BIOLOGY

FORM ONE NOTES

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Introduction to Biology

- Biology derived from Greek words-BIOS meaning LIFE and LOGOS meaning STUDY or KNOWLEDGE.
- Biology means "life knowledge".
- It is the study of living things/organisms.

Branches of Biology

- Botany - study of plants.
- Zoology - study of animals.
- Microbiology - study' of microscopic organisms.
- Morphology - study of external structure of organisms.
- Anatomy - study of internal structure of organisms.
- Physiology - study of the functioning or working of the cells or body.
- Biochemistry - study of the chemistry of materials in living organisms.
- Cytology - study of cells.
- Genetics - study of inheritance.
- Ecology- study of the relationship between organisms and their environment.
- Taxonomy - sorting out of organisms into groups.
- Histology - study of fine structure of tissues.
- Virology - study of viruses.
- Bacteriology - study of bacteria.
- Entomology - study of insects.
- Ichthyology - study of fish.

Importance of Biology

- One learns about the functioning of the human body.
- One understands the developmental changes that take place in the body.
- It contributes immensely to improved life.
- It enables one to enter careers such as:
  - Medicine,
  - Nutrition,
  - Public Health,
  - Dentistry,
  - Agriculture
  - Environmental Studies.
  - Teaching

Characteristics of Living Things

Life defined through observations of activities carried out by living things;

- **Nutrition –**
  - Nutrition is the processes by which food/nutrients are acquired/made and utilized by living organisms.
  - Green plants and certain bacteria make their own food.
  - All other organisms feed on complex organic materials.
- **Respiration –**
  - This is the breakdown of food to provide energy.
  - The energy released is used for various activities in the organism.
- **Gaseous Exchange –**Process throw which respiratory gases(CO_2&O_2) are taken in and out through a respiratory surface.
- **Excretion –**
  - Excretion is the removal of metabolic wastes from the body.
  - Substances like urea, carbon dioxide (Carbon (IV) oxide).
  - These substances are poisonous if allowed to accumulate in the body.
- **Growth and Development –**
  - Growth means irreversible change in size.
  - All organisms increase in size that is, they grow.
  - Development is irreversible change in complexity.
  - As they do so, they also become differentiated in form.
- **Reproduction-**Reproduction is the formation of new individuals of a species to ensure continued existence of a species and growth of its population.
- **Irritability –**
  - The ability of organisms to detect and respond to changes in the environment. This is of great survival value to the organism.
- **Movement –**
  - Is the progressive change in position from one place to another.
  - Some organisms are sessile (i.e. fixed to the substratum).
  - The majority of plants move only certain parts.

Collection and Observation of Organisms

Biology as a practical subject is learnt through humane handling of organisms.

Materials needed for collection of organisms:-

- Knives to cut portions of plant stem/root or uproot.
- Polythene bags to put the collected plant or specimens.
- Insect collecting jars.
- Insect killing jars.

- Hand gloves.
- Sweep nets
- Pooters
- Traps

Observation of Organisms

- Observe the plant/animal in its natural habitat before collecting.
- Identify the exact place -on surface, under rock, on tree trunk, on branches.
- What does it feed on?
- How does it interact with other animals and the environment?
- How many of that kind of plant or animal are in a particular place?
- Plant specimens placed on the bench and sorted out into;- ***seeds/stems/roots/leaves/fruits.***
- Animal specimens may be left inside polythene bags if transparent.
- Others (killed ones) are put in petri dishes.
- Use hand lens to observe the external features of small animals.

Presenting the Results of Observations

- Organisms are observed and important features noted down: colour, texture hard or soft; if hairy or not. Size is measured or estimated.
- **Biological Drawings** - It is necessary to draw some of the organisms.
- In making a biological drawing, magnification (enlargement) is noted.
- Indicate the magnification of your drawing.
- i.e how many times the drawing is larger/smaller than the actual specimen MG=length of drawing/length specimen

How to Draw

- Several drawings of one organism may be necessary to represent all features observed, e.g.
- Anterior view of grasshopper shows all mouth parts properly, but not all limbs.
- Lateral (side) view shows all the legs.

Collection, Observation and Recording of Organisms

Collection

- Plants and animals collected from the environment, near school or within school compound using nets, bottles and gloves.
- Animals collected include:-arthropods, earthworms and small vertebrates like lizards/chameleons/ rodents.
- Place in polythene bags and take to the laboratory.
- Stinging/poisonous insects killed using ether.
- Other animals are observed live and returned to their natural habitat.
- Plant specimen collected include:- leaves, flowers and whole plants.
- Observations are made to show the following:-
  - Plants have roots, stems, leaves and flowers.
  - Animals have legs, hair, hard outer covering, feathers, eyes, mouth, limbs and other appendages,

The differences between animals and plants collected.

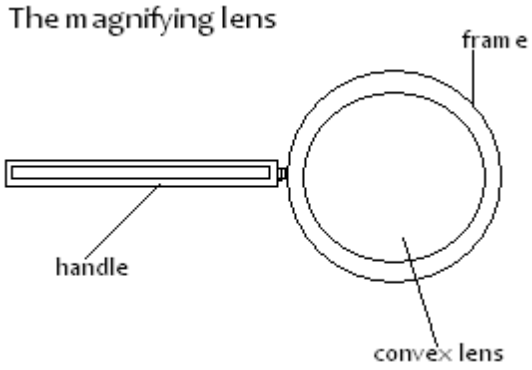
Comparison Between Plants And Animals

Plants	*Animal*
I. Plants are fixed in position and do not" move. 2. Respond slowly to stimuli. 3. Cells have cellulose cell walls. 4. Plants make their own food from simple materials such as CO_2 and water using light energy.	I. Most animals move in search of food, shelter and mates. 2. Respond quickly to stimuli. 3. Cells have no cell walls only a cell 4. Animals feed on already made food.

Classification I

Introduction

- Classification is putting organisms into groups.
- Classification is based on the study of external characteristics of organisms.
- It involves detailed observation of structure and functions of organisms.
- Organisms with similar characteristics are put in one group.
- Differences in structure are used to distinguish one group from another.
- The magnifying lens is an instrument that assists in the observation of fine structure e.g. hairs by enlarging them.



