NUTRITION IN ORGANISMS

Nutrition refers to the process by which living organisms obtain, consume and use food substances to maintain their life processes (metabolic processes).

These food substances are called nutrients.

These nutrients in green plants include; water, mineral salts, carbon dioxide and in animals include; carbohydrates, proteins, lipids, etc.

Modes of nutrition

Nutrition is broadly classified into two groups namely;

1. Heterotrophic nutrition (nourishment on others).
2. Autotrophic nutrition (self-nourishment).

1. Autotrophic nutrition

This is a mode of nutrition where by an organism is able to synthesize its own food from inorganic nutrients using some external source of energy. Such organisms are called Autotrophs

Autotrophic nutrition can be divided into two depending on the external source of energy used to drive there processes;

Photosynthesis:

This is the type of nutrition where organisms make food with the help of sunlight energy. Examples include; green plants, algae, photosynthetic bacteria.

Chemosynthesis:

This is where organisms make their own food with the help of energy from specific chemical reactions (oxidation of various inorganic compounds). Examples include; chemosynthetic bacteria.

2. Heterotrophic nutrition

This is the mode of nutrition where by organisms obtain their food by feeding on already manufactured organic (food) compounds.

Heterotrophs are incapable of making their own food.

They include; all animals, fungi, insectivorous plants and most bacteria.

Heterotrophic nutrition is of 5 major types, which include:

1. Parasitism

This is an association between two living organisms of different species in which one organism (parasite) obtains food and shelter from the other organism (host) which instead suffers injury and harm. For examples;

- A tape worm in the gut of man
- A cow and a tick.
- A bedbug and a man.

2. Phagocytosis:

This is the process of nutrition where simple cells or unicellular organisms engulf solid food particles. For example amoeba and the white blood cells.

3. Saprophytic/saprotrophic nutrition:

Saprotrophic nutrition is a mode of heterotrophic nutrition where an organism feeds on dead decaying matter where by they absorb solutions from this dead decaying matter.

Examples include; Mushrooms, mucor, common bread mould.

4. Symbiosis / Mutualism;

This is a nutritional relationship between two organisms of different species where both organisms benefit. However, only one organism benefits nutritionally.

Examples include;

- Fungi and algae (lichen).
- Leguminous plants and rhizobium bacteria.
- Protozoa and ruminants.
- Root nodules
- Egret white bird and a cow.
- Bacteria and man in the small intestine.

5. Holozoic nutrition;

This is the mode of nutrition where by food nutrients are taken into the body and broken down into smaller soluble molecules which can be absorbed and assimilated (utilized) by the body.

Animals which undergo holozoic nutrition can be classified into three groups; **Herbivores;** These live entirely on plant vegetation.

Carnivores; These feed on flesh e.g. lion, cat, dog.

Omnivores; These feed on both plants and animals e.g. man and a pig.

FOOD

Food is any substance which can be digested and absorbed by the body to maintain the body's life processes (Metabolic process).

Food is required by organisms for:

i) Growth so as to build new cells. ii) Respiration to produce energy iii) Repair of

worn out cells or tissues iv) Protection of the body against diseases e.g. vitamins, proteins.

Classes of food

There are three classes of food, namely:-

a) Energy giving foods (fats and oils).
b) Body building foods (growth foods) e.g. proteins.
c) Protective foods, these protect the body against infections and diseases e.g. vitamins and minerals.

Types of food/nutrient compounds

There are six different nutrient compounds namely:-

1. Carbohydrates
2. Proteins
3. Vitamins
4. Mineral salts
5. Roughages and water
6. Fats and oils (lipids)

CARBOHYDRATES

These are made up of carbon, hydrogen and oxygen. Carbohydrates are grouped into 3 categories; disaccharides, monosaccharides and polysaccharides depending on number of sugar molecules they are composed of.

i) Monosaccharides

Monosaccharides (mono=one, saccharide= sugar) are substances consisting of one molecule of sugar. They are also known as simple sugars.

Properties of monosaccharides

- They have a sweet taste
- They dissolve in water
- They form crystals
- Can pass through a selectively permeable membrane.
- They change the colour of benedict's solution from blue to orange when boiled with the solution thus they are known as ***reducing sugars.***

Monosaccharides include the following:

1. Glucose (present in grapes)
2. Fructose (present in many edible fruits)

3. Galactose (present in milk) **ii) Disaccharides**

Disaccharides (di=two, saccharide= sugars) are carbohydrates molecules made up two simple sugars joined together. When the two monosaccharides combine, it results in the loss of one molecule of water and this reaction is called a condensation reaction.

Glucose + Glucose = **maltose** + water

Glucose + Galactose = **lactose** + water

Glucose + Fructose = **sucrose** + water

The disaccharides have the following properties:

i) They are sweeter than monosaccharides ii) They can be crystallized iii) They are soluble in water iv) Do not change the colour of Benedict's solution when heated with it (apart from maltose)- they are known as non-reducing sugars

iii) Polysaccharides

v) Can be broken down into simple sugars by dilute mineral acids and enzymes

Examples of disaccharides include:

1) Sucrose (present in sugar cane)
2) Maltose (present in germinating seeds)
3) Lactose (present in milk)

Polysaccharides (poly = many, saccharide = sugar) are complex carbohydrates made up of many units of simple sugars.

Properties of polysaccharides include: Cannot be crystallized

- ✓ Are not sweet Do not change the colour of Benedict's
- ✓ Do not dissolve in water solution

Examples are: Starch**,** Glycogen and Cellulose.

Functions of carbohydrates

i) They provide energy in the body when oxidized during respiration.

ii) They are the cheap sources of energy for living things iii) They act as food reserves which are stored within organisms e.g. many plants store food as starch and animals as glycogen.

iv) They are important components of body structures e.g. cellulose is a component cell walls, chitin forms exoskeleton of arthropods, and heparin is anticoagulant in mammalian blood.

v) They are important for commercial values as they provide raw materials for manufacture of various products such as cellulose provides raw materials for manufacture of paper and textiles.

Deficiency of carbohydrates results in a deficiency disease called marasmus.

Symptoms of marasmus

i) High appetite. iv) Wastage of muscles

ii) Dehydration of the body v) Misery and shrunken appearance iii) Growth retardation

FOOD TESTS ON CARBOHYDRATES

1. Test for reducing sugars

The reagent used is Benedict's solution (blue) or Fehling's solution (blue). Boiling is required.

Procedure	**Observation**	**Conclusion**
To 1 cm^3 of food solution, add 1 cm^3 of Benedict's solution and boil.	Colourless or turbid solution turned to a blue solution, then to a green solution, to a yellow precipitate, to orange precipitate and to a brown precipitate on boiling.	Little/Moderate/Much/Too much; ***reducing sugars present.***

	Colourless or turbid solution turned to a blue solution which persists on boiling.	Reducing sugars absent.

Examples of reducing sugars include:

1) Glucose (present in grapes)
2) Fructose (present in many edible fruits)
3) Galactose (present in milk)
4) Maltose (present in germinating seeds)

The conclusions based on colour changes are according to the following observations:

*Blue **solution**- no sugars*

*Green **solution**- little sugars present*

*Yellow **precipitate**- moderate sugars present*

*Orange **precipitate**- much sugars present*

*Brown **precipitate**- too much reducing sugars present*

2. Test for non-reducing sugars

procedure	**Observation**	**conclusion**
To 1 cm^3 of food solution add 1 cm^3 of dilute hydrochloric acid and boil, cool under water then add 1 cm^3 of sodium hydroxide solution, followed by 1 cm^3 of Benedict's solution and boil.	Colourless or turbid solution turned to a blue solution, then to a green solution, to a yellow precipitate and to a brown precipitate on boiling.	Little/Moderate/Much/Too much; ***non-reducing sugars present.***
	Colourless or turbid solution turned to a blue solution which persists on boiling.	Non-reducing sugars absent.

Note:

i) When boiled with dilute HCl, the non- reducing sugars breaks down into the reducing sugars.

ii) Sodium hydroxide solution or sodium hydrogen carbonate powder is added to neutralize the acid so that Benedict's solution can work.

Examples of non-reducing sugars are sucrose (present in sugar cane) **and** lactose (present in milk)

3. Test for starch:

The reagent used is iodine which is a brown or yellow solution).

Procedure	**Observation**	**Conclusion**
To 1 cm^3 of food solution, add 3 drops of iodine solution.	Colourless or turbid solution turned to a black or blue-black or blue solution or brown solution with black specks.	Much/moderate/little ***starch present.***
	Colourless or turbid solution turned to a yellow or brown solution.	Starch absent.

PROTEINS

These are food nutrients containing carbon, hydrogen, oxygen and nitrogen and sometimes Sulphur or phosphorus. The smallest and building unit of proteins are called Amino acids. The amino acid molecule can condense to form dipeptide; further condensation gives rise to polypeptide molecule (protein).

The **amino acids** can be differentiated into essential and non-essential amino acids. There are a total of twenty (20) amino acids present thus allowing the formation of a variety of proteins.

Types of amino acids

i) Essential amino acids: These are amino acids which cannot be synthesized in the body. This means they can only be got from the diet. **ii) Non-essential amino acids:** These are amino acids that can be synthesized by the body so they are not essential in the diet.

