NUTRITION

- Is the process by which organisms obtain, consume and use food substances to maintain life processes.

There are basically 2 types of nutrition namely;

1. Autotrophic nutrition[autotrophism]
2. Heterotrophic nutrition [heterotrophism]

AUTOTROPHIC NUTRITION

- Is the type of nutrition where organisms manufacture their own food materials.
- Organisms that exhibit autotrophism are called autotrophs.

HETEROTROPHIC NUTRITION

- Is the type of nutrition where organisms feed on already manufactured food materials.
- Organisms that exhibit heterotrophism are known as heterotrophs.

1. AUTOTROPHISM

- This is the type of nutrition where organisms manufacture their own complex organic food materials from simple and inorganic matter.
- There are 2 types of autotrophism namely;

(i) PHOTOAUTOTROPHISM

- Is the mode of autotrophic nutrition where green plants and some bacteria manufacture their own complex organic food materials from simple inorganic materials using sunlight energy trapped by chlorophyll.
- It is also known as photosynthesis.

NB: Photosynthetic bacteria carry out photosynthesis because they possess bacteriochlorophyll.

(ii) CHEMOAUTOTROPHISM

- Is the mode of autotrophic nutrition where some microbes like bacteria synthesize their own complex organic food materials from simple inorganic compounds using energy obtained from oxidation of chemicals.
- It is also called chemosynthesis.

Question: Define the following terms;

(i) Autotrophic nutrition/autotrophism
(ii) Chemoautotrophism/chemosynthesis
(iii) Photoautotrophism/photosynthesis
(iv) Heterotrophism

NB: Nutrition supplies the body with food nutrients biologically called **chemicals of life**.

CHEMICALS OF LIFE

- These are important chemical substances required to maintain life processes.
- There are inorganic and organic chemicals of life.
- The major chemicals of life include;
  1. Water
  2. Carbohydrates
  3. Lipids
  4. Proteins
  5. Vitamins
  6. Mineral salts
  7. Roughages

1. WATER

- Without water life could not exist on earth.
- The special characteristics of water are;

(i) Water is a liquid at room temperature
(ii) Water is a universal solvent
(iii) Water has a high surface tension
(iv) Water is wet.
(v) Water has a very high specific heat capacity
(vi) Water has a very high latent heat of vaporization
(vii) Water has a very high latent heat of fusion.
(viii) Water is colourless and transparent.
(ix) Water is difficult to compress i.e. is compressible
(x) Water is denser than air.
(xi) Water has a low viscosity.
(xii) Water has a high tensile strength

The biological functions of water include;

- Water is the main structural constituent of organisms.
- Water is a reagent in hydrolysis i.e is a metabolite.
- Is a medium for metabolic reactions; since all chemical reactions in cells occur in an aqueous medium.
- It is a transportation medium of materials in the body; it is essential for diffusion of materials in cells.
- It is a raw material for photosynthesis
- Is a habitat for aquatic organisms; provides support to aquatic organisms which live in water.
- Is provides a medium in which fertilization of gametes occurs.
- It activates hydrolytic enzymes thus required for seed germination.
- Is a dispersal agent for insects' gametes, larvae of aquatic organisms, seeds and spores of some terrestrial organisms.
- Provides support in plants due to turgidity and supports growth as a result of osmosis.

- Is a coolant in biotic systems due to high latent heat of evaporation during transpiration, sweating and panting.
- Is necessary for excretion of metabolic wastes from the body i.e. is a medium for excretion of wastes.
- Is important for osmoregulation.
- Watery endolymph and perilymph is important for hearing and balance in mammalian ear.
- Is a lubricant in joints like synovial fluid.
- Supports organisms through hydrostatic skeleton, turgor pressure of amniotic fluids, aqueous and vitreous humour of the eye.

FOOD

- Food refers to organic compounds that provide living organisms with nourishment in form of raw materials and energy.

CLASSES OF FOOD

- There are 3 main classes of food viz;
  1. Energy giving foods: Provide energy in the body by respiration.
     These are lipids and carbohydrates.
  2. Body building foods: Form new cells and tissues during growth and repair of worn out tissues. These are proteins.
  3. Protective foods: Protect the body against infection and diseases.
     These are vitamins and mineral salts.

2. CARBOHYDRATES

- Carbohydrates are organic compounds containing carbon, hydrogen and oxygen.
- The general formula of carbohydrates is $C_x(H_2O)_y$.

CLASSES OF CARBOHYDRATES

- Carbohydrates are divided into 3 main classes namely;
  (i) Monosaccharides
  (ii) Disaccharides
  (iii) Polysaccharides

(i) MONOSACCHARIDES

These are single sugar units with general formula $(CH_2O)_n$.

Monosaccharides are grouped according to the number of carbon atoms (n) into;

- ✓ Trioses(3n)
- ✓ Tetroses(4n)
- ✓ Pentoses(5n)
- ✓ Hexoses (6n)
- ✓ Heptoses(7n)

PROPERTIES OF MONOSACCHARIDES

a) They are sweet.
b) They are readily soluble in water.
c) They are crystalline solids.
d) They are reducing sugars. i.e. the reduce copper(II) ions[blue] in Benedict's solution to copper(I) ions/copper [Brown/orange].
e) They are small organic molecules.

f) They have low molecular mass.

NB: Monosaccharides are the basic building blocks of carbohydrates.

(ii) DISACCHARIDES

These are 2 sugar unit carbohydrates.
They are formed when 2 monosaccharides combine in condensation reaction.
A condensation reaction is a reaction accompanied by loss of water molecules.
E.g.

a) $Glucose + Glucose \longrightarrow Maltose + Water$
(Malt sugar)

b) $Glucose + Fructose \longrightarrow Sucrose + Water$
(Cane sugar)

c) $Glucose + Galactose \longrightarrow Lactose + Water$
(Milk sugar)

PROPERTIES OF DISACCHARIDES

(a) They are sweet.
(b) They are soluble in water.
(c) They are crystalline.
(d) They are non-reducing sugars except maltose and lactose.
(e) They are broken down to their constituent monosaccharides in a reaction called hydrolysis which involves addition of water molecule.

E.g.

a) $Sucrose + Water \underset{\text{Condensation}}{\overset{\text{Hydrolysis}}{\rightleftharpoons}} Glucose + Fructose$

(iii) POLYSACCHARIDES

These are formed when many monosaccharides combine by condensation like starch (plant cells), glycogen (animal cells) and cellulose (plant cell wall).
Properties of polysaccharides

(a) They are not sweet.
(b) They are insoluble (slightly soluble) in water.
(c) They are non-crystalline.
(d) They are large organic molecules.
(e) They have high molecular mass.
(f) They are non-reducing sugars.

Question: Give 5 differences between monosaccharides and polysaccharides.

FUNCTIONS OF CARBOHYDRATES

1. Pentose sugars, ribose and deoxyribose are building blocks of nucleic acids like DNA& RNA.
2. Ribose is used for synthesis of the coenzymes NAD and NADP.

3. Ribose is used in the synthesis of ATP.
4. The pentose sugar ribulose is used for synthesis of RuBP.
5. The hexose sugar fructose sweetens fruits to attract animals for dispersal.
6. Carbohydrates provide energy when oxidized in the body during respiration.
7. Carbohydrates are food reserves for storage of energy and materials.
   NB: Plants store, starch; animals and fungi store glycogen.
8. Carbohydrates are structural components of organisms like cellulose is a component of plant cell walls.
9. Carbohydrates are raw materials for the industrial manufacture of sugar, paper, textiles, timber, fuel/firewood.

SOURCES OF CARBOHYDRATES

(i) Cereals; such as wheat, rice, sorghum, maize, millet, simsim.
(ii) Tubers; like sweet potatoes, cassava, yams, irish potatoes.
(iii) Fruits; like banana, mango, orange.
(iv) Sugar; from sugar cane, beet root.

3. LIPIDS

- Lipids are organic compounds formed by condensation between fatty acids and glycerol.
- A molecule of glycerol combines with 3 molecules of fatty acids by formation of ester bonds forming a lipid.
- A lipid is therefore a triglyceride.

$$Glycerol + 3\ Fatty\ acids \xrightarrow{Condensation} Lipid + 3\ Water$$

(Triglyceride)

- Lipids which are liquid at room temperature are called oils.
- Lipids which are solid at room temperature are called fats.
- Hydrolysis of lipids under suitable conditions yields glycerol and 3 fatty acids.

PROPERTIES OF LIPIDS

- They are inert.
- They are emulsified by dilute alkalis.
- They solidify when subjected to very low temperatures.
- They are soluble in organic solvents like ether.
- They are insoluble in water.
- They are poor conductors of heat.

FUNCTIONS OF LIPIDS

1. They are oxidized to yield energy during respiration.
2. Are useful energy reserves in animals, seeds and fruits; since they yield more energy than equal mass of carbohydrates.
3. They insulate the body against heat loss due to their deposition beneath the skin; since are poor conductors of heat.

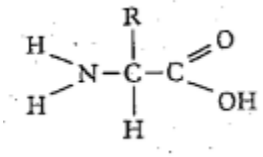
4. Protect delicate internal organs like kidneys, heart against physical/mechanical damage as they surround them since they are shock absorbers.
5. They increase buoyancy and floatation of large aquatic animals since they are less dense than water.
6. Waxes and oily secretions water proof bodies of organisms.
7. Are structural components of cell membranes.
8. Used for formation/synthesis of steroid/sex hormones like testosterone, progesterone and oestrogen from steroids.
9. Are sources of <u>metabolic water</u> on oxidation in respiration; important for survival of desert animals.
10. For synthesis of scents in plants flowers to attract pollinating insects from fatty acids and their derivatives.
11. Used to construct honey combs from wax and nectar synthesis by bees.

SOURCES OF LIPIDS

- Meat
- Milk
- Dairy products like butter, ghee, yoghurt, ice cream, margarine.
- Seeds like simsim, ground nuts.

4. PROTEINS

- <u>Proteins</u> are large organic molecules made from <u>amino acids</u>; containing carbon, hydrogen, oxygen, nitrogen and sometimes sulphur.
- Protein may also contain iron, phosphorus, copper and zinc.
  <u>Amino acids</u>
- Amino acids are small organic molecules containing an <u>acidic carboxyl (-COOH) group</u> and a <u>basic amino (-NH_2) group</u>.
  i.e.



- There are 20 amino acids commonly found in proteins.
  Types of amino acids
- There are 2 main types of amino acids namely;
  (i) Essential amino acids
  (ii) Non-essential amino acids
  (i) **<u>Essential amino acids</u>**; are amino acids which must be included in the diet because they cannot be made in the body at all OR They are made too slowly to meet body needs.
    - ✓ 8 of the 20 amino acids are essential for adult humans.
    - ✓ 10 amino acids are essential in plants.

The essential amino acids are; arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, theorine, tryptophan and valine

(ii) **Non-essential amino acids**; are amino acids made by the body.
the non-essential amino acids are; asparagine, aspartic acid, cysteine, glutamic acid, glutamine, glycine, proline, serine, tyrosine and alanine.

FORMATION OF PROTEIN

- The combination of 2 amino acids by a condensation reaction between an amino group of an amino acid and carboxyl group of another forms a dipeptide.
- The bond formed between 2 amino acids is called a peptide bond.
- When many amino acids are joined by condensation a polypeptide is formed which is a protein.

CLASSES OF PROTEINS

- There are 2 main classes of proteins namely;

(a) First class proteins: These are proteins that contain all the essential amino acids like soya beans, milk and meat.
(b) Second class proteins: These are proteins that lack one or more of the essential amino acids like most plant proteins.

FUNCTIONS OF PROTEINS

(i) They form important structural components of organisms like keratin forms hair, nails, hooves and horns etc.
(ii) They form enzymes which speed up the rate of metabolic (biochemical) reactions.
(iii) They form respiratory pigments like haemoglobin that transport respiratory gases like oxygen and carbon dioxide.
(iv) They form hormones which regulate metabolic processes.
(v) For transportation of fatty acids by plasma proteins like albumin.
(vi) Some proteins protect and defense the body against diseases and infections like antibodies and fibrinogen.
(vii) For movement and locomotion by contractile proteins like myosin and actin of myofilaments due to muscle contraction.
(viii) For storage of mineral salts and energy by storage proteins like caseinogen.
(ix) Some proteins are toxins used for defence and predation like snake venom.
(x) Cell membrane proteins are important enzymes, receptor sites for antigens and drugs/transmitters and transport sites of materials.
(xi) Mucin protein forms mucus that traps food in filter feeders; prevents autolysis of gut; lubricate vaginal wall during sexual intercourse; keeps respiratory surfaces moist during gaseous exchange.
(xii) Protein opsin is a visual pigment causing vision by retina.
(xiii) Plasma proteins are blood PH buffers that maintain a constant blood PH.

(xiv) For formation of new cells, growth, repair and replacement of worn out tissues.

(xv) Phytochromes are proteins that receive light stimulus in plants thus control growth and development.

SOURCES OF PROTEINS

- Soya beans
- Meat
- Milk
- Liver
- Fish
- Chicken
- Beans
- Pork etc

5. VITAMINS

- Vitamins are complex organic molecules required in small quantities for normal growth, metabolism and good health.
- Vitamins are grouped as water-soluble and fat-soluble.
- The lack of a particular vitamin in the diet impairs metabolism and produces a characteristic symptomatic disorder called a deficiency disease with particular deficiency symptoms.

A summary of names, sources, functions, deficiency disease and symptoms of vitamins required in the human diet

NAME, TYPE, SOURCE	FUNCTIONS	DEFICIENCY DISEASE AND SYMPTOMS
A. FAT-SOLUBLE VITAMINS (ADEK) (i) Vitamin A(Retinol) - Fish, liver, liver oil, fruits, dairy products, vegetables (carrots, spinach)	• Controls normal structure and growth of epithelia • Needed to make retinal for vision. • Enables night vision.	• Dry skin • Dry cornea • Poor night vision • Complete night blindness. • Permanent blindness (keratomalacia)
(ii) Vitamin D (Calciferol) - Fish, liver oil, liver, egg yolk, diary products, margarine, action of sunlight on skin.	• Controls absorption & metabolism of calcium and phosphorus. • Used in formation of teeth and bones	• Rickets • Bowlegs in young children • Osteomalacia in adults
(iii) Vitamin E (Tocopherol) - Wheat grains, brown bread, liver, green vegetables.	• Affects muscles & reproductive system. • Prevents breakdown of redblood cells.	• Anaemia • Sterility and muscular dystrophy
(iv) Vitamin K	• Necessary factor in	• Mild deficiency causes

(Phylloquinone) - Green vegetables (spinach, cabbage)	blood clotting.	prolonged blood clotting. • Serious deficiency stops blood clotting.
B. WATER-SOLUBLE VITAMINS (v) Vitamin B_1 (Thiamine) - Wheat grains, rice, yeast extract, whole meal flour, liver, kidney, heart, legumes	• Important in respiration	• Beriberi • Weak & painful muscles. • Mental disturbances • Heart failure • Oedema • Impaired child growth
(vi) Vitamin B_2 (Riboflavin) - Yeast extract, liver, eggs, dairy products.	• Important in respiration	• Sore tongue • Sore corners of the mouth.
(vii) Vitamin B_3 (Niacin) - Yeast extract, liver, whole meal bread, meat.	• Important in respiration	• Pellagra (skin lesions & roshea) • Diarrhea
(viii) Vitamin B_5 (Panthothetic acid) - Liver	• Important in metabolism	• Neuromotor disorders • Fatigue • Muscular cramps
(ix) Vitamin B_6 (Pyridoxine) - Eggs, liver, kidney, whole grains, fish, vegetables	• Important in metabolism of lipids and proteins	• Nervous disorders • Depression and irritability. • Anaemia • Diarrhea • Dermatitis
(x) Vitamin B_{12} (Cyanocobalamine) - Eggs, liver, fish, diary products	• Needed for formation of RBCs	• Pernicious anaemia • Malformation of RBCs
(xi) Vitamin B_6/Vitamin M(Folic acid) - Liver, white fish, green vegetables	• Formation of RBCs	• Anaemia in pregnane women
(xii) Vitamin C (Ascorbic acid) - Citrus fruits, tomatoes, potatoes, green vegetables, black currant.	• Production of strong skin	• Scurvy (bleeding gums) • Wounds fail to heal • Anaemia • Heart failure
(xiii) Vitamin H (Biotin) - Liver, yeast extract, kidney, egg white	• Important in protein synthesis	• Dermatitis • Muscle pains

6. MINERAL SALTS

- An **essential mineral /element** is an element important for successful growth and reproduction of an organism.
- **Macroelements/macrominerals**; are the major elements required in relatively large amounts.
- **Trace elements/microelements**; are the minor elements required in very small amounts.
- The absence/ deficiency of any essential element causes deficiency symptoms.
- A deficiency disease is a disease caused by deficiency of certain mineral element.

A summary of nutrient elements needed by plants, their functions and deficiency symptoms

Mineral element	Taken as	Function(s)	Deficiency symptoms
A) MACROELEMENTS (i) Nitrogen (N)	$N\bar{O}_3/NH_4{}^+$	For synthesis of amino acids, proteins, nucleic acids, vitamins, hormones like auxins, ATP, coenzymes, chlorophyll.	Chlorosis that appears first in older leaves. Stunted growth in plants.
(ii) Phosphorus (P)	$PO_4{}^{3-}/$ $H_2PO_4{}^-$,	For synthesis of nucleic acids, ATP, NAD, NADP & phospholipids. Constituent of cell membranes and some proteins..	Poor root growth. Dull green leaves. Premature leaf fall.
(iii) Sulphur(S)	$SO_4{}^{2-}$	Constituent of some amino acids, proteins, vitamins, co-enzymes like Acetyl co-enzyme A. Promotes root development Promotes root nodules formation in legumes.	Chlorosis , first in young leaves. Poor development of plants
(iv) Sodium(Na)	Na^+	Important in photosynthesis, respiration, active transport, anion-cation balance. Causes opening & closing of stomata. Facilitates turgidity of plant cells.	Stunted growth. Yellow & brown shriveled leaf margins. Older leaves appear mottled. Premature death.
(v) Potassium (K)	K^+	• Same functions as Na	• Same as those of Na
(vi) Magnesium	Mg^{2+}	Forms parts of chlorophyll	Interveinal

(Mg)		molecule. Important as cofactor of enzymes. For synthesis of fats. Important in respiration. Part of binding components of ribosomes.	chlorosis of older leaves. Severe deficiency causes <u>necrosis</u>.
(vii) Calcium (Ca)	Ca^{2+}	For normal cell development For growth of roots and shoot tips. For cell division, cell enlargement & translocation of carbohydrates.	Stunted growth. Poor root growth. Leaf tips become hooked. Chlorosis of young leaves. Dieback of shoots due to death of apical buds.
(viii) Chlorine (Cl)	$\overline{C}l$	Anion-cation balance in cells. • Osmotic pressure balance • Same as Na and K	• Same as those of Na and K.
B) TRACE ELEMENTS (ix) Manganese (Mn)	Mn^{2+}	• Activates carboxylases • Important in photosynthesis and respiration.	Leaves develop grey spots due to <u>chlorosis</u> and <u>necrosis</u> in interveinal zones.
(x) Copper (Cu)	Cu^{2+}	• Important in photosynthesis and respiration.	<u>Dieback</u> of shoots. <u>Necrosis</u> of tips of young leaves & then the margins. <u>Exanthema</u> in citrus plants.
(xi) Zinc (Zn)	Zn^{2+}	• Component of auxins. • Activates some enzymes. • Component of some enzymes.	Mottle leaves of citrus plants. Malformed leaves. Reduced internode length.

