DIVERSITY AND CLASSIFICATION OF LIVING ORGANISMS

Scientific classification is the grouping of organisms according to similarities and differences in their characteristics. The branch of science that deals with classification of organisms is known as taxonomy.
Taxonomy involves identification of living organisms as they are discovered, grouping them into various levels and naming of organisms scientifically. This enables scientists to make meaning of the great diversity observed among living organisms. It is thought that humans share the earth with an uncountable number of organisms, which all needed to be classified in order to make meaning out of them. During identification, classification and naming, morphological, anatomical and physiological similarities and differences are considered. Characteristics which change depending on the environment of an organism are not usually considered.

IMPORTANCE OF CLASSIFYING ORGANISMS

Classifying organisms is important for the following reasons:

1) Enables easy identification of living organisms. After discovery of new organisms, they can easy be identified by comparison with already identified organisms.
2) It eases the studying of living organisms by studying them in groups as opposed to studying each individually.
3) Enables scientists to establish evolutionary relationships among living organisms. Related organisms are usually grouped together and unrelated organisms are grouped separately.
4) To assign every species of living organisms a scientific name that differentiates it from the rest. This prevents confusion that may occur with using common names.

TYPES OF CLASSIFICATION

There are two forms of classification basing on the principles used.

a) **Artificial classification**

This involves grouping organisms for the convenience of study of such organisms. Therefore this classification is based on simple easily observable characteristics. Such characteristics may include size, habitat, ways of movement, etc. For example organisms in kingdom *protoctista* are simply placed there due to being eukaryotic and unicellular, though they have no evolutionary relationship between them.

b) **Natural classification**

This is where classification is based on similarities and differences in many external and internal characteristics in order to bring out the natural relationship between organisms. This system of classification uses information from many branches of biology in order to establish the phylogenetic relationships between groups of organisms. A phylogeny is a historical evolutionary relationship among organisms.

CRITERIA OF CLASSIFYING ORGANISMS/ PRINCIPLES OF CLASSIFICATION

When an organism is to be classified, it's obtained and its characteristics observed. Organisms with similar characteristics are placed in the same group while those with differing characteristics are placed in different groups. Modern classification however also seeks to establish the evolutionary relationships between organisms. The following characteristics are therefore considered;

1) **Morphological characteristics**

Morphology is the scientific study of form and structure of plants and animals without regard to function. External morphological characteristics of organisms are usually considered. This includes presence or absence of parts, arrangement of parts, number of parts, etc.

2) **Anatomy of the organisms**

This is the study of the external and structures of living organisms, but also relating them to their functions. Organs with a similar anatomy use the same structure for the same function.

3) **Physiology**

This is the study of the functioning of organs, tissues and cells of living organisms. It includes the study of all the metabolic processes that occur in organisms. The study of physiology is closely related to anatomy. Physiological processes important in classification include photosynthesis, nutrition, reproduction, growth, etc.

DICHOTOMOUS KEY

During collection of organisms to be identified, they are carefully observed. The characteristics seen are then noted down, and identification keys may be constructed to ease the identification process. The most common identification key is the dichotomous key.
A dichotomous key is a key consisting of statements about the characteristics of organisms with each with each step having only two possible alternatives.

Procedure of constructing a dichotomous key

The following steps are followed;

a) Organisms to be identified are carefully observed and external observable characteristics are noted.
b) Organisms are then divided into two groups basing on the characteristics noted. The characteristics chosen must be perfect opposites of each other.
c) The two groups obtained above are also each divided into two smaller groups.
d) The above step (step C) is repeated until each group eventually consists of only one organism.

A flow chart may then be made with each step having two branches or a dichotomous key may be written directly.

Example:

Given 5 insects with following characteristics of legs and mouth parts,

Organism	**Characteristics of legs**	**Characteristics of mouth parts**
A	Spines on tibia	Has mandibles
B	Smooth legs	Has mandibles
C	Hairy legs	Has a proboscis
D	Smooth legs	Has a proboscis, piercing stylets
E	Hairy legs	Has mandibles

Construct a dichotomous key to identify the above insects.

<u>A dichotomous key to identify specimens A, B, C, D and E</u>

1 a) Organism with appendages on legs (A, C, E) ……. go to 2
b) Organism without appendages on legs (B, D) ……..…..…..… go to 4

2 a) Organism with spines on tibia ……..... A
b) Organisms with hairs on tibia (C, E) ……..... go to 3

3 a) Organism with a proboscis ……..... C
b) Organism with mandibles ……..… E

4 a) Organism with piercing stylets ……..... D
b) Organism without piercing stylets ……. B

Question: Collect five insects from the environment around the school. Using only their features of wings and mouth parts, construct a dichotomous key to identify the specimens.

LEVELS OF CLASSIFICATION

During classification, scientists place living organisms into seven major levels known as taxa (singular taxon). Each taxon contains organisms sharing certain common characteristics which also indicate ancestry. The seven taxa in descending order of size are Kingdom, Phylum, Class, Order, Family, Genus and Species.

The kingdom is the largest level of classification containing many organisms with few general characteristics that are common to all of them.

A species is the smallest level into which organisms are classified and includes organisms that are so similar to each other. A species is defined as *a group of similar organisms that can successfully interbreed to produce viable offspring.*

The modern system of classification places all living organisms into five kingdoms. Each of these kingdoms is split into several phyla with each containing several classes. Classes are then split into orders which are also split into families. Each family contains many genera and each genus contains one or several species.

The table below shows classification of three organisms; human, domestic dog and cassava plant into the seven taxa.

Taxon	**Human**	**Domestic dog**	**Cassava**
Kingdom	Animalia	Animalia	Plantae
Phylum	Chordate	Chordate	Spermatophyta
Class	Mammalia	Mammalia	Dicotyledonae
Order	Primates	Canivora	Malpighiales
Family	Hominidae	Canidae	Euphorbiaceae
Genus	Homo	Canis	Manihot
Species epithet	sapiens	familiaris	*esculeta*

BINOMIAL NOMENCLATURE

When assigning scientific names to organisms, each species of organisms is assigned two names. This form of nomenclature is known as binomial nomenclature and was first proposed by a Swedish scientist Carl Linnaeus.

The first name to be written is the genus name starting with a capital letter, and the second name is the species name (specific epithet) written starting with a small letter. The whole name is then underlined or italicized. E.g. the scientific mane of a domestic dog is *Canis familiaris.*

Question: using information in the table above, write down the scientific names of a human and cassava plant.

Scientific names are used in order to eliminate the confusion that arises due to use of common names. Common names may differ from one place to another and from one language to another.

KINGDOMS OF ORGANISMS

There are five kingdoms into all organisms are placed. These are;

1. Monera
2. Protoctista
3. Fungi
4. Plantae
5. Animalia

When dividing organisms into kingdoms, the following are considered:

- **Cell structure:** this considers whether the cells are prokaryotic or eukaryotic. It also looks at the cell organelles present
- **Chemical composition:** this examines the chemical compounds present in the various cell structures such as cell walls, granules in the cytoplasm
- **Level of cell organization:** whether the organism is unicellular or multicellular

N.B: Viruses are not placed in any of the above kingdoms. This is because they are considered non living but rather a simple collection of molecules. However, they posses some characteristics of living organisms and affect living organisms hence they are of much interest to biologists.

VIRUSES

These are particles consisting of genetic material surrounded by a layer of proteins that are capable of invading other cells.

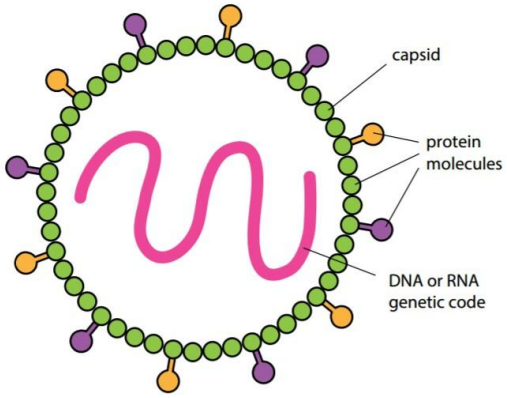
General characteristics of viruses

1) They are much smaller than bacteria or eukaryotes.
2) They can only survive inside host cells i.e. they are obligate parasites.
3) They use the host cell machinery for their own metabolism.
4) Their particle consists of mainly a genetic material (DNA or RNA) surrounded by a protein coat, having no definite cell structures and organelles i.e. they are acellular.
5) They can be crystallized when outside host cells and stored for long periods of time.
6) When inside a host cell, they take control over their metabolism.
7) They only reproduce using the host cell machinery.

Reasons why viruses are considered non living things

1) They cannot survive outside host cells, except as crystals
2) They can only carry out metabolism using the host cell machinery
3) Thy only reproduce when inside host cells
4) They have no cellular components and organelles

Structure of a virus



A virus particle consists of a genetic material surrounded by a protein coat known as a capsid. The genetic material may be DNA or RNA and maybe single stranded or double stranded. The capsid has surface proteins which act as receptors to the host cell. Some viruses have an additional coat of lipids for protection. Viruses are known as **akaryotes** because they don't have cell organelles.

TYPES OF VIRUSES

Viruses are classified according to the nature of genetic material they have or type of life cycle. They are not classified according to their own characteristics because their characteristics are related t the host organism.

The common types according to genetic material are;

a) Single stranded RNA viruses
b) Double stranded RNA viruses
c) Single stranded DNA viruses
d) Double stranded DNA viruses

According to lifecycle, the types are;

a) Lytic viruses, which burst their host cell during reproduction for the new virus particles to come out E.g. Ebola virus
b) Lysogenic viruses, which just bud off from the host cell when new virus particles are coming out of the host cell, leaving the host cell alive. E.g. influenza virus
c) Retroviruses, these are viruses that change their genetic material from RNA to DNA during the life cycle. E.g HIV

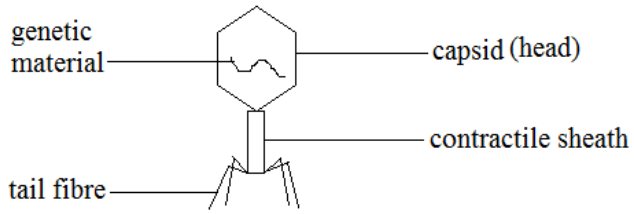
N.B: since all viruses are obligate endoparasites, viruses cause diseases in kingdoms of organisms by infecting their cells. In animals they cause diseases such as AIDS, Ebola, Yellow fever, influenza, polio, foot and mouth disease, Rabies, new castle disease. etc.
In plants, viral diseases include cassava mosaic, tomato bush stunt disease, tobacco mosaic, etc.

