NUTRITION IN PLANTS AND ANIMALS

KCSE Biology Notes Form 1 Topic 5

TOPICS/ SUN-TOPICS

Meaning, importance and types of nutrition

Nutrition in plants (autotrophism)

Definition of photosynthesis and its importance in nature

Adaptations of leaf to photosynthesis

Structure and function of chloroplast

Process of photosynthesis - light and dark stages (omit details of electron transport system and chemical details of carbon dioxide fixation)

Factors influencing photosynthesis

Light intensity

Carbon dioxide concentration

Water

Temperature

Chemical compounds which constitute living organisms

Chemical composition and functions of carbohydrates, proteins and lipids (omit details of chemical structure of these compounds and mineral salts in plant nutrition).

Properties and functions of enzymes (omit lock and key hypothesis)

Nutrition in Animals (heterotrophism)

Meaning and types of heterotrophism

Modes of feeding in animals

Dentition of a named carnivorous, herbivorous and omnivorous mammal

Adaptation of the three types of dentition to feeding

Internal structure of mammalian teeth

Common dental diseases, their causes and treatment

Digestive system and digestion in a mammal (human)

Digestive system, regions, glands and organs associated with digestion

Ingestion, digestion, absorption, assimilation and egestion

Importance of vitamins, mineral salts, roughage and water in human nutrition

Factors determining energy requirements in humans

Practical activities

Carry out experiments on factors affecting photosynthesis

Observe stomata distribution

Carry out food test experiments

Carry out experiments on factors affecting enzymatic activities

Investigate presence of enzymes in living tissues (plants and animals)

Observe, identify, draw and label different types of mammalian teeth

Carry out dissection of a small mammal to observe digestive system and associated organs (demonstration)

Specific Objectives

By the end of the topic, the learner should be able to:

a) Define nutrition and state its importance in living organisms

b) Differentiate various modes of feeding

c) Describe photosynthesis and show its importance in nature

d) Explain how the leaf is adapted to photosynthesis

e) Explain the factors affecting photosynthesis

f) Distinguish between carbohydrates proteins and lipids

g) State the importance of various chemical compounds in plants and animals

h) Explain the properties and functions of enzymes

i) Relate various types of teeth in mammals to their feeding habits

j) Differentiate between omnivorous, carnivorous and herbivorous modes of feeding

k) Relate the structures of the mammalian (human) alimentary canal to their functions

l) Explain the role of enzymes in digestion in a mammal (human)

m) Explain the factors that determine energy requirements in humans.

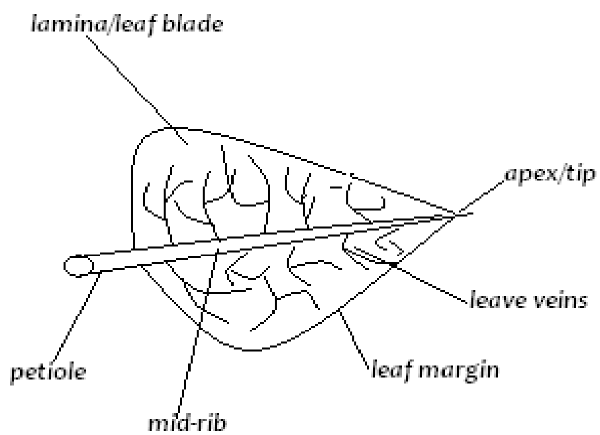
Structure of the Leaf

External Structure

The external structure of the leaf consists of a leaf stalk or petiole and a broad leaf blade or lamina.

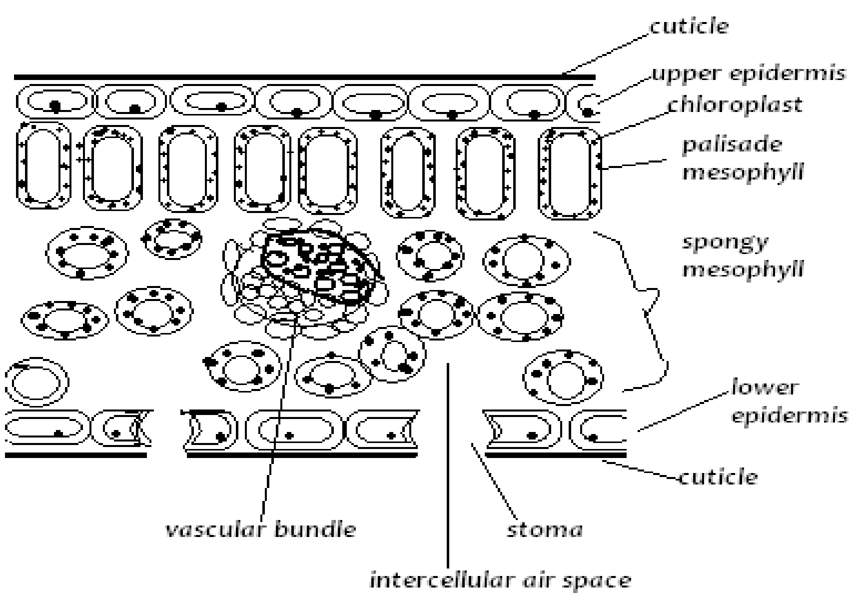
The lamina has a main vein midrib from which smaller veins originate.

The outline of the leaf is the margin and the tip forms the apex.



External structure of a leaf

Internal Structure of the Leaf



Transvers section of a leaf showing internal structure

Epidermis

This is the outer layer of cells, normally one cell thick.

It is found in both the upper and lower leaf surfaces.

The cells are arranged end to end.

The epidermis offers protection and maintains the shape of the leaf.

It is covered by a layer of cuticle which reduces evaporation.

Leaf Mesophyll

Consists of the palisade layer, next to upper epidermis, and the spongy layer next to the lower epidermis.

Palisade Mesophyll Layer

The cells are elongated and arranged close to each other leaving narrow air spaces.

These contain numerous chloroplasts and are the main photosynthetic cells.

In most plants, the chloroplast are distributed fairly uniformly throughout the cytoplasm.

In certain plants growing in shaded habitats in dim light, most chloroplasts migrate to the upper region of the palisade cells in order to maximize absorption of the limited light available.

Spongy Mesophyll Layer

The cells are spherical in shape.

They are loosely arranged, with large intercellular spaces between them.

The spaces are air-filled and are linked to the stomatal pores.

The spongy mesophyll cells have fewer chloroplasts than the palisade mesophyll cells.