(xii) Molybdenum(Mo)	$Mo^{4+}, Mo^{5+},$	Activates some enzymes. Nitrates to nitrites	Slight growth retardation. May cause flower-fall. Molting or necrosis first in older leaves then in young leaves. Scald disease of leaves.
(xiii) Boron (B)	$BO_4{}^{3-},$	Increases uptake of water and calcium ions. For normal cell division. For pollen tube growth. Involved in translocation of carbohydrates.	Death of stem and root apices. Thickened leaves that curl and become brittle. Reduced flower production. Heart rot in beets. Stem crack of celery.

NB:

- ✓ **Chlorosis**; is the yellowing of leaves due to low chlorophyll content.
- ✓ **Necrosis**; is the localized death of tissues, like buds, leaf tips or margins, scattered spots on leaves.
- ✓ **Dieback of shoots**; is the death of the shoot tips or the meristems.

MINERAL NUTRITION IN ANIMALS

A summary of the food sources and functions of elements needed by man

Element & form	Major food source	Function(s)
A) MACROMINERALS (i) Calcium (Ca^{2+})	• Dairy foods, eggs, green vegetables, carrots, cauliflower, fish, hard water.	• Constituent of bones and teeth. • Needed in blood clotting. • Activates many enzymes. • Activates ATPase during muscle contraction. • Regulates heart, nerve & muscular

		activity.
(ii) Chlorine ($\overline{Cl}$)	• Table salt, bacon, cabbage, eggs, cheese, bread.	• Maintains anion/cation balance and osmotic pressure balance. • Constituent of hydrochloric acid in gastric juice.
(iii) Magnesium(Mg^{2+})	• Meat, leafy vegetables	• Component of bones & teeth. • Cofactor of many enzymes. • Constituent of coenzymes.
(iv) Phosphorus ($PO_4{}^{3-}$)	• Dairy foods, eggs, meat, vegetables, fish, rice, cereals.	• Important in muscle and nerve activity. • For synthesis of nucleic acids, ATP & some proteins. • Constituent of bones & teeth. • Constituent of coenzymes and phospholipids. • Maintains normal blood PH. • Regulates heart beat rate.
(v) Sulphur ($SO_4{}^{2-}$)	• Meat, eggs, dairy foods, fish.	• Component of proteins and coenzymes. • For muscle growth.
(vi) Potassium (K^+)	• Meat, fruits especially bananas, vegetables.	• For nerves & muscles action. • Maintains anion-cation balance. • For normal heart functioning. • Maintains osmotic balance. • For cell membrane functioning.
(vii) Sodium (Na^+)	• Table salt, bacon, dairy foods, meat,	• Same as those of K.

	eggs, vegetables.	
B) MICROMINERALS (viii) Iron(Fe^{2+}/Fe^{3+})	• Liver, green vegetables, meat, eggs, nuts, molasses.	• Constituent of many enzymes, electron carriers, haemoglobin, myoglobin.
(xiv) Manganese (Mn^{2+})	• Liver, kidney, tea, coffee, fruits, nuts, legumes.	• Growth factor in bone development. • Activates some enzymes.
(xv) Copper(Cu^{2+})	• Liver, meat, fish	• For formation of bones and heamoglobin. • Constituent of enzymes.
(xvi) Zinc (Zn^{2+})	• Liver, fish, shell fish, yeast products, sea food, pumpkin and pumpkin seeds.	• Activates enzymes. • Contributes to wound healing.
(xvii) Molybdenum (Mo^{4+})	• Liver, kidney, cereals, green vegetables.	• For DNA metabolism
(xviii) Iodine (I^{-})	• Sea foods, fish, iodized salt, onion.	• Component of thyroxine hormone.
(xix) Fluorine (F^{-})	• Many water supplies, milk.	• Component of bone & teeth enamel. • Increases resistance to tooth decay.

MINERAL DEFICIENCY DISEASES AND SYMPTOMS IN ANIMALS

1. Nitrogen deficiency causes kwashiorkor due to lack of proteins.
2. Sodium deficiency causes muscular cramps.
3. Chlorine deficiency causes muscular cramps.
4. Calcium deficiency causes rickets in children and osteomalacia in adults. Pregnant and lactating mothers need more calcium intake to meet the needs of the foetus and newborn.
5. Manganese deficiency causes poor bone development.
6. Iron deficiency causes anaemia because iron is a component of haemoglobin of RBCs. Symptoms of anaemia include; tiredness, lethargy, dizziness, headache. Anaemia is more common in women due to loss of blood during menstruation.
7. Cobalt deficiency causes pernicious anaemia.
8. Fluorine deficiency makes dental decay rapid.
9. Iodine deficiency causes goitre and cretinism in children.
10. Phosphorus deficiency causes rickets in children.

NB: Intake of excess salt (NaCl) increases blood pressure (hypertension) leading to OR compounding, other cardiovascular diseases.

7. ROUGHAGES

- These are also known as dietary fibres.
- Roughage/dietary fibre; is the indigestible cellulose form plant cell walls.

FUNCTIONS OF ROUGHAGES

1. Stimulate peristalsis in the intestines.
2. Create feeling of satiety.

DEFICIENCY SYMPTOMS OF ROUGHAGES

- Lack of roughages in the diet causes constipation.

SOURCES OF ROUGHAGES

- Green leafy vegetables, whole wheat grains, brown bread.

BALANCED DIET AND BIOMASS INDEX (BMI)

Research and make a write up on balanced diet, BMI and its implications.

ENZYMES

- These are organic catalysts, protein in nature that alter and speed up the rate of chemical reactions in the body of living organisms and remain chemically unchanged at the end of the reaction.

Question: Define the term an enzyme. (02 marks)

NB: A catalyst is a chemical substance which speeds up the rate of chemical reaction but remains unchanged itself at the end of the reaction.

A summary of selected enzymes, their substrates and products formed

ENZYME	SUBSTRATE	PRODUCT(S)
1. Salivary amylae(ptyalin)	Starch Maltose	Maltose Glucose
2. Maltase	Sucrose	Glucose + Fructose
3. Sucrase	Lactose	Glucose + Galactose
4. Lactase	Protein	Peptides
5. Pepsin	Peptides	Amino acids
6. Peptidase	Hydrogen peroxide	Water + Oxygen
7. Catalase	Lipids	Glycerol + Fatty acids
8. Lipase	Polypeptides	Shorter peptides/peptones
9. Trypsin	Protein	Peptides
10. Protease		

CLASSIFICATION OF NOMENCLATURE OF ENZYMES

Nomenclature: Enzymes are commonly named using suffix "***ase***" added at the end of the substrate acted upon.

Classification: enzymes are classified according to;

1. **Site of action in 2 ways**;
   (a) Intracellular enzymes; are secreted and used within the cells producing them, as in the case of respiratory enzymes.
   (b) Extracellular enzymes; are secreted within the cell, but achieve their effects outside the cell producing them, as in the case of digestive enzymes.
2. **The type of reaction catalyzed;**
   Enzymes are classified according to the type of reaction they catalyse.
   E.g.
   (a) Transferases; catalyse the transfer of a specific chemical group from one molecule to another like transaminases.
   (b) Hydrolases; catalyse formation of 2 products from a substance by hydrolysis like digestive enzymes.

   HINT: Hydrolysis is the splitting of chemicals by addition of water.

   (c) Oxidoreductases; are enzymes that catalyse the transfer of hydrogen or oxygen atoms or electrons from one molecule to another. Oxidoreductases are categorized into;
   (i) Dehydrogenases; which catalyse the removal of hydrogen atoms from molecules.
   (ii) Oxidases; which catalyse the addition of oxygen atoms to molecules.
3. **The substrate worked on;**

- A substrate is a substance acted upon by an enzyme.
  (a) Sucrases; working on sucrose.
  (b) Celluases; working on cellulose.
  (c) Proteases; working on proteins.
  (d) Lipases; working on lipids.
  (e) Maltases; working on maltose.
  (f) Carbohydrases; working on carbohydrates.

Question: What is a **substrat**e?

CHARACTERISTICS OF ENZYMES

1. Are globular proteins in nature with a specific shape.
2. Have a high turnover i.e. work very rapidly.
   NB: The fastest known enzyme is catalase.
3. Are specific in nature/function.
4. They control/catalyse reversible reactions and work in either direction of the reaction.
5. Are effective in small quantities/amounts/concentrations.

6. Are sensitive to temperature i.e. inactivated by low temperatures; denatured by high temperatures; work best at optimum temperature.
7. Are sensitive to PH; some have optimum PH in acidic medium, some under alkaline and others in neutral medium.
8. Their activity is reduced/completely stopped by inhibitors i.e. are inhibited by enzyme inhibitors like cyanide poison.
9. Many enzymes require non-protein components called enzyme cofactors for efficient activity like activators, coenzymes and prosthetic groups.
10. Are soluble in water.

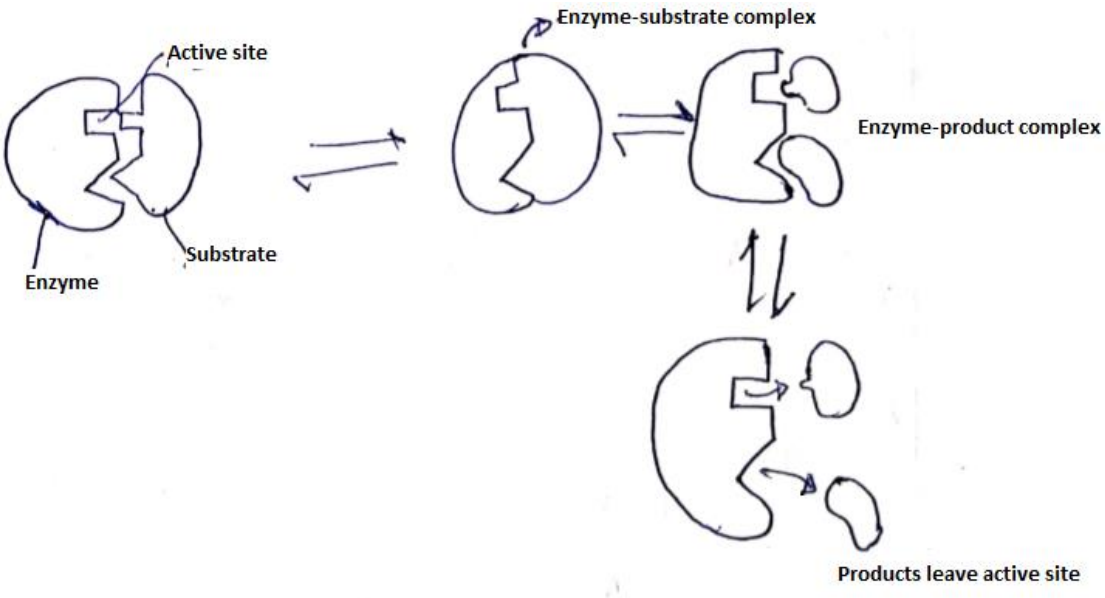
Other properties included;

- Are produced by living cells.
- Don't participate in the reaction thus remain chemically unchanged at the end of the reaction.
- Possess active sites where catalysis occurs.
- Are coded for by DNA.
- Function by lowering activation energy of the reaction they catalyse.
- Are denatured by excessive heat.

THE LOCK AND KEY MECHANISM OF ENZYME ACTION

- The lock and key hypothesis of enzyme action suggests that each enzyme has a particular shape with special depressions called active sites; into which a specific substrate with a complementary shape fits exactly like a key fits in a lock; forming enzyme-substrate complexes; activation energy is lowered by the enzyme; catalysis occurs to form products; thus enzyme-products complexes formed; products no longer compatible to enzyme's active sites thus escape leaving the active sites free for binding by other substrate molecule.

Illustration



- The rate of enzyme-catalysed reactions is measured by the amount of substrate changed/amount of product formed per unit time.

FACTORS AFFECTING THE RATE OF ENZYME ACTIVITY

These include;

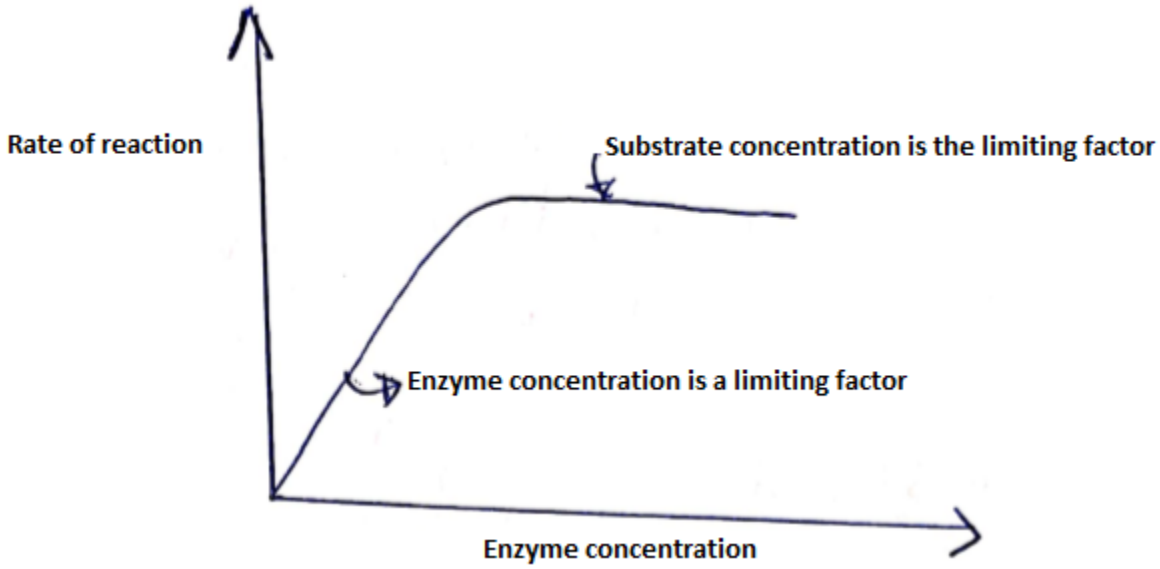
1. Enzyme concentration
2. Substrate concentration
3. Temperature
4. PH
5. Enzyme inhibitors
6. Enzyme cofactors

1. ENZYME CONCENTRATION

The rate of enzyme activity increases rapidly with increase in enzyme concentration, then slowly until it remains constant.

This is because increasing enzyme concentration increases the number of active sites for binding substrate molecules; slow increase is due to few substrate molecules; remains constant because substrate concentration becomes a limiting factor i.e. no substrate to be worked upon.

A graph showing the variation of rate of reaction with enzyme concentration



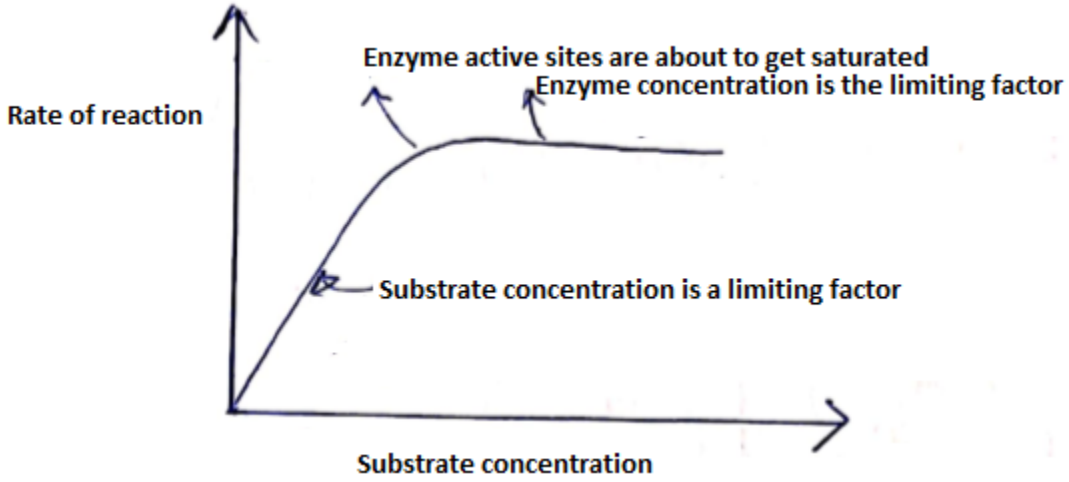
2. SUBSTRATE CONCENTRATION

The rate of enzyme activity increases rapidly with increase in substrate concentration, then slowly until it remains constant.

This is because increasing substrate concentration increases the number of occupied active sites for binding substrate molecules; slow increase is due to few unoccupied active sites

available; remains constant because all enzyme's active sites are fully saturated thus enzyme concentration becomes the limiting factor.

A graph showing the variation of rate of reaction with enzyme concentration



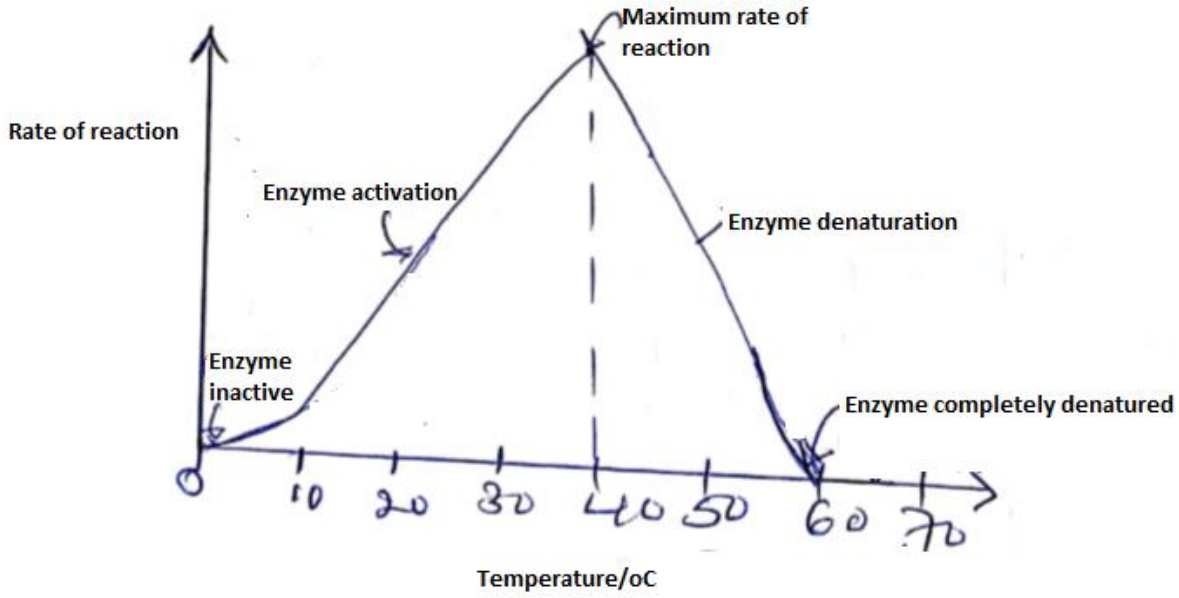
3. TEMPERATURE

- At/below 0°C, there is no enzyme activity.
- From 0°C to 37/40°C, the rate of enzyme activity increases rapidly upto a maximum.
- From 37°C/40°C to 60°C, the rate of enzyme activity decreases rapidly upto zero.

