MOUNTAIN TOP UNIVERSITY

E-Courseware

SCHOOL OF BASIC AND APPLIED SCIENCES

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COURSE GUIDE

COURSE TITLE: BIO 102

COURSE CODE: GENERAL BIOLOGY II

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COURSE OBJECTIVES

At the end of this course, students should be able to: have a good knowledge and understanding of the generalized plant and animal kingdoms based mainly on the study of similarities and differences in the external features, ecological adaptation of these forms.

COURSE CONTENTS

LECTURE 1

EXTERNAL FEATURES AND ADAPTION OF MONERA, PROTISTA AND FUNGI

1.0 Introduction

Bacteria belong to kingdom *Monera* according to the five kingdoms of classification proposed by Robert Whittaker in 1969. Others include Protista, Fungi, Plantae and Animalia. The idea of micro-organisms and pathogens which cannot be seen with the naked eye, dated back to 400AD Rome and bacteria was only officially discovered in the 17th century, after the invention of a microscope. Bacteria are the most diverse and abundant group of organisms on Earth. They inhabit practically all environments on earth. Some are extremophiles which thrive in extreme climates or environment, e.g. intense heat or intense cold. Bacteria are mostly useful, but some cause disease.

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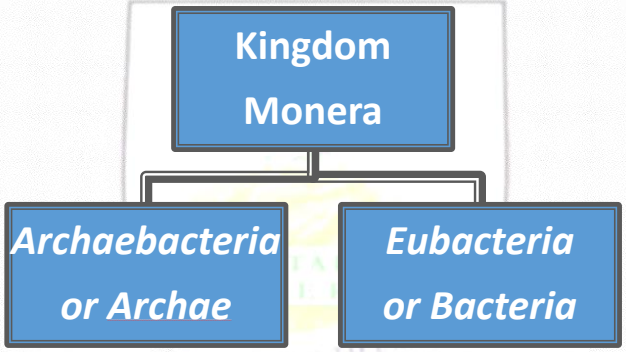


Figure 1.1: Classification of monera

Objectives

At the end of this lecture, students should be able to:

i. State the two groups of monera
ii. Draw and explain the structure of bacterial cell
iii. State the adaptation of bacterial cell
iv. State the two groups of protista
v. Draw a well-labelled diagram of a named plant-like protist
vi. Draw a well-labelled diagram of a named animal-like protist
vii. State the adaptations of protists
viii. Give the classifications of fungi
ix. Draw the diagram and explain the external features of Rhizopus and mushroom

Pre-Test

a. Enumerate the two groups of kingdom monera
b. Draw a well-labelled diagram of bacterial cell
c. State the 2 groups of protista and give their examples
d. Draw a well-labelled diagram of spirogyra
e. Draw a well-labelled diagram of paramecium
f. State the classification of fungi and give one example each
g. Draw a well-labelled diagram of Rhizopus

CONTENT

1.1 External Features And Adaption Of Monera (Bacteria)

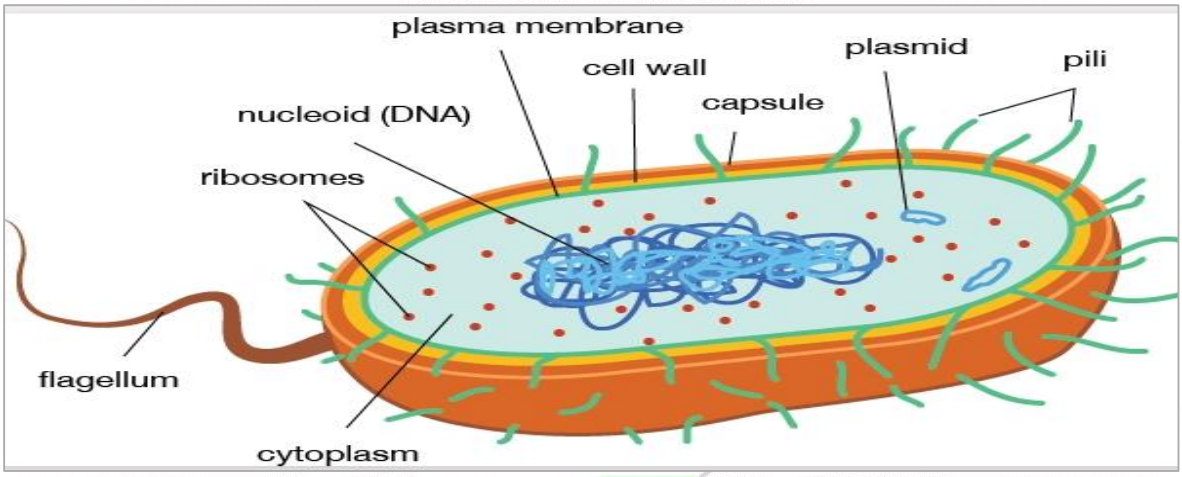


Figure 1.1: *Bacterial cell showing the various components of the cell*
Source: collagenrestored.com

1.1.1 Component of Bacterial Cell

A bacterial cell has five essential structural components

I. A nucleoid (DNA)
II. Ribosomes
III. Cell membrane
IV. Cell wall, and
V. Surface layer (which may or may not be an inherent part of the wall).

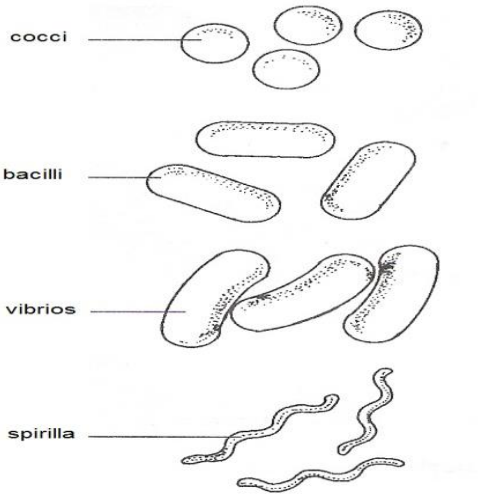
Structurally, there are three architectural regions of bacterial cell

- **The appendage s** (attachments to the cell surface) in the form of flagella and pili (or fimbriae)
- **A cell envelope** consisting of a capsule, cell wall and plasma membrane; and
- **A cytoplasmic region** that contains the cell chromosome (DNA) and ribosomes and various sorts of inclusions

1.1.2 Bacterial Shape

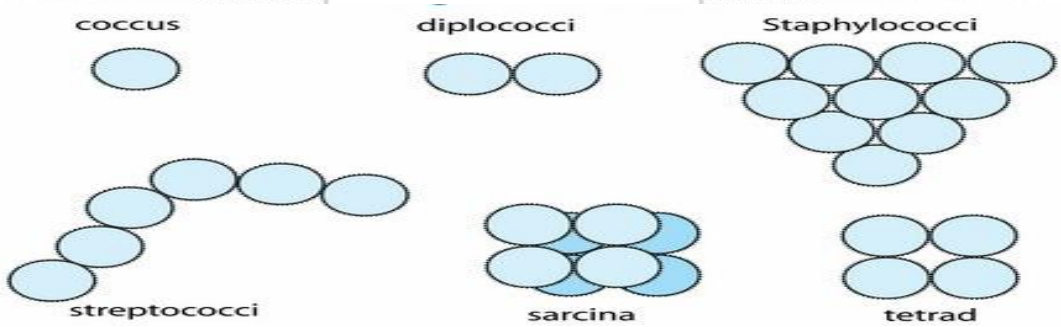
Bacteria are unicellular and are made up of simple cells, but have ability to carry out all the functions of living organisms. Bacteria vary in shape and can be classified as follows:

- Spherical-shaped bacteria are called cocci.
- Rod-shaped bacteria are called bacilli.
- Spiral-shaped bacteria are called spirilla
- Comma-shaped bacteria are called vibrios.



More so, bacteria can occur singly, in chains (streptococcus) or in clumps (staphylococcus).

Figure 1.2: Bacterial shapes



Source: en.wikipedia.org

Flagellum (plural: flagella)

- This is a threadlike, cellular extension that functions in the locomotion of bacterial cells and of unicellular eukaryotic organisms; flagella are longer and less numerous than cilia.
- It is a rigid rotating tail.
- Some bacteria move with the help of one or more flagella. Flagella are longer and thicker than pilli. Their structure is different from flagella of eukaryotes.

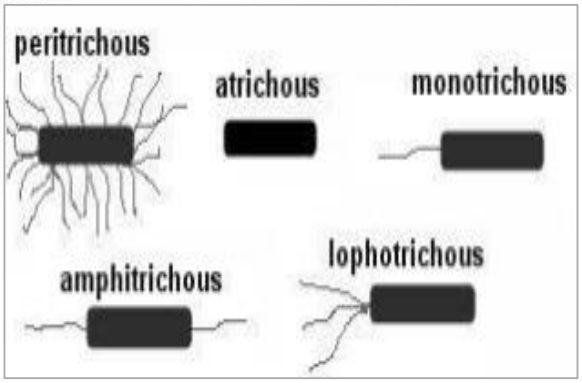


Figure 1.3: Flagellation in Bacteria
Source: embibe.com

Function

- It helps the cell to move in clockwise and anticlockwise, forward and also helps the cell to spin.

- The rotation is powered by H+ gradient across the cell membrane.

Pilli:

These are thin thread like tubular structures projecting out from the cell wall in some bacteria

- It is a Short protein appendages.
- It is smaller than flagella.
- *Function*: It fixes bacteria to surfaces.
- It also helps in reproduction during conjugation.

Fimbriae:

- This is similar to Pilli, but shorter and more abundant on the cell surface.
- Function: Adhesion of cells to surface and formation of pellicles (biofilms) containing thin sheets of cells on a liquid surface.

Capsule:

- A loose gel- or slime-like structure that is rich in polysaccharides and that frequently coats the outer surface of a bacterial cell Wall. Most pathogenic bacteria have a waxy capsule. Capsules may be divided into three categories:

(a) Macrocapsules, which are sufficiently thick to be detected by light microscopy;
(b) Microcapsules, which are too thin to be detected by light microscopy but can be detected by serological techniques; and
(c) Slime layers, which are diffuse secretions that adhere loosely to the cell wall and have no definite borders; they generally become dispersed in the medium when the organism is grown in liquid culutre

Functions

- Capsule is a kind of slime layer, which covers the outside of the cell wall.
- They are composed of a thick polysaccharide.
- It is used to stick cells together and works as a food reserve.
- It protects the cell from dryness and from chemicals.

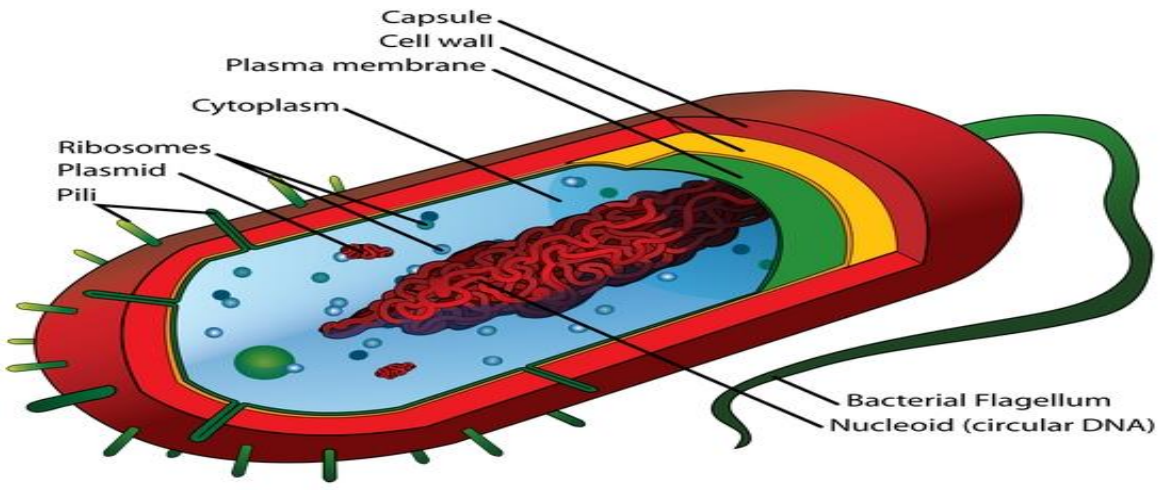


Figure 1.4: Bacterial cell showing the arrangement of cell envelop
***Source**: fanpop.com*

Cell Wall:

- All prokaryotes have a rigid cell wall, which protects and gives shape to the cell.
- The cell wall is made up of a chemical called peptidoglycan (also known as murein or mucopeptide) which is unique to bacteria.
- It also composed of lipids, polysaccharides and some proteins.
- Peptidoglycan composition also differ in certain properties in the two groups of bacteria, namely gram-negative and gram-positive.
- In Gram positive, Peptidoglycan form about 40 sheets & constitute about 50% of the cell wall or more of the dry weight of some Gram positive bacteria, while in Gram negative, Peptidoglycan form about 1-2 sheets & constitute about 10% of the cell wall
- *Function*: Cell wall helps in providing support, mechanical strength and rigidity to cell.
- It also protects cell from bursting in a hypotonic medium.

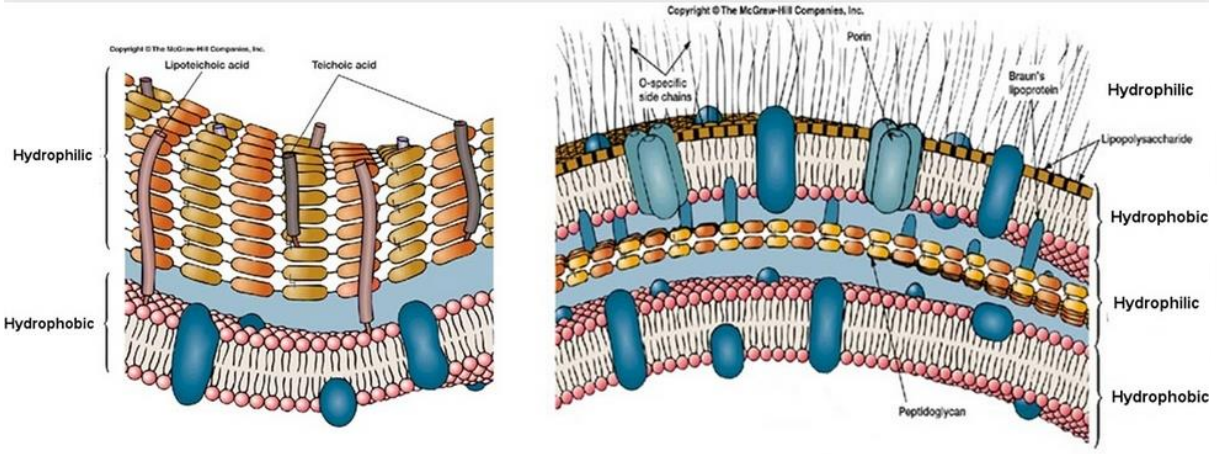


Figure 1.5: Bacterial cell wall showing the Peptidoglycan layers (Gram positive (left) and Gram negative (right))
***Source**: is.muni.cz*

Plasma Membrane:

- This is also known as *cytoplasmic membrane* (or) *cell membrane.*
- It is present below the cell wall and it encloses the cytoplasm and other cell contents.
- It is composed of phospholipids, proteins and carbohydrates, forming a fluid-mosaic as in eukaryotes.
- *Function*: It helps in transportation of substances including removal of wastes from the body.
- It helps in providing a mechanical barrier to the cell.
- Plasma membrane acts as a semi permeable membrane, which allows only selected material to move inside and outside of the cell.

Glycocalyx:

- Structure: Polysaccharide layers; can be thick and stable like capsule or loosely attached to cell wall like slime layer.
- *Function*: Assist cells in adhesion to solid surface, and also protect pathogenic bacteria from the attack of the host's immune system.

Cytoplasm:

- Helps in cellular growth, metabolism and replication.
- Cytoplasm is the store houses of all the chemicals and components that are used to sustain the life of a bacterium

Genetic Material:

- Prokaryotes do not possess true nucleus with many Chromosomes as we have in Eukaryotes.
- But they possess one circular chromosome made of a double helical molecule of DNA located in a region of the cytoplasm called Nucleoid.
- The DNA carries out the functions of a nucleus.
- They act as the store house of information necessary for Protein synthesis.
- They have ability to transfer this information to new (daughter) cells

Plasmid:

- Apart from the chromosome, several species of bacteria possess one or more additional rings of DNA called plasmids, which replicate along with bacterial chromosome and bear genes for antibiotic resistance and act as the sex factor or F-factor.
- Plasmids are small circle of DNA.
- Bacterial cells have many plasmids.
- Plasmids are used to exchange DNA between the bacterial cells.

Ribosomes:

- These are small particles of about 20 µm, which could be up to 10,000 in a single cell.
- They composed of protein (40%) and Ribonucleic acid (60%).
- They possess sedimentation constant of 70S and are attached to intracellular membrane
- They are responsible for Protein synthesis in the cell.

