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UNIT 1: CLASSIFICATION AND NAMING OF ORGANISMS

There are millions of living organisms in the world. Some of these organisms are related and others are not. Again, these organisms may be called differently by different people. There ought to be a system that will ensure that related organisms are grouped together and also produce a unified identification system so scientist everywhere can have a common name for organisms. This unit introduces participants to scientific classification of organisms. The unit will expose learners to the concept of classification, organization plan of classification, the binomial system of nomenclature and the characteristics/ Life processes of living things.

Learning outcome(s)
By the end of the unit, the participant will be able to:

- demonstrate understanding of the concept of classifying organisms
- outline the use of a hierarchical system for grouping organisms
- explain the binomial system of naming organisms.
- describe life processes of living things.



Session 1: Concept of biological classification

In this session, we will focus on the concept of classifying living things. The principle behind classification and the importance of classification will be discussed.

Learning outcomes
By the end of the session, the participant will be able to:

1. define classification of living things.
2. enumerate some importance of classifying living things.

In everyday life, we classify different items into groups on the basis of some shared features they have in common. This act is also done in the biological world by scientists. Biological classification can be defined as grouping living things according to their structural or physical similarities. Biological classification is also seen as the scientific procedure of arranging organisms into a hierarchical series of groups and sub-groups on the basis of their similarities.
A group of organisms is similar enough to be classified together by certain characteristics. Characteristics are the appearance/form and behaviour/function of something. These characteristics decide which organisms will be placed in a group. For example, a dog has limbs, but a snake does not. A dog and a snake can move, but plants cannot. These are the characteristics of different organisms. These features help scientist to classify them into different groups.

Importance of classification

Classifying organisms comes with lots of benefits. Some of the importance associated with classification of organisms are listed below:

- Classification helps us to make sense out of the overwhelming number different kinds of organisms.
- It helps scientists to identify new organisms by enabling them find what group an organism belongs to.
- It makes study of organisms easy

- Classifying organisms helps to understand the relationship, similarities, and differences between different organisms.
- Classification simplifies the understanding of the characteristics of organisms.

Session 1: Organization plan of classification

We have seen that scientists classify organisms based on the features expressed by the organisms. However, there may be organisms that may share some specific features while other organisms may share broad features. For instance, both cat and bird are animals but they differ extremely. To further ensure that more similar organisms are grouped together, scientists use a system like an organizational plan to identify organisms. In this session, we will discuss the organizational plan of biological classification.

Learning outcome(s)

By the end of the unit, the participant will be able to:

- demonstrate understanding of the hierarchical system of biological classification.
- outline the various taxonomic ranks

From the historical point, Aristotle classified different animals based on the habitat, characteristics, etc. This was an attempt to group organisms. Later, a Swedish botanist Carolus Linnaeus introduced a system where organisms can be ranked and put into groups. This created a sort of organogram for classifying organisms. This organizational plan for classifying organisms is known as the taxonomic hierarchy Categories. Thus, the hierarchical system of biological classification was born. This system of classification is followed globally till date.

Taxonomic hierarchy refers to the sequence of categories in increasing or decreasing order. In other words, taxonomic hierarchy is the process of arranging various organisms into successive levels of the biological classification either in a decreasing or an increasing order from kingdom to species and vice versa. This means that organisms are grouped based on broad features to the narrowest of features or vice versa.
Each of this level of the hierarchy is called the taxonomic category or rank. The word “Taxonomy” is derived from a Greek word – “taxis”, meaning arrangement or division, and “nomos”, meaning method. Taxonomy is a branch of Biology that refers to the process of classifying different living species. A taxon is referred to as a group of organisms classified as a unit. The taxonomic ranks into which organisms are classified are the kingdom, phylum, class, order, family, genus and species.

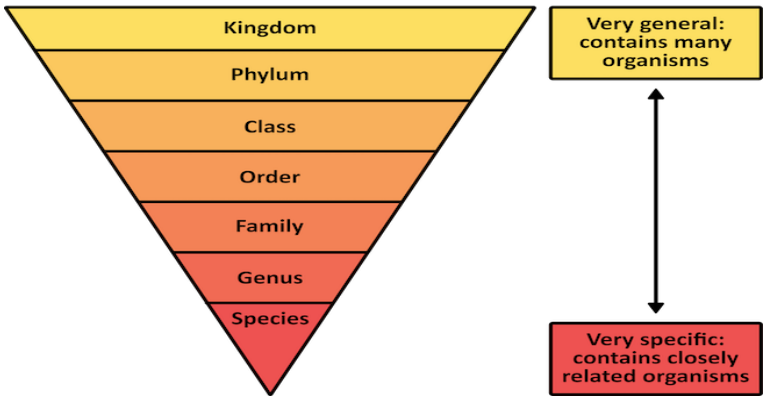


Figure 1: Hierarchical taxonomic arrangement

Kingdom

The kingdom is the highest level of classification, which is divided into subgroups at various levels. There are 5 kingdoms in which the living organisms are classified, namely, Animalia, Plantae, Fungi, Protista, and Monera (Prokaryotae) Organisms at the kingdom level will share very broad characteristics which may not be so similar. For instance, elephants and snakes belong to kingdom Animalia.

Phylum (plural, phyla)

This is the next level of classification and it is more specific than the kingdom. This means that organisms that belong to the same phylum will share more peculiar features than those that belong to different phylum. In the kingdoms Fungi and Plantae the equivalent term for Phylum is Division.

Class

The class ranks below the phylum. Members of a class share more characteristics with each other than they do with other organisms in the same phylum. Amphibians and reptiles both belong to the phylum chordata, but each belongs to a different class. Members of the class amphibia (chiefly frogs, toads, and salamanders) have moist, smooth skin and reproduce by laying large quantities of jellylike eggs in water. Members of the class reptilia (snakes, lizards, turtles, and tortoises) have dry scaly skin and reproduce by laying small clutches of leathery eggs on land.

ORDER

The order ranks below the class in the taxonomic hierarchy. The groups in an order have more in common with each other than they do with other members of the same class. This means that organisms in the same order resemble each other more than those within the same class. For example, bats and mice belong to the class (Class Mammalia) but bats belong to the Order Chiroptera and the mice the Order Rodentia.

FAMILY

In taxonomy, the family ranks below the order. Members of the same taxonomic family are more closely related to each other than they are to other members of the same order. For example, foxes,

coyotes, lions, and cats, all belong to the Order Carnivora. However, foxes and coyotes belong to the family Canidae. Lions and cats belong to the family Felidae.

GENUS

The genus (plural, genera) is the taxonomic rank between family and species. The groups of organisms in a genus share many structural similarities and are very closely related. Members of a genus are more closely related to each other than they are to other genera in the same family. The cat family, Felidae, includes lions, tigers, domestic cats, and lynx. However, lions and tigers belong to the genus *Panthera*, and domestic cats are part of the genus *Felis*, and lynx are in the genus *Lynx*.

