucose well** → become weaker, lose weight	• **Insufficient glucose for respiration** to provide energy for various cell activities and body functions
Stimulus detected	Glucose in blood **increases above normal** range	Glucose in blood **decreases below normal** range
Response by endocrine gland	Islets of Langerhans in pancreas secrete **insulin** hormone into blood.	Islets of Langerhans in pancreas secrete **glucagon** hormone into blood.
Response by target organ(s)	**Insulin:** • stimulates liver and muscles to convert excess glucose into glycogen for storage • increases permeability of cell membranes to glucose → greater uptake of glucose • causes increase respiration rate to utilise more glucose	**Glucagon:** • stimulates liver and muscles to convert stored glycogen back to glucose → diffuse back into blood
Effect	Blood glucose **decreases** back within normal range	Blood glucose **increases** back within normal range

Endocrine Control vs Nervous Control

		Endocrine	Nervous
1	Type of message	Involves hormones (chemical substances)	Involves nerve impulses (electrical signals)
2	Transported by?	Blood	Neurones
★ 3	Time for response to take effect	Usually slow responses	Usually quick responses
4	Duration of response	Can be short-lived or long-lived	Short-lived
5	Voluntary / involuntary	Always involuntary	May be voluntary or involuntary
6	No. of target organs affected	May affect one or more target organs	Usually localised (affects 1 target organ)
	Examples	• Regulation of glucose levels by insulin/glucagon hormones • Regulation of phases of menstrual cycle by oestrogen and progesterone	• Reflex actions like knee-jerk reflex, pupil reflex, etc • Voluntary nervous responses like picking up a book when you notice it dropped.

CHAPTER 10a – REPRODUCTION IN PLANTS

(a) Define asexual reproduction as the process resulting in the production of genetically distinct offspring from one parent.

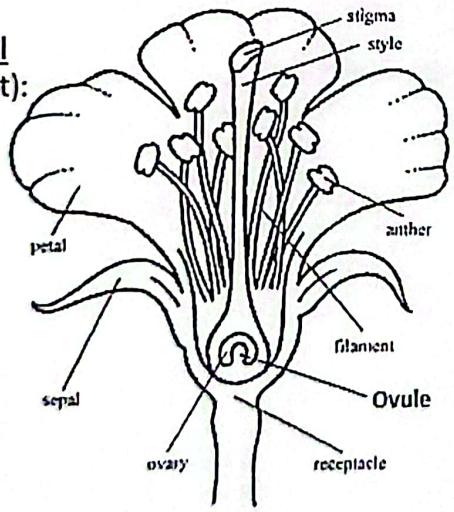
(b) Define sexual reproduction as the process involving the fusion of nuclei to form a zygote and the production of genetically dissimilar offspring.

	Asexual	Sexual
Definition	Process which results in production of - **genetically identical** offspring - from **one parent**	Process which results in production of - **genetically distinct** offspring - involving the **fusion of nuclei** from a male and **female gamete** - to **form a zygote**
Offspring	**Genetically identical** (→uniformity as there is no variation)	**Genetically distinct** (→leads to more variation)
Parent(s)	Only **one parent required** (→less time and energy required)	Two parents required – **a male and a female gamete*** need to fuse. (→ more time and energy required)
Implications on survival	**lower chance of surviving** environmental changes because: - Offspring are genetically identical - Less likely to have successful adaptation to environment to survive	**Higher chance of surviving** environmental changes because: - Offspring are genetically distinct - Large amount of variation among offspring - Allows at least some to successfully survive and adapt to changes in environment

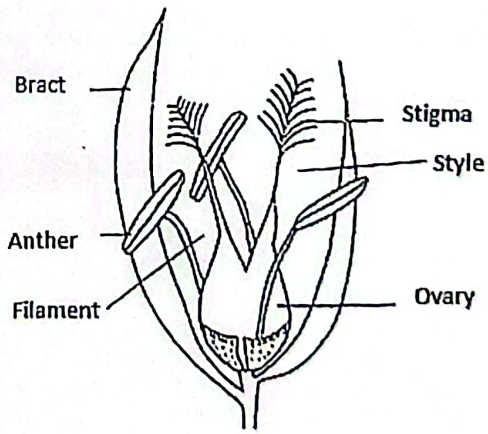
(c) State the functions of the sepals, petals, anthers and carpels.

Insect-Pollinated Flower

Carpel/Pistil (Female part): Ovary + ovule + style + stigma



Wind-Pollinated Flower



Stamen (male part): Anther + Filament

Part of Flower		Structure	Function
Stamen (Male part)	Anther	• Has 2 lobes, each consisting of 2 pollen sacs	• Produces and contains pollen grains
	Filament	• Long stalk	• Holds the anther in a suitable position to disperse pollen
	Pollen grains (not visible on diagram)	• Contains 23 chromosomes (*n*) – half the usual number of chromosomes (*2n*) FYI: *haploid number*	• Contains male gamete which is required for fertilisation
Carpel / Pistil (Female part)	Stigma	• Found at the end of the style	• Receives pollen grains • Mature stigma secretes sugary fluid to stimulate pollen grains to germinate
	Style	• Stalk connecting stigma to ovary	• Holds the stigma in suitable position to receive pollen grains
	Ovary	• Enlarged structure at the bottom of the style	• Produces and contains ovule(s) • Develops into fruit after fertilisation • Develops into seed after fertilisation
	Ovule	• Contains 23 chromosomes (*n*) – half the usual number of chromosomes (*2n*) FYI: *haploid number*	• Contains female gamete (ovum) which is required for fertilisation
Neither male nor female	Receptacle	• Enlarged end of the flower stalk	• Contains other parts of the flower/ fruit after fertilisation and pollen tube germination
	Petal	• Modified leaves forming most obvious part of flower • Sometimes has nectar guides on insect-pollinated flowers	In insect-pollinated flowers: • Usually brightly-coloured to attract insects • Provide a platform for insects to land In wind-pollinated flowers: • Usually small and dull-coloured
	Sepal	• Modified leaves that usually forms the outermost layer	• Enclose and protect the flower during the bud stage
	Pedicel	• Flower stalk	• Holds the flower in a suitable position

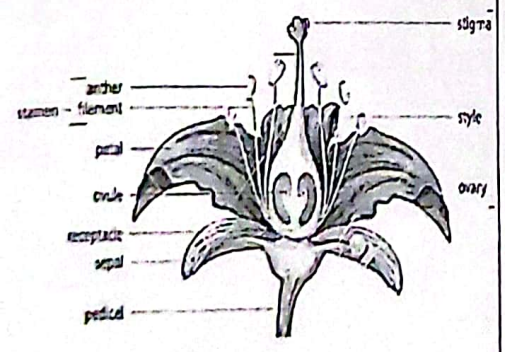
d) Outline the process of pollination and distinguish between self-pollination and cross-pollination.

Definition of POLLINATION – Transfer of pollen grains from anther to stigma.