Question: Outline methods of preventing the spread of viral diseases.

Lifecycle of a Bacteriophage

A Bacteriophage is a virus that infects bacteria. It's an example of a virus with a simple lifecycle.

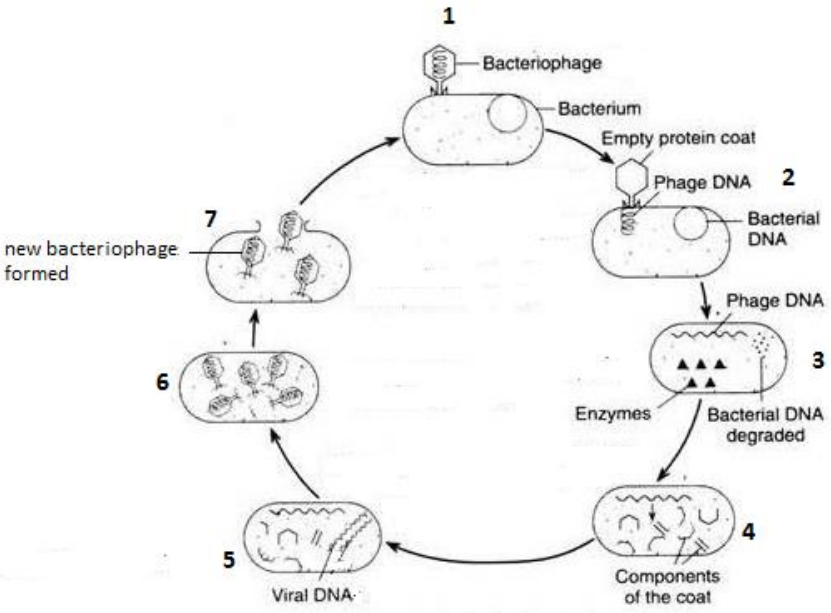
Structure of a Bacteriophage



Its lifecycle begins as follows;

1. The Bacteriophage approaches the bacteria and attaches to its surface (the cell wall) using receptors in the tail fibers.
2. The Bacteriophage then drills through the bacteria's cell wall using pins at the base of the contractile sheath and injects its genetic material.
3. The virus DNA (phage DNA) is then used to synthesize hydrolytic enzymes that breakdown the DNA of the bacterium. The virus DNA then takes control of the bacterium.
4. The viral DNA codes for the synthesis of virus components such as the surface proteins, sheath and tail fibers.
5. The virus DNA replicates forming many copies of its self.
6. The virus components are assembled to form new copies of the Bacteriophage.
7. Due to breakdown of the bacterial cell wall by enzymes and increase in internal osmotic pressure, the cell wall bursts releasing the new Bacteriophage particles into the surrounding medium. The released particles then attack other bacteria.

Illustration



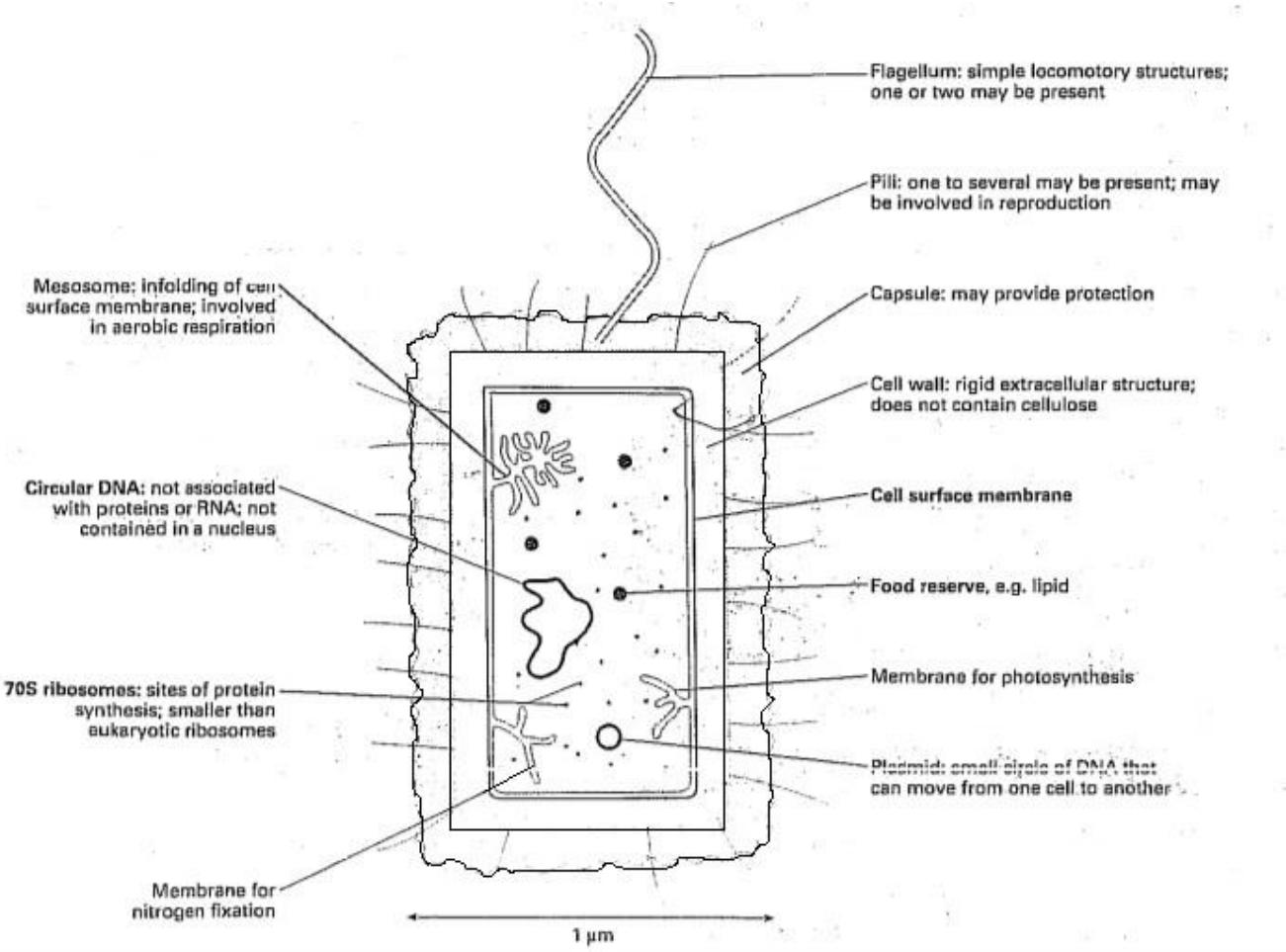
KINGDOM MONERA

This is a kingdom of prokaryotic organisms consisting of bacteria and blue-green algae. These organisms are much smaller than eukaryotes, but much bigger than viruses.

Characteristics of bacteria

i. They have no nucleus in their cells
ii. They have circular DNA in their cells and its always naked (not associated with histones)
iii. Lack double membrane bound organelles such as mitochondria, golgi bodies, etc.
iv. Have smaller 70s ribosomes
v. Cells have cell walls, made up of peptidoglycans
vi. Cells divide by binary fission
vii. They exist as single cells (unicellular) or small groups of cells (colonial).

Drawing of a bacterial cell



The structures that are present in all bacteria are cell wall, cell membrane, cytoplasm, 70s ribosomes and circular DNA.

Question: state the differences between prokaryotic and eukaryotic cells.

DOMAINS OF BACTERIA

Bacteria fall into two groups depending on the characteristics of their cells. These are;

a) **Archaea bacteria:** these are ancient bacteria that inhabit extreme environmental conditions such as hot springs. They differ from the true bacteria by not having peptidoglycan in their cell walls and having 70s ribosomes with features similar to those of eukaryotes.
b) **Eubacteria:** these are the true bacteria having all the characteristics of bacteria. Eubacteria are considered more advanced than archaea.

Although all bacteria share some basic characteristics, they vary widely in size, shape and mode of nutrition.

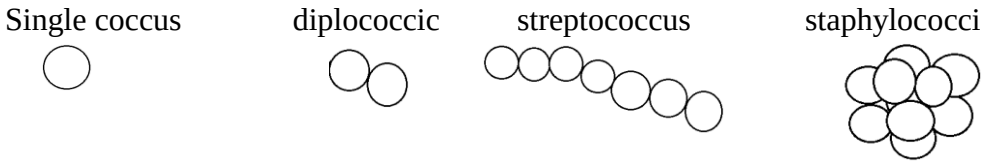
TYPES OF BACTERIA

1. According to shape, bacteria are of the following types

a) Round shaped bacteria (cocci)

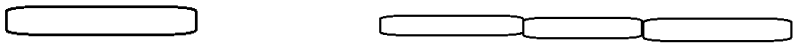
These are bacteria with a circular shape usually without flagella. They may occur singly, in pairs (diplococcic), in clusters (staphylococci) or chains (streptococci).

Examples of cocci bacteria Diplococci pneumoniae causing pneumonia, streptococci pyogens



b) Rod shaped bacteria (bacilli)

These are bacteria with a cylindrical shape. They may occur singly or in chains and may have one to several flagella. Examples are Bacillus anthracis and Azotobacter.



c) Spiral shaped bacteria (spirilla)

These are bacteria whose shape is curved like a spring.

Examples include helicobacter pylori and treponema pallidum.