SPECIES

The species is the most fundamental unit in taxonomy and ranks at the base of the biological classification hierarchy. Members of the same species share the same evolutionary history and are more closely related to each other than they are to any other organisms, including other members of the same genus. Organisms are grouped into a species based on physical and genetic similarities. They have several common characteristics and resemble each other closely. All members of a species have the same number of chromosomes. A species is the group of organisms that share similar characteristic features and capable of breeding to produce fertile offspring. The most important factor in species classification is the ability of members to successfully interbreed—that is, to mate and produce viable offspring (those that can in turn breed and produce more offspring). Individuals of the same species can successfully interbreed with one another but almost never with members of other species. Different species within a genus have been known to produce hybrid offspring, but the offspring are almost always sterile. An example of this is the mating of a horse and a donkey, which produces a mule. Because mules are sterile, the interbreeding is not considered successful.

Session 3: The binomial system of nomenclature

Organisms can be found in different locations of the world. Each location may have their different language and dialects. For instance, in Ghana, different tribes have different names for dog. Multiple local names make it extremely difficult to identify an organism globally and keep a track of the number of species. Thus, it creates a lot of confusion. To get rid of this confusion, a standard protocol came up. According to it, each and every organism would have one scientific name which would be used by everyone to identify an organism. This process of standardized naming is called the Binomial Nomenclature. In this session, we are going to discuss the binomial system of nomenclature.

Learning outcome(s)

By the end of the unit, the participant will be able to:

- describe the binomial system of nomenclature.
- demonstrate understanding of how to write scientific name for organisms.

Binomial nomenclature is the biological system of naming organisms through the use of two names where, the first part indicates the genus and the second part indicates the species of the organism**.** The binomial nomenclature was proposed by Carolus Linnaeus (1707-1778). The binomial nomenclature is used to come up with a scientific name for a species . In this system each organism has two names which could be Latin (most often) or Greek. The two names are composed of a **generic name** (coming from the genus of the organism) beginning with a capital letter and the second which is the **species name** (coming from the species of the organism) beginning with a lower case. The system can commonly be likened to a general name and a specific name or family name/surname and first name of a person. When handwritten the two names are underlined separately e.g. Anopheles gambiae. If typewritten, they are put in italics (*Anopheles gambiae*) but not underlined.

Session 4: Characteristics/ Life processes of living things

The universe is made up of lots of different materials. There are microscopic particles that cannot be seen with the naked eye. Of those materials that can be seen, some do not have life while others are living. How can we distinguish between things that are living and those that are not? This session will take a critical look at processes expected to be seen in organisms that are living.

Learning outcome(s)

By the end of the unit, the participant will be able to:

- outline the life processes of living things
- describe the life processes of living things
- distinguish between living and non-living things.

Life processes are series of actions that are essential to determine if an organism is alive. These processes are undertaken by all living things including plants and animals. They are necessary and essential for the survival of the organisms. Among many organisms, the inability to perform some of these life processes could be detrimental to the existence of the organism. These life processes are movement, respiration, sensitivity, growth, reproduction, excretion and nutrition. Let's discuss each of these processes.

Movement

All living things including plants move. Animals move to look for food and shelter, and to escape from danger. They have bodies that support the ability to move. Most animals can move their whole body from one place to another. This is known as locomotion. The movement in plants is mostly seen as bending, turning, twisting or elongation of parts of the plant. Plants movements are mostly towards sunlight, or roots growing into the soil.

Reproduction

Reproduction is a biological process by which organisms bring forth offspring that are biologically similar to the parent organism. Reproduction enables and ensures the continuity of species,

generation after generation. It is the main feature of life on earth. Some organisms reproduce by giving birth to young ones, others lay eggs while in others parts of their bodies are used to produce young ones. Thus, reproduction can be sexual or asexual. Asexual reproduction refers to the type of reproduction in which only a single organism gives rise to a new individual while sexual reproduction involves the production of an offspring by the fusion of male and female gametes.

Sensitivity

All living things can respond to changes in their surroundings. Thus, they notice and react/respond to changes around them. Animals use their senses to see, hear, taste, touch and smell the world around them. Plants move towards sunlight and water and they also respond to touch.



Figure 2: Seedling moving towards light.



Figure 3: Mimosa plant folding up due to touch

Growth

All living things grow. Thus, they become bigger, taller and heavier over time.
Animals grow from babies to adults and seeds grow into plants. Animals including human beings grow at a fairly steady pace until they reach adulthood. Every day as they get older their bodies are changing. Their skeleton grows with them, each bone getting bigger over time. Other animals such as insects, spiders, crabs and other animals with external skeletons – grow by shedding their skeleton and grow a new one! Plants also grow by increasing in height and width. Some plants grow from seeds (germination) to adult plants.

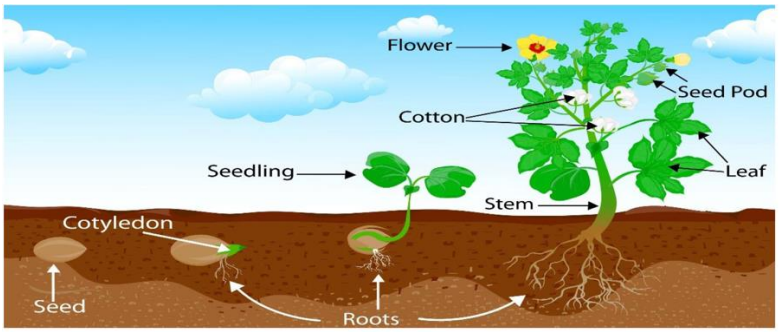


Figure 4: Process of plant growth

Respiration

All living things use oxygen in the air for survival. The oxygen helps the organism to break down nutrient to get energy. This process is described as respiration. Respiration is the process in which organisms exchange gases between their body cells and the environment to convert glucose to energy. Respiration is a chemical reaction and occurs in every cell in living things.

Excretion

All living things get rid of waste – like when humans sweat or urinate. Excretion is the process by which metabolic waste materials produced by the body are removed. In animals, excretion gets rid of carbon dioxide, water and other harmful substances from your body. Plants get rid of water, and wastes such as resins, saps, latex and tannins.

Nutrition

All living things require energy in order to survive. The energy is derived from nutrients, or food. This allows living things to grow and heal. Green plants, algae, and some bacteria can make their own food from water and carbon dioxide via a chemical reaction called photosynthesis. Photosynthesis relies on a chemical called chlorophyll, which helps to capture the light energy needed to convert water and carbon dioxide into glucose, a basic sugar that the organism can then use for respiration.

However, animals need to get their nutrients from external sources: either by eating plants, or other animals. Different types of animal have evolved to have very different diets, but there are three main groups:

Carnivores - exclusively eat meat

Herbivores - exclusively eat plants

Omnivores - eat both meat and plants

All living things undergo all these processes in order to survive. Thus, we are able to distinguish between living and non-living things based on the life processes. On your own, identify some differences between living and non-living things?

Key ideas

- Biological classification ensures that related organisms are grouped together and also produces a unified identification system so scientist everywhere can have a common name for organisms.
- Organisms have been grouped based on broad features to the narrowest.
- All living things are named by two names emanating from their genus and species.
- Living things have processes they all undergo in order to survive.