Sources of proteins: Food substances rich in proteins are eggs, lean meat, beans, Soya, milk and its products, fish and groundnuts.

Properties of proteins

i) Most dissolve in water to form colloidal or sticky suspensions.

ii) They are denatured by high temperatures-there structure is completely changed.

iii) They have both acidic and alkaline properties

The main functions of proteins

i) Body building which brings about growth i.e. from structures like in cell membrane, certain as in horns, fingernails, hooves etc.

ii) Repair and regenerate tissues that are damaged or worn out. iii) Synthesis of body chemicals like enzymes, hormones, hemoglobin etc. iv) Provision of energy in times of starvation.

Note: Protein deficiency results in poor health especially in children where it causes ***kwashiorkor.***

Symptoms of kwashiorkor

i) Loss of appetite iv) Growth retardation ii) Diarrhea v) Pot belly i.e. swollen lower abdomen iii) The hair becomes soft and can easily be plucked vi) Swollen legs and joints i.e. Oedema. out accompanied by loss of its colour. vii) Wasted muscles

TEST FOR PROTEINS

There are two food tests for proteins: the ***biuret*** test and ***Millon's*** test. Due to toxic nature of Millon's reagent, it not commonly used any more.

The biuret test is more commonly used. **The Biuret test:**

Procedure	Observation	Conclusion
To 1 cm^3 of food solution, add 1 cm^3 of sodium hydroxide solution, then add 3 drops of Copper II sulphate solution and shake.	Turbid solution turned to a colourless solution then to a violet or purple solution.	Proteins present.
	Turbid or colourless solution turned to a blue solution.	Proteins absent.

LIPIDS (FATS AND OILS)

Lipids also contain carbon, hydrogen and oxygen but with higher proportions of hydrogen and less oxygen than carbohydrates. Because of this, they are able to yield more energy than carbohydrates or proteins weight for weight when oxidized. Lipids are made up **fatty acids and glycerol.**

Fats differ from oils in that they are solids at room temperature whereas oils are liquids at room temperature (25^0C). Fats are mainly found in animal tissues while oils are obtained from plant tissues. Examples of fats include; kimbo, cow boy, tamu, margarine, etc. Examples of oils include; fortune buto, sun seed cooking oil, ufuta cooking oil, etc.

Food sources are, Ground nuts**,** Eggs**,** Sun flower**,** Palm oil**,** Castor oil, etc.

Properties of lipids

i) They make a permanent translucent mark or spot on papers. ii) They also don't dissolve in water

Functions of lipids

i) Energy production during respiration ii) Insulate the body to prevent excessive heat loss. iii) Prevent water loss and entry in cells and tissues iv) They are also constituents of waxy cuticle of animals and plants and the cell membrane. v) In some areas of animals they act as shock absorbers vi) They can be used as a source of water in desert animals such as camels- when stored fat is broken down in the body, much water is produced.

TESTS FOR LIPIDS

They are tested for using the emulsion test or the grease spot (translucent spot) test. **a) The emulsion test:**

The reagents used are ethanol and water.

Procedure	Observation	Deduction
To 1 cm^3 of food solution, add 1 cm^3 of ethanol and shake. Then add 5 drops of water and shake.	A turbid solution turns to a cream emulsion	Lipids present.
	Turbid or colourless solution remains a turbid or colourless solution.	Lipids absent.

b) Translucent spot test:

Procedure	Observation	Conclusion
Add 2 drops of test solution on a piece of filter paper, allow to dry and observe under light.	A translucent spot is left on the paper.	Lipids present
	No translucent spot is formed on the paper.	Lipids absent.

VITAMINS

These are organic compounds required in small amounts in the diet for the normal functioning of the body. They are designated with alphabetical letters and are classified into two: Water soluble vitamins and Fat soluble vitamins.

Water soluble vitamins are those which dissolve in water. They include vitamins B and C.

Fat soluble vitamins dissolve in fats but not in water. They include vitamins A, D, E, and K.

A table showing vitamins and their deficiency diseases

Vitamin	Common food source	Functions	Symptom of deficiency
A Retinol	Green vegetables, liver, butter, margarine, egg yolk and carrots	Growth in children, resistance to diseases of eye (night blindness) and respiratory tract and good night(Dim light) vision	Night blindness, frequent cold sore eyes and unhealthy skin.
B_1 Thiamine	Yeast, beans, lean meat, egg yolk, bread and rice husks	Tissue respiration, keeps the heart, nerves and digestive organs healthy	Tiredness, retarded growth in children and poor appetite, constipation **(beriberi)**
B_2 Riboflavin	Yeast, milk, liver, cheese, leafy vegetables.	Tissue respiration, growth and health of skin. Keeps mucus membrane healthy	Retarded growth especially in children, cracks on lips, poor vision and skin disorders
B_3 - Nicotinic acid/Niacin	Cereal grains, milk and its products, liver and yeast	Same as B_2	Memory loss & depression (pellagra)
B_{12} cobamine	Beef, kidney, liver, yeast	Forms red blood cells	Low blood count(Anemia)

C Ascorbic acid	Fresh fruits and row vegetables	Development of teeth and bones and normal growth.	**Scurvy** - Sore gums, poor healing of sores in the gum
D Calciferol	Liver, fish, egg yolk. It is also formed beneath skin of man in sunlight.	Building strong and hard bones and teeth, promotes absorption of phosphorus and calcium in the gut	Weak bones and teeth, **rickets** in children and dental decay.
E Tocopherol	All foods	Anti-oxidant to prevent excess energy production. Promotes fertility in animals e.g. rats	Sterility (infertility) in some animals like rats.
K- Phyllaquinone	Cabbage, spinach	Normal clotting of blood	Prolonged bleeding.

TEST FOR VITAMIN C:

The reagent used is **DCPIP** (Dichloro Phenol Indole Phenol). It is a deep blue solution. The sources of vitamin C are fresh fruits e.g. oranges, mangoes, lemon, etc.

Procedure	Observation	Conclusion
To 1 cm^3 of DCPIP solution in the test tube, add the food solution drop wise.	The blue DCPIP solution is decolorized or turned to a colourless solution.	Vitamin C present
	The blue DCPIP solution remained blue.	Vitamin C absent

MINERAL ELEMENTS AND SALTS

These are inorganic food constituents required in small amounts but whose deficiency affects the normal functioning of the body leading to deficiency diseases.

Mineral salts can be divided into;

Essential mineral elements (macro elements): These are mineral elements required in relatively large amounts. They are sodium, potassium, phosphorous, calcium, iron, etc.

Non-essential or Trace mineral elements (micro- elements): These are mineral elements required in relatively very small amounts. However, their presence in the diet is of at most importance. They are Zinc, Molybdenum, cobalt, Manganese, etc.

A table showing some elements and their deficiency diseases

MINERAL ELEMENT	SOURCE	IMPORTANCE	DEFFICIENCY
Fe Iron	Beef, liver, kidney, G.nuts, beans, eggs, green vegetables.	- It is a constituent of Haemoglobin.	**Anemia** - Reduced red blood cell account. - Reduction in oxygen transportation rate.
Ca Calcium	Vegetables, fish, milk, bread, eggs.	- In blood clotting -hardening of bones and teeth.	Rickets in children Delay in blood clotting Soft bone, poor skeletal growth.
P Phosphorus	Most foods	Formation of teeth & bones.	It is not likely for one to be deficient of phosphorus since it is found in most foods.
I Iodine	- Iodized salts - Marine fish	It is a constituent of the growth hormone	**Goiter:** Swelling of the Thyroid gland. Muscle cramp (sharp pains in muscles).
F Fluorine	Drinking water	Strong bones and teeth.	Weak teeth in children.
K Potassium	Fish, beef, liver, mushrooms	Transmission of nerve impulse along neurons	Muscular cramp
Na sodium	Common salt (NaCl) and cheese	Transmission of nerve impulse along neurons	

WATER AND ROUGHAGES/DIETARY FIBRES Water

This compound is made of two elements namely Oxygen and Hydrogen. In living things, water forms about 60% of weight

Importance of water The plasma of blood is made up of water.

- ✓ It's a universal solvent in which absorbed foods, wastes and hormones are transported around the body in blood.
- ✓ It participates in many metabolic reactions or processes as a raw materials e.g respiration, photosynthesis, gaseous exchange, digestion, and removal of wastes.
- ✓ Plays a role in temperature regulation ie cooling the body on hot days and plants through transpiration.
- ✓ Offers turgidity thus acts as a hydrostatic skeleton- hence supporting organisms.
- ✓ It softens food.
- ✓ It is an agent of seed dispersal.
- ✓ It is a habitat (home).
- ✓ It acts as a Lubricant e.g. salvia lubricant the mouth, tears lubricate eyes, synovial fluids lubricate the joints.

Roughages / dietary fibre

They are indigestible materials in food and consist mostly of cellulose, pectin, and lignin.

The major sources of roughages include: vegetables, such as cabbages, dodo, fruits, etc.

