LOCOMOTION AND NUTRITION OF ANIMALS

SEMESTER: I

UNIT: 2

Movement and locomotion-Amoeboid movement-Ultrastructure of cilia and ciliary movements-Action of muscles. Nutrition-Types of nutrition: Autotrophic and heterotrophic. Apparatus for nutrition: Food Vacuole- Animals without alimentary canal-incomplete-complete-alimentary canal. Brief account of digestion in invertebrates

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MOVEMENT AND LOCOMOTION

MOVEMENT is a displacement from one point to another.

LOCOMOTION is the movement of a WHOLE organism from one place to another.

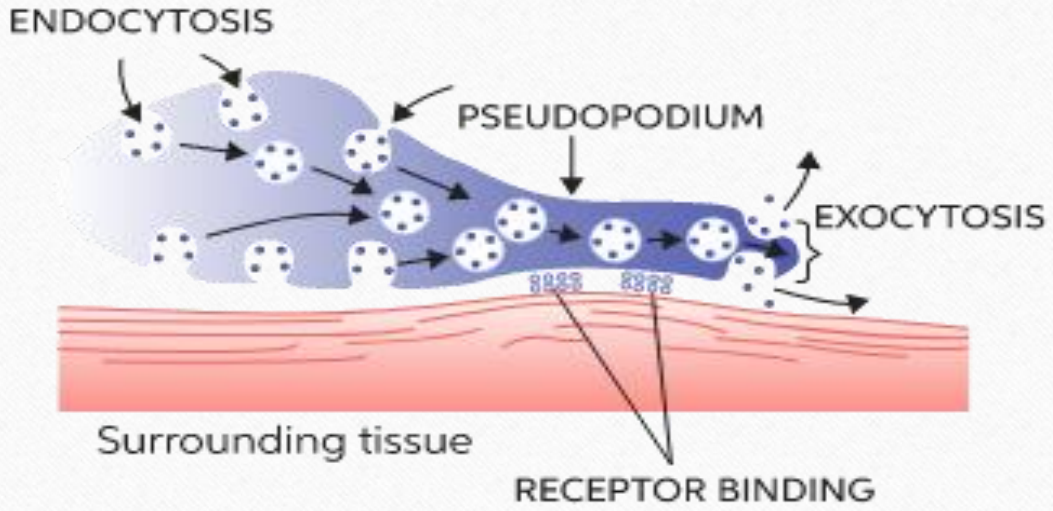
ONLY ANIMALS carry out locomotion.

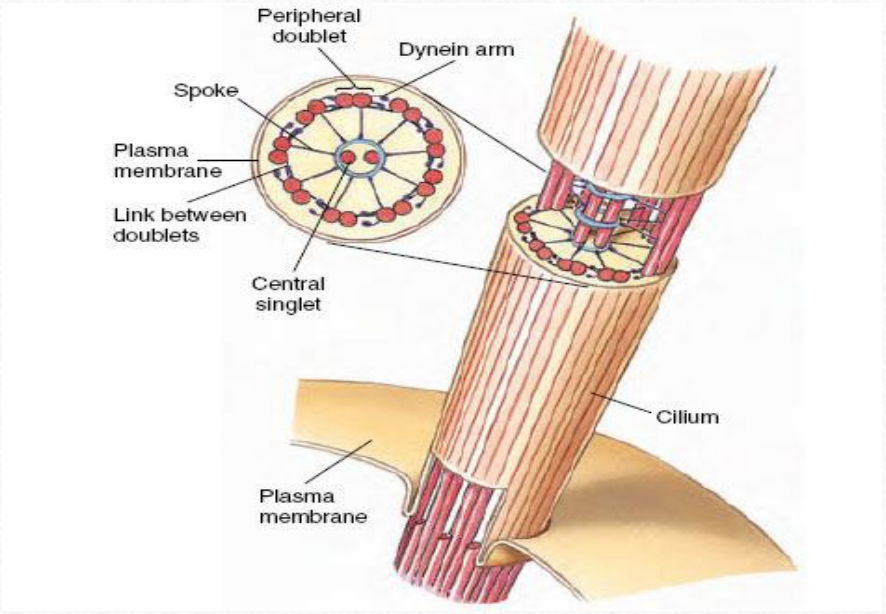
Reasons why animals move from place to place

1. To obtain food
2. To escape predators
3. To find a mate
4. To distribute offspring
5. To reduce competition
6. To avoid danger
7. To maintain position
8. To avoid waste products

TYPES OF CELLULAR MOVEMENTS

- AMEBOID MOVEMENT
- *CILIARY MOVEMENT*





AMOEBOID AND CILIARY MOVEMENT

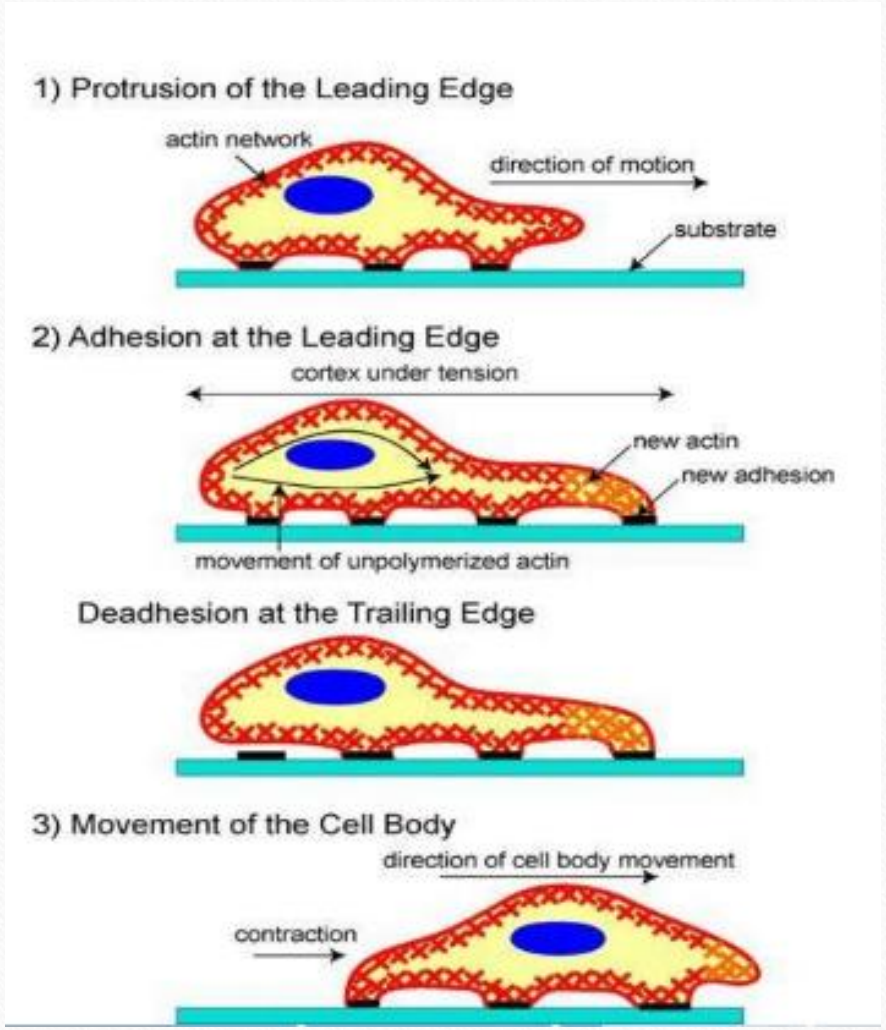
Ameboid movement

Movement of an entire cell in relation to its surroundings

Involves pseudopodium and ATP

Mechanism

- formation of new cell membrane & exocytosis at one end
- Attachment of pseudopodium to tissues
  - Receptor proteins
- Absorption of the membrane & endocytosis in mid & rear portions
- Detachment of receptor proteins



MECHANISM

Two effects are essential for forward movement of the cell.

- The first effect is attachment of the pseudopodium to surrounding tissues so that it becomes fixed in its leading position, while the remainder of the cell body is pulled forward toward the point of attachment.
- The second essential effect for locomotion is to provide the energy required to pull the cell body in the direction of the pseudopodium.

FIRST EFFECT

- This attachment is effected by *receptor proteins* that line the insides of exocytotic vesicles. When the vesicles become part of the pseudopodial membrane, they open so that their insides evert to the outside, and the receptors now protrude to the outside and attach to ligands in the surrounding tissues.
- At the opposite end of the cell, the receptors pull away from their ligands and form new endocytotic vesicles. Then, inside the cell, these vesicles stream toward the pseudopodial end of the cell, where they are used to form still new membrane for the pseudopodium.