Reflection

- How do you organisms get their taxonomic names?
- How do life processes of organisms affect their habitat?

Discussion

- How will you distinguish living things from non-living things?
- Discuss the consequence of an organism will suffer if it fails to undergo a named life process.

UNIT 2: CELL

Complex structures are always made up of small parts that come together to make a complete whole. For instance, buildings are made up of blocks that come together make the whole edifice. This is how living things have been structured. This unit will discuss the organizational structure of living things starting from the cell, the cell theory and classification of cells, cell structure and organelles, functions of the organelles of a cell, differences that exist between plant and animal cells and cells in relation to tissues, organs, systems and organism.

Learning outcome(s)

By the end of the unit, the participant will be able to:

- demonstrate understanding of the cell as basic unit of life.
- outline the cell theory.
- classify different types of cells.
- describe the structure of a cell.
- identify the functions of organelles of the cell.
- different between plant and animal cells.

The cell is a membrane-bound unit that contains the fundamental molecules of life and of which all living things are composed. In other words, cells are the basic building blocks of all living things. The human body is composed of trillions of cells. Cells provide structure for the body, take in nutrients from food, convert those nutrients into energy, and carry out specialized functions.

Session 1: The cell theory

Early prediction and speculation about the nature of the cell were generally unsuccessful. The decisive event that allowed the observation of cells was the invention of the microscope in the 16th century, after which interest in the "invisible" world was stimulated. Cell theory was not formulated for nearly 200 years after the introduction of microscopy. Explanations for this delay range from the poor quality of the microscopes to the persistence of ancient ideas concerning the definition of a fundamental living unit. Many observations of cells were made, but apparently none of the observers was able to assert forcefully that cells are the units of biological structure and function. Three critical discoveries made during the 1830s, when improved microscopes with suitable lenses, higher powers of magnification without aberration, and more satisfactory illumination became available, were decisive events in the early development of cell theory. In this session, we will briefly discuss the cell theory.

Learning outcomes

By the end of the session, the participant will be able to:

- outline the tenets of the cell theory.

The cell theory is a scientific theory that describes the properties of cells. In 1839 German physiologist Theodor Schwann and German botanist Matthias Schleiden promulgated that cells are the "elementary particles of organisms" in both plants and animals and recognized that some

organisms are unicellular and others multicellular. This theory marked a great conceptual advance in biology and resulted in renewed attention to the living processes that go on in cells.
Essentially, the cell theory is the first three statements below but have been expanded to include some modern ones:

a. All living things are made up of cells and the products of cells such as scales
b. The cell is the structural and functional unit of all living things
c. All cells come from pre-existing cells by division-spontaneous generation does not occur
d. Cells contain hereditary material (DNA) which is passed from cell of the next generation during cell division
e. All cells are basically the same in chemical composition
f. All energy flow (metabolism and biochemistry) of life occurs within cells
g. The activity of an organism depends on the total activity of independent cells.

The cell theory holds true for all living things; no matter how big or small or how simple or complex.

Session 2: Types of cells

There are variety of organisms on earth. These organisms compose of cells. In this session, we will take a look at the types of cells.

Learning outcomes

By the end of the session, the participant will be able to:

- demonstrate understanding of the types of cell
- outline the characteristics of prokaryotic cells.
- enumerate the characteristics of eukaryotic cells
- identify differences between prokaryotic and eukaryotic cells.

Cells fall into one of two broad categories: prokaryotic and eukaryotic. The single-celled organisms of the domains Bacteria and Archaea are classified as prokaryotes (pro = before; karyon– = nucleus). Animal cells, plant cells, fungi, and protists are eukaryotes (eu = true). All cells share four common components:

1. plasma membrane-an outer covering that separates the cell's interior from its surrounding environment
2. cytoplasm – consisting of a jelly-like cytosol within the cell in which there are other cellular components
3. DNA – the cell's genetic material and
4. Ribosomes – which synthesize proteins.

However, prokaryotes differ from eukaryotic cells in several ways. Let's discuss the two types of cells.

Prokaryotic cells

A prokaryotic cell is a simple, single-celled (unicellular) organism that lacks a nucleus, or any other membrane-bound organelle. Example of prokaryotic cell is bacteria. Organisms with prokaryotic cells are called **prokaryotes**. They were the first type of organisms to evolve and are still the most common organisms today. The cell size ranges from 0.1 to 0.5 μm in diameter. Prokaryotic DNA is found in the central part of the cell in a darkened region called the nucleoid.

Prokaryotes have a cell wall made of peptidoglycan, comprised of sugars and amino acids, and many have a polysaccharide capsule. The cell wall acts as an extra layer of protection, helps the cell maintain its shape, and prevents dehydration. The capsule enables the cell to attach to surfaces in its environment. Some prokaryotes have flagella, pili, or fimbriae. Flagella are used for locomotion, while most pili are used to exchange genetic material during a type of reproduction called conjugation. Conjugation is a process by which one bacterium transfers genetic material to another through direct contact. Bacteria use fimbriae to attach to a host cell.

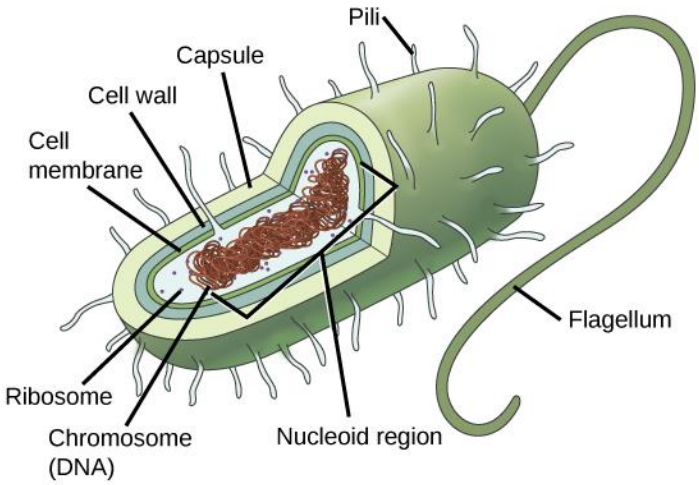


Figure 5: A generalized structure of a prokaryotic cell.

Eukaryotic cells

Eukaryotic cells can be found in animals, plants, protists, and fungi. Eukaryotes are organisms composed of eukaryotic cells. Eukaryotic cells are usually larger than prokaryotic cells, and they are found mainly in multicellular organisms.

Eukaryotic cells have a membrane-bound nucleus where their DNA is stored. Eukaryotic cells also contain other organelles besides the nucleus. An **organelle** is a structure within the cytoplasm that performs a specific or specialized job in the cell. Since organelles are membrane bound, each function occurs in a different compartment within the cell. The word eukaryotic means "true kernel" or "true nucleus," alluding to the presence of the membrane-bound nucleus in these cells. The word "organelle" means "little organ".