Vascular Bundles

These are made up of the xylem and the phloem tissues.

The xylem transports water and mineral salts to the leaves.

The phloem transports food manufactured in the leaf to the other parts of the plant and from storage organs to other parts.

Adaptations of Leaf for Photosynthesis

Presence of veins with vascular bundles.

Xylem vessels transport water for photosynthesis.

Phloem transports manufactured food from leaves to other parts of the plant.

Leaf lamina is thin to allow for penetration of light over short distance to reach photosynthetic cells.

Broad lamina provides a large surface area for absorption of light and carbon (IV) oxide.

Transparent cuticle and epidermal layer allow light to penetrate to mesophyll cells.

Palisade cells are close to the upper epidermis for maximum light absorption.

Presence of numerous chloroplasts in palisade mesophyll traps maximum light.

Chloroplast contain chlorophyll that traps light energy.

Spongy mesophyll layer has large intercellular air spaces allowing for gaseous exchange.

Presence of stomata for efficient gaseous exchange (entry of carbon (IV) oxide into leaf and exit of oxygen).

Mosaic arrangement of leaves to ensure no overlapping of leaves hence every leaf is exposed to light.

Structure and Function of Chloroplasts

Chloroplasts are large organelles (5 um in diameter) found in the cytoplasm of green plant cells.

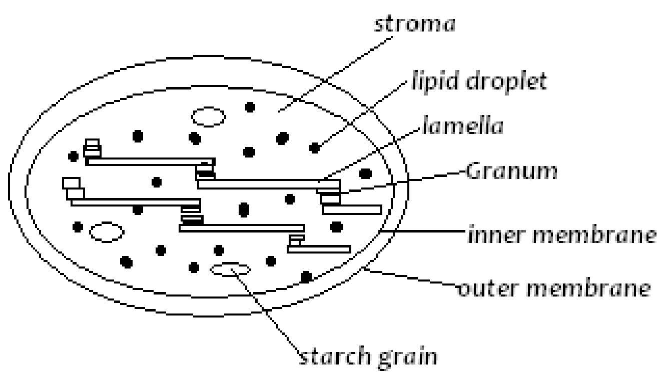
They are visible under the light microscope.

They contain chlorophyll, a green pigment and other carotenoids which are yellow, orange and red in colour.

Certain plants have red or purple leaves due to abundance of these other pigments.

Chlorophyll absorbs light energy and transforms it into chemical energy.

The other pigments absorb light but only to pass it onto chlorophyll.



Structure of Chloroplast

The wall of chloroplast consists of an outer and an inner membrane.

The two make up the chloroplast envelop.

Inner membrane encloses a system of membranes called lamellae.

At intervals, the membranes form stacks of fluid filed sacs known as grana (singular granum).

Chloroplast and other pigments are attached to the grana.

In between the lamellae is a gel-like stroma that contains starch grains and lipid droplets.

Enzymes for the dark stage reaction (light independent stage) are embedded in the stroma.

Enzymes for the light dependent stage occur in the grana.

Functions of Chloroplast

Absorption of light by chlorophyll and other pigments.

Light stage of photosynthesis occurs on the grana. (Transformation of light energy to chemical energy.)

Carbon fixation to form carbohydrate takes place in the stroma which has enzymes for dark stage of photosynthesis.

$$\text{Carbon (IV) Oxide} + \text{Water} + \frac{\textit{light energy}}{\textit{chrolophylI}} = \text{Glucose} + \text{Oxygen}$$

$$6CO_2 + 6H_2O + \frac{\textit{light energy}}{\textit{chrolophylI}} = C_6H_{12}O_6 + 6O_2$$

The reaction occurs in two main phases or stages.

The initial state requires light and it is called the light dependent stage or simply light stage.

It takes place on the lamellae surfaces.

Its products are used in the dark stage.

The dark stage does not require light although it occurs in the light and is called light independent stage.

Light-Stage

Two reactions take place that produce raw materials for the dark stage:

Light energy splits the water molecules into hydrogen and oxygen.

This process is called photolysis.

The hydrogen is taken up by a hydrogen acceptor called ***Nicotinamide adenine dinucleotide phosphate*** (NADP) while oxygen is released as a by-product.

$$2H_2O_{(l)} + \frac{energy}{photolysis} = 4H + O_2$$

Light energy strikes the chlorophyll molecules and sets in motion a series of reactions resulting in the production of a high energy molecule called adenosine triphosphate (ATP).

Dark Stage

This stage involves the fixation of carbon i.e. the reduction of carbon (IV) oxide by addition of hydrogen to form carbohydrate.

It uses the products formed during the light stage. ***Carbon (IV) oxide + Hydrogen = Carbohydrates***

The synthesis of carbohydrates does not take place in a simple straight line reaction as shown in the equation above.

It involves a series of steps that constitute what is known as the Calvin cycle.

Carbon (IV) oxide is taken up by a compound described as a carbon (IV) oxide acceptor.

This is a 5-carbon compound known as ribulose biphosphate and a six carbon compound is formed which is unstable and splits into two three-carbon compounds.

Hydrogen from the light reaction is added to the three carbon compound using energy (ATP) from the light reaction.

The result is a three carbon (triose) sugar, (phosphoglycerate or PGA).

This is the first product of photosynthesis.

Glucose, other sugars as well as starch are made from condensation of the triose sugar molecules.

The first product is a 3-carbon sugar which condenses to form glucose (6-C sugar).

From glucose, sucrose and eventually starch is made.

Sucrose is the form in which carbohydrate is transported from the leaves to other parts of the plant.

Starch is the storage product.

Other substances like oils and proteins are made from sugars.

This involves incorporation of other elements e.g. nitrogen, phosphorus and sulphur.

Factors Influencing Photosynthesis

Certain factors must be provided for before photosynthesis can take place.

The rate or amount of photosynthesis is also influenced by the quantity or quality of these same factors.

Carbon (IV) Oxide Concentration

Carbon (IV) oxide is one of the raw materials for photosynthesis.

No starch is formed when leaves are enclosed in an atmosphere without carbon (IV) oxide.

The concentration of carbon (IV) oxide in the atmosphere remains fairly constant at about 0.03% by volume.

However, it is possible to vary the carbon (IV) oxide concentration under experimental conditions.

Increasing the carbon (IV) oxide concentration up to 0.1 % increases the rate of photosynthesis.

Further increase reduces the rate.

Light Intensity

Light supplies the energy for photosynthesis.

Plants kept in the dark do not form starch.