Mesosomes:

- They are specialized structures formed from cell membrane by convoluted invaginations which may be large and irregular.
- The 2 types are Septal and Lateral Mesosomes.

  1. They function in the formation of cross walls during cell division and also for attachment of enzymes involved in DNA replication.
  2. They are also involved in Protein secretion in some organisms

Porin:

- This is an integral protein of the outer membrane in gram-negative bacteria.
- Porins are arranged in a hexagonal lattice, with trimmers at each corner, resulting in electron micrographs that have been interpreted as being indicative of pores; the latter are believed to be responsible for the permeability of the membrane to small polar (hydrophilic) molecules.

1.1.3 Adaptation in Bacterial Cell

Adaptations are special features that allow a plant or animal to live in a particular place or habitat. It is the adjustment or changes in behavior, physiology, and structure of an organism to become more suited to an environment.

In favourable conditions, bacteria will reproduce rapidly by binary fission, an asexual process whereby one bacteria can split into two every 10-15 minutes.

When bacteria encounter a new challenge in their environment, such as treatment with an antibiotic or a poor nutrient source, their population faces tremendous selective pressure to evolve in order to grow better under the new conditions, for example, the following mechanisms may be used:

- They can acquire an antibiotic resistance gene, or
- Modify an existing enzyme to make better use of a nutrient source by rewiring the cell's metabolism,
- Loss of function mutations can provide substantial fitness benefits under this challenging conditions

In unfavourable conditions, bacteria may survive by becoming dormant. They form spores with a thick, protective coat around them, which will split open in favourable conditions.

- Endospores are spores created by a small group of bacteria. They are specialized to withstand unfavourable conditions. They can survive for thousands of years and can cause diseases such as tetanus and anthrax

Pathogenic bacteria infect our bodies in order to get food. They may:

- Destroy body cells which are then used as a source of food.
- Absorb material directly from body fluids such as blood.
- Release harmful substances, called toxins. Toxins may:
  - Cause symptoms like a rash or a high temperature.
  - Block metabolic pathways in the host cells which can have a devastating effect on the body.

1.2 External Features and Adaption of Protista (Spirogyra & Paramecium)

Protista are organisms that cannot be classified as Monerans, fungi, plants or animals. The group was created because of classification problems. Some members share the characteristics of more than one other kingdom.e.g. Euglena has chloroplasts & is an autotroph like plants, but has no cell wall and can swim using a flagella, so also like an animal. Most of the protists are unicellular organism while a few are colonies of identical cells. Protists are distinguished from unicellular Monerans because they are eukaryotes i.e. they have a nuclear membrane and other organelles. Kingdom Protista are categorized into two taxons: Algae and Protozoa

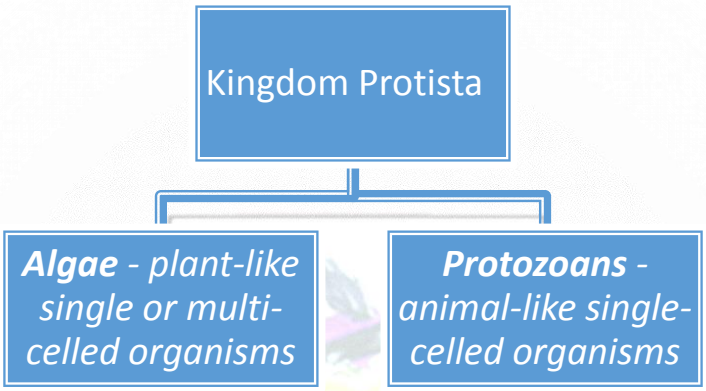


Figure 1.6: Schematic representation of the classification of protista

1.2.1 Algae (Plant – like Protists)

Algae (singular: alga) are morphologically simple, chlorophyll-containing organisms which could either be microscopic unicellular (single-celled) or very large macroscopic and multicellular. They are a group of predominantly aquatic in nature.

Unicellular Algae have unicellular bodies. They are divided into 3 phyla:

- Phylum Euglenophyta e.g. Euglena
- Phylum Pyrrophyta e.g. dinoflagelates, plankton
- Phylum Chrysophyta e.g. diatoms

Multi-cellular algae have multicellular bodies. They are once classified as plants because they have chlorophyll and perform photosynthesis but now classified as protists because they have reproductive structures different from plants. Three phyla have been identified:

- Phylum Chlorophyta (green algae) e.g. Spirogyra
- Phylum Rhodophyra (red algae) e.g. Gelidium, alga
- Phylum Phaeophyta (brown algae) e.g. Sargassum

1.2.2 External feature and adaptation of Spirogyra

Figure 1.7: Spirogyra filaments
Source: bionotesportal.blogspot.com

1.2.3 Hierarchical order in the classification of Spirogyra

Kingdom: Protista
Phylum: Chlorophyta
Class: Chlorophyceae
Order: Conjugales
Family: Zygnemaceae
Genus: Spirogyra
Common name: Pond-scum/ Pond silk

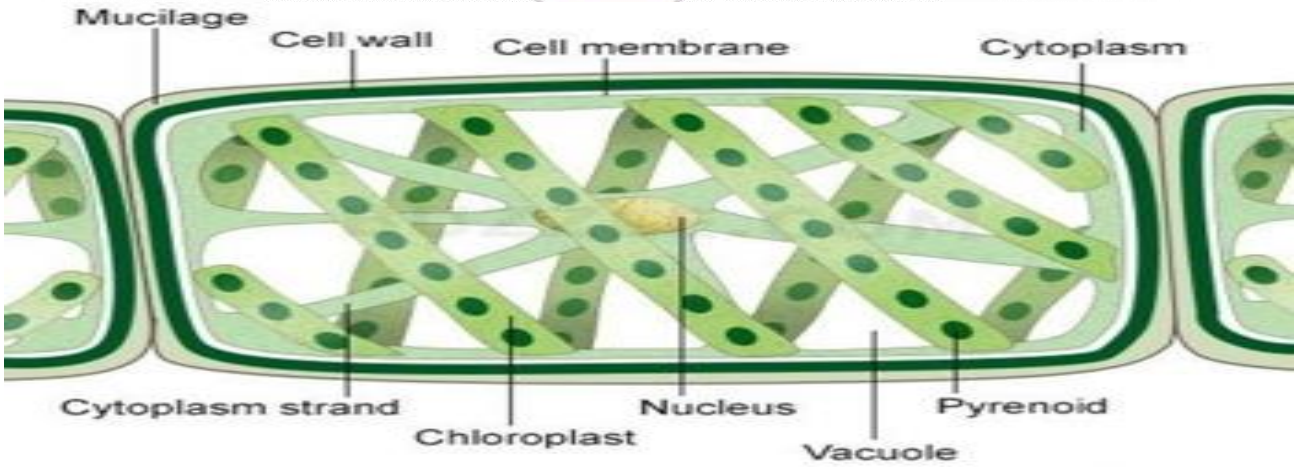


Figure 1.8: Structure of spirogyra cells
Source: qsstudy.com

1.2.4 Parts of Spirogyra

- **Shape and Structure:** The plant body of spirogyra is a gametophytic thallus which is elongated cylindrical, unbranced, silky thread-like structure known as filament. Each filament consists of numerous elongated rectangular cells joined end to end in a row.

The cells are separated by a partition wall known as Septum. Each cell can be differentiated into two; cell wall and protoplast.

- **The Cell Wall:** This is the outermost protective double layered structure. The inner layer of which is made of cellulose and the outer layer contains pectose. The outermost lining of Pectose turns into Pectin and get dissolved in water to form Mucilage which surrounds the filament and forms Mucilagenous sheath.
- **The Protoplast:** This contains Plasma membrane, cytoplasm, single large centrally located vacuole and Chloroplast containing Pyrenoids.
- **Plasma Membrane:** This lies inner to the cell wall and is semi-permeable in nature (allows the passage of selective substance).
- **Cytoplasm:** There is presence of granular cytoplasm which is distributed in the peripheral region of the cell. Cytoplasm is traversed by several cytoplasmic strands.
- **Vacuole:** Spirogyra contains a single large vacuole bounded by Tonoplast and containing watery fluids. Cell sap occupies the central part of the cell.
- **Chloroplast:** This is a spirally coiled ribbon shaped containing Pyrenoids. The number of chloroplast ranges from 1-16 depending upon the species. Spirogyra is named due to spiral arrangement of chloroplast
- **Pyrenoids:** These are rounded Proteineous structures which lie equidistant from each other inside the chloroplast. They contain Central core of starch surrounded by Protein plates and help in formation and storage of starch.
- **Nucleus:** Spirogyra contains a single prominent nucleus lies at the center of the cell. It is held in position by the thin delicate, radiating cytoplasmic strands.
- **Cytoplasmic Organelles:** Golgi bodies, Mitochondria and Endoplasmic reticulum are present in the cytoplasm.

1.2.5 Adaptation in Spirogyra

Spirogyra is a bright green, filamentous fresh water algae.

It is generally found as free floating slimy masses on the surface of stagnant water in ponds & ditches, hence it is also called pond scum. The body is a haploid, multicellular, and unbranched filament

- All the cells are capable of growth, and reproduction.
- Its basal cell differ from all other cells in not having chlorophyll and its in-ability to divide.
- It fixes the filament to substratum, hence, these basal cell is called hold fast.
- It can reproduce during favourable and unfavourable conditions. For instance, It reproduces during unfavourable condition by asexual methods.
- It can also reproduce vegetatively by mere fragmentation of the filaments
- Spirogyra can also reproduce sexually through Conjugation by Scalariform and lateral methods

1.2. Protozoan (Animal-like Protists)

Protozoans are heterotrophs and can move. They are classified on the way they move into four categories:

- *Sacordinia* - move using pseudopod. e.g. *Amoeba, Foraminiferans*
- *Zooflagellata* - move using flagella. e.g. *Trypanosoma gambiense*
- *Ciliaphora* - move using cilia. e.g. *Paramecium*
- *Sporozoa* - forms spores. e.g. *Plasmodium*

Figure 1.9: Paramecium cell showing the cilia
Source: Dennis Kunkei microscopy, inc. 2004

1.3.1 Hierarchical order in the classification of Paramecium

- Domain: Eukaryota
- Kingdom: Protista
- Phylum: Ciliophora
- Class: Oligohymenophorea
- Order: Peniculida
- Family: Parameciidae
- Genus: Paramecium

1.3.2 Parts of Paramecium:

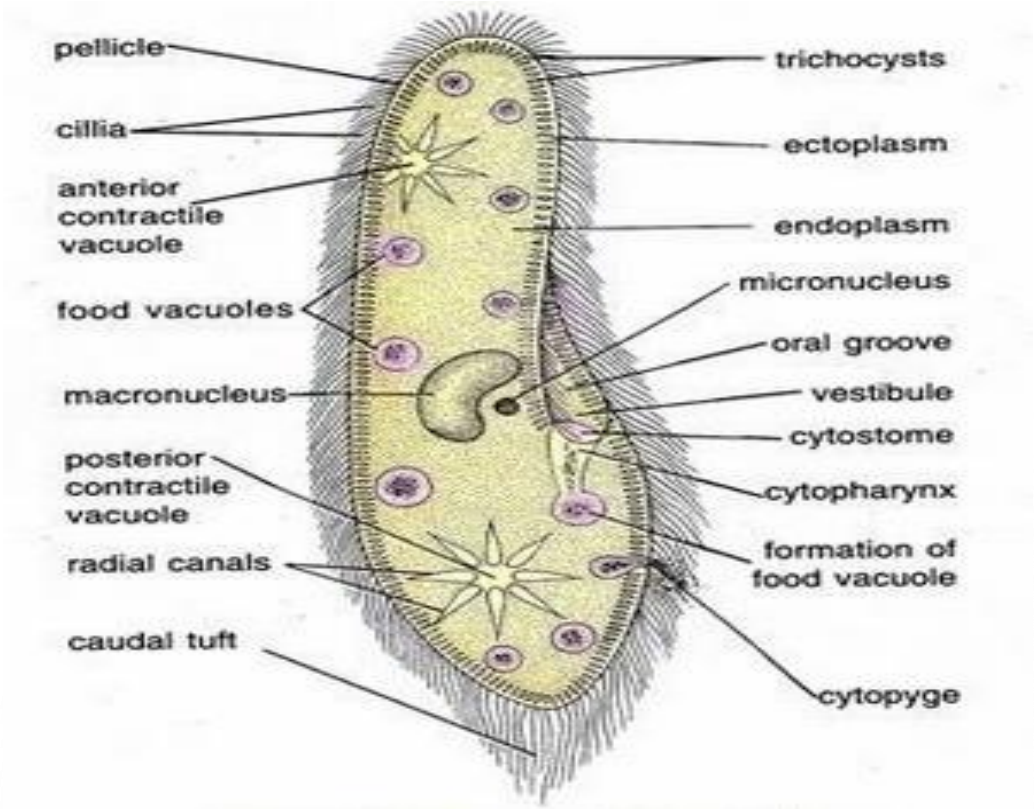


***Figure 1.10*: Paramecium cell showing the organelles**
Source*: *biologydiscussion.com.

1) ***Size***: Paramecium is a microscopic, a cellular elongated organism visible to the baked eye as a whitish or greyish spot. It is 120-300
2) ***Shape***: Paramecium is a slipper shaped, cigar shaped, or spindle shaped animalcule. Its shape is usually constant and a symmetrical, because slipper like shape. The body is elongated, blunt and rounded at the anterior end and somewhat pointed of the posterior end.
   The body is distinguished into an oral or ventral surface and an aboral or dorsal surface.
3) ***Pellicle***: The body of paramecium externally covered by living, thin, clear, firm and elastic cuticular membrane. The pellicle or periplast. It gives a definite body form to the organism.
4) ***Cilia***: The entire body surface is covered by a uniform covering of numerous, hair like protoplasmic fine projections. These emerge out from the centre of each polygonal depression (circumelliary space) of pellicles. These measure 10 to 12m in length and up to 0.27m in diameter. There are 10,000 to 14,000 cilia covering the whole body surface
   Functions of cilia are locomotion and capturing the food particles
5) ***Oral groove:*** The ventral surface of body bears a prominent, oblique and shallow depression. It arises from the middle of body and extends to the left side of anterior end.
6) ***Gullet***: this is the cavity of the pharynx.

7) ***Endoplasm***: This is below the ectoplasm. It is a large, central, granular and sense fluid zone called endoplasm or medulla. It includes the usual cell components like: food vacuoles, reserve food granules of starch, glycogen and fat, mitochondria, golgi bodies, ribosomes and various crystals and other cytoplasm inclusions of varying size, shape and character.
8) ***Trochocyst***: this is the root of a vibrative cilium of a paramecium.
9) ***Nuclear apparatus***: Paramecium is heterokaryotic as it differs from amoeba in having two types of nuclei which can be seen in properly stained specimens
    a. ***Macronucleus***: This is the somatic or vegetative nucleus and it controls the metabolic activities of the cell. It is derived from micronucleus during reproductive processes
    b. ***Micronucleus***: It controls the reproductive activities of the organism.
10) ***Contractile Vacuoles*:** Unlike amoeba, there are two large liquid filled contractile vacuoles occurring somewhat fixed position in endoplasm. Main functions of contractile vacuoles are:

    a. Osmoregulation
    b. Excrete excess water taken up from the hypotonic medium.
    c. Posterior vacuole pulsates faster than anterior vacuole.

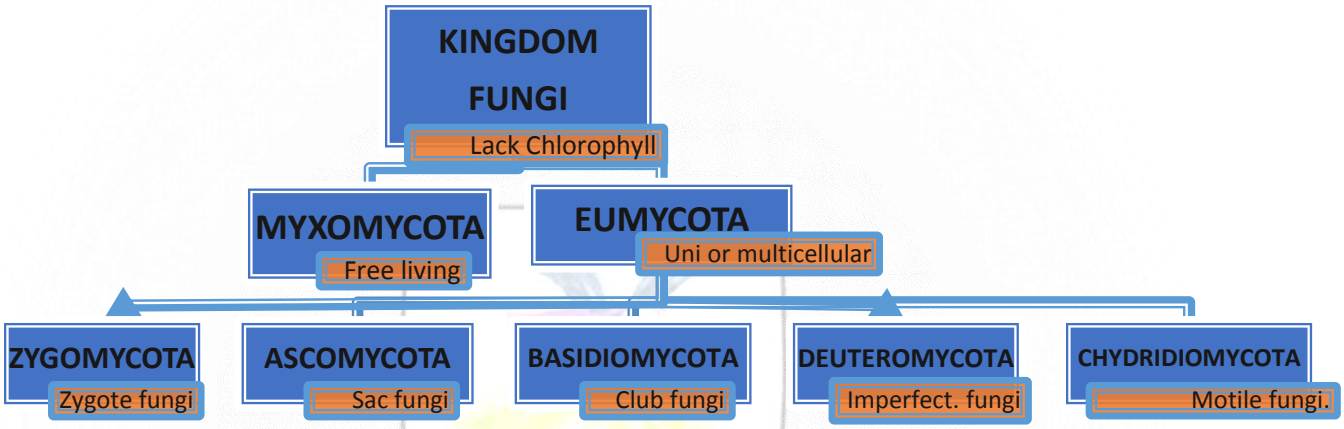
Adaptation in Paramecium

Paramecia and other ciliates are the most complex of all single-celled organisms.