Using a Magnifying Lens

- A specimen is placed on the bench or held by hand,
- Then the magnifying lens is moved towards the eye until the object is dearly focused and an enlarged image is seen.
- The magnification can be worked out as follows:

$$\text{Magnification} = \frac{\text{length of the drawing}}{\text{length of the specimen}}$$

- ***Note: magnification has no units.***

Nececity/need for Classification

- To be able to identify organisms into their taxonomic groups.
- To enable easier and systematic study of organisms.
- To show evolutionary relationships in organisms.

Major Units of Classification (Taxonomic Groups)

- Taxonomy is the study of the characteristics of organisms for the purpose of classifying them.
- The groups are Taxa (singular Taxon).

The taxonomic groups include:

- ***Species:*** This is the smallest unit of classification. Organisms of the same species resemble each other. The number of chromosomes in their cells is the same. Members of a species interbreed to produce fertile offspring.
- ***Genus (plural genera):*** A genus is made up of a number of species that share several characteristics. Members of a genus cannot interbreed and if they do, the offspring are infertile.
- ***Family:*** A family is made up of a number of genera that share several characteristics.
- ***Order***: A number of families with common characteristics make an order.
- **Class**: Orders that share a number of characteristics make up a class.
- ***Phylum/Division:*** A number of classes with similar characteristics make up a phylum (plural phyla) in animals. In plants this is called a division.
- ***Kingdom:*** This is made up of several phyla (in animals) or divisions (in plants). It is the largest taxonomic unit in classification.

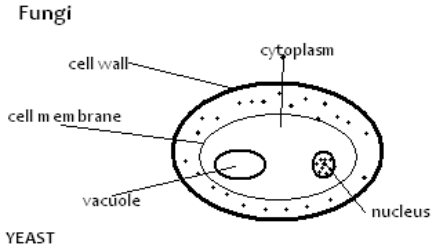
Kingdoms

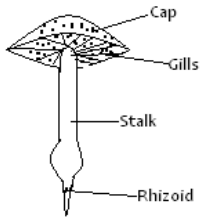
Living organisms are classified into five kingdoms;

- Monera,
- Protoctista,
- Fungi,
- Plantae
- Animalia.

Kingdom Fungi

- Some are unicellular while others are multicellular.
- They have no chlorophyll.
- Most are saprophytic e.g. yeasts, moulds and mushrooms.
- A few are parasitic e.g. ***Puccinia graminae.***





mushroom (Agaricus spp.)

Kingdom Monera (Prokaryota)

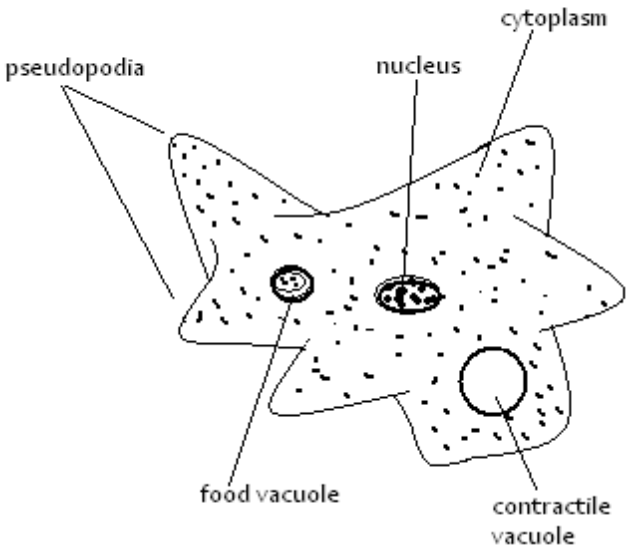
- These are very small unicellular organisms.
- They lack a nuclear membrane
- do not have any bound membrane organelles.
- Hence the name Prokaryota.

- They are mainly bacteria, e.g. ***Vibrio cholerae***.

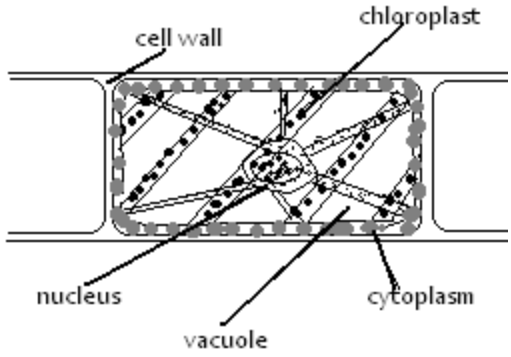
Kingdom Protoctista

- They are unicellular organisms.
- Their nucleus and organelles are surrounded by membranes (eukaryotic).
- They include algae, slime moulds - fungi-like and protozoa

Amoeba-a protozoan(Protoctist)



Spyrogyra-filamentous green algae



Kingdom Plantae

- They are all multicellular.
- They contain chlorophyll and are all autotrophic.
- They include; Bryophyta (mossplant), Pteridophyta (ferns) and Spermatophyta (seed bearing plants).

Kingdom Animalia

- These are all multicellular and heterotrophic.

- Examples are annelida (earthworms), mollusca (snails),athropoda, chordata .
- Example of Arthropods are ticks, butterflies.
- Members of Chordata are fish, frogs and humans.

External Features of Organisms

In plants we should look for:-

- Spore capsule and rhizoids in moss plants.
- Sori and fronds in ferns.
- Stem, leaves, roots, flowers, fruits and seeds in plants.

In animals, some important features to look for are:

- Segmentation, presence of limbs and, number of body parts, presence and number of antennae. These are found in phylum arthropoda:
- Visceral clefts, notochord, nerve tube, fur or hair, scales, fins, mammary glands, feathers and wings.
- These are found in chordata.

Binomial Nomenclature

- Organisms are known by their local names.
- Scientists use scientific names to be able to communicate easily among themselves.
- This method of naming uses two names, and is called Binomial nomenclature.
- The first name is the name of the genus: (generic name) which starts with a capital letter.
- The second name is the name of the species (specific name) which starts with a small letter.
- The two names are underlined or written in italics.
- Man belongs to the genus *Homo,* and the species, *sapiens.*
- The scientific name of man is therefore *Homo sapiens.*
- Maize belongs to the genus *Zea,* and the species *mays.*
- The scientific name of maize is *Zea mays.*

Practical Activities

- Use of Collecting Nets, Cutting Instruments and Hand Lens.
- Forceps are used to collect crawling and slow moving animals.
- Sweep nets are used to catch flying insects.
- Cutting instrument like scapel is used to cut specimen e.g. making sections.
- Hand lens is used to magnify small plants and animals.
- Drawing of the magnified organism are made and the linear magnification of each calculated.