Explanation

- At/below 0°C, there is no enzyme activity because enzymes are <u>inactivated by freezing temperatures.</u>
- From 0°C to 40°C, the rate of reaction increases rapidly due to increased enzyme activation (increased kinetic energy, increasing the number of molecular collisions, increasing rate of enzyme-substrate complexes formation; increasing the rate of catalysis, increasing the rate of enzyme activity)
- At 40°C, the rate of reaction is highest; because 40°C is the optimum temperature for enzyme activity.
- From 40°C to 60°C, the rate of reaction decreases rapidly; because enzymes are denatured by excessive heating beyond the optimum temperature.

A graph showing the variation of rate of reaction with temperature



Question: The table below shows the effect of increasing temperature on the rate of an enzyme-controlled reaction.

Temperature/°C	0	10	20	30	40	50	60	70
Rate of reaction(au)	0.0	1.1	1.8	4.3	8.5	2.8	0.0	0.0

(a) Represent the above information in a suitable graphical form.
(b) Describe the shape of the graph.
(c) Explain the behavior of the graph;
  (i) At 0°C
  (ii) From 20°C to 30°C
  (iii) At 40°C
  (iv) From 45°C to 55°C

Solution

(a) See the graph
(b)

- At 0°C, the rate of reaction was 0.0 au;
- From 0°C to 20°C, the rate of reaction increased gradually;
- From 20°C to 40°C, rate of reaction increased rapidly upto a peak;
- From 40°C to 60°C, the rate of reaction decreased rapidly to 0.0au;
- From 60°C to 70°C, the rate of reaction remained constant at 0.0au;

(c)
  (i) At 0°C, the rate of reaction was 0.0 au; because enzymes were inactivated by freezing temperature thus there was no reaction;
  (ii) From 20°C to 30°C, rate of reaction increased rapidly; because increase in temperature increased the increased kinetic energy; increasing the number of

molecular collisions between enzyme and substrate molecules, increasing rate of enzyme-substrate complex formation; increasing the rate of products formation; and increasing the rate of enzyme activity;

(iii) At 40°C, the rate of reaction was highest because 40°C was the optimum temperature for enzyme activity;

(iv) From 45°C to 55°C, the rate of reaction decreased rapidly because enzymes were denatured by excessive heating beyond the optimum temperature;

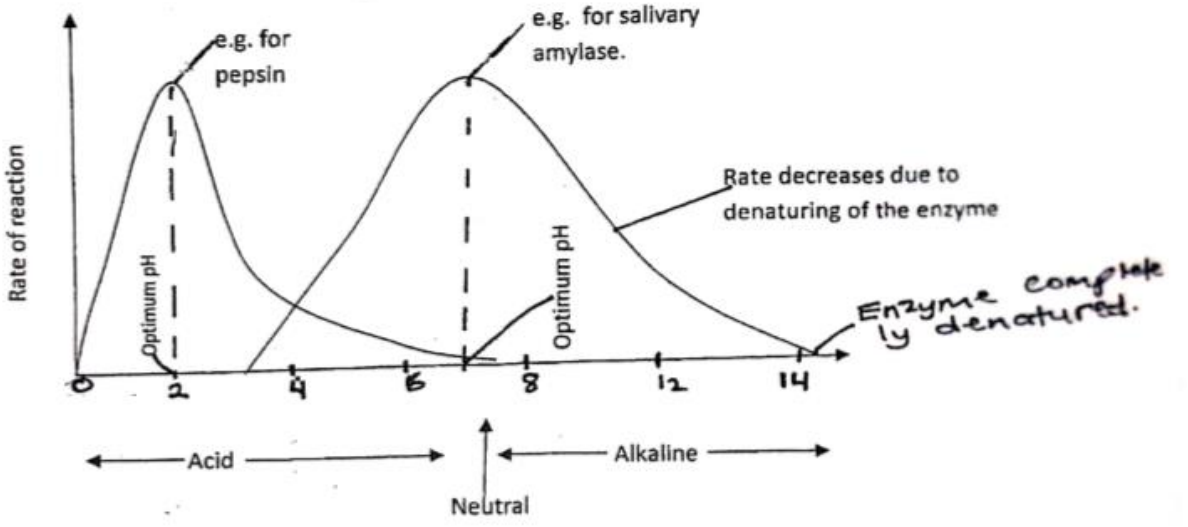
4. PH

- The PH at which an enzyme has maximum activity is called optimum PH.
- When PH is changed above/below the optimum PH, the rate of reaction decreases rapidly, because enzymes are rapidly denatured by deviation in PH away from the optimum PH.

NB: Each enzyme functions best at its own specific optimum PH.

i.e.

Enzyme	Optimum PH
Salivary amylase	Neutral (7.0) to slightly alkaline
Pepsin	2.0 (acidic)
Rennin	2.0 (acidic)
Trypsin, lipase, pancreatic amylase	7.0 to 8.0 (neutral to alkaline)



5. ENZYME INHIBITORS

- The presence of enzyme inhibitors reduces the rate of enzyme activity; and absence of enzyme inhibitors increases the rate of enzyme activity.

6. ENZYME COFACTORS

- Enzyme cofactors are non-protein components required for enzyme to function efficiently.
- Enzyme cofactors include; enzyme activators, prosthetic groups and coenzymes.
- The presence of cofactors increases the rate of enzymes activity; and absence of cofactors decreases the rate of enzyme activity.

EXPERIMENTS ON ENZYMES ACTIVITY: **Refer to practical workbook**.

NUTRITION IN PLANTS

PHOTOSYNTHESIS

- Is the process by which green plants and some bacteria manufacture their own complex organic food materials from simple inorganic materials using sunlight energy trapped by chlorophyll.
- Complex organic materials formed include glucose; from simple inorganic materials like carbon dioxide and water. Thus can be summarized by the equation below.

  i.e. $6CO_2(g) + 6H_2O(l) \xrightarrow{Light\ energy} C_6H_{12}0_6(s) + 6O_2(g)$

  carbon dioxide water Chlorophyll Glucose Oxygen

- From the above equation;
- There are 2 raw materials for photosynthesis namely;
  (i) Carbon dioxide
  (ii) Water

CARBON DIOXIDE

- This is absorbed from atmosphere by terrestrial plants through stomata. For aquatic plants, it is absorbed in form of hydrogen carbonate/ bicarbonate ions by diffusion.
- It provides carbon atoms required to form carbon skeleton of the carbohydrate.

WATER

- It is absorbed by root hairs from soil and transported up the plant to leaves, the sites of photosynthesis.
- It provides hydrogen atoms required to form the carbohydrate.
- There are 2 conditions
  (i) Chlorophyll
  (ii) Sunlight energy

CHLOROPHYLL

- Is the green pigment that traps /absorbs sunlight energy for photosynthesis.

SUNLIGHT

- Is the source of energy used for splitting water by photolysis.
- There are 2 products
  (i) Carbohydrate (glucose ⟶ starch)
  (ii) Oxygen

HINT: After photosynthesis, glucose is converted into sucrose in leaves for transportation to other plants where it is converted into starch for storage.

The plant parts modified for starch storage include;

Part	Modification	Examples
Root	Root tubers	Cassava, carrots
Stem	Stem tubers	Irish potatoes

MECHANISM OF PHOTOSYNTHESIS

Photosynthesis occurs in 2 stages namely;

(i) Light stage
(ii) Dark stage

LIGHT STAGE

- During this stage light trapped by chlorophyll is used to split water into hydrogen ions and oxygen by photolysis.
- Hydrogen atoms are taken to dark stage for carbohydrate formation.
- Oxygen is released as a byproduct.

DARK STAGE

- Hydrogen atoms reduce carbon dioxide from atmosphere to form the carbohydrate like glucose containing carbon, hydrogen and oxygen.

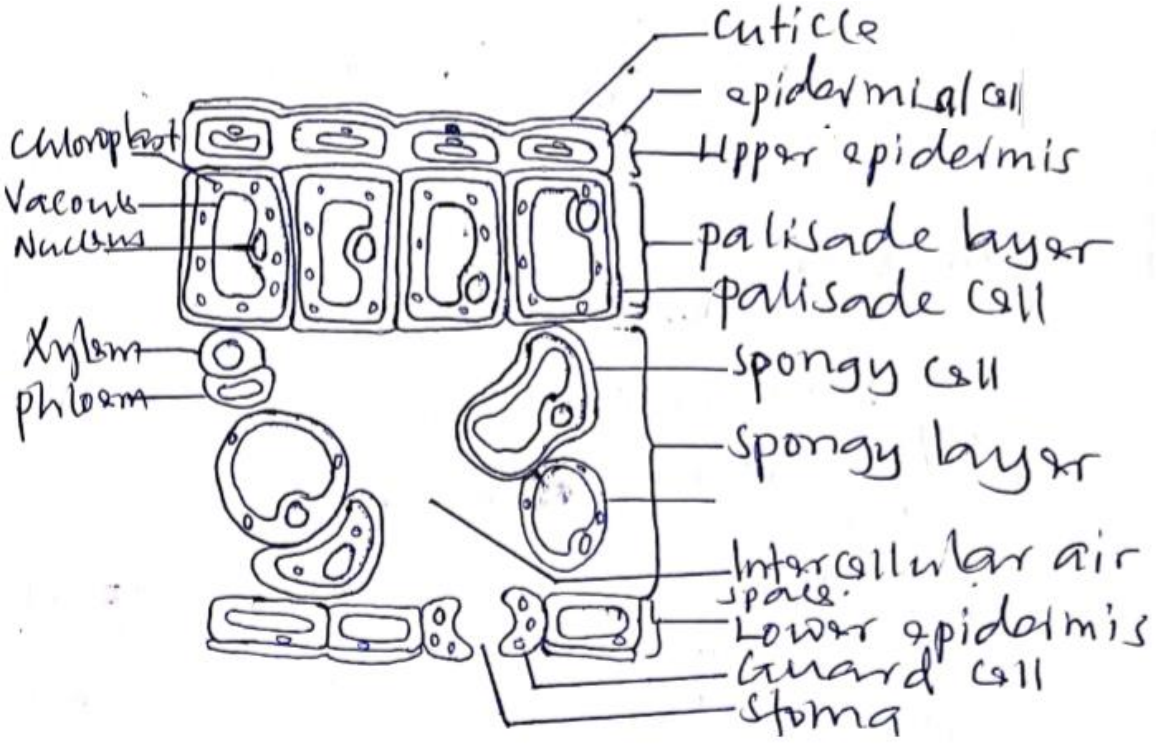
NB: Oxygen in the carbohydrate comes from carbon dioxide but NOT water.

IMPORTANCE OF PHOTOSYNTHESIS

- It's a source of food inform of organic matter to heterotrophs (plants and animals)
- It provides oxygen to aerobes for aerobic respiration through increasing oxygen in the atmosphere.
- It reduces on carbon dioxide level in atmosphere thus preventing global warming.

LEAF AS A SITE FOR PHOTOSYNTHESIS

INTERNAL STRUCTURE OF THE LEAF



Description of internal structures

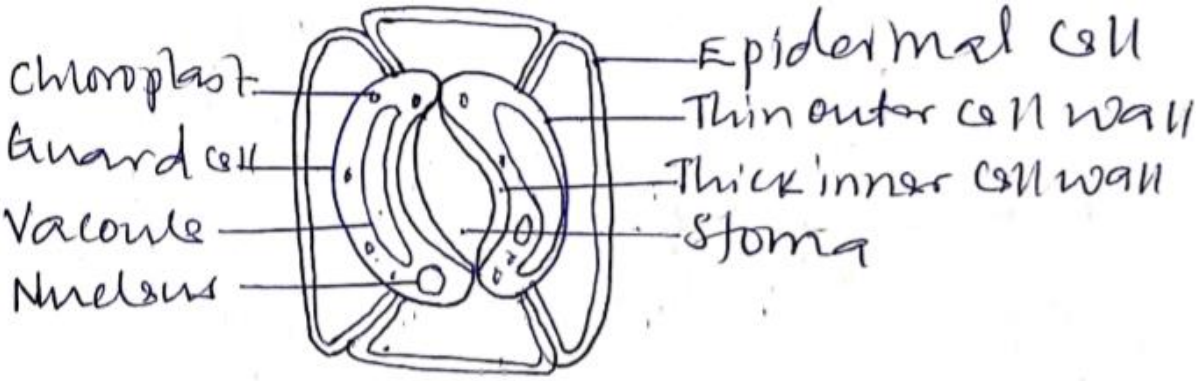
(i) Epidermis/epidermal tissue

- It is the outer layer with a single layer of cells. These cells are called epidermal cells.
- It is found on both sides of the leaf.

1. Upper surface has <u>upper epidermis</u>.
2. Lower surface has <u>lower epidermis</u>.

- It is covered by a waxy cuticle which is impermeable to water, secreted by epidermal cells.
- The cuticle is thicker on upper than lower surfaces of the leaf. It contains no chloroplasts therefore doesn't photosynthesize.
- Epidermis bears <u>stomata</u> especially in the lower epidermis.

A drawing showing a stoma and its adjacent cells



Function of stomata

- For gaseous exchange
- Control water loss by transpiration.

Function of guard cells

- Have chloroplasts for photosynthesis
- Used to open and close the stomata.

(ii) Palisade mesophyll layer

- It contains elongated cells called palisade cells. These are closely packed with no intercellular air spaces.
- It contains numerous chloroplasts and this is why most of the photosynthesis occurs here.

(iii) Spongy mesophyll layer

- It contains spongy cells that are loosely arranged and irregular in shape.
- The layer has very large intercellular air spaces to allow gaseous exchange by diffusion.
- It contains fewer chloroplast compared to palisade cells.

HINT: Since palisade layer is near the upper surface, it has more chloroplasts than spongy mesophyll layer, the upper is greener than the lower surface.

Question: Describe the structure of;

(i) Palisade tissue
(ii) Spongy tissue

Question: Compare palisade layer and spongy layer.

(iv) Chloroplasts

- These contain a green pigment, chlorophyll which traps solar energy for photosynthesis.
- These are found in mesophyll cells, guard cells with stomata.

NB: The leaf is the major organ of the plant where photosynthesis occurs.

The leaf is adapted to carry out this in a number of ways.

Question: Describe the adaptations of leaves for photosynthesis.

Solution

1. They have broad and flat leaf blade/lamina to provide a large surface area for maximum sunlight/carbon dioxide absorption during photosynthesis.
2. They are thin to provide a short distance for faster diffusion of carbon dioxide/rapid light penetration to reach photosynthesizing cells.
3. Have transparent cuticle and epidermis for rapid light penetration into photosynthesizing cells.

4. Have numerous chloroplasts containing chlorophyll in palisade cells for maximum sunlight absorption during photosynthesis.
5. Have numerous intercellular air spaces in-between spongy cells for gaseous exchange to provide carbon dioxide during photosynthesis.
6. Have numerous stomata for maximum carbon dioxide absorption during photosynthesis.
7. Have many veins with xylem for transportation of water and mineral salts to photosynthetic cells; and phloem to transport away the manufactured food.
8. Have a waxy cuticle that is water proof and prevents excessive waterloss by transportation.
9. They are arranged into a mosaic pattern to minimize overlapping for maximum sunlight absorption during photosynthesis.
10. Palisade cells are closely packed forming a continuous layer for maximum sunlight absorption during photosynthesis.
11. Chloroplasts move/ arranged alongside cell wall facing sunlight for efficient sunlight absorption during photosynthesis.

Food for thought: Describe how leaves are adapted for sunlight energy absorption. (05 marks)

FACTORS AFFECTING THE RATE OF PHOTOSYNTHESIS

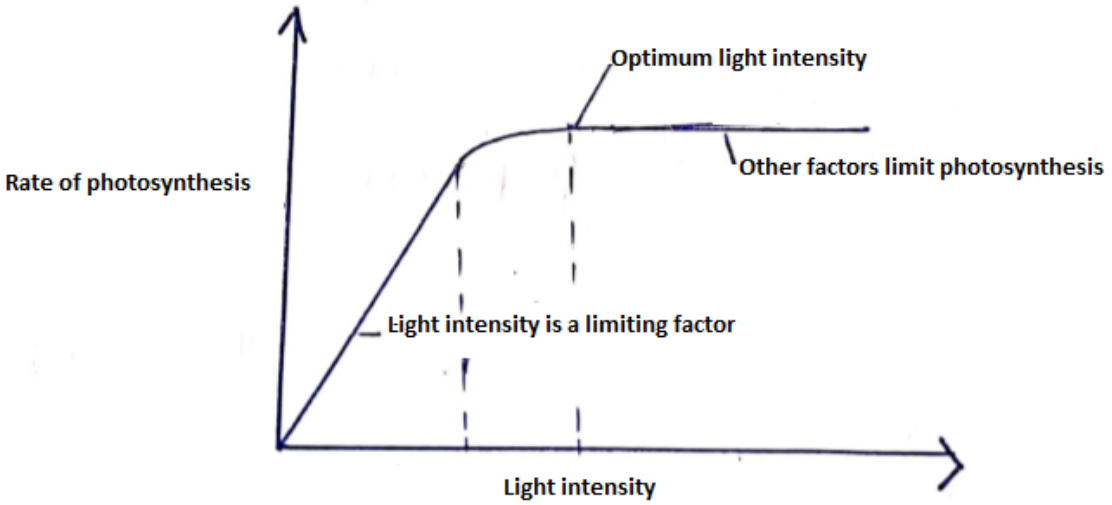
- Basically there are 6 major factors that affect the rate of photosynthesis namely;

1. Light intensity
2. Temperature
3. Carbon dioxide concentration
4. Water availability
5. Chlorophyll concentration
6. Oxygen concentration

1. LIGHT INTENSITY

- Sunlight is a source of energy for photosynthesis.
- The lower the light intensity, the lower the rate of photosynthesis.
- Increase in light intensity increases the rate of photosynthesis up to the optimum light level (a certain point) and then remains constant.
- This is because light intensity is a limiting factor of photosynthesis , thus its increase, increases the rate of photosynthesis up to optimum light level/certain point beyond which it remains constant because another factor needed to increase photosynthesis like carbon dioxide concentration becomes the limiting factor i.e. limit photosynthesis.