Generally, increase in light intensity up to a certain optimum, increases the rate of photosynthesis.

The optimum depends on the habitat of the plant.

Plants that grow in shady places have a lower optimum than those that grow in sunny places.

Water

Water is necessary as a raw material for photosynthesis.

The amount of water available greatly affects the rate of photosynthesis.

The more water available, the more the photosynthetic rate, hence amount of food made.

Effect of water on photosynthesis can only be inferred from the yield of crops.

It is the main determinant of yield (limiting factor in the tropics).

Temperature

The reactions involved in photosynthesis are catalysed by a series of enzymes.

A suitable temperature is therefore necessary.

The optimum temperature for photosynthesis in most plants is around 30^0C.

This depends on the natural habitat of the plant.

Some plants in temperate regions have 20°C as their optimum while others in the tropics have 45°C as their optimum temperature.

The rate of photosynthesis decreases with a decrease in temperature below the optimum.

In most plants, photosynthesis stops when temperatures approach O°C although some arctic plant species can photosynthesise at -2°C or even -3°C.

Likewise, increase in temperature above the optimum decreases the rate and finally the reactions stop at temperatures above 40°c due to enzyme denaturation.

However, certain algae that live in hot springs e.g. Oscilatoria can photosynthesis at 75°C

Chlorophyll

Chlorophyll traps or harnesses the energy from light.

Leaves without chlorophyll do not form starch.

Chemical Compounds Which Constitute Living Organisms

All matter is made up of chemical elements, each of which exists in the form of smaller units called atoms.

Some of the elements occur in large amounts in living things.

These include carbon, oxygen, hydrogen, nitrogen, sulphur and phosphorus.

Elements combine together to form compounds.

Some of these compounds are organic.

Organic compounds contain atoms of carbon combined with hydrogen and they are usually complex.

Other compounds are inorganic.

Most inorganic compounds do not contain carbon and hydrogen and they are usually less complex.

Cells contain hundreds of different classes of organic compounds.

However, there are four classes of organic compounds found in all cells.

These are: *carbohydrates, lipids, proteins and nucleic acids.*

Carbohydrates

- ✓ Carbohydrates are compounds of carbon, hydrogen and oxygen.
- ✓ Hydrogen and oxygen occur in the ratio of 2: 1 as in water.
- ✓ Carbohydrates are classified into three main groups: monosaccharides, disaccharides and polysaccharides.

Monosaccharides

- ✓ These are simple sugars.
- ✓ The carbon atoms in these sugars form a chain to which hydrogen and oxygen atoms are attached.
- ✓ Monosaccharides are classified according to the number of carbon atoms they possess.
- ✓ The most common monosaccharides are:
    - Glucose - found free in fruits and vegetables.
    - Fructose - found free in fruits and in bee honey.
    - Galactose - found combined in milk sugar.
- ✓ The general formula for these monosaccharides is $(CH_2O)_n$ where n is 6.
- ✓ They have the same number of carbon, hydrogen and oxygen molecules i.e. $C_6H_{12}O_6$.

Properties of Monosaccharides

- ✓ They are soluble in water.
- ✓ They are crystallisable.
- ✓ They are sweet.
- ✓ The are all reducing sugars.
- ✓ This is because they reduce blue copper (II) sulphate solution when heated to copper oxide which is red in colour and insoluble.

Functions of Monosaccharides

- ✓ They are oxidised in the cells to produce energy during respiration.
- ✓ Formation of important biological molecules e.g. deoxyribonucleic acid (DNA) and ribonucleic acid (RNA).
- ✓ Some monosaccharides are important metabolic intermediates e.g. in photosynthesis and in respiration.
- ✓ Monosaccharides are the units from which other more complex sugars are formed through condensation.

Disaccharides

- ✓ These contain two monosaccharide units.
- ✓ The chemical process through which a large molecule (e.g. a disaccharide) is formed from smaller molecules is called condensation and it involves loss of water.
- ✓ Common examples of disaccharides include sucrose, maltose and lactose.

Monosaccharide units	**Disaccharides**
Glucose + fructose	Sucrose(cane sugar)
Glucose + glucose	Maltose(malt sugar)
Glucose + galactose	Lactose(milk sugar)

Disaccharides are broken into their monosaccharide units by heating with dilute hydrochloric acid.

This is known as hydrolysis and involves addition of water molecules.

The same process takes place inside cells through enzymes.

Sucrose + water + hydrolysis = glucose + fructose

Properties of Disaccharides

- ✓ Sweet tasting.
- ✓ Soluble in water.
- ✓ Crystallisable.
- ✓ Maltose and lactose are reducing sugars while sucrose is non-reducing sugar.
- ✓ Sucrose is the form in which carbohydrate is transported in plants:
- ✓ This is because it is soluble and chernically stable.
- ✓ Sucrose is a storage carbohydrate in some plants e.g. sugar-cane and sugar-beet.
- ✓ Disaccharides are hydrolysed to produce monosaccharide units which are readily metabolised by cell to provide energy.

Polysaccharides

- ✓ If many monosaccharides are joined together through condensation, a polysaccharide is formed.
- ✓ Polysaccharides may consist of hundreds or even thousands of monosaccharide units.

Examples of polysaccharides:

- ✓ **Starch** - storage material in plants.
- ✓ **Glycogen** is a storage carbohydrate in animals like starch, but has longer chains.
- ✓ **Inulin** - a storage carbohydrate in some plants e.g. Dahlia.
- ✓ **Cellulose** - structural carbohydrate in plants.
- ✓ **Chitin** - forms exoskeleton in arthropods.

Importance and Functions of Polysaccharides

They are storage carbohydrates - starch in plants glycogen in animals.

They are hydrolysed to their constituent monosaccharide units and used for respiration. .

They form structural material e.g. cellulose makes cell walls.

Cellulose has wide commercial uses e.g.

- ✓ Fibre in cloth industry.
- ✓ Cellulose is used to make paper.
- ✓ Carbohydrates combine with other molecules to form important structural compounds in living organisms.

Examples are:

Pectins: Combine with calcium ions to form calcium pectate.

Chitin: Combine with (NH) group. Makes the exoskeleton of arthropods, and walls of fungi.

Lipids

These are fats and oils.

Fats are solid at room temperature while oils are liquid.

They are made up of carbon, oxygen and hydrogen atoms.

The structural units of lipids are fatty acids and glycerol.

Fatty acids are made up of hydrocarbon chain molecules with a carboxyl group (-COOH) at one end.