Collection and Detailed Observation of Small Plants and Animals

e.g. moss, ferns, bean.

Look for the following:

- Moss plants: Rhizoids and spore capsules.
- Fern plants: Rhizomes with adventitious roots; large leaves (fronds) with Sori (clusters of sporangia).
- Seed plants: Tree/shrub (woody) or non-woody (herbs) e.g. bean.
- Root system - fibrous, adventitious and tap root.
- Stem - position and length of interrnodes.
- Type of leaves - simple or compound; arranged as alternate, opposite or whorled.
- Flower - colour, number of parts, size and relative position of each:
- Fruits - freshy or dry; edible or not edible.
- Seeds - monocotyledonous or dicotyledonous.

Small animals e.g. earthworms, tick, grasshopper, butterfly, beetles.

Observe these animals to see: ey1

- Number of legs.
- Presence or absence of wings.
- Number of antennae.
- Body covering.
- Body parts.

THE CELL

Introduction

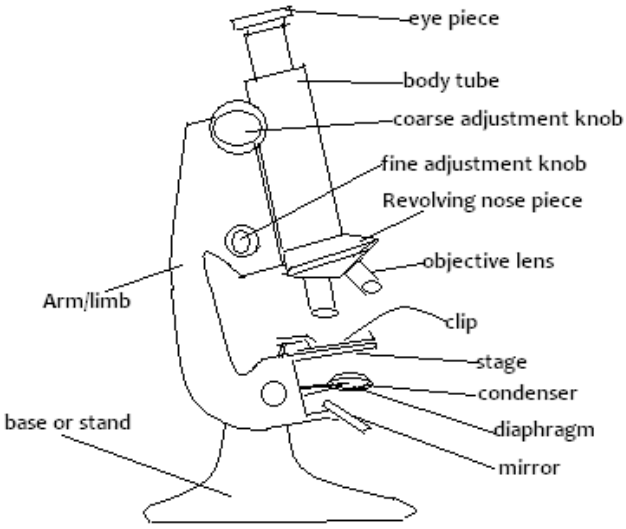
- The cell is the basic unit of an organism.
- All living organisms are made up of cells.
- Some organisms are made up of one cell and others are said to be multicellular.
- Other organisms are made of many cells and are said to be multicellular.
- Cells are too little to see with the naked eye.
- They can only be seen with the aid of a microscope.

The microscope

The microscope is used to magnify objects.

Magnification

- The magnifying power is usually inscribed on the lens.
- To find out how many times a specimen is magnified, the magnifying power of the objective lens is multiplied by that of the eye piece lens.
- If the eye piece magnification lens is x10 and the objective lens is x4, the total magnification is x40.
- Magnification has no units.
- It should always have the multiplication sign.e.g.x40



The light microscope

Microscope parts and their functions

Parts	*Function(s)*
Eye piece	Has a lens which contributes to the magnification of the object
Coarse adjustment	Moves the body tube up and down for long distances and it brings into focus.
Fine adjustment knob	Moves the body tube and brings the image into fine focus.
Body tube Ji	Holds the eye piece and the revolving nose piece. It directs light objective lenses to the eye piece lens.
Revolving nose piece	Holds and brings objective lenses into position.
Objective	Contributes to the magnification of the object.
Arm/limb	It is for handling the microscope and also tilting it.
Stage	Is the flat platform onto which the slide with the object is placed.
Clips	They hold the slide firmly onto the stage.
Condenser	Concentrates light onto the object.
Diaphragm	~egulates the amount of light passing through the object.
Mirror	Reflects light into the condenser.
Hinge screw	Fixes the arm to the base and allows for tilting of the arm.
Base/stand	Provides support to the microscope.

To View the Object

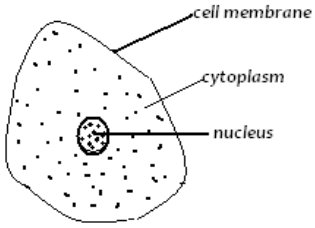
- Turn the low power objective lens until it clicks into position.
- Looking through the eye piece, ensure that enough light is passing through by adjusting the mirror.
- This is indicated by a bright circular area known as the field of view.
- Place the slide containing the specimen on stage and clip it into position.
- Make sure that the specimen is in the centre of the field of view.
- Using the coarse adjustment knob, bring the low power objective lens to the lowest point.
- Turn the knob gently until the specimen comes into focus.
- If finer details are required, use the fine adjustment knob.

- When using high power objective always move the fine adjustment knob upwards.

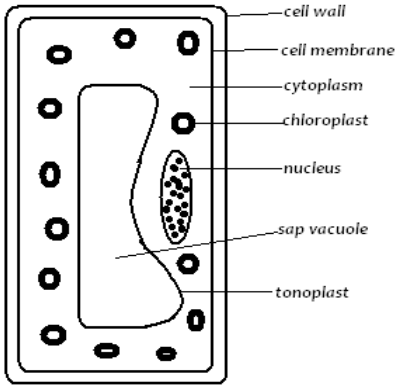
Care of a Microscope

- Great care should be taken when handling it.
- Keep it away from the edge of the bench when using it.
- Always hold it with both hands when moving it in the laboratory.
- Clean the lenses with special lens cleaning paper.
- Make sure that the low power objective clicks in position in line with eye piece lens before and after use.
- Store the microscope in a dust-proof place free of moisture.

Cell Structure as Seen Through the Light Microscope



A typical animal cell



Generalised plant cell

The cell as seen above has the following:

Cell membrane (Plasma membrane):

- This is a thin membrane enclosing cell contents.
- It controls the movement of substances into and out of the cell.

Cytoplasm:

- This is a jelly-like substance in which chemical processes are carried out.
- Scattered all over the cytoplasm are small structures called organelles.
- Like an animal cell, the plant cell has a cell membrane, cytoplasm and a nucleus.

vacuole.

- Plant cells have permanent, central **vacuole.** It contains cell sap where sugars and salts are stored.

Cell wall:

- This is the outermost boundary of a plant cell.