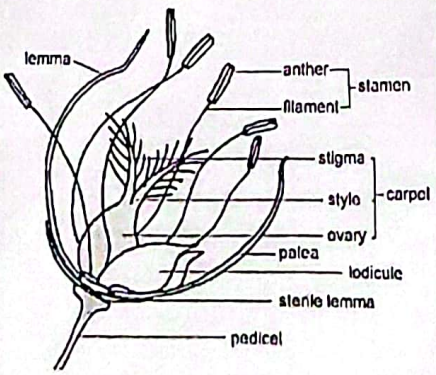
2 Types of Pollination *(where is pollen transferred to?):*
- Self-pollination
- Cross-pollination

2 Methods of Pollination *(how was pollen transferred?)*
- Pollinated by wind
- Pollinated by insects

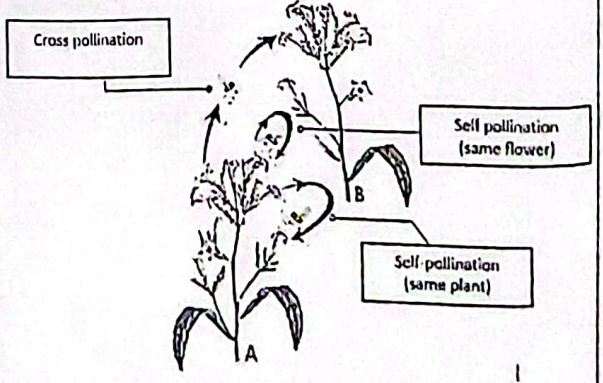
Insect-Pollinated



Wind-Pollinated



Self vs Cross Pollination



Summary: Cross vs Self Pollination

2 TYPES:	Cross-Pollination	Self-Pollination
Definition	Transfer of pollen grains - from anther of one plant - to the stigma on a flower of ***different plant***	Transfer of pollen grains - from anther of one plant - to the stigma on a (same or different) flower of the ***same plant***
Structural features of a flower	•Plants that bear flowers consisting of only male (stamens) or female parts (carpels) •Anthers and stigmas may mature at different times •Stigmas of flower maybe situated some distance away from the anthers	•Plants bear bisexual flowers with anther and stigma maturing at same time •Stigma is located directly below anthers
Advantages	•Offspring produced may inherit beneficial qualities from both parents •More varieties of offspring produced, leading to greater genetic variation in offspring → more likely to survive environmental changes	•Only one parent plant required •Less pollen and energy wasted •Does not depend on external factors like wind and insects for pollination •Higher chance of inheriting beneficial qualities from parent
Disadvantages	• Two parent plants required • Depends on insect or wind for pollination • More energy and pollen wasted	• Less genetic variation in offspring → offspring is less well-adapted to environmental changes • Offspring inherits negative qualities from parent

Summary: Insect vs Wind Pollination

Characteristics of INSECT-Pollinated Flower	How does an INSECT pollinate the flower?
❖ Petals are **large and attractive** to attract insects ❖ **Nectar** present. ❖ **Nectar guides** present to guide insects into flower towards nectar. ❖ Flowers give out **strong smells** ❖ **Stigmas are small, compact** and do not protrude out of flower ❖ **Stamens are short** and usually do not protrude out of flower. ❖ **Pollen grains are larger, with rough surfaces** to cling/stick onto body of insects.	1. Insect lands on the petals of the flower 2. Follows the nectar guide into the flower 3. The anthers brush against the body of the insect and pollen grains from the anther stick to the insect. 4. At the same time, the pollen grains (from a different flower) already stuck to the insect will be transferred to the sticky surface of stigma.

Characteristics of WIND-Pollinated Flower	How does WIND pollinate the flower?
❖ Flowers are **small, dull and unattractive** with small or no petals. ❖ Nectar and nectar guide **absent.** ❖ Flowers do not have scents (odourless). ❖ **Stigmas are** o **large, feathery,** → provide **larger surface area** o **protrude out of flower** → to be in a good position to receive pollen grains floating in wind. ❖ Stamens have **long, pendulous filaments and protruding anthers** → **easily comes in contact with wind and shake out pollen grains** when wind blows ❖ **Pollen are tiny, lightweight and have smooth surfaces** to be easily blown around by wind. Pollen grains are more abundant.	1. When wind blows, **stamens sway and shake free the pollen grains.** 2. Pollen grains are very lightweight and are dispersed by the wind. 3. Mature stigmas which are **large and feathery with large surface areas to receive pollen grains** floating in the wind.

(e) Describe the growth of the pollen tube and its entry into the ovule [ie. Germination], followed by fertilization

Germination of Pollen Tube → leading to Fertilisation

After pollination, pollen grains have landed on the mature stigma.

1. **Sugary fluid** secreted by **mature stigma** causes **pollen grain to germinate** (grow).

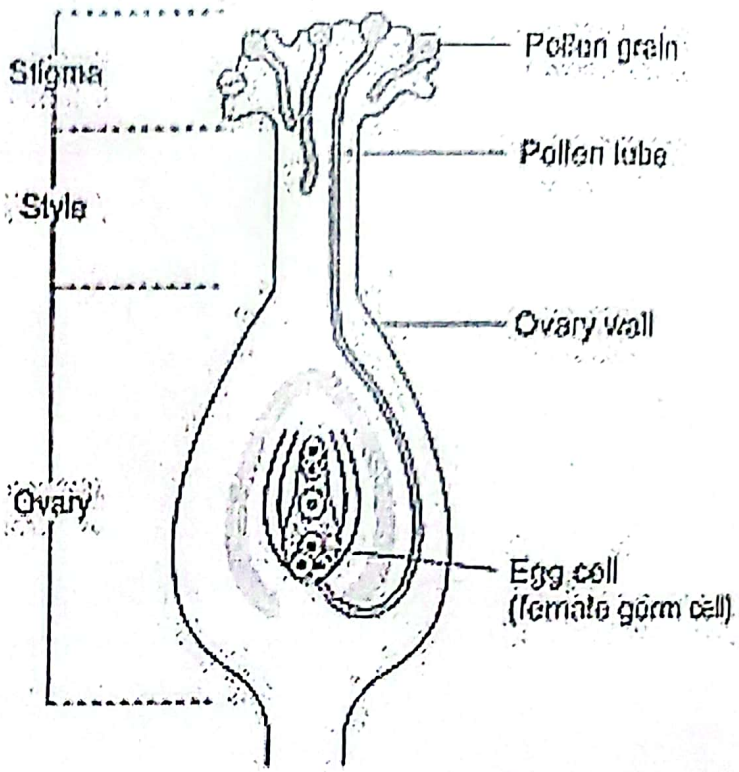
2. A **pollen tube grows** out from each pollen grain. Male gametes from pollen grain enters pollen tube.

3. Pollen tube grows down the style and ovary towards the ovule. To do so, pollen tube secretes **enzymes to digest surrounding tissue** of style and ovary.

4. Pollen tube enters ovule through the micropyle. (*Micropyle = an opening in the ovule wall*).

5. In the ovule, tip of pollen tube bursts open to **release male gametes.**

6. Nucleus of male gamete fuses with nucleus of female gamete/ovum to form the zygote.
   → **Fertilisation has occurred.**

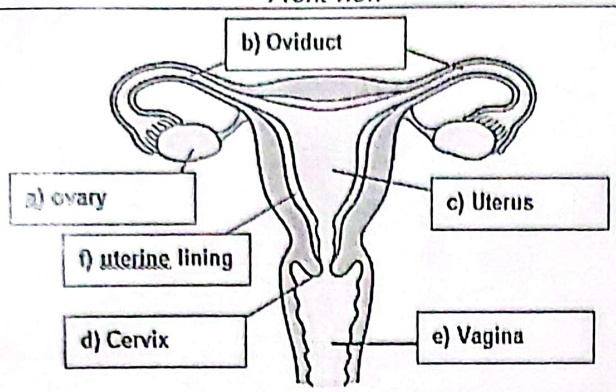


Germination of pollen grains on stigma and fertilization

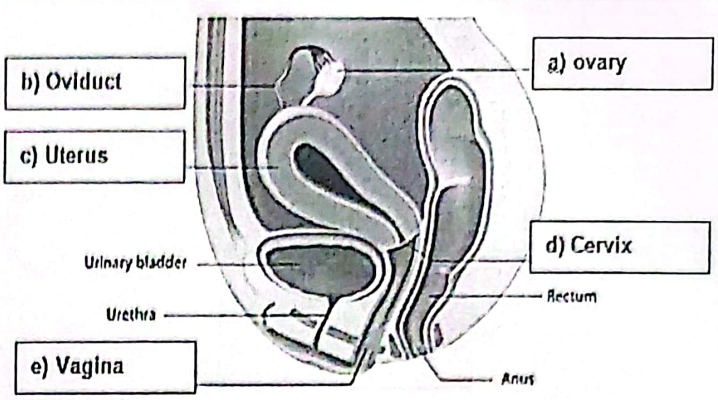
CHAPTER 10b – REPRODUCTION IN HUMANS

(g) Identify on diagrams of the female reproductive system and give the functions of ovaries, oviducts, uterus, cervix, and vagina.