- The paramecium has a stiff outer covering that gives it a permanent slipper shape.
- It swims rapidly by coordinated wavelike beats of its many cilia (short, hair-like projections of the cell).
- A paramecium normally moves forward in a corkscrew fashion but is capable of reversing direction when it encounters adverse conditions.
- The paramecium has an external oral groove lined with cilia and leading to a mouth pore and gullet; food (typically smaller organisms, such as bacteria) is digested in food vacuoles.
- There are also an anal pore, two contractile vacuoles that regulate the water content of the cell.
- There are two nuclei. The larger nucleus, or macronucleus, is thought to regulate most cell functions, while the smaller nucleus, or micronucleus, is involved in reproduction.

1.4 External Features and Adaptions of Fungi (Rhizopus, Mushroom)

Fungi are Eukaryotic organism. They do not contain chlorophyll (non-photosynthetic). Most are saprobes – i.e. live on other dead organisms. They have Extracellular digestion (i.e. they digest food outside of their body by secreting hydrolytic enzymes). They Store their food energy as glycogen which is similar to what is obtained in animal. They are important decomposers & recyclers of nutrients in the environment. In addition, most are multicellular, but some are unicellular like yeast. Fungi are classified into five divisions, these are: Zygomycota, Chytridiomycota, Ascomycota, Basidiomycota, Deuteromycota



(Imperfect fungi).

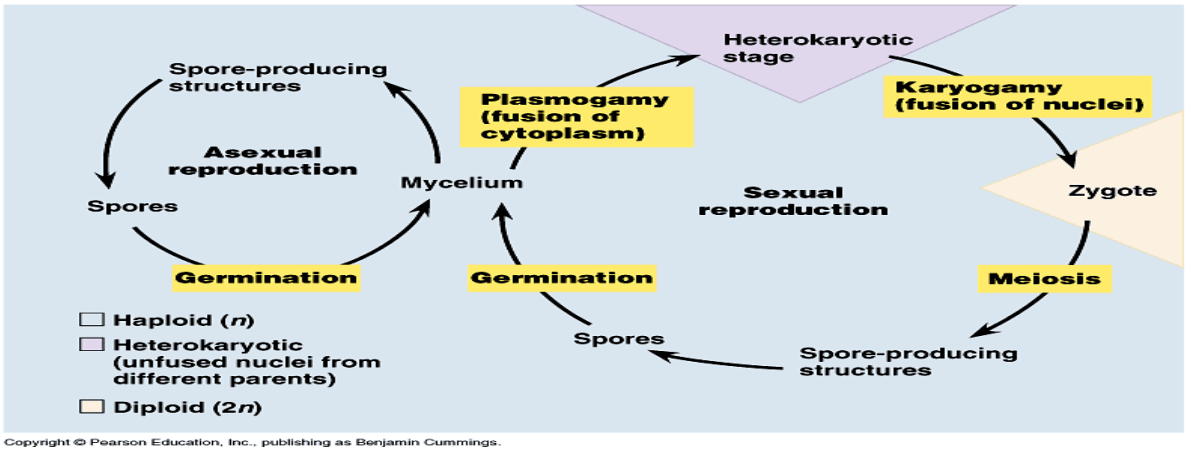
Figure 1.11: Classification of fungi

1.4.1 Stages of Fungi Life Cycle

Two distinct stages in the union of partners during fungi sexual reproduction are;

- *Plasmogamy:* The fusion of the parents' cytoplasm when their mycelia come together
- *Karyogamy :* Fusion of the haploid nuclei of the 2 parents

- The two stages may be separated in time by hours, days, or years. During the



interim, the hybrid is a *heterokaryon*

Figure 1.12: Generalized life cycle of fungi

Source: wordpress.com

1.4.2 External Structure of Rhizopus

Rhizopus are sometimes called sporangium fungi or common molds. These Include moulds and blights such as Rhizopus stolonifer (bread mold). Rhizopus lack septa in their hyphae (coenocytic) and their asexual reproductive structure is called sporangium.

Rhizopus stolonifer was first discovered in 1818 by the German scientist Christian Gottfried Ehrenberg as *Rhizopus nigricans*. A French mycologist Vuillemin J. P. in 1902 later renamed it as *Rhizopus stolonifer*. R. stolonifer is one of the most common fungi in the world and it is often considered as the most important species in the genus *Rhizopus*. It is also the common agent of decomposition of stored foods.

The hierarchical classification of *Rhizopus stolonifer* is as follows:

Kingdom	**Fungi**
Phylum	Zygomycota
Class	Zygomycetes
Order	Mucorales
Family	Mucoraceae
Genus	*Rhizopus*
Species	*R. stolonifer*

- Other common species of Rhizopus include: *R. oryzae*, *R. caespitosus*, *R. delemari*, *R. homothallicus*, *R. microspores*, *R. reflexus*, *R. schipperae* etc.

Parts of *Rhizopus Stolonifer*

- **A sporangium** (plural: sporangia) is an enclosure in which sporangiospores (spores) are formed. A cluster of sporangia that have become fused in development is called a synangium.
- **A columella** (plural: columellae) is a sterile (non-reproductive) structure that extends into and supports the sporangium
- **A stolon** connects sporangiophores together. It is occasionally present as a septate hypha.
- A **hypha** (plural hyphae) is a long, branching filamentous structure of a fungus. Hyphae are the main mode of vegetative growth, and are collectively called a mycelium. It is also present in oomycete and actinobacterium
- The sexual spore is produced by conjugation when (+) and (-) hyphae fused together called zygospore. Zygospores can endure harsh environments until conditions improve and new sporangium is formed.

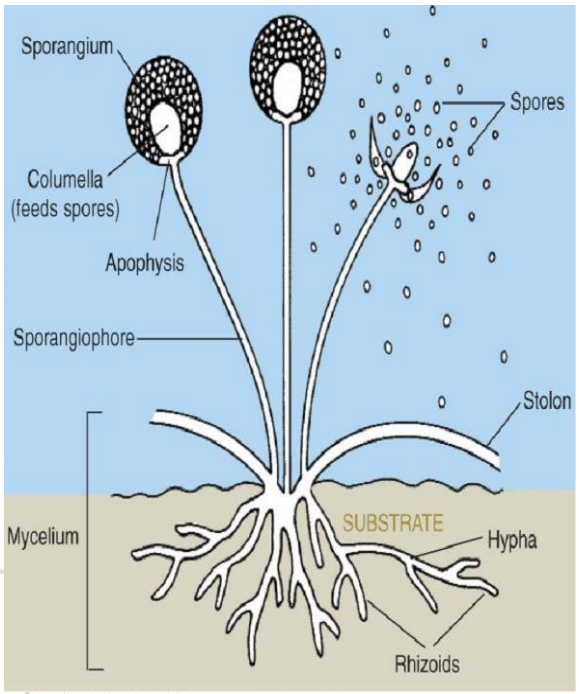


Figure 1.13: Structure of Rhizopus
Source: eduladder.com

- Hyphae grow by elongating at the tips and each part of a hypha is capable of growth. The two types of hyphae are:
    - Septate hyphae: here, the cells are divided by cross-walls (septa).
    - Coenocytic (Aseptate) hyphae: this is a long, continuous cells that are not divided by septa.

  Structurally, hyphae could be divided into:
    - Vegetative Hypha: Portion that obtains nutrients.
    - Reproductive or Aerial Hypha: Portion connected with reproduction.

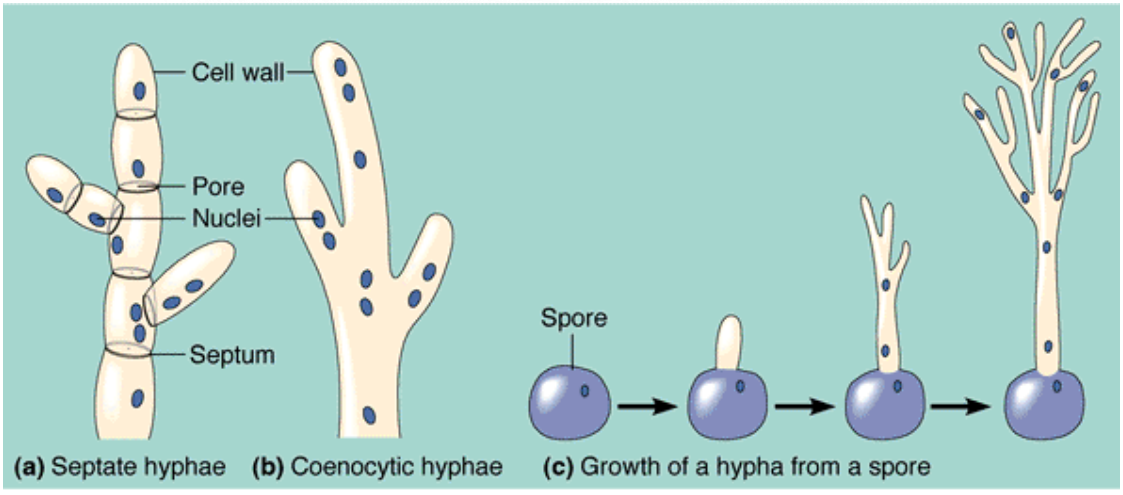


Figure 1.14: Types of hyphae
Source: Benjamincummings

- **Mycelium**: this is a large, visible, filamentous mass made up of many hyphae. It is the underground portion of the mushroom. At its very bottom, it has hypha, which are root-like white filaments that collect water and organic matter for the mushroom

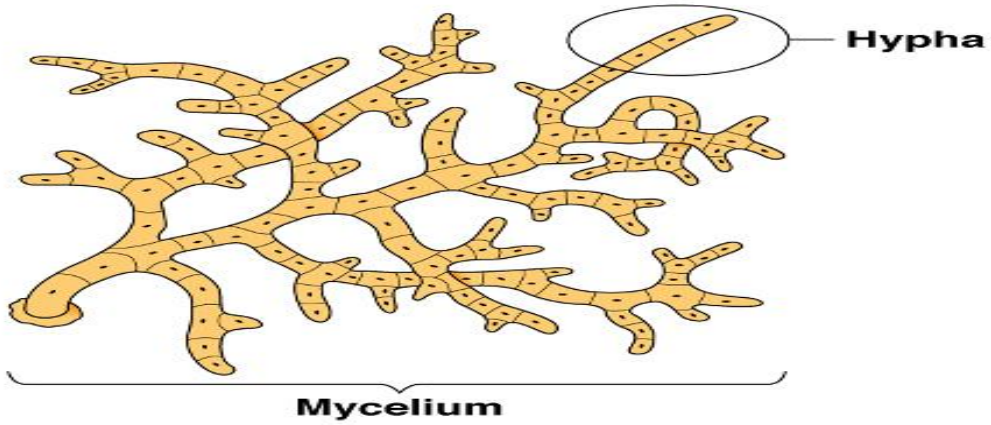


Figure 1.15: Structure of fungal mycelium
Source: Addison Wesley Longman, inc

1.4.4 External Structure of Mushroom

Mushrooms are the fruiting bodies produced by some fungi. And it should be noted that not all fruit bodies are true mushrooms. *Puffballs* and *morels* are edible fruit bodies that are sometimes called mushrooms. The hierarchical classification of common mushroom are as follows:

Domain:	**Eukaryota**	**Eukaryota**	**Eukaryota**
Kingdom:	Fungi	Fungi	Fungi
Phylum:	Basidiomycota	Basidiomycota	Basidiomycota
Class:	Agaricomycetes	Hymenomycetes	Hymenomycetes
Order:	Agaricale	Agaricale	Agaricale
Family:	Agaricaceae	Agaricaceae	Tricholomataceae
Genus:	Agaricus	Agaricus	Pleurotus
Species:	*A. biosporus*	*A. compestris*	*P. Ostreatus*
Common Name:	Button or White Mushroom	Meadow Mushroom	Oyster Mushroom

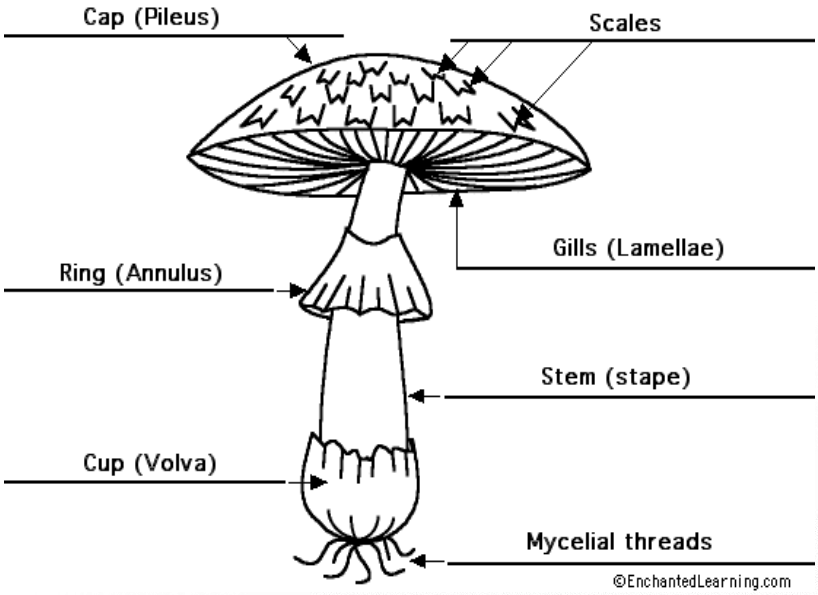


Figure: 1.16: External structure of a mushroom
Source: kullabs

1.4.5 Parts of Mushroom

The parts of the mushroom are: the cap, gills or pores, spores, stem, ring, volva, mycelium and hypha. Mushroom can be divided into: underground and aboveground sections

- ***The cap*** of the mushroom is the top-most part. It can be conical, flat or spherical. It has a variety of textures depending on the type of mushroom and stage of development. Its function is to protect the gills,
- ***The Gills***: these are found on the underside of the cap and composed of thin, paper-like layers stacked side by side. Some mushrooms have pores instead of gills. These are tiny tubes packed tightly together that resemble a sponge. The gills and pores produce spores, the reproducing element of the mushroom.
- ***The stem*** of the mushroom supports the cap and may not be present in certain types.
- ***The ring*** of the mushroom is found on the upper portion of the stem and is a remnant of a protective covering for the gills that ruptured as the cap grew.
- ***Volva***: this is at the base of the stem which is a similar remnant covering that once protected the entire mushroom.
- ***Hyphae***: This is a long filaments of cells joined together. **Mycelium**: this is the underground portion of the mushroom. it has numerous hypha, which are root-like white filaments that collect water and organic matter for the mushroom
- ***Basdiocarp*** – this is made up of stalk called the stipe & a flattened cap
- ***Stipe*** - this may have a skirt like ring below cap called the annulus
- ***Basidium*** – this is sexual reproductive structure that make basidiospores
- ***Basidiospores*** – these are released from the gills & germinate to form new hyphae & mycelia

Vegetative structures found below ground & include rhizoids (anchor & absorb nutrients), hyphae, & mycelia.

1.4.6 Adaptations in Fungi

- Fungi are constructed of tiny filaments called *hyphae*, & the hyphae form an interwoven mat known as *mycelium*
- Fungi have cell walls, most made of chitin which is made of the same material as exoskeleton of insects and arthropods
- Extensive surface area adapts fungi for absorptive nutrition
- Fungi can reproduce both sexually and asexually
- Absorptive nutrition allows fungi to serve as decomposers (*saprobes*), parasites, or mutualistic symbionts
- Saprobic fungi absorb nutrients from non-living organic material (animal waste, dead plants & animals)
- Parasitic fungi absorb nutrients from cells of living hosts which Caused about 80% of plant diseases
- Mutualistic fungi absorb nutrients from the host but also benefit the host, such as aiding in uptake of nutrients

Nutritional Adaptations of Fungi

Fungi absorb their food, rather than ingesting it.

- Almost all molds are aerobic. Most yeasts are facultative anaerobes.
- Fungi are more resistant to high osmotic pressure than bacteria.
- They can break down complex carbohydrates (wood, paper), that most bacteria cannot**.**
- They can grow on substances with very low moisture.
- They can also grow better at a pH of 5, which is too acidic for most bacteria.
- Fungi require less nitrogen than bacteria to grow.