- It is made of cellulose.
- Between the cells is a middle lamella made of calcium pectate.

Chloroplasts;

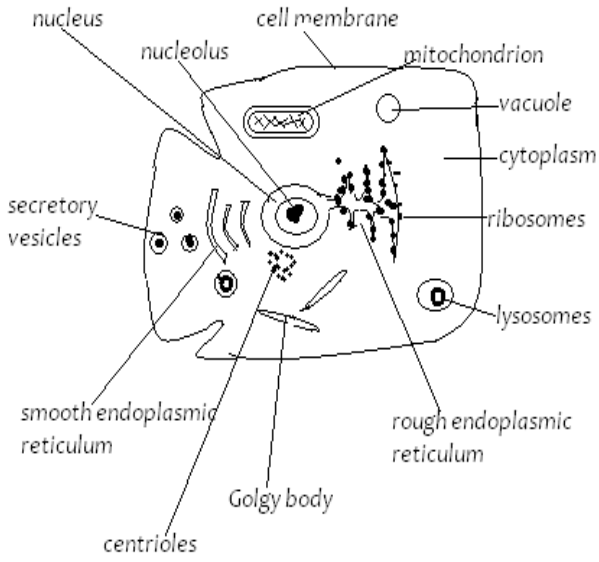
- With special staining techniques it is possible to observe **chloroplasts.**
- These are structures which contain chlorophyll, the green pigment responsible for trapping light for photosynthesis.

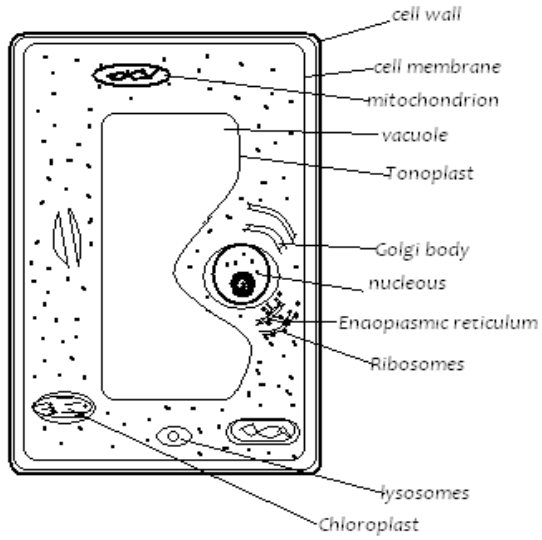
The Electron Microscope (EM)

- Capable of magnifying up to 500,000 times.
- The specimen is mounted in vacuum chamber through which an electron beam is directed.
- The image is projected on to a photographic plate.
- The major **disadvantage** of the electron microscope is that it **cannot be used to observe living objects**.
- However, it provides a **higher magnification** and **resolution** (ability to see close points as separate) than the light microscope so that specimen can be observed in more detail.

Cell Structure as Seen Through Electron Microscope

A generalised anumal cell as seen under Electron microscope

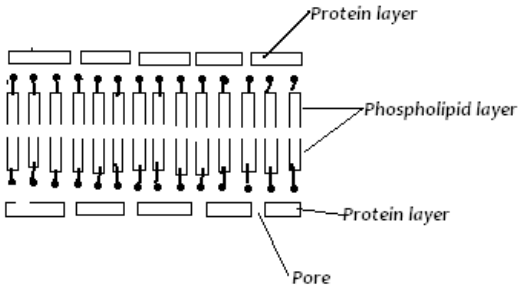




A generalised plant cell as seen under the electron microscope

The Plasma Membrane

- Under the electron microscope, the plasma membrane is seen as a double layer.
- This consists of a lipid layer sandwiched between two protein layers.
- This arrangement is known as the unit membrane and the shows two lipid layers with proteins within.
- Substances are transported across the membrane by active transport and diffusion.



Cell membrane Structure

The Endoplasmic Reticulum (ER)

- This is a network of tubular structures extending throughout the cytoplasm of the cell.
- It serves as a network of pathways through which materials are transported from one part of the cell to the other.
- An ER encrusted with ribosomes it is referred to as **rough endoplasmic reticulum**.
- An ER that lacks ribosomes is referred to as **smooth endoplasmic reticulum.**
- The rough endoplasmic reticulum transports **proteins** while the smooth endoplasmic reticulum transports **lipids.**

The Ribosomes

- These are small spherical structures attached to the ER.
- They consist of protein and ribonucleic acid (RNA).
- They act as sites for the synthesis of proteins.

Golgi Bodies

- Golgi bodies are thin, plate-like sacs arranged in stacks and distributed randomly in the cytoplasm.
- Their function is packaging and transportation of glycol-proteins.
- They also produce lysosomes.

Mitochondria

- Each mitochondrion is a rod-shaped organelle.
- Made up of a smooth outer membrane and a folded inner membrane.
- The foldings of the inner membrane are called **cristae.**
- They increase the surface area for respiration.
- The inner compartments called the matrix.
- Mitochondria are the sites of cellular respiration, where energy is produced.

Lysosomes

- These are vesicles containing hydrolytic enzymes.
- They are involved in the breakdown of micro-organisms, foreign macromolecules and damaged or worn-out cells and organelles ..

The Nucleus

- The nucle s is surrounded by a nuclear membrane which is a unit membrane.
- The nuclear membrane has pores through which materials can move to the surrounding cytoplasm.
- The nucleus contains proteins and nucleic acid deoxyribonucleic acid (DNA) and RNA.
- The chromosomes are found in the nucleus.
- They are the carriers of the genetic information of the cell.
- The nucleolus is also located in the nucleus but it is only visible during the non-dividing phase of the cell.

The Chloroplasts

- These are found only in photosynthetic cells.
- Each chloroplast consists of an outer unit. membrane enclosing a series of interconnected membranes called lamellae.
- At various points along their length the lamellae form stacks of disc like structures called grana.
- The lamellae are embedded in a granular material called the stroma.
- The chloroplasts are sites of photosynthesis.
- The light reaction takes place in the lamellae while the dark reactions take place in the stroma.