Front view



Side view

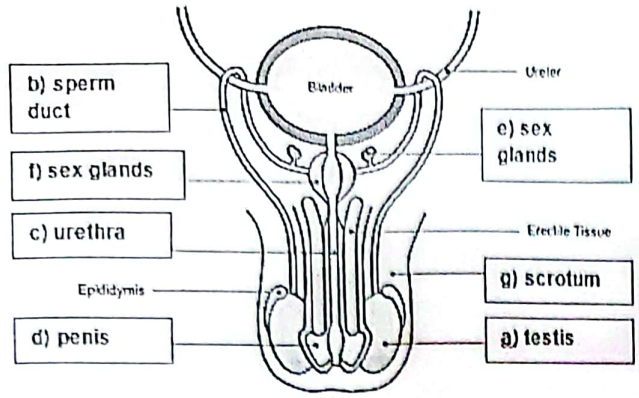


	Structure	Function
a)	**OVARY** • female sex organ	❖ Produces eggs and female sex hormones (oestrogen & progesterone) ❖ Releases one mature egg every menstrual cycle → ovulation ❖ Female sex hormones – responsible for changes during puberty, phases in menstrual cycle
b)	**OVIDUCTS** AKA fallopian tubes	❖ Transports egg released from ovary, to the uterus ❖ Peristalsis + has cilia to sweep egg towards uterus ❖ Site of fertilisation by sperm
c)	**UTERUS** • Elastic muscle walls	❖ Embryo implanted into uterine lining ❖ Site where foetus develops into baby during pregnancy

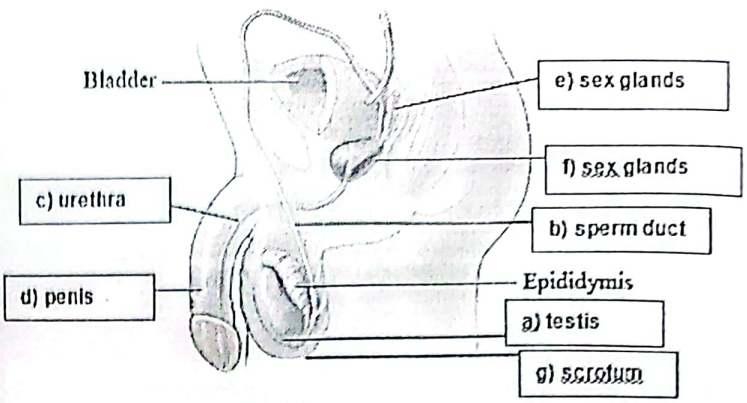
	Structure	Function
d)	**CERVIX** • Narrow opening to vagina	❖ Cervix widens to allow baby to pass into vagina during childbirth
e)	**VAGINA** • AKA birth canal • Links cervix to outside the body	❖ Site where semen containing sperms is deposited during sexual intercourse ❖ Widens to allow baby to pass out childbirth
f)	**UTERINE LINING** • Smooth inner lining of uterus	❖ Shed and removed every menstrual cycle during menstruation if no fertilisation occurred

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

Front view



Side view



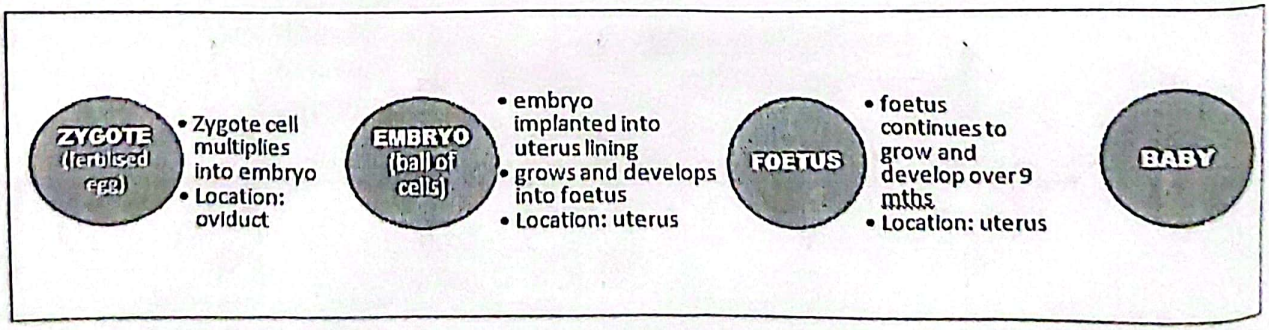
	Name & Structure	Function
a)	**TESTIS** (sing.) • Male sex organ • Contained outside body in scrotum	❖ Produces sperms and male sex hormones ❖ Male sex hormones – stimulates puberty changes
b)	**SPERM DUCTS** •Links testes to urethra	❖ Transports sperms from testes to the urethra
c)	**URETHRA** •Links bladder to centre of penis to outside the body	❖ Semen (sperms + fluid) and urine pass through the urethra (at different times) out of the body

	Name & Structure	Function
d)	**PENIS** • Male sex organ	❖ Deposits sperms (in semen) inside vagina of a woman during sexual intercourse
e) f)	**SEX GLANDS** •e: seminal vesicles •f: prostate gland	❖ Secrete fluid containing nutrients and enzymes to allow sperms to swim
g)	**SCROTUM** • Pouch-like sacs • Contain testes outside the body	❖ So that testes are at temperature lower than body temperature → essential for optimal development of sperms

(j) Briefly describe fertilisation 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

FERTILISATION → a process where the nuclei from male and female gametes fuse to form a zygote.
In humans, fertilization occurs in the oviduct/fallopian tube.

After fertilization:

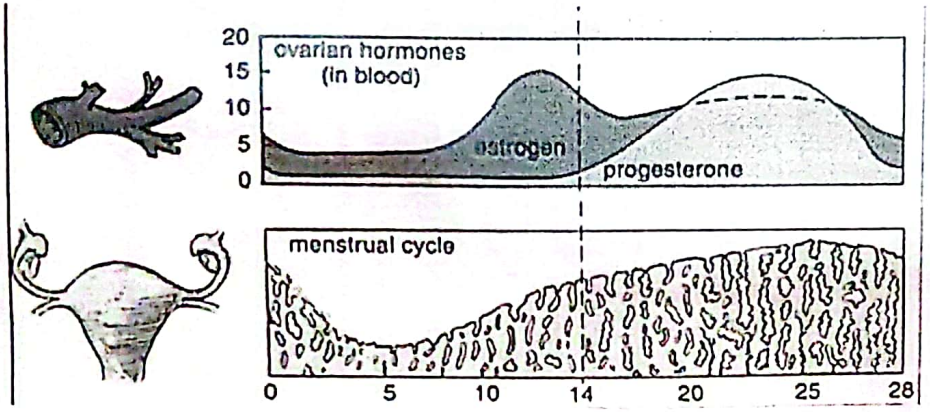


(h) Briefly describe the menstrual cycle with reference to the alternation of menstruation and ovulation, the natural variation in its length, and the fertile and infertile phases of the cycle, with reference to the roles of oestrogen and progesterone only.