Session 3: Cell structure and organelles

Cells have many parts, each with a different function. As seen in the earlier session, organelles are structures within the cytoplasm that perform specialized tasks within the cell. In this section, we will discuss the various organelles found within a eukaryotic cell.

Learning outcomes

By the end of the session, the participant will be able to:

- describe the organelles of the cell
- enumerate functions of the organelles

Cell Structure

The cell structure comprises individual components with specific functions essential to carry out life's processes. These components include- cell membrane, cytoplasm, nucleus, and cell organelles.

Cell membrane

The cell membrane, or plasma membrane, is a selective permeable biological membrane that surrounds the cytoplasm of a cell. It is a selective membrane because it allows some materials to pass through while blocking or refusing to let other materials from entering through. In other words, its selects materials that can enter the cell.
This is mainly because of the sizes and polarity of molecules.

In animals, the plasma membrane is the outer boundary of the cell, while in plants and prokaryotes it is usually covered by a cell wall. This membrane serves to separate and protect a cell from its surrounding environment. The cell membrane supports and protects the cell. It controls the movement of substances in and out of the cells. It separates the cell from the external environment. The cell membrane is present in all the cells. The cell membrane is the outer covering of a cell within which all other organelles as well as the cytoplasm and nucleus are enclosed.

Cytoplasm

The organelles of a cell sit in a matrix called **cytoplasm**. The part of the cell referred to as cytoplasm is slightly different in eukaryotes and prokaryotes. In eukaryotic cells, which have a nucleus, the cytoplasm is everything between the plasma membrane and the nuclear envelope. In prokaryotes, which lack a nucleus, cytoplasm simply means everything found inside the plasma membrane.

One major component of the cytoplasm in both prokaryotes and eukaryotes is the gel-like **cytosol**. In eukaryotes, the cytoplasm contains the membrane-bound organelles, which are suspended in the cytosol. The cytoskeleton, a network of fibers that supports the cell and gives it shape, is also part of the cytoplasm and helps to organize cellular components.

Nucleus

The nucleus contains the hereditary material of the cell, the DNA. It sends signals to the cells to grow, mature, divide and die. The nuclear envelope is a double-membrane structure that constitutes the outermost portion of the nucleus. The nuclear envelope is punctuated with pores that control the passage of ions, molecules, and RNA between the nucleoplasm and cytoplasm. The nucleoplasm is the semi-solid fluid inside the nucleus, where we find the chromatin and the nucleolus. The nucleolus appears as a rounded darkly stained structure inside the nucleus

Cell organelles and their functions

Ribosomes

Ribosomes are the cellular structures responsible for protein synthesis. They are tiny organelles (20 nm in diameter) that are found in large numbers throughout the cytoplasm. Ribosomes are

found in practically every cell because of their function of processing proteins. This makes them particularly abundant in cells that synthesize large amounts of protein. Ribosomes can be found either floating freely or bound to a membrane.

Endoplasmic reticulum

The endoplasmic reticulum (ER) is a series of interconnected membranous sacs and tubules. The ER is involved in the transportation of substances throughout the cell. The ER comes in two forms: the rough ER and the smooth ER.
The rough ER has ribosomes on its surface. The smooth ER on the other hand lacks ribosomes. Rough ER is concerned with the transport of proteins which are made by ribosomes on its surface. The smooth ER is involved in lipid synthesis.

Golgi apparatus/complex

The golgi apparatus consists of a stack of flattened, membrane-bound sacs called cisternae. There is a system of associated vesicles (small sacs) called Golgi vesicles. The function of the Golgi complex is to transport and chemically modify the materials contained within it. It is particularly important in secretory cells.

Mitochondria

Mitochondria (singular = mitochondrion) are often called the "powerhouses" or "energy factories" of a cell because they are site for production of energy. Cells with high energy requirements possess great number of mitochondria. Each mitochondrion is bounded by two membranes; the outer one being separated from the inner by a narrow space called the intermembranal space. The inner membrane is folded inwards into several shelf-like cristae. The cristae increase the surface, providing space for the components of the respiratory chain.

The Centrosome

The centrosome is a microtubule-organizing center found near the nuclei of animal cells. It contains a pair of centrioles, two structures that lie perpendicular to each other. Each centriole is a cylinder of nine triplets of microtubules. The centrosome (the organelle where all microtubules originate) replicates itself before a cell divides, and the centrioles appear to have some role in pulling the duplicated chromosomes to opposite ends of the dividing cell.

Lysosomes

Lysosomes protect the cell by engulfing the foreign bodies entering the cell and help in cell renewal. Therefore, they are known as the cell's suicide bags.

Chloroplasts

Chloroplasts are plant cell organelles that carry out photosynthesis. Photosynthesis is the series of reactions that use carbon dioxide, water, and light energy to make glucose and oxygen. Chloroplasts have outer and inner membranes, but within the space enclosed by a chloroplast's

inner membrane is a set of interconnected and stacked fluid-filled membrane sacs called thylakoids. The chloroplasts contain a green pigment called chlorophyll, which captures the light energy that drives the reactions of photosynthesis

Vacuoles

Vacuoles are membrane-bound sacs that function in storage and transport. The membrane of a vacuole does not fuse with the membranes of other cellular components. Additionally, some agents such as enzymes within plant vacuoles break down macromolecules. Plant cells each have a large central vacuole that occupies most of the area of the cell

Session 4: Differences between plant and animals

In the previous session, we discussed the various organelles that can be found in a cell. During the discussion, it could be seen that specific mentions were made as to whether such organelles are found in animal or plant cell. In this session, we are going to briefly different between plant and animal cells**.**

Learning outcomes
By the end of the session, the participant will be able to:

- differentiate between plant and animal cells

Although both plant and animal cells are eukaryotic cells, there are some differences in terms of the organelles that are present or absent in them.

Animal cell	Plant cell
It does not have a cell wall.	Has a cell wall composed of cellulose.
Vacuoles are usually small and sometimes they are absent.	Presence of a large vacuole
Cilia is present in most animal cells	Cilia is absent
Absence of plastids.	Presence of plastids.
Presence of lysosomes.	Lysosomes are very rare
Animal cells have centrosomes.	Centrosomes are absent in plant cells