Comparison between animal cell and plant cell

Plant	*Animal Cell*
• Has a cell wall and a cell membrane.	· Has cell membrane only.
• Nucleus at periphery.	• Nucleus at the center.
• Have	• Have no chloroplasts.
• Has a large central vacuole.	· Has no vacuoles, they are small and
• Are usually	• Are usually small.
• Are regular in shape.	· Irregular in shape.
• Has no	· Has centrioles.
• Stores starch, oils and protein.	· Store glycogen and fats.

Cell Specialisation

Cells are specialised to perform different functions in both plants and animals.

Example;

- Palisade cells have many chloroplasts for photosynthesis.
- Root hair cells are long and thin to absorb water from the soil.
- Red blood cells have haemoglobin which transports oxygen.
- Sperm cells have a tail to swim to the egg.

- Multicellular organisms cells that perform the same function are grouped together to form a tissue.
- Each tissue is therefore made up of cells that are specialised to carry out a particular function.

Animal Tissues- Examples of animal tissues

Type of Tissue	Functions	Characteristics
I. Epithelial Tissue (a) Squamous (b) Columnar (c) stratified (d) Cuboidal	Covering. allowing movement of materials Covering of internal organs. lining Secretion. absorption e.g. in the Covering surfaces, protection e.g. Absoption e.g. in the kidney tubules.	Thin flat cells. Cells that are longer than they Several layers of epithelial squamous. cuboidal or cube like cells.
2. Muscular Tissue (a) Striated voluntary (b) Smooth involuntary (c) Cardiac muscle	Contraction, bringing about Contract and allow movement. cover internal organs; allow peristalsis. Cause contraction of the heart.	Contists of units called Are multicleated; have controlled by voluntary Are spindle-shaped. controlled by involuntary contract rhythmically; are (ability to contract is within)
3. Supporting Tissue (a) Cartilage (b) Bone	Support the body. provide a rigid framework, protect soft tissue.	Cells that produce hard
4. Blood	Transport of materials. protection	A complex tissue consisting of cells suspended in a fluid
5. Nerve Tissue	Receive stimuli and transmit co-ordinate body activities	Consists of cells called which are interconnected axons to enable transmission

Plant Tissues
Example of plant tissues

Type of Tissue	*Functions*	*Characteristics*
L *Meristematic*	Undergo division and cause e.g. increase in length and girth	Small thin-walled celis, contain a lot of cytoplasm; found mostly at the tip of shoots and roots.
2. Parenchyma	Photosynthesis gaseous support; storage.	Thin walled cells; vary in shape and size; many intercellular spaces.
3. *Collenchyma*	Strengthening.	Thickened walls; no intercellular spaces; found in cortex of stems.

4. Sclerenchyma	Strengthening.	Vary in shape; thick cell walls; are usually dead.
5. *Vascular* (a) Xylem (b) Phloem	Transport materials. Transport of water and mineral Transport of organic materials (manufactured food).	Tubular vessels and trancheids joined end to end. Sieve elements joined to each other through sieve pores.

Organs

- An organ is made up of different tissues
- e.g. the heart, lungs, kidneys and the brain in animals and roots, stems and leaves in plants.

Organ systems

- Organs which work together form an organ system.
- Digestive, excretory, nervous and circulatory in animals and transport and support system in plants.

organism

- Different organ systems form an organism.

Practical Activities

Observation and Identification of parts of a light microscope and their functions

- A light microscope is provided.
- Various parts are identified and observed.
- Drawing and labelling of the microscope is done.
- Functions of the parts of the mircroscope are stated.
- Calculations of total magnification done using the formula.

- **Eye piece lens maginification** x **objective lens rnaginification.**

Preparation and Observation of Temporary Slides of Plant Cells

- A piece of epidermis is made from the fleshy leaf of an onion bulb. It is placed on a microscope slide and a drop of water added.
- A drop of iodine is added and a cover slip placed on top.
- Observations are made, under low and medium power objective.
- The cell wall and nucleus stain darker than other parts.
- A labelled drawing is made.
- The following are noted: **Nucleus, cell wall, cytoplasm and cell membrane.**

Observation of permanent slides of animal cells

- Permanent slides of animal cells are obtained e.g, of cheek cells, nerve cells and muscle cells.
- The slide is mounted on the microscope and observations made under low power and medium power objectives.
- Labelled drawings of the cells are made.

- A comparison between plant and animal cell is made.

Observation and Estimation of Cell Size and Calculation of Magnification of Plant Cells.

- Using the low power objective, a transparent ruler is placed on the stage of the microscope.
- An estimation of the diameter of the field of view is made in millimeters.
- This is converted into micrometres (1mm=1000u)
- A prepared slide of onion epidermal cells is mounted.
- The cells across the centre of the field of view are counted from left and right and top to bottom.
- The diameter of field of view is divided by the number of cells lying lengthwise to give an estimate of the length and width of each cell.

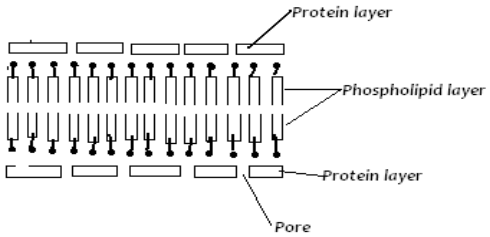
Cell Physiology

Meaning of cell physiology

- The term physiology refers to the functions that occur in living organisms.
- Cell physiology refers to the process through which substances move across the cell membrane.
- Several physiological processes take place inside the cell.e.g. respiration.
- Oxygen and glucose required enter the cell while carbon (IV) oxide and water produced leave the cell through the cell membrane.

Structure and properties of cell membrane

- The cell membrane is the protective barrier that shelter cellular contents.
- Movement of all substances into and out of the cells takes place across the cell membrane.
- It is made up of protein and lipid molecules.
- Lipid molecules have phosphate group attached to it on one end.
- They are then referred to phospholipids.
- The phospholipids are arranged to form a double layer.
- The ends with phosphate group face outwards.
- the proteins are scattered throughout the lipid double layer.
- Some of these proteins act as carrier molecules that channel some material in and outside the cells.
- The cell membrane allows certain molecules to pass through freely while others move through with difficulty and still others do not pass through at all.
- This is selective permeability and the cell membrane is described as semi-permeable.



Cell membrane Structure

Properties of cell membrane

Permeability

- The cell membrane is semi-permeable.
- it allows small molecules that are soluble in lipid to pass through with more ease than water soluble molecules.
- this is due to the presence of the phospholipids double layer.