A graph showing the variation of rate of photosynthesis with light intensity



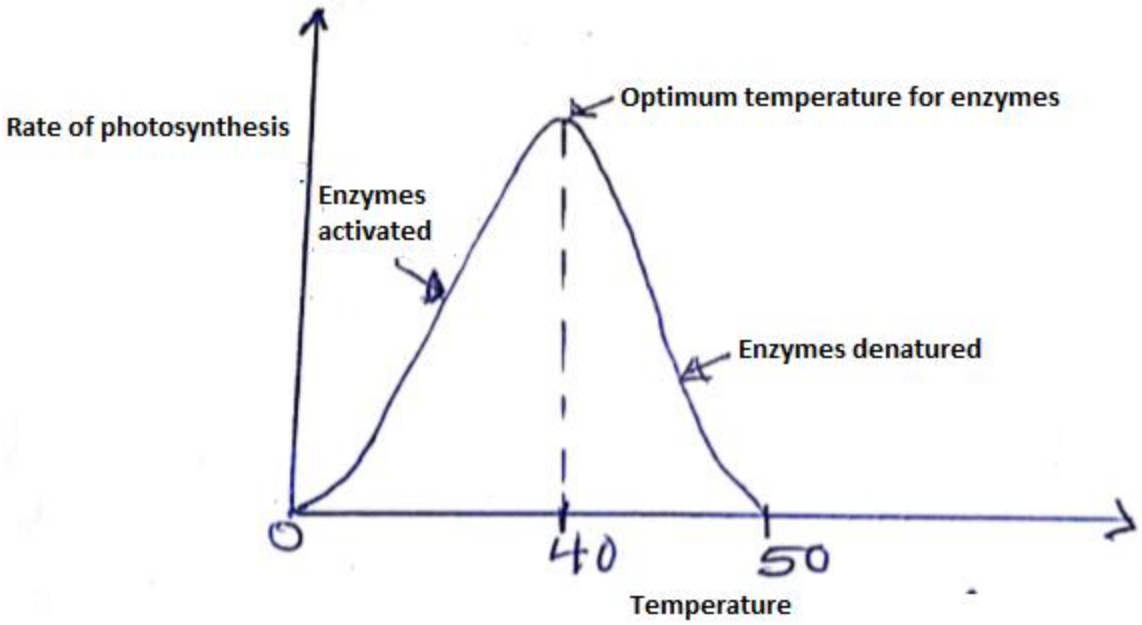
2. TEMPERATURE

- At very low temperatures, the rate of photosynthesis is very low.
- Increase in temperature leads to rapid increase in rate of photosynthesis upto maximum; at optimum temperature (40°C) and then decreases rapidly with further increase in temperature.

Explanation

- At very low temperature, rate of photosynthesis is very low because photosynthetic enzymes are inactive.
- Increase in temperature, rapidly increases the rate of photosynthesis upto maximum due to activation of photosynthetic enzymes up to optimum temperature (40°C).
- Beyond optimum temperature (40°C), increase in temperature leads to rapid decrease in rate of photosynthesis due to denaturation of photosynthetic enzymes; since photosynthesis is an enzyme-controlled process.

A graph showing the variation of rate of photosynthesis with temperature

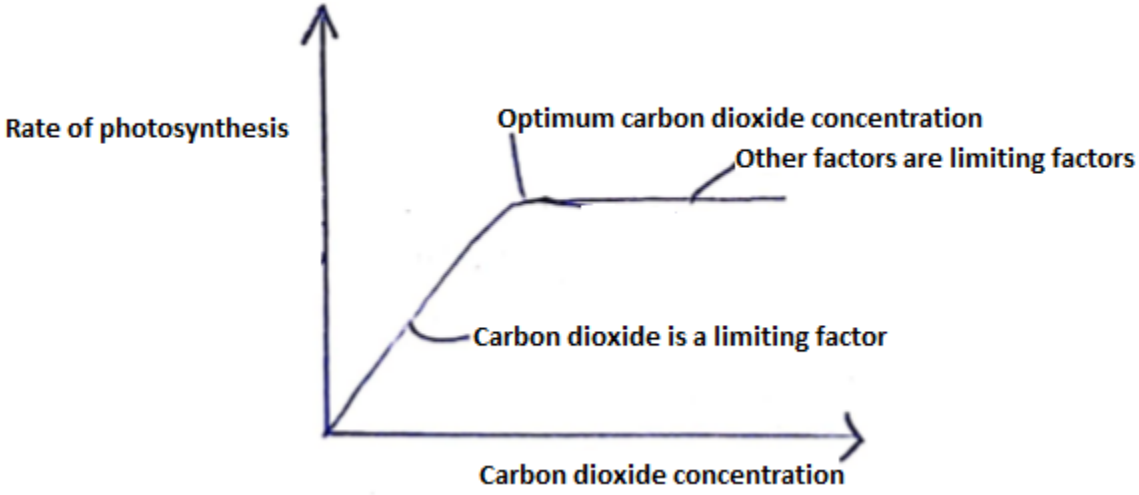


NB: The rate of photosynthesis doubles with every 10°C rise in temperature between 0°C and 40°C.

3. CARBON DIOXIDE CONCENTRATION

- Carbon dioxide is a raw material for photosynthesis. Thus;
- The lower the carbon dioxide concentration, the lower the rate of photosynthesis.
- Increase in carbon dioxide concentration rapidly increases the rate of photosynthesis upto optimum carbon dioxide level; because carbon dioxide is a limiting factor. Beyond which it remains constant with increase in carbon dioxide concentration, because other factors like light intensity, water are limiting photosynthesis process.

A graph showing the variation of rate of photosynthesis with carbon dioxide concentration



4. WATER AVAILABILITY

- Water is a raw material for photosynthesis. It provides hydrogen ions for reducing carbon dioxide into carbohydrates therefore without water the process of photosynthesis cannot occur.
- The higher the amount of water in the plant, the more the hydrogen ions produced thus faster rate of photosynthesis.
- The lower the amount of water in the plant, the less the hydrogen ions are produced thus the slower the rate of photosynthesis.

5. CHLOROPHYLL CONCENTRATION

- The lower the chlorophyll concentration present in a leaf, the lower the rate of photosynthesis.
- The higher the chlorophyll concentration present in a leaf, the higher the rate of photosynthesis due to increased light energy absorption that promotes photosynthesis.

6. OXYGEN CONCENTRATION

- Oxygen is a byproduct of photosynthesis that is released into the atmosphere. Thus the higher the oxygen concentration in atmosphere, the lower the rate of photosynthesis.
- The lower the oxygen concentration in atmosphere, the higher the rate of photosynthesis.

SPECIAL FACTORS

(i) EFFECT OF MINERAL SALTS

- The manufacture of chlorophyll requires the presence of mineral salts like iron, nitrogen and magnesium.
- When plants are grown in soils deficient in any one of those mineral salts, the chlorophyll concentration is reduced and leaves become yellow a condition called chlorosis.
- The lack of those mineral salts therefore greatly reduces the rate of photosynthesis.

(ii) THE AMOUNT OF CARBOHYDRATES IN THE LEAF

- Carbohydrates are the main products of the process of photosynthesis.
- The higher the amount of carbohydrates present in the leaf, the lower the rate of photosynthesis.
- The lower the amount of carbohydrates present in a leaf, the higher the rate of photosynthesis.

(iii) ENVIRONMENTAL POLLUTION

- Environmental pollution causes malfunctioning of leaves i.e. the soot settles on the stomata thus blocking them and this hinders the uptake of carbon dioxide via the stomata thus reducing the rate of photosynthesis.

EXPERIMENTS ON PHOTOSYNTHESIS

1. AN EXPERIMENT TO TEST FOR STARCH IN A LEAF

REQUIREMENTS

- Leaf
- Water
- Water bath/beaker
- Test tube/boiling tube
- Ethanol
- Iodine solution
- Dropper
- White tile
- Heat source/Bunsen burner
- Tripod stand
- Wire gauze
- Forceps

PROCEDURE

- A green leaf from a plant which had received sunlight for 2/3 hours is detached.
- The leaf is placed in a beaker of boiling water for 5 minutes.

Reason: To kill the protoplasm and stop further reactions; burst and present the starch grains and make leaf cells permeable to iodine solution.

- The leaf is then placed in attest tube containing ethanol and boiled for 5 minutes under water bath.

Reason: To remove green chlorophyll; make the leaf permeable to iodine solution; decolourise the leaf for easy observation of colour changes with iodine solution.

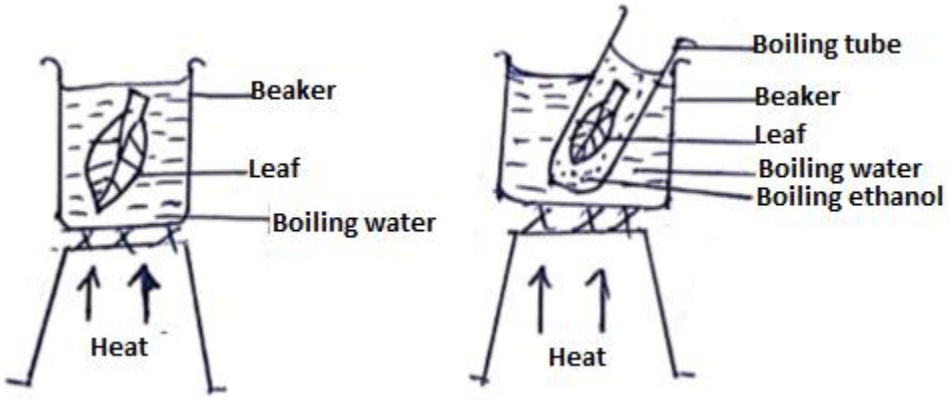
NB: Ethanol is not boiled directly with the leaf but placed in a water bath because it is flammable.

- The brittle leaf is then boiled in hot water.

Reason: To soften it since it is stiffened by alcohol; remove excess alcohol.

- The leaf is then transferred and spread on a white tile and 4/5 drops of iodine solution are applied over its surface using a dropper.

EXPERIMENTAL SET UP



OBSERVATION

- The leaf stains black/blue.

CONCLUSION

- Starch present in the leaf.

NB: If the leaf stains brown; it means starch is absent.

EXPLANATION

- The green leaf of a plant is placed in sunlight carried out photosynthesis and stored the manufactured carbohydrates in form of starch.
- When the brown iodine solution combined with starch, it forms black/blue starch-iodine complex. This confirms the presence of starch.

2. AN EXPERIMENT TO SHOW THAT LIGHT IS NECESSARY FOR PHOTOSYNTHESIS

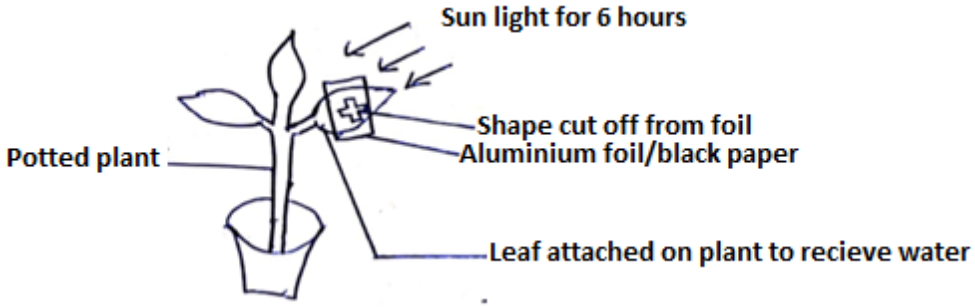
REQUIREMENTS

- Aluminium foil/black paper
- Potted plant with fresh green leaves
- Iodine solution
- White tile
- Water
- Cellotape/clips
- Razorblade
- Beaker

PROCEDURE

- Leaves of a potted plant are destarched by keeping the plant in darkness for 2 days.
- 1 leaf is plucked off and tested for starch to ensure that starch is completely absent in leaves.
- An X-shape from an aluminium foil/black paper is cut.
- A stencil/strip of aluminium foil/black paper is attached on a part of a destarched plant leaf while the leaf is still attached to plant.
- The potted plant is then placed in bright sunlight about 6/3 hours.
- After which the leaf is removed and tested for starch.
- The uncovered parts of the leaf act as the <u>control</u>.

EXPERIMENTAL SET UP



OBSERVATION

- The covered parts of the leaf stain brown with iodine solution.
- The uncovered parts of the leaf stain blue/black.

CONCLUSION

- Light is necessary for photosynthesis.

EXPLANATION

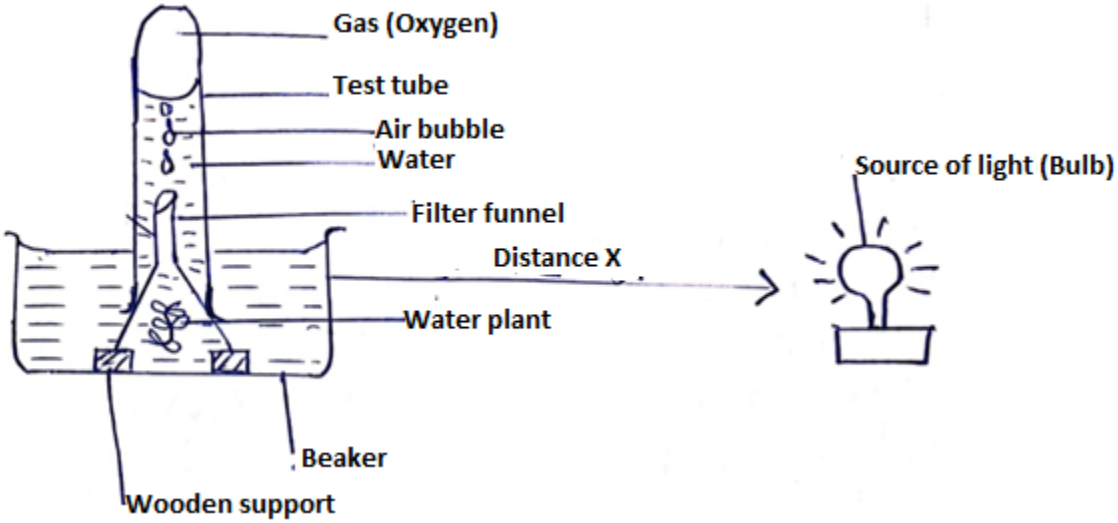
- Uncovered parts of the leaf absorbed light and photosynthesized to form starch thus stained blue/black with iodine solution.
- Covered leaf parts didn't absorb light thus didn't photosynthesize to form starch thus stained brown with iodine solution.

3. AN EXPERIMENT TO DETERMINE THE EFFECT OF LIGHT INTENSITY ON RATE OF PHOTOSYNTHESIS

REQUIREMENTS

- Water plant
- Support e.g. plasticine/wooden blocks
- Water
- Bench lamp
- Ruler
- Filter funnel
- Beaker
- Test-tube

PROCEDURE



- The experiment is arranged as shown above.
- Change the distance of source of light/bench lamp X like 10cm, 20cm, 30 cm, 40cm and 50cm.
- Count the number of bubbles of oxygen gas produced in a given time like per minute in each experimental trial.

SAMPLE RESULTS

Distance(X) of light source from beaker(cm)	10	20	30	40	50
Number of bubbles produced per minute	120	80	60	30	20

Questions

(a) Represent the above data graphically.
(b) Describe the graph plotted in (a) above.

(c) Explain your graph.

4. AN EXPERIMENT TO SHOW THAT CARBON DIOXIDE IS NECESSARY FOR PHOTOSYNTHESIS

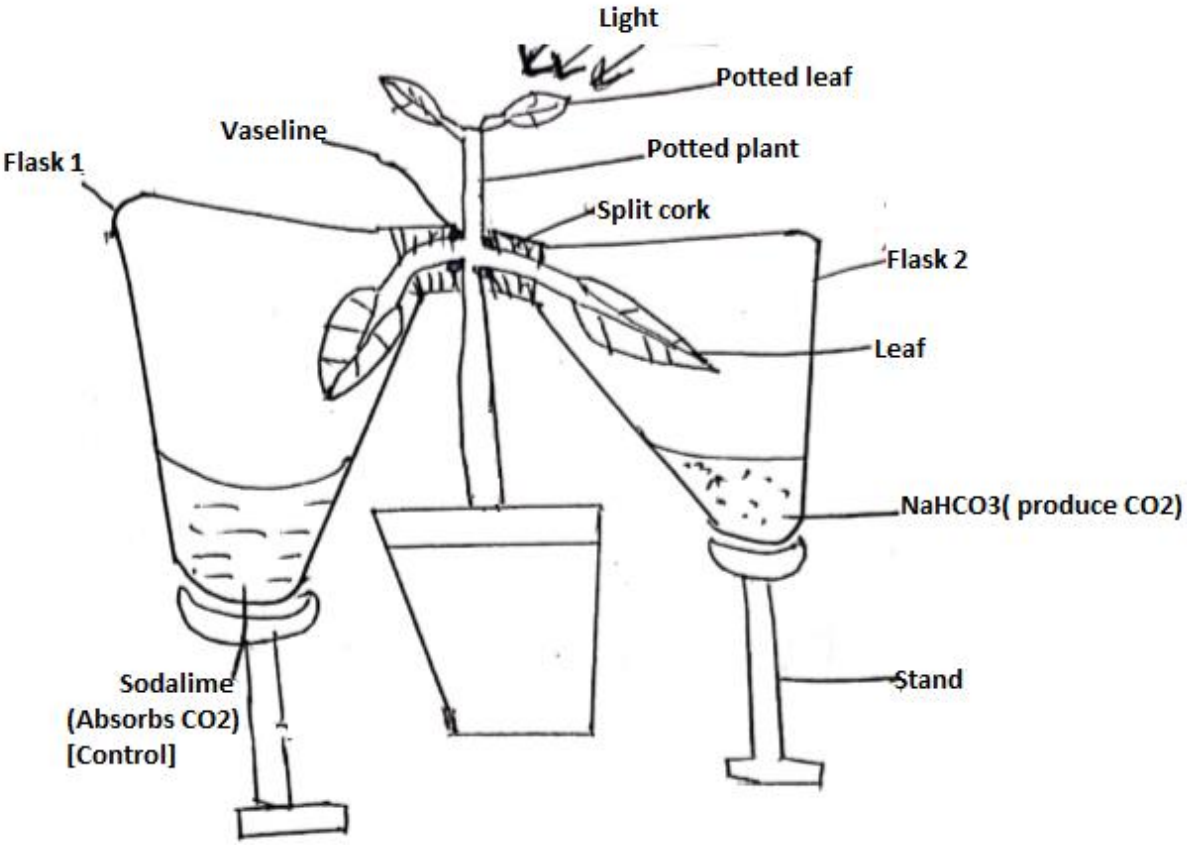
REQUIREMENTS

- Potted plant
- Water
- Sodium hydroxide(caustic soda)/potassium hydroxide(caustic potash/soda lime)
- Sodium hydrogen carbonate
- 2 split corks
- Vaseline
- Iodine solution
- Ethanol
- White tile
- 2 conical flasks

PROCEDURE

- The leaves of a potted plant are destarched by keeping the plant in darkness for 2 days.
- One leaf is tested for starch to ensure that the leaves have been completely destarched.
- One leaf on the plant is enclosed in a conical flask labeled 1 containing sodalime/caustic soda to absorb all the carbon dioxide enclosed in the flask by passing its petiole via split cork.This serves as the **control experiment**.
- Another leaf is enclosed in a conical flask labeled 2 containing sodium hydrogen carbonate to produce carbon dioxide **OR** water that has no effect on carbon dioxide in the flask.
- The flasks are covered with a split cork and supported by the clamps and stands.
- Vaseline is applied (smeared) onto the neck of the flask on the split corks.
- Vaseline makes flasks airtight, preventing entry of air that could interfere with the experiment.
- The entire set up is placed in bright sunlight for 3 hours after which the enclosed leaves are detached from the plant and tested for starch.