Some spirochetes are shaped like a comma and these are known as vibrios. E.g vibrio cholerae

2. According to mode of nutrition, bacteria are of the following types

a) Autotrophic bacteria

These are bacteria that are capable of manufacturing their own food from simple inorganic compounds and elements. These are also subdivided into;

i. Photoautotrophic bacteria: these use sunlight energy trapped by bacterial chlorophyll to manufacture organic compounds. Examples are cyano bacteria and purple sulphur bacteria.
ii. Chemoautotrophic bacteria: these are bacteria that use energy from oxidation of chemicals to synthesize their own food. Examples include nitrobacter, nitrosomonas.

b) Heterotrophic bacteria

These are bacteria which depend on already manufactured food compound by other organisms. They are subdivided into;

i. Free living saprotrophic bacteria which obtain energy by breaking down dead decaying matter. In so doing they speed up the decomposition process hence recycling nutrients.
ii. Parasitic bacteria which depend on other living organisms causing harm to them. All disease causing bacteria are parasitic bacteria. Examples of bacteria diseases in plants and animals are; plague anthrax, pneumonia, cholera, food poisoning, typhoid, gonorrhea, meningitis, tuberculosis, etc.
iii. These include bacteria in root nodules, bacteria in guts of ruminants and non ruminants. Mutualistic bacteria which live with other living organisms with both organisms benefiting.

ECONOMIC IMPORTANCE OF BACTERIA

Due to their nature and mode of nutrition, bacteria are of great economic importance.

Question: state the economic importance of bacteria

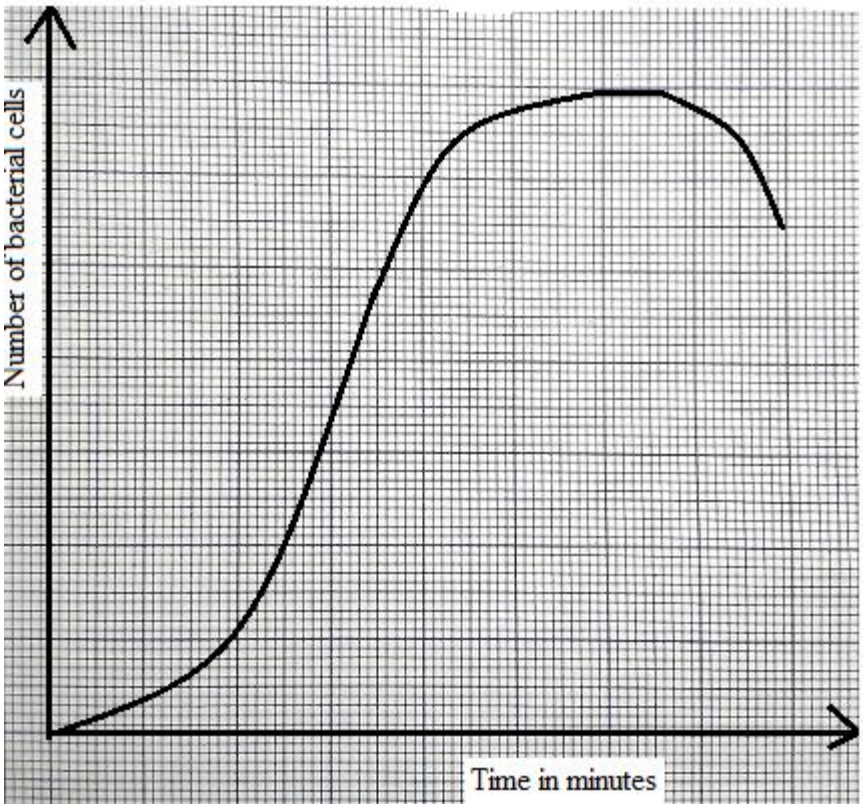
FACTORS THAT AFFECT BACTERIAL GROWTH

Bacteria can easily be cultured/ grown in the laboratory by placing a small amount of them into a medium with nutrients and conditions essential for their growth. The following factors affect the rate at which the bacterial population would grow by affecting the rate of bacterial cell division.

1. Availability of nutrients: bacteria require nutrients such as glucose and mineral ions for them to grow. Large quantities of such nutrients favor rapid bacterial growth.
2. Availability of oxygen: aerobic bacteria require oxygen for respiration hence its presence favors rapid population growth of such bacteria.
3. Temperature: increase in temperature increases the rate of bacterial population growth rate up to about 40^{o}C beyond which the rate of growth reduces. This is because temperature affects the activity of bacterial enzymes.

4. Availability of moisture: bacteria easily thrive and reproduce in an environment that contains relatively high levels of moisture.
5. Accumulation of toxic waste products: these include carbon dioxide, lactic acid. They reduce the rate of bacterial growth when their concentration increases. Accumulation of carbon dioxide lowers PH with affects enzymes.

Graph showing growth of a population of bacteria in a culture



Question: state the differences between bacteria and viruses.

KINGDOM PROTOCTISTA

This kingdom was formerly known as Protista. It includes all single celled eukaryotic organisms such as algae and protozoa. Algae are autotrophic while protozoa are heterotrophic.
These organisms have no common ancestral origin but share some common characteristics among them.

Characteristics of protists

1. They are unicellular or colonial organisms
2. They have a true nucleus an other double membrane bound organelles
3. They reproduce asexually by mitosis.

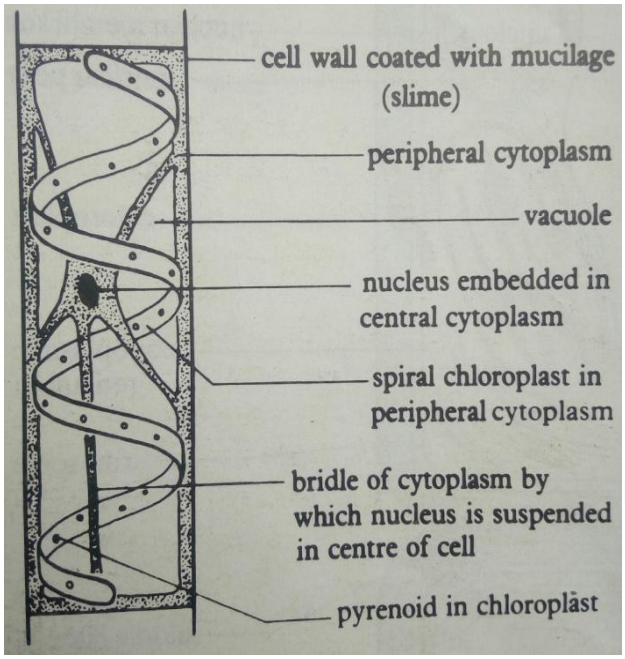
4. They have a cellular level of organization
5. They only stay in aquatic habitats or habitats containing water

Kingdom protoctista is divided into many phyla since the organisms show a great diversity. The common phyla are shown in the table below.

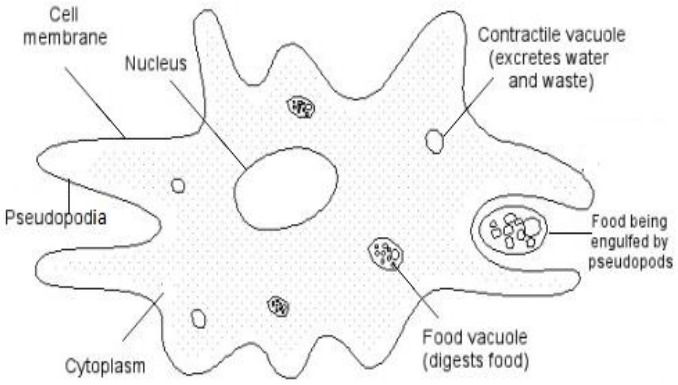
Phylum	Characteristics	Examples
Rhizopoda	• Have pseudopodia for locomotion and feeding	Amoeba, entamoeba
Zoomastigina	• Heterotrophic with cilia for locomotion	Trypanosome
Apicomplexa	• Parasitic organisms that reproduce by multiple fission	Plasmodium
Cilliophora	• Use cilia for movement	Paramecium
Euglenophyta	• Organisms with cilia but autotrophic	Euglena
Chlorophyta	• Plant like photosynthetic organisms	Green algae, e.g. spirogyra
Rhodophyta	• Photosynthetic organisms with red pigments in addition to chlorophyll.	Chondrus

<u>Drawings of common protists</u>

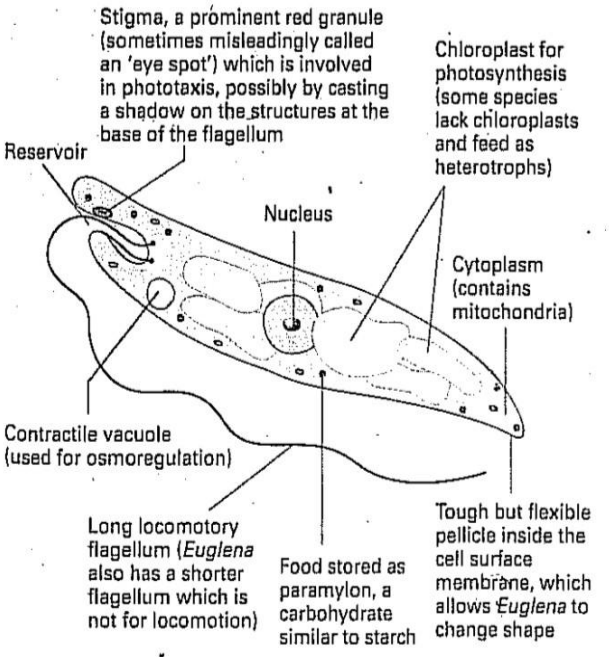
Spirogyra



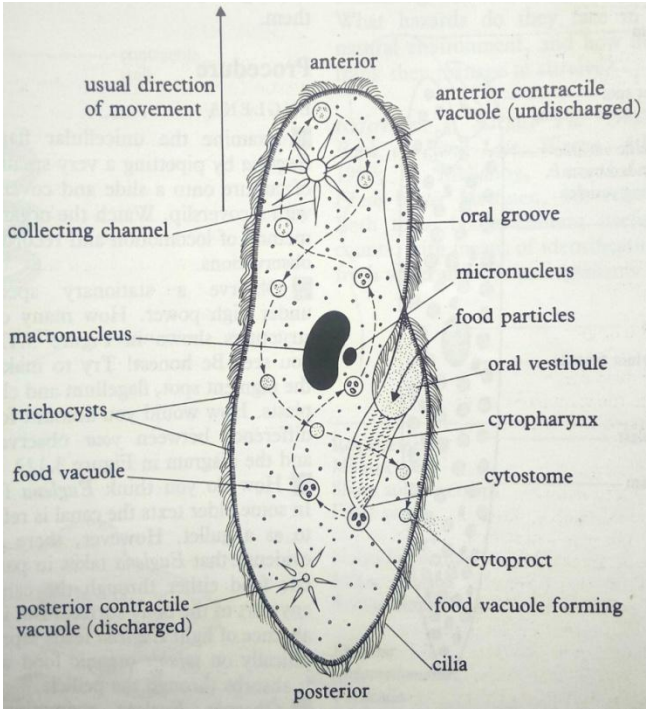
Amoeba



Euglena



Paramecium



ECONOMIC IMPORTANCE OF PROTISTS

1. They cause diseases to plant and animals by living as parasites. They cause diseases like Dysentery, malaria, trypanasomiasis, etc.
2. Some decompose organic matter in the ecosystem
3. Some carryout photosynthesis which produces food and oxygen in the ecosystem.
4. Some have industrial uses.
5. Algal blooms cause pollution in water bodies
6. Some algae are cultivated for animal consumption as a protein source.