Graphs: Menstrual Cycle

How **concentration of female sex hormones** change in a menstrual cycle:

How **thickness of uterine lining** change in a menstrual cycle:



Function of the **2 key female sex hormones** produced by ovaries:

- **Oestrogen:**
  stimulate ovulation, and to start repair of uterine lining
  - Highest at or approaching Day 14 (ovulation – release of mature egg from ovary)
- **Progesterone:**
  stimulate thickening of uterine lining, and maintain thickness
  - Highest in middle of Thickening phase

Phase	Day	Thickness of Uterine Lining	Concentration of hormones	Implications on conception
MENSTRUATION	1st to 5th (5 days)	▪ Thickness of U.L. decreases ▪ U.L. is shed, together with blood and unfertilised egg. → **Menstruation**	❖ Oestrogen and progesterone levels are both low. → allows menstruation to occur.	Not fertile because ➢ there is no egg and U.L. is not thick enough to support pregnancy.
REPAIR of uterine lining	6th to 10th (5 days)	▪ Thickness of U.L. starts to increases again	❖ Oestrogen levels start increasing → stimulates repair of U.L. ❖ Progesterone levels remain low.	
FERTILE (due to **Ovulation on 14th day**)	11th to 18th (8 days)	▪ Thickness of U.L. continues to increase → to prepare for possible implantation of embryo in case of fertilisation	❖ Oestrogen levels increase to maximum to <u>stimulate ovulation</u>, and then start decreasing ❖ Progesterone levels start increasing.	Fertile because ➢ Egg is present due to ovulation around Day 14 ➢ Sperm is present due to sexual intercourse ➢ U.L. sufficiently thick for implantation
THICKENING of uterine lining	19th to 28th (10 days)	▪ Thickness of U.L. continues increasing and maintains thickness →to prepare for pregnancy and support growth of foetus in case there was fertilisation	❖ Oestrogen levels continue decreasing ❖ Progesterone levels increase to maximum, maintain levels, then decrease nearing Day 28 (to facilitate menstruation again)	*If **no** fertilisation occurred: ➢ Not fertile because ➢ Egg has died *If **fertilisation** occurred: ➢ Progesterone levels remain high to maintain thick U.L. for pregnancy

Revision Video (Menstrual Cycle Graph): <u>https://tinyurl.com/MsYTMLHumanRepro1</u>

- *Different individuals' menstrual cycle can **vary in length** because of these factors:

    - Prolonged stress / traveling
    - Malnutrition
    - Being on prolonged medication/ sickness
    - Taking contraceptives like *birth control pills*

(i) Explain the length of the fertile period by relating to the lifespan of the sperm and egg

Why is the fertile phase longer than just the day of ovulation?

- After ovulation, the egg can remain viable (survive) for about 2 days.
- Sperms can remain viable for up to 3 days.
- Hence, the fertilisation is still able to occur if sexual intercourse occurred a few days before or after day of ovulation.

Therefore, the duration of the fertile period is ~8 days though ovulation occurs only on the 14th day.

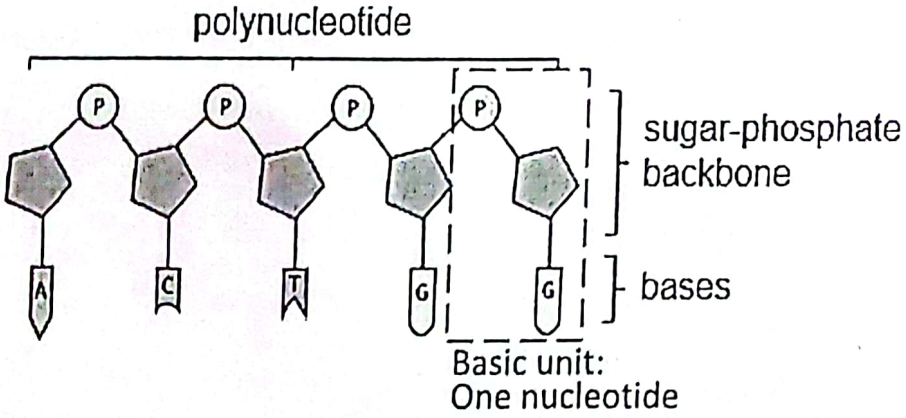
(k) Discuss the spread of human immunodeficiency virus (HIV) and the methods by which it may be controlled.

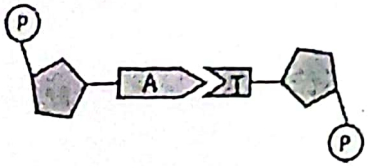
- The Human ImmunoDeficiency Virus (HIV) causes Acquired Immunodeficiency Syndrome (AIDS).
- AIDS is a Sexually-Transmitted Infection (STI) where HIV infects the white blood cells of the body and weakens the immune system.

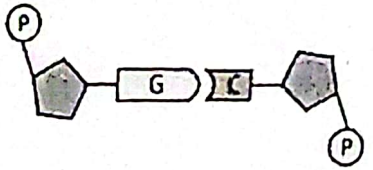
How HIV can spread (via contact with infected blood/ infected sexual fluids)	How to **prevent** spread of HIV
➢ Sharing contaminated needles (eg. tattooing equipment, syringes, etc) ➢ Unprotected sexual intercourse with infected person ➢ Transfusion of infected blood ➢ From an infected pregnant mother to her child through childbirth, pregnancy or breastfeeding	➢ Use only sterilised or new disposable needles ➢ Abstinence ➢ Sexual intercourse only with uninfected spouse

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

- DNA consists of 2 strands of polynucleotides which are antiparallel, and coiled together in a double helix structure.
- Each polynucleotide strand of DNA is made up of smaller basic units called nucleotides joined together, sharing a sugar-phosphate backbone.
- In turn, each nucleotide is made up of 3 parts – A deoxyribose pentose sugar molecule, a phosphate group and A nitrogeneous base.
- There are 4 types of nitrogeneous bases – Adenine (**A**), Thymine (**T**), Guanine (**G**) and Cytosine (**C**). The type of base determines the type of nucleotide it is.
- A always binds to T and G always binds to C, according to the rule of complementary base-pairing.





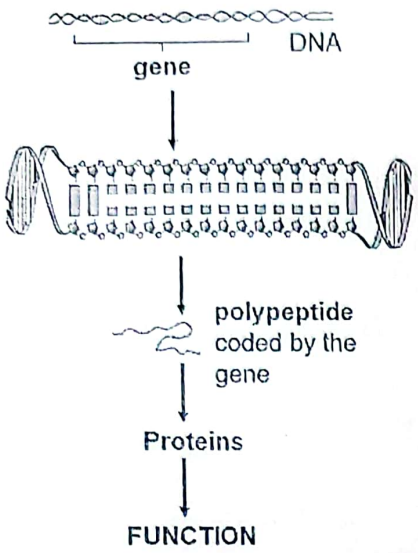


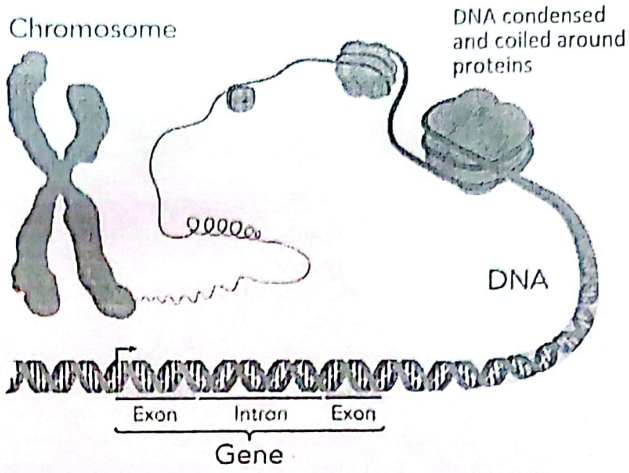
(c) State the rule of complementary base pairing.

Adenine always only binds to Thymine and Guanine always only binds to Cytosine, with the formation of hydrogen bonds.