EXPERIMENTAL SETUP



OBSERVATION

- The leaf placed in flask 1 containing sodalime retained the brown colour of iodine solution i.e. turned brown.
- The leaf placed in flask 2 containing water/sodium hydrogen carbonate turned black/blue on addition of Iodine solution.

CONCLUSION

- Carbon dioxide is necessary for photosynthesis.

EXPLANATION

- When the plant is kept in the darkness for very long hours, no photosynthesis occurs.
- The stored starch is used up for respiration.
- Starch is thus removed from the leaves by a process called **destarching**.
- In flask 1, the leaf turned brown indicating the absence of starch.
- This means that no photosynthesis occurred because carbon dioxide necessary for photosynthesis was removed from the plant by soda lime/sodium hydroxide solution.
- In flask 2, the leaf turned blue/black indicating the presence of starch thus photosynthesis occurred due to presence of carbon dioxide

5. AN EXPERIMENT TO SHOW THAT OXYGEN IS PRODUCED/EVOLVED DURING PHOTOSYNTHESIS

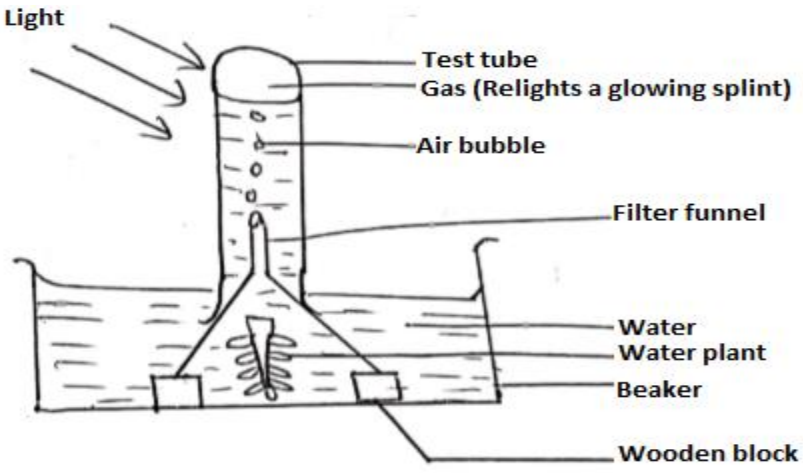
REQUIREMENTS

- Water plant/water weed e.g. Elodea plant.
- Beaker
- Filter funnel
- Test tube
- Fresh water/distilled water
- Small wooden blocks/plasticine/supports
- Glowing splint
- Sodium hydrogen carbonate/sodium bicarbonate

PROCEDURE

- A beaker is filled ¾ way with distilled water.
- A small amount of sodium bicarbonate is added into water to supply extra carbon dioxide to the plant.
- The pond weed (Elodea) is placed into the water and covered with an inverted short stemmed filter funnel.
- The funnel is slightly raised from the bottom using small wooden blocks, to allow the free circulation of water under the funnel.
- The test tube is filled with water and inverted directly over the stem of the filter funnel.
- The setup is placed in strong/bright sunlight for about 5 hours.
- On collection of enough gas in the test tube, the test tube is removed and the gas is tested by inserting a glowing splint in it.
- Another similar set up is prepared using freshwater and placed in darkness so that no light reaches the water weed. This acts as the **control experiment**.

EXPERIMENTAL SET UP



OBSERVATION

- Bubbles of a colourless gas are evolved and collected in a test tube for the set up exposed to sunlight. The collected gas relighted a glowing splint and has no effect on limewater.
- In the control experiment gas bubbles of a colourless gas are evolved and collected in a test tube for the set up placed in darkness. The collected gas extinguished the glowing splint and turned limewater milky.

CONCLUSION

- Oxygen is evolved during photosynthesis.

EXPLANATION

- In the set up exposed to light the weed carried out photosynthesis to produce oxygen.
- Oxygen relights a glowing splint and has no effect on limewater.
- In the control (experiment) set up placed in darkness there was no light for photosynthesis but respiration occurred producing carbon dioxide.
- Carbon dioxide extinguishes a glowing splint and turns limewater milky.

NB: The set up can be used to estimate the rate of photosynthesis by counting the number of bubbles produced per unit time/volume of gas produced per unit time.

6. AN EXPERIMENT TO SHOW THAT CHLOROPHYLL IS NECESSARY FOR PHOTOSYNTHESIS

REQUIREMENTS

- Potted plant with variegated leaves like *Breynia nivosa*.
- Beaker
- Tripod stand
- Wire gauze
- Dropper
- Test tube
- Iodine solution
- Ethanol
- Bunsen burner
- Cupboard/dark room
- A pair of compass

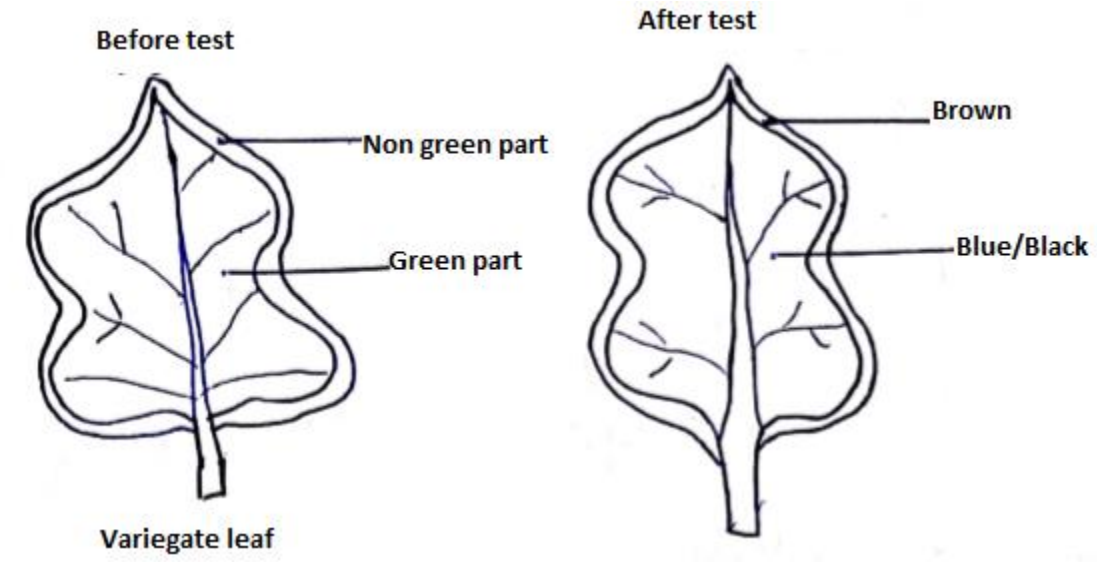
PROCEDURE

- A potted plant with variegated leaves is destarched by keeping it in darkness for 2 days.
- Marks are made on edges of the non-green patches (parts) by piercing using a compass.
- The plant is then placed in bright sunlight for about 6 hours (3 hours).
- A variegated leaf is then detached/ removed and tested for starch using iodine solution.

OBSERVATION

- The green parts of the leaf turned blue/black on addition of iodine solution.
- The non-green parts of the leaf remained brown on addition of iodine solution.

ILLUSTRATION



CONCLUSION

- Chlorophyll is necessary for photosynthesis

EXPLANATION

- Chlorophyll is the green pigment necessary for photosynthesis and gives the characteristic green colour to leaves.
- In variegated leaves, the green parts contain chlorophyll thus absorbed light and photosynthesized to form starch therefore turned blue/black with iodine. The non-green parts remained brown since they don't contain chlorophyll thus didn't contain starch since didn't photosynthesize.

THE COMPENSATION POINT CONCEPT

During photosynthesis, the plant absorbs carbon dioxide and evolves oxygen.

i.e. $6CO_2(g) + 6H_2O(l) \xrightarrow[\text{Chlorophyll}]{Light\ energy} C_6H_{12}0_6(s) + 6O_2(g)$

But during respiration, the plant absorbs oxygen and evolves carbon dioxide.

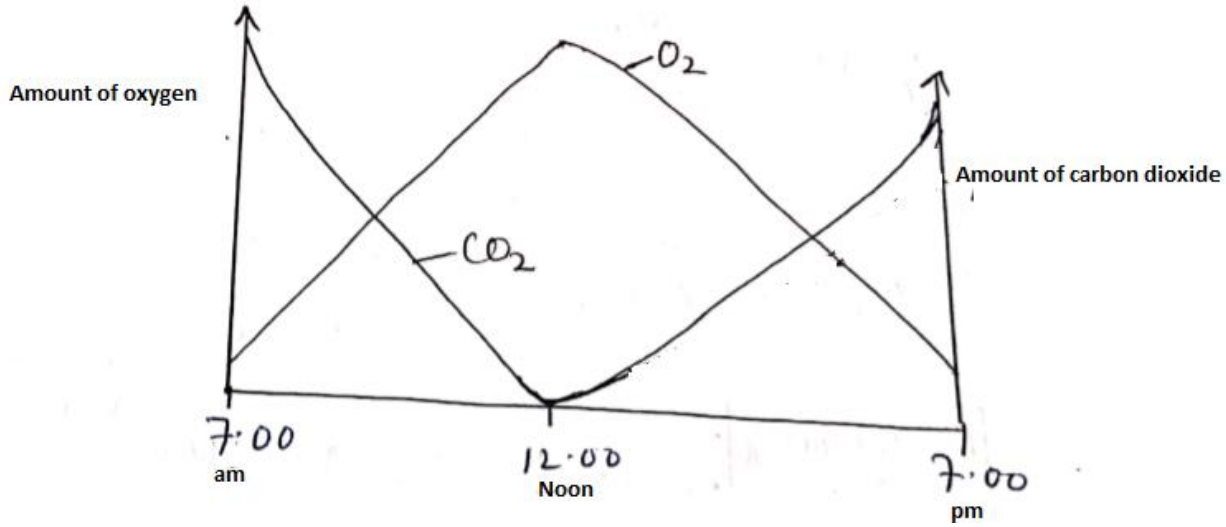
E.g. $C_6H_{12}0_6(s) + 6O_2(g) \longrightarrow 6CO_2(g) + 6H_2O(l) + ATP$

In darkness, no photosynthesis occurs but plants continue to respire thus oxygen is used up and carbon dioxide is given off. At low light intensity, some photosynthesis occurs and some carbon dioxide produced in respiration is taken up by the plant for photosynthesis to occur.

But there is a net loss of carbon dioxide. As light intensity increases, a point is reached when carbon dioxide produced in respiration exactly balances that being used in photosynthesis. This is called the **compensation point**.

At this point, there is no net exchange of gases between plant and atmosphere.

A graph showing the variation of oxygen and carbon dioxide in a forest with time of the day



EXPLANATION

- From 7am to 12noon, the amount of oxygen increased rapidly up to the maximum; while the amount of carbon dioxide decreased rapidly upto the minimum level; because of the increase in light intensity which increased the rate of photosynthesis and produced more oxygen and used more carbon dioxide; respectively.
- From 12 noon to 7pm, the amount of oxygen decreased rapidly; while the amount of carbon dioxide increased rapidly due to decrease in the light intensity that decreased the rate of photosynthesis; yet the plant remained respiring using up oxygen and producing carbon dioxide.

MINERAL NUTRITION IN PLANTS

Element	**Functions**	**Deficiency symptom(s)**
Nitrogen ($N\bar{O}_3$)	• Chlorophyll formation • Forms proteins like enzymes	• Yellowing of leaves (chlorosis) • Stunted growth
Magnesium (Mg^{2+})	• Forms chlorophyll • Activates enzymes	• Yellowing of leaves (chlorosis) or red, orange, purple leaves. • Stunted growth
Phosphorus (${PO_4}^{3-}$)	• For proper root growth • Energy production in form of ATP • Fruit and seed formation • Cell membrane formation • Regulates enzyme activity	• Poor root development • Poor fruit and seed development • Red/brown/purple areas on leaves especially at/along the margins • Stunted growth
Sulphur (${SO_4}^{2-}$)	• Activates certain enzymes • Forms some proteins, enzymes, vitamins.	• Chlorosis (complete yellowing of leaves) • Stunted growth
Calcium(Ca^{2+})	• Forms cell wall & middle lamella. • Improves vigour & stiffness of stem. • Activates enzymes • Forms shoot & root apex • Reduces acidity of soil.	• Weak stems • Poor root growth • Premature shoot, root/bud death • Death of leaves. • Splitting of edges of leaves.
Potassium (K^+)	• Cell sap + cell membrane component. • Activates enzymes • For opening and closing stomata.	• Yellow/brown/dry leaf margins • Mottled leaves/curled leaves.

Questions

(a) What is a culture solution? (02 marks)
(b) What is the difference between a complete and an incomplete culture solution? (04 marks)
(c) Describe an experiment you would perform to show that certain mineral elements are necessary for normal growth of plants.

Solution

(a) Is a solution containing mineral elements mixed in different amounts/proportions.
(b) A complete culture solution is one containing all mineral elements required for normal growth of a plant in their correct amounts and proportions.

While

An incomplete culture solution lacks one or more elements and results in abnormal growth of the plant.

(c) **An experiment to show that certain mineral elements are necessary for normal plant growth**.

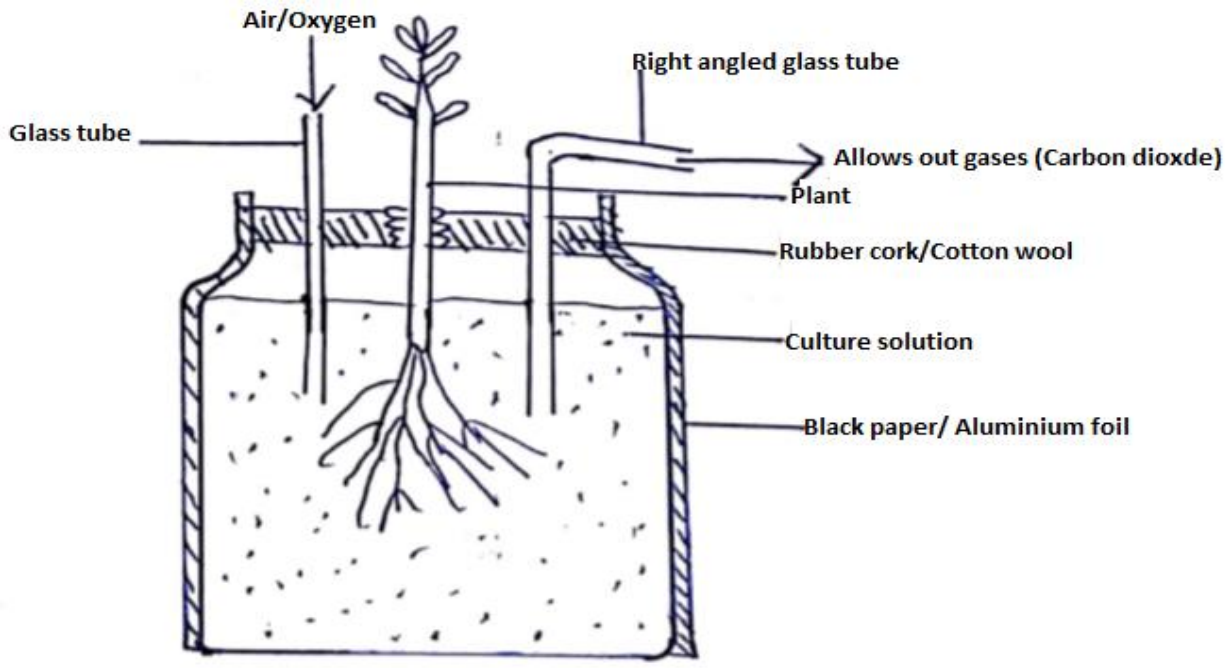
Apparatus

- Seedling germinated on cotton wool
- Salts, calcium sulphate, calcium phosphate, magnesium sulphate, potassium nitrate, iron(III) chloride.
- Support like a glass tube
- Right angled galss tube
- Bottles/jars(9)
- Black paper/black paint
- Cotton wool/rubber corks with 3 holes/asbestos.
- Distilled water.

Procedure

- Prepare a culture solution of salts balanced for healthy plant growth by adding the following to distilled water;
  - ✓ 0.25g of calcium sulphate
  - ✓ 0.25g of calcium phosphate
  - ✓ 0.25g of magnesium sulphate
  - ✓ 0.75g of potassium nitrate
  - ✓ 0.005g of iron (III) chloride

Experimental setup



- Set up of more control solutions, but in each case miss out one of the essential elements by substituting one of others for it like;

(i) To make a control lacking sulphur, use magnesium chloride instead of magnesium sulphate.

(ii) To make a control lacking magnesium use potassium sulphate instead of magnesium sulphate.

(iii) To make a control lacking calcium, use potassium nitrate instead of calcium nitrate.

(iv) To make a control lacking iron, omit iron (III) chloride, iron(II) chloride altogether.

(v) To make a control lacking all essential elements, use distilled water.

- Observe the seedlings over the next 2-4 weeks.
- Record;
  (i) The quality of roots
  (ii) Leaf colour
  (iii) Any deforming/ abnormalities

Observation

- Plants that grew from only distilled water are stunted and weak.
- Those grown in a complete culture solution are healthy and strong.
- Those that lacked magnesium have yellow leaves (chlorosis).
- Plants that lack nitrogen have a few and small leaves with yellow colour (chlorosis).
- Those without phosphorus have a few and shoot roots.
- Those without potassium have short stems with orange-brown leaves.
- Those without calcium have stunted growth

Conclusion

- All the essential elements are required for normal healthy growth of a plant.