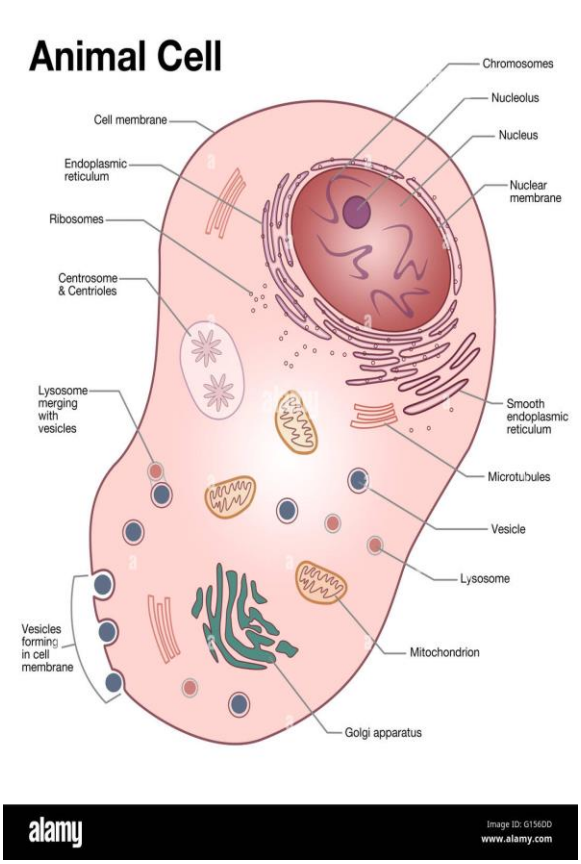


Figure 6: A generalized animal cell

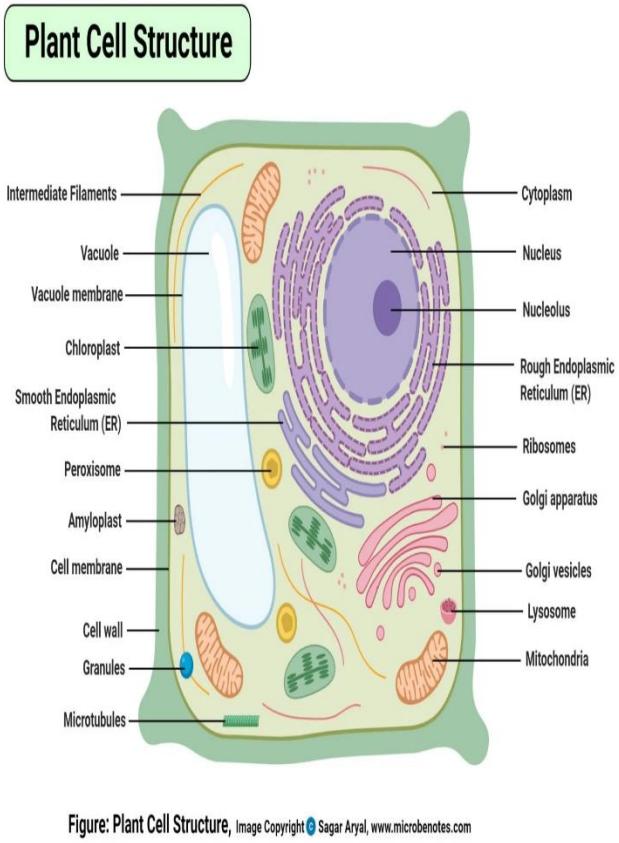


Figure 7: A generalized plant cell

Session 5: Levels of Organization

Living things are highly organized and structured. Following a hierarchy that we can examine from one level to the other or on a scale from small to large. The **atom** is the smallest and most fundamental unit of matter. Atoms come together to form **molecules.** In the same light, the cell being the basic block forms part of a complex structure. In this session, we will describe the complex structure of living things in relation to cells.

Learning outcomes

By the end of the session, the participant will be able to:

- describe the organizational structure of living things.

Cells have been seen to be the basic building block of all living things. Cells are made up of unit aggregates of macromolecules surrounded by membranes and these are what we know as organelles. In complex organisms such as plants and animals, cells form tissues, organs, and organ systems. Tissues are groups of cells that have similar structures and functions. For example, connective tissues, one of the four types of animal tissue, are found between organs. Organs are groups of tissues that carry out a specific function or set of functions and may be comprised of either similar or different tissue types. The heart, for example, is found in most animals and pumps

blood throughout the body to provide other organs with oxygen and nutrients as well as remove waste products. Finally, groups of organs make up organ systems that work together to carry out vital processes. For example, the animal's cardiovascular system is comprised of the heart, vessels, and blood. In plants, a diverse set of tissues create the root and shoot system that provides different functions. Ultimately, the organ systems come together to make the organism.

- Cells are the basic building blocks of all living things.
- All cells arise from pre-existing cells.
- Organisms can either be eukaryotic or prokaryotic
- Eukaryotic cells have organelles that perform specific function to help sustain the cell and ultimately the organism.
- Plants and animals differ in terms of the components of their cells.
- There is biological organizational structure that sustains life.



Figure 8: Biological levels of organization

Key Ideas

Reflections

- How does the presence of organelles affect the sustenance of life of organisms?
- How does the difference between plant and animal cells affect plant and animal life?

Discussion

- Discuss the fate of a cell that has a malfunctioning mitochondrion.
- Justify why animal cells do not need a chloroplast.

UNIT 3: STRUCTURE AND FUNCTION OF FLOWERING PLANTS

Plants belong to kingdom Plantae and can produce their own food. The ability to produce their own food through a process called photosynthesis sets them apart from other organisms. Plants serve as the primary producers in the food chain which make them very critical in the survival of other organisms in the ecosystem. There are different types of plants but for this unit we are going to discuss structure and function of flowering plants. The unit will focus on discussing the structure and function of vegetative parts of flowering plants, the two groups of flowering plants (monocots and dicots), the reproductive parts of a flowering plant**,** pollination, agents that facilitate pollination and finally fertilization.

Learning outcomes
By the end of this unit, you should be able to:

- describe the structure and function of the vegetative parts of a flowering plant
- distinguish between monocot and dicot plants
- describe the reproductive part of a flowering plant
- describe the functions of parts of the flower
- draw half and full flowers
- explain pollination and the various types
- define fertilization

SESSION 1: STRUCTURE AND FUNCTION OF VEGETATIVE PARTS OF A FLOWERING PLANT

Plants have different parts. These parts can be grouped broadly into the vegetative parts and the reproductive parts. The vegetative parts of a plant are those parts that do not participate in sexual reproduction process. All flowering plants have three main vegetative parts which the leaves, stem, and roots. These parts are grouped into two systems. The leaves and stem form the shoot system and the roots constitute the root system. This session seeks to describe the various parts of the vegetative parts of flowering plant~~s~~.

Learning outcomes
After going through this session, you should be able to;

- describe the parts of the shoot system of a plant
- identify the types of roots

The two systems of the vegetative parts of the plant are the shoot and root systems.

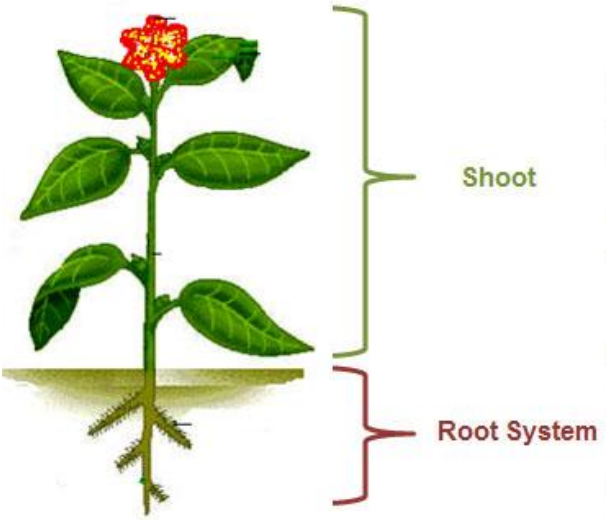


Figure 9: The two systems of flowering plants

The shoot system

The shoot system of plants grows above ground and are made up of the leaves and stem. Leaves form on the stem at places known as nodes. The gap between two nodes is called the internode.