SECOND EFFECT

- In the cytoplasm of all cells is a moderate to large amount of the protein *actin*.
- Much of the actin is in the form of single molecules that do not provide any motive power; however, these polymerize to form a filamentous network, and the network contracts when it binds with an actin-binding protein such as *myosin*.
- The whole process is energized by the high-energy compound ATP.
- A network of actin filaments forms anew inside the enlarging pseudopodium.
- Contraction also occurs in the ectoplasm of the cell body, where a preexisting actin network is already present beneath the cell membrane.

TYPES OF CELLS EXHIBITING AMEBOID MOVEMENT

- White blood cells (WBCs):when they move out of the blood into the tissues to form *tissue macrophages*.
- Fibroblasts: move into a damaged area to help repair the damage and even the germinal cells of the skin, though ordinarily completely sessile cells, move toward a cut area to repair the opening
- Embryonic cells: migrate long distances from their sites of origin to new areas during development of special structures.

CILIARY MOVEMENT AND ITS OCCURENCE

A second type of cellular motion, *ciliary movement*, is a whiplike movement of cilia on the surfaces of cells.

This occurs in only two places in the human body:

- On the surfaces of the respiratory airways In the nasal cavity and lower respiratory airways,
- the whiplike motion of cilia causes a layer of mucus to move at a rate of about 1 cm/min toward the pharynx, in this way continually clearing these passageways of mucus and particles that have become trapped in the mucus

Cilia and Ciliary movements

- Whiplike movement of cilia on the surfaces of cells
- A sharp pointed hair projecting 2-4micrometers from the surface of the cell.

Structure of a cilium

Covered by an outcropping of cell membrane

Supported by 11 microtubules, 9 double tubules at the periphery and 2 single tubules down the center.

Each cilium is an outgrowth of a structure that lies immediately beneath the cell membrane, called *basal body* of the cilium

Mechanism of ciliary movement

Sudden fast forward whip like stroke

Slow backward stroke

An effective way of pushing the fluid in the direction of forward stroke.

CELLS EXHIBITING CILIARY MOVEMENT

1- Respiratory airways

2- Uterine tubes of the female reproductive tract.

Types of Cilia

Following are the two different types of cilia:

Motile Cilia

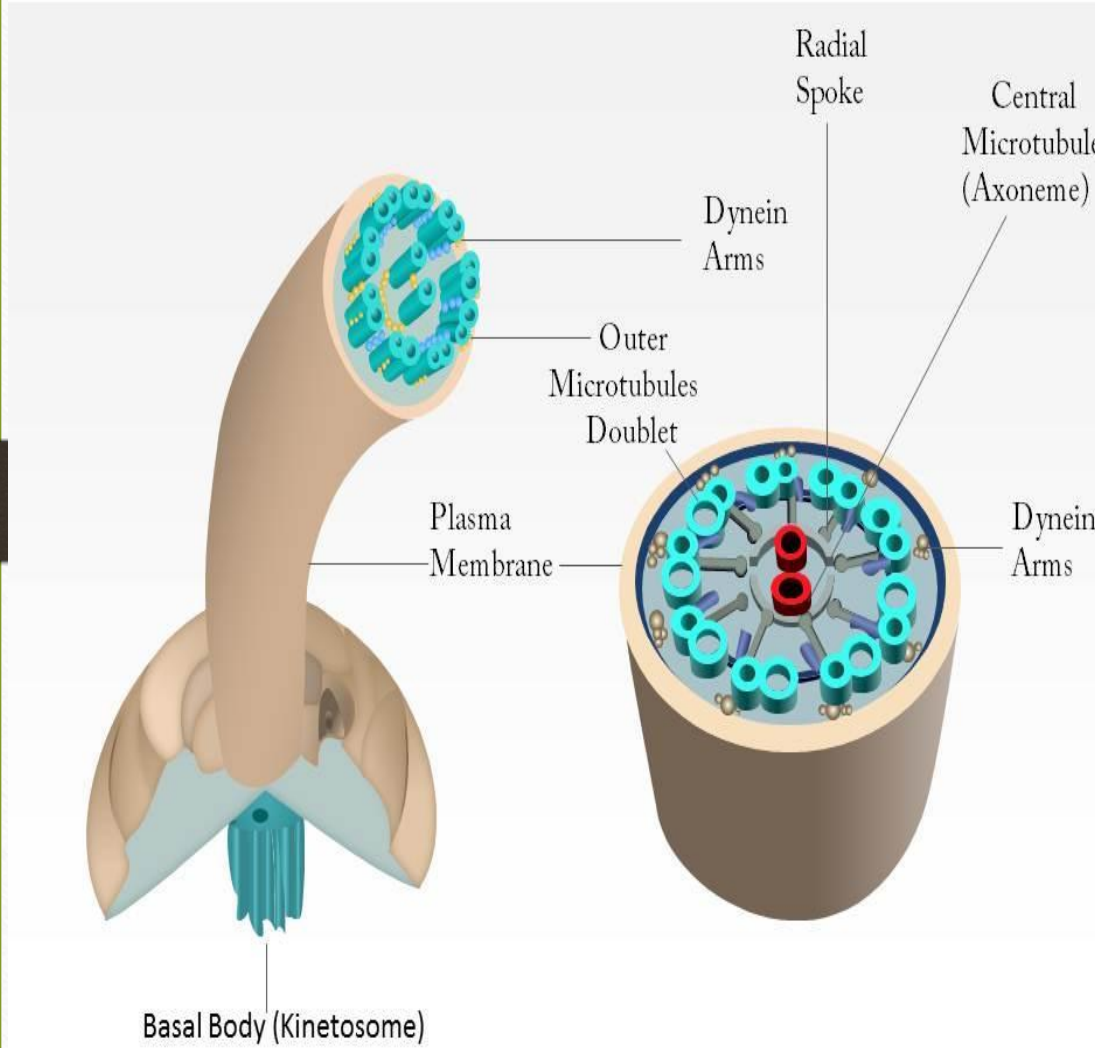
These are found in large numbers on the surface of the cell. In humans, these are found in the respiratory epithelium of the respiratory tract. Here, they function by clearing the mucus and dust out of the lungs.

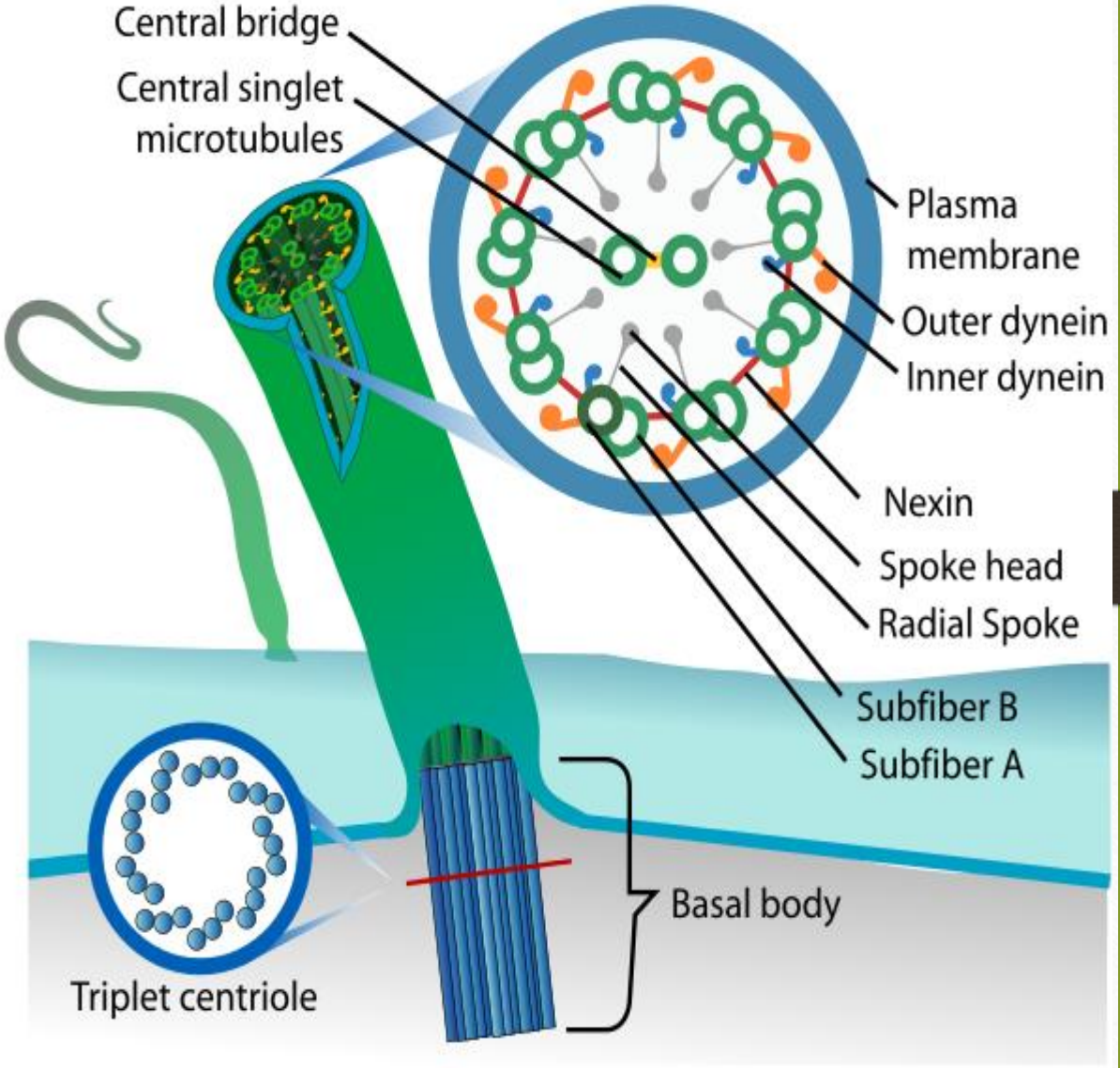
Non-motile Cilia

Primary Cilia are non-motile cilia that were first discovered in 1898. These structures were long believed to be vestigial organelles. However, recent researches presented the biological roles of primary cilia that they function as a sensory cellular antenna that coordinates a large number of cellular signalling pathways. Apart from these, they also help in:

- Proper urine flow by signalling the kidney cells.
- They act as mechanoreceptors or sensory receptors.
- The cilia function by permitting the transfer of important particles from one side of the light-sensitive cells to another in the retina.

Cilia

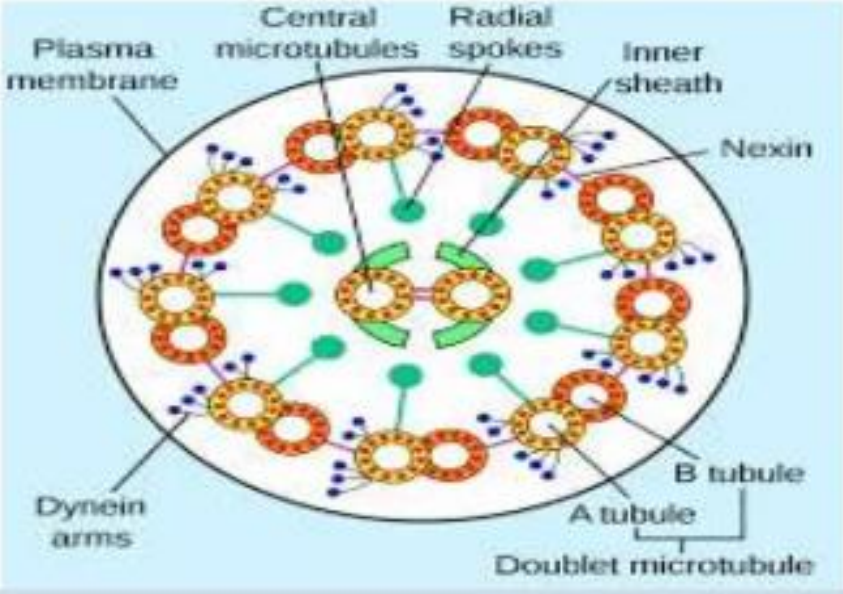

Radial
Spoke
Central
Microtubule
(Axoneme)
Dynein
Arms
Outer
Microtubules
Doublet
Plasma
Membrane
Dynein
Arms
Basal Body (Kinetosome)


Central bridge
Central singlet
microtubules
Plasma
membrane
Outer dynein
Inner dynein
Nexin
Spoke head
Radial Spoke
Subfiber B
Subfiber A
Basal body
Triplet centriole

ULTRA STRUCTURE OF CILIA

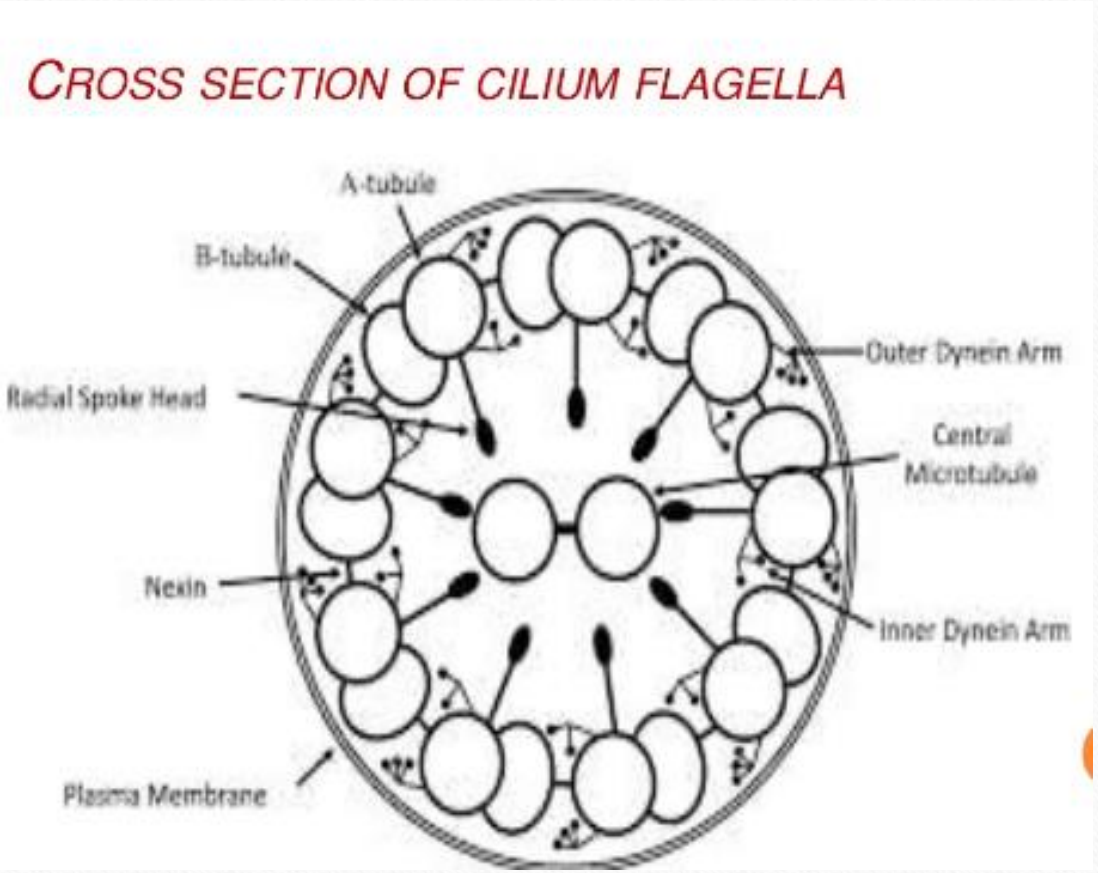
STRUCTURE

- Entire ciliary or flagellar projection is covered by a membrane , continuous with plasma membrane of cell.
- Core of cilium is called axoneme, contains an array of microtubules.



- Axoneme of motile cilium or flagella consist of nine peripheral doublet microtubules surrounding central pair of singe microtubules, known as 9+2 array.
- All microtubules have same polarity (+ends at tip of projection & -end at base).
- Each peripheral doublet consist of one complete tubule, A tubule and one incomplete, B tubule.
- Basic structure of axoneme discovered in 1952 by Irene Manton (plants) & Don Fawcett and Keith Porter (animals).

- Central tubules enclosed by central sheath, that is connected to A tubule by radial spokes.
- Doublets are connected to each other by interdoublet bridge, composed of nexin.
- A pair of arms (an inner arm & outer arm) project from A tubule.
- Cilium or flagellum emerges from a basal body.
- If a cilium is sheared , a new organelle is regenerated as outgrowth of basal body.



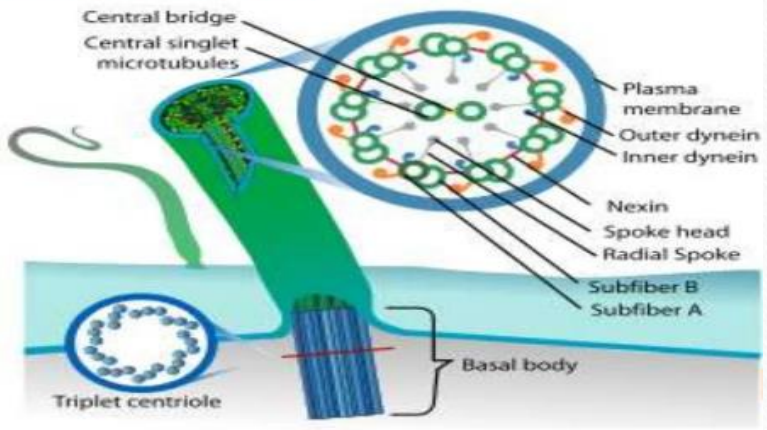
AXONEME

- Length of axoneme vary from a few microns to 2mm. Diameter about 0.2µ to 2000Aº at base, reaches upto 10µ above cell surface.
- Axoneme is surrounded by an outer ciliary membrane of 90Aº thick.
- It is continuous with PM and composed of lipoprotein.