Reproductive Adaptation in Fungi

- All have some means of asexual reproduction involving mitosis and cytokinesis while most reproduce sexually
- They can also reproduce through budding and asexual spore formation
- Filamentous fungi produce lightweight spores that disperse over large distances

Post-Test

a. Enumerate the two groups of kingdom monera
b. Draw a well-labelled diagram of bacterial cell
c. State the 2 groups of protista and give their examples
d. Draw a well-labelled diagram of spirogyra
e. Draw a well-labelled diagram of paramecium
f. Given the name and labelling of figure K

g. State the functions of structures 1-12 in figure K
h. State 10 characteristics of fungi
i. State the classification of fungi and give one example each
j. Draw a well-labelled diagram of Rhizopus
k. Draw a well-labelled diagram of mushroom
l. State all the parts A-H in the figure Q
m. State the functions of the labelled parts in figure Q

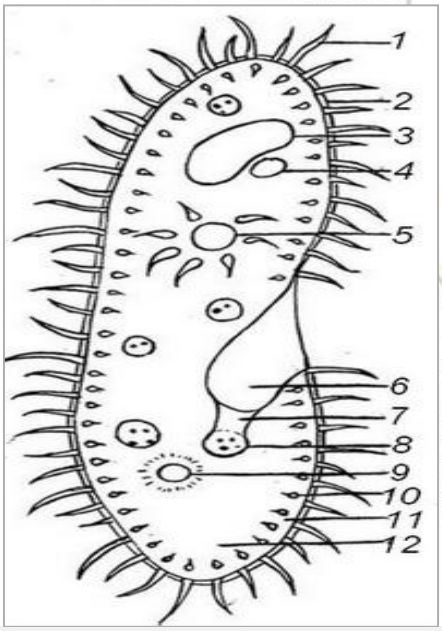


Figure K
Source: microbewiki.kenyon.edu

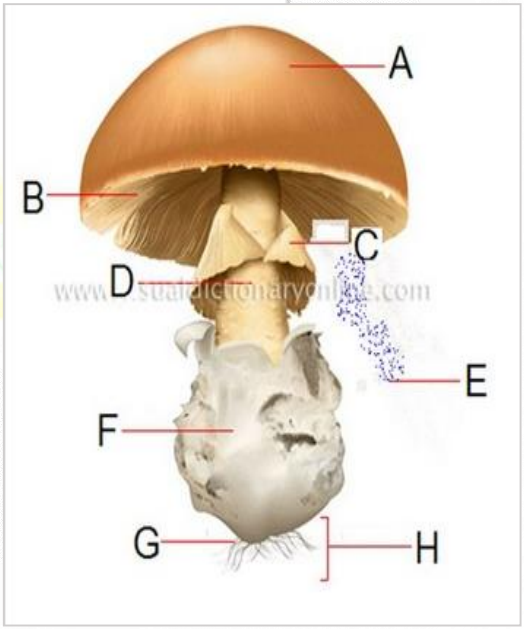


Figure Q
Source: visualdictionaryonline.com

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LECTURE 2
KINGDOM PLANTAE

2.0 Introduction

This lecture focusses on the external features and ecological adaptations of the various phyla in the kingdom Plantae to life on land and in water. The groups to be studied include Bryophyta, Pteridophyta and Coniferophyta. It will also focus on the problems and challenges of plants from a transition of life in water to life on land.

Objectives

At the end of this lecture, students should be able to:

1. Know the various phyla in the kingdom Plantae
2. Be familiar with the external features of a named representative of each group
3. Be conversant with the ecological adaptation of each group, and the problems associated with transition from life in water to life on land.

Pre-Test

1. What are the characteristics of plants?
2. What are characteristics that plants have in common with animals?
3. Mention the phyla that make up the kingdom Plantae

CONTENT

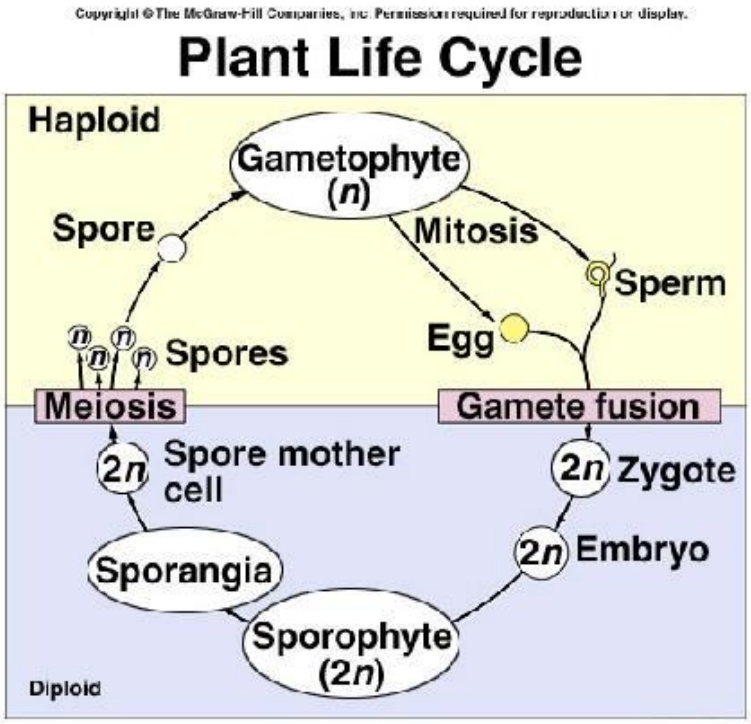
2.1 Adaptation and Ecology of Plants to Life on Land and Water

Divisions / phylum of the kingdom plantae which include but not limited to:
Bryophyta
Pteridophyta
Coniferophyta
However, how do they adapt to life on land and water? i.e. Water (Aquatic) and Land (Terrestrial) is questionable.

2.2 Factors Associated with Transition of Plant from Aquatic to a Terrestrial Environment

Desiccation: Any plant not protected in some way for example by a waxy cuticle.
Reproduction: Delicate sex cells (male gametes) must be protected. The male gametes had to swim in water to reach the female gametes……
Note: On terrestrial environment, there is no water for movement of male gametes, though sexual reproduction cannot be achieved on land.
To broaden our knowledge, let us refresh our memory on reproduction of phylum bryophyta. They undergo what is called Alternation of generation, that is

A haploid gametophyte generation
A diploid sporophyte generation



Source: http://faculty.southwest.tn.edu/rburkett/classification_of_organisms.htm

Nutrition: Light and carbondioxide for photosynthesis, above ground. Minerals and water below ground.
Support: In comparison to water, air (on terrestrial environment) offers no support to the plant body.
Gaseous exchange: For photosynthesis and respiration, carbon dioxide and oxygen must be exchanged with the atmosphere rather than a surrounding solution.
Environmental variables: Water, particularly large bodies of water like lakes and oceans, provides a very constant environment. A terrestrial environment, however, is much more subject to changes in important factors such as temperature, light intensity, ionic concentration and pH.

2.3 Bryophyta (Mosses)

1. Adaptation of mosses to aquatic (Water) environments

They depend on water for reproduction because spores must swim to the archegonia. There are no special supportive structures, so the plants are restricted in upward growth. They are dependent on availability of water and mineral salts close to or at the surface of the soil, because they have no roots to penetrate the substrate. However, rhizoids are present for anchor, an adaptation to a solid substratum.

2. Adaptation of mosses to terrestrial (Land) environments.

They are partly adapted to land because the gametophyte develops reproductive structures, the antheridia and the archegonia. Mode of spore dispersal, depends on the drying out of the capsule. Dispersal of small, light spores by wind.

Scientific Advances Associated with Adaptation of Plant Life on Land:

1. Development of two types of spore (heterospory)
2. Development of non-swimming gametes
3. Development of seeds

Features that make Seed Plants to be Adaptable to Life on Land:

1. Prevention of water loss -

i Most fruit leaf and stem are covered with a protective waxy layer called the cuticle.
ii Waxes are biomolecules that do not dissolve in water.
iii The waxy cuticle creates a barrier that helps prevent loss of water in the plant tissues into the air carrying out photosynthesis.

2. Roots -

i Roots are plants organs that absorb water and minerals from the soil.
ii They contain tissues and transport organs for nutrients circulation through the stem.

Movements of water and minerals:

1. Water moves from the root of tree to its leaves and the sugars produced in the leaves moves to the root through the stem.
2. A stem provides support for growth. It contains tissues for transporting food, water from one part of the plant to another.
3. They can also serve as organ for food storage. In green cells, some cells contain chorophyll and can carry out photosynthesis.

Reproductive Strategy:

1. Some plants reproduce through seed formation. A seed is a plant organ that contains an embryo along with a food supply and is covered with a protective coat.
2. It prevents embryo from drying and also aid dispersal.
3. Land plants are produced by either spores or seeds.

2.4 Pteridophyta (Ferns)

For certain ferns, the gametophyte generation is a delicate prothallus and it produces male gametes, or sperm, dependent on water for swimming.
They are heterosporous in nature.
They produce large spores called megaspores in one type of sporangium (megasporangium) and small spores called microspores in another type of sporangium (microsporangium).
When spores grow they form gametophytes.
Megaspores produce female gametophytes and microspores produce male gametophytes.

Seed bearing plants – Gymnosperms and Angiosperms

1. In seed bearing plants the gametophytes (megaspores and microspores) are very small and never released from the spores.
2. Thus, the gametophytes are protected from desiccation, an evolutionary advance.
3. However, sperms from the male gametophyte still have to travel to the female gametophyte.

This is made easier by:
Dispersal of the microspores: - Being very small they can be produced in large numbers and blown away from the parent sporophyte by wind. By chance…..This is the basis of pollination.

Pollen tubes: - The male gametes no longer have to swim to the female gametes because seed plants have evolved pollen tubes. These grow from the pollen grains to the female gametes and deliver the male gametes.

Pollination can take place through:

1. Wind

2. Insect.

Note: Due to the fact that seed plants megaspores are retained on the parent plant within the megasporangium, it makes adaptation easier.

The ovule contains the female gamete. Once this is fertilised the ovule is known as the seed. Thus a seed is a fertilised ovule.

The seed is a complex structure because it contains cells from three generations, a parent sporophyte, a female gametophyte and the embryo of the next sporophyte generation.

General Characteristics Elucidating the Adaptations of Seed Bearing Plants to life on Land.

The major advantages that seed plants have over other plants are as follows:

i. Gametophytes are always protected inside a sporophyte, which is well adapted for life on land.

ii. Fertilisation is not dependent on water. The male gametes are non-motile and carried within pollen grains dispersed by wind or insects. Final transfer of the male gametes to the female gametes after pollination is by means of pollen tubes.

iii. The fertilised ovule (seed) is retained for some time on the parent sporophyte from which it obtains protection and food before dispersal.

iv. Certain seed plants have the potentials to become trees or shrubs and are able to compete effectively for light and other resources.

v. True roots enable water in the soil to be reached.

vi The plant is protected from desiccation by an epidermis with a waterproof cuticle (or by cork after secondary growth has taken place).

vii. The epidermis of aerial parts, particularly leaves, has many small holes, called stomata, which allow gaseous exchange between plant and atmosphere.

viii. Plant can show adaptation to hot dry environments.

The Influence of Temperature on the Growth and Distribution of Plants

Temperature can act as a limiting factor in the growth and development of plants by influencing cell division, photosynthesis and other metabolic processes.

Photosynthesis, and accumulation of sufficient food materials enable the plant to complete its lifecycle,

Are some of the important factors in determining the geographical range of plants.

Adaptation of Plants to Low Temperatures

Plants living in extreme low temperatures are subjected to long periods of adverse conditions, such as low light intensity, low temperature and frozen soil.

However, in order to survive in these conditions, plants show many structural, physiological and behavioural adaptations.

Most temperate woody perennials are deciduous and lose their leaves, under the influence of the plant growth regulator substance Abscisic Acid (ABA)

Many coniferans species dominate the vegetation of the more temperate regions. These species have needle – like leaves which reduce the amount of snow which can accumulate on them in winter and have a thick cuticle to prevent water loss in summer.
Many species of annuals have short growing periods and survive the winter by producing resistant seeds.
Low temperature are required by many plant species in order to break dormancy, e.g. lilac buds develop more quickly after being exposed to low temperature than high temperature.

Adaptation of Plants to High Temperatures
In many regions of the world, high temperature are associated with water shortage.
Plants ability to resist desiccation
Plants in these areas have structural and physiological adaptations to avoid overheating.
It is the area parts of plants which are exposed to the heating effect of solar radiation, and the largest exposed surface is that of the leaves.
A thin leaf has a relatively low heat capacity and therefore will usually assure the temperature of the surroundings.
In hot regions, secretion of shining cuticle by the epidermis which reflects much of the incident light, thus preventing heat being absorbed.
Wilting:- this occurs when the rate of transpiration is greater than the rate of water uptake. There is an overall loss of turgidity by cells such as parenchyma.
Plants living in dry conditions are called Xerophytes and show many structural adaptations which enable them to survive.
In most cases these adaptations are primarily concerned with regulating water loss, although the characteristics needle – shaped leaves permit maximum heat loss.

Post-Test

1. Explain the following processes in plants,
   i. Osmosis
   ii. Transpiration
   iii. Turgidity
2. State five general characteristics of members of the Phylum Filicinophyta
3. State five general characteristics of members of the Phylum Coniferophyta

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LECTURE 3
INVERTEBRATES

3.0 Introduction

This lecture focuses on the external features and ecological adaptations of the major phyla of the invertebrate group. These include Porifera, Cnidaria, Platyhelminthes, Nematoda, Annelida, Arthropoda, Mollusca and Echinodermata. A representative member of each phylum will be studied as an example.

Objectives

At the end of this lecture, students should be able to:

4. Know the major phyla of invertebrates.
5. Identify the external features of a named representative of each phylum.
6. Discuss the ecological adaptation of each phylum, using a named representative as an example

Pre-Test

4. What similarities and differences exist between *Ascaris* and earthworm?
5. What are the ecological adaptations of the external features of a typical insect?
6. State the features of the canal system in *Sycon.*

CONTENT

3.1 Background

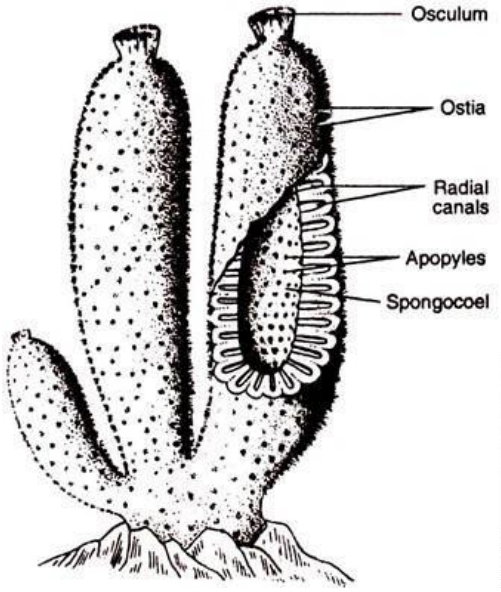
An organism needs food, water, air, shelter, suitable temperature and protection from predators in order to survive. The survival of an organism also depends on the characteristics of the organism itself. Each organism has characteristics, both behavioural and physical, which enable it to survive in its own particular habitat. These characteristics are called **adaptations**. An adaptation can be defined as a characteristic of an organism that makes it suited to its environment or its particular way of life. It is a structural, physiological (concerned with the body and how a body functions) or behavioural characteristic that enables the organism to survive and reproduce.

3.2 Ecological Adaptation of *Sycon* (Phylum Porifera)

External features:

Morphology - *Size and Shape* – The body is vase-shaped and grows to about 2.5 to 7.6 centimetres in length. ***Colour*** – The body of *Sycon* is green or light brown. ***Body structure*** - *Sycon* contains groups of cylinders, which are branched and connected to a base. This attaches to the substratum while at the apex of the cylinder is an opening called osculum. Around the osculum are monaxon spicules arranged in a circle called osculum fringe. The Monaxon spicules prevent small animal from entering into the body. The body surface bears minute pores called ostia.

Body wall – This is made up of two layers; derma and gastra layers with mesenchyme present in between them. The body of the sponge is covered externally by a thin dermal epithelium or ectoderm.



Source: http://www.biologydiscussion.com/invertebrate-zoology/phylum-porifera/an-example-of-phylum-porifera-sycon/32600

Canal system – The *Sycon* shows the syconoid type of canal system. The course of water current is shown below.

Course of water current :

Outside water → dermal ostia → incurrent canal → prosopyle → radial canal → apopyle → excurrent canal → spongocoel → osculum → outside.