Functions of roughages

- ✓ They stimulate muscular movements called peristalsis which move food (propel) through the alimentary canal.
- ✓ Some delay food in the intestines whereas others enable food pass through the intestines very fast.
- ✓ The deficiency or lack of roughages causes constipation.

Balanced Diet:

A balanced diet is a meal containing all food nutrients in their right proportions. If a person depends on a poor diet (unbalanced diet) i.e. containing inappropriate quantities of nutrients, then the person suffers from Mal nutrition.

Mal-Nutrition:

This simply refers to an unhealthy state of the body resulting from a long term deficiency or excess of one or more of the essential nutrients. Malnutrition is normally detected by the onset of some deficiency diseases like kwashiorkor, marasmus, obesity, etc.

ENZYMES

Enzymes are organic compounds protein in nature that speed up the rate of biochemical reactions in the body of an organism and remains unchanged at the end of the reaction.

Importance of enzymes

- They *speed up the rate of the reaction without changing the product formed and the nature of reaction.*
- *They also control metabolic processes hence promoting normal body functions.*

Nomenclature of enzymes

Enzymes are named by adding a suffix "ase" to their substrates. A substrate is a substance, which the enzyme acts upon, or simply it is the raw material for the enzyme.

Examples of enzymes and their substrates

Enzyme	Peptidase	lipase	Maltase	Sucrose	Lactase	Cellulase
Substrate	Peptides	Lipids	Maltose	Sucrose	Lactose	Cellulose

Some enzymes however retained their names they had before this convention. Such enzymes include pepsin and trypsin.

Sometimes the enzymes digesting carbohydrates are generally called carbohydrases and those digesting proteins as proteases.

Properties of enzymes

1) They are all protein in nature.
2) They are specific in their action i.e. they catalyze specific food i.e. Maltase on Maltose.
3) They speed up the rate of chemical reactions (they are catalysts).
4) They are effective even in small amounts.
5) They remain unchanged at the end of the reaction.
6) They are denatured by high temperatures since they are protein in nature and are inactivated by low temperatures.
7) They are inactivated by inhibitor chemicals (poisons e.g. cyanide).
8) They work at a specific PH. (either acidic or alkaline).
9) Their reactions are reversible.
10) Their activity can be enhanced by enzyme activators e.g. chloride ions activate amylase.

Factors affecting enzyme activities

i) Temperature iv) Presence of activators

ii) Concentration of the substrate v) Presence of inhibitors iii) PH of the medium vi) Concentration of the enzyme

1) Concentration of substrate:

A substrate is a substance (food) acted upon by the enzyme to form simpler products. The rate of enzyme reaction increases with increase in substrate concentration and enzymes work slower when the substrate concentration is low.

However, further increase in substrate concentration will not increase enzyme reaction rate since all its active sites are fully saturated with food.

2) Temperature:

Enzymes work best at optimum temperatures of (approximately 37^0C). At very low temperatures, the rate of enzyme reaction is very slow because the enzyme is inactive at such low temperatures.

As the temperatures increase, the rate of reaction also increases gradually until it attains a peak where it has maximum activity and this always correspond to optimum temperatures. *An optimum temperature is which promotes maximum enzyme activity*.

However with further increase in temperature, the rate of reaction decreases exponentially/sharply since at high temperatures, the enzyme is denatured i.e. the active site of the enzyme which is (protein in nature) is altered (changed) or completely destroyed.

A graph showing the variation of enzyme activity with temperature

3) Enzyme concentration:

As the concentration of the enzymes increases, the rate of reaction also increases until all the substrates are being acted upon when the rate finally becomes constant.

4) **The PH of the medium.**

Enzyme reactivity is reduced or stopped completely if placed in a medium whose PH is different from that in which it works best (optimum PH).

PH varies slightly above or below an enzyme's optimum PH resulting in a marked fall in the enzyme efficiency. E.g. pepsin enzyme in the human stomach has a maximum activity with in acidic pH of 1.5 and 2.5 while the enzymes in the duodenum e.g. trypsin work at maximum with in alkaline pH of 8.5 to 9.5.

5) **Presence of enzyme inhibitors**

Enzyme activities decrease in presence of enzyme inhibitors and increase in their absence.

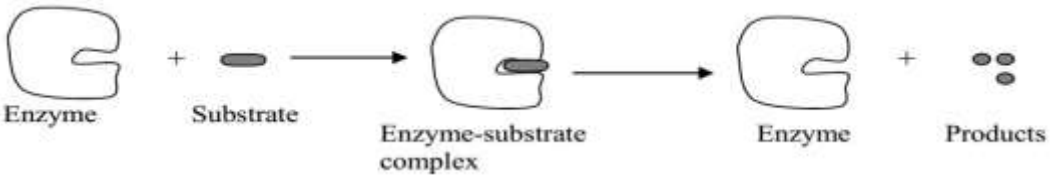
6) **Presence of activators**

Enzyme activators increase with presence of enzyme activators and decrease with absence of enzyme activators.

Mechanism of enzyme action

The widely accepted mechanism by which enzymes are known to work is the "**key and lock" hypothesis**.

The hypothesis suggests that the enzyme has a specific region known as the active site where the substrate fits like a key fits in a lock. The substrate must have a complementally shape to the active site of the enzyme. In this hypothesis the key is analogous to the substrate and the lock to the enzyme. When the substrate combines with the enzyme, an enzyme- substrate complex is formed. This breaks down to release the products and the enzyme, which can pick other substrates.



MAMMALIAN TEETH

Mammals have different types and shapes of teeth and they are thus termed **Heterodonts.** Those which have teeth of the same size and shapes are termed as **Homodonts**.

In mammals teeth consist of an exposed portion known as **a crown** and a portion that is firmly fixed or anchored in a jaw bone called a **root.**

Types of teeth in mammals There are 4 types of teeth in mammals and these include;

1) Incisors

These are the front teeth in both the upper and lower jaws in man.

The crowns are chisel shaped (sharp flat edge) and have only one rot.

Incisors are used for cutting food

Structure of an Incisor

2) Canines

These are found next to the incisors and they are normally long and pointed.

They are poorly developed in herbivores and very prominent in carnivores.

They have a conical shaped crown which is sharp and pointed.

They have one root. ***They are used for tearing flesh.***

structure of a canine

3) Premolars

These lie behind the canines on both jaws.

These have flat broad surfaces which are used for grinding food.

Premolars possess two or more **cusps** and **ridges** and have two roots.

Premolars are used for grinding and chewing food.

Structure of a premolar

4) Molars

They are absent in young mammals.

These have wider crowns with more ridges and cusps compared to premolars.

They may have three or more roots.

Molars are used for grinding and crashing food.

Structure of a molar

Note:

- Elephant tusks are **incisors.**
- Carnivores have a special type of teeth called the **carnassial** teeth which are adopted for cracking bones and scrapping (removing) of meat from bones.

Internal structure of mammalian tooth Each tooth consists of a crown, Neck and root.

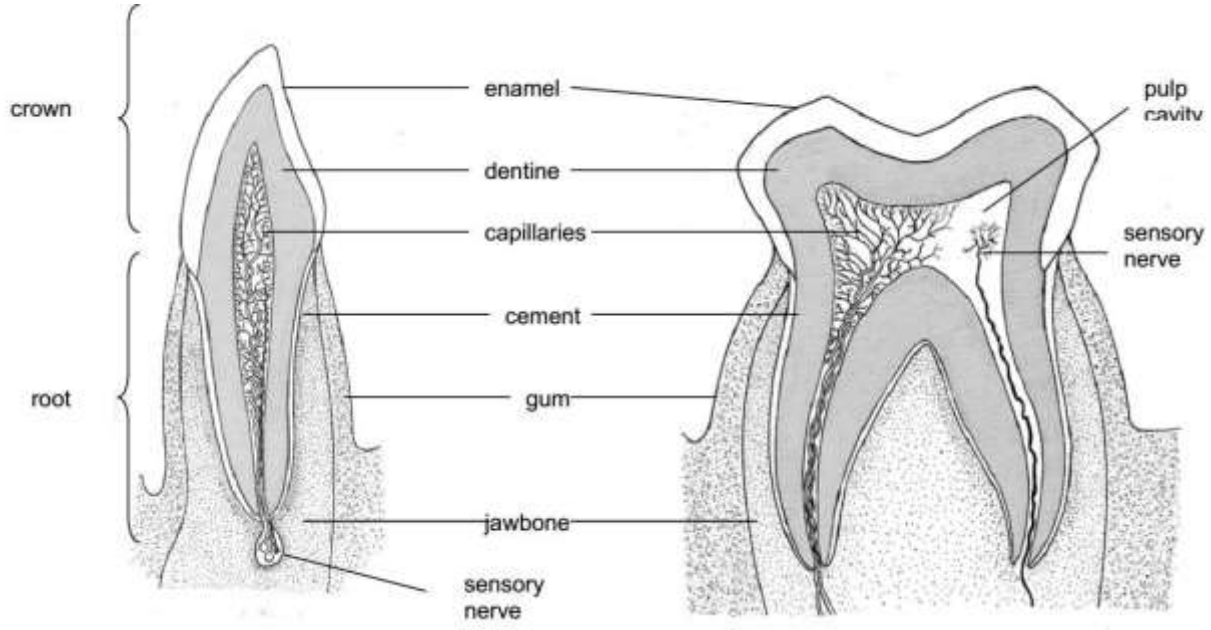
i) **Crown:** This is a region of the tooth which projects above the gum; it is used for breaking down food.

ii) **Neck:** This is the junction between the crown and the root.

iii) **Root:** This is the region which lies embedded in the jaw bone. It cannot be seen and it anchors / fixes firmly the root into the jaw bone.