Precautions

- The outside of the jars/bottles must be painted black/covered with black paper to keep away light, to prevent growth of algae that can block the root hairs preventing normal absorption of nutrients.
- The underside of the cotton wool/ corks/asbestos must be kept dry to prevent stems from rotting.
- Air must be blown through the right angled tube every day to provide oxygen for the roots.
- The jars/bottles are placed where the shoots receive sunlight equally and the solutions are topped up with distilled water.
- The solutions should be renewed at the end of every 2 weeks.
- Seedlings germinated from seeds with little food reserves like sorghum should be used to quickly exhaust them to depend on the culture solution for their minerals.

NUTRITION IN ANIMALS

HETEROTROPHIC NUTRITION [HETEROTROPHISM]

- **Defn:** Is the type of nutrition where organisms feed on already manufactured food materials.
- It occurs in bacteria, protozoa, fungi and animals.

TYPES OF HETEROTROPHISM

There are basically 5 major types of heterotrophic nutrition namely;

(i) Phagocytosis
(ii) Saprophytism
(iii) Parasitism
(iv) Predation
(v) Holozoic nutrition

NB: Special modes of heterotrophism include;

1. Mutualism. } symbiosis
2. Commensalism }

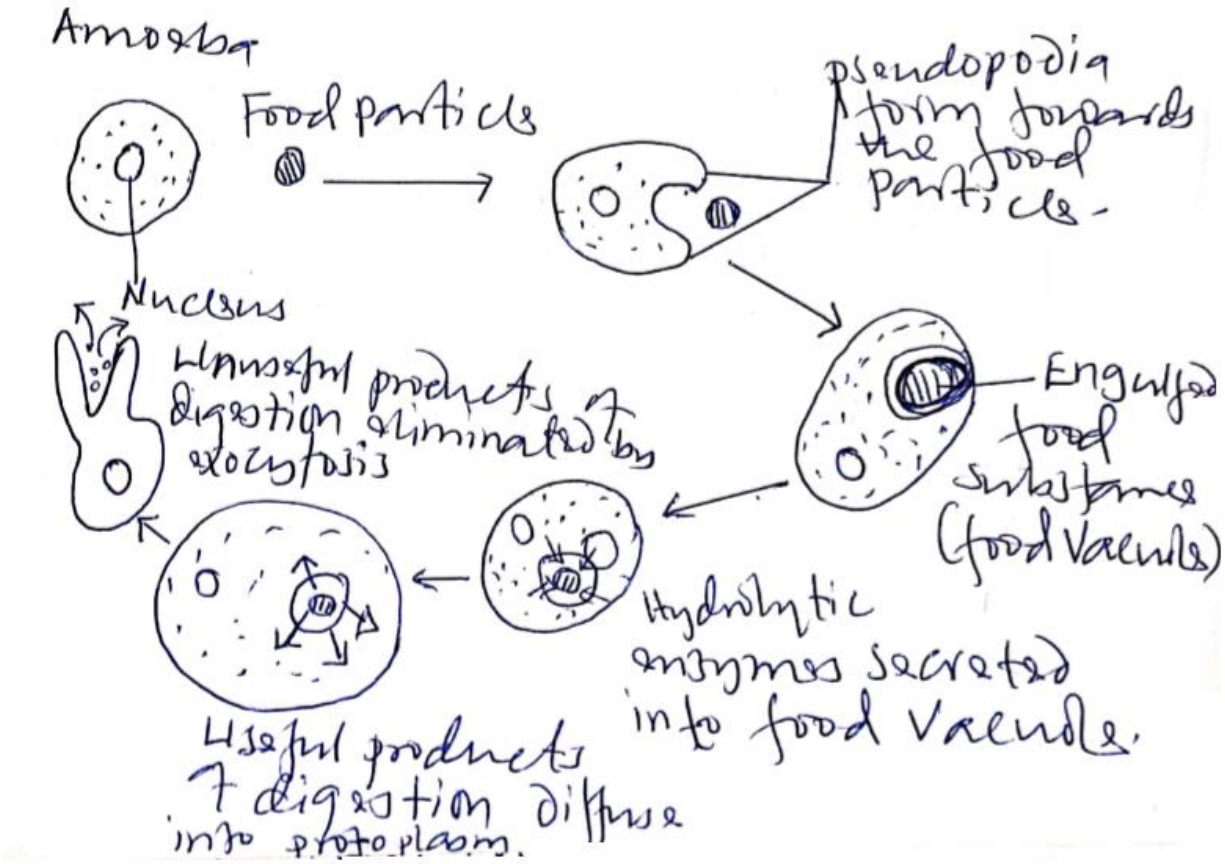
These are discussed under symbiosis together with parasitism.

1. PHAGOCYTOSIS

This is the process of by which cells take in solid substances by use of cell membrane like in amoeba and white blood cells.

NUTRITION IN AMOEBA

- Amoeba feeds on microscopic organisms such as algae, bacteria and some protozoa by a process called phagocytosis.
  Process description
- When amoeba detects chemicals from a food substance, it develops a projection called pseudopodium and moves towards the food particle.
- The pseudopodium encloses the food particle together with little water forming a food vacuole.
- Enzymes are then secreted from the lysosome its protoplasm into the food vacuole by fusing with it.
- The food substance is digested, after which digested soluble food diffuses out of the food vacuole into the protoplasm where it is assimilated in the body of the amoeba.
- The undigested food matter is egested into the surrounding water and the amoeba moves away.
  Illustration of feeding in amoeba i.e. phagocytosis



Question:

(a) Define the term phagocytosis. (02 marks)
(b) Describe the mode of feeding in amoeba. (13 marks)

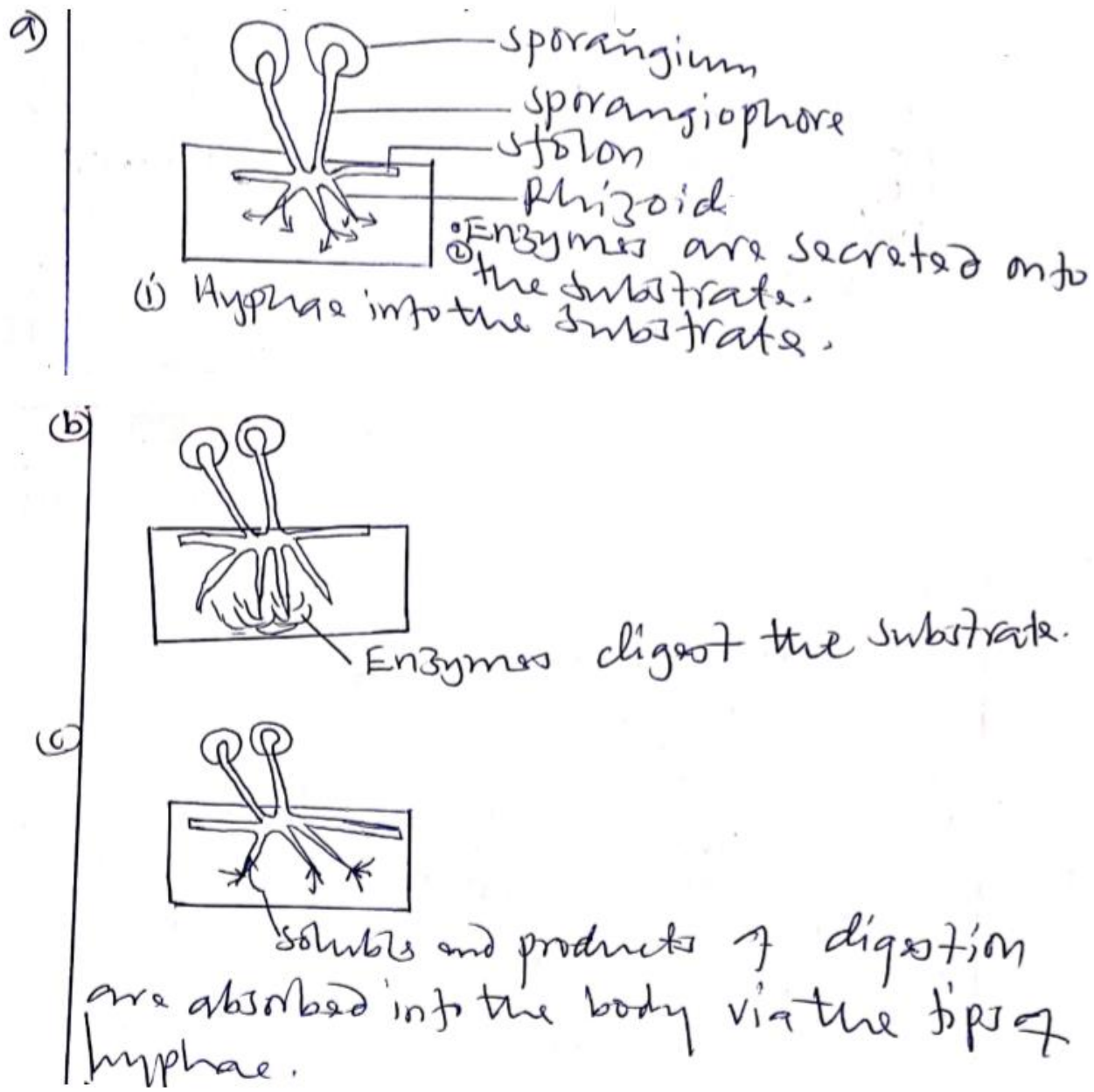
2. SAPROPHYTISM (sapro=Rotten)

- Is the mode of heterotrophic nutrition where organisms feed on dead decaying organic matter.
- Organisms that carryout saprophytes/saprobionts like in fungi such as common bread mould (*Rhizopus*).

NUTRITION IN RHIZOPUS (BREAD MOULD)

- Under favourable conditions of warmth, moisture, suitable PH and presence of organic substrate, spores germinate on the substrate like bread.
- A network of thread-like structures called hyphae spread into the substrate.
- The tips of the rooting hyphae called rhizoids, secrete ectoenzymes into the food substrate.
- The ectoenzymes digest the food substrate extracellularly, giving rise to soluble nutrients that are absorbed into hyphae of the fungus (mould).

Illustration



- The mode of nutrition in fungi is <u>saprophytism</u> and the type of digestion is <u>extracellular</u>, outside the cells of body.
- Fungi obtain their nutritional requirements from dead decomposing organic matter. This is a form of heterotrophic nutrition in which an organism feeds on dead organic matter of plant and animal materials. Thus cause decomposition and recycling of nutrients into ecosystem for reuse.

Question: Describe the mode of nutrition in a mucor/Rhizopus. (10 marks)

Question: State the significance of saprophytes in an ecosystem. (03 marks)

3. PARASITISM(PARASITIC NUTRITION)

- **Parasitism** is a close association between 2 organisms of different species where one organism, the parasite obtains nourishment (food/nutrients) and shelter from another organism, the host and inflicts harm and irritation in long run.
- The host doesn't benefit from the relationship at all.
- A successful parasitic relationship is one where the parasite lives with a host for a long time without inflicting (causing) serious (severe) harm to the host i.e. A good parasite should inflict a mild harm to the host.

Question: Define the term "***parasitism***." (02 marks)

TYPES OF PARASITES

- There are basically 2 major types of parasites viz;
  (i) Endoparasites
  (ii) Ectoparasites

Question: State the 2 categories of parasites. (02 marks)

ENDOPARASITES

- These are parasites which live inside the body of a host.
- They are mainly obligate (full-time) parasites i.e. they live a basic parasitic existence.
- These include;
  - ✓ Hook worms
  - ✓ Tapeworms
  - ✓ Ascaris
  - ✓ Roundworms
  - ✓ Blood flukes
  - ✓ Liver flukes etc

ECTOPARASITES

- These are parasites which live on the outer surface of the host.
- They are facultative (part-time) parasites i.e. they can live independently without hosts at times.
- These include;
  - ✓ Bedbugs
  - ✓ Ticks
  - ✓ Lice
  - ✓ Leeches
  - ✓ Mosquitoes
  - ✓ Fleas

NATURE OF PARASITISM

(a) Obligate parasites: These are full-time parasites that can only survive and grow inside the host cell. i.e. They can't live separate/independent existence like tapeworms, clostridium tetani.
(b) Facultative parasites: These are part-time parasites which can live independently without a host by saprophytic feeding on dead decaying organic matter. Like bedbugs, lice, ticks and mosquitoes etc.

Question: Describe the 2 major categories of parasites giving an example in each ease.

Adaptations of parasites to their parasitic mode of life (nutrition)

(i) Structural adaptations

1. Some parasites have structures of attachment by hooks, suckers to hold/cling onto epithelial layer of the host to prevent them from falling off(dislodgement) like tapeworms, ticks etc
2. Some are long and thin to provide a large surface are for absorption of nutrients over their body wall by diffusion like tapeworms.
3. Some have thick cuticles to prevent digestion by host enzymes like tapeworms.
4. Some have specialized mouthparts for sucking/feeding on the host nutrients.
   E.g.
   - Suckers=tapeworms
   - Chelicerae=ticks
   - Piercing and sucking= mosquitoes.
5. Some produce eggs covered by a hard cyst(coat) which are resistant to host enzymes like liver flukes.
6. Some lack unnecessary structures like eyes, alimentary canal to minimize food demand due to small body size since they are no longer needed.

(ii) Physiological adaptations (factors)

1. Some have ability to respire anaerobically in absence of oxygen.
2. Some are chemosensitive which enables them to locomote and inhabit/live in locations with optimal conditions inside the host's body like optimum temperature and PH of chemicals like acids.
3. Some are resistant to harsh conditions like high temperature and varying PH due to mucus secretion.
4. Some have the ability to produce enzymes which enables them to penetrate through the host's body.
5. Some secrete anti-enzymes that protect them from the host's digestive enzymes attack in order to digest their body wall.
6. Some blood feeder parasites produce anti-coagulants that prevent blood from blood clotting like female anopheles mosquitoes.
7. Degeneration; some have the ability to lose unnecessary organs like eyes, alimentary canal and less to minimize food demands since are no longer needed.

(iii) Reproductive adaptations

1. They produce numerous eggs like round worms produce 200,000 eggs for rapid multiplication to increase their survival chances.
2. Some female parasites like liver flukes carry the male flukes on their back therefore allow effective fertilization thus increased reproductive chances.
3. Some parasites have a short life cycle which effects a high reproductive rate like mosquitoes.
4. Some have reproductive bodies like eggs, spores etc that are resistant to harsh environmental conditions.
5. In some, their reproductive bodies are covered by hard cuticles/coats called cysts which protect them from harsh environmental conditions.
6. Some reproduce both sexually and asexually for rapid multiplication to increase their survival chances.
7. Some are hermaphrodites which enables them to have self-fertilization thus effecting a high reproductive rate.

(iv) Behavioural adaptations, (RESEARCH)

Question: Explain how parasites are adapted to their mode of nutrition.

Question: Explain the factors that enable parasites to suit their parasitic mode of life.

4. PREDATION

- Is a loose association between 2 organisms of different species where one organism, the predator hunts, kills and feeds on another organism, the prey.
- Predators can be insects, amphibians, birds and other animals.

NUTRITION IN INSECTS

- Insects carry out extracellular digestion, they feed on a wide variety of food materials using varying feeding methods which include;

(i) Some insects like house flies, bees and butterflies feed on both plant and animal fluids using their specialized mouth parts, proboscis for sucking plant and animal juices.

(ii) Some insects like tsetse flies, mosquitoes, aphids, bedbugs. They have piercing & sucking mouth parts.
Blood sucking insects further have an anticoagulant, to prevent blood clotting during the feeding process.

(iii) Large number of insects like grasshoppers, termites, cockroaches, praying mantis has modified mouth parts for biting and chewing, the mandibles and they feed on solid food materials like vegetation, papers and even other insects.

NUTRITION IN AMPHIBIANS

- Amphibians carry out extracellular digestion. They normally feed on food of animal origin however, young amphibians feed on plants.
- Adult amphibians feed on insects, worms etc which they trap with their tongue.

- Amphibians flip out the forked end of their long, sticky tongue covered with mucus at a high speed with great accuracy.
- This mechanism is an adaptation for capturing prey which moves rapidly.
- Sometimes, they leap towards flying insects or stationary insects and trap them with their wide mouth/gape.
- Some toads can also swallow their victims (prey) alive.

NUTRITION IN BIRDS

- Birds feed on different types of food like seeds, insects, fish, rodents and dead decaying mammals.
- Their beaks and feet are well adapted to suit the kind of food they eat and the habitat in which they stay to obtain this food.

Examples

1. **FLESH EATING BIRDS(PREDATORY BIRDS)**

These include;

- Vultures
- Hawks
- Owls
- Eagles

They show the following adaptations specialized for feeding on flesh;

(i) They have strong curved hooked toes for killing prey and tearing flesh.

(ii) Their toes have long sharp claws for capturing and holding prey.

(iii) They have strong/keen eye sight for effective location of prey at a distance; for swift and accurate legal attack.

(iv) They possess sharp curved beaks for easy tearing of flesh.

Question: Explain how birds that feed on flesh are adapted to the type of food/diet they feed on. (08 marks)

2. **SEED EATERS**

- These include; domestic birds which feed on seeds like sparrows, domestic fowls, parrots etc.
- They exhibit the following adaptations;

(i) They possess short beaks for easy picking up of seeds.

(ii) Their upper beak slightly overlaps the lower beak and it has a hook-like structure at its distal end for easy cracking and crushing of seeds

(iii) Their toes are curved to enable the bird scratch and pick up the seeds easily.

Illustration

Question: Explain how birds that feed on seeds are adapted/suited to their mode of feeding. (06 marks)

3. FILTER FEEDERS

- These include; ducks, goose, shoebill.
- They show the following adaptations to obtain food;
  (i) They have flat webbed toes on their feet that enable them to swim and search for food in water.
  (ii) Their beaks have serrated edges for sieving out food from mud.
  (iii) They have webbed feet that provide a large surface area so that they don't get stuck in mud as they are walking in muddy water.

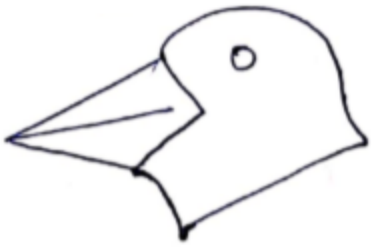
Illustration

Question: Explain how the filter feeders are able to survive in muddy habitat. (06 marks)

4. WOODPECKERS(INSECTIVORES)

- These include; kingfisher, swallow.
- They show the following adaptations specialized for pecking with quick movements as the beak hits and eats.
  (i) They have a chisel-shaped beak used for drilling into trees to pick up insects.
  (ii) ……

Illustration



5. LIQUID FEEDERS

- These include; sunbirds and humming birds etc.
- They show the following adaptations to suit their feeding on nectar in flowers.
  (i) They possess long, slender, curved and pointed beaks for easy probing into flowers to suck nectar.