Lifecycle of plasmodium parasite

The plasmodium sp. Is a group of four species of parasitic protozoans that cause malaria fever in humans, leading to many deaths world wide. It uses humans and female anopheles mosquitoes as hosts.

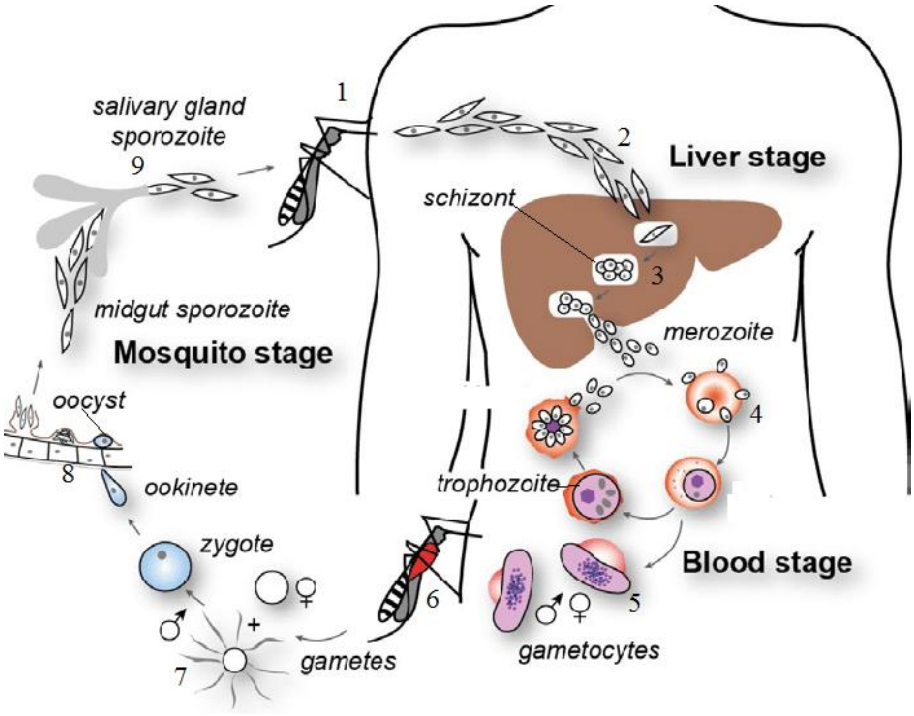
The lifecycle is as follows;

1) An infected mosquito bites a non affected person injecting plasmodium sporozoites into the blood.
2) The injected sporozoites travel through blood and migrate to the liver where they mature to schizonts.
3) The schizonts divide by schizogony to produce many haploid merozoites. The merozoites are released from the liver and enter blood.

4) Merozoites in blood enter red blood cells where they undergo multiple divisions by mitosis to produce more merozoites, and this causes rapture of the red blood cell releasing the merozoites into blood plasma. The released merozoites attack more red blood cells and the process repeats it's self.
5) Some of the merozoites divide and differentiate into gametocytes which stay in blood.
6) When an infected person is bitten by a mosquito, the mosquito sucks blood containing the gametocytes.
7) Male and female gametocytes fuse to form zygotes that mature to ookinetes.
8) The ookinetes mature into Oocysts in the mosquito gut.
9) Oocysts rapture releasing sporozoites which migrate to and stay in the mosquito's salivary glands. The cycle then repeats it's self when the infected mosquito bites a non affected person.

N.B: 1. Rapture of red blood cells when infected by merozoites leads to development of malaria fever. In worse cases the person may become anaemic when the number of red blood cells reduces significantly.
2. The human immune system cannot easily eliminate malaria pathogens from the body because the parasites spend most of their time inside liver cells or red blood cells.
3. There are four species of plasmodium i.e. Plasmodium vivax, P. malarie, P. ovale, P. falcipurum. The most severe malaria causing most deaths is caused by P. falcipurum.

Illustration



LEVELS OF ORGANISATION

The kingdoms Monera and Protoctista consist of unicellular organisms. Such organisms have cellular level of organization with cells existing independently e.g. paramecium. In some cases, the cells loosely interact to form colonies (colonial organization) e.g. staphylococci bacteria. However, the kingdoms fungi, Plantae and Animalia consist of multicellular organisms where cells are organized into specialized tissues (tissue level organization), organs and organ systems (organ level organization).

Advantages of being multicellular

1. The multicellular state allows organisms to increase in size as they grow. This is because growth of an individual cell is limited by the nucleus and therefore in multicellular organisms, cells divide as they grow allowing an increase in size of the whole organism.
2. It allows efficiency of various processes since different cells specialize to carry out different functions.
3. Enables the organism to carryout more sophisticated processes that cannot be carried out by a single cell. This occurs as a result of the cumulative effect of the cells functioning. E.g. feeding on large prey, fast locomotion.
4. Allows the organisms to exploit various habitats which cannot be exploited by unicellular organisms due to development of complex physiological processes. E.g. control of water loss, temperature regulation.

Challenges faced by multicellular organisms

1. Cells lose their independence as they have to depend on other cells for various functions such as provision of nutrients and removing wastes. This limits their functioning by slowing down the rate of their activities.
2. Difficulty in acquisition of resources such as food and oxygen due to reduction in surface area to volume ratio that accompanies the increase in size. When the surface area to volume ratio is small, resources cannot be absorbed over the body surface.
3. Difficulty in control and coordination of the various cell processes in the multicellular state since cell activities are dependent.
4. Difficulty in the internal transportation of materials over long distances in the body of the organism. Materials such as food nutrients have to be transported to all body cells and wastes have to be removed from each cell and processes such as diffusion, osmosis and active transport are no longer efficient.
5. Challenge of support of the increased mass of the body, which may also involve carrying it form one place to another.
6. Finding large amounts of food to provide nutrients to every body cell, since all the body cells require nourishment.
7. Difficulty in loss of heat from the body as the organisms become larger and increase in size. This is because the rate of heat loss is directly proportional to the surface are to volume ratio.

KINGDOM FUNGI

This is a kingdom of unicellular and multicellular eukaryotic heterotrophic organisms that have chitin in their cell walls. Lichens, which are associations between fungi and algae are callsfied according to the fungus present and are hence placed in this kingdom.

Characteristics of fungi

i. Cells are eukaryotic and have cell walls made of chitin and have no plastids
ii. Body consists of multinucleate hyphae that form a body called 16ycelium
iii. They usually feed saprophytically or parasitically
iv. Carbohydrates in the cells are stored in form of glycogen
v. Reproduction usually occurs by formation of spores.
vi. They inhabit damp places

PHYLA UNDER KINGDOM FUNGI

This kingdom has many phyla but the most important ones are;

- Zygomycota
- Ascomycota
- Basidiomycota

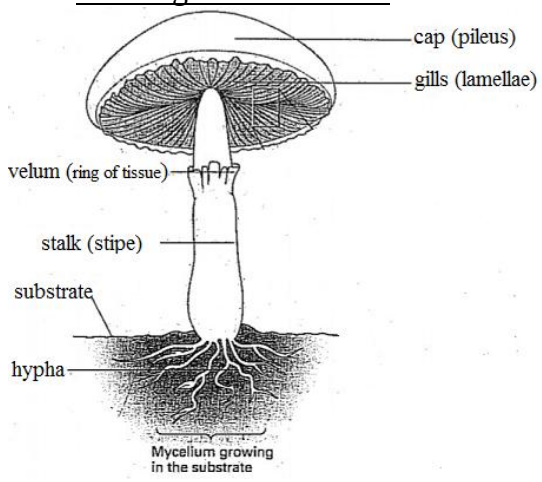
PHYLUM BASIDIOMYCOTA

This includes organisms that produce spores from cap shaped structures called a basidium. They include mushrooms, puccinia, puffballs, toadstools

Characteristics of mushrooms

- Spores are produced asexually
- Sporangia are located in cap shaped structures consisting of many densely packed gills.
- Densely packed mycelium is in soil or supporting medium
- Have septate hyphae

Drawing of a mushroom



PHYLUM ZYGOMYCOTA

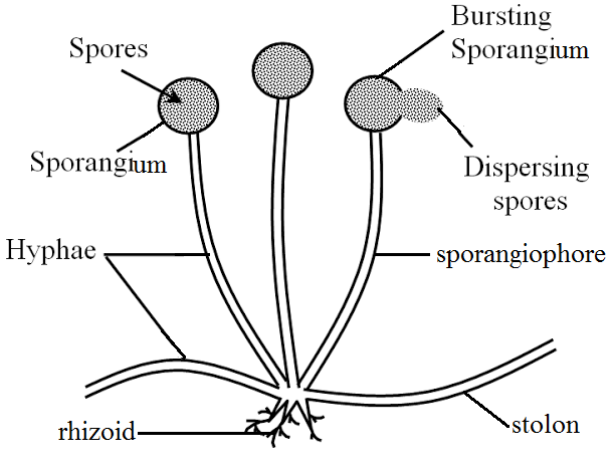
This phylum includes organisms like mucors or moulds (e.g. bread mould) that produce spores from sporangi carried on stalks.