In the synthesis of a lipid, three fatty acid molecules combine with one glycerol molecule to form a triglyceride.

Three molecules of water are lost in the process.

This is a condensation reaction and water is given off.

Lipids are hydrolysed e.g. during digestion to fatty acids and glycerol, water is added.

Condensation = Glycerol + 3 Fatty hydrolysis Lipid + Water acids

Properties

- ✓ Fats are insoluble in water but dissolve in organic solvents e.g. in alcohols.
- ✓ They are chemically inactive, hence used as food storage compounds.

Functions of Lipids

- ✓ **Structural materials** - as structural material they make up the cell membrane.
- ✓ **Source of energy** - they are energy rich molecules. One molecule of lipid provides more energy than a carbohydrate molecule.
- ✓ **Storage compound** - They are stored as food reserves in plants. In animals e.g. mammals, all excess food taken is converted to fats which are stored in adipose tissue, and around internal organs such as the heart and kidneys.

- **Insulation -** They provide insulation in animals living in cold climates. A lot of fat is stored under the skin e.g. blubber in seals.
- **Protection -** Complex lipids e.g. wax on leaf surfaces protects the plant against water-loss and overheating. Fats stored around some internal organs acts as shock absorbers, thus protecting the organs.
- **Source of Metabolic Water** -:-lipids when oxidised produce metabolic water which supplements water requirements in the body. Desert animals e.g. the camel accumulate large quantities of fat in the hump which when oxidised releases metabolic water.

Proteins

- Proteins are the most abundant organic compounds in cells and constitute 50% of total dry weight.
- Proteins are compounds which are made up of carbon, hydrogen, nitrogen, oxygen and sometimes sulphur and phosphorus.
- The structural units of proteins are amino acids.
- The nature of a protein is determined by the types of amino acids it is made of.
- There are about 20 common amino acids that make up proteins.

Essential and Non-Essential Amino Acids

- Essential amino acids are those which cannot be synthesised in the body of an organism and must therefore be provided in the diet.
- There are ten amino acids which are essential for humans.
- These are valine, leucine, phenylalanine, lysine, tryptophan, isoleucine, methionine, threonine, histidine and arginine.
- Non-essential amino acids are those which the body can synthesise and therefore need not be available in the diet.
- There are ten of them.

- ✓ These are glycine, alanine, glutamic acid, aspartic acid, serine, tyrosine, proline, glutamine, arginine and cysteine.
- ✓ Proteins are essential in the diet because they are not stored in the body.
- ✓ Excess amino acids are deaminated.

Formation of Proteins

- ✓ Proteins are made up of many amino acid units joined together through peptide bonds.
- ✓ When two amino acids are joined together a dipeptide is formed.
- ✓ The chemical process involved is called condensation and a molecule of water is eliminated .
- ✓ When many amino acids are joined together a polypeptide chain is formed.
- ✓ The nature of a particular protein depends on the types, number and sequence of amino acids from which it is made.

Functions of Proteins

As structural materials proteins-

- ✓ These are the basic building structures of protoplasms
- ✓ Proteins in conjunction with lipid form the cell membrane.

Examples of structural proteins include:

- ✓ Keratin (in hair, nails, hoofs, feathers and wool)
- ✓ Silk in spider's web.
- ✓ Elastin forms ligaments that join bones to each other.

Protective proteins.

- ✓ Antibodies that protect the body against foreign antigens.
- ✓ Fribrogen and thrombin are involved in clot formation, preventing entry of micro-organisms when blood vessel is cut.

As functional chemical compounds.

Examples are hormones and enzymes that act as regulators in the body.

Respiratory pigments.

Examples are haemoglobin that transports oxygen in the blood and myoglobin that stores up oxygen in muscles.

Contractile proteins - make up muscles, i.e. myosin and actin.

Proteins combine with other chemical groups to form important substances e.g. mucin in saliva.

Source of energy.

Proteins are a source of energy in extreme conditions when carbohydrates and fats are not available e.g. in starvation.

Enzymes

- ✓ Enzymes are biological catalysts that increase the rate of chemical reaction in the body.
- ✓ They are all produced inside cells.
- ✓ Some are intracellular and they catalyse reactions within the cells.
- ✓ Others are extracellular and are secreted out of the cells where they work. E.g. digestive enzymes.

Properties of Enzymes

- ✓ Enzymes are protein in nature.
- ✓ Enzymes are specific to the type of reaction they catalyse.
- ✓ This is referred to as substrate specificity.
- ✓ Enzymes work in very small amounts.
- ✓ They remain unchanged after the reaction.
- ✓ They catalyse reversible reactions.

- They work very fast (high turnover numbers) e.g. the enzyme catalase works on 600 thousand molecules of hydrogen peroxide in one second.

Naming of enzymes

Enzymes are named by adding the suffix -ase to:

Name of substrate that they work on e.g.

- Carbohydrates - carbohydrases e.g.sucrase.
- Starch (amylose) - amylase
- Protein - proteinase (protease)
- Lipids -lipases

Type of chemical reaction catalised e.g.

- **Oxidation** - oxidase
- **Reduction** - reductase
- **Hydrolysis** - hydrolase

Factors Affecting Enzyme Action

Temperature

- Enzymes are sensitive to temperature changes.
- Generally, the rate of an enzyme-controlled reaction doubles with every 10OC increase in temperature.
- However, temperatures above 40°C do not favour enzyme reaction.
- This is because enzymes are denatured by high temperatures.

pH

- Every enzyme has a particular pH range over which it works best.
- Some enzymes work best in acidic media while others function better in alkaline media.
- Many enzymes function well under neutral conditions.

Enzyme Concentration

- ✓ Under conditions where the substrate is in excess, the rate of an enzyme-controlled reaction increases as the enzyme concentration is increased.

Substrate Concentration

- ✓ If the concentration of the substrate is increased while that of the enzyme remains constant, the rate of the reaction will increase for some time and then become constant.
- ✓ Any further increase in substrate concentration will not result in corresponding increase in the rate of the reaction.

Enzyme Inhibitors

- ✓ These are substances that either compete with substrates for enzyme active sites or combine with enzymes and hence they inhibit the enzyme reaction; e.g. certain drugs, cyanide and nerve gas.

Co-factors

- ✓ Most enzymes require the presence of other compounds known as co-factors which are non-proteins.
- ✓ There are three groups of co-factors.
- ✓ Inorganic ions - e.g. iron, magnesium, copper and zinc.
- ✓ Complex organic molecules known as prosthetic groups are attached to the enzyme e.g. flavin adenine dinucleotide (FAD) derived from vitamin B2 (riboflavin).
- ✓ Co-enzymes e.g. coenzyme A is involved in respiration.
- ✓ All co-enzymes are derived from vitamins.