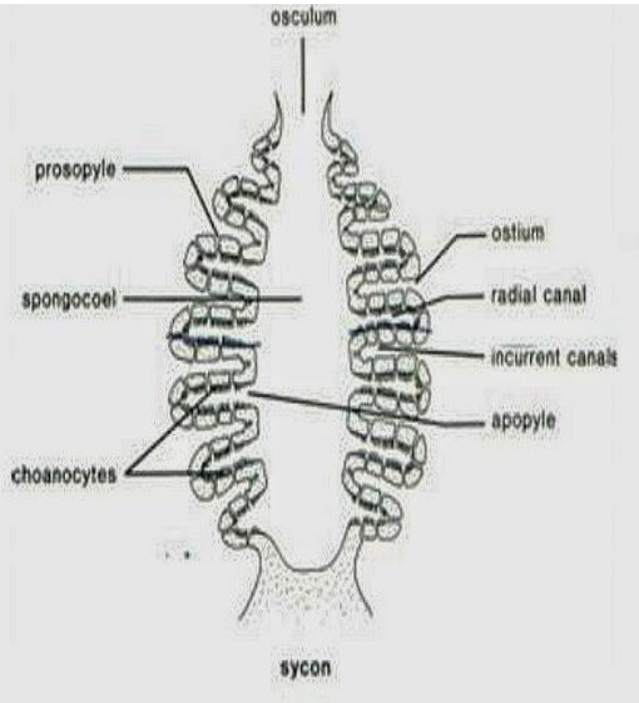
Ostia – These are present on the body of the *Sycon*. They open into incurrent canals. The ostium is surrounded by myocytes which help in regulating the inflow of water.

Incurrent canals – These are narrow canals lined inside by pinacocytes. They end blindly towards inside. They show some openings here and there called prosopyles through which the incurrent canals open into the radial canal.

Radial canal – Radial canals are present at regular intervals in the foldings of the body wall. In between two successive radial canals is the incurrent canal. Radial canals and incurrent canals are arranged alternately. The radial canals are lined with flagellated cells (choanocytes) whose action brings water into the body. It ends blindly to the exterior.

Apopyle– The radial canal opens into excurrent chamber through apopyle openings. The apopyle is surrounded by myocytes.

Excurrent chambers – It is short and wide chamber. This chamber is lined by flat epithelial cells. It opens into spongocoel.
Spongocoel – This is a narrow cavity present in the centre of the body of *Sycon*. It is also known as paragastric cavity or gastral cavity. It opens out through the osculum at the apex. It is lined with epithelial cells.



Canal system

Source: https://www.bioscience.pk/topics/item/266-canal-system-in-sycon-sponge

Functions of the Canal System

1. It brings constant supply of water into the body and helps in respiration.
2. Water brings with it small food particles which are used by the sponge.
3. It helps in the process of reproduction.
4. It helps in the process of discarding waste matter out of the body.

Ecological adaptations:

Habit and Habitat - *Sycon* is a widely distributed, small colonial marine sponge. It is sedentary attaching itself to rocks, shells etc. in shallow sea water to a depth of 90 metres where there is plenty of food and well oxygenated water. *Sycon* feeds on small minute bacteria, diatoms, protozoans etc which enters the sponge along with incurrent water also called nutritive current. Digestion is intracellular. The food particles are usually captured and digested by choanocytes. The undigested matter is sent out through osculum along with excurrent water.
Reproduction – This could be sexual or asexual. *Sycon* is monoecious.
Asexual reproduction – This is by budding or regeneration.
1. Budding – When conditions are favourable, small projections arise from the basal region of the adult sponge. This grows and develops into a small bud which separates from the body of the parent. When it comes in contact with a substratum, it attaches to it and develops into an independent animal.

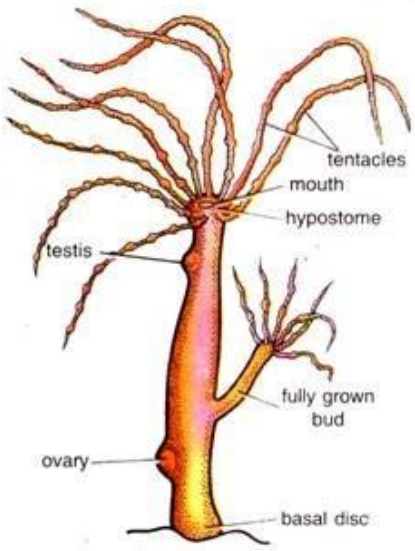
2. Regeneration – If by accident, the sponge body becomes cut into pieces, each piece develops into a young and complete sponge.

Sexual reproduction - This is by internal fertilisation of sperms and ova. Along with incurrent water, sperms enter the body of a sponge and unite with ovum forming a zygote. The zygote develops into Amphiblastula larva. This larva comes out of the sponge through the osculum and swims in water for some time with the help of flagella. Then it undergoes metamorphosis into a young sponge.

a. Ecological Adaptation of *Hydra* (Phylum Cnidaria)

External Features:

Morphology - *Size and Shape* - *Hydra* has a cylindrical body. Most are tiny, reaching a maximum of only about 30 mm long when fully extended. It is easily visible to the naked eye. ***Colour*** - They range in colour from green, through varying shades of brown. ***Body structure -*** They are fairly simple animals in terms of their body construction. Their bodies are basically just a hollow cylinder, which is solid at the base, with an opening at the mouth end. The proximal end is drawn out into a slender stalk at the end of which is the basal disc for attachment to the substratum. The free distal end or oral end of the body bears a conical elevation called hypostome. The hypostome bears an aperture at its apex called mouth which opens into the gastrovascular cavity or enteron. The hypostome is encircled by 6-10 tentacles which can be greatly extended during feeding or locomotion. At the proximal end, it may bear lateral projections called buds in various stages of development. A well-developed bud bears its own mouth, hypostome and tentacles. Gonads may also be present on its body. The testes are found near the oral end as conical projections while ovaries are situated towards the proximal end as oval projections.



Source: http://www.biologydiscussion.com/invertebrate-zoology/phylum-coelenterata/hydra-history-habitat-and-locomotion-with-diagram/28686

Ecological adaptations:

Habit and Habitat - *Hydra* is found in freshwater ponds and slow-moving rivers, where they usually attach themselves to submerged plants or rocks. When it is undisturbed, its body remains extended with tentacles spread out. It shows expansions and contraction without any apparent reason. It is carnivorous in habit and feeds on small insects, insect larvae and small crustaceans. The mouth is surrounded by a variable number of tentacles (usually between 6 and 10). The cells in the tentacles called nematocysts can pull food towards the hydra, sting it, and stuff the food down inside the tube to be digested. Because the hydra does not have a separate opening for waste, any material that cannot be digested is regurgitated out of its mouth.

Reproduction - *Hydra* reproduce by asexual and sexual methods of reproduction depending on the season.

Asexual reproduction – This involves budding new individuals from the body wall. Basically, a branch of the body cylinder is produced, with a digestive cavity, which is continuous with that of the parent, tentacles and a mouth at the top. Eventually the base will pinch off from the parent, becoming a new separate hydra. No fusion of sexual cells is involved and new individuals produced in this way are genetically same as their parent. This is the usual method of reproduction in warmer months.

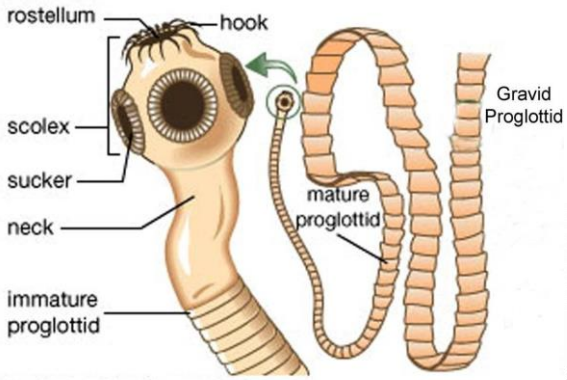
Sexual reproduction - As it begins to get colder, sexual reproduction may start to take over. Most *Hydra* species have individuals which are either male or female. Eggs are produced in the outer body wall of female hydra and are fertilised by sperm released into the water by neighbouring male hydras. Some species of *Hydra* are hermaphrodite, with each individual having both male and female reproductive organs. The seasonal timing of sexual reproduction is a way of helping the species survive over the winter. This is because the fertilised eggs have a tough shell or covering and can form a resting stage over cold periods. In the spring, the shell softens and a new hydra will emerge. This has the advantage of giving the new baby hydra a different combination of DNA than either of its parents allowing hydras to evolve rapidly to respond to changes around them.

b. Ecological Adaptation of *Taenia* (Phylum Platyhelminthes)

External features:

The body of *Taenia solium* is long, dorsoventrally flattened, narrow, ribbon-like, reaching a length of 2-3 metres. The body is covered with cuticle which is a thick, waxy, enzyme resistant covering. The colour of the body is opaque-white and the body consists of scolex, neck and strobila or body segments. The scolex with its suckers and hooks is an organ of attachment to the intestinal wall of the host. The neck is thin, small, narrow and unsegmented and it grows continuously and proliferates proglottids by transverse fission or asexual budding. The neck is followed by the flattened, ribbon-like body called strobila. This consists of a series of

proglottids arranged in a linear fashion. The strobila of a mature tapeworm measures about 3 metres in length having 800 to 900 proglottids. The youngest proglottid is next to the neck and the oldest at the posterior end of the strobila.



Source: http://www.writeopinions.com/rostellum

Ecological adaptations:

Habit and Habitat – *Taenia solium,* the adult pork tapeworm of man lives in the intestine of man as an endoparasite. Its mode of nutrition is saprozoic as it absorbs digested liquid food from the intestine of the host through its general body surface. The life cycle is completed in two hosts with man being the primary host and pig as secondary host. Other animals like goat, cattle, horse and monkey can also serve as secondary hosts. It causes injuries to mucous membrane lining the alimentary canal where it adheres by its scolex. The disease caused by this worm is called taeniasis.

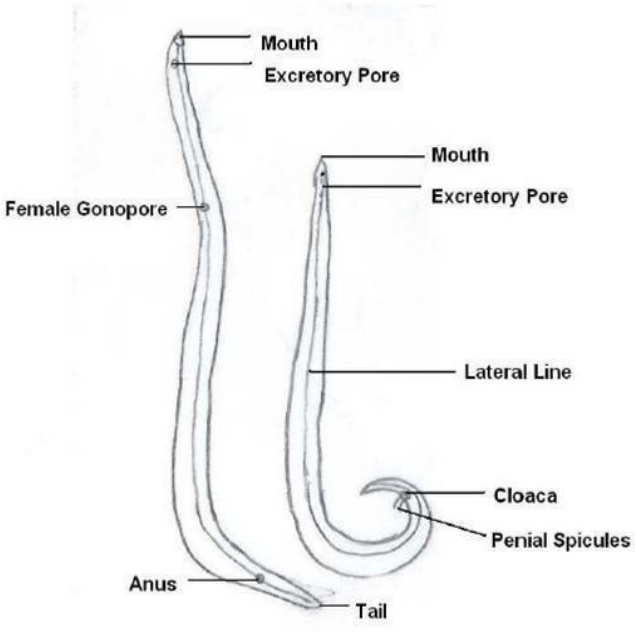
Parasitic adaptations of *Taenia*

1. It has four well developed suckers and hooks to anchor to the intestinal wall of the host which prevents it from being pushed out with food during peristaltic movement.
2. The body is covered with tegument which protects it from hosts' digestive juices.
3. Loss of alimentary canal is compensated by freely permeable tegument for water and nutrients from the digested food of the host intestine.
4. It respires anaerobically and this enables its survival in the intestinal environment that is oxygen free.
5. The long flattened body provides larger surface area for its saprozoic mode of nutrition.
6. The sense organs are altogether absent due to its sheltered habit.
7. High fecundity ensures at least a few embryos will be transferred to pig and larvae transferred from pig to man.
8. High survival rate. A tapeworm can survive for more than thirty years and every year, it sheds nearly 2500 gravid proglottids.
9. The simplicity of its life cycle increases chances of infectivity from pig to man and man to pig.

c. Ecological Adaptation of *Ascaris* (Phylum Nematoda)

External features:

Morphology – *Size and shape* – Females grow up to 35 cm in length measuring 3-6 mm in diameter. Males grow up to 30 cm in length and 2-4 mm in diameter. *Ascaris* is elongated, cylindrical, and tapering at both ends; in males, the tail curves ventrally. ***Colour* –** white to light pink. **Body structure –** The body is covered by a smooth, tough and elastic cuticle which is striated transversely and gives the pseudosegmented appearance to the worm. The cuticle protects the worm from the harmful effects of the host's digestive enzymes. *Ascaris* has a triangular mouth that is surrounded by one mid-dorsal and two ventrolateral lips. Tail is straight in female and carries a transverse anus and a chemoreceptor called amphid between the anus and the tip of tail. In male the tail is curved and anus is replaced by cloaca from which two equal chitinous spicules or penial setae project out.



Source: https://microbiologynotessite.wordpress.com/2017/05/31/ascaris-lumbricoides/

Ecological adaptations:

Habit and Habitat – *Ascaris* is an obligate internal parasite and the adults usually reside in the small intestine of humans, specifically the jejunum. It is the largest intestinal parasite. It is one of the predominant helminthic human infections worldwide and is more frequently found in children. It is a monogenetic parasite passing the life cycle in a single host. The mode of nutrition is holozoic as it feeds on host's partly digested food by sucking action of its pharynx.

Parasitic adaptations of *Ascaris*

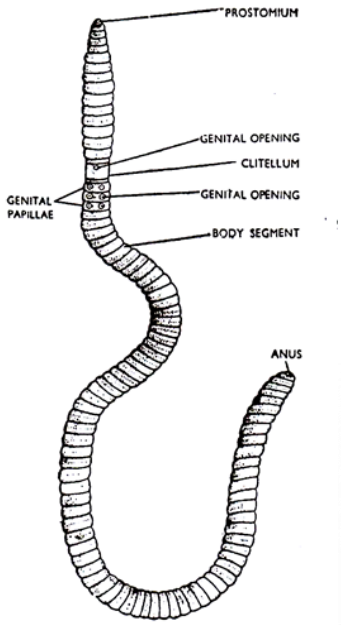
Ascaris exhibits the following anatomical and physiological adaptations to live as endoparasite in the intestine of man.

- Body is long, flexible and cylindrical in shape with both the ends pointed to adjust to the narrow lumen of intestine.
- Body is covered externally by cuticle that helps to resist digestive juices of the host.
- The worm also secretes antienzymes to protect it from the digestive enzymes of the host.
- Adhesive organs are not found but there are papillae on lips to anchor on to the villi of intestine.
- Muscular pharynx facilitates ingestion of tissue and blood by sucking action.
- There is a continuous supply of food digested by the host intestine, which it absorbs readily through its skin.
- There are no elaborate digestive glands as it feeds on partially digested food.
- Pseudocoelomic fluid carries out absorption, transport and distribution of food, oxygen and wastes.
- Mode of respiration is obligatory anaerobic as it lives in an oxygen deficient environment in intestine.
- Sense organs are very poorly developed because of endoparasitic life.
- Millions of eggs are produced which compensates for the death of large number of them in the course of transfer to the host. Adult females can produce up to 200,000 eggs every single day.
- The hard shell of eggs protects the developing juveniles from the environmental hazards.
- Direct infection to man through contamination and abundance of eggs in the environment increases its chances of reinfection of man.

d. Ecological Adaptation of Common earthworm (Phylum Annelida)

External Features:

Morphology - *Size and Shape* - The earthworm has a long cylindrical and symmetrical body that is covered by a moist, protective cuticle. These features help it to burrow into the soil. ***Colour*** – The earthworm's skin is brown coloured like the colour of mud. This gives it protection from its enemies. ***Body structure*** **-** An earthworm has circular muscles that surround each body segment. It also has longitudinal muscles that run the length of its body. These two groups of muscles work together to help the earthworm move. The body of an earthworm is segmented and these segments are called Annuli. Furrows on the surface of the body mark the division between each segment. The first segment encloses the mouth, and has a fleshy, muscular lobe on the top. This lobe can be pulled in to seal the mouth, or extended forward to probe the immediate surroundings. All annelids except leeches have tiny hair like bristles called setae, projecting from their cuticle. The setae are composed of chitin. All segments, except the first, have eight retractable setae that help the earthworm to attach itself to the ground and prevent it from sliding back during peristaltic movement. The body is flexible, as it has no skeleton. At one end is the mouth which is covered by a flap, called the prostomium. The prostomium helps the earthworm sense light and vibrations, as it has neither eyes nor ears. At the other end is the anus through which waste is excreted.



Source: http://www.biologydiscussion.com/invertebrate-zoology/earthworms/dissection-of-earthworm-zoology/60761

Ecological adaptations:

Habit and Habitat - Earthworms live in moist soil which contains organic matter. Earthworms are sensitive to heat, light and touch. This adaptation is important to the survival of the earthworm. In the winter the earthworm travels deep in the soil to avoid the frost. In the hot summer the worm also travels deep into the soil in order to avoid dehydration. During the night an earthworm surfaces to let off their castings. Most species of earthworms share some common traits or adaptations, such as their streamlined body shape which is an adaptation to living in narrow burrows underground and the need to move easily through the soil. Many earthworms secrete a mucus (coelomic fluid) that helps them to move more easily through the soil. In some burrowing species, this fluid forms a cement-like substance that lines their burrows to help keep the walls from collapsing. However, different species of earthworms have adapted to different habitats and occupy different niches within the ecosystem. As a result, earthworm adaptations are many and varied. The family of earthworms that is most important in enhancing agricultural soil is Lumbricidae, which includes the genuses *Lumbricus, Aporrectodea*, and several others.