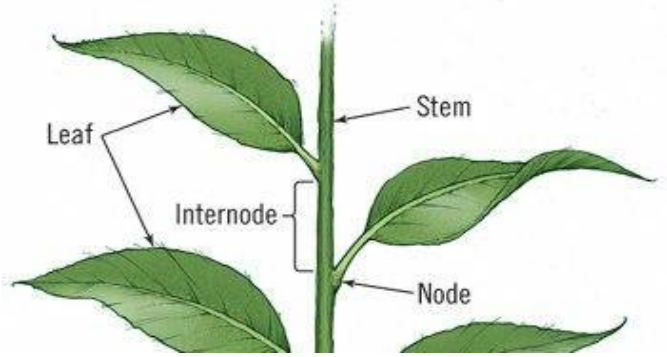


Figure 10: Stem showing nodes and internodes

Leaves

The leaves are outgrowth of the shoot apex and mostly have a flattened portion known as the blade or lamina and a stalk called petiole. A complex system of veins runs through the lamina with a main vein called midrib. The midrib arises from the leaf base and runs through the petiole and the lamina ending at the tip of the leaf. The margin of the leaf which is the edge of the lamina may be smooth or serrated. The angle between the petiole and the stem is the axil. The axils contain axillary or lateral buds which may develop into lateral shoots or flowers.

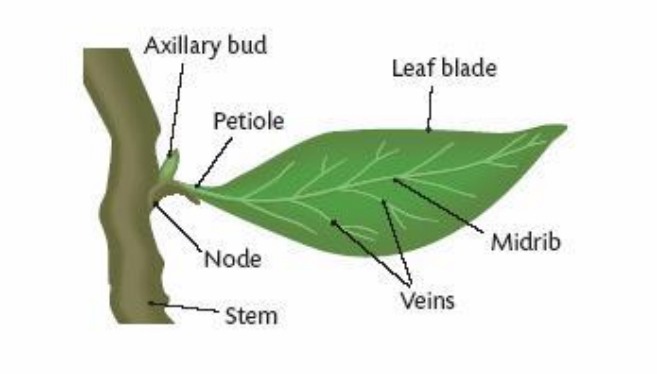


Figure 11: Stem with a leaf

In figure 12, we can see that there are veins on the leaf. The pattern of veins on a leaf is called venation. There are two common types of venation: parallel venation and net (reticulate) venation. In parallel venation, the veins run alongside each other while in net or reticulate venation the veins form a branching network.



Parallel venation



Net venation

Figure 12: Leaf venations in flowering plants

Functions of the leaves

The leaves serve numerous functions to the plant. Some of the functions are listed below.

Photosynthesis- the leaves are light capturing photosynthetic organs of most plants. They help the plant to make its own food through a process called photosynthesis. Through this process plants obtain the food they need to live.

Gas exchange-Plants take in carbon dioxide and release oxygen through their leaves.

Transpiration- Plants lose water through their leaves. As a result, fresh water enters the leaves through the midrib and veins.

Food storage- some plants store their food in the leaves.

Stems

A stem is the main axis of a plant along with its lateral branches. The stem of a flowering plant terminates in tissue that allows the stem to elongate and produce leaves. The stem supports leaves in such a way that each leaf is exposed to as much sunlight as possible. As already mentioned, the leaves are attached to the stem at the nodes and the region between two nodes is the internode. The presence of nodes and internodes is used to identify stems. In some plants the nodes of horizontal stems asexually produce new plants.

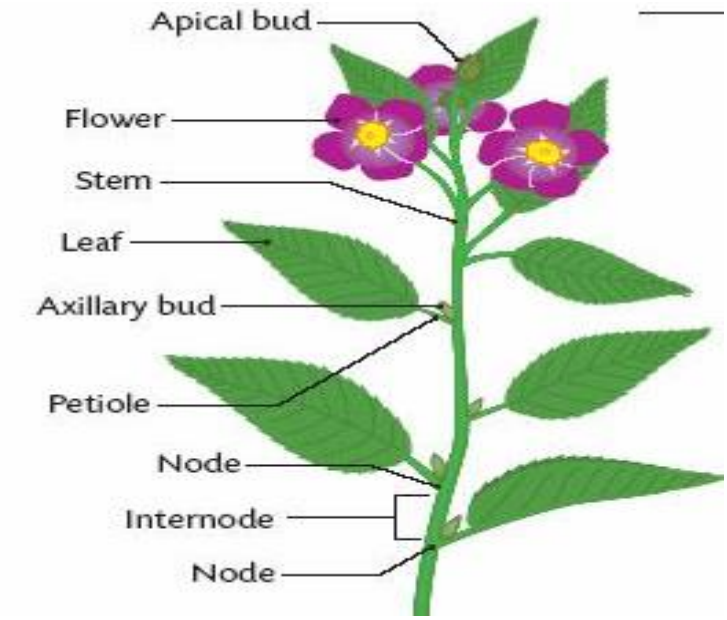


Figure 13: Structure of a stem of a flowering plant

Functions of stem

Now that we have seen the structure of the stem, let us take a look at some of the functions the stem performs for the plant.

1. Stems support leaves so that the leaves will have enough sunlight for photosynthesis.
2. Stems conduct water from the roots to all parts of the plants.
3. They also transport inorganic nutrients from the roots to all parts of the body.
4. They bring products of photosynthesis to where they needed or stored.

Roots

Roots are the parts of the plant usually found below ground or in the soil. They anchor the plant in the soil. As you may be aware, the roots of mango tree are different from that of maize. This indicates that there are different types of roots. The types of roots are taproot, adventitious roots and fibrous roots. Taproots grow deep into the soil and consist of one main vertical root that develops from the radicle of the embryo. The taproots give rise to lateral roots. The adventitious and fibrous roots grow from parts of the plant other than the radicle of the embryo. The adventitious roots develop from the lower part of the stem. The fibrous roots have no predominant root and are made up of thin roots spreading out below the soil surface. The fibrous roots are usually shallower and concentrated in the upper few centimetres of the soil.

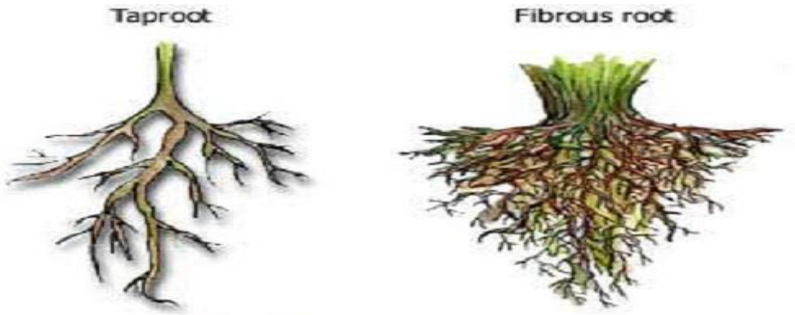


Figure 14: Types of root

Functions of roots

1. The root is the organ that anchors the plant in the soil. It is the root that holds the plant firmly in the soil so that it can survive.
2. It absorbs water from the soil.
3. Roots also absorb minerals from the soil.
4. Some roots store organic nutrients.