(d) State that DNA is used to carry the genetic code (no need translation, transcription), which is used to synthesise specific polypeptides

(e) State that each gene is:
(i) a sequence of nucleotides, as part of a DNA molecules (structure)
(ii) controls the production of one polypeptide (function)





Segment of DNA with a specific sequence of nucleotides that control production of one polypeptide with a specific function

Chromosome	DNA	Gene
• The form of DNA found in the nucleus of cells • DNA that has been wrapped around proteins, coiled and condensed many times (hence, most visible under electronmicroscopes) • Humans have 22 pairs of chromosomes and 1 pair of sex chromosomes • **Function:** contains all genetic information of an organism	• The basic, uncoiled, uncondensed form • A double-stranded helical structure (*Recall: Structure of DNA*) • **Function:** contains all genetic information of an organism	• A **segment of the DNA** which... • **Function:** ...contains genetic information **coding for a polypeptide for a specific trait** • The sequence of the nucleotides/ bases in the gene determines what polypeptide is produced, and hence the expressed phenotype of the trait coded by the gene

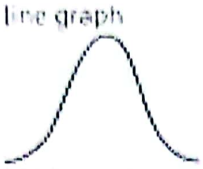
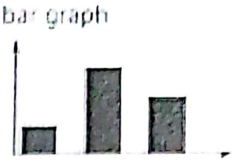
(a) Outline the relationship between genes, chromosomes, and DNA

- A chromosome is DNA in a form that is wrapped around proteins, coiled, and condensed.
- A gene is only a segment of the entire DNA molecule.
- While the chromosome and DNA contains genetic information for the whole organism,
- coding for different polypeptides,
- each gene only codes for 1 specific polypeptide for 1 specific function, according to the specific sequence of nucleotides of the gene

CHAPTER 12 – INHERITANCE

(b) Describe the difference between continuous and discontinuous variation and give examples of each.

Definition of ***variation*** → differences in traits between individuals of the same species.

	Continuous Variation 	**Discontinuous Variation** 
Examples	Height, weight, skin colour, intelligence	Blood types, ability to roll tongue, gender, disease/no disease
Phenotypes	Involves a few **clear-cut distinctive phenotypes**	Involves **a range of phenotypes** with intermediate forms
Genes	• Phenotype expressed is caused by the **additive effect** of **many genes**	• Usually controlled by **one or a few genes only** • Genes do not show additive effect
Environmental Conditions	• **Greatly** influenced by environmental conditions	• **Relatively unaffected** by environmental conditions

(a) Define a *gene* as a unit of inheritance and distinguish clearly between the terms *gene* and *allele*

(c) Explain the terms *dominant*, *recessive, homozygous, heterozygous, phenotype, and genotype*

Term	**Definition**
Gene	Unit of inheritance in the form of a segment of DNA consisting of a sequence of nucleotides that code for a specific trait *(Recall: Trait – characteristic of an organism encoded by a gene)*
Allele	Different forms of the same gene, occupying the same locus on a pair of chromosomes.
Phenotype	Trait that is expressed in an organism
Genotype	The combination of genes (genetic make-up) in an organism. - Consists of 2 alleles and can be homozygous or heterozygous
Homozygous	Condition where both alleles in a genotype are the same - can be homozygous dominant, or homozygous recessive
Heterozygous	Condition where the alleles in a genotype are different
Dominant	expressed when there is at least one allele present in the genotype
Recessive	expressed only when both alleles present in genotype

Inheritance
Revision Video 1:
Meaning of Key Terms

https://tinyurl.com/MsYTMLInheritance1

(d) Predict the results of simple crosses [genetic diagrams] with expected ratios of 3:1 and 1:1, using the terms *homozygous*, *heterozygous*, *F_1 generation* and *F_2 generation*.

EXAMPLE QUESTION

Trait: Height of pea plants Possible phenotypes: Tall (dominant), Dwarf (recessive)
A pure-bred (ie: homozygous genotype) Dwarf Pea Plant was crossed with a heterozygous Tall Pea Plant.
Let T represent the allele for Tall pea plants, and t represent the allele for dwarf pea plants.

(i) Using a genetic diagram, predict the **percentage** of **F1 offspring** which would be **Tall.**

Method 1 (Genetic cross)

1 *Parents' phenotypes:* Dwarf plant x Tall plant (Dwarf) (Tall)

2 *Parents' genotypes:* tt Tt

3 *Gametes:* 

4 *Offspring's genotypes:* tT tt tT tt

5 *Offspring's phenotypes:* Tall Dwarf tall dwarf

6 *Working for percentage:* 50%

Method 2 (Punnett Square)

To explain genetic crosses in words, can follow this format:

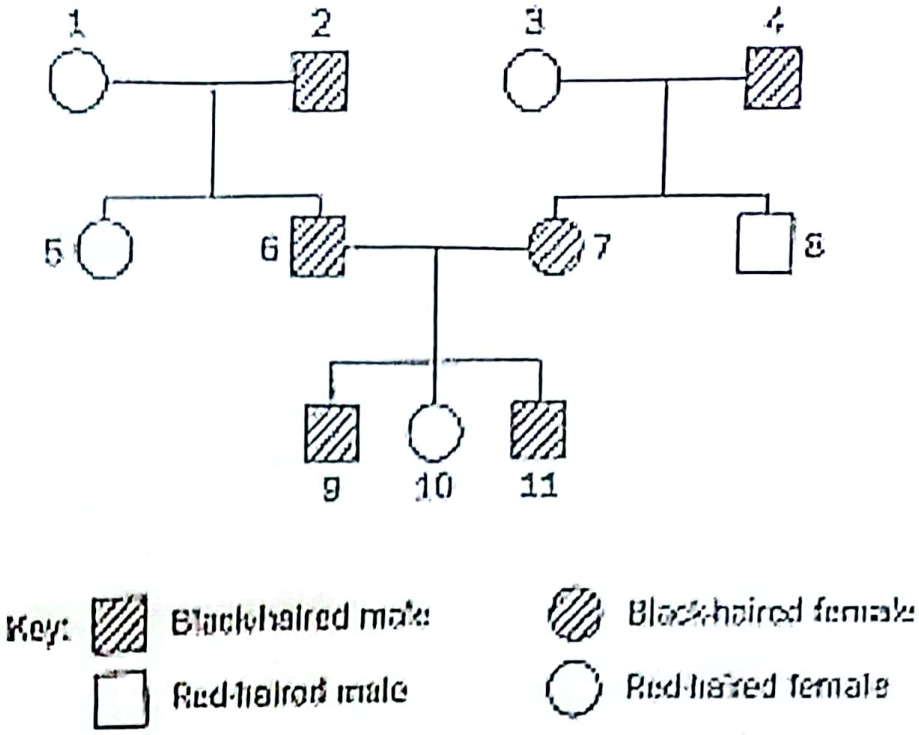
- ✓ Genotype and phenotype of both parents.
- ✓ Offspring inherits first allele (dominant or recessive?) from which parent?
- ✓ Offspring inherits second allele (dominant or recessive?) from which parent?
- ✓ Therefore, offspring has what genotype? Causing what phenotype?

EXAMPLE QUESTION (Family Tree questions)

The diagram on the right shows the inheritance of hair colour in the Smith family.

How to approach Family Tree questions:

- ✓ Is the trait sex-linked?
  (*ie. Would a male have higher chance of getting disease?)*
- ✓ Figure out what is the dominant and recessive phenotypes.
- ✓ Label genotype for all recessive phenotypes first.
- ✓ Annotate the possible genotypes for the rest, starting from the ones nearest the labelled recessive phenotypes, see if you can decide the genotype for the others.



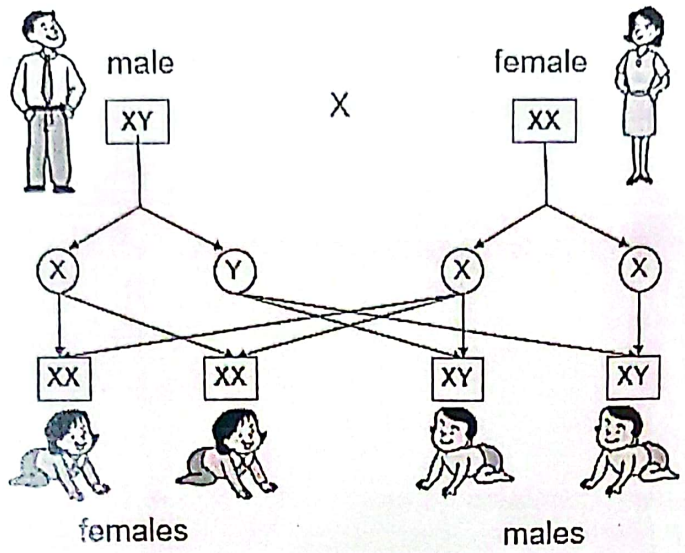
(e) State why observed ratios often differ from expected ratios, especially when there are small numbers of progeny.