Earthworms feed on humus, which is the rich organic matter found in soil. They are major decomposers of dead and decomposing organic matter, and derive their nutrition from the bacteria and fungi that grow upon these materials. They fragment organic matter and make major contributions to recycling the nutrients it contains.

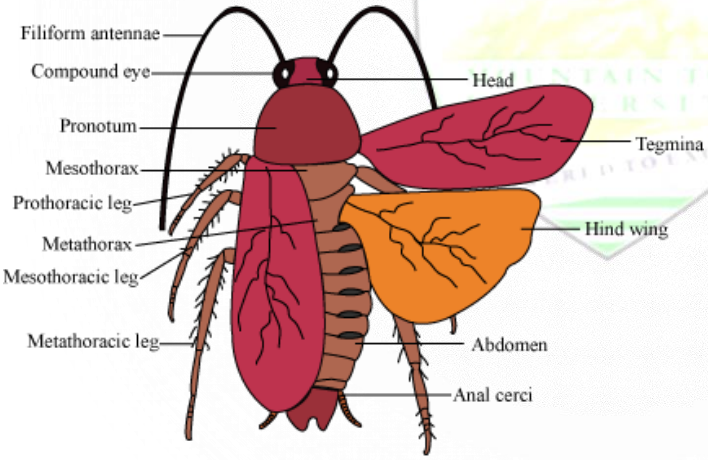
Adult (sexually mature) earthworms have a distinct swelling called a clitellum. The clitellum is a thickened glandular section of the body wall in earthworms and leeches that secretes a viscid sac in which the eggs are deposited. It produces most of the material secreted to form earthworm egg sacs or cocoons. Earthworms are hermaphrodites (both male and female sex organ), but most need a mate to reproduce. When two earthworms are ready to mate they adopt a head-to-tail position, cover themselves in a layer of mucus, and exchange sperm. The saddle produces a mucous tube which detaches and moves forward along the body, collecting

on the way the earthworm's own eggs and the sperm received from its partner. Fertilization occurs in the mucous tube which is shed from the anterior end of the earthworm. This dries in the soil to become an egg capsule, from which one or more young earthworms will eventually hatch. Many species can reproduce several times a year.

e. Ecological Adaptation of *Periplaneta americana* (Phylum Arthropoda)

External features:

Morphology - *Size and Shape* - Adults are approximately 34-53 mm long. Its body is narrow, elongated, compressed dorso-ventrally and bilaterally symmetrical. ***Colour*** – A cockroach is dark brown or reddish brown in colour, which helps it to hide in dark spaces and crevices. ***Body structure*** **-** A cockroach has an externally segmented body divided into three main parts- the head, thorax and abdomen. Its body is protected by an exoskeleton of a thick cuticle made of chitin. The inner, softer layer allows movement between the body segments and the limb joints. The head bears compound eyes that allows the cockroach to see simultaneously in all directions. It has a pair of long antennae that helps it to smell. The thorax has three segments. Each segment bears a pair of jointed lateral appendages that helps it in movement. The last two segments of the thorax have two pairs of wings which help it to fly short distances. There are two wind sensitive hairs called cerci on the last segment of its body. These act as a warning system against its enemies. A flattened body allows it to creep into very narrow crevices.



Source: http://termitepestcontrolsbaruimu.blogspot.com.ng/2017/01/external-morphology-of-cockroach.html

Ecological adaptations:

Habit and Habitat - About 3,500 species of cockroaches exist worldwide. *P. americana* is found in many different habitats. When indoors, the nymphs and adults are usually found in dark, warm and moist areas of basements and crawl spaces, and in and around bathtubs, clothes hampers, floor drains, pipe chases, and sewers. Although they generally live in moist areas, they can survive in dry areas if they have access to water. It is a nocturnal animal hiding in holes and crevices during the day and coming out at night to feed. It is omnivorous in diet, a fast runner and can also fly though it seldom flies. It is dioecious and oviparous and exhibits

parental care. The adults can survive two or three months without food but only about a month without water.

Locomotion – Cockroach is a swift runner as well as a flier. The six legs are helpful in walking or running. The cockroach's walking pattern can be described as follows: "The cyclic movement of a walking leg consists of two parts, the power stroke (also stance phase or support phase) and the return stroke (also swing phase or recovery phase). During the power stroke, the leg is on the ground where it can support and propel the body. In a forward-walking animal, this corresponds to a retraction movement of the leg. During the return stroke, the leg is lifted off the ground and swung to the starting position for the next power stroke." The wings are used during flight. The fore-wings are held at right angles to the body axis and they do not beat. In fact, the beating of hind-wings with the help of flight muscles helps the cockroach in flying.

Reproduction - Female *P. americana* produce many different sex pheromones to attract a suitable mate. Sperm transfer occurs through the use of a spermatophore, which is sometimes eaten by the female because of its protein-rich nature. A spermatophore is a capsule or packet enclosing sperm, produced by males of several invertebrate groups and a few vertebrates. Once fertilization has occurred, a female forms oothecae, or egg sacs. Parthenogenesis or egg production without fertilization does occur, but eggs either fail to hatch, or produce only a few nymphs. The ootheca is a dark reddish to blackish brown; about 8 mm long, with length about 1.5 times the width. The female deposits her ootheca within a few hours or up to 4 days after it is formed. It is dropped or glued with an oral secretion to a suitable surface, usually in a crack or crevice of high relative humidity near a food source. Usually one capsule is produced each week and is often glued to a hidden surface with secretions from the female's mouth. On average, females produce 9-10 (range 6-14; maximum 90) oothecae, each containing 14-16 eggs. The length of the egg stage varies from 29 to 58 days. At room temperature, nymphs hatch out in 50 to 55 days. Young nymphs are grayish brown and after the first few molts become reddish brown. The nymphal stage varies in length from 160 to 971 days. The number of offspring per year averages 800. Adult females live about 440 days (range 102-588; maximum 913) at 20°C, but at 29°C, adult females live about 225 days (range 90-706), whereas adult males live about 200 days (range 90-362) at 29°C. The development of *P. americana* is hemimetabolous, meaning there is no major metamorphosis. The nymphs look very much like small adults. Nymphs are given no parental care; hatchling roaches are left to fend for themselves. The nymph grows by molting and it goes through about 13 molts before it reaches the adult form. The next to last nymphal stage has wing pads, but only adult cockroaches have wings.

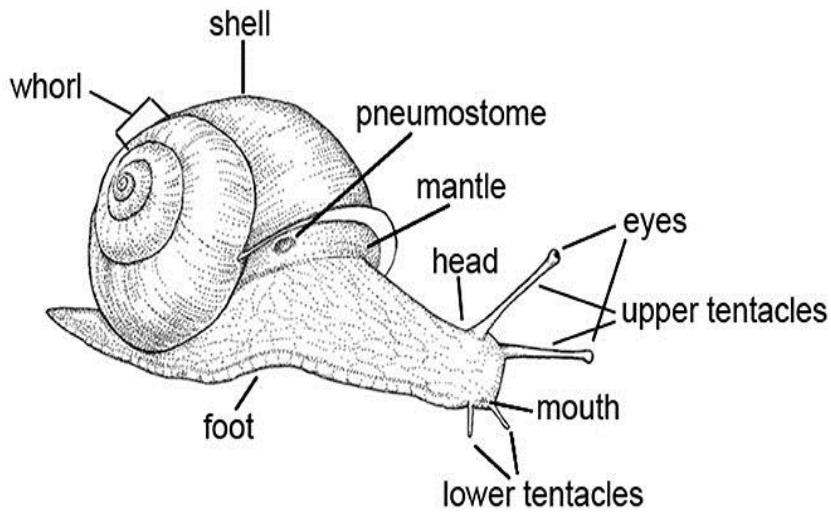
3.8 Ecological Adaptation of *Achatina* (Phylum Mollusca)

External Features:

Morphology - *Size and Shape* - The giant African land snail is the largest species of snail found on land and generally grow to around 20 cm in length. The average adult shell has a conical shape. ***Colour*** – They have light to dark brown shells with vertical stripes of a darker shade of brown on them. This covers at least half of the length of the snail.

Body structure – The basic structures of the snail are foot, head, shell and visceral mass. The visceral mass includes internal organs housed within the shell. A very important part of the

anatomy of the snail is the tongue, which is called the radula. They have small spikes on the tongue that allow it to grab food easily. They have very powerful foot muscles that is flat and modified for creeping by the large ventral sole. The foot is provided with a large tubular slime gland which produces profuse quantity of slime. They also have a pair of eyes located on the tentacles. The eyes are able to move about to get the best possible view.
The shell is the location where the Giant African Land Snail takes refuge from predators. They will also spend time inside of their shells when the temperatures begin to dip too low at night for their comfort. While this shell is very hard, it can dry out if they don't get enough moisture. There are several layers of this shell. Each one has its own process so that the outer shell can be strong. The shell continues to grow as the snail does for almost one year. Giant African land snails reach their adult size by the time they are 6 months old and although their growth rate slows at this point, giant African land snails never stop growing.



Source:
https://clipartxtras.com/categories/view/b95856951d40631237f1eb83762e27d9893bb0b3/land-snail-drawing.html

Ecological adaptations:

Habit and Habitat - The giant African land snail is native to humid, forest areas of East Africa but has been introduced into Asia, the Caribbean and a number of islands in both the Pacific and the Indian oceans. They can be found in agricultural areas, coast land, natural forest, planted forests, shrub lands, urban areas, and wetlands. The Giant African Land Snails don't seem to interact with each other except for when they are going to mate. They don't have any sounds and they spend their time moving, eating, and resting. They are considered to be active between 9°C and 29°C but they are able to survive above 2°C degrees by hibernating inside of the shell during the colder months. During this time, they are able to slow their bodies down enough that they don't need to eat or to move during that period of time. They can remain inside of the shell for several months before they emerge again. Sometimes, you will find that these snails may aestivate in the summer months as well. This is caused by drought conditions because their shell will dry out. They are able to keep it moist by creating a barrier with a thin layer of mucus that their bodies secrete. In case of severe drought, they are able to aestivate up to three years. They have an average life span of about 5-7 years. When they have enough food and the weather is comfortable, they tend to live

much longer. Some of them have been known to live up to 10 years. Giant African land snails are active during the night and spend the daytime hours safely buried underground.

Locomotion – The foot is the organ of locomotion. The foot is very much elongated and has a flat ventral sole. The normal progression of a snail is by muscular action, with a series of contraction waves proceeding from the posterior to the anterior end of the gliding portion of the foot. Their movements are very slow which is where the saying moving at a snail's pace comes in. They often blend in very well to their surroundings and this helps to make up for the fact that they can't move very fast. They also release a slippery substance, a kind of mucus, as they move to help them move through rough materials without damage.

Nutrition – They are primarily herbivorous but equally feed on dead insects and snails. They consume a wide variety of plants, fruits and vegetables. The presence of well-developed two-lobed crop in *Achatina* is an adaptation to devour maximum quantity of food and to store them for future use. They also need calcium in order to ensure their shell stays very strong, so they consume more of particular types of plants in order to get enough of the calcium they need. When they are not able to get enough calcium in their diet from plants, they may feed on bones from carcasses, sand or small stones. They also consume small amounts of water that they can get from the food they consume as well. Giant African land snails have a huge appetite. They are known to eat at least 500 different types of plants. If fruits or vegetables are not available, the snails will eat a variety of ornamental plants, tree bark and even paint and stucco on houses.

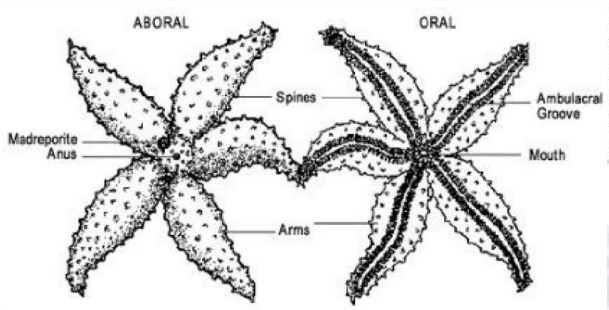
Reproduction - The Giant African Land Snail is categorized as a hermaphrodite. This means that they possess the reproductive organs for both males and females. They do not self-fertilize except in rare cases. The snails choose their mates with respect to size and age, but the reproductive stage-dependent mate is a more attractive mate than the body size-dependent mate choice. Mating occurs when one snail encounters a prospective partner that the individual snail deems acceptable to mate with. They mate by one snail mounting the shell of another. The mating will begin once the two snails exchange sperm with one another. However, this is only the case if the snails are around the same size. If there is a size difference, the larger snail will act as the female and the gametes will only be transferred from the smaller snail to the larger snail, mating unilaterally. The sperm is used to fertilize the eggs in the snails, but it can also be stored inside the body for up to two years. The fertilized eggs are laid between 8-20 days after mating has occurred, and are deposited in nests, in the dirt and leaves or among rocks and soils on the ground. This is to protect and disguise the eggs. The number of eggs that an individual snail lays often depends on the maturity and age of the snail and is between 100 to 500 eggs. They don't have a set breeding period and on average they lay 5-6 clutches of eggs per year, containing each one close to 200 eggs per clutch with the right conditions. The eggs usually hatch at temperatures above 15°C after 11-15 days into immature snails which grow to adulthood in about six months.

3.9 Ecological Adaptation of *Asterias* (Phylum Echinodermata)

External features:

Morphology - ***Size and Shape*** – Common sea stars have five-point radial symmetry, which means that their body plan has five sections arranged around a central disk. ***Colour*** – Starfish come in a variety of colours and have many different types of patterns. The colours range from yellowish-brown to deep purple. Many wear striking colours that camouflage them or scare off potential attackers. ***Body structure*** **–**They have tough, bony, calcified skin, which

protects them from most predators. This tough covering on their upper side is made up of plates of calcium carbonate with tiny spines on their surface. This gives them a rough appearance. A sea star's spines are used for protection from predators, which include fish, sea otters and birds. At the tip of each arm is a small red or orange light sensitive eye spot. The body is dorsoventrally flattened. At the end of each arm, on the 'oral side,' are hundreds of tiny projections known as tube feet. The tube feet allow the starfish to move along the ocean bottom and open upon the scallops and clams they hunt for food. On the 'aboral' top side, the sea star has a series of tiny pedicellaria which can remove unwanted particles from the sea star's body. If food falls on the aboral side, it can also use these pedicellaria to transport the food to the arms and then into its mouth. Instead of blood, starfish have a seawater vascular system that circulates nutrients and powers their tube feet, allowing them to move about their environment.



Source: https://www.researchgate.net/figure/Aboral-and-oral-sides-of-a-generic-Asteroid_fig2_321906663

Ecological adaptations:

Habit and Habitat - There are over 2,000 species of starfish. Starfish are found in every ocean of the world and shallow water as well. They live in tropical intertidal zones and on the seafloors of colder climates. They are never found in fresh water but a few live in brackish water. They can live for a variety of different ages; some live for around five to thirty years depending on species. They are famous for their ability to regenerate limbs, and in some cases, entire bodies. They accomplish this by housing most or all of their vital organs in their arms. Some require the central body to be intact to regenerate, but a few species can grow an entirely new sea star just from a portion of a severed limb.

Locomotion -. The tiny tube feet of the sea star are used for locomotion, attachment and respiration.

Nutrition - Starfish have evolved to fit their environment by developing various specialized feeding habits. Many species of starfish are predatory, meaning they feed on other animals. The common starfish is a carnivorous hunter that feeds on mussels, clams, oysters and sea snails. Starfish have developed special digestive systems adapted to the food sources found in their particular environment. They locate their quarry with light-sensing eyespots at their arm tips. They are very good at detecting chemical signals. They smell their food through chemicals being released as they get washed down to them in currents. They use the current and the smell to basically move up and find their food.

Reproduction - Most starfish release eggs and sperm into the open water where fertilization occurs. Females can release up to 2.5 million eggs. The large production of eggs and sperms into the water gives them a better chance of survival. Fertilized eggs develop into free-swimming larvae which settle and morph into adults. They can also reproduce asexually using the fragmentation method. This means an arm or leg falls off and that makes a new starfish.

Post-Test

4. State 3 parasitic adaptations of *Taenia solium.*
5. What are the two forms of asexual reproduction in *Sycon*?
6. What is the role of prostomium in the adaptation of earthworm to its environment?

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LECTURE 4

CHORDATES

4.0 Introduction

This lecture focusses on the external features and ecological adaptations of the various classes in the phylum chordate. The groups to be studied include urochordata, cephalochordata, agnatha, chondricthyes, osteichthyes, amphibia, reptilian, aves and mammalia. A representative members in each group will be studied as an example.