BASAL BODIES

- Flagellum or cilium arises from spherical or granular or short rod shaped body – basal body.
- Also known as kinetosome, basal granule, proximal centriole.
- They are structurally similar to centrioles.
- It is hollow cylindrical body and in protoplasm there are 9 groups of tubules.
- Each tubule is formed of 3 units:- 2 units extend into flagellum and third one ends between basal body and flagellum.

EUKARYOTIC CILIUM



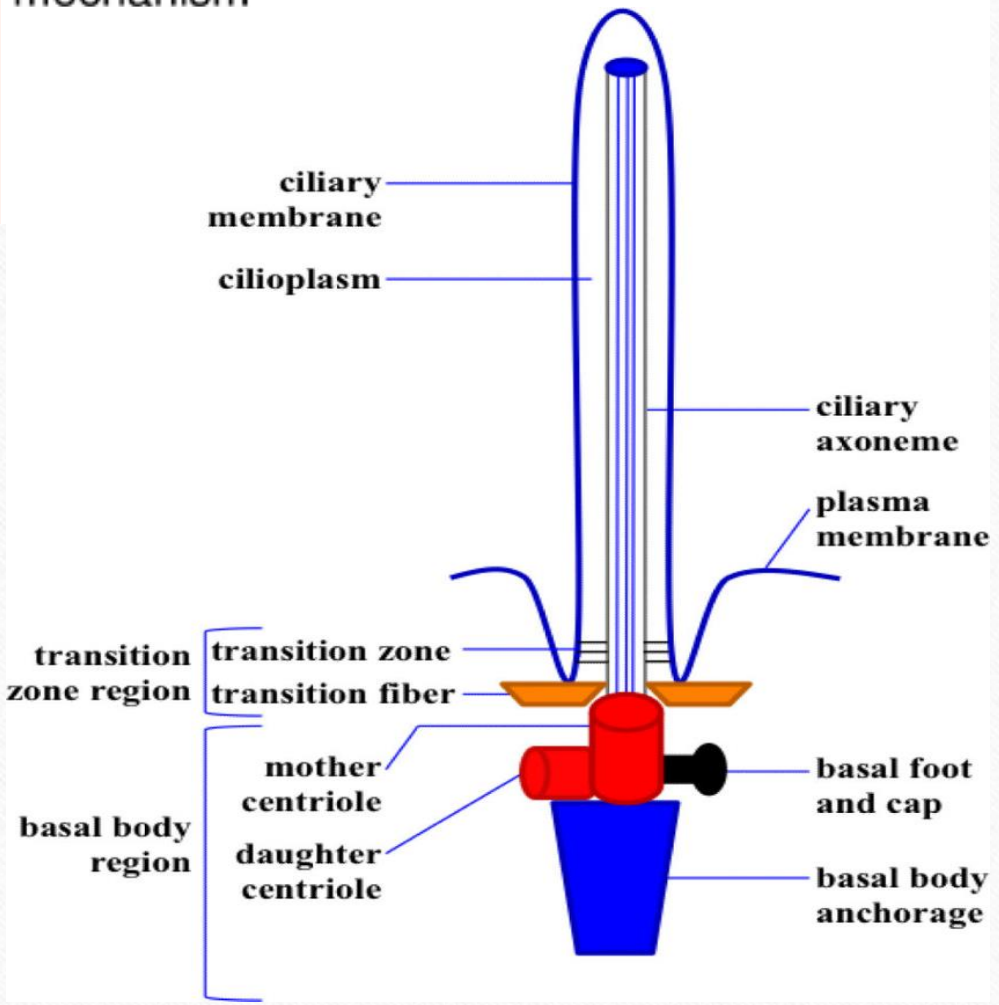
CILIARY ROOTLETS

- Additional hair like structure arise from basal body and extend to cytoplasm – ciliary rootlets.
- Characteristics of ciliated epithelial cells of mammals.
- Also help to anchor basal body with cilium.

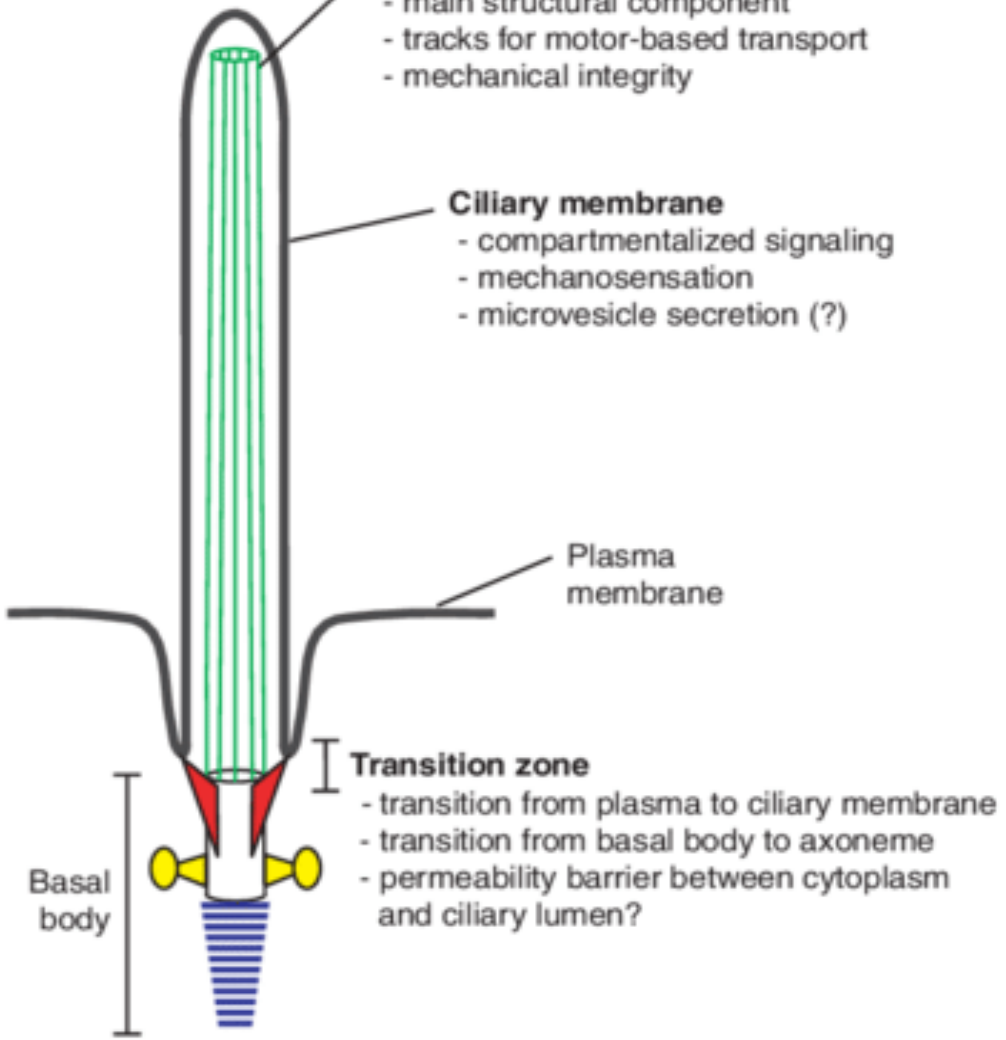
INTRAFLAGELLAR TRANSPORT

- Movement of particles in space between peripheral doublets and surrounding plasma membrane is called intraflegellar transport (IFT).
- It is responsible for assembling and maintaining these organelles.
- IFT depend on activity of both plus and minus end.
- Kinesin 2 moves complex arrays of IFT particles together with associated building materials along protofilaments of peripheral doublets to assembly site at tip of growing axoneme.

Kinesin 2 molecules transported back towards basal body by cytoplasmic dynein powered mechanism



Primary cilium



Ciliary axoneme
- main structural component
- tracks for motor-based transport
- mechanical integrity

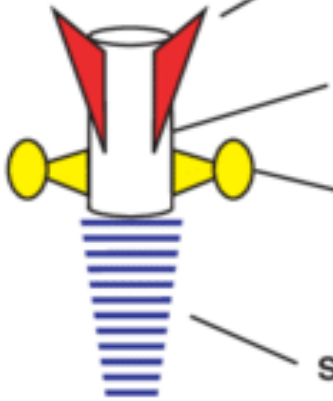
Ciliary membrane
- compartmentalized signaling
- mechanosensation
- microvesicle secretion (?)

Plasma membrane

Transition zone
- transition from plasma to ciliary membrane
- transition from basal body to axoneme
- permeability barrier between cytoplasm and ciliary lumen?