Characteristics of a bread mould (rhizopus sp.)

- Reproduction occurs by production of spores in a sporangium located on top of a stalk called sporangiophore
- Have three types of hyphae, 1.e. rooting hyphae (rhizoids that are root-like), connecting hyphae (stolons), stalk hyphae (sporangiophore)
- Spores may be produced sexually or asexually
- They grow on rooting matter such as bread

Question; describe how a bread mould reproduces by conjugation

Drawing of a bread mould (rhizopus stolonifer)



PHYLUM ASCOMYCOTA

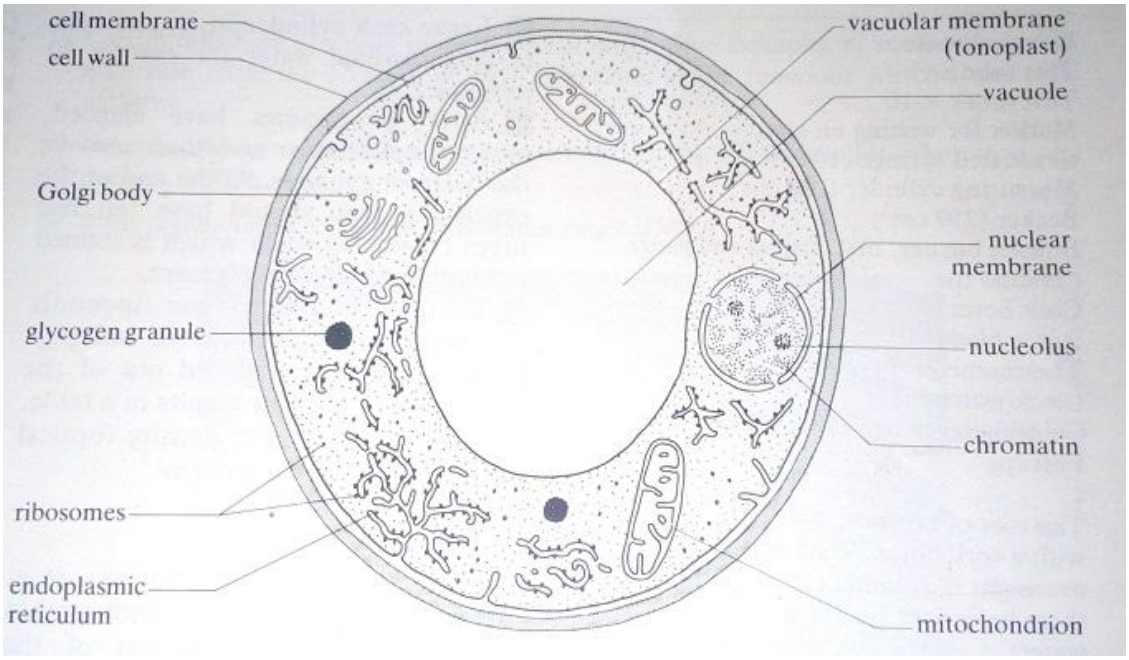
This phylum includes organisms that produce spores in sacs-like structures. They include yeast (saccharomyces) and penicillium.

Characteristics of yeast

- Have oval shaped cells
- It is unicellular
- Reproduces by budding

Question: describe the process of budding in yeast

Drawing of a yeast cell



ECONOMIC IMPORTANCE OF FUNGI

1. They cause decomposition of dead organic matter in the environment which recycles nutrients.
2. Some are used industrially to produce antibiotics e.g. penicilium
3. Some are used industrially in alcohol production by fermentation e.g. yeast.
4. Yeast is used in baking
5. They spoil stored food and spoil materials like leather
6. Some are eaten as food e.g. mushrooms
7. Some are poisonous to humans when eaten
8. Some cause diseases in plats and animals. These include candidiasis, ring worm, powdery mildew.

Question: state methods of preventing the spread of fungal diseases.

NOTE: yeast is used industrially for alcohol production because during anaerobic conditions, yeast breaks down simple sugars to form ethanol and carbon dioxide. Yeast Hs enxymes that break down glucose, fructose, galactose and sucrose rapidily. However yeast breaks down starch slower compared to sugars due to less concentration of amylase.

Yeast does not breakdown lactose due to absence of lactase enzyme.

Carbon dioxide produced by anaerobic respiration raises dough during baking.

KINGDOM PLANTAE

This is a kingdom of multicellular autotrophic organisms that have chlorophyll in their cells.

Characteristics of organisms in kingdom plantae

- They are multicellular eukaryotic autotrophs
- They have chlorophyll in their cells hence carrying out photosynthesis
- Cells have cell walls containing cellulose
- Carbohydrates are stored as starch
- Life cycle shows alternation of generations.

Plants are believed to have evolved from green algae by becoming multicellular and getting adaptations to survive n land.

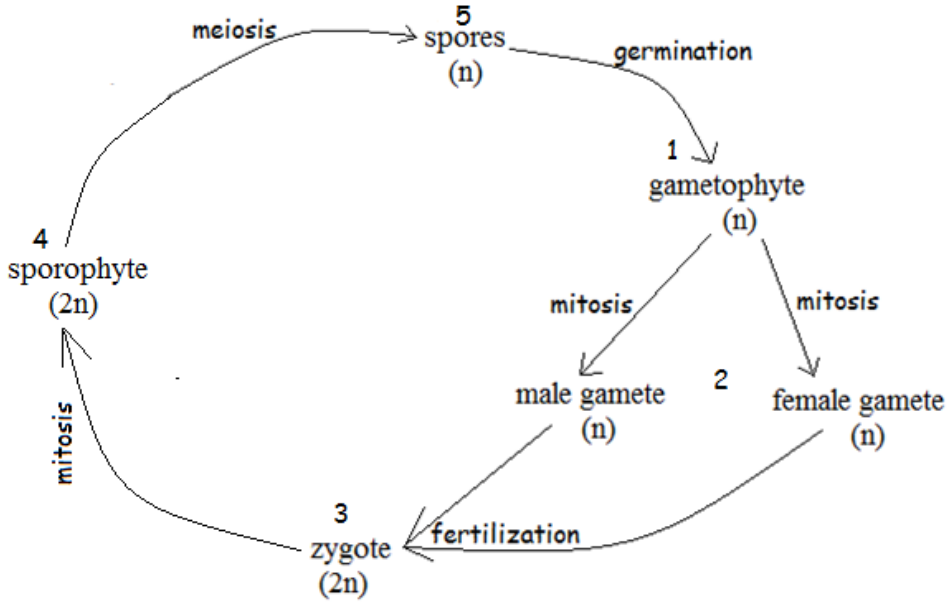
Major characteristics considered in plant classification

a) Presence or absence of vascular tissues (xylem and phloem)
b) Differentiation of the body into roots, stem and leaves
c) The mode of reproduction, whether using seeds or spores
d) The extent to which the life cycle shows alternation of generations
e) The structure of the flowers if present
f) The structure of the leaves and fruits

Alternation of generations

This is a life cycle which has two distinct generations of life that is the haploid gametophyte generation and the diploid sporophyte generation. This kind of life cycle occurs in plants, with the haploid gametophyte producing gametes by mitosis while the diploid sporophyte generation producing spores by meiosis. Alternation of generations enables plants to produce large numbers of offspring in two different generations which increases chances of survival of the species.

Illustration of alternation of generations



Plants are divided into 3 phyla known as divisions. i.e.

- Bryophyta
- Pteridophyta
- Spermatophyta

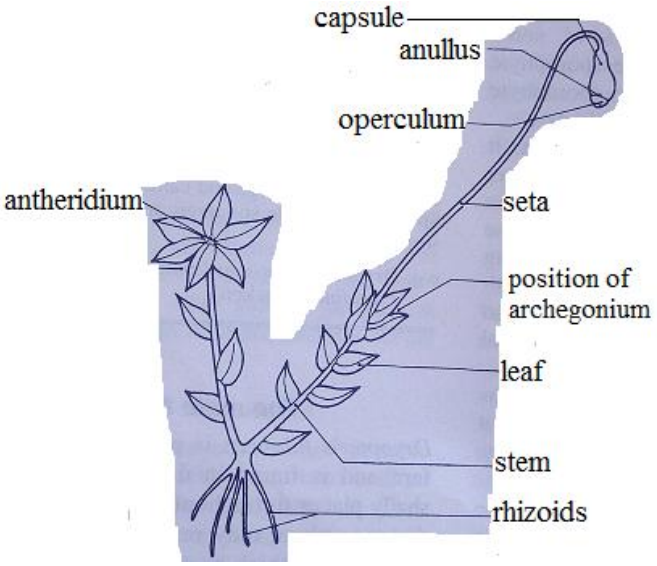
DIVISION BRYOPHYTA

It includes mosses and liverworts. They are considered the least developed organisms in the plant kingdom.