Objectives

At the end of this lecture, students should be able to:

7. Know the various classes in the phylum chordata
8. Be familiar with the external features of a named representative of each class
9. Be conversant with the ecological adaptation of each class, using a named representative as an example

Pre-Test

7. What are chordates?
8. What are vertebrates?
9. In what way are chordates and vertebrates related?

CONTENT

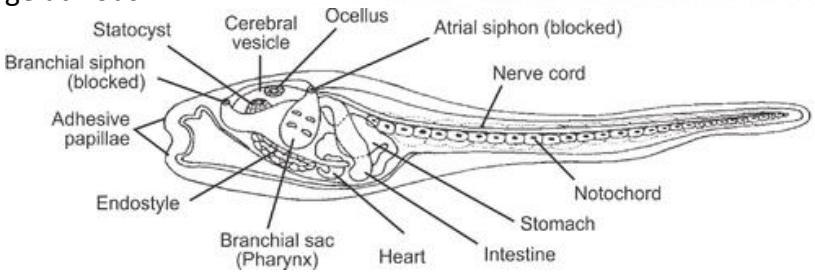
4.1 Members of the Phylum Chordata

The phylum Chordata is divided into three subphylums: Urochordata (tunicates), Cephalachordata (lancelets), and Vertebrata (vertebrates).

4.2 Subphylum Urochordata e.g. *Ciona*

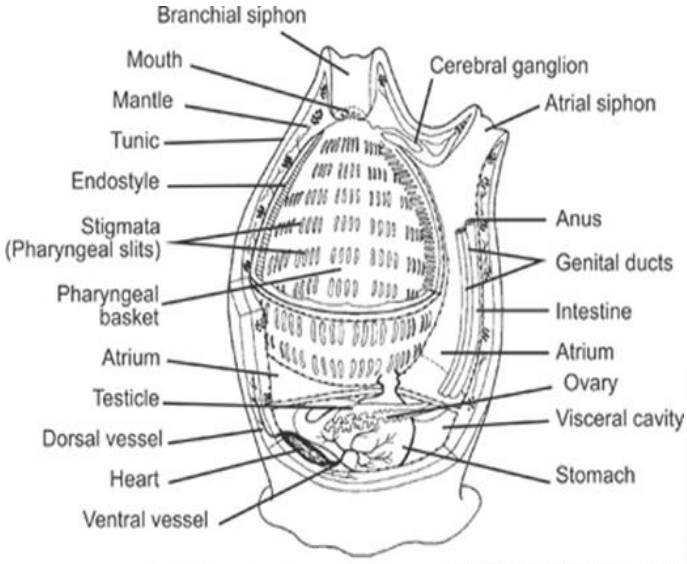
External Features:

The Urochordates (tail chordates) more commonly referred to as tunicates. This group (also called tunicata) also includes animals known as ascidians (and commonly called sea squirts). All the animals in the family Cionidae are called tunicates because the body is surrounded by a test or tunic, from which the subphylum derives its name. This varies in thickness between species but may be tough, resembling cartilage, thin and delicate, or transparent and gelatinous.



Larval stage of *Ciona*

Source: https://en.wikipedia.org/wiki/Tunicate



Internal and external features of *Ciona*

Source: https://en.wikipedia.org/wiki/Tunicate

Ecological Adaptations:

Ciona intestinalis can be found in the marine habitat, from near shoreline areas to deeper waters, and in estuaries, and is more common in silty conditions in shallow waters. The majority of them are sessile as adults, although some are free living. Adult members are commonly embedded in a tough secreted tunic containing cellulose (a glucose polysaccharide not normally found in animals). It is considered to be an invasive species and grows in dense aggregations on rocky substrate, marine plants, shells, on any floating or submerged substrate, particularly and man-made constructions like piers, buoys, aquaculture vessels in the lower intertidal to sub-tidal zones. They are is a cylindrical, translucent ascidian, ending in a cone-shaped siphon. The body wall is a pale yellow-green, translucent, and tubular with terminal inhalent and sub-terminal exhalent siphons (openings). The inhalent siphon is surrounded by eight distinct lobes and the exhalent siphon by six; the lobes are interposed with red or orange pigment spots. The body is usually soft but heavy fouling may cause it to become tough and hard.

Ciona intestinalis is a filter feeder, and feeds mainly on fine detrital particles and phytoplankton. The free-swimming larval form of *C. intestinalis* as well as the eggs are consumed by jellyfish while the juveniles are eaten by certain species of snails. Certain fish are also known to feed on the juvenile forms. The life span of most ascidians is about one year. The *Ciona intestinalis* is hermaphroditic and releases sperm and eggs through the exhalent siphon. Fertilization occurs at sea, and a tadpole-like larva is formed about 25 hours later.

4.3 Subphylum Cephalochordata e.g. Branchistoma

External Features:

Also called Acrania or Lancelet. They are small, fishlike marine invertebrates, and are probably the closest living relatives of the vertebrates. There are about 20 species in two families, each with a single genus. *Branchiostoma* was formally called *Amphioxus*, a name that is retained as an informal term. They are marine lancelets: slender, laterally compressed,

translucent animals about 5 to 7cm in length that inhabit the sandy bottoms of coastal waters around the world. They possess the following characteristics

1. All marine
2. Elongate and bilaterally flattened
3. Unpigmented
4. Pointed at anterior and posterior ends
5. No recognizable specialized head
6. Many gill slits in pharyngeal wall. These do not appear externally as they are covered by a fold of skin; the atrium thus formed is a fluid-filled space round the gill slits, opening at the atriopore
7. Possess a tail, that portion of the body that projects behind the opening of the anus
8. Muscles arranged in blocks (myotomes) that are easily visible
9. There is a notochord composed of muscle fibres
10. Sense organs apparently located on cirri anterior and in a few places along the nerve cord.

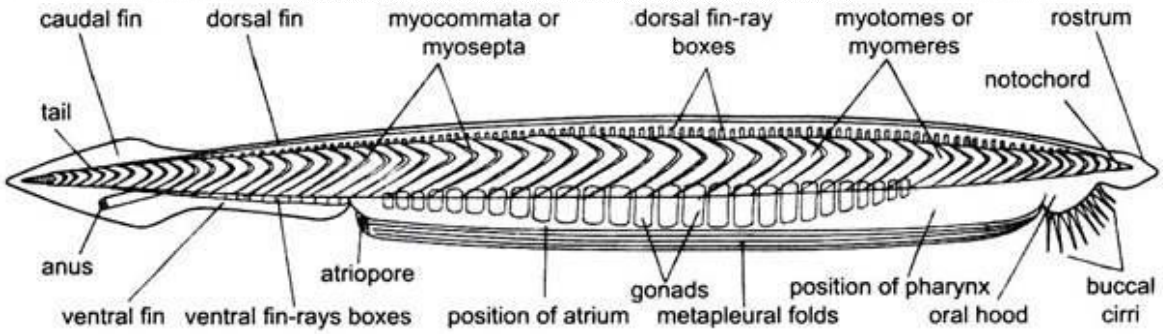


Fig. 6.1. *Branchiostoma*. Entire animal in right side view.

External Morphology of Branchiostoma

Source: http://www.notesonzoology.com/phylum-chordata/branchiostoma/external-morphology-of-branchiostoma-with-diagram-chordata-zoology/7350

Ecological Adaptations:

Lancelets are distributed throughout the world along tropical and temperate coasts. They are usually found in shallow parts of temperate or tropical seas. They inhabit soft bottoms ranging from sand to coarse shelly sand or gravel in shallow coastal water. Lancelets lie buried beneath this substrate, often with their mouths protruding above the surface, allowing them to take in water laden with food. They are slender, laterally compressed, translucent animals about 5 to 7cm in length that inhabit the sandy bottoms of coastal waters around the world. Amphioxus are often buried in sand seafloor of the shallow and coastal waters and in estuaries all over the world. E.g *Branchiostoma nigeriensis.*

Lancelets are streamlined animals. They are swimming animals, with several fins; a dorsal fin extends along the upper surface of the body and continues as a caudal fin around a tail and as a ventral fin to an atrium on the lower surface.

Amphioxus (*Branchistoma*) is a microphagic suspension-feeder. The larva is capable of feeding on larger materials such as copepods. When they are buried, their head sticks out to filter out food particles from the water

4.4 Subphylum Vertebrata (or Craniata; Vertebrates)

Also called Craniata, any animal of the subphylum Vertebrata, the predominant subphylum of the phylum Chordata. They have backbones, from which they derive their names. The vertebrates are also characterized by a muscular system consisting primarily of bilaterally paired masses and a central nervous system partly enclosed within the backbone. The subphylum is one of the best known of all groups of animals. Its members include the classes Agnatha, Chondrichthyes and Osteichthyes (all fishes); Amphibia (amphibians); Reptilia (reptiles); Aves (birds); and Mammalia (mammals).

Fishes are cold blooded vertebrate animals found in the fresh and salt waters of the world. Fishes range from the primitive, jawless lampreys and hagfishes through the pisces (which are cartilaginous fishes: sharks, skates, and rays and the abundant and diverse bony fishes).

The study of fishes is called Ichthyology

Characteristics

1. Locomotory organs are fins – paired pectorals fins, pelvic fins, unpaired ventral fins or anal fins and caudal fins.
2. Organs of respiration are gills (and "lungs" in only the lung fishes) only.
3. Their bodies have scales which are used for various purposes e.g. protection from injury and diseases; colouration; growth and age declaration.
4. All live in water

4.5 Classification

Fishes are best arranged in two super classes and four classes of lower vertebrates:

Super Class Agnatha (for Jawless fishes)

Class Myxini (Hagfisnes)

Class Cephalaspidomorphi (lamprey)

Super Class Gnathostomata

Class Chondrichthyes (Cartilaginous fishes)

Class Osteichthyes (Bony fishes)

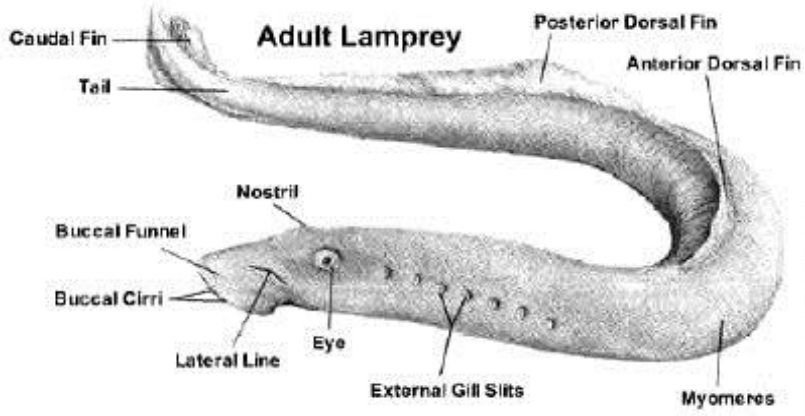
4.6 Super Class Agnatha - Lampreys (e.g. *Petromyzon marinus*)

External Features

1. They possess a round sucking mouth with horny teeth and rasping tongue
2. They have 7 pairs of pharyngeal gill pouches
3. They are predaceous
4. Their nostrils are located on top of the head
5. They have a distinct freshwater larval stage called ammocoete
6. They possess one or two median fins
7. They have a blind olfactory sac.

Lampreys, which number about 41 species, are found in cool, fresh, and coastal waters of all continents except Africa. They are primitive jawless, with their bodies being smooth,

slimy, scaleless, and eel-shaped, but have a soft, cartilaginous skeleton. They lack paired fins but have well-developed dorsal and caudal fins, and there are seven open gill slits on each side.

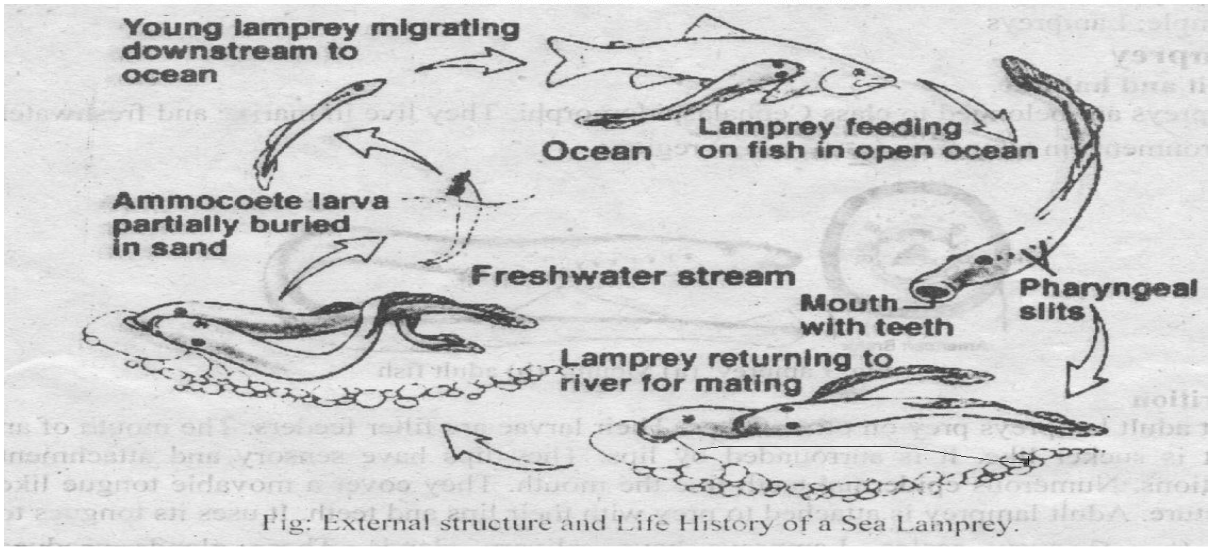


External features of the Lamprey

Source: https://7vertebrates.weebly.com/class-agnatha.html

Ecological Adaptations

Adult lampreys inhabit a saltwater marine environment but swim up rivers to reach freshwater breeding grounds. Lampreys are parasitic species that use their sucker-like mouths to attach to a fish host. They use the many teeth in their mouths and on their tongues to rub at the flesh of their prey. It rasps into the flesh with a toothed, tongue-like structure on the floor of the mouth. Saliva containing an anticoagulant facilitates the ingestion of blood and muscle tissue. On attaining full adult size, the lamprey ceases to feed, migrates upstream to a spawning ground, mates, and dies.



Life Cycle of Lamprey

Source: https://biologyboom.com/survey-of-fishes/

4.7 Super Class Gnathostomata

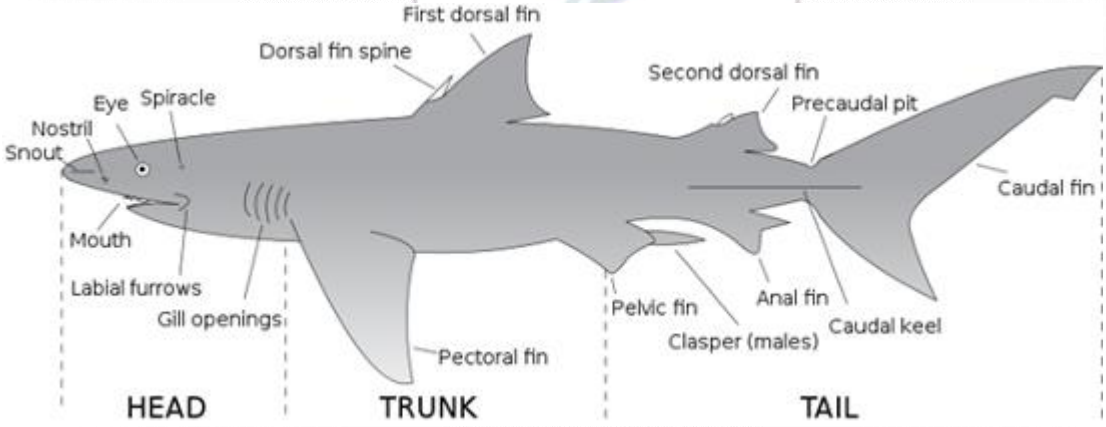
Class Chondrichthyes

These are cartilaginous fishes with string jaws lined with teeth, their bodies are dorsoventrally flattened, fusiform (spindle shaped) with heterocercal tail (diphycercal in chimaeras); paired fins; no swim bladder or lungs. The pelvic fins in males are often modified to form claspers and they also have gill arches which are internal to the gills. They have reduced notochord, lateral-line system, and paired nostrils, while internal nares are absent. Their sexes are separate while fertilization is internal and direct development; oviparous, ovoviviparous or oviparous.

4.8 A representative Chondrichthyes – Dogfish

External Features of the Dogfish

The head is bluntly pointed, and the trunk is spindle shaped, largest near the pectoral fin, and tapering behind. There are two separate median dorsal fins (each proceeded by a spine in the spiny dogfish, *Squalus*), a median caudal fin, and two pairs of lateral fins, pectoral and pelvic. In a mature male each pelvic fin bears a slender, grooved appendage, the claspers used in copulation. The smooth dogfish (*Mustelus*) has also a median anal fin. The tail is heterocercal, the vertebral column turning upwards and extending almost to the tip of the caudal fin.