Nutrition in Animals

Heterotrophism

Meaning and Types of Heterotrophism

- ✓ This is a mode of nutrition whereby organisms feed on complex organic matter from other plants or animals.
- ✓ All animals are heterotrophs.
- ✓ Their mode of feeding is also said to be holozoic to distinguish it from other special types of heterotrophic nutrition namely:
  - Saprophytism
  - Parasitism
- ✓ Saprophytism/saprotrophysim- occurs in most fungi and some forms of bacteria.
- ✓ Saprophytes feed on dead organic matter and cause its decomposition or decay.
- ✓ Parasitism is a mode of feeding whereby one organism called the parasite feeds on or lives in another organism called the host and harms it.

Modes of Feeding in Animals

- ✓ Animals have developed various structures to capture and ingest food.
- ✓ The type of structures present depend on the method of feeding and the type of food.
- ✓ Carnivorous animals feed on whole animals or portions of their flesh.
- ✓ Herbivorous animals feed on plant material.
- ✓ Omnivorous animals feed on both plants and animal materials.

Feeding in Mammals

- ✓ The jaws and teeth of mammals are modified according to the type of food eaten.
- ✓ Mammals have different kinds of teeth.
- ✓ Each type of teeth has a particular role to play in the feeding process.

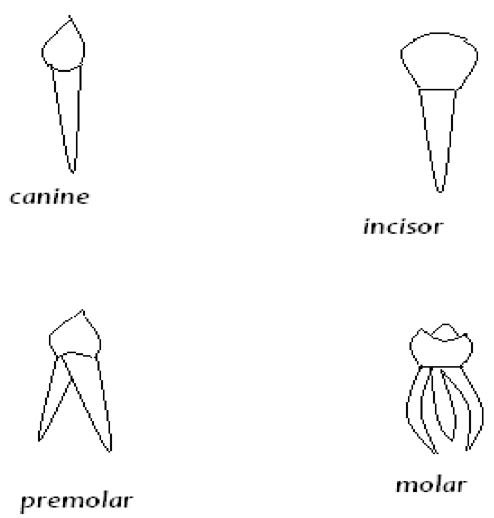
Feeding in Mammals

- ✓ The jaws and teeth of mammals are modified according to the type of food eaten.
- ✓ Mammals have different kinds of teeth.

- ✓ Each type of teeth has a particular role to play in the feeding process.
- ✓ This condition is described as heterodont.
- ✓ The teeth of reptiles and amphibians are all similar in shape and carry out the same function.
- ✓ They are said to be homodont.

Types of Mammalian Teeth

- ✓ Mammals have four kinds of teeth.
- ✓ The incisors are found at the front of the jaw.
- ✓ They are sharp-edged and are used for biting.
- ✓ The canines are located at the sides of the jaw.
- ✓ They are pointed and are used for tearing and piercing.
- ✓ The premolars are next to the canines and the molars are at the back of the jaw.
- ✓ Both premolars and molars are used for crushing and grinding.
- ✓ Teeth are replaced only once in a lifetime.
- ✓ The first set is the milk or deciduous teeth.
- ✓ These are replaced by the second set or the permanent teeth.



Different types of teeth in humans

- ✓ Dentition refers to the type of teeth, the number and their arrangement in the jaw.
- ✓ A dental formula shows the type and number of teeth in each half of the jaw.

- ✓ The number of teeth in half of the upper jaw is represented above a line and those on the lower jaw below the line.
- ✓ The first letter of each type of teeth is used in the formula i.e. i = incisors, c = canines, pm = premolars and m = molars.
- ✓ The total number is obtained by multiplying by two (for the two halves of each jaw).

Adaptation of Teeth to Feeding

In general, incisors are for cutting, canines for tearing while premolars and molars are for grinding.

However, specific modifications are observed in different mammals as an adaptation to the type of food they eat.

Teeth of Herbivores

- ✓ Incisors are long and flat with a sharp chisel like edge for cutting.
- ✓ The enamel coating is thicker in front than at the back so that as the tooth wears out, a sharp edge is maintained.
- ✓ Canines are reduced or absent.
- ✓ If absent, the space left is called the diastema.
- ✓ The diastema allows the tongue to hold food and push it to the grinding teeth at the back of the mouth.

Premolars and molars:

- ✓ These are transversely ridged.
- ✓ The ridges on the upper teeth fit into grooves on the lower ones.
- ✓ This gives a sideways grinding surface.
- ✓ The teeth of herbivores have open roots i.e., wide opening into the pulp cavity.
- ✓ This ensures a continued adequate supply of food and oxygen to the tooth.
- ✓ In some herbivores, such as rabbits and elephants, the incisors continue to grow throughout life.

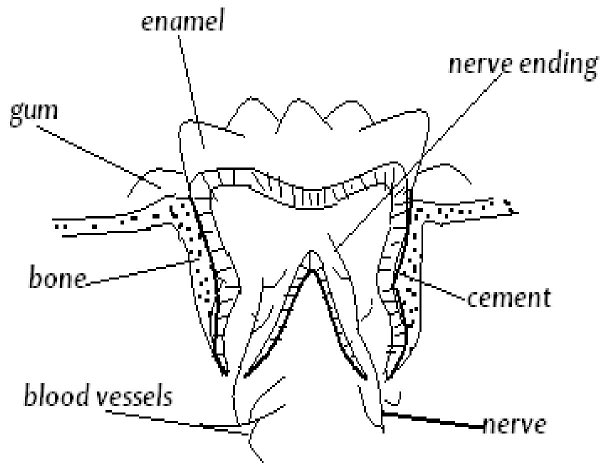
Teeth of Carnivores

- ✓ Incisors are reduced in size and pointed.
- ✓ They are well suited for grasping food and holding prey.
- ✓ Canines are long, pointed and curved.
- ✓ They are used for piercing and tearing flesh as well as for attack and defence.
- ✓ **Premolars and molars:** In general, they are long and longitudinally ridged to increase surface area for crushing.
- ✓ **Carnassial Teeth:** These are the last premolars on the upper jaw and the first molars on the lower one.
- ✓ They are enlarged for cutting flesh.
- ✓ They act as a pair of shears.
- ✓ They also crush bones.
- ✓ The teeth of carnivores have closed roots i.e., only a very small opening of the pulp cavity to allow food and oxygen to keep teeth alive.
- ✓ Once broken, no re-growth can take place.