Characteristics of bryophytes

- ❖ They have no true roots, stems and leaves. i.e. their body is in form of a thallus
- ❖ They have no vascular tissues i.e. no xylem and phloem
- ❖ The gametophyte generation is the dominant generation in the life cycle
- ❖ The body is anchored to the ground by root-like rhizoids
- ❖ They inhabit damp places

Drawing of a moss



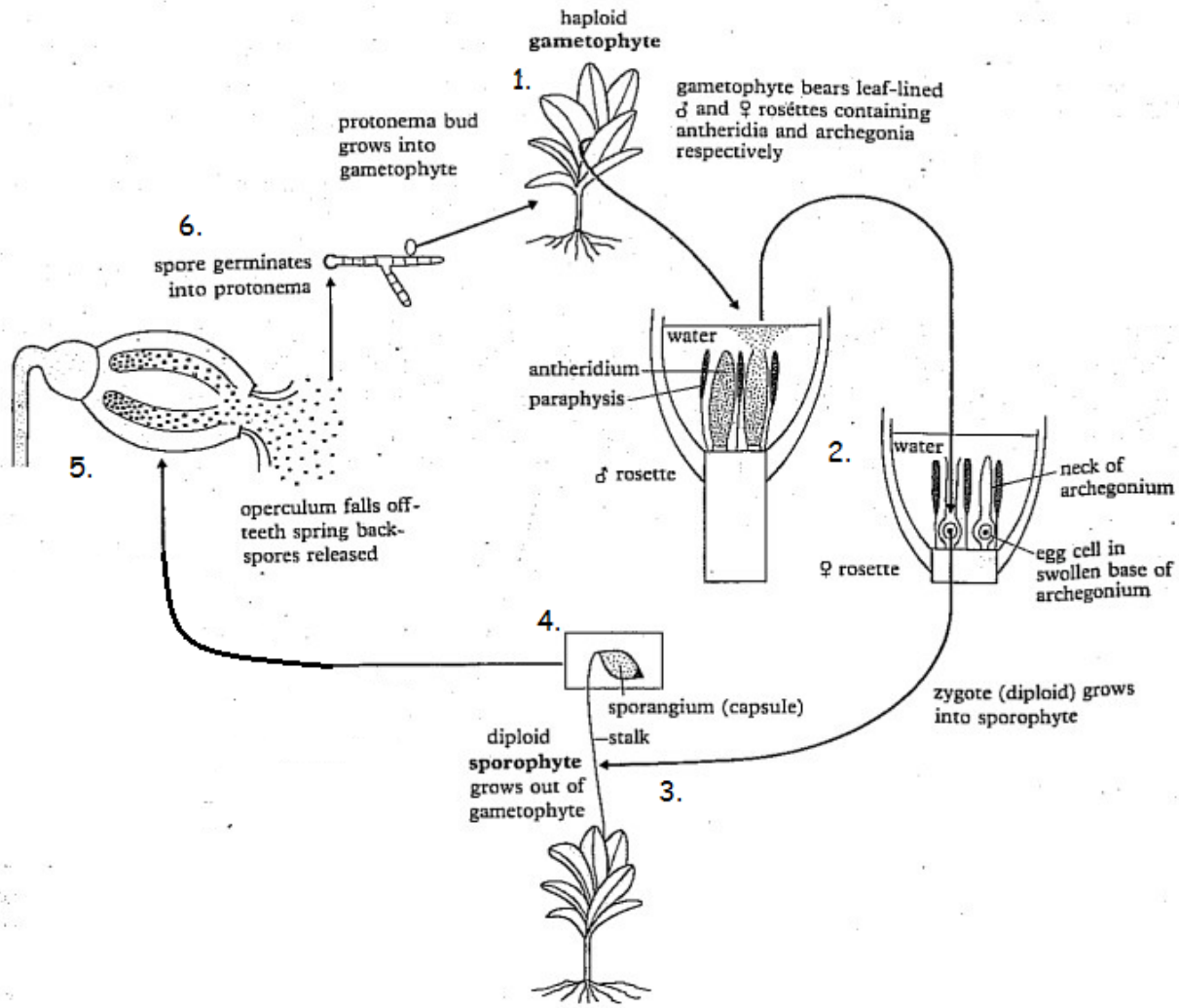
ALTERNATION OF GENERATIONS IN MOSSES

Mosses show alternation of generations with the gametophyte generation being the dominant stage in the lifecycle.

1. The haploid gametophyte produces gametes by mitosis. The male gamete is produced from the antheridium and the female gamete from the archegonium.
2. The antheridium raptures, releasing male gametes (sperms) which swim through water using flagella to the archegonium. The neck of the archegonium opens and sperms enter the archegonium where they fuse with the egg to from a diploid zygote.
3. The zygote undergoes division by mitosis to form a sporophyte that remains attached to the gametophyte and depends on it.

4. In the capsule of the sporophyte, spores are formed by meiosis
5. In dry whether, the capsule operculum opens and spores fall out and are dispersed by wind.
6. When spores fall in a moist environment they germinate to from a protonema. The Protonema then develops buds which grow into new a gametophyte, and the cycle repeats itself.

Illustration



DIVISION PTERIDOPHYTA/ FILICINOPHYTA

This phylum consists of ferns, and fern allies such as club mosses and horse tails.

Characteristics of Pteridophytes

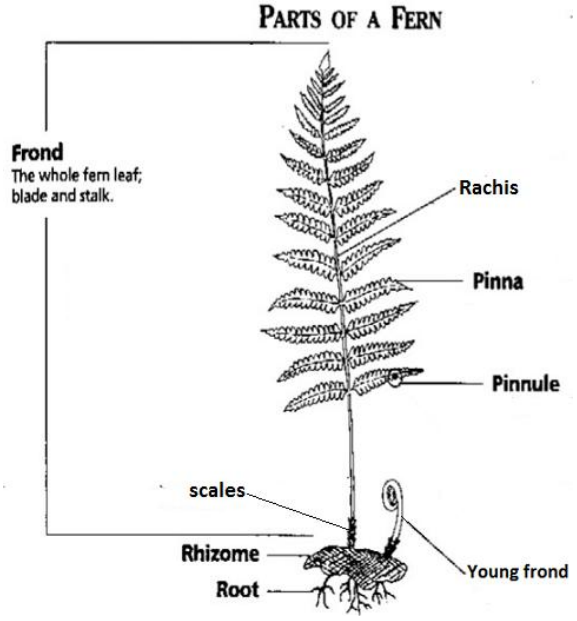
1. They have leaves in form of fronds
2. They show alternation of generations with the sporophyte being the dominant stage
3. Their body is differentiated into roots, stem and leaves
4. They have vascular tissues (xylem and phloem) although the xylem has only tracheids

Ferns are more adapted to terrestrial environments than mosses. This is due to;

- Possession of a waxy cuticle on the fronds which prevents water loss
- Having specialized vascular tissues to transport water and mineral salts
- Having lignin in the vascular tissues which enables support of a large body mass
- Possession of true roots for absorption of water and mineral salts
- Possession of a stem in form of a rhizome which can survive in dry conditions.

However, ferns are less adapted to terrestrial environments compared to conifers and angiosperms. This is because the gametophyte lacks the adaptations possessed by the sporophyte and depends on water for the movement of flagellated sperms hence it's entirely confined to damp conditions.

Drawing of a fern



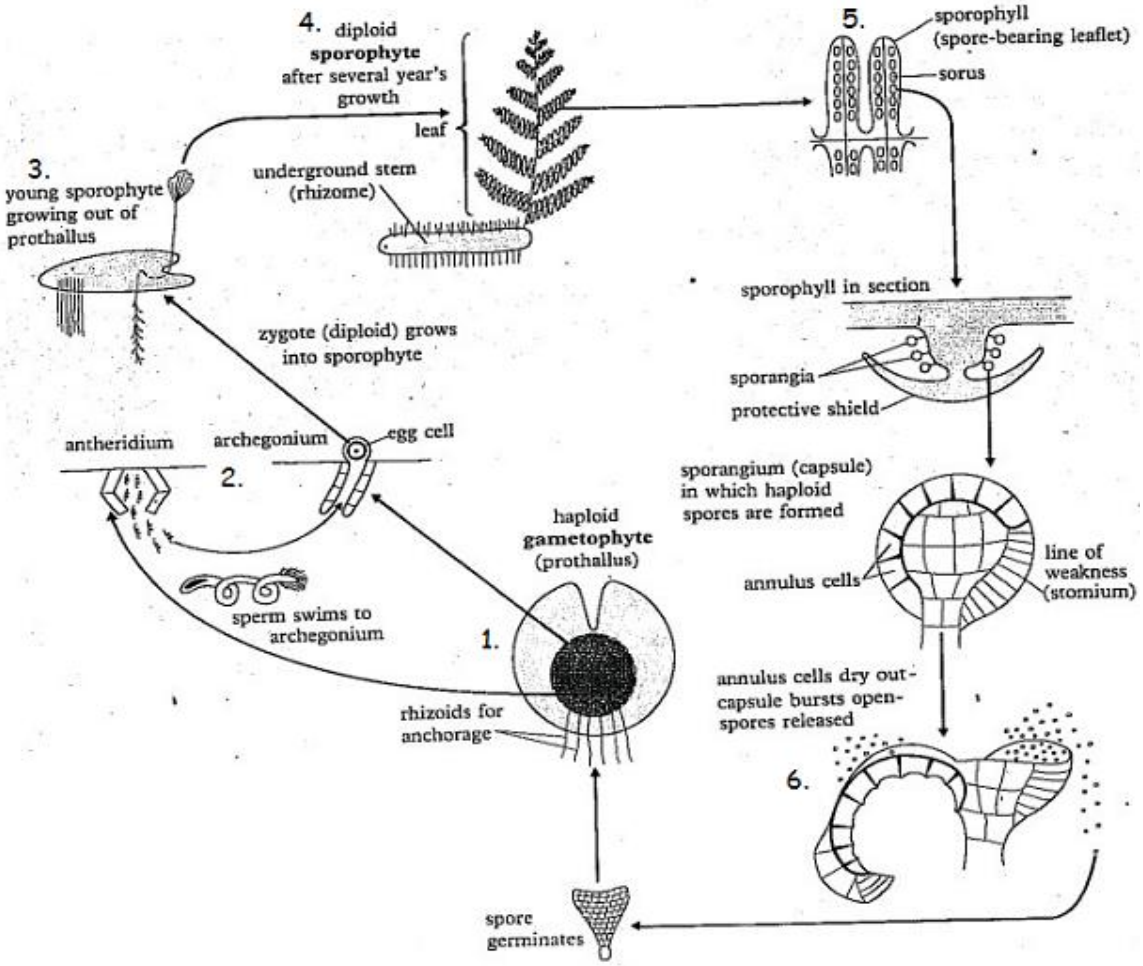
ALTERNATION OF GENERATIONS IN A FERN

The sporophyte is the dominant stage in the lifecycle and the gametophyte is reduced to a structure called a prothallus.