External features of a dogfish

Source: https://www.sharksider.com/shark-anatomy/

Ecological Adaptations

The dogfish can be found at extreme depths. They often live in swarms consisting of thousands of animals. These swarms are formed in order to hunt together, but also as protection against enemies. Females and males usually live in separate swarms. Mixed groups are rare. Their dorsal side is gray, and they have a white ventral side; this color dynamic has provided the dogfish with a type of camouflage.

The dogfish is an opportunistic feeder eating whatever prey is abundant. In general their diet is comprised of small fishes such as capelin, cod, haddock, hake, herring, menhaden and ratfish. They also eat invertebrates such as krill, crabs, polychaete worms, jellyfish, ctenophores, amphipods, squid and octopus.

The sexes are separate. In the male, sperm develop in two long testes anterior in the body cavity. At mating, the claspers are placed closed together, and the two organs are inserted into the cloaca. Dogfish usually have a life span of 25-100 years. Female dogfish are ovoviviparous (live-bearers), which means they retain their eggs inside the body until the young hatch, which are then born "alive." This method provides the young with protection from predators during their earliest developmental stages. They produce between 2 and 16 individuals. Sexual maturity in males is reached at about 11 years of age, while in the female it is reached at between 18 and 21 years of age.

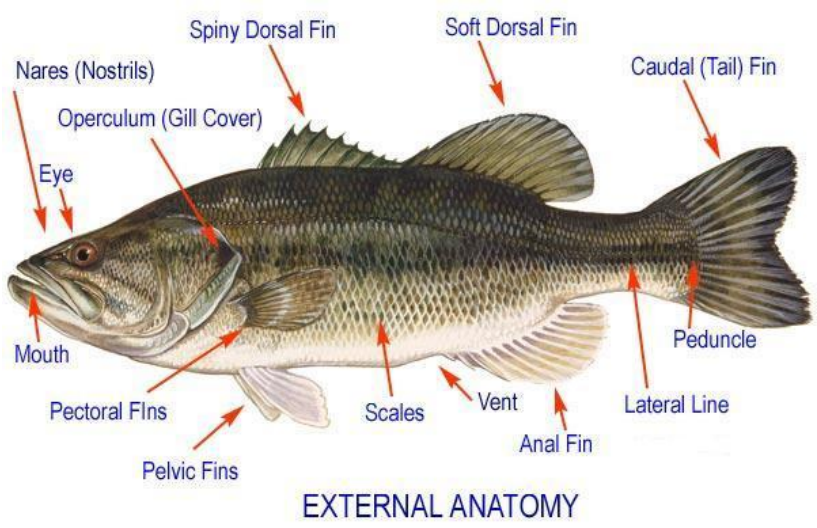
4.9 Class Osteichthyes (Bony fishes)

They possess jaws while their skeleton are partially or fully ossified. There is also the presence of a swim bladder, paired fins, gills for respiration covered by an operculum. The mouth is usually terminal with many teeth, while there are scales on the body. There is the presence of paired nostrils without internal nares. They have a lateral-line system, while the nervous system comprises of a brain with small olfactory lobes, large cerebellum, 10 pairs of cranial nerves and 3 semicircular canals. They are mostly oviparous with external fertilization, while some are however ovoviviparous or viviparous. The tails are usually homocercal or dicercal (in lung fishes).

4.10 A representative Osteichthyes (Bony Fishes – Nile Perch)

External features

Nile Perch (*Lates niloticus*) is a large-mouthed fish, the Nile perch is greenish or brownish above and silvery below and grows to about 6 ft. and 140 kg. It has an elongated body, a protruding lower jaw, a rounded tail, and two dorsal fins. It has distinctive dark-black eyes, with a bright-yellow outer ring. As one of the largest freshwater fish, it reaches a maximum length of more than 6 ft. weighing up to 200 kg.



Source: https://bentonzoology.wikispaces.com/Perch+Dissection+-+A+Supplement

It is relatively intolerant of low-oxygen waters, and therefore is somewhat restricted from entering swamps. Zones with vegetation in calm waters provide shelter to larvae and young. Adults inhabit deep water, while juveniles are found in shallow to or near shore environments. It is not present in the littoral rocky habitat.

A voracious predator which predominantly feeds on fish (including its own species), crustaceans, and insects, while the juveniles feed on larger crustaceans and insects (e.g., anisopterans, zygopterans and chironomids), and are also planktivorous. They however use schooling as a mechanism to protect themselves from other predators.

They have a long spawning season February-August. It reproduces around the year, with peaks in the rainy season. It probably spawns in shallow sheltered areas. Juveniles occur over wide depth range but the highest concentration of small juveniles are found in littoral and sub-littoral zones. Sexual dimorphism: females larger than males.

4.11 Class Amphibia e.g. *Bufo*

The word Bufo is a latin word for toad. Toad is any of a number of species of amphibians in the order Anura that are characterized by dry, leathery skin, short legs and parotoid glands. The Nigerian toad is Bufo *perreti*

Classification

- Kingdom : Animalia
- Phylum : Chordata
- Class : Amphibia
- Order : Anura
- Family : Bufonidae
- Genus : Bufo
- Species : perreti

External Anatomy of the Frog

Source: http://slideplayer.com/slide/8692637/

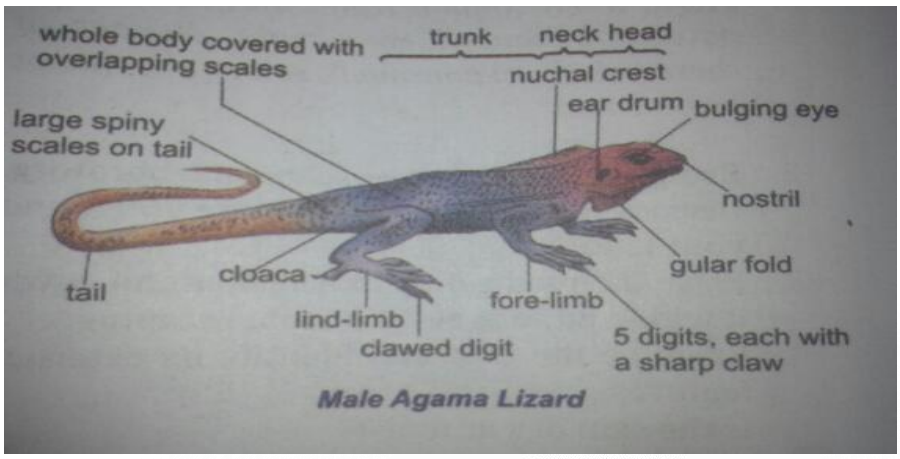
4.12 Ecological Adaptations of the Toad

Respiratory system of toad is adapted to utilize gaseous oxygen resulting in the presence of lungs and loss of gills. The skin of toad can resist drying up in a terrestrial environment. It is sensitive to mechanical and chemical stimuli and to temperature changes. Skin on the digits are sensitive and become increasingly so during the mating season. When the toad is swimming, its dark dorsal surface and light ventral surface make it difficult to detect. On land, it changes its colour to blend with environment to escape predators. When the toad is disturbed, the skin produces a poisonous and distasteful substance. Various sense organs of a toad are modified to detect stimuli in terrestrial as well as aquatic environment. The toad smells its food by using special olfactory organs in the head and this functions both in water and air.

They have well developed eyes that shows the animal a wide field of vision as well as sharp eyesight. It depends on good vision to obtain food, mate and avoid danger

They possess organs that produce sound. During breeding season, females are attracted to males by loud croaking of the latter. Females must be able to preserve and recognize the croaking of males (sound perception).

4.12 Class Reptilia *e.g.* The Rainbow Lizard *Agama agama*



Source: http://awaycande.blogspot.com.ng/2016/07/the-rainbow-lizard-agama-agama.html

Commonly called the redheaded Agama or The rainbow lizard. It is called the rainbow lizard because of the impressive colouration on the body of the dominant male. Agama means "Unmarried", because the animals are polygamous. The Agama lives in groups that comprise one dominant male, a couple of subordinate males and a large number of females (six or more females).

Colour: The color of the species depends on the gender and its position within the group.

Females: All females are green or brown.

Subordinate males: They have a body that is brown, grey, red, blue or yellow in color.

Dominant male: The dominant male is brightly colored. It has blue body with red or yellow head. Dominance in the group is accomplished through cock fighting. The dominant male is called cock and has privileges:

a) Mates with the females.

b) Gets the best place for rest.

Size:

They can reach 15.7 inches in length.

Classification

- Kingdom : Animalia
- Phylum : Chordata
- Subphylum: Vertebrata
- Class : Reptilia

- Order : Squamata
- Sub Order: Lacertilia
- Family : Agamidae
- Subfamily: Agaminae
- Genus : *Agama*
- Species : *agama*

Adaptations:

1. They are nocturnal and come out to hunt for food at night.
2. Tail breaks off easily when grabbed by prey, the tail is also used as fat storage for times when there is not much food for them to eat (desert species).
3. They have dry scaly skin an effective adaptation to life on land. Desert lizards have scales on skin that allow dew to collect on skin and slowly run towards mouth. This is a water source in arid deserts.
4. Lizards have well developed limb with five toes ending in claws for climbing, digging holes for laying of eggs and running on land.
5. Lizards evolve different sizes and shapes to adapt to their habitat. Lizard living on islands without large predators grow to very large sizes. Lizard that live in competitive environment with little food have smaller sizes.
6. Camouflage that helps them to blend in with the environment. Display of colors are used in attracting mates. Some of them have ability to adjust colors due to temperature fluctuation and this is called metachromatism. At cool temperatures lizard becomes darker. Dark colours increase heat. At high temperatures colors become lighter. Lighter colours reflect heat.
7. They carry out thermoregulation by orientation of body to suns angle. When lizard needs to increase temperature, it turns body towards strongest ray of sun. If it needs to cool of it turns away from the sun. Some bury themselves in sand to escape the heat of the top layer of sand and the direct sunlight.
8. The hemipenis allows for internal fertilization.
9. An improvement on the more necessary sense organs namely the eyes, ears and nose, reptiles have a more developed brain than amphibians.
10. The neck allows the lizard to move its head independently of its body so that it can watch its prey without moving.

4.13 Class Aves

Pigeons are birds with a small head, plump body, short legs and smooth feathers (Smooth and compact plumage). They are birds that belong to the family Columbidae.

Body Division:
The body is divided into a small head, a neck, compact trunk and tail.

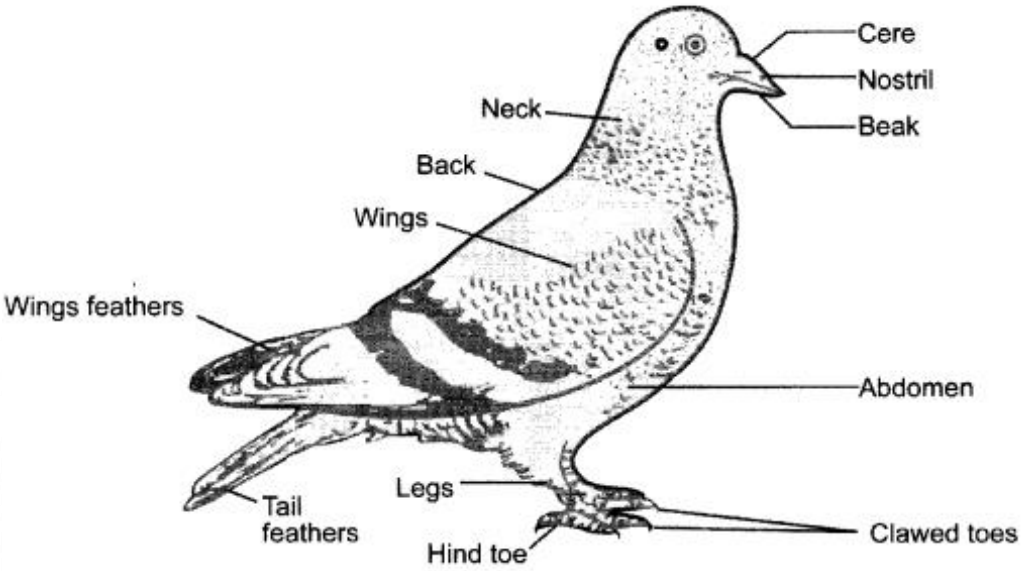


Fig. 7.5. Pigeon - External features

Source: http://www.cbsesamplepapers.info/cbse/cbse-class-9-science-practical-skills-animal-kingdom

Classification
Kingdom : Animalia
Phylum : Chordata
Class : Aves
Order : Columbiformes
Family : Columbidae
Genus : *Columba*
Species : *livia*
Common Name: Common pigeon
Rock dove

Morphological adaptations:
Body form fusiform form or spindle shaped.
Body covered with feathers.
Contour feathers make body streamlined and reduce friction to the minimum.
Feathers make body light.
Feathers hold considerable blanket of enveloping air around the body and add much to its buoyancy.
Feathers insulate body perfectly and prevent loss of heat which enables a bird to endure intense cold at high altitudes and maintain constant temperature.

Feather forms broad surface for striking the air.
Fore limb transformed into unique & powerful propelling organ the wings.
Mobile neck & beak.
Extreme mobility of long and flexible neck for reaching food.

Bipedal locomotion – The anterior of body becomes modified for flight and posterior part of body becomes modified for movement on land.

To support the entire body weight the hind limbs occupy a somewhat exterior position on trunk & become more stable.

Perching – The hind limbs are specialized for perching.

Short tail bears a tuff of long tail feathers or rectrices which spread out in a fan like manner & serves as a rudder for flight. They also assist in steering lifting & counter balances during flying & perching.

4.15 Class Mammalia e.g. *Rattus rattus*

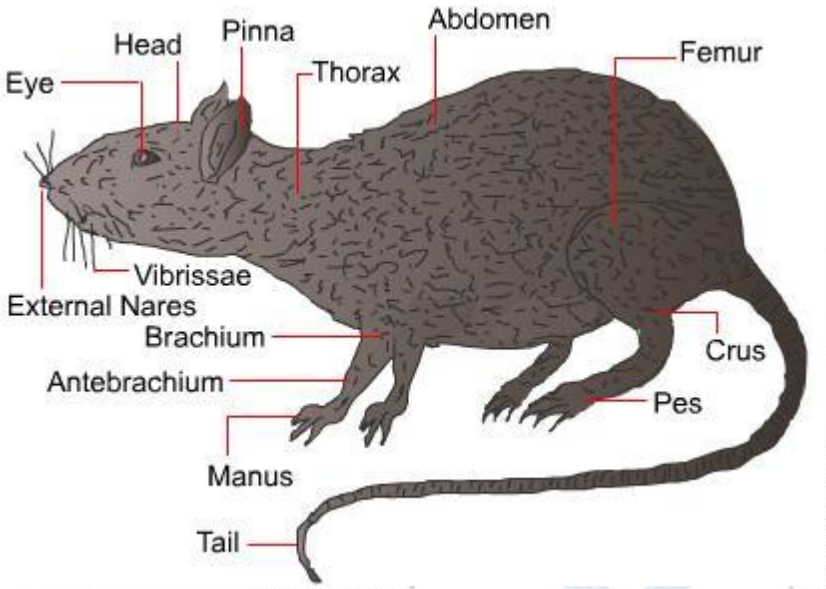
Rattus rattus (Commonly called the black rat)
Distribution: All continents of the earth. They are native to India.
Habit: Nocturnal, Climbers.

Classification

- Kingdom : Animalia
- Phylum : Chordata
- Class : Mammalia
- Order : Rodentia
- Family : Muridae
- Genus : *Rattus*
- Species : *rattus*

Body Division:

The body is divided into head, neck, trunk and tail.



The external features of a black rat

Source: https://www.tutorvista.com/content/biology/biology-iii/animal-morphology/rat-mammal.php

Ecological adaptations:

1. The small size allows it to squeeze through small openings and escape from predators.
2. The hair or fur keeps it warm in cold temperatures.
3. They have whiskers that help them in gathering information about the environment.
4. They use the tail for balance (They balance on ropes wrapping their tails around the rope).
5. The dentition affords them access to a variety of food and shelter.
6. They are nocturnal and become more active at night.
7. They are opportunistic omnivores (They take advantage of whatever food is available).
8. They live in packs and groups which make them more secure and protected.
9. They are skilled climbers and swimmers.
10. They are very prolific, producing 3-5 litters in a year.

- Each litter contains 1-16 young.
- A Single female can produce 56 young.
- At age 12-16 weeks females can reproduce.
- While still suckling a litter female can conceive.

11. They show parental care and construct nests of grass and twig often in roof of houses (That's where they got the name roof rat).
12. They are very aggressive.
13. They can survive in a wide variety of habitats and take advantage of shelters and resources provided by vacant buildings.

Post-Test

7. What is the preen gland in pigeon used for?
8. Mention some characteristics common to both aves and mammals
9. Name the different kinds of feathers found in aves

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