Vertical section through an incisor

Vertical section through molar



Functions of the parts of the tooth

i) **Crown**; this break down food into small particles during chewing, grinding and cutting.

ii) **Enamel**; this strengthens the tooth to enable it grind and cut. It protects the dentine and pulp cavity. It is the hardest material in the body. It is white in colour and made up of ***calcium phosphate salts.***

iii) **Root**; this fixes the tooth into the jaw. **iv) Dentine**; this strengthens the tooth.

v) **Pulp cavity**; this contains nerves that provide sensitivity to the tooth and blood vessels that transport food and oxygen to the tooth.

vi) **Gum**; this is fibrous which fixes or anchors the teeth firmly in the jaw. It is also called the gingiva.

vii) **Cement**; this is a thin layer of bone-like material that fixes the tooth in the jawbone.

Dental formula

This is a formula indicating the number of each type of teeth in half upper jaw and half the lower jaw. The dental formula gives evidence that the dentition of an animal is closely related to its diet. The number of teeth in the upper jaw is written above that of the lower jaw. The different types of teeth are represented by letters i.e.

Incisors-**I,** Canines-**C,** Molars **M,** Premolars-**PM**

The dental formula of an adult human is written as below:

$\mathbf{I}\ \frac{2}{2}$; $\mathbf{C}\ \frac{1}{1}$; $\mathbf{PM}\ \frac{2}{2}$, $\mathbf{M}\ \frac{3}{3} = 32$

This means that man has 2 incisors on each half on the top and lower jaws, one canine on each half of the top and lower jaws, 2 premolars on each half of the top and lower jaws. Therefore man has 8 teeth on each half on the jaws which adds up a total of 32 teeth.

Dental formulae of some animals

Mammal	Dental formulae	Total number of teeth
Man		32
Dog	$\mathbf{I}\ \frac{3}{3}$; $\mathbf{C}\ \frac{1}{1}$; $\mathbf{PM}\ \frac{4}{4}$, $\mathbf{M}\ \frac{2}{3}$	42
Rat	$\mathbf{I}\ \frac{1}{1}$; $\mathbf{C}\ \frac{0}{0}$; $\mathbf{PM}\ \frac{0}{0}$, $\mathbf{M}\ \frac{3}{3}$	16
Cow	$\mathbf{I}\ \frac{0}{3}$; $\mathbf{C}\ \frac{0}{1}$; $\mathbf{PM}\ \frac{3}{3}$, $\mathbf{M}\ \frac{3}{3}$	32

Dental care in man

Although hard, teeth are delicate and need proper care if their life is to be sustained. Common problems that may arise if teeth are not cared for include:- **i) Tooth decay or dental caries.**

This is caused by lodging (when food gets stuck) of food particles especially sugars between the teeth. This food is then attacked by micro-organisms (bacteria) which ferment this food producing 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 wearing away forming a hole which gets larger and larger as more food gets stuck in the now bigger hole and fermentation process continues. Tooth ache commences into the dentine, the pulp cavity with nerves and blood vessels get affected and a lot of pain is felt. **ii) Periodontal diseases.**

These are diseases which make the gum soft and flabby so that they do not support the tooth well.

Sometimes these diseases may lead to bleeding of the gum and passing out of pus. The 2 periodontal diseases known are; Pyorrhea and Gingivitis.

They are characterized by reddening of the gums, bleeding and presence of pus in the gums. **Prevention of dental decay and proper care of teeth** Visit a dentist regularly for checkup.

- Proper cleaning of teeth (brushing after meals)
- Avoid sweet sugary foods like sweets which encourage bacterial growth.
- Avoid opening bottles using teeth.
- Avoid eating very hot and very cold foods especially at a go since they result into alternate expansion and contraction since it leads to cracking or chipping of the enamel.
- Eating foods rich in calcium, phosphates and vitamins A, D, and C
- Exercising your teeth by eating hard fibrous foods like sugar canes, carrots, etc. This stimulates the flow of saliva which neutralizes acids formed by bacterial fermentation.

Carnivore dentition

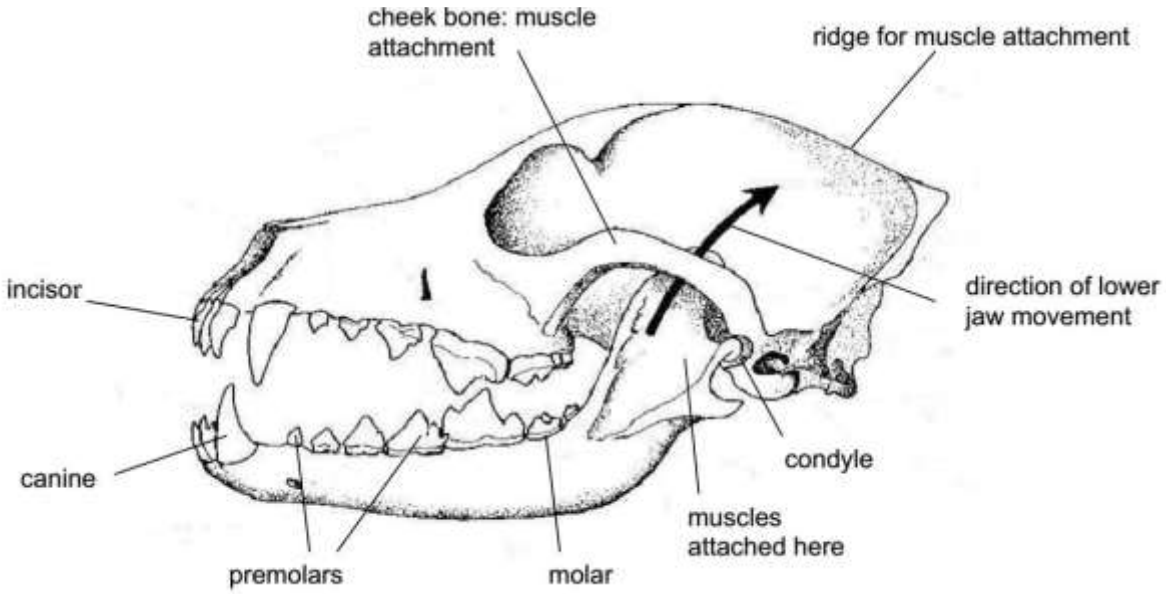
Carnivorous animals such as dogs, cats and lions are adapted for feeding on other animals. Their teeth are adapted for capturing and killing other animals and tearing their flesh.

Their incisors are chisel shaped and enable them to grip and strip off pieces of flesh from bones.

Their canines are long, curved and pointed used for piercing the prey and preventing it from escaping.

The upper fourth premolar and the first lower molar are large and powerful. They are called ***carnassial teeth***. They overlap like blades of scissors and are used for tearing and slicing flesh.
The other premolars and molars have jagged edges that fit perfectly together making them ideal for cracking bones.

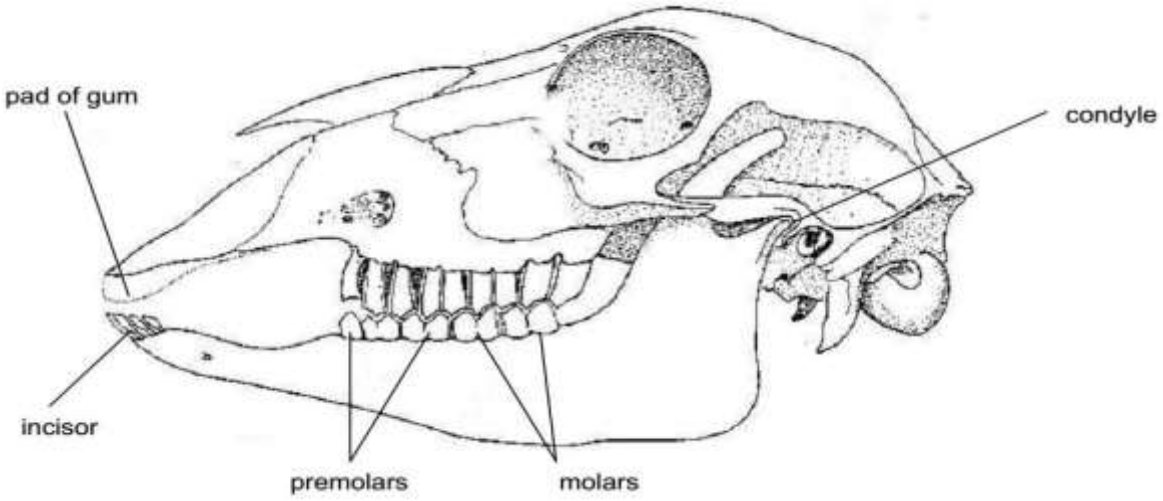
Diagram showing dentition in the carnivore e.g. a dog



Herbivore dentition

Herbivorous animals e.g. cows, goats and elephants eat plant foods such as grass, leaves and small stems. Their teeth are adapted for crushing and grinding vegetables. Their incisors and canines are chisel shaped and only found in the lower jaw. In the upper jaw, the incisors and canines are replaced by a thick horny pad. Grass and other vegetables are gripped between the incisors and canines on the lower jaw and the horny pad. Between the front teeth and the cheek teeth is a large gap called ***diastema***. It provides space for the tongue to manipulate vegetation in such a way that the material being chewed is kept away from that which is freshly gathered.