Polarity

- The cell membrane has electrical charges across its surface.it has positive charged ions on the outside and negatively charged ions on the inside. This property contributes to electrical impulses sent along nerve cells.
- Sensitivity to changes in temperature and pH
- Very high temperatures destroy the semi-permeability nature of the cell membrane because the proteins are denatured by extreme pH values have the same effect on the membrane permeability.
- Physiological processes
- Some of the physiological processes include diffusion, osmosis and active transport.

Diffusion

- Diffusion is the movement of molecules or ions from a region of high concentration to a region of low concentration aided by a concentration gradient..
- diffusion continues to occur as long as there is a difference in concentration between two regions (concentration gradient).
- Stops when an equilibrium is reached i.e., when the concentration of molecules is the same in both regions.
- Diffusion is a process that occurs inside living organisms as well as the external environment..
- Does not require energy.

Factors Affecting Diffusion

- **Concentration Gradient**

An increase in the concentration of molecules at one region results in a steeper concentration gradient which in turn increases the rate of diffusion.

- **Temperature**

High temperature increases kinetic energy of molecules. They move faster hence resulting in an increase in rate of diffusion, and vice versa.

- **Size of Molecules or Ions**

The smaller the size of molecules or ions, the faster their movement hence higher rate of diffusion.

- **Density**

The denser the molecules or ions diffusing, the slower the rate of diffusion, and vice versa.

- **Medium**

The medium through which diffusion occurs also affects diffusion of molecules or ions. For example, diffusion of molecules through gas and liquid media is faster than through a solid medium.

- **Distance**

This refers to the thickness or thinness of surface across which diffusion occurs. Rate of diffusion is faster when the distance is small i.e., thin surface.

- **Surface Area to Volume Ratio**

The larger the surface area to volume ratio, the faster the rate of diffusion.
For example, in small organisms such as Amoeba the surface area to volume ratio, is greater hence faster diffusion than in larger organisms.

Role of Diffusion in Living Organisms

Some processes that depend on diffusion include the following:

- Gaseous exchange: Movement of gases through respiratory surfaces is by diffusion.
- Absorption of materials into cells Cells obtain raw materials and nutrients from the surrounding tissue fluid and blood through diffusion, e.g., glucose needed for respiration diffuses from blood and tissue fluid into cells.
- Excretion: Removal of metabolic waste products like carbon (IV) oxide, and ammonia out of cells is by diffusion.
- Absorption of the end-products of digestion from the intestines is by diffusion.

Osmosis

- Osmosis is the movement of water molecules from a region of high water concentration to a region of low water concentration through a semi-permeable membrane.
- Osmosis is a special type of diffusion that involves the **movement of water molecules only** and **not solute molecules.**

- Osmosis takes place in cells across the cell membrane as well as across non-living membranes
- e.g. cellophane or visking tubing which are also semi-permeable,
- It is purely a physical process.
-

Factors Affecting Osmosis

- **Size of solute molecules-**

Osmosis' occurs only when solute molecules are too large to pass through a semi-permeable membrane.

- **Concentration Gradient .**

Osmosis occurs when two solutions of unequal solute concentration are separated by a semi-permeable membrane.

- **Temperature ,.**

High temperatures increase movement of water molecules hence influence osmosis. However, too high temperatures denature proteins in cell membrane and osmosis stops.

- **Pressure**

Increase in pressure affects movement of water molecules.
As pressure increases inside a plant cell, osmosis decreases.

Roles of Osmosis in Living Organisms

The following processes depend on osmosis in living organisms:

- Movement of water into cells from the surrounding tissue fluid and also from cell to cell.
- Absorption of water from the soil and into the roots of plants.
- Support in plants especially herbaceous ones, is provided by turgor pressure, which results from intake of water by osmosis.
- Absorption of water from the alimentary canal in mammals.

- Re-absorption of water in the kidney tubules.
- Opening and closing stomata.

Water Relations in Plant and Animal Cells

- The medium (solution) surrounding cells or organisms is described by the terms **hypotonic, hypertonic** and **isotonic.**
- A solution whose solute concentration is more than that of the cell sap is said to be **hypertonic**. A cell placed in such a solution loses water to the surroundings by osmosis.
- A solution whose solute concentration is less than that of the cell sap is said to be **hypotonic**. A cell placed in such a solution gains water from the surroundings by osmosis.
- A solution which has the same solute concentration as the cell sap is said to be **isotonic**. When a cell is placed in such a solution there will be no net movement of water either into or out of the cell.

Osmotic Pressure

- The term osmotic pressure describes the tendency of the solution with a high solute concentration to draw water into itself when it is separated from distilled water or dilute solution by a semi-permeable membrane.
- Osmotic pressure is measured by an osmometer.
- When plant cells are placed in distilled water or in a hypotonic solution, the osmotic pressure in the cells is higher than the osmotic pressure of the medium.
- This causes the water to enter the cells by osmosis.
- The water collects in the vacuole which increases in size.
- As a result the cytoplasm is pushed outwards and it in turn presses the cell membrane next to the cell wall.
- This builds up water pressure (hydrostatic pressure) inside the cell.
- When the cell is stretched to the maximum, the cell wall prevents further entry of water into the cell.
- Then the cell is said to be **fully** turgid.
- The hydrostatic pressure developed is known as **turgor** pressure.

Plasmolysis

- When a plant cell is placed in a hypertonic medium, it loses water by osmosis.
- The osmotic pressure of the cell is lower than that of the medium.
- The vacuole decreases in size and the cytoplasm shrinks as a result of which the cell membrane loses contact with the cell wall.
- The cell becomes flaccid. The whole process is described as plasmolysis.
- **Incipient** plasmolysis is when a cell membrane just begins to lose contact with the cell wall.
- Plasmolysis can be reversed by placing the cell in distilled water or hypotonic solution.
- However, full plasmolysis may not be reversed if cell stays in that state for long.

Wilting

- The term wilting describes the drooping of leaves and stems of herbaceous plants after considerable amounts of water have been lost through transpiration.
- It is observed in hot dry afternoons or in dry weather.
- This is when the amount of water lost through transpiration exceeds the amount absorbed through the roots.

- Individual cells lose turgor and become plasmolysed and the leaves and stems droop.
- The condition is corrected at night when absorption of water by the roots continue while transpiration is absent.
- Eventually, wilting plants may die if the soil water is not increased through rainfall or watering.