Teeth of Omnivores

- ✓ Incisors have a wide surface for cutting.
- ✓ Canines are bluntly pointed for tearing.
- ✓ Premolars and molars have cusps for crushing and grinding.
- ✓ The premolars have two blunt cusps while the molars have three to four.

Internal Structure of tooth



Internal structure of a tooth

The tooth consists of two main parts:

Crown: The portion above the gum; it is covered by the enamel.

Root: The portion below the gum; it is covered by the cement.

The tooth has two roots.

Neck: Is the region at the same level with the gum.

- ✓ It forms the junction between the crown and the root.
- ✓ It is covered by enamel. Incisors and canines have one root only.
- ✓ Premolars have one or two roots while molars have two to three roots each.
- ✓ Internally, the bulk of the tooth is made up of dentine which consists of living cells and extends to the root.
- ✓ It is composed of calcium salts, collagen and water.
- ✓ It is harder than bone but wears out with use.
- ✓ This is why it is covered by enamel which is the hardest substance in a mammal's body.

Pulp Cavity: Contains blood vessels which provide nutrients to the dentine and remove waste products. It also contains nerve endings which detect heat, cold and pain.

Cement: Fixes the tooth firmly to the jaw bone.

Common Dental Diseases

Dental Carries

Dental carries are the holes or cavities that are formed as acid corrodes enamel and eventually the dentine.

Causes

- ✓ This is caused by bacteria acting on the food left between teeth and on the cusp.
- ✓ Acids are formed that eventually corrode the enamel.
- ✓ The pulp cavity is eventually reached.
- ✓ A lot of pain is experienced then.
- ✓ The bacteria then infect the pulp cavity and the whole tooth decays.

Treatment

Treatment depends on the extent of the dental caries:

Extraction of Tooth.

Filling

This involves replacing the dentine with amalgam, a mixture of hard elements e.g. silver and tin.

Root Canal Treatment

This involves surgery and reconstruction.

It saves severely damaged teeth.

The nerves in the root canal are surgically severed.

The tooth is cleaned and filled up with amalgam.

Periodontal Diseases

- ✓ These are diseases of the gum.

- ✓ The gum becomes inflamed, and starts bleeding.
- ✓ Progression of the disease leads to infection of the fibres in the periodontal membranes and the tooth becomes loose.
- ✓ This condition is known as pyorrhoea.
- ✓ The diseases are caused by poor cleaning of the teeth.
- ✓ The accumulation of food particles leading to formation of plaque, lack of adequate vitamin A and C in the diet.

Treatment

- ✓ Nutrition - by taking adequate balanced diet rich in vitamins A and C.
- ✓ Antibiotics are used to kill bacteria.
- ✓ Anti-inflammatory drugs are given.
- ✓ Antiseptic is prescribed to use in cleaning the mouth daily to prevent further proliferation of bacteria.
- ✓ The plaque is removed-drilled away - a procedure known as scaling.

Care of Teeth

In order to maintain healthy teeth the following points should be observed:

- ✓ A proper diet that includes calcium and vitamins, particularly vitamin D is essential.
- ✓ The diet should also contain very small quantities of fluorine to strengthen the enamel.
- ✓ Large quantities of fluorine are harmful.
- ✓ The enamel becomes brown, a condition known as dental fluorosis.
- ✓ Chewing of hard fibrous foods like carrots and sugar cane to strengthen and cleanse the teeth.
- ✓ Proper use of teeth e.g. not using teeth to open bottles and cut thread.
- ✓ Regular and thorough brushing of teeth after meals.
- ✓ Dental floss can be used to clean between the teeth.
- ✓ Not eating sweets and sugary foods between meals.
- ✓ Regular visits to the dentist for checkups.

- ✓ Washing the mouth with strong salt solution or with any other mouth wash with antiseptic properties.

Digestive System and Digestion in Humans

Organs that are involved with feeding in humans constitute the digestive system.

Digestive System and Associated Glands

- ✓ Human digestive system starts at the mouth and ends at the anus.
- ✓ This is the alimentary canal.
- ✓ Digestion takes place inside the lumen of the alimentary canal.
- ✓ The epithelial wall that faces the lumen has mucus glands (goblet cells).
- ✓ These secrete mucus that lubricate food and prevent the wall from being digested by digestive enzymes.
- ✓ Present at specific regions are glands that secrete digestive enzymes.
- ✓ The liver and pancreas are organs that are closely associated with the alimentary canal.
- ✓ Their secretions get into the lumen and assist in digestions.

Digestive system consists of:

- ✓ Mouth.
- ✓ Oesophagus.
- ✓ Stomach.
- ✓ Small intestines - consist of duodenum, the first part next to the stomach, ileum - the last part that ends up in a vestigial caecum and appendix which are nonfunctional.
- ✓ Large intestines consist of: colon and rectum that ends in the anus.

Ingestion, Digestion and Absorption

- ✓ Feeding in humans involves the following processes:
- ✓ Ingestion: This is the introduction of the food into the mouth.

- ✓ Digestion: This is the mechanical and chemical breakdown of the food into simpler, soluble and absorbable units.
- ✓ Absorption: Taking into blood the digested products.
- ✓ Assimilation: Use of food in body cells.
- ✓ Mechanical breakdown of the food takes place with the help of the teeth.
- ✓ Chemical digestion involves enzymes.

Digestion in the Mouth

- ✓ In the mouth, both mechanical and chemical digestion takes place.
- ✓ Food is mixed with saliva and is broken into smaller particles by the action of teeth.
- ✓ Saliva contains the enzyme amylase.
- ✓ It also contains water and mucus which lubricate and soften food in order to make swallowing easy.
- ✓ Saliva is slightly alkaline and thus provides a suitable pH for amylase to act on cooked starch, changing it to maltose.
- ✓ The food is then swallowed in the form of semisolid balls known as boluses.
- ✓ Each bolus moves down the oesophagus by a process known as peristalsis.
- ✓ Circular and longitudinal muscles along the wall of the alimentary canal contract and relax pushing the food along.

Digestion in the Stomach

- ✓ In the stomach, the food is mixed with gastric juice secreted by gastric glands in the stomach wall.
- ✓ Gastric juice contains pepsin, rennin and hydrochloric acid.
- ✓ The acid provides a low pH of 1.5-2.0 suitable for the action of pepsin.
- ✓ Pepsin breaks down protein into peptides.
- ✓ Rennin coagulates the milk protein casein.