1. The haploid gametophyte (prothallus) produces gametes by mitosis. The male gametes (sperms) are produced from the antheridium, and are flagellated. Female gametes (eggs) are produced from the archegonium.
2. The flagellated male gametes swim from the antheridium to the archegonium where they fuse with the egg cell to from a diploid zygote.
3. The zygote grows into the sporophyte by mitosis. The sporophyte remains attached to the gametophyte for a short time and later separates from it.
4. The sporophyte continues to grow and increases in size, forming a rhizome with adventitious roots and fronds.

5. Spores form in sporangia on the underside of the fronds by meiosis, and the sporangia occur in clusters called sori.
6. The sori rapture releasing spores. The spores are dispersed by wind and when they land in a moist environment they germinate into heart-shaped gametophytes and the cycle repeats it's self.

Illustration



Question: compare alternation of generations in mosses and in ferns.

DIVISION SPERMATOPHYTA

These are seed bearing plants that include gymnosperms (conifers) and angiosperms.

Characteristics of spermatophytes

1. They reproduce by means of seeds
2. They have well developed vascular tissues
3. They have a pronounced sporophyte generation
4. They are well adapted to life on land and hence can inhabit dry environments
5. Reproduction can occur by vegetative means

This phylum is divided into two sub phyla i.e.

- Gymnospermae (the conifers/gymnosperms)
- Angiospermae (the angiosperms/ flowering plants)

GYMNOSPERMS

These are seed bearing plants that produce seeds on cones. They are therefore non flowering. Examples include: pine, cypress, cedar, larch, fir and redwood.

Characteristics of gymnosperms

- They bear seeds and gametes on cones
- They produce naked ovules and seeds (not enclosed in testa or integuments)
- Ovules are not enclosed in ovary
- They mostly have narrow needle-like leaves
- The xylem tissue is made up of only tracheids.

ANGIOSPERMS

These are flowering plants.

Characteristics of flowering plants

- They have seeds enclosed in a testa
- They produce ovules inside an ovary
- They bear flowers from where gametes are produced
- Xylem has vessels and tracheids
- Seeds develop inside fruits

Angiosperms fall into two classes i.e

- ❖ Monocotyledonae
- ❖ Dicotyledonae

Moncotyledonae

This is a group of monocotyledonous plants such as maize, millet, sugar cane, bananas, and palms.

<u>Characteristics</u>

i. Seeds have one seed leaf (one cotyledon)
ii. Vascular bundles are scattered in the stem ground tissue
iii. Floral parts are in groups of 3 or multiples of 3
iv. Calyx and corolla usually fused
v. Have narrow leaves with parallel venation
vi. Leaves have leaf sheaths
vii. Have a fibrous root system
viii. Germination usually hypogeal

Dicotyledonae

This is a class of dicotyledonous plants such as beans, ground nuts, cassava, and sweet potatoes

Characteristics

i. Seeds have two cotyledons (embryo has two seed leaves)
ii. Vascular bundles arranged in a ring in the stem
iii. Floral parts arranged in groups of 4 or 5or their multiples
iv. Have broad leaves with network venation
v. May undergo secondary growth due to presence of a vascular cambium
vi. Leaves have a solid stalk
vii. Have a tap root system
viii. Germination usually epigeal

Adaptations of spermatophytes to life on land

1. They have a well developed vascular system for transportation of water and mineral salts
2. They have a waxy cuticle which prevents evaporation of water from the plant.
3. They do not require water for fertilization since male gametes do not swim
4. Have a pronounced sporophyte generation which is specifically adapted with features such as long strong roots, strong stems and leaves
5. Have seeds with stored food to be fed on by the embryo
6. Gametophyte is entirely dependent on the sporophyte hence getting protection
7. They have lignin in their cell walls which ensures strength for support

Alternation of generations in spermatophytes

Spermatophytes show alternation of generations but to a smaller extent compared to the mosses and ferns. They have a pronounced sporophyte generation, and the gametophyte is much reduced and entirely dependent on the sporophyte.

The male parts of the sporophyte (anther heads or male cones) contain microspore mother cells which produce pollen grains which are the microspores and the female parts of the sporophyte (ovary or female cones) produce ovules which contain the megaspore. When the pollen grain germinates after landing on the stigma, a male gametophyte is formed which releases the sperm nuclei. The ovule is the female gametophyte which produces the egg nuclei.
After fertilization the zygote is formed and is enclosed in a seed, which later is dispersed and germinates to form a new sporophyte.

KINGDOM ANIMALIA

This is a kingdom of animals.

Characteristics of animals

1. They are multicellular eukaryotes
2. Their cells have no cell walls
3. They feed heterotrophyically
4. They are usually motile
5. They at least one opening into the body, such as a mouth
6. They usually have nervous coordination enabling rapid response to stimuli.

Major characteristics considered in animal classification

a) Symmetry: asymmetrical organisms are those which cannot be divided into two equal parts while symmetrical ones are those which can be divided into two equal parts. The important types of symmetry are bilateral symmetry and radial symmetry. Symmetrical organisms easily balance during locomotion or easily detect food and threats from any side.

b) Segmentation: this is the repetition of body sections along the body. This repetition is specifically called metameric segmentation. Segmentation allows specialization of body structures to different functions hence increasing efficiency. In classification, segmented organisms re considered more advanced than non segmented ones.

c) Appendages: these are protruding parts on the body that carry out various functions. The most important appendages are legs, mouth parts, tentacles, antennae, etc. the presence and nature of appendages shows the degree of adaptability to the environment.

d) Skeleton: the nature of the skeleton is very important in animal classification since the skeleton has various functions. The types of skeletons are exoskeleton, endoskeleton and hydrostatic skeleton.

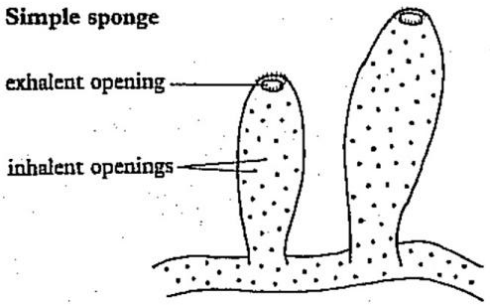
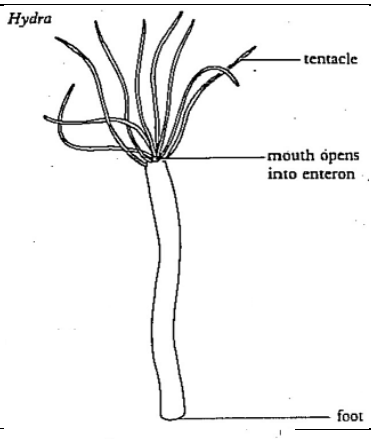
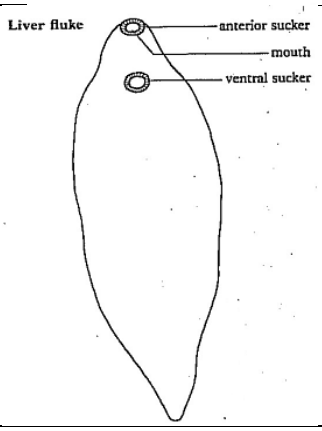
e) Sex: this relates to whether a species of organisms has separate sexes or are hermaphrodites. More advanced organisms usually have separate sexes (dioecious).

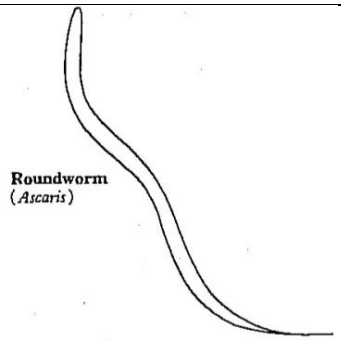
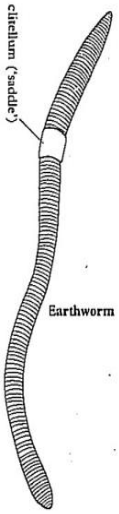
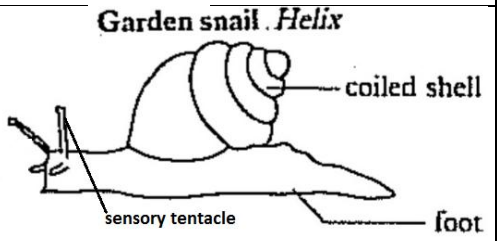
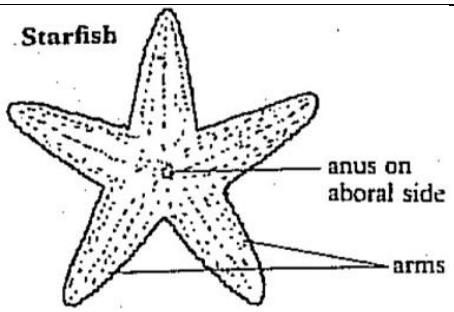
f) Embryonic development: this involves consideration of the mode of egg cleavage, and further changes that occur to the embryo.