Dentition of a sheep



DIGESTION IN MAN

Digestion is the process by which complex food substances are broken down into simpler soluble compounds that can be absorbed and assimilated (utilized) by the body. Digestion can be divided into; physical (mechanical) digestion and chemical digestion.

Physical digestion: This is the breakdown of food due to the mechanical action of teeth, muscular contractions and bile juice.

Chemical digestion: This is the breakdown of food due to enzyme action or enzymatic action.

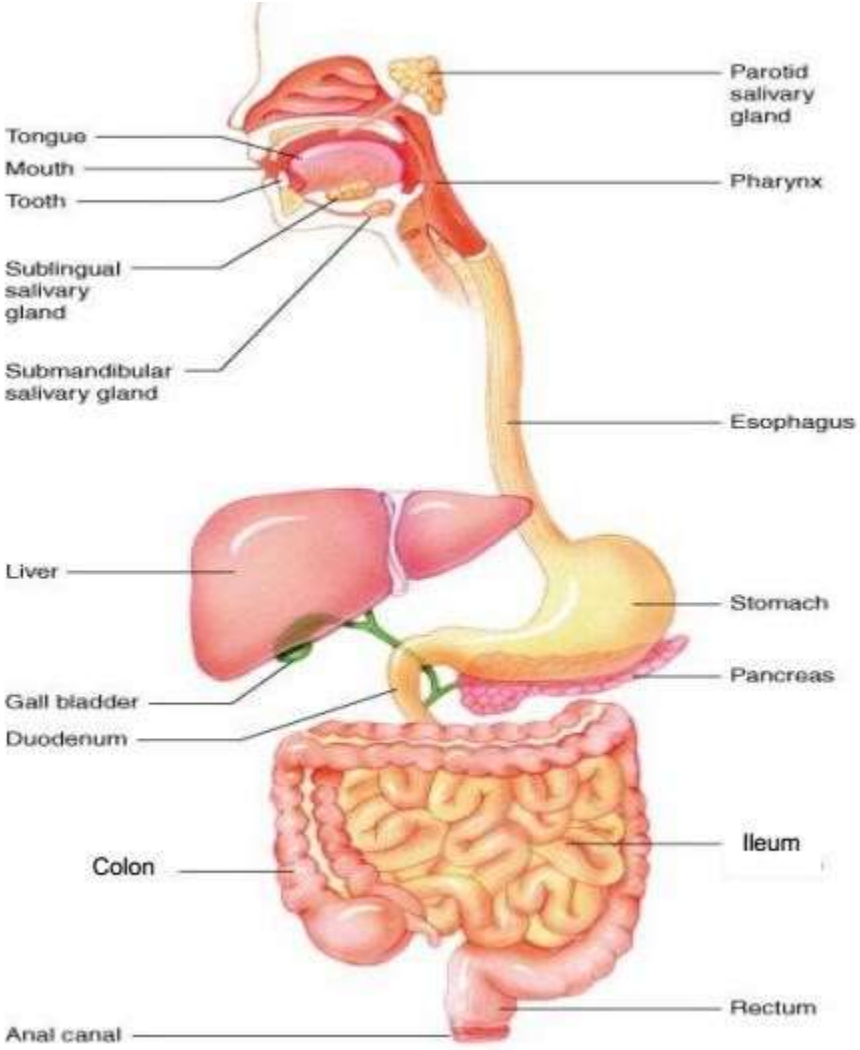
Steps involved in digestion of food

Ingestion ⟶ Digestion ⟶ Egestion

Ingestion: This is the taking in of food into the body.

Egestion: This is the process by which insoluble undigested compounds of food are discharged or expelled from the body as faeces.

The human alimentary canal



Digestion in the mouth

Digestion in the mouth is both physical and chemical.

Physical digestion:

Physical digestion in the mouth is carried out by the action of teeth or is the act of Mastication / chewing.

Mastication is important in that;

i) Increase the surface area of food for efficient Enzyme action.

ii) It helps to mix the food with saliva and in so doing; it softens the food, mixes it with the enzymes and lubricates it with the mucus in the saliva. iii) With the help of the tongue, the food is rolled into a Bolus (a small ball) for easy swallowing and movement in the gut.(alimentary canal)

iv) Chewing stimulates enzyme secretion because the secretion of saliva is a reflex action stimulated by the presence of food in the mouth.

NOTE: The secretion of saliva can also be stimulated by sight, smell and sought of food.

Chemical digestion in the mouth:

Chemical digestion is carried out by the enzyme salivary amylase (ptyalin)
Saliva is an alkaline watery solution (high PH) and it provides the optimal PH for the action of amylase. Salivary amylase acts only on starch breaking it down to disaccharide called Maltose.

Cooked starch $\xrightarrow[\text{(Ptyalin)}]{\text{Salivary amylase}}$ Maltose.

The act of swallowing:

Food is rolled into a Bolus which is then transferred into the Oesophagus (gullet).
During the act of swallowing, breathing momentarily stops and the epiglottis closes the entrance into the trachea preventing food from entering into the trachea.
At the same time, the soft palate also closes the entrance into the nose cavity preventing the food from escaping or passing through the nose.
Once the bolus is in the oesophagus, the food moves by a wave of muscular contractions called ***Peristalsis.***

Digestion in the stomach

Most of the digestion in the stomach is chemical. Food is allowed into the stomach from the oesophagus by a ring of muscle called the ***Cardiac Sphincter.***

In the stomach, there is only protein digestion.

Gastric juice is secreted and it contains two enzymes, (pepsin and renin), hydrochloric acid, mucus and water.

Pepsin acts upon proteins breaking them down into polypeptides.

Pepsin is initially secreted in an inactive form called Pepsinogen which is activated into active pepsin by hydrochloric acid. This is the safe guard mechanism because if pepsin was stored in its active form, it would destroy the gut walls or stomach walls since they are protein in nature (self-digestion).

Pepsin works at low PH i.e. acidic conditions provided by the presence of Hydrochloric acid (HCl).

Renin coagulates milk protein in baby mammals from soluble milk protein caseinogen to an insoluble curd, casein which is then acted upon by pepsin breaking it down to polypeptide.

Caseinogen (Soluble protein) —Renin→ Casein (Insoluble protein)

Proteins —pepsin→ polypeptides

Functions of HCl in the stomach

i) It kills some bacteria in ingested food.

ii) It activates pepsin and renin and provides ideal medium for their activity. iii) It stops the action of salivary amylase and ensures protein digestion only. iv) It prevents fermentation of food in the stomach by bacteria.

Mucus:

Mucus forms a barrier between stomach walls and Gastric juice thus protecting the stomach walls from the action of hydrochloric acid (which can give rise to stomach ulcers due to its corrosive action) and also stops the action of pepsin which can digest the stomach walls also giving rise to ulcers.

Digestion in the duodenum

The chyme from the stomach enters the duodenum in small quantities at a time regulated by the ***pyloric sphincter.*** There are access organs which provide secretions. They secret bile from the gall bladder and pancreatic juice from the pancreas

Functions of bile

i) It contains high % of water and adds it to the food coming from the stomach called chyme.

ii) It's alkaline and neutralizes the HCl of the chime to stop the action of the stomach enzymes and allow enzymes in the pancreatic juice to begin working.

iii) It reduces the surface tension of fats and breaks them into minute droplets i.e. emulsifies fat.

The arrival of food in the duodenum stimulates the production of a hormone called ***secretin*** from the pancreas and another hormone called ***cholecystokinin*** which

stimulates secretion of bile from the gall bladder. The secretions are alkaline thus stopping the action of pepsin and provides an ideal medium for enzymes in pancreatic juice to work. Pancreatic juice contains a number of enzymes which are called the *pancreatic enzymes.*

Enzymes	**Food acted upon**	**Products**
Trypsin	Proteins	Peptides and Amino acids
Pancreatic amylase	Starch	Maltose
Pancreatic lipase	Lipids	Fatty acids and glycerol

Trypsin is also secreted in an **inactive** form, **trypsinogen** to prevent it from digesting the duodenum walls.

Both trypsin and pancreatic amylase act upon proteins and starch that were not broken down in the stomach and mouth respectively.

Digestion in the ileum This is where final digestion takes place.

Food moves down from the duodenum into the ileum by peristalsis.

The presence of food in the ileum stimulates the secretion of the ***intestinal juice, succus entericus by walls of the ileum***.

Succus entericus contains several enzymes which complete the process of digestion forming a milky fluid substance called ***chyle*** (food after final digestion is called **chyle**).