The observed ratio of traits (and sex) inherited is often different from the expected ratio from our genetic crosses and calculations because of **2 main reasons**:

1) The **sample size is too small** so the ratio is statistically inaccurate.
2) The combination of sex chromosomes during **fertilisation is random**. [sex-determination]
   OR The combination of alleles during fertilisation is random. [inheritance of traits]

(f) Describe the determination of sex in humans – XX and XY chromosomes

Genetic cross for sex-determination



Punnett Square:

Note:

From the **mother**: offspring will always inherit an **X** chromosome

From the **father**: offspring can inherit either **X** or **Y** chromosome.

- If **X** chromosome inherited → offspring is ***female***.
- If **Y** chromosome inherited → offspring is ***male***.

Hence, 50% chance.

(h) Name radiation and chemicals as factors which may increase the rate of mutation.

Definition of ***mutation*** → a sudden random change in the structure of a gene (gene mutation) or in the chromosome number (chromosome mutation)

Mutations can be caused by **mutagens** (chemicals/factors encouraging mutations) such as:

- ❖ Radiation
- ❖ UV light
- ❖ Toxic chemicals like tar (eg. found in cigarette smoke)

(g) Describe mutation as a change in structure (sequence) of a gene, as in sickle cell anaemia, or in chromosome number such as the 47 chromosomes in Down's Syndrome.

1) Gene Mutation

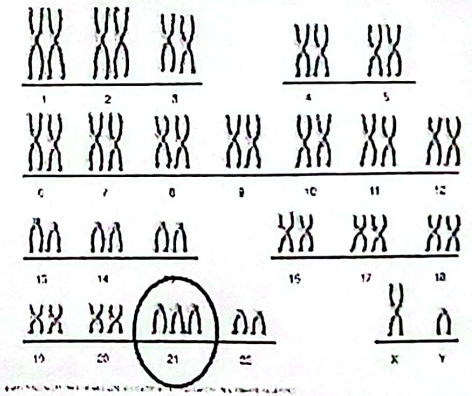
Definition → Mutation that results in a change in the sequence of the nucleotides in the gene

Example:	How the mutation caused the disease:	Effect of disease:
Sickle Cell Anaemia *(mutation causing a change in sequence of the gene controlling Haemoglobin production)*	1. A mutation occurred in the gene controlling the production of haemoglobin protein. 2. This caused the sequence of nucleotides in the gene to change, 3. Causing a different amino acid to be produced. 4. The change in amino acid led to a change in the polypeptide and hence, the haemoglobin protein produced.	• Mutated haemoglobin produced has an abnormal shape, causing the red blood cell to clump together to become sickle-shaped. • This reduces SA:vol ratio of RBC, and the ability of RBC to move through capillaries. • This reduces the ability of the red blood cells to transport oxygen, and can lead to fatigue and death.

2) Chromosomal Mutation

Recall: Normal human cells each have 23 pairs of chromosomes = 46 chromosomes.

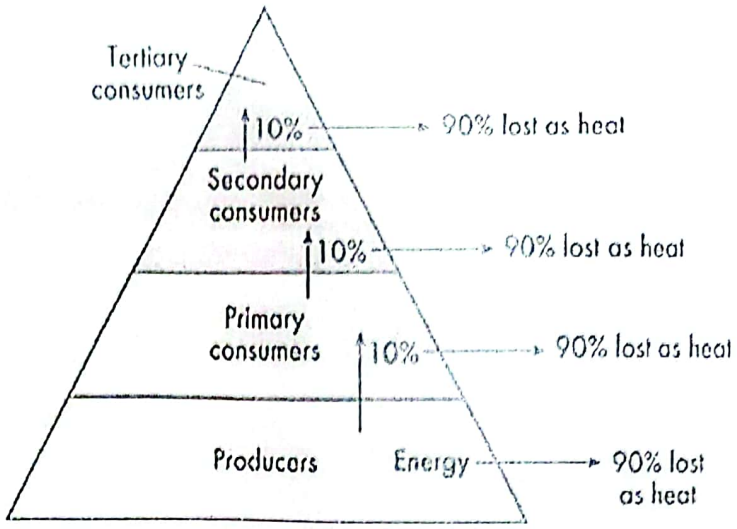
Definition → Mutation that results in a change in the number of chromosomes

Example:	How the mutation caused the disease:	
Down's Syndrome *(mutation causing a change in the number of chromo -somes)*	A mutation occurred causing there to be an extra copy of Chromosome 21. **Effect of disease:** Offspring with Down's Syndrome has abnormal physical and/or mental development.	

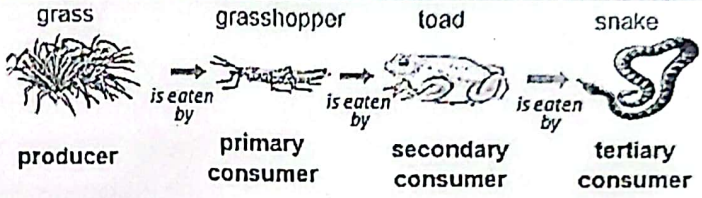
CHAPTER 13 – ORGANISMS & ENVIRONMENT

(a) Briefly describe the non-cyclical nature of energy flow

- At each trophic level, most of the energy is lost to the environment in the form of heat energy from respiration, or chemical energy trapped in uneaten tissues or egested/excreted wastes.
- The lost energy is not returned to the organisms in the ecosystem.
- Hence, more light energy has to be constantly supplied to the producers in ecosystem.
- Hence, the energy flow in ecosystems is linear and not cyclical.



(b) Establish the relationship of the following in food webs: producer, consumer, herbivore, carnivore, decomposer, food chain, trophic level



Term	Definition
Habitat	Place where organisms live *(eg. habitat of koi fish is the pond)*
Population	Group of organisms of the same species living together in one habitat *(eg. population of koi fish in the pond)*
Community	All the populations living and interacting with one another in one habitat *(eg. koi fish population + pondweed population)*
Ecosystem	Community of organisms interacting with one another and with the environment
Trophic Level	Each stage in a food chain
Herbivore	Organism which consumes only plants. Typically a primary consumer.

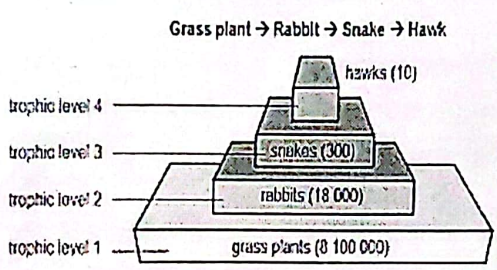
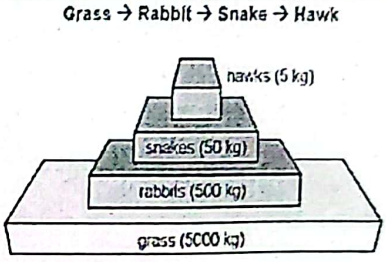
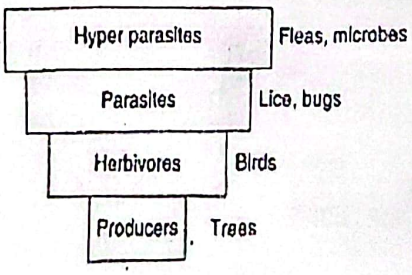
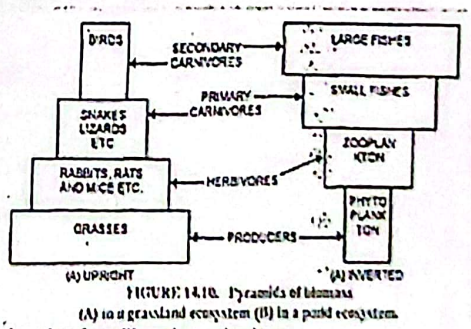
Term	Definition
Producer	Organisms that can trap light energy and convert it to chemical energy stored in manufactured food, by photosynthesis
Consumer	Organisms that obtain energy and nutrients by feeding on other organisms as they cannot photosynthesise.
Decomposer	Organisms that break own decaying organic matter (eg. dead bodies, faeces) into nutrients which are returned to the environment.
Food Chain	A series of organisms through which energy is transferred in the form of food
Food Web	Consists of interlinked food chains
Carnivore	Organism which consumes only animals. Typically a secondary consume at least..