Water Relations in Plants and Animals

Haemolysis

- Haemolysis is the bursting of cell membrane of red blood cells releasing their haemoglobin.
- It occurs when red blood cells are placed in distilled water or hypotonic solution.
- This is because the cell membrane does not resist further entry of water by osmosis after maximum water intake.

Crenation

- Takes place when red blood cells are placed in hypertonic solution.
- They lose water by osmosis, shrink and their shape gets distorted.
    - **Animal cells** have mechanisms that regulate their salt water balance (osmoregulation) to prevent above processes that lead to death of cells.
    - An Amoeba placed in distilled water, i.e. hypotonic solution, removes excess water using a contractile vacuole.
    - The rate of formation of contractile vacuoles increases.

Active Transport

- Active transport is the movement of solutes such as .glucose, amino acids and mineral ions;
- From an area of their low concentration to an area of high concentration.
- It is movement against a concentration gradient and therefore energy is required.
- As such it only takes place in living organisms.
- The energy needed comes from respiration.
- Certain proteins in the cell surface membrane responsible for this movement are referred to as **carrier proteins or channel proteins.**
- The shape of each type of carrier protein is specific to the type of substances conveyed through it.
- It has been shown that the substance fits into a particular slot on the protein molecule,
- As the protein changes from one form of shape to another the substance is moved across and energy is expended.

Factors Affecting Active Transport

Availability of oxygen

- Energy needed for active transport is provided through respiration.
- An increase in the amount of oxygen results in a higher rate of respiration.
- If a cell is deprived of oxygen active transport stops .

Temperature

- Optimum temperature is required for respiration, hence for active transport.
- Very high temperatures denature respiratory enzymes.
- Very low temperatures inactivate enzymes too and active transport stops.

Availability of carbohydrates

- Carbohydrates are the main substrates for respiration.
- Increase in amount of carbohydrate results in more energy production during respiration and hence more active transport.
- Lack of carbohydrates causes active transport to stop.

Metabolic poisons

- Metabolic poisons e.g. cyanide inhibit respiration and stops active transport due to lack of energy.

Role of Active Transport in Living Organisms

Processes requiring active transport:

- Absorption of mineral salts from the soil into plant roots.
- Absorption of end products of digestion e.g. glucose and amino acids from the digestive tract into blood stream.
- Excretion of metabolic products e.g.urea from the cells.
- Re-absorption of useful substances and mineral salts back into blood capillaries from the kidney tubules.
- Sodium-pump mechanism in nerve cells.
- Re-absorption of useful materials from tissue fluid into the blood stream.

Practical Activities

1.**Experiment to Demonstrate Diffusion**

- Various coloured substances such as: dyes, plant extracts and chemicals like potassium pennanganate are used.
- Potassium manganate (VII) crystals are introduced to the bottom of a beaker filled with water using a glass tubing or drinking straw which is then removed.
- Observations are made and the disappearance of the crystals and subsequent uniform colouring of water noted.

2.**Experiment to Demonstrate Osmosis Using a Visking Thbing**

- A strip of visking tubing 8-10 cm is cut and tied at one end using strong thread.
- About 2 ml of 25% sucrose solution is put inside and the other end tied with thread.
- The tubing is washed under running water and then blotted to dry.
- It is immersed in a beaker containing distilled water and left for at least one hour or overnight.
- It will then be observed that the visking tubing has greatly increased in size and has become firm.
- A control experiment can be set up using distilled water inside the visking tubing in place of sucrose solution.

3.Experiment to Show Osmosis using Living Tissue

- Irish potato tubers are peeled and scooped out to make hollow space at the centre.
- Sucrose solution is placed inside the hollow, and the potato tuber placed in a beaker or petri-dish with distilled water. A conttrol is set using a boiled potato.
- Another one using distilled water inside hollow in place of sugar solution.
- The experiment is left for 3 hours to 24 hours.

4.Experiment to Demonstrate Turgor and Plasmolysis in Onion Epidermal Cells

- Two strips of onion epidermis are obtained.

- One is placed on a slide with distilled water while the other is placed on a slide with 25% sucrose solution and a coverslip placed on top of each.
- The mounted epidermis is observed under low power microscope and then left for 30 minutes.
- After 30 minutes, observations are made again.

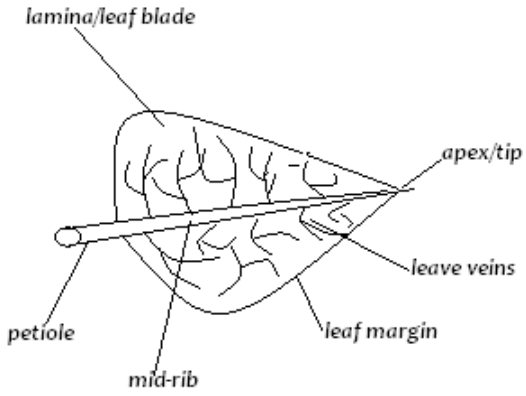
The cells in distilled water have greatly enlarged. Cells in 25% sucrose have shrunk.

Nutrition in Plants and Animals

Structure of the Leaf

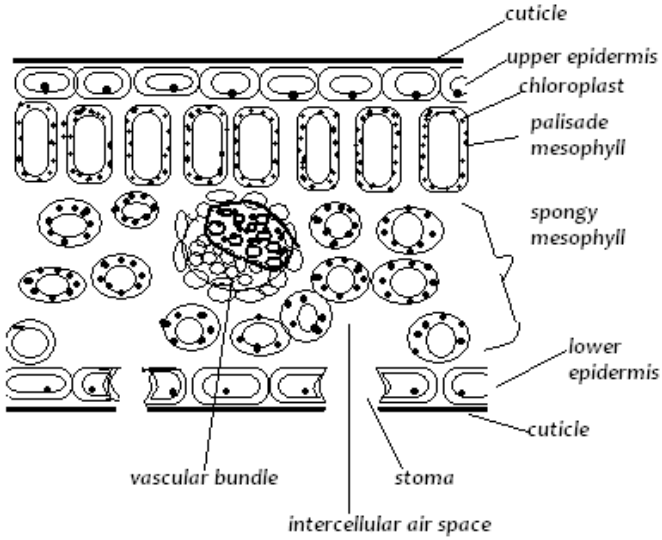
External Structure

- 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 maximise 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 airfilled 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.