Illustration

5. HOLOZOIC NUTRITION

- This is the type of heterotrophic nutrition where organisms/animals take in complex food materials wholly which are digested and soluble end products are absorbed into the body.

NUTRITION IN MAMMALS

- Mammals feed holozoically, food acquired is passed through alimentary canal where it is digested into soluble, absorbable particles that can be utilized by the body.
- Different types of mammals feed on different types of food.
- Each mammal is therefore well adapted to obtain nourishment from its diet.
- Mammals are subdivided into 3 groups depending on their major source of food namely;

(i) Herbivores

- These are animals that feed on plant materials entirely like cows, goats etc.

(ii) Carnivores

- These are animals that feed on other animals like lions, leopards etc.
- Carnivores have adaptations to their feeding mode that enable them acquire their food.

(iii) Omnivores

- These are animals that feed on both plant and animal materials like man.

Holozoic nutrition occurs in 5 stages namely;

1. Ingestion
2. Digestion
3. Absorption
4. Assimilation
5. Egestion

Question: State the 5 stages that are involved in holozoic nutrition.

1. **INGESTION**: This is the process by which complex organic food substances from the environment are taken into the body of an organism (alimentary canal).
2. **DIGESTION**: This is the process by which complex food substances are broken down into simple soluble compounds that can be absorbed and assimilated by the body.
3. **ABSORPTION**: This is the uptake of the soluble food materials from the alimentary canal into the body fluids like blood and lymph.
4. **ASSIMILATION**: This is the process by which digested and absorbed food materials are used by the body and incorporated in the body.
5. **EGESTION**: This is the elimination of undigested food substances from the body.

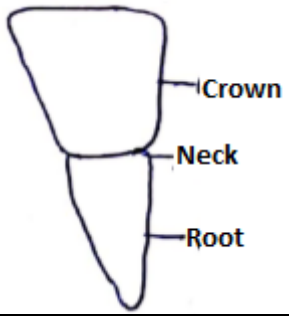
MAMMALIAN TEETH

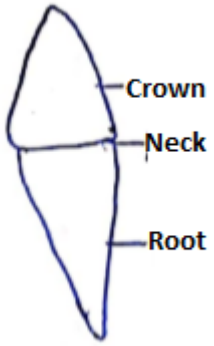
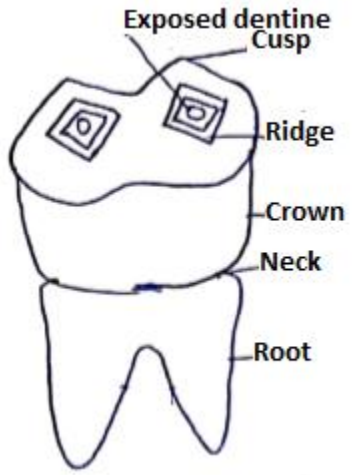
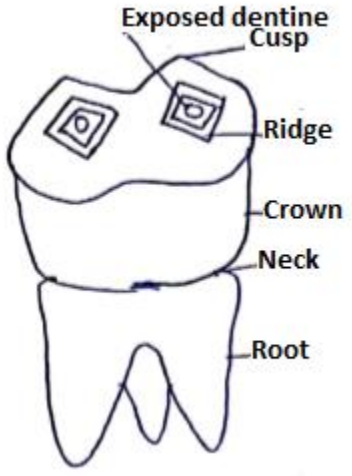
- Teeth are structures holding the jaw of most vertebrates. They perform several functions like chewing, tearing, holding and scraping food.
- Mammals have different types of teeth therefore they are called *heterodonts*.
- Those which have teeth of the same size and shape are called *homodonts*.
- In mammals, teeth consist of an exposed portion called *crown* and the portion firmly fixed into the jaw is called the *root*.

TYPES OF TEETH IN MAMMALS

- There are 4 types of teeth in mammals namely;
  1. Incisor teeth
  2. Canine teeth
  3. Premolar teeth
  4. Molar teeth

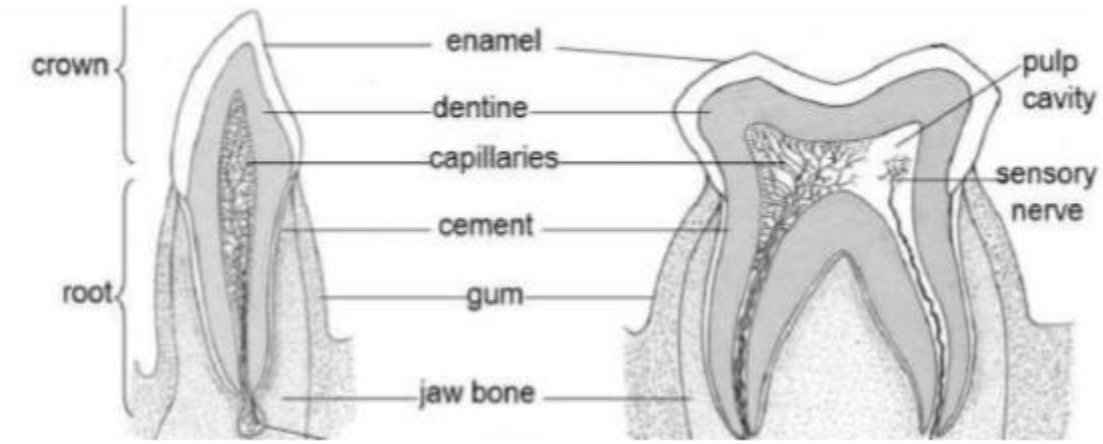
A summary of teeth description and their function(s)

TOOTH STRUCTURE	DESCRIPTION & FUNCTION
	**Incisor teeth** • These are front teeth in both upper and lower jaws of man. • The crown is chisel-shaped, sharp with flat edge. • They have one root. **Function** • They are used for cutting food. However, they may be used for holding, gnawing and defence.

	**Canine teeth** • They are found next to the incisor teeth and are normally long and pointed. • They are poorly developed in herbivores and prominent in carnivores. • They have a <u>conical shaped</u> crown which is <u>sharp</u> and <u>pointed</u>. • They have one root. **Function** • They are used for tearing flesh. **NB**: Carnivores may use canines for stabbing.
	**Premolar teeth** • These lie behind the canine teeth on both jaws. • They have a <u>flat broad surface</u> which is used for <u>grinding</u> food. • They have <u>cusps</u> and <u>ridges</u>. • They have 2 roots. **Function** • They are used for grinding and chewing food.
	**Molar teeth** • They are absent in young mammals • They have wide crowns with more ridges and cusps than premolar teeth. • They have 3/4 roots. **Function** • They are used for chewing, grinding and crushing food.

INTERNAL STRUCTURE OF THE TOOTH

THE INCISOR TOOTH **THE MOLAR TOOTH**



FUNCTIONS OF DIFFERENT PARTS OF A TOOTH

1. **ENAMEL**: This is the hardest substance made by animals consisting of mineral salts like calcium phosphates bound together to form the enamel.
- It is brittle and non-living.
- It forms the crown of the tooth.
- Its main function is to strengthen and protect the dentine and pulp cavity.

2. **DENTINE**: This is found beneath the enamel.
- It isn't as hard as the enamel.
- It contains channels through which cytoplasmic extension of the dentine forming cells extend to form dental blasts.
- It also strengthens the tooth.

3. PULP CAVITY
- It is a soft connective tissue in the centre of the tooth.
- It contains blood vessels that deliver food nutrients and oxygen to the dentine.
- It also has nerve endings that are sensitive to heat and cold therefore producing a sensation of pain in tooth which leads to tooth decay.

4. **ROOT**: This part fixes the tooth in the socket of the tooth firmly into the jaw.
5. **GUM**: This is a soft fibrous tissue that fixes the tooth firmly into the jaw bone and covers the root in the jaw bone.
6. **NERVE FIBRES/ENDINGS**: These are fibres that detect heat and coldness in the tooth.
7. **BLOOD VESSELS**: The tooth has a rich supply of many capillaries that deliver nutrients and respiratory gases to the tooth.

Question: Explain how the canine tooth is adapted to its function.

Question: Giving the function, describe the characteristics of different types of teeth.

DENTITION

- This refers to the number, the type and arrangement of teeth in an animal jaws.

DENTAL FORMULA: This is the number and arrangement of teeth in one half of upper and lower jaw.

- It is a formula which shows the type and number of teeth in each half of the jaw.

DENTAL FORMULAE OF SELECTED ANIMALS

- The different types of teeth are represented by the following symbols;
  - ✓ Incisor teeth(I)
  - ✓ Canine teeth (C)
  - ✓ Premolar teeth (PM)
  - ✓ Molar teeth (M)
- Each of these symbols is characterized by a numerator representing teeth in the upper jaw and a denominator representing teeth in the lower jaw.

MAMMAL	DENTAL FORMULA	TOTAL NUMBER OF TEETH
Adult man	$I\frac{2}{2}C\frac{1}{1}PM\frac{2}{2}M\frac{3}{3}$	32
Dog	$I\frac{3}{3}C\frac{1}{1}PM\frac{2}{3}M\frac{3}{3}$	38
Mature dog	$I\frac{3}{3}C\frac{1}{1}PM\frac{4}{4}M\frac{2}{3}$	42
Cow	$I\frac{0}{3}C\frac{0}{1}PM\frac{3}{3}M\frac{3}{3}$	32
Rat	$I\frac{1}{1}C\frac{0}{0}PM\frac{0}{0}M\frac{3}{3}$	16

MILK TEETH AND PERMANENT TEETH

- Some mammals are born with teeth like rabbits and dogs.
- Other mammals like man, the teeth begin to emerge a few months after birth.
- Most mammals normally have 2 sets of teeth i.e. milk teeth (temporary teeth) and permanent teeth (permanent).
- The first set of teeth is used when the mammal is still young, when it is basically depending on the mother for milk.
- The second set replaces the milk teeth to adapt the mammal to its characteristic diet.
- In humans, the jaw increases in length as one grows and gradually teeth begin to emerge.
- At 6 years, the first set is fully developed. The second set grows and pushes out the milk set; however, not all of them are lost. Premolar teeth remain in the jaw. At the age of about 20 years the last molar teeth usually called wisdom teeth will appear.
- In humans, a complete set of teeth is 32 teeth.

TEETH ADAPTATIONS TO DIET

- The dentition of all animals is related and adapted to their diet.

1. OMNIVORES (man, pig)

- These are animals which feed on both plant and animal materials.
- They have specialized dentition in order to feed on a wide range of food materials as below;
  - (i) They have incisor teeth for cutting and biting food.
  - (ii) Have canine teeth for tearing flesh.
  - (iii) Have premolar teeth and molar teeth for chewing and crushing food.

2. CARNIVORES (tiger, lion, leopard)

- They have well adapted teeth for hunting and killing their prey.

Adaptations of carnivores to their type of diet

(i) Have long pointe canine teeth for piercing into the prey and thus providing quick killing actions.

(ii) The last premolar tooth in the upper jaw and the first molar tooth in the lower jaw were modified into carnassial teeth for shearing (tearing) and slicing through flesh as well as crushing bones.

(iii) Have strong jaws, muscles and a firm hinge joint to avoid dislocation during eating and when holding a struggling prey when it dies.

Question: How different types of mammals have their tooth structure suited for their diet.

3. HERBIVORES

- These include animals like cows, goats, rabbits etc.
- These eat food of plant materials like grass and leaves.
- Their teeth are adapted to chewing and grinding vegetation that contain cellulose.

Adaptations of herbivorous teeth to their type of diet

(i) Have premolar and molar teeth with cusps and ridges for crushing small materials like leaves and stems containing cellulose.

(ii) Their upper incisor teeth were replaced by a hard thick pad that provides a cutting edge for the lower incisor teeth.

(iii) Have a large gap, *diastema* that lies between the front teeth and premolar teeth for manipulation of food by tongue during chewing food (mastication).

(iv) Their canines if present are very similar to the incisors for easy cutting of food/vegetation.

DENTAL CARE IN MAN

- Although hard, teeth are delicate and need care if their life it to be sustained.
- Common problems that arise when teeth are not cared for include;
  - (i) Tooth decay/dental caries
  - (ii) Periodontal diseases

(i) Tooth decay/dental carries

- These occur by lodging of food particles i.e. when food gets stuck, especially sugars within teeth.
- This food is attacked by microorganisms (bacteria) which ferment food materials for production of an acid which reacts chemically with the enamel and removes calcium from it making it soft.
- During chewing, the soft part of the enamel begins to wear away forming a hole, which becomes longer to accommodate more food particles thus fermentation continues.
- Toothache begins in the dentine and pulp cavity because it contains nerves and blood vessels. This ache arises because the nerves and blood vessels are affected by bacteria therefore causing a lot of pain.

Question: Explain how tooth decay arises in man.

(ii) Periodontal diseases

- These are diseases that make the gum soft and flabby thus can't support the well.
- Sometimes these diseases may lead to bleeding of the gum and may pass out puss in the a bad situation.
- The 2 periodontal diseases include;
  1. Pyorrhea
  2. Gingivitis

Question: State 2 periodontal diseases. (02 marks)

CAUSES OF DENTAL CARIES IN MAN

1. Lack of cleaning of teeth properly.
2. Lack of calcium in the diet.
3. Lack of hard food in one's diet like sugar canes and bony meat.
4. Lack of vitamin D in the diet.
5. Lack of enough exposure to sunlight.
6. Eating a lot if sweets and sugary food stuffs.

CAUSES OF PERIODONTAL DISEASES

1. Lack of massage of the gum.
2. Imperfect cleaning of the gum.
3. Lack of vitamin A and C in the diet.

DIGESTION IN MAMMALS

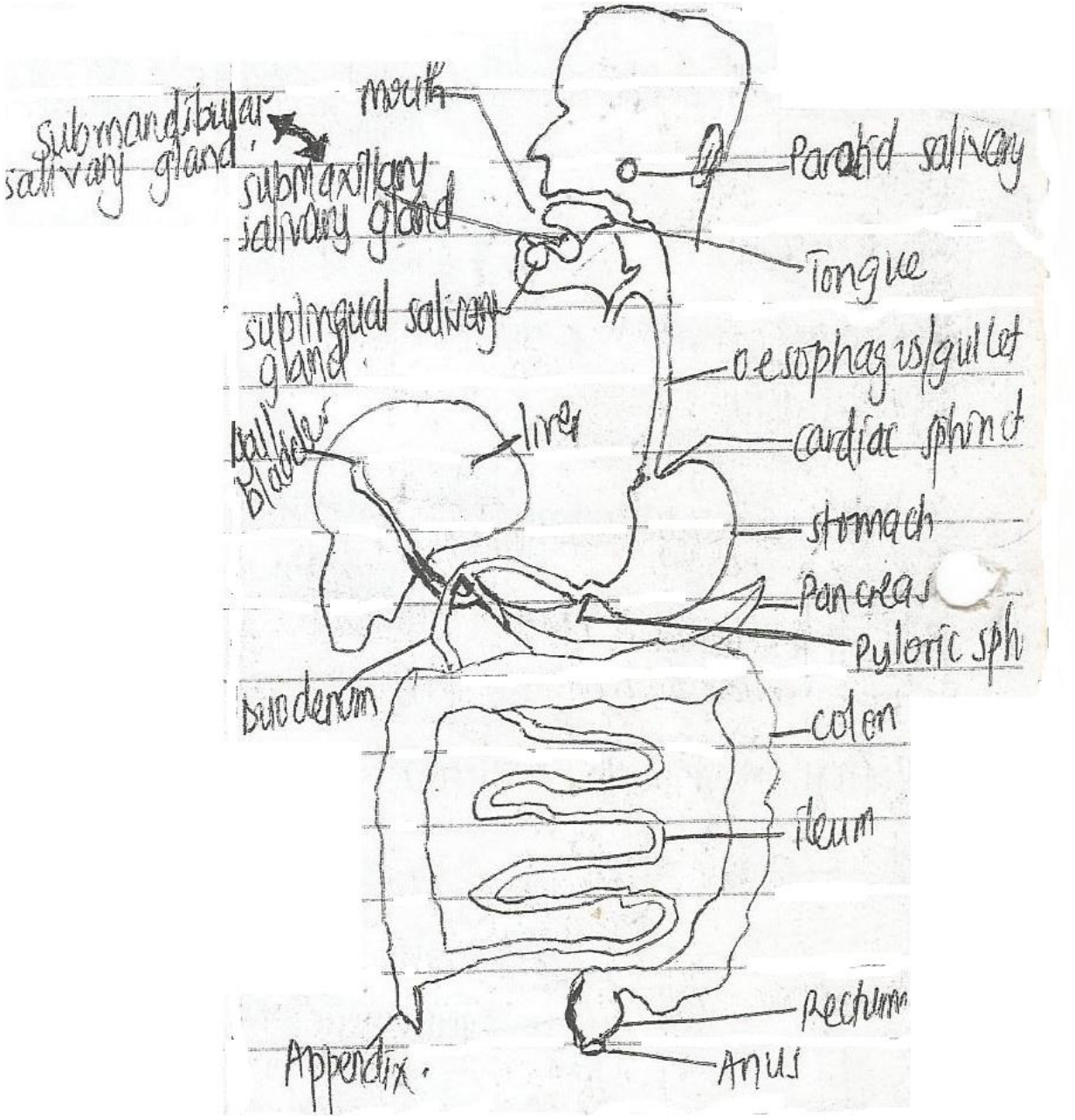
DIGESTION IN MAN

- Digestion is the process by which complex substances are broken down into simpler soluble products that can be absorbed and assimilated into the body.
- In man, digestion occurs in the alimentary canal which is a long tube running from the mouth to the anus.

- This system (digestive system) is modified into various regions for effective digestion.
- It is aligned with several glands which include; salivary glands in the mouth, gastric glands in the stomach wall, brunner's glands in the duodenum.
- It is also closely related with organs like liver and pancreas which produce secretions like enzymes.

Question: State the glands and organs that are associated with the alimentary canal. ($02\frac{1}{2}$ marks)

A DIAGRAM SHOWING THE HUMAN DIGESTIVE SYSTEM



DIGESTION IN THE MOUTH

PHYSICAL DIGESTION

- Food in the mouth is chewed by teeth, breaking it down into smaller particles to increase the surface area for enzyme activity and for easy swallowing.
- This process is called mastication.
- Mastication is important because;

(i) To increase the surface area of food for efficient enzyme action.
(ii) To enable the mixing of food with saliva and in so doing soften the food and lubricates it with mucus in the saliva.
(iii) With aid of the tongue, food is rolled into a bolus(a small ball) for easy swallowing and movement in the alimentary canal/gut.
(iv) Chewing stimulates enzyme secretion because the secretion of saliva is a reflex action stimulated by presence of food in the mouth.

NB: The secretion of saliva can be stimulated by taste of food, smell of food or sight of food.