SESSION 2: MONOCOTS AND DICOTS

Plants differ in various forms. As you are aware, grasses are different from mango trees. These differences manifest in various parts of the plant. This session will explore the types of flowering plants.

Learning outcomes:

By the end of this session, you will be able to;

- identify a monocot plant.
- identify a dicot plant.
- distinguish between dicots and monocots.

Now read on…

Differences between monocots and dicots

Flowering plants are divided into two groups based on the number of cotyledons or seed leaves in the embryo. The cotyledons provide nutrient for the seedlings before they develop leaves capable of undergoing photosynthesis. Plants with one cotyledon are known as monocotyledonous (monocots) plants while plants with two cotyledons are called dicotyledonous (dicots) plants. In the previous session, we had discussions on the vegetative parts of the flowering plants. These parts of the plants differ between dicots and monocots. Aside these vegetative parts that differ, other parts of the plants differ based on the number of cotyledons. We are now going to look at how monocots and dicots differ.

From our earlier discussion, we noted that monocots and dicots differ based on their cotyledons. Dicots have two cotyledons while monocots have one cotyledon. The leaves of monocots have parallel venation but that of dicots exhibit net venation. In the stems, the vascular tissue (these are the tissues that help the stem to transport of substances) of monocots are scattered but that of the dicots are usually arranged in ring. Monocots usually have fibrous root with dicots having taproot. In most monocots, the floral parts are usually in multiples of three but that of dicots are in multiples of four or five.

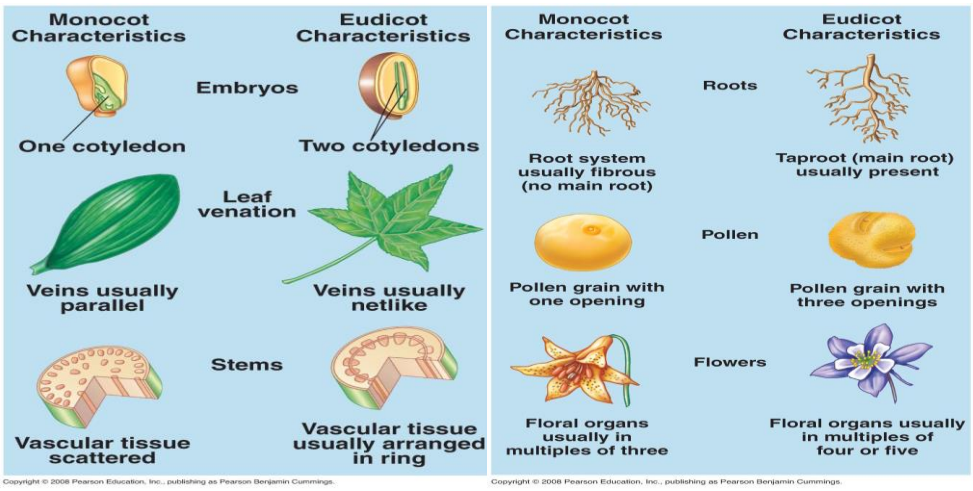


Figure 15: Differences between monocots and dicots.

SESSION 3: REPRODUCTIVE PARTS OF A FLOWERING PLANT

One of the characteristics of living organisms is their ability to reproduce. There are organs that facilitate the process of reproduction in living organisms. This session seeks to discuss the reproductive parts of flowering plants.

Learning outcomes:
After studying this session, you should be able to;

- identify the reproductive part of the flowering plant.
- describe the parts of a flower
- identify the functions of the various parts of the flower.

Flower Structure
The flower is the part of the plant which produces gametes. It is the reproductive part necessary for sexual reproduction in plants. A flower may be solitary (single) or in clusters. A cluster of flowers is called an inflorescence and have a stalk called peduncle. The stalk of each flower is known as pedicel. However, if the flower has no stalk it is described as sessile. The flower is a specialized shoot that can have up to four rings of modified leaves or whorls which are attached to a receptacle. These whorls are sepals, petals, stamen, and carpels. The sepals are usually green which start at the base of the flower and enclose the flower before it opens. The sepals may be free or fused(united). Sepals that are free are known as polysepalous and those that are fused or united are called gamosepalous. The sepals protect the flower at the bud stage and supports inner whorls. The sepals are collectively called calyx.

The petals are found above the sepals. Most petals are brightly coloured to aid in attracting pollinators. Petals of flowers that are pollinated by wind generally are not brightly coloured. The petals could also be free or fused. What was the name for fused or free sepals? The petals also have similar names. Thus, petals that are fused are known as gamopetalous and those that are free are

called polysepalous. The petals are collectively called corolla. If the petals and sepals are similar making distinguishing between them difficult, then they are collectively called the perianth. The sepals and petals are the sterile floral parts meaning that they are not directly involved in reproduction.

The stamens are considered as the male part of the flower because it holds the part that produces the male gamete. A stamen consists of a stalk called the filament and a terminal sac called the anther. The anther produces pollen grains. The stamens are collectively called the androecium. Carpels (pistils) are the female reproductive parts of the flower. A carpel is made up of a swollen base called the ovary, a stalk that is called the style and a sticky or hairy stigma which receives the pollen. The ovary contains the ovules which contains the female gametes. When the ovary is attached above the other floral parts then such ovary is described as a superior ovary (hypogynous flower) and when the ovary is attached below the other floral parts then is known as an inferior ovary (epigynous flower). Some plants have their flowers possessing both the male and female parts of the flower while others may have one of them. When both male and female parts are present in the same flower, such flower is described as bisexual or hermaphrodite. Unisexual flowers have only the male or the female parts. Flowers differ in shape, colour, scent and size. When it comes to shape, flowers can be described as actinomorphic or zygomorphic. Actinomorphic flowers are radially symmetrical indicating that they can be divided into two equal halves by any radial plane which passes through their centre. Zygomorphic flowers on the other hand can be divided into two equal halves by only one radial plane which passes through their centre. Flowers can also be termed as complete or incomplete. Complete flowers are those that have all the floral parts while incomplete flowers lack one or more of the floral parts.