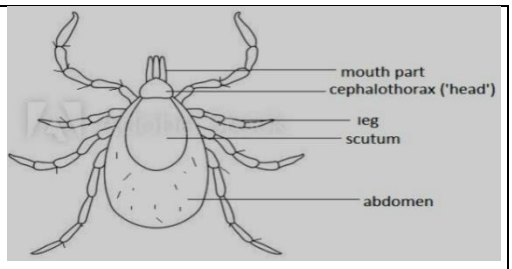
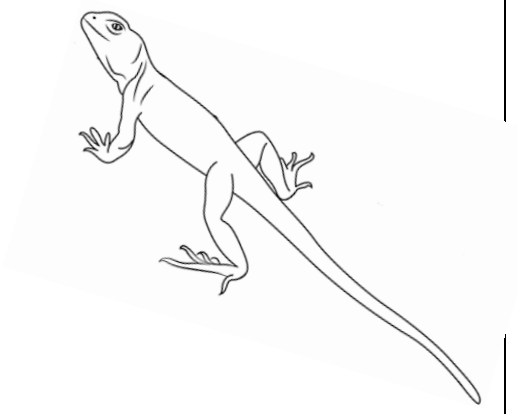
Kingdom animalia is divided into 9 phyla. These are;

1. Porifera	2. Coelenterata	3. Platyhelminthes	4. Nematoda	5.Annelida
6. Mollusca	7. Echinodermata	8. Arthropoda	9. Chordata	

TABLE SHOWING THE DETAILS OF THE ANIMAL PHYLA

Phylum	Characteristics	Drawing
Porifera - sponges	• Have a body cavity called a spongocoel connected to outside by pores • Have a spicule skeleton made up of calcareous, siliceous or horny plates • They are sessile • Have one layer of body cells • Have no nervous system/ no coordination between cells • They are marine dwellers	
Cnidaria (Coelenterata) e.g. hydra, sea anemone, sea corals, obelia, jelly fish	• Have sac like body with a cavity called the enteron • Have one body opening • They are diploblastic (2 cell layers) • Show radial symmetry • Have nematoblasts that can produce poison in their tentacles • Exist in two forms; polyp and medusa • They are marine dwellers	
Platyhelminthes – flat worms e.g. liver flukes, planaria, tape worms, blood fluke (schistosoma)	• Body dorsal-ventrally flattened • Have one body opening (mouth) • Are hermaphrodites • Have flame cells for excretion • They are triploblastic	

Nematoda – round worms e.g. ascaris, hook worm, pin worms, whip worms	• Hale a long body pointed at both ends • The body is cylindrical • Have two body openings • The body is un segmented	
Annelida – segmented worms e.g. lug worms, earth worms, leeches	• Have an elongated worm like body • The body is segmented • Have two body openings • They are triploblastic • Have a closed circulatory system • Have a well developed nervous system • Use nephridia for excretion • Show bilateral symmetry • They have a coelom (they are coelomates)	
Mollusca e.g. snails, slugs, octopus, squids	• Have a soft muscular foot on ventral side • Have a visceral hump • Have a rasping tongue-like radula • Use gills for respiration • Are always moist, protected by a shell • Have a coelom	
Echinodermata e.g. star fish, brittle star, sea cucumber, sea urchin	• Have an endoskeleton of calcareous plates • Have spins on the body • Show pentamerous symmetry • They are marine dwellers	

Arthropoda e.g. flies, millipedes, ants	• Have an exoskeleton • Have a segmented body • Have jointed appendages Arthropods have advanced features like coelom and triploblastic organization,bilateral symmetry, internal fertilization and thus they are the most advanced among the invertebrates	
Chordata e.g. amphioxus, sharks, cats	• Have an endoskeleton of bone or cartilage • Have a post anal tail • Have pharyngeal gill slits • Have a notochord that may develop into the vertebral column • Have a nerve chord that develops into the central nervous system Chordates are the most advanced among the animal kingdom. They posses other features such a coelom, troploblastic organization, closed circulation, internal fertilization, bilateral symmetry, which adapts them to the environment.	

NOTE:

- ❖ A Coelom is a body cavity into which visceral organs such as digestive organs are suspended. A coelom separates visceral organs from the rest of the body enabling them to move and grow independently and a ceolomic fluid bathing the organs which supplies nutrients and act as a hydrostatic skeleton.
- ❖ Diploblastic organisms have only two cell layers in the body i.e. the ectoderm and endoderm. Triploblastic organisms have three cell layers i.e. ectoderm, mesoderm and endoderm. These layers may be differentiated into organs allowing more specialization and increase in size.

PHYLUM ARTHROPODA

This is the largest and most successful phylum in the animal kingdom containing more than 70% of all animal species. It is divided into 5 classes;

- Class Crustacea
- Class Chilopoda
- Class Diplopoda
- Class Arachnida
- Class Insecta

TABLE SHOWING DETAILS OF THE ARTHROPOD CLASSES

Class and examples	Characteristics
Crustacea e.g. woodlice, lobsters, Daphnia, cray fish, crabs, barnacles, shrimps	• Have 2 pairs of antennae • Have two main body parts i.e. cepalothorax and abdomen • Have compound eyes on movable stalks • They inhabit damp or aquatic environments
Diplopoda e.g. millipedes, wire worms	• Have one pair of antennae • Have 2 pairs of legs on each body segment • Body is cylindrical and elongated • They are herbivorous and terrestrial • They have simple eyes
Chilopoda e.g. centipedes	• Have one pair of antennae • Have one pair of legs per body segment • Body is dorso-ventrally falettened • They are carnivorous and terestrial
Arachnida e.g. scorpion, spiders, mites, ticks	• Have 2 main body parts i.e. cephalothorax and abdomen • Have 4 pairs of legs • They have no antennae • Use booklungs for gaseous exchange • Usually carnivorous with sharp appendages for capturing prey
Insecta e.g. cockroaches, silverfish	• Have 3 main body parts • Have three pairs of legs • Have three thoracic segments In addition to the above features, insects also have one pair of antennae and have compound eyes

CLASS INSECTA

This is the largest and most successful class of arthropods. It's divided into several orders. The most important ones are shown in the table below.

	Order and examples	Characteristics
1	**Diptera** e.g. houseflies, mosquitoes	One pair of wings, one pair of haltares, have a proboscis
2	**Dictyoptera** e.g. cockroaches	Two pairs of wings, dorso-ventrally flattened, chewing mouth parts (mandibles, labium, labrum)

3	**Orthoptera** e.g. grasshoppers, locusts, crickets	Chewing mouth parts, 2 pairs of wings, female with long ovipositor
4	**Coleoptera** e.g. beetles, ladybirds	2 pairs of wings with very hard outerwings (elytra), chewing mouth parts
5	**Siphonaptera** e.g. fleas, jiggers	Piercing and sucking mouth parts, no wings, no eyes
6	**Hymenoptera** e.g. wasps, bees	2 pairs of wings which can interlock using hooks, chewing mouthparts and proboscis, social
7	**Isoptera** e.g. ants, termites	Mostly no wings, social insects
8	**Hemiptera** e.g. bedbugs	Piercing and sucking mouth parts,
9	**Lepidoptera** e.g. butterflies, moths	2 pairs of wings, scales on the wings, proboscis present
10	**Odonata** e.g. dragon flies	2 pairs of wings that cannot be folded, chewing mouth parts

Question: state the reasons why arthropods are very successful organisms.

PHYLUM CHORDATA

This is the most advanced phylum of animals having the most adapted organisms.
It is divided into 5 classes i.e. Pisces, Amphibia, Reptilia, Aves, Mammalia

Class	**Examples**	**Characteristics**
Pisces - fish	Sharks, skates, rays. Nile perch, cod, cat fish	• Have jaws on the body • Have scales on the body • Have paired fins • Use gills for gaseous exchange • They are aquatic dwellers • Have homodont teeth • Have a 2 chambered heart • Fertilization is external
Amphibia	toads, frogs, and newts	• Have a moist skin • Live both on land and in water • Use gills, skin and lungs for gaseous exchange • Have a three chambered heart • Show metamorphosis
Reptilia	lizards, snakes, crocodiles, and tortoise	• Have a dry scaly skin • Use lungs for gaseous exchange • Have a four chambered heart • Lay an amniotic egg (cleidoic egg) • Fertilization internal

Aves	ostrich, fowl, doves	• Have feathers on the body • Use lungs for gaseous exchange • Have a 4 chambered heart • Lay amniotic eggs • Are homoeothermic • Fore limbs modified to wings • Mouth modified to horny beak • Sternum expanded • No teeth
Mammalia	rats, porcupines, kangaroos, baboon	• Have glands in skin such as mammary glands • Are homeothermic • Have hair on the skin • Have a diaphragm • Heart is four chambered • Have heterodont teeth

N.B: class pisces is a class of fish. This class is divided into two sub classes i.e.

- **Chondrichthyes** that have a cartilaginous skeleton. Modern cartilaginous fish are known as elasmobranches. E.g. sharks, skates, rays.
- **Osteichthyes** that have a bony skeleton. Modern bony fish are called teleosts e.g. tilapia, nile perch, cod, cat fish

Among the animal and plant groups, some organisms are aquatic while some are terrestrial. More advanced organisms are usually terrestrial.

Challenges faced by organisms living on land (terrestrial organisms)

1. Difficulty in support and locomotion
2. Desiccation due to dry air
3. Reproduction without water
4. Varying environmental temperature

Adaptations of animals to overcome challenges on land

1. Some have skeletal systems made up of strong materials such as bone which provides a framework for support
2. Some have muscle cells specialized for producing a strong force for movement and locomotion
3. Possession of internal gaseous exchange surfaces which reduces the amount of water that evaporates
4. Having a skin covered with scales preventing evaporation of water
5. Having a keratinized skin which is impermeable to water hence reducing evaporation

6. Having internal fertilization which protects the gametes and zygote from desiccation
7. Laying of a cleidoic egg which is covered by a hard shell that prevents water loss and mechanical damage
8. Having a high metabolic rate and being endothermic which minimizes temperature changes in the body
9. Excreting urea and uric acid which require little water to be removed
10. Possession of specialized locomotory structures such as wings and legs which ais rapid locomotion

Achieving of large surface area to volume ratio in large organisms

As a result of the multicellular state and increase in size, large organisms would have a small surface area to volume ratio and hence would not be able to exchange materials with the environment efficiently. Due to this, large organisms have evolved in various ways in order to increase the surface are to volume ratio. This has been achieved as follows;

1. Having a flattened body as in flat worms which exposes most of the cells on the body surface
2. Having respiratory surfaces that are highly folded or branched which increases the surface are for exchange of gases
3. Having folded absorptive surfaces of the digestive system such as the ileum which increases the surface area
4. Having body extremities that are flattened, such as ears of elephants which increases the are available for heat loss
5. Organizing body cells into sheets such as in diploblastic organisms such as sponges which presents a large surface area
6. Having flattened body organs such as leaves of plants which presents a large surface area
7. Having highly branched organs and tissues such as roots or blood capillaries that increases the surface area for exchange of materials.

THE END