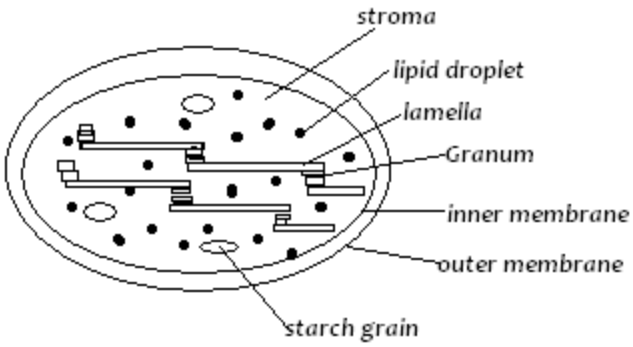
Adaptations of Leaf for Photosynthesis

- 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

- .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.

Process of Photosynthesis

- Photosynthesis involves a series of chemical reactions, all of which take place inside chloroplasts.
- A general equation for photosynthesis is:

$$\text{Carbon (IV)Oxide+Water} \xrightarrow[\text{chlorophyll}]{\text{light energy}} \text{Glucose+Oxygen}$$

$$6CO_2+6H_2O \xrightarrow[\text{chlorophyll}]{\text{light}} C_6H_{12}O+6O_2$$

- 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.

$$2H_2O_{(l)} \xrightarrow[\text{photolysis}]{\text{light energy}} 4H + O_2$$

- 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 triphophate (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.
- *ATP*
  Carbon + Hydrogen --- Carbohydrates
- (IV) oxide
- 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"C.
- 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 photosynthesise 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 andjchernically 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 contituent 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 <u>*hydrolysis*</u> 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-***
  - 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 enzymecontrolled reaction doubles with every $10^{O}C$ 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 sometime 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.
- Herbiverous 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

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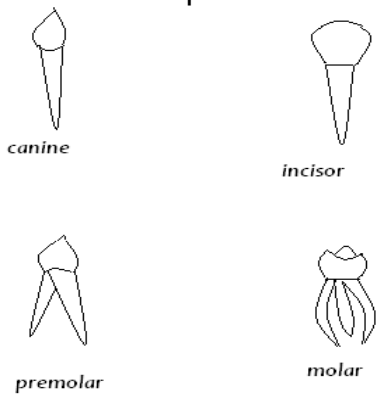
- Mammals have different kinds of teeth.
- Each type of teeth has a particular role to play in the feeding process.
- This condition is described as heterodont.
- The teeth of reptiles and amphibians are all similar in shape and carry out the same function.
- They are said to be homodont.

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 chisellike 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.

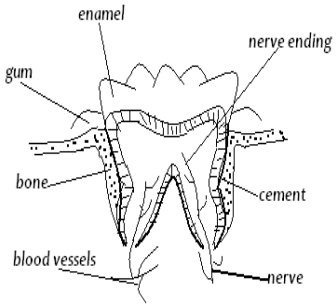
Teeth of Carnivores

- 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-inflamatory 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 flourosis.
- 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 checkup.
- 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

- 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 and juice produced	*pH*	*Contents*	*Food*	*Products*	*Notes*
Salivary glands (Saliva)	7.4	Water, mucus and salts			Soften and lubricate food, provide neutral pH.
		Amylase	Starch	Maltose	Glucose if food stavs mouth.
Stomach (Gastric Juice)	1'.8	Hydrochlori acid	Nucleo-proteins	Nucleic + protein	Not an enzyme but the nuclear proteins. 1. Kills micro-organisms. 2. Provides acidic medium. 3. Activates enzyme pepsinogen and protennin.
		Rennin	Milk protein	Curd coagulated milk (casein)	abundant in infants prorennin.

		Pepsin	Protein	Peptones	Secreted as pepsinogen
Pancreas (Pancreat juice)	8.8	Trypsin	Protein	Peptones	Secreted as trypsinogen activated by enterokinase trypsin
		Chymotrypsin	Peptones, casein	Amino acids	Secreted as chymotrypsin activated to trypsin.
		Amylase	Starch glycogen	Maltose Maltose	
		Lipase	Lipids	Fatty acids and	PH in duodenum lowered 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	
		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 mulfunction 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 resistance to diseases of skin is reduced.
B, (Thiamine)	Yeast, whole grain, liver, kidney, beans, meat, spinach	Formation f the enzyme carboxylase important conversion of pyruvic respiration.	Beriberi - swelling of the slowing of heartbeat and intestinal disorder.
B2 (Riboflavin)	Whole grain, eggs, milk, groundnuts, cheese, yeast	Formation of f1avoproteins that form enzymes and for	Sores on tongue surface comers of the mouth.
B3 (Nicotinic	Liver, kidneys, milk, yeast whole grain.	Makes co-enzyme 1 and 2 (NAD & NAD P) It is also co-enzyme A needed in respiration.	Pellagra - inflammation of nervous disorders leading to
B, (Pantothenic acid)	In most foods	Forms parts of co-enzyme A.	Poor co-ordination of 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, vegetables, bananas	In intracellular body fluids buffer and for nerve transmission.	Nervour transmission interfered with.
		Present in tissue fluid.	

Chloride *p*	Table salt, sea foods.	water balance essential for digestion. Constituent of hydrochloric acid.	
Magnesiu	Green vegetables.	Also needed as a co-factor respirator enzymes. contraction.	
Iodine	Iodised table salt food.	Constituent of the thyroxine that controls metabolism.	In young animals leads cretinism. Simple goitre adults.
Manganes e	Eggs, milk, fish.	Activates certain enzymes.	
Iron	Liver, greet leaves, lean meat, grains, milk.	A constituent of haemoglobin and myoblobin.	Anaemia.
Sulphur	Protein foods	A constituent of some 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 iron (found in Vitamin ~2)'	Needed in very small amounts.
Zinc	Fruits and vegetables Seeds of cucubitaceae	Needed for proper growth hair, influences working of insulin.	Needed in very small amounts.
Fluorine	Water, fruits and vegetables.	Strengthening of enamel	Needed in small amounts.
Molybdenu m	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 reuslts 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.

THE END

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

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