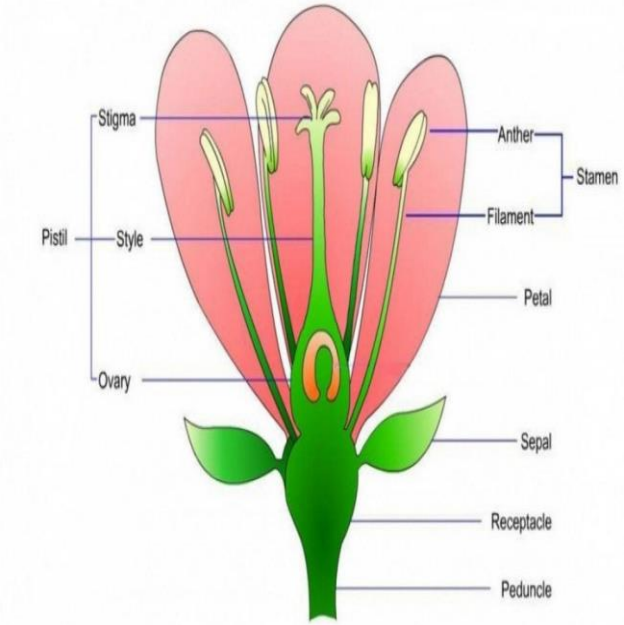


Figure 16: Parts of a flower

SESSION 4: POLLINATION

Plants need to propagate and multiply. There are two forms of reproduction in plants. These are sexual reproduction and asexual (vegetative) reproduction. For sexual reproduction to occur, there should be the mating of male and female gametes. This session will explore the process that facilitates sexual reproduction in flowering plants.

Learning outcomes:
By the end of this session, you will be able to;

- define pollination.
- identify the types of pollination

Pollination is the transfer of pollen grains from the anther of a flower to the stigma. Pollination is an essential stage in sexual reproduction of flowering plants, whereby pollen is transferred from its site of production (the anthers) to the stigma.

Types of Pollination
There are two types of pollination. Self-pollination is the transfer of pollen grains from the anther of a flower to the stigma of the same flower or another flower on the same plant. **Cross-pollination** is the transfer of pollen grains from the anther of a flower to the stigma of a flower on another plant of the same species.

Self-pollination
Adaptation of flowers that make self-pollination likely include the following:

- The flower is bisexual (hermaphrodite), e.g. wild marigold.
- The plants are **monoecious**, i.e. separate male and female flowers occur on the same plant, e.g. maize, coconut.
- The flower is **homogamous**, i.e. the anthers and stigmas mature at the same time, e.g. tomato.
- The flower is **cleistogamous**, i.e. the flower does not open until self-pollination has taken place.
- The flower is buried in the ground

Cross-pollination
Adaptations that make cross-pollination likely include:

- The plants are **dioecious**, i.e. male and female, i.e. male and female flowers occur on separate plants, e.g. pawpaw.
- Each flower is bisexual, but male and female parts mature at different times. The flower is **protandrous** (e.g. cowpea) when the androecium matures first or **protogynous** when the gynaecium matures first.
- Each flower exhibits self-sterility, i.e. the pollen grains cannot germinate on the stigma of the same flower and even if they do, fertilisation cannot occur, e.g. passion flower.
- Each flower is **herkogamous**, i.e. there is a physical barrier between androecium and gynaecium so that the pollen grains cannot reach the stigma. It may be a space, e.g. maize.
- The flowers show **heterostyly**, i.e. male and female parts are of different lengths in flowers of the same species. For example, long style and short stamen and vice versa. This prevents pollen grains reaching the stigma of the same flower.

- The flowers are **chasmogamous**, i.e. they are conspicuously large and adapted to cross-pollination y insects, birds and wind.
- The flowers are **dichogamous**, i.e. male and female parts of the flower mature at different times, ensuring that self-pollination does not occur.
  Cross-pollination is more common than self-pollination. It guarantees variation. Which can help survival of a species.

SESSION 5: AGENTS OF POLLINATION

Plants cannot move from one place to another to ensure that the pollen has been transferred to the stigma. How then does pollination occur in plants? This session will discuss the means through which the pollen can be transferred to the stigma.

Learning outcomes:
After going through this session, you will be able to;
- identify the agents of pollination.
- describe the characteristics of flowers pollinated by insects.

The factors responsible for the transfer of pollen grains to the stigma are referred to as **agents of pollination**. The two most common agents are wind and insects. Water, birds and bats are also known to carry out pollination.

Adaptations of wind Pollinated flowers

Flowers that are wind pollinated are termed as **anemophilous**. Such flowers do not usually have sepals and petals. Even if they are present, these structures are small and inconspicuous. Wind pollinated flowers include Guinea grass, sugar cane and maize.

In wind pollinated flowers, the male inflorescence is found at the top end of the plant. It is made up of long slender branches bearing male flowers only. These occur in pairs, each pair having three stamens. When mature, the anthers hang out of the flowers on long thin filaments. The anthers swing freely in the wind. Wind pollinated flowers produce large quantity of smooth pollen grains. The female inflorescences occur in the axils of leaves lower down the stem. The stigma is feathery, and so provides a large surface area on which pollen grains can be trapped. The flowers are usually not scented.

Adaptations of insect Pollinated Flowers

Insect pollinated flowers are termed as **entomophilous**. They normally have large flowers with bright petals and a sweet scent. The flower also has a nectary which produces nectar. Insects such as bees and butterflies are attracted to the flowers by these features. The stigma is sticky and compact and usually enclosed in the flower. The pollen grains are large and rough which are normally produced in few quantities as compared to wind pollinated flowers. The stamen in insect pollinated flowers are short with stout filaments. Their anthers are usually enclosed in the flower.

SESSION 6: FERTILIZATION

The pollen has been transferred to the stigma during pollination. How does the flower get a young one after this process? This session will discuss the next stage of sexual reproduction in flowering plants.

Learning outcomes:
After going through this session, you will be able to;

- define fertilization.
- explain double fertilization.

Fertilization in plants
After pollination, the next stage of the sexual reproduction process in flowering plants is fertilization. Fertilization is the fusion of the nuclei of the male and female gametes. Fertilization takes place in the ovule in flowering plants. The pollen grain after falling on the stigma will swell up after absorbing water and nutrients. The nucleus of the pollen grain divides into two forming a tube nucleus and generative nucleus. The nucleus of the pollen moves through the stigma through the help of pollen tube. The pollen tube will grow through the style towards the ovary. In the ovary, there are the ovules.

The ovule is made up of an embryo sac and two protective layers called integuments. The embryo sac contains the egg nucleus and two polar nuclei. There is a tiny pore at the end of the embryo sac through which the pollen tube enters the embryo sac. Flowering plants undergo a process called double fertilization. This is where one male nucleus fuses with the egg to form a zygote and the other male nucleus fuses with the polar nuclei to form primary endosperm nucleus. The zygote undergoes cell division to form the embryo. The ovule develops into the seed and the ovary becomes the fruit.
The zygote undergoes cell division to form the embryo. The embryo has the plumule, the radicle and cotyledon. The micropyle remains as a small hole in the seed coat through which water is absorbed during germination.

- Plants have both vegetative and reproductive parts.
- Flowering plants have different structural differences.
- The flower is an integral organ of reproduction in flowering plants.
- Different parts of the flower are suited for different functions
- Plants are adapted differently to ensure pollination

Key ideas

Reflection

- How do flowers adapt themselves to suit a particular form of pollination?
- Plants differ in form and structure to survive

Discussion

- Identify differences between a grass and mango leaf.
- Discuss the probable agent of pollination a flower with sweet scent and nectar.