Enzymes	**Food and Upon**	**Products**
Sucrase	Sucrose	Glucose and fructose
Maltase	Maltose	Glucose and glucose
Lactase	Lactose	Glucose and galactose
Peptidase	Polypeptides	Amino acids
Lipase	Lipids	Fatty acids and glycerol

The composition of chyle is a group of soluble end products of digestion namely; Glucose, Fructose, Amino acids, Glycerol, Vitamins and Mineral salts.

Digestion in the large intestines/colon

In the colon, water and mineral salts are absorbed. The undigested and indigestible food substances pass down into the large intestines which are eventually removed from the body as faeces through the anus. ***There is no digestion in the large intestine.***

Accumulation of hard particles like stones, small sticks in the appendix results into a condition known as **appendicitis.** The appendix is thus removed surgically by a simple operation.

Question 1: Describe the digestion process that occurs when a person consumes Posho (starch)?

A piece of Posho is placed into the mouth, a process called ingestion.

In the mouth; The Posho is thoroughly chewed by teeth, breaking it into smaller particles. During this chewing, Posho is mixed with saliva to make it soft and easy to swallow.

Saliva contains salivary amylase which breaks down cooked starch in Posho into maltose under neutral conditions.

Food is then pushed down the Oesophagus by a process called peristalsis.

In the stomach; no digestion of starch occurs because of acidic conditions due to presence of hydrochloric acid which provide un favourable pH for activity of salivary amylase.

In the duodenum; the pancreatic juice contains pancreatic amylase which speeds up the breakdown of undigested cooked starch to maltose.

In the ileum, intestinal juice contains maltase which speed up the breakdown of maltose to glucose molecules which are soluble hence easily absorbed by the body. This marks the end of the digestion for Posho.

Question 2: Describe the process of digestion of proteins in man.

In the mouth; Protein food is chewed by the teeth and swallowed into the stomach.

In the stomach; gastric juice is produced which contain pepsin that digests proteins to peptides and rennin coagulates protein milk in babies.

In the duodenum; presence of food stimulates pancreas to secrete pancreatic juice containing trypsin which digests undigested proteins to peptides.

In the ileum; intestinal juice is produced containing peptidase which break down peptides to amino acids which are later absorbed through the ileum walls.

THE PROCESS OF ABSORPTION AND ASSIMILATION OF FOOD

ABSORPTION

Absorption is the process by which soluble products of digestion diffuse through the cellular lining of the villi into the blood stream.

The villi are located in the ileum (small intestine) and thus absorption takes place in the small intestine. Some nutrients like minerals and vitamins also enter the villi by active transport.

The ileum shows various adaptions to suit the process of absorption which includes:

i) It is highly coiled/folded and consequently long thus providing a large surface area for digestion and absorption of food. (It is six (6) meters long).

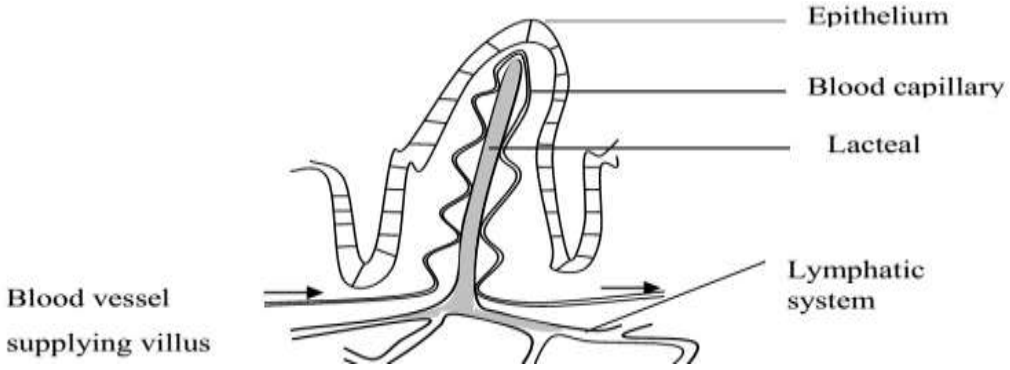
ii) Has a thin layer of cells to reduce the diffusion distance over which soluble food passes through.

iii) They are highly supplied with blood capillaries and lacteals which transport away absorbed food thus maintaining a diffusion gradient.

iv) Have finger-like projections called the villi which increase the surface area for absorption of soluble food.

v) The villi also have hair like extensions called the micro villi which ***further*** increase the surface area for absorption of soluble food products. The villi are the actual sites for absorption of soluble food products.

Diagram of Villus



Fatty acids and glycerol are absorbed into the lacteal of the villi. These lacteal later join up to form the lymphatic system carrying these food materials and distributing them to all parts of the body.

Glucose, Amino acids and Fructose pass into the blood capillaries of the villus which join up to form the Hepatic portal vein which transport these nutrients to the liver.

ASSIMILATION

This is the process by which absorbed food materials are built up into complex constituents of the organism. Assimilation is also the incorporation/utilization of the products of digestion into the body's metabolism for life processes e.g. respiration, growth and repair and digestion.

Question:

Describe the fate of the absorbed food materials in the human body? Or Describe what happens to the absorbed food materials in the human body after they are absorbed? **Solution:**

1) **Carbohydrates: (Glucose)**

Glucose is mainly broken down in the process of respiration to provide energy for the body's metabolic process. Excess glucose is stored as **Glycogen** (animal starch); however, the liver has the ability to re-covert back the glycogen to Glucose in periods of starvation.

2) **Proteins**

Amino acids are used in the synthesis of new proteins especially regulators like enzymes, and hormones.

Some Amino acids are used in body growth and repair and in absence of Glucose and Fats, Amino acids can instead be used in the process of respiration to produce energy.

Excess Amino acids are not stored in the liver, they are instead **deaminated** by the liver (removal of the Amino group) to form urea which is then passed on to the kidneys and excreted in urine.

Deamination is the removal of the amino group from Amino acids to form urea (which is a toxic waste product).

3) **Lipids (Fatty acids & Glycerol)**

Fatty acids and glycerol in the absence of Glucose can be oxidized to release energy. Fats produce much more energy compared to glucose considering the same amount by mass.

Fats are used for body insulation i.e. they prevent heat loss from the body which is an important temperature regulatory mechanism.

Lipids are used in the formation of structures like the cell membrane.
Excess fats and Glycerol are stored under the skin in the **adipose tissue.**

THE LIVER

This is the largest organ in the body and it carries out several functions within the body. The liver is the body's metabolic center as it receives all nutrient supplies from the blood through the ***hepatic portal vein.***

Functions of the Liver

i) Assimilation and metabolism of carbohydrates, proteins and lipids.

ii) Production of heat helps in temperature regulation. 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 and it plays a great role in temperature regulation.

iii) Manufacture of plasma proteins in clotting of blood. The liver helps to manufacture proteins like Albumin, Globulin and fibrinogen which are important in body process like clotting of blood (stopping bleeding).

iv) Production of bile which emulsification lipids. The liver produces bile which is important in the process of digestion i.e. in the emulsification of lipids.

v) Storage of iron and other minerals. The liver destroys worn out blood cells and removes the ion group from them which it stores for future formation of other blood cells.

vi) Formation of red blood cells with the iron yet from the above process, coupled with vitamin B_{12}. New red blood cells can formed in the bone narrow using these raw materials.

vii) Storage of blood. Blood vessels in the liver can expand and contract to great extents such that the amount of blood in the liver can vary from $300cm^3$ – $1500cm^3$ an increase of five times thus the liver can be a blood reservoir.

viii) Detoxification. The liver convert toxic substances to harmless substances by altering their chemical structure and later sends them to the excretory organs for expulsion e.g. it converts Ammonia to urea which is then expelled by the kidneys.

ix) Elimination of sex hormones. Testosterone and oestrogen are sent to the kidneys by the liver for excretion.

DIGESTION IN HERBIVORES

Animals that depend on plant materials (herbivores) like leaves, wood, grass are faced with a problem of digesting the cellulose that make up the plant walls.

It is necessary to break through the cellulose to release the inside cell nutrients which are required by the herbivores.

These herbivores cannot secret the enzyme which digests cellulose because they cannot produce **cellulase.** However, some protozoans and bacteria can produce the enzyme cellulase.

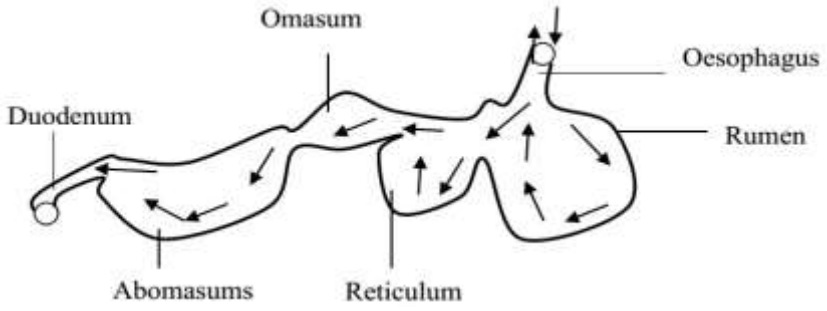
Fortunately, some of these micro-organisms can live in the guts of herbivores in a harmless beneficial nutritional association called ***symbiosis.***

Digestion of cellulose in ruminants

Ruminants are mammals which chew cud. Cud is imperfectly / incompletely chewed grass or plant materials that are taken into the stomach (rumen) and later returned back to the mouth for further chewing through a process called ***regurgitation.***

Ruminants have a complicated stomach made up of four chambers namely; Rumen, Reticulum, Omasum and Abomasum.