Basal body

Basal body



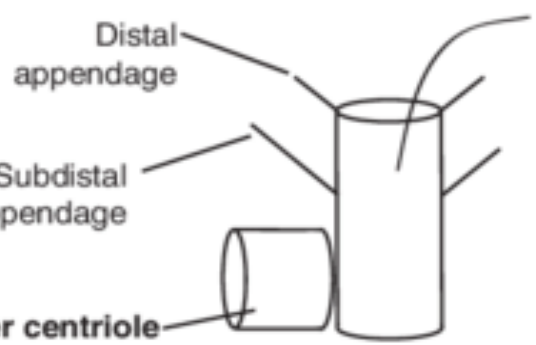
Transition fiber
- plasma membrane attachment
- ciliary pore

Mother centriole
- basal body core

Basal foot and cap
- microtubule attachment

Striated rootlets
- basal body anchorage

Centrioles



Distal appendage

Subdistal appendage

Daughter centriole
- microtubule nucleation

Mother centriole
- microtubule nucleation
- microtubule anchoring
- centriole duplication template

MECHANISM OF CILIARY AND FLAGELLAR LOCOMOTION

- Contraction of muscle results from sliding of actin filaments over adjacent myosin filaments.
- As muscle system as a model, ciliary motion was explained by sliding of adjacent microtubular doublets relative to one another.
- Dynein arms act as swinging cross bridges.
- It generate forces required for ciliary or flagellar movement.
- In intact axoneme, stem of each dynein molecule is tightly anchored to outer surface of A tubule.
- With globular head and stalks projecting towards B tubule of neighbouring doublet.

FUNCTIONS OF CILIA AND FLAGELLA

Cells in motion:

- Cellular appendages capable of specific types of movement.
- Flagella are capable of undulating or rotational movement.
- With a whip like motion, cilia can move from one place to another.

Cells that swim:

- Eukaryotic flagella exhibit wiggling or undulating movement to propel an entire cell.
- Eg ; single celled protozoa use flagella to swim through aquatic environment for food.
- Reproductive cells use flagella for locomotion.

A bacterial motor:

- Tail like extension or filament of bacterial flagellum is connected through a hooked segment to proteins that generate torque.
- This motor rotates the entire filament which moves the bacterium.

Cellular dusting:

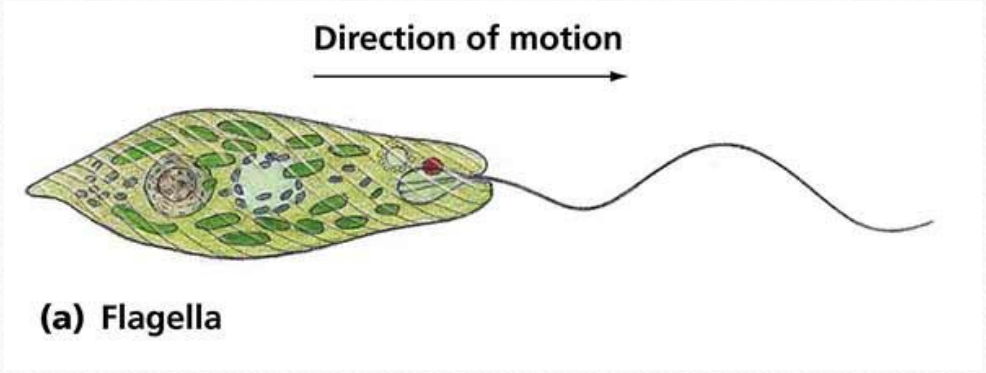
- Group of cilia work together for steady movement of water, mucous, and other extra cellular substances.
- Eg :human respiratory tract contain special cells called ciliated epithelial cells.
- They work together with goblet cells to keep lungs clean.

Taxis

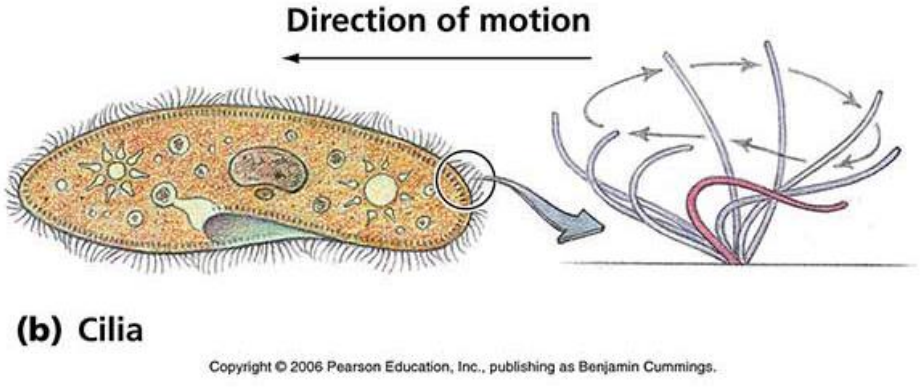
Around half of all known bacteria are motile. Motility serves to keep bacteria in an optimum environment via taxis *(def)*.

Taxis is a motile response to an environmental stimulus.

Bacteria can respond to chemicals (chemotaxis), light (phototaxis), osmotic pressure (osmotaxis), oxygen (aerotaxis), and temperature (thermotaxis)



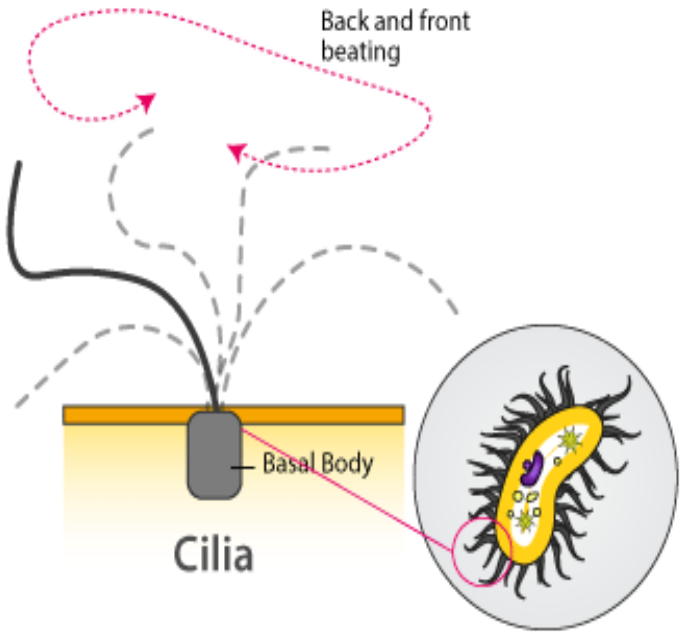
(a) Flagella

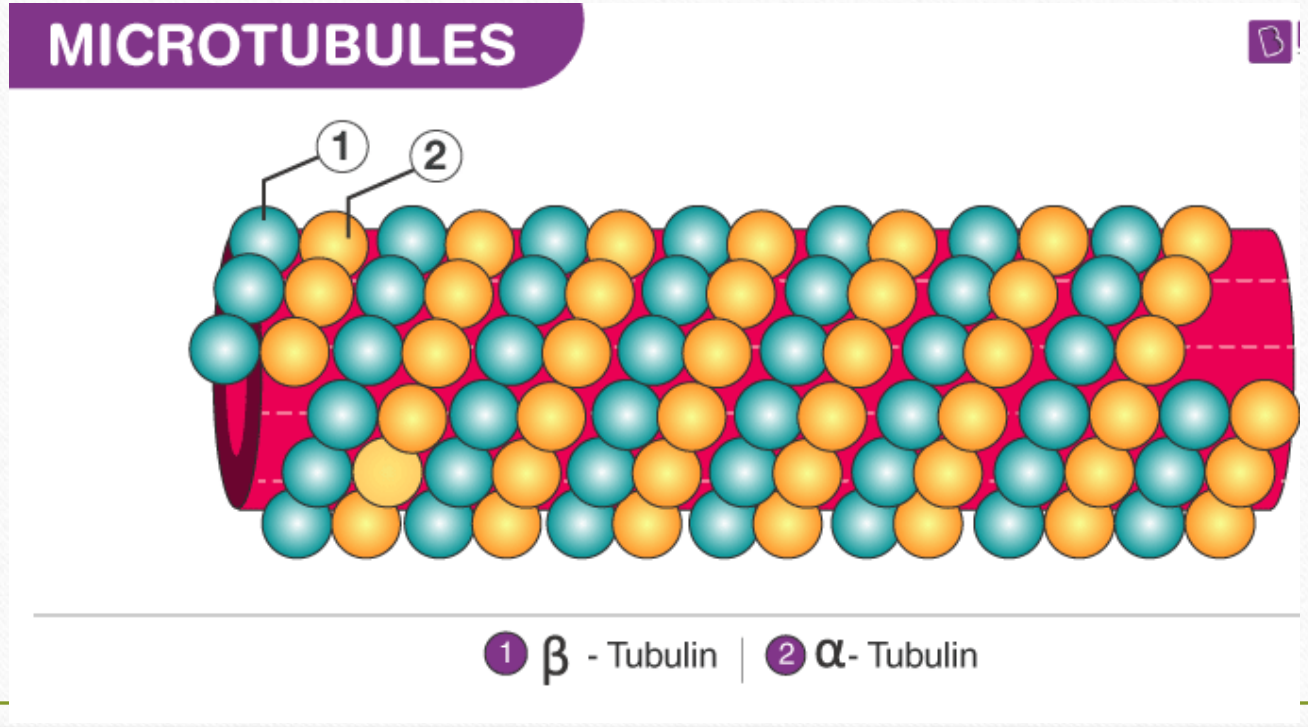


(b) Cilia

CILIARY MOVEMENTS

Ciliary movement refers to the rhythmic movement of cilia, which causes movement of the fluid or the cell. E.g. in Paramecium, ciliary movement helps in the movement of the cell as well as in the movement of the food inside the cell. Cilia are present in the epithelial lining such as the fallopian tube, respiratory tract, where they help in the movement of fluid as well as trap any external particles in the mucus.





ACTION OF MUSCLES

The muscular cells of invertebrates can be divided into three major classes on the basis of their striation pattern: transversely striated, obliquely striated, or smooth muscle.

Transversely striated muscles have either continuous or discontinuous Z lines and, thus, can be subdivided into two types respectively.

Of all invertebrate muscles, the transversely striated muscle with continuous Z lines is the most similar to the vertebrate skeletal muscle and is present in arthropods, whose musculature (including the visceral muscles) only consists of this cell type. These muscles are multinucleate cells that contain myofibrils showing well-defined sarcomeres.

Transversely striated muscles with discontinuous Z lines, consisting of multiple small electron dense patches, are found in the translucent portions of adductor muscles of some bivalves and in the heart muscle of the gastropods. This muscle is formed by mononucleated cells with centrally-located nuclei and a single myofibril.

The obliquely striated muscle appears in nematodes, annelids, molluscs, brachiopods and chaetognathes and consists of mononucleated cells with both thick and thin myofilaments which form sarcomeres delimited by Z lines.

The thick (myosin) myofilaments show a variable length (from 2.2 microns up to 6 microns) and width (from 14 nm up to 231 nm) and contain a central core of paramyosin, which is absent in vertebrate muscles. Thick filaments are homogenous in transversely striated muscles and either homogeneous or fusiform in the obliquely striated and smooth muscles.

Thin filaments measure 6 nm in diameter. They contain tropomyosin and, only in striated muscles, also troponin. The thin/thick filament ratio varies from 3/1 to 6/1, even in smooth muscles. The plaques for filament anchorage (Z lines in striated muscles or electron dense bodies in smooth muscles) contain alpha-actinin. The striated (transversely or obliquely) muscles show long sarcomeres (up to 9 microns) and the number of thin filaments around each thick filament varies from 3 to 12, so that each thin filament is shared by two thick filaments. .

Many striated muscles contain titin (connectin) and intermediate filaments and display a sarcotubular system consisting of T tubules and sarcoplasmic reticulum tubules. Both structures form dyads and, more rarely, triads.

The location of T tubules as well as the configuration and distribution of sarcoplasmic reticulum vary among muscles and species. Invertebrate smooth muscle differs from that of vertebrates principally in the higher proportion and larger diameter of thick myofilaments.

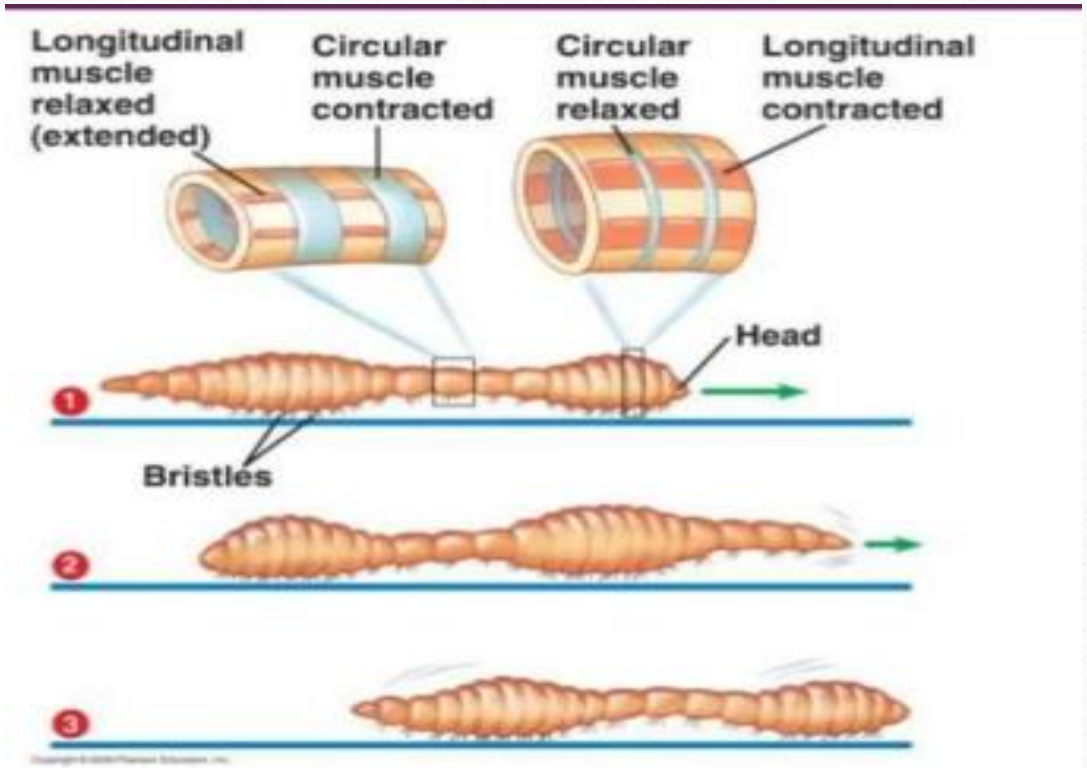
These may be fusiform and their size and number may vary widely among cells. These muscle cells may be classified by the characteristics of both the thick filaments and the electron dense bodies for filament anchorage.

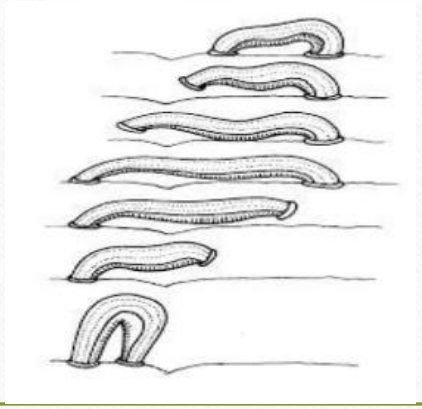
THE MUSCULAR SYSTEM OF INVERTEBRATES

A few functional differences among invertebrates muscle indicate some of the differences from the vertebrate skeletal muscle.

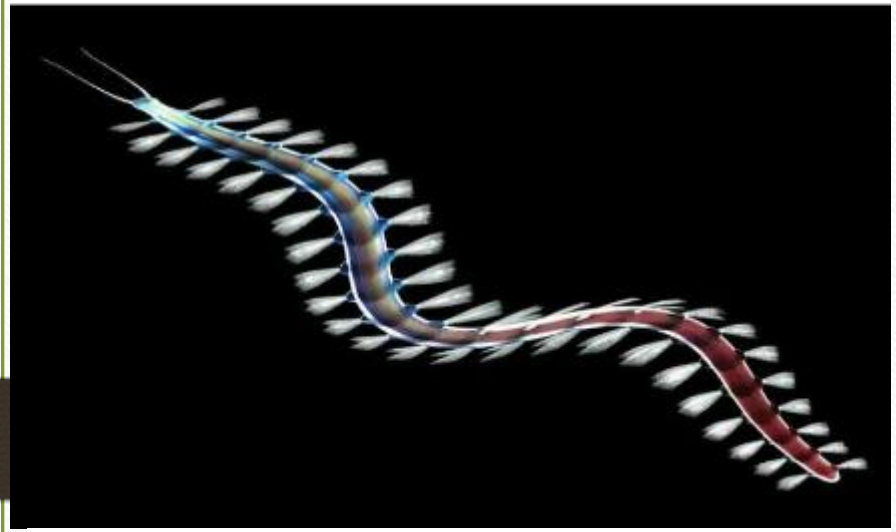
The Locomotion of Soft-Bodied Invertebrates

- **Pedal locomotion** – move by means of waves of activity in the muscular system that applied to the substrate.
- **Looping movement** – arching movements are equivalent to the contraction of longitudinal muscle.



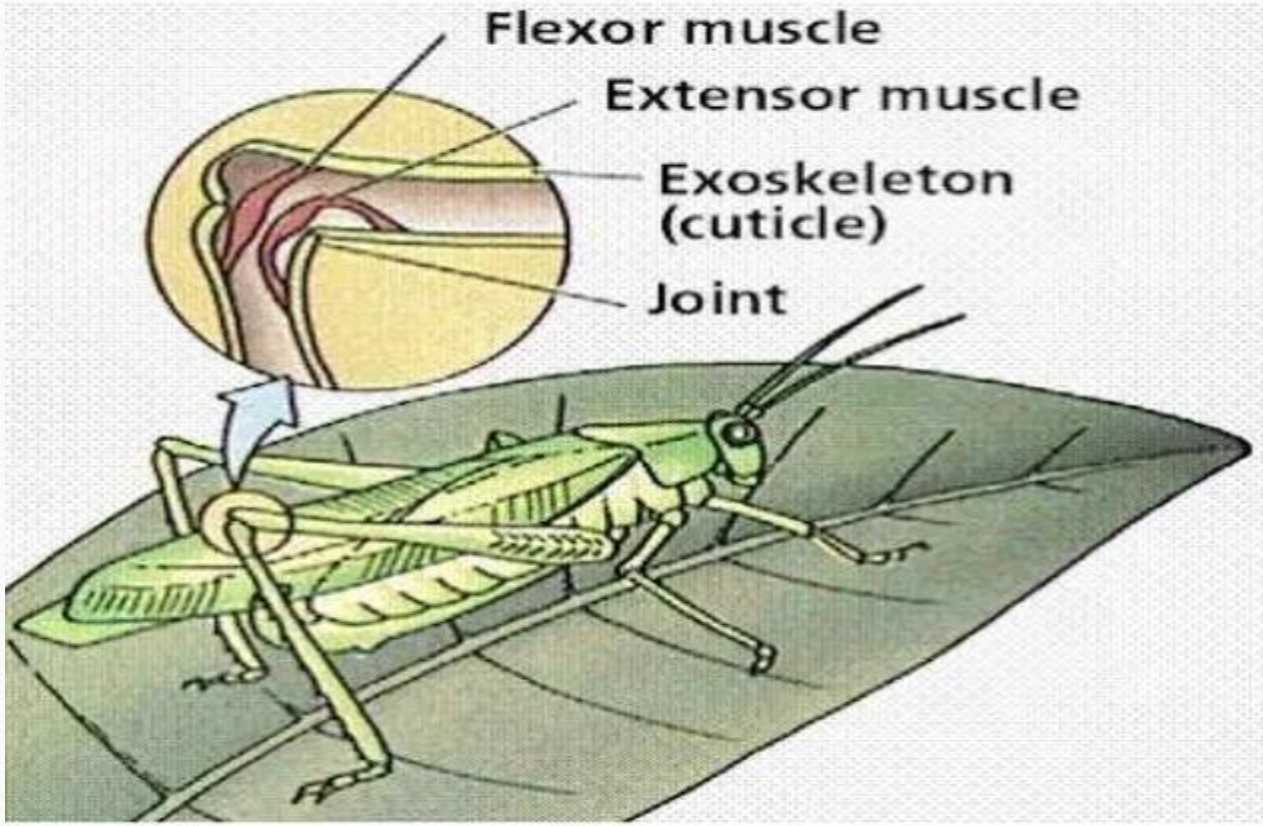


- Polychaete worms move by the alternate movement of multiple limbs (parapodia)



- The water vascular system of echinoderms provides a unique means of locomotion.
- Along each canal are reservoir ampullae and tube feet.

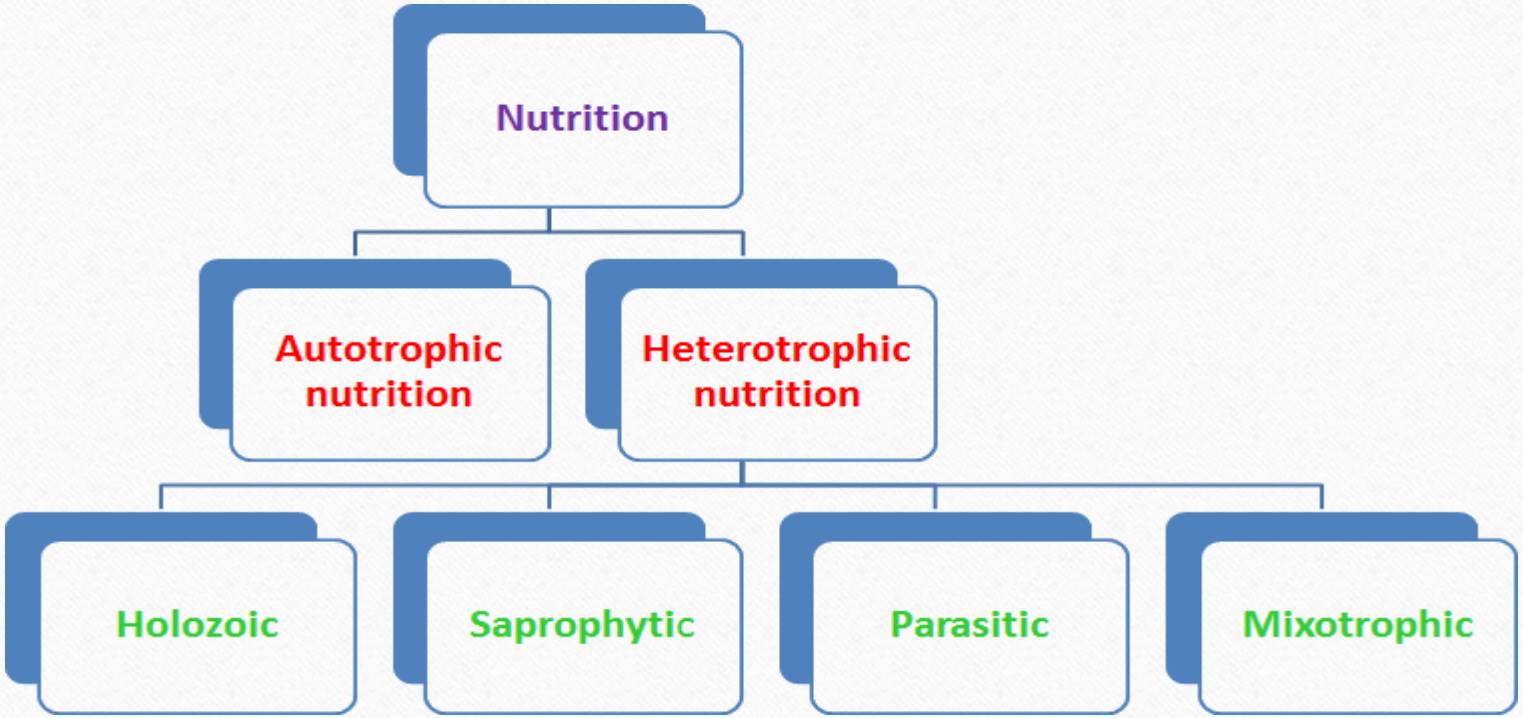
THE MUSCULAR SYSTEM IN INSECTS



NUTRITION

Nutrition is the biochemical and physiological process by which an organism uses food to support its life. It provides organisms with nutrients, which can be metabolized to create energy and chemical structures.

TYPES OF NUTRITION



Types Of Nutrition

AUTOTROPHS

(autos : self ; trophos : feed)

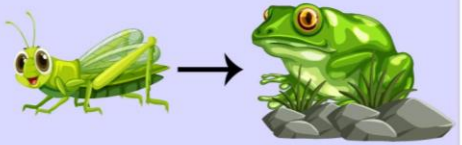
Use simple inorganic substances and either light energy (photosynthesis) or chemical energy (chemosynthesis) to synthesise food.

HETEROTROPHS

Obtains energy through intake & digestion of organic substances (animal / plant tisssue)

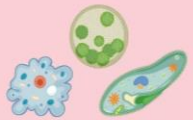
AUTOTROPH vs HETROTROPH

Grass



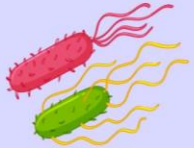
Grasshopper Frog

Plants Bacteria



Algae

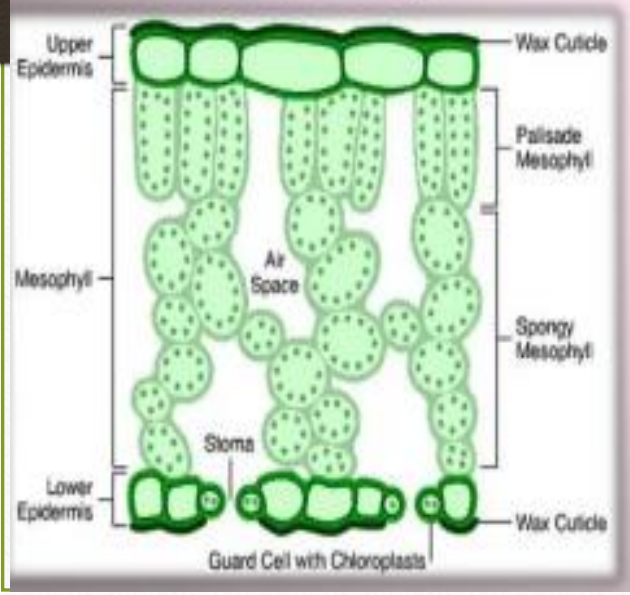
Animals Fungi

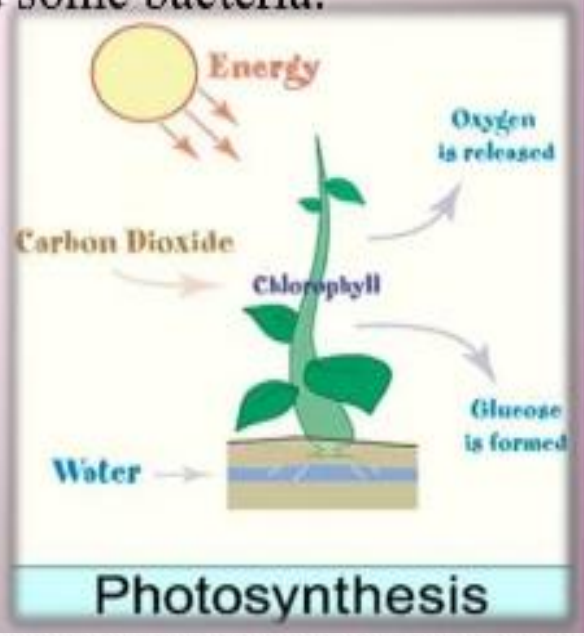


Most Bacteria

Autotrophic nutrition

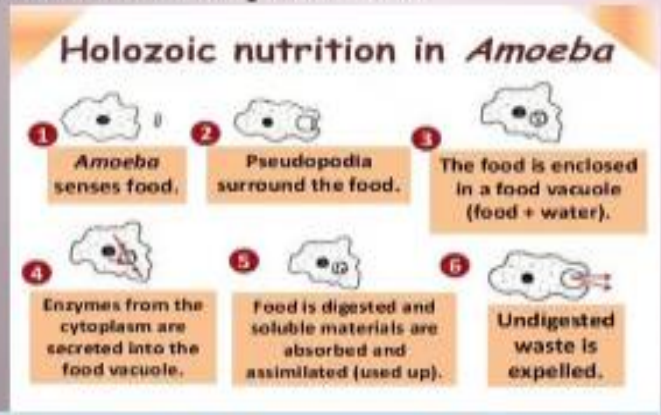
- Autotrophic nutrition :- is nutrition in which organisms prepare their own food from simple inorganic substances like carbon dioxide and water in the presence of sunlight and chlorophyll.
- Eg :- all green plants and some bacteria.





Amoeba – A case study

- The cell membrane of amoeba keeps on protruding into pseudopodia.
- Amoeba surrounds a food particle with pseudopodia and makes a food vacuole. The food vacuole contains the food particle and water. Digestive enzymes are secreted in the food vacuole and digestion takes place.
- After that, digested food is absorbed from the food vacuole.
- The food vacuole moves near the cell membrane and undigested food is expelled out.



SYMBIOSIS

- A mutually beneficial association of two different kinds of organisms.
- To live together; a condition in which two animals, two plants, or a plant and an animal live in partnership. The relationship can be that of commensalism, where one organism benefits from activities of the other; parasitism, where one organism lives on another to the detriment of its host; or mutualism, where both organisms benefit from the association.
- The living together of unlike organisms in a close, long-lasting association.

Most diatoms produce, and they assist as support for the sponge.

lichen

- In symbiosis, at least one member of the pair benefits from the relationship. The other member may be :-
  1. Injured = parasitism
  2. Relatively unaffected = commensalism
  3. May also benefit = mutualism
- Example of other aquatic heterotrophs that show symbiosis :-
  1. sponges
  2. sea anemones
  3. planarians
  4. clams
- Also harbor algae within their cells.

The ash bolete (*Gyroden merulioides*), which occurs under ash trees in North America (*Fraxinus Americana*), has a symbiotic association with aphids (seen in cross section).

Holozoic nutrition

- ***Holozoic nutrition*** (Greek: *holo* whole and *zoikos* of animals) is a method of nutrition that involves the ingestion of liquid or solid organic material, digestion, absorption and assimilation of it to utilize it. It includes taking in the complex substances and converting them into simpler forms. Eg :- amoeba, paramecium, birds, fishes, humans etc.
- In this mode of nutrition, the food may be a small bacterium, a plant, or an animal. This nutrition involves:
- ***Ingestion*:** Taking in complex organic food through mouth opening.
- ***Digestion*:** Change of complex food into simple form by action of enzymes.
- ***Absorption*:** Passing of simple, soluble nutrients through blood or lymph.
- ***Assimilation*:** Utilization of absorbed food for various metabolic processes.
- ***Egestion*:** Expelling out the undigested food.

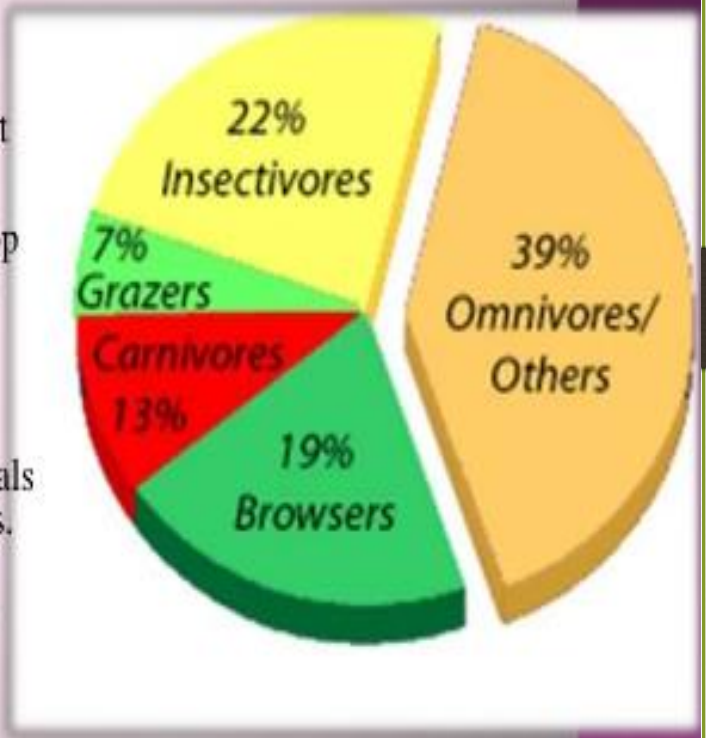
Types of Holozoic nutrition

- ***Holozoic nutrition*** has it's three subtypes:-

Carnivores:- Term applied to a heterotrophs, usually an animal, that eats other animals. Carnivores function as secondary, tertiary, or top consumers in food chains and food webs.

Omnivores:- The category of animals that feed on both plants and animals. (Omni-all; vore-eater)
such as bears and humans, eat both meat and plants.

Herbivores:- Feeding on plants. For example, animals such as moose and snowshoe hares are herbivorous.



HETEROTROPHIC NUTRITION

All animals including man & all non green plants depend on green plants for organic food .They are known as heterotrophs & their mode of nutrition is called heterotrophic nutrition .This involves following steps :

1. INGESTION

- This is the process in which food is taken inside the body.

2. DIGESTION

- It is the process of breaking complex molecules of organic food into simpler molecules .This takes place with the help of digestive juices which contain different Specific enzymes acting on specific food components like carbohydrates , fat, protein etc. This process is called digestion.

3 .ABSORPTION

- In this process digested food is absorbed & transported to each & every cell of the body.

4. ASSIMILATION

- Inside the cell absorbed food is converted into living substance i. e. protoplasm .This is called assimilation.

5 . EGESTION

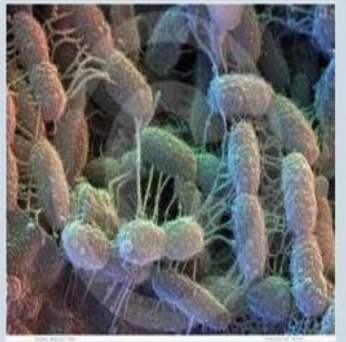
- The undigested food is eliminated outside the body.

Heterotrophic Nutrition

Heterotrophs are organisms who are unable to produce their own food and therefore must obtain food from an external source.

Examples:

- Bacteria
- Protozoans (amebas)
- Fungi
- Animals



HETEROTROPHIC

Holozoic Nutrition

- The organism feed by ingesting solid organic matter which is then digested and absorbed into their