- The stomach wall has strong circular and longitudinal muscles whose contraction mixes the food with digestive juices in the stomach.

Digestion in the Duodenum

- In the duodenum the food is mixed with bile and pancreatic juice.
- Bile contains bile salts and bile pigments.
- The salts emulsify fats, thus providing a large surface area for action of lipase.
- Pancreatic juice contains three enzymes:
    - Trypsin which breaks down proteins into peptides and amino acids,
    - Amylase which breaks down starch into maltose, and
    - Lipase which breaks down lipids into fatty acids and glycerol.
- These enzymes act best in an alkaline medium which is provided for by the bile.

Digestion in ileum

- Epithelial cells in ileum secrete intestinal juice, also known as succus entericus.
- This contains enzymes which complete the digestion of protein into amino acids, carbohydrates into monosaccharides and lipids into fatty acids and glycerol.

Absorption

- This is the diffusion of the products of digestion into the blood of the animal.
- It takes place mainly in the small intestines though alcohol and some glucose are absorbed in the stomach.

The ileum is adapted for absorption in the following ways:

- It is highly coiled.
- The coiling ensures that food moves along slowly to allow time for its digestion and absorption.
- It is long to provide a large surface area for absorption.
- The epithelium has many finger-like projections called villi (singular villus).

- ✓ They greatly increase the surface area for absorption.
- ✓ Villi have microvilli that further increase the surface area for absorption.
- ✓ The wall of villi has thin epithelial lining to facilitate fast diffusion of products of digestion.
- ✓ Has numerous blood vessels for transport of the end products of digestion.
- ✓ Has lacteal vessels; for absorption of fatty acids and glycerol and transport of lipids.

Absorption of Glucose and Amino Acids

- ✓ Glucose and other monosaccharides as well as amino acids are absorbed through the villi epithelium and directly into the blood capillaries.
- ✓ First they are carried to the liver through the hepatic portal vein, then taken to all organs via circulatory system.

Absorption of Fatty Acids and Glycerol

- ✓ Fatty acids and glycerol diffuse through the epithelial cells of villi and into the lacteal.
- ✓ When inside the villi epithelial cells, the fatty acids combine with glycerol to make tiny fat droplets which give the lacteal a milky appearance.
- ✓ The lacteals join the main lymph vessel that empties its contents into the bloodstream in the thoracic region.
- ✓ Once inside the blood, the lipid droplets are hydrolysed to fatty acids and glycerol.

Absorption of Vitamins and Mineral Salts

- ✓ Vitamins and mineral salts are absorbed into the blood capillaries in' the villi. Water is mainly absorbed in the colon.
- ✓ As a result the undigested food is in a semi-solid form (faeces) when it reaches the rectum.
- ✓ Egestion: This is removal of undigested or indigestible material from the body. Faeces are temporarily stored in the rectum then voided through the anus. Opening of the anus is controlled by sphincter muscles
- ✓ Assimilation: This is the incorporation of the food into the cells where it is used for various chemical processes.

Carbohydrates

- ✓ Carbohydrates are used to provide energy for the body.
- ✓ Excess glucose is converted to glycogen and stored in the liver and muscles.
- ✓ Some of the excess carbohydrates are also converted into fat in the liver and stored in the adipose tissue' (fat storage tissue), in the mesenteries and in the connective tissue under the skin, around the heart and other internal organs.

Proteins

- ✓ Amino acids are used to build new cells and repair worn out ones.
- ✓ They are also used for the synthesis of protein compounds.
- ✓ Excess amino acids are de-aminated in the liver.
- ✓ Urea is formed from the nitrogen part.
- ✓ The remaining carbohydrate portion is used for energy or it is converted to glycogen or fat and stored.

Lipids

- ✓ Fats are primarily stored in the fat storage tissues.
- ✓ When carbohydrates intake is low in the body, fats are oxidised to provide energy.
- ✓ They are also used as structural materials e.g. phospholipids in cell membrane. They act as cushion, protecting delicate organs like the heart.
- ✓ Stored fats under the skin act as heat insulators.

Summary of digestion in humans

Digestive gland and juice produced	**pH**	**Contents**	**Food Substances**	**Products**	**Notes**
Salivary glands (Saliva)	7.4	Water, mucus and salts			Soften and lubricate food, provide neutral pH.
		Amylase	Starch	Maltose	Glucose if food stays longer in mouth.
Stomach (Gastric Juice)	1.8	Hydrochloric acid	Nucleo-proteins	Nucleic acid + protein	Not an enzyme but hydrolyses the nuclear proteins.

					1. Kills micro-organisms. 2. Provides acidic medium. 3. Activates enzyme precursors, pepsinogen and protennin.
		Rennin	Milk protein	Curd coagulated milk (casein)	abundant in infants secreted as prorennin.
		Pepsin	Protein	Peptones	Secreted as pepsinogen
Pancrease (Pancreatic juice)	8.8	Trypsin	Protein	Peptones	Secreted as trypsinogen activated by enterokinase to trypsin
		Chymotrypsin	Peptones, casein	Amino acids	Secreted as chymotrypsin activated to trypsin.
		Amylase	Starch	Maltose	
		Lipase	glycogen Lipids	Fatty acids and glycerol	PH in duodenum lowered to 5.5 by acid from stomach
		Sodium bicarbonate			Provides alkaline conditions
Ileum (succus entericus)	8.3	Peptidases (erepsin)	Peptides	Amino acids	Erepsin contains a mixture of peptidases
		Invertase made of sucrase	Sucrose	Fructose + glucose	
		Lactase	Lactose	Galactose + glucose	
		Maltase	Maltose	Glucose	
		Lipase	Lipids	Fatty acids and glycerol	
		Enterokinase			Activates trypsinogen to trypsin.

Importance of Vitamins, Mineral Salts, Roughage and Water in Human Nutrition

Vitamins

- ✓ These are organic compounds that are essential for proper growth, development and functioning of the body.
- ✓ Vitamins are required in very small quantities.
- ✓ They are not stored and must be included in the diet.

- ✓ Vitamins Band C are soluble in water, the rest are soluble in fat.
- ✓ Various vitamins are used in different ways.

Mineral Salts

- ✓ Mineral ions are needed in the human body.
- ✓ Some are needed in small amounts while others are needed in very small amounts (trace).
- ✓ All are vital to human health.
- ✓ Nevertheless, their absence results in noticeable malfunction of the body processes.