Question: Explain the significance of mastication. (07 marks)

Chemical digestion

- Chemical digestion is carried out by enzymes like salivary amylase.
- Saliva is an alkaline watery fluid/solution with high PH and it provides optimum PH for the action of salivary amylase.
- Salivary amylase acts on starch breaking it down to a disaccharide called maltose.
  i.e. Cooked starch $\xrightarrow{Salivary\ amylase}$ Maltose

Question: Describe chemical digestion in mouth. (04 marks)

ACT OF SWALLOWING

- Food is rolled into the bolus which is then pushed into the back of the mouth(pharynx) for swallowing to begin.
- The epiglottis acts as a trap door to close the entrance into the trachea to prevent food from entering it.
- At the same time, the soft palate also closes the entrance into the nosal cavity, to prevent food from entering the nose.
- Towards the oesophagus, the food moves by contraction and relaxation of muscles caused by the movement of food through the alimentary canal.
- Its movement is called peristalsis.
- By peristalsis, food moves to the stomach.
- The stomach is a thick muscular bag connected to oesophagus. The upper wider end is called the cardiac region and lower narrow region is called pyloric region.

DIGESTION IN STOMACH

- Most of the digestion in the stomach is <u>chemical digestion</u>.
- Only protein digestion occurs in the stomach.
- Presence of food in the stomach stimulates gastric glands in the stomach wall to secrete gastric juice which contains 2 enzymes; **renin** and **pepsin** enzymes.
- It also contains hydrochloric acid, mucus and water.

Question: State the components of gastric juice. ($02\frac{1}{2}$ marks)

Functions of hydrochloric acid in the stomach

(i) It kills some bacteria swallowed with food.
(ii) It provides optimum PH for gastric enzymes, pepsin and renin to work efficiently.
(iii) It stops the action of salivary amylase to ensure only protein digestion.
(iv) Ti prevents fermentation of food in the stomach by bacteria.
(v) Activates gastric enzymes.

Question: Explain the significance of hydrochloric acid in the stomach. (05 marks)

- The enzyme pepsin and renin are secreted in their inactive forms called <u>pepsinogen</u> and <u>prorenin</u> respectively, to prevent the enzymes from digesting proteins in the cells producing them as well as lining of the gastric glands.
- Pepsin hydrolyses proteins to peptides and peptones.
- Renin in young mammals coagulates soluble milk protein <u>*caseinogen*</u> into insoluble proteins <u>casein</u> that can be acted upon by pepsin into peptides.

i.e.

$$\text{Proteins} \xrightarrow{Pepsin} \text{peptides + peptones}$$

$$\text{Caseinogen} \xrightarrow{Rennin} \text{Casein}$$

Functions of mucus

- Mucus forms a barrier between stomach walls and gastric juice; therefore, protecting the stomach walls from corrosive action of hydrochloric acid; in the stomach causing ulcers.

Question: Describe the significance of mucus in the stomach. (03 marks)

DIGESTION IN THE DUODENUM

- When the pyloric sphincter relaxes, acidic chime is released from the stomach in small bits/amounts into the duodenum.

- Presence of acidic chime in the duodenum stimulates the secretion of a hormone called cholecystokinin (CCK) that causes the release of pancreatic juice from the pancreas and bile from the gall bladder in the liver under the influence of secretin hormone.

NB: Bile is a green alkaline liquid that contains organic salts and hydrogen carbonate/bicarbonates that emulsify fats and provide suitable PH for the action of pancreatic enzymes by neutralizing the hydrochloric acid in chime respectively.

Question: State the organic solutes within secretions released into the duodenum.

FUNCTIONS OF BILE

(i) It contains a high percentage of water and therefore adds it to food that is coming from the stomach.

(ii) It is alkaline, thus it neutralizes acidic hydrochloric acid from stomach into an alkaline liquid called chyle. This stops action of stomach enzymes and allows enzymes in the pancreatic juice to begin performing their function i.e. provides optimum PH for pancreatic enzymes activity (alkaline PH).

(iii) It reduces surface tension of lipids/fats and breaks them down mechanically into fat droplets to increase surface area for enzyme reaction. This process is called *emulsification* of lipids.

- Pancreatic juice contains a number of enzymes which are called pancreatic enzymes as shown in the table below.

Enzyme	Food acted upon	Product(s)
1. Trypsin	Protein	Peptides & amino acids
2. Pancreatic amylase	Starch	Maltose
3. Pancreatic lipase	Lipids	Fatty acids & glycerol

NB:

- ✓ Trypsin is also secreted in an inactive form of trypsinogen to prevent it from digesting the duodenal walls.
- ✓ Both trypsin and pancreatic amylase act upon proteins and starch respectively that were not broken down in stomach and mouth.

Question: Explain the functions of bile in the digestive system.

Question: Explain why emulsification of fats takes place in duodenum.

Question: Describe the process of formation of products of digestion in duodenum.

DIGESTION IN THE ILEUM

- Food moves from the duodenum to the ileum by peristalsis.
- The presence of food in the ileum stimulates secretion of intestinal juice called succus entericus. This contains several enzymes which complete the process of digestion of various food particles.

- At the end of their activity, food is a milky product called chyle which is ready for absorption.
- The enzymes in succus entericus carry out the following hydrolysis/conversions;

Enzyme	Food acted upon	Products
1. Sucrase	Sucrose	Glucose + Fructose
2. Maltase	Maltose	Glucose + Glucose
3. Lactase	Lactose	Glucose + Galactose
4. Peptidase	Polypeptides & peptides	Amino acids
5. Lipase	Lipids	Fatty acids +Glycerol

Question: Describe the process of formation of products of digestion.

Question: State the end products, food acted upon and enzymes of digestion in the ileum.

Composition of chyle is therefore a group of soluble end products of digestion which include;

- ✓ Glucose
- ✓ Galactose
- ✓ Fatty acids
- ✓ Minerals
- ✓ Vitamins
- ✓ Fructose
- ✓ Glycerol
- ✓ Amino acids

Question: State the end products of digestion in ileum. (04 marks)

DIGESTION IN LARGE INTESTINES (COLON)

- In the colon, water and mineral salts are absorbed.
- The undigested food substances pass down into the large intestines and are eventually removed from the body in form of faeces through the anus.

NB: Accumulation of hard particles like stones in the appendix results into a condition called appendicitis. This can lead to surgical removal of the appendix.

Question: Describe the process of digestion that occurs when a person consumes a meal of posho and beans.

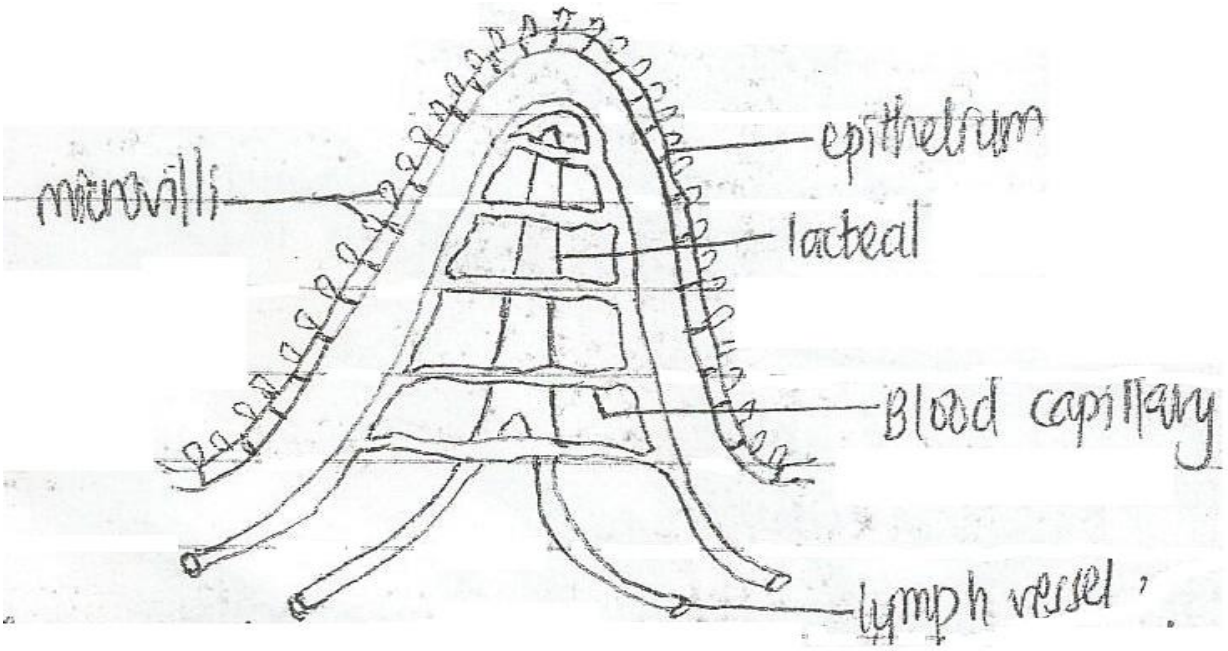
ABSORPTION AND ASSIMILATION OF FOOD

ABSORPTION

- This is the process by which soluble products of digestion diffuse through the semi-permeable membrane of villi into blood stream.
- Some nutrients like mineral salts and vitamins also enter the villi directly by active transport without digestion.

Question: Define the term <u>absorption</u>. (02 marks)

A DIAGRAM SHOWING THE STRUCTURE OF VILLUS



- Ileum shows adaptations to suit its function of absorption. These adaptations include;

1. It is long to increase surface area for absorption of digested food.
2. Has a thin epithelium that provides a short diffusion distance for rapid diffusion of food nutrients.
3. Has a dense network of blood capillaries to maintain a steep diffusion gradient for faster transport of absorbed food.
4. Has numerous villi to increase surface area for absorption of digested food.
5. Has numerous microvilli to further increase surface area for absorption of digested food.
6. The villi possess mitochondria that provide energy for absorption of food by active transport.
7. Has lacteals for absorption and transportation of absorbed lipids (fatty acids and glycerol).
8. Is greatly folded to increase surface area for absorption of food products.

ADAPTATIONS OF ILEUM FOR FOOD DIGESTION

- Has numerous enzymes for chemical digestion of food.
- Has mucus lining for its protection from peptic enzymes.
- Has circular and longitudinal muscles for peristalsis thus physical digestion of food.

- Is greatly folded to increase surface area for digestion/absorption of food without occupying much space.
- Is long to increase surface area for food digestion.

NB:

- The fatty acids and glycerol are absorbed in lacteal of villi.
- The lacteals later join up to form lymphatic system which carries away these food nutrients and distributes them to different parts of the body.
- Glucose amino acids and fructose pass into blood capillaries of the villi which later form up the vein called hepatic portal vein that takes them to the liver from where they are distributed all over the body.

ASSIMILATION

- This is the process by which absorbed food nutrients are built up into complex constituents of an organism.
- Assimilation is also the utilization of end products of digestion into the body's metabolism for life processes like respiration, growth and repair, reproduction and digestion.

1. Carbohydrates (Glucose)

- Glucose is mainly broken down in the process of respiration to provide energy for the body's metabolic processes.
- Excess glucose is stored as glycogen, however, the liver has the ability to reconvert back the glycogen to glucose in periods of starvation.

2. Proteins (amino acids)

- Amino acids are used in the synthesis of new proteins especially regulators like enzymes and hormones.
- Some amino acids are used in the body for growth and repair.
- In the absence of glucose, fats and amino acids can be used in the process of respiration to produce energy.
- Excess amino acids are not stored in the liver, they are instead deaminated (removal of amino group) by the liver to form urea which is then passed on to the kidney and excreted in form of urine.
- Deamination is the enzymatic removal of amino group from amino acids to form urea.

NB: Urea is a toxic waste product of metabolism.

Question: State the 2 body regulators synthesized from absorbed amino acids.(02 marks)

Question: Define the term ***deamination***. (02 marks)

3. Lipids (fatty acids and glycerol)

- In the absence of glucose, fatty acids and glycerol are oxidized to release energy.

NB: Lipids produce much energy compared to glucose considering the same amount by mass.

- Fats are used for body insulation against heat loss .i.e. They prevent heat loss from the body which is important for temperature regulation mechanism.
- Lipids are used in the formation of structures like cell membrane.
- Excess fatty acids and glycerol are stored under the skin in form of adipose tissue.

Question: Describe the fate of absorbed food nutrients in the body after digestion. (10-13 marks)

THE LIVER

- The liver is the largest organ/gland in the body with a reddish brown appearance and lobes.
- It receives oxygenated blood and blood rich in nutrients from the hepatic artery and hepatic portal vein from the alimentary canal.
- Deoxygenated blood from the liver is joined to the vena cava through hepatic vein.

Question: State the 2 blood vessels that supply the liver with blood.

Question: State the composition of blood in the hepatic portal vein.

FUNCTIONS OF THE LIVER

1. For assimilation and metabolism of carbohydrates, proteins and lipids.
2. Production of heat since there are many metabolic reactions occurring in the liver. There is a lot of heat given off and this heat is distributed throughout the body, thus plays a role in temperature regulation.
3. Manufacture of blood proteins like albumin, globulins, fibrinogen and prothrombin responsible for the process of blood clotting etc.
4. Production of bile which emulsifies lipids/fats.
5. For storage of mineral salts like iron etc.
6. For destruction of worn out red blood cells and removes iron from them which it stores for future formation of new blood cells.
7. For formation of red blood cells using iron and vitamin B_{12}.
8. Detoxification; it converts toxic substances to harmless substances by changing them chemically and later send them to excretory organs for expulsion like it converts more toxic ammonia to less toxic urea then expelled to kidney for elimination.
9. Removal of cholesterol in form of fats and masses which blocks blood vessels and causes hypertension.
10. Deamination; it removes an amino group from amino acids to from amino acids to form urea which is passed to the kidneys and diluted with water then eliminated as urine.
11. Regulation of blood sugar by converting glucose, amino acids and other substances into glycogen for storage.
12. For storage of fat soluble vitamins like ADEK; important in body etc.

HERBIVORES

- These are animals that feed on vegetation like cow, goat, sheep etc.
- Plant materials contain a substance called cellulose which is digested by an enzyme called cellulase.
- It is important to note that mammals feed on plant materials containing cellulose but don't secrete cellulose enzyme.
- They live mutually with cellulose-digesting (cellulase-secreting) organisms in order to overcome this problem.
- These micro-organisms include; protozoa and bacteria that secrete cellulase enzyme.
- They live in gut of herbivores in a harmless, beneficial, nutritional association called symbiosis.

Question: Giving examples, define the term ***mutualism***.

Question: Describe the mutualistic relationship between herbivores (ruminants) and cellulose-digesting bacteria.

DIGESTION IN RUMINANTS

- These are mammals which chew cud and have a 4 chambered stomach.
- Cud is the incomplete chewed grass of plant materials that is taken into the stomach (rumen) and later returned back to the mouth for further chewing in a process called *regurgitation*.
- Ruminants have 4 chambered stomachs namely;
  1. Rumen (1st store)
  2. Reticulum (stores chewed food)
  3. Omasum
  4. Abomasum (chemical digestion); **[RROA]**
- Rumen is a temporary store for food as animal graze.
- Vegetation is kept in this chamber as incomplete chewed food.
- The animal stores this food until at rest when ready to chew cud.
- The rumen contains bacteria that secrete cellulase, which causes fermentation of cellulose into simple structure such as acetic acid, simple fatty acids which are absorbed into the blood stream and later utilized by the body in processes like tissue respiration.
- Fermented food from the rumen passes into the reticulum where further fermentation occurs, food is then regurgitated back into the mouth for further chewing process called rumination.

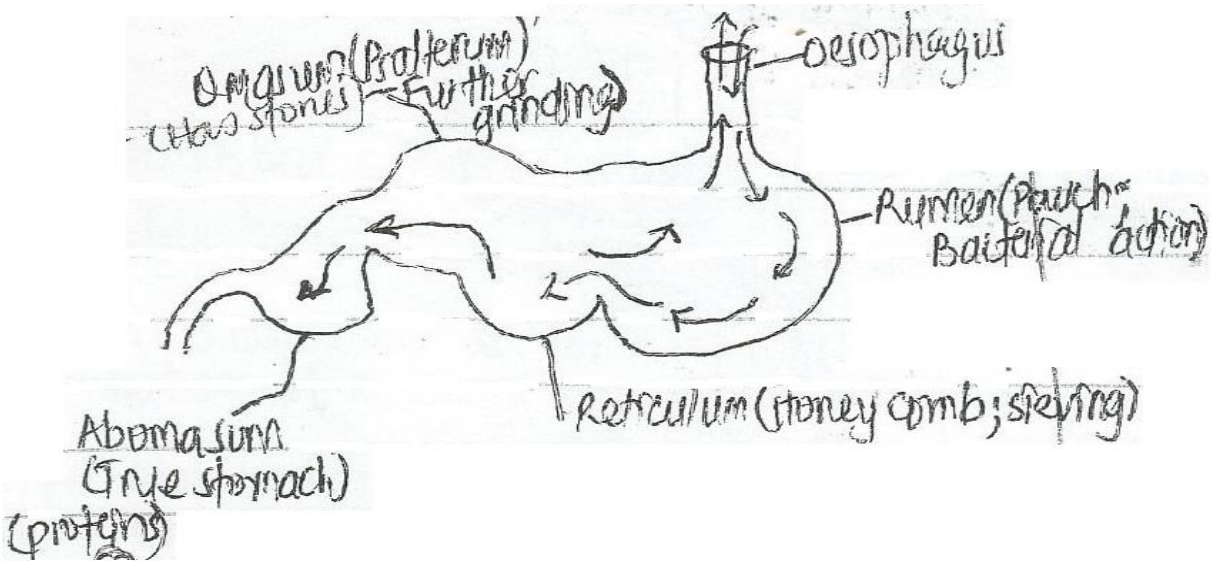
Question: Define the term rumination.

- After chewing the cud is swallowed directly in the omasum.
- In the omasum, most of the water is absorbed from the food.
- The omasum has many infoldings that look like pages of a book.

- This increases surface area for churning food and breaking it down mechanically before the food material is passed to the abomasum.
- In the abomasum which is the true stomach, gastric juice is secreted for chemical digestion to occur on the food materials, similar to that occurs in mammals like man.

Question: Describe the process of digestion in ruminants.

Diagram showing stomach of a ruminant and the flow of food through it



DIGESTION OF CELLULOSE IN TERMITES

- Digestion of cellulose occurs in the gut (stomach) with the aid of protozoa which live symbiotically in the gut of termites.
- These protozoa have the ability to produce the enzyme cellulase which digests cellulose.

Question: Describe the symbiotic relationship between protozoans and termites in their guts.

Comparison between ruminant and non-ruminant digestion

Similarities

- In both young animals, have a single stomach where digestion occurs.
- The final digestion of carbohydrates and proteins occurs in the small intestine (ileum).

Differences

RUMINANT	NON-RUMINANT
• Chew cud • Salivary amylase absent in saliva (ptyalin). • Most absorption and digestion occurs in stomach.	• Don't chew cud. • Salivary amylase present in saliva. • Most digestion and absorption occurs in ileum

END