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



In the mouth, the saliva does not contain any enzyme. So only mastication (chewing) and softening of food takes place. The food moves through the oesophagus by peristalsis (wave like motion). **Digestion of cellulose in termites**

Termites eat wood, dry leaves and other plant materials which contain cellulose. The digestion of cellulose also takes place in the gut (stomach) with the help of protozoans which lives symbiotically in the termite's gut. These protozoa have the ability to produce the enzyme cellulase which digests cellulose.

Comparisons between ruminant and non-ruminant digestion Similarities:

i) In both, young animals have a single stomach where digestion takes place.
ii) The final digestion of proteins and carbohydrates takes place in the small intestines. **Differences:**

Ruminant	Non-Ruminant
Chew cud.	Do not chew cud.
Have a four chambered stomach.	Have a single stomach.
Ptyalin (salivary amylase is absent in saliva.	Ptyalin is present in saliva.
Most digestion and absorption takes place in the stomach.	Most digestion and absorption takes place in the ileum.
Water absorption takes place in the stomach.	Water absorption takes place in the colon.

NUTRITION IN PLANTS

Nutrition in plants is by a process called photosynthesis.
The process of photosynthesis occurs in all green plants in organs called **chloroplast** most of which are found in leaves.
Chloroplast contains chlorophyll which traps sunlight energy.
The process of photosynthesis is very complicated but it can be summarized by the equations below.

Carbon dioxide + water $\xrightarrow[\text{Chlorophyll}]{\text{Sunlight energy}}$ starch (Glucose) + oxygen

$$6CO_{2(g)} + H_2O_{(l)} \xrightarrow[\text{Sunlight energy}]{\text{Chlorophyll}} C_6H_{12}O_{6(s)} + 6O_{2(g)}$$

Conditions necessary for photosynthesis

to take place 1) Chlorophyll:

Chlorophyll is a green pigment that absorbs light energy from the sun. The amount of chlorophyll present in a leaf is directly related to the rate of photosynthesis.

2) Carbon dioxide:

It is absorbed from the atmosphere by terrestrial plants through their stomata. For aquatic plants like algae, they absorb the carbon dioxide as hydrogen carbonates which diffuse directly from the water in plant tissues. The use of carbon dioxide is

to combine or react with hydrogen atoms to form carbohydrates. Thus CO_2 is used as a raw material.

3) Light:

This is the source of energy necessary for the process of photosynthesis to take place. The rate of photosynthesis increases in light intensity, up to a maximum when it levels off. The energy of light is used for the following purposes:

i) Used to split water molecules into hydrogen atoms and oxygen. The oxygen is given off by the photosynthesizing plants. The hydrogen atoms combine with CO_2 to form carbohydrates.

$H_2O \xrightarrow{\text{split by light energy}} 2H^+ + O_2$

ii) Provides energy for photosynthesis. The process by which light energy splits water into H^+ and oxygen is called photolysis of water.

4) Temperature:

Temperature influences the rate of chemical reactions which are controlled by enzymes which are protein in nature. The rate of photosynthesis doubles for every ten degrees centigrade (10^0C) rise in temperature up to about 400C where the rate of photosynthesis drops drastically because the enzymes are denatured **5) Water:**

Water is a raw material for the process of photosynthesis. It is absorbed by the root hairs from the soil and transported up the rot by the xylem vessels.

A decrease in the concentration of water lowers the rate of photosynthesis.

6) Oxygen:

Oxygen is not necessary for the process of photosynthesis i.e. it is a bi-product of thus its accumulation instead lowers the rate of photosynthesis.

Adaptation of leaves to carry out photosynthesis The leaf is the major organ of photosynthesis in a plant.

The leaf is adapted to carry out the photosynthesis process in a number of ways namely **External adaptations:**

i) **Leaves are broad and flat:** This provides a large surface area for trapping sunlight and taking in of Carbon dioxide.

ii) **Numerous leaves:** This helps to increase the total surface area exposed to the sun thus increasing the rate of photosynthesis.

iii) **Leaf arrangement / leaf mosaic:** Leaves are usually arranged in such a way that they rarely shade or block each other thus ensuring that each leaf obtains maximum sunlight for photosynthesis. This is termed as a leaf mosaic.

iv) **Thinness:** Most leaves are just a few cells thick thus providing a small diffusion distance for penetration of carbon dioxide and sunlight.

Internal adaptation of a leaf:

v) **Palisade mesophyll layer contains numerous chloroplasts** especially the palisade thus it is the best position to receive sunlight. **vi) The spongy mesophyll** layer has mainly **air spaces** thus allowing many gases to easily diffuse into all the photosynthesizing cells.

vii) **Network of veins (vascular tissues) which** contains the phloem and the xylem where by the phloem conducts food made by the leaf and the xylem conducts dissolved mineral salts up to the stem.

viii) **Presence of stoma which** controls passage of gases and water vapour between air and the leaf. There are more stomata on the lower side of the leaf compared to the upper side to reduce water loss by transpiration.

ix) **Has cuticle** which is a water proof layer and so it helps to prevent desiccation (water loss) by the photosynthesizing tissues.

x) **Numerous chloroplasts** ensure that enough sunlight is trapped by the chlorophyll.

Factors that affect the rate of photosynthesis

1) **Amount of chlorophyll:** The more chlorophyll, the more the light energy absorbed leading to increased rate of photosynthesis. The less the chlorophyll, the less light energy absorbed leading to decreased rate of photosynthesis

2) **Amount of CO_2 in the atmosphere:** It is required as a raw material for photosynthesis thus the rate of photosynthesis increases in CO_2 concentration and it decreases with the lowering of CO_2 concentration.

3) **Light intensity**

The rate of photosynthesis increases with increase in light intensity. And it lowers with decrease in light intensity.

4) **Temperature**

It is required for the activity of enzymes that control the rate of photosynthesis. Thus the rate of photosynthesis increases with increase in temperature till the optimum temperature for enzyme action. Beyond which the enzymes are denatured leading to decrease rate of photosynthesis.

5) **Number of stomata**

The more the stomata, the more the gaseous exchange. This avails more CO_2 to the plant leading to high rate of photosynthesis.

6) **Surface area for photosynthesis**

The larger the area for photosynthesis (more leaves) the more light energy is absorbed which causes increased rate of photosynthesis.

7) **Availability of water**

Importance of photosynthesis

i) Photosynthesis helps to purify the environment by removing excess Carbon dioxide from the atmosphere which is a pollutant.

ii) During the photosynthesis process, oxygen is released back into the atmosphere and it is very vital in the respiration process of most organisms. iii) It provides energy. This energy is mainly organic in nature in form of fuels like coal, petroleum, firewood, all of which are products of photosynthesis.

AN EXPERIMENT TO TEST A LEAF FOR STARCH

The presence of starch is evidence that photosynthesis has been taking place.

Apparatus:

- A green leaf, □ absolute alcohol (99%-OH),
- water bath, □ beaker,
- Iodine solution, □ white surface or tile
- Water **Procedure:**

1) A leaf from a health plant which has been receiving sunlight is removed and placed in boiling water (water bath) for about 5 minutes. This softens the leaf cell wall protoplasm and makes it permeable to Iodine.
2) The leaf is then placed in a beaker containing 99% alcohol and boiled using a water bath until all the chlorophyll is dissolved out. This decolorizes the leaf and makes detection of any colour changes possible and easier.
3) The leaf is then washed in hot water which softens it.
4) The leaf is now spread on a white surface tile and drops of iodine added on it.

Observation:
A blue black colour shows that starch is present.
NOTE: If the brown colour of iodine remains, this shows that the leaf lacks starch or the starch is absent.
Conclusion: The presence of starch in a leaf shows that photosynthesis was taking place.

AN EXPERIEMENT TO SHOW THAT OXYGEN IS GIVEN OFF DURING PHOTOSYNTHESIS Apparatus:

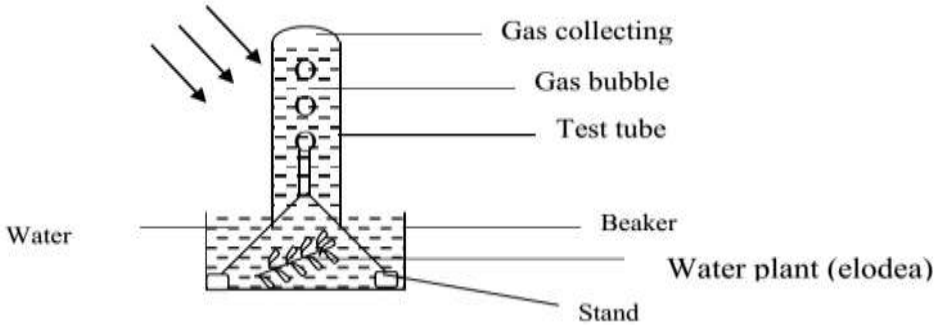
- Afresh water weed.
- Funnel and wooden blocks.
- Test tube,
- beaker
- Water.
- Sodium hydrogen carbonate.

Procedure:

a) The funnel is inverted in the beaker over the plant.
b) Sodium hydrogen carbonate is added to the water to provide CO_2
c) The funnel is raised slightly above the bottom of the beaker using small wooden blocks to allow water to circulate freely under it.
d) The apparatus is then placed in the bright sunlight.
e) Another similar set up is made and placed in darkness. This acts as the control experiment.

The apparatus is arranged as shown below:

Experimental setup



Observation:
Gas bubbles are evolved and sufficient gas is collected at the top of the test tube. In the control experiment, no bubbles are evolved.

Conclusion:

The gas collected relights the glowing split proving that it is oxygen. The evolution of oxygen by the water plant in the presence of sunlight is an indication that photosynthesis is taking place.

NOTE: This experiment can also be carried out to estimate the rate of photosynthesis (speed) by counting the number of bubbles produced per unit time.

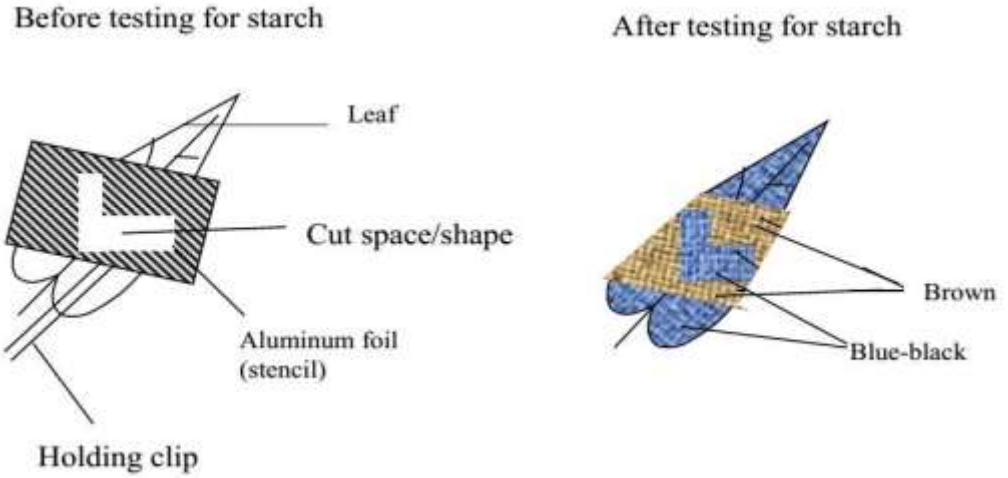
AN EXPERIMENT TO SHOW THAT LIGHT IS NECESSARY FOR PHOTOSYNTHESIS

Apparatus/materials:

- Potted plant White tile Boiling tube Aluminum foil Source of heat Razor blade.
- Water Wire gauze
- Ethanol Dropper

Procedure:

1) Get a potted plant and place it in darkness for 24 hours to de-starch it.
2) Make a shape in an aluminum foil and make a stencil
3) Place the stencil around the leaf with the cut shape facing upwards where light strikes.
4) Place the plant in sunlight for 3 hours.
5) Remove the leaf with a stencil from the plant using a razor blade 6) Remove the stencil and carry out the test for starch.



Observation:

The parts, which were covered by the stencil, turned brown while the parts exposed to light turned blue-black. **Conclusion:** Light is necessary for photosynthesis to take place.

Explanation:

Putting the leaf in darkness removes starch in the leaf by all the starch being converted into simple sugars. Putting the plant in light is to allow photosynthesis to take place. Covering the leaf with a stencil is to prevent light from reaching certain parts of the leaf. During exposure to light, the parts covered do not access sunlight and do not photosynthesize while the un-covered parts access sunlight and photosynthesize. Testing for starch helps to find out whether photosynthesis took place or not.

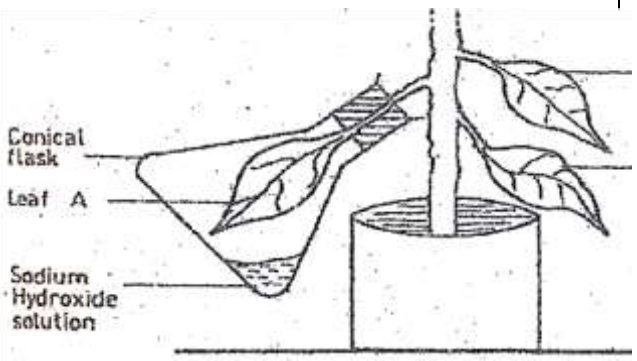
AN EXPERIMENT TO SHOW THAT CARBONDIOXIDE IS NECESSARY FOR THE PROCESS OF PHOTOSYNTHESIS

Apparatus:

- Sodium hydroxide/Potassium Hydroxide
- Conical flasks fitted with corks with a hole,
- well watered de-starched plants,
- Iodine,
- 99% alcohol
- water beaker,
- white tile
- Test tubes.

Procedure:

a) The leaves of a potted plant de-starched by keeping the pl in darkness for two days.
b) The petiole of the leaf (stalk) is passed through the hole cork so that the leaf is completely enclosed in a flask cor Sodium Hydroxide (The Sodium Hydroxide absorbs all C dioxide enclosed in the flask.)
c) The flask is then made air tight by smearing Vaseline at of the flask to prevent any air from entering.
d) A control experiment is also set up, however here the fla contains water which does not absorb Carbon dioxide.
e) The plant and the flasks are then placed in sunlight for 6 hours.
f) The enclosed leaves are then removed from the plant and then tested for starch using Iodine solution.



Observation:

The leaf in the flask containing Sodium Hydroxide solution remains brown (the colour of Iodine persisted) when tested for starch while that (the flask containing water / control experiment) turned blue black.

Conclusion:

The leaf in the flask containing Sodium Hydroxide didn't contain starch since it lacked Carbon dioxide which was absorbed from the flask by the Sodium Hydroxide solution thus Carbon dioxide is necessary for photosynthesis.

AN EXPERIMENT TO SHOW THAT CHLOROPHYLL IS NECESSARY FOR PHOTOSYNTHESIS Apparatus:

- A beaker,
- Alcohol,
- Iodine,
- test tube, and
- white tile
- Plant with variegated leaves.

A variegated leaf *is one which has chlorophyll in some parts of the leaf lamina and not in other parts of the same leaf. It has green and yellow parches on the same leaf.*

Procedure:

a) After a period of de-starching (removing starch) by placing a plant in a dark cupboard for two days, the variegated plant is then exposed to sunlight for about two (2) hours.

b) The parts of the leaf that are not green are used as the control experiment.

c) At the end of the two hours, the leaf is removed and then tested for starch.

Observation:

The parts that were green are stained blue black with iodine solution while the yellow patches stained brown with iodine (brown is the colour of iodine).

Conclusion:

The green parts of leaf contained starch because they contained chlorophyll and thus turned blue black while the yellow patches (non-green parts) did not contain starch because they lacked chlorophyll. Chlorophyll is thus necessary for photosynthesis.

Gaseous exchange and compensation point

Both respiration and photosynthesis take place in a green plant. In darkness, Green plants do not photosynthesize, however they continue to respire. Here oxygen is

used up (through respiration) and carbon dioxide is given off and there is an overall net consumption of sugars and glucose during respiration.

At low light intensity, some photosynthesis occurs and some carbon dioxide produced in respiration by plants is used up in photosynthesis. However, there is a net loss of Carbon dioxide.

As the light intensity increases, the rate of photosynthesis also increases until a point is reached when all the Carbon dioxide produced during the process of respiration is reused in the process of photosynthesis. This point is called the **compensation point**.

The compensation point *is that point of light intensity at which the rate of Carbon dioxide produced by respiration is equal to the amount of Carbon dioxide consumed during photosynthesis.*

At the compensation point, the rate of photosynthesis is equal to the rate of respiration ie the rate at which food (glucose) is manufactured is equal to the rate at which it is used up in the process of respiration and this means that there is no net gain or loss in the mass of the plant.

MINERAL NUTRITION IN PLANTS

Pants need mineral elements for proper growth. Mineral elements are divided into two categories depending on the relative amounts of element needed.

i) **Essential elements:** These are elements needed in large quantities for proper plant growth, e.g. nitrogen, phosphorus, magnesium, potassium, calcium, sulphur, carbon, hydrogen, oxygen, etc.

ii) **Trace elements:** These are elements need in small quantities for proper plant growth they include manganese zinc boron silicon aluminum copper, molybdenum, and iron.

Plants obtain minerals from mineral salts present in the soil; Mineral salts are absorbed in form of soluble salts e.g. nitrogen as nitrate, phosphorus as phosphates, sulphur as sulphate. When a particular element is missing in the soil, a plant shows deficiency signs.