Water

- ✓ Water is a constituent of blood and intercellular fluid.
- ✓ It is also a constituent of cytoplasm.
- ✓ Water makes up to 60-70% of total fresh weight in humans.
- ✓ No life can exist without water.

Functions of Water

- ✓ Acts as a medium in which chemical reactions in the body takes place.
- ✓ Acts as a solvent and it is used to transport materials within the body.
- ✓ Acts as a coolant due to its high latent heat of vaporisation.
- ✓ Hence, evaporation of sweat lowers body temperature.
- ✓ Takes part in chemical reactions i.e. hydrolysis.

Vitamins, sources, uses and the deficiency disease resulting from their absence in diet

Name of Vitamin	Sources	Uses in body	Deficiency disease(s)/Disorder
A (retinol) Soluble	Liver, egg-yolk, carrots, milk, spinach	Synthesis of rhodopsin, Control of growth of epithelium	Hardening of cornea of the eye (xerophthalmia), poor night vision; resistance to diseases of skin and gut is reduced.
B, (Thiamine)	Yeast, whole grain, liver, kidney, beans, meat, spinach	Formation f the enzyme co- carboxylase important in conversion of pyruvic acid respiration.	Beriberi - swelling of the feet; slowing of heartbeat and gastro intestinal disorder.

B2 (Riboflavin)	Whole grain, eggs, milk, liver, groundnuts, cheese, yeast	Formation of f1avoproteins that form dehydrogenase enzymes and for respiration.	Sores on tongue surface and at the comers of the mouth.
B3 (Nicotinic acid)	Liver, kidneys, milk, yeast eggs, whole grain.	Makes co-enzyme 1 and 2 (NAD & NAD.P) It is also co-enzyme A needed in cell respiration.	Pellagra - inflammation of tongue; nervous disorders leading to paralysis.
B, (Pantothenic acid)	In most natural foods	Forms parts of co-enzyme A.	Poor co-ordination of muscles and nervous muscle cramp.
B6 (Pryidoxine) water soluble	Eggs, kidneys, whole grain, vegetables.	Makes a co-enzyme for amino acids metabolism.	Irritability, depression, dermatitis.
Potassium	Milk, eggs, liver, green vegetables, bananas.	In intracellular body fluids as a buffer and for nerve impulse transmission.	Nervour transmission interfered with.
Chloride	Table salt, sea foods.	Present in tissue fluid. Maintains water balance essential for digestion. Constituent of hydrochloric acid.	
Magnesium	Green vegetables.	Also needed as a co-factor in respirator enzymes. Muscle contraction.	
Iodine	Iodised table salt and sea food.	Constituent of the hormone thyroxine that controls body metabolism.	In young animals leads to cretinism. Simple goitre in adults.
Manganese	Eggs, milk, fish.	Activates certain enzymes.	
Iron	Liver, greet vegetable leaves, lean meat, whole grains, milk.	A constituent of cytochromes haemoglobin and myoblobin.	Anaemia.
Sulphur	Protein foods	A constituent of some proteins; needed in synthesis of certain enzymes and phospholipids in cell membranes.	
Copper		Catalyses use of iron, a constituent of cytochrome oxidase (an enzyme)	Needed in very small amounts.
Cobalt		Influences the use of copper and iron (found in Vitamin B2)	Needed in very small amounts.
Zinc	Fruits and vegetables. Seeds of cucubitaceae.	Needed for proper growth of hair, influences working of insulin.	Needed in very small amounts.
Fluorine	Water, fruits and vegetables.	Strengthening of enamel	Needed in small amounts.

Molybdenum	Plant seeds	Activates enzyme system in mucleic acid metabolism.	Very small amounts needed, excess is dangerous.
Chromium		Involved in use of glucose.	Needed in small amounts.

Roughage

- ✓ Roughage is dietary fibre and it consists mainly of cellulose.
- ✓ It adds bulk to the food and provides grip for the gut muscles to enhance peristalsis.
- ✓ Roughage does not provide any nutritional value because humans and all animals not produce cellulase enzyme to digest cellulose.
- ✓ In herbivores symbiotic bacteria in the gut produce cellulase that digests cellulose.

Factors Determining Energy Requirements in Humans

- ✓ **Age:** Infants, for instance, need a greater proportion of protein than adults.
- ✓ **Sex:** males generally require more carbohydrates than females.
- ✓ The requirements of specific nutrients for females depends on the stage of development in the life cycle.
- ✓ Adolescent girls require more iron in their diet; expectant and nursing mothers require a lot of proteins and mineral salts.
- ✓ **State of Health:** A sick individual requires more of certain nutrients e.g. proteins, than a healthy one.
- ✓ **Occupation:** An office worker needs less nutrients than a manual worker.

Balanced Diet

A diet is balanced when it contains all the body's nutrient requirements and in the right amounts or proportions.

A balanced diet should contain the following:

- ✓ Carbohydrates
- ✓ Proteins
- ✓ Lipids

- ✓ Vitamins
- ✓ Mineral Salts
- ✓ Water
- ✓ Dietary fibre or roughage

Malnutrition

This is faulty or bad feeding where the intake of either less or more than the required amount of food or total lack of some food components.

Deficiency Diseases

Deficiency diseases result from prolonged absence of certain components in the diet.

Examples are:

Marasmus:

Lack of enough food results in thin arms and legs, severe loss of fluid, general body wasting, sunken eyes.

Kwashiorkor

Lack of protein in the diet of children. The symptoms of kwashiorkor include wasting of the body, red thin hair, swollen abdomen and scaly skin.

Other deficiency diseases are due to lack of accessory food factors (vitamins and mineral salts.). Such diseases include rickets, goitre and anaemia.

Treatment of these deficiency diseases is by supplying the patient with the component missing in the diet.

Practical Activities

- ✓ Experiments to show that Carbon (IV) Oxide is necessary for Photosynthesis
- ✓ Experiment to Show Effect of Light on Photosynthesis
- ✓ Experiment to Show the Effect of Chlorophyll on Photosynthesis
- ✓ Experiment To Observe Stomata Distribution in Different Leaves
- ✓ Test for Reducing Sugar
- ✓ Test for non-reducing sugar
- ✓ Test for Lipids;

  a) Grease Spot Test

  b) Emulsion Test

- ✓ Test for Proteins -Biuret Test
- ✓ Experiment To Investigate Presence of Enzyme in Living Tissue
- ✓ Dissection of a Rabbit to show the Digestive System