(c) Describe energy losses between trophic levels and infer the advantages of short food chains.

The more trophic levels there are in a food chain,
the more the energy lost...
...and **the less the energy transferred** to the last trophic level.

- At each trophic level, most of the energy is lost to the environment in the form of heat energy from respiration, or chemical energy trapped in uneaten body parts or egested/excreted wastes.
- Only 10% of energy is transferred to the next trophic level.
- Since shorter food chains have fewer trophic levels, so less energy is lost and more energy is transferred to the organisms in the last trophic level.

(d) Interpret pyramids of numbers and biomass

	Pyramid of Numbers	Pyramid of Biomass
Purpose	Can compare the number of organisms (population) in each trophic level at one particular time	Can compare the dry mass* of organisms in each trophic level at one particular time
Typical Shape (upright pyramid)	• Pyramid is upright. • Each trophic level is broader than the next so that the population of the lower trophic level is sufficient to sustain the next trophic level.  • The first trophic level at the base of the pyramid is the broadest as the number of grass is the greatest, followed by the number of rabbits, then snakes, then hawks. • The last trophic level at the top of the pyramid is the narrowest as the number of hawks is the smallest.	• Pyramid is upright. • The first trophic level at the base of the pyramid is the broadest as the biomass of grass is the greatest,  followed by the biomass of rabbits, then snakes, then hawks. • The last trophic level at the top of the pyramid is the narrowest as the biomass of hawk is the smallest. • Each trophic level is broader than the next so that the energy trapped in the biomass of these organisms is sufficient to sustain the organisms in next trophic level.
Exceptions	Inverted/ non-upright pyramid if one of the trophic levels has: • Parasitic organisms o usually at the highest trophic level o E.g.: protozoa, decomposer bacteria, etc.  • One large organism o usually at the first trophic level o E.g.: a tree	Inverted/ non-upright pyramid if one of the trophic levels has an: • Organism that reproduces very rapidly o usually at the first trophic level  FIGURE 14.10 Pyramids of biomass (A) in a grassland ecosystem (B) in a pond ecosystem o E.g.: photosynthetic microbes like phytoplankton

(e) Describe how carbon is cycled within an ecosystem and Explain the importance of the carbon cycle and outline the role of forests and oceans as carbon sinks.

Importance of Carbon Cycle: 3 Reasons

1) *About Photosynthesis:*
   - Ensures that there is continuous supply of carbon dioxide for plants to continue to carry out photosynthesis as producers in food chains.

2) *About Energy flow in food chains:*
   - Enables energy to flow through food chains in ecosystems through processes like feeding and decomposition.
   - Organisms which do not photosynthesise rely on plants to convert light energy to chemical energy, which are then passed down to these organisms when they feed on plants.

3) *About Carbon dioxide in atmosphere:*
   - Maintains correct concentration of carbon dioxide in the atmosphere

How Carbon is Cycled in an Ecosystem:

- Carbon is an organic molecule that is present and continuously recycled in our environment in the carbon cycle
- in various forms such as carbohydrates (starch, sugars), fossil fuels, and carbon dioxide gas.
- Carbon is continuously **removed from** our environment through photosynthesis,
- and **released into** our environment through processes like aerobic respiration, combustion, decomposition.
- Carbon compounds trapped in the tissues of organisms is also transferred from one organism to the next in the food chain through the process of feeding.

Role of Forests & Oceans as Carbon Sinks:

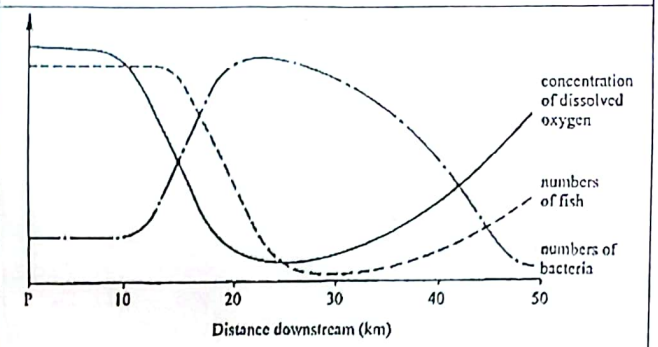
Carbon Sinks:

- An area that stores carbon compounds for an indefinite (very long) period.
- Since it stores more carbon dioxide than it releases,
  it can help remove carbon dioxide from the atmosphere and act as a carbon reservoir to store it
  → reduces global warming as carbon dioxide is a greenhouse gas

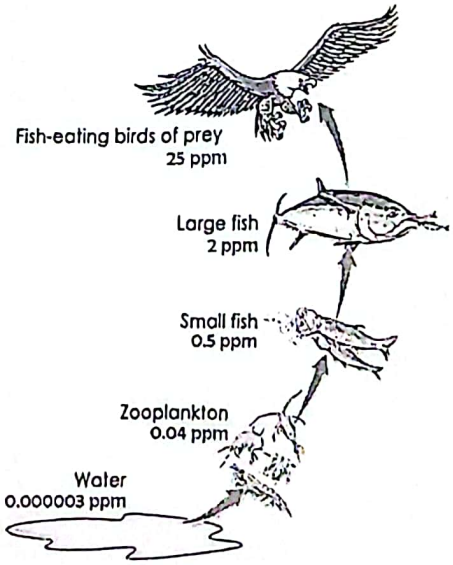
Carbon Sinks	Oceans	Forests
Why it is a good carbon sink	• Largest carbon sink in the world • Absorb CO_2 from the atmosphere as ocean's water can dissolve CO_2 / CO_2 is highly soluble in the water • Plants, algae, photosynthetic phytoplankton in the ocean uses the CO_2 for photosynthesis	• Plants in forests absorb CO_2 from atmosphere for photosynthesis • Large amount of carbon compounds formed from photosynthesis is stored in the trees for a very long time and can become fossil fuels after death

(f) Evaluate and explain the effects of:

(i) Water pollution by sewage

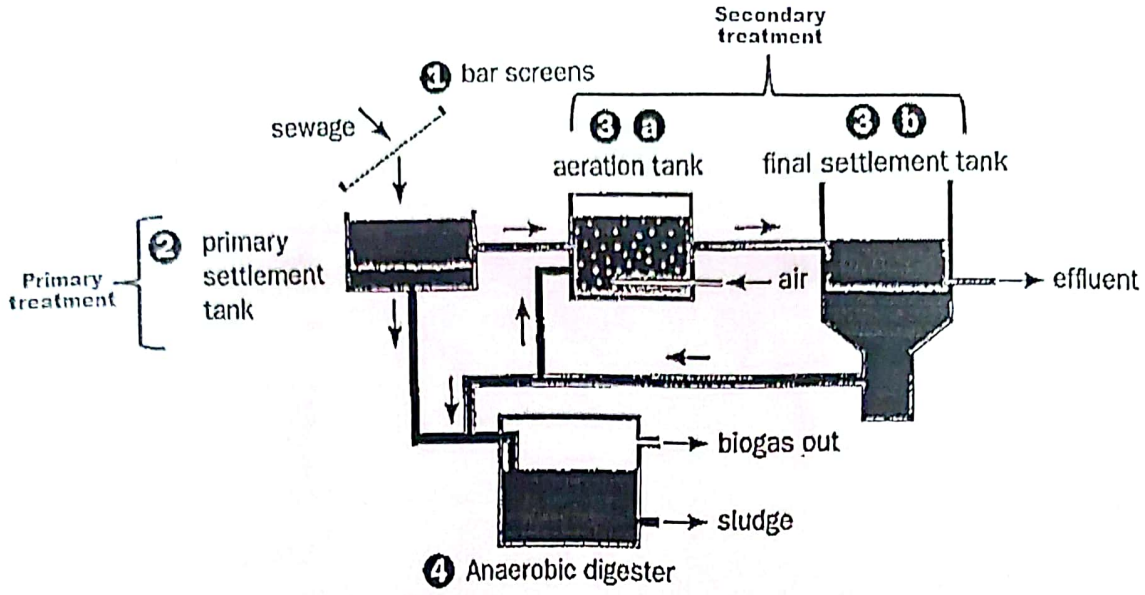
Scenario 1	Scenario 2
1. Untreated sewage discharged into water bodies/ Excess fertilisers may be washed away into nearby water bodies like rivers. 2. Untreated sewage/ Fertiliser run-off contains **phosphates and nitrates.** 3. These cause rapid/**increased growth of water plants and algae** in the water →resulting in **eutrophication.** 4. Excessive growth of water plants and algae cause **overcrowding and blocks sunlight** from reaching submerged plants in the water. 5. Submerged plants receive **insufficient light for photosynthesis and die.** 6. Dead plants and algae are then **decomposed by aerobic bacteria** in the water, which uses up oxygen. 7. As **decomposer bacteria and fungi grow** and multiply, they use up more oxygen. 8. There is **insufficient oxygen for aerobic respiration** for water organisms like fish, and **die.**	 1. Untreated sewage discharged into water bodies 2. **Bacteria in water use up oxygen to decompose**/break down the sewage (respiration by bacteria) and bacteria multiplies. 3. Oxygen concentration in the water decreases. 4. Other **aquatic organisms have insufficient oxygen** for respiration for energy, and die. 5. Populations of other aquatic organisms decrease.

(ii) Pollution due to insecticides including bioaccumulation up food chains, and impact on top carnivores



1. Inorganic substances are **non-biodegradable** and remain in the soil or water for a long time.
2. They are **consumed by primary consumers** like plankton, and are **stored in their tissues**
3. With time, as primary consumers consume more of such inorganic substances, the **concentrations stored in their tissues increase.** → **Bioaccumulation** occurs.
4. The inorganic substances are then **passed along the food chain** to the secondary consumers and the subsequent consumers, with **increasing concentrations passed along with each trophic level.**
5. The **last consumer in the food chain would contain the highest concentrations** of the inorganic substances, and hence, may face harmful effects (or more harmful effects as compared to organisms in the lower trophic levels.).

(g) Outline the roles of micro-organisms in sewage treatment as an example of environmental biotechnology



▲ **Figure 22.5** Sewage treatment in a water reclamation plant

	Phase	Process/ Equipment	What is occurring?
PRIMARY Treatment	1	Bar screens Process: Filtration	• Sewage is channelled into the water reclamation plant. • The used water is passed through bar screens to remove large coarse materials (e.g. grit, sticks, etc.).
PRIMARY Treatment	2	Primary Settlement Tank	• The screened liquid is sent to primary settlement tank. • Liquid flows through slowly to allow solid suspensions to settle at the bottom of the tank. • The sediment at the BOTTOM forms primary sludge → sent to Step 4: Anaerobic Digester • The liquid at the TOP → flows into the next step 3: Aeration Tank.
SECONDARY Treatment	3a	Aeration Tank Process: Activated Sludge Process	• Activated sludge process is carried out, involving aerobic respiration by microorganisms. • Aerobic microorganisms like bacteria are mixed into the liquid. • Bubbles of compressed air containing dissolved oxygen is pumped into the liquid. • Water is treated when the microorganisms use the oxygen to break down the organic pollutants in the water during respiration.
SECONDARY Treatment	3b	Final Settlement Tank	• The treated water and the microorganisms is sent to the final settlement tank. • The microorganisms settle to the bottom of the tank, forming sludge. • The liquid (effluent) is further sent for treatment by reverse osmosis to produce clean water (NEWater). • Excess sludge is sent to Anaerobic Digester. • Some of the sludge is returned to Aeration Tank to be reused.
	4	Anaerobic Digester (closed tank)	• Anaerobic bacteria decompose/break down the sludge in a closed tank. • No oxygen is supplied. • Biogas (e.g. methane) is produced, which can be used as a fuel to generate electricity. • The remaining solid materials are removed and used as fertiliser or burnt in incinerators.

- Microbes such as aerobic bacteria are used to break down carbon compounds in sewage by carrying out decomposition (respiration) in the presence of oxygen.

(h) Discuss reasons for conservation of species with reference to maintenance of biodiversity and how this is done, e.g. management of fisheries and management of timber production.

Maintaining Biodiversity

Conservation is the protection and preservation of natural resources, including the variety of organism species and ecosystems in the environment.

5 Reasons for Conservation:

Prevent extinction of species to maintain biodiveristy	•To maintain a large gene pool that is genetically distinct –> less likely to die out in event of diseases or environmental changes •Different species may possess different favourable genes –> can improve agricultural produced through cross-breeding.
Maintable stable and balanced ecosystems	• to reduce disruption of natural cycles (eg. carbon cycle) and reduce global warming
For scientific research	• studying environment and living organisms around us provides useful information to humans
For economic purposes	• source of food • source of raw materials (eg. cotton fibres, wood, rubber)
Preserve environment and wildlife for appreciation	• enables outdoor recreation activities (eg. hiking, skiing,etc)

Management of Fisheries & Timber Production

	Issue: **Deforestation/ Timbre Industries** Cause: Timber Industries, clearing of forests for land for farming, industrialisation, urbanisation, etc.	Issue: **Overfishing** Cause: **uncontrolled fishing practices** leading to species of fish being fished a rate faster than the fish populations can regenerate
Government **laws to regulate the industries** → to ensure that resources are harvested at a sustainable rate allowing enough time for populations to regenerate	Pass laws to **regulate timber industries** • regulate the number and type of trees that can be cut down • regulate the locations where trees can be cut down	Pass laws to **regulate fishing industries** • Regulate the number of fishing ships in fishing grounds • Limiting the time period of fishing • Banning the fishing of endangered species
	Pass laws to **designate certain areas as protected forest reserves** and ban/prohibit all human activities that may harm the living organisms in the reserves.	Pass laws to regulate fishing equipment: • **Ban harmful fishing equipment** that indiscriminately trap marine life • using **nets with a larger hole size** so that young fish are not caught and allowed to grow to reproduce
Help to **introduce new populations**	**Reforestation:** Replanting new seedlings or trees to replace those that have been removed.	**Raising endangered species of fish in hatcheries** and releasing them into fishing areas where populations are endangered.
Government to **protect existing resources and enforce laws**	Set up government bodies to: • Protect health of existing trees (eg. NParks, Forestry departments) • Enforce laws and ensure industries follow them	Set up government bodies to: • Protect health of existing marine species (eg. Marine biologists) • Enforce laws and ensure industries follow them (eg. coastguards)
Use **Science to conduct Research & Development** to help strengthen the populations	Carry out research on how to **improve the health, reproduction rate and survival rate**	

What are the possible Key Terms where you might be tested on the definition? Collate them in this table here.

KEY TERM	DEFINITION

NOTES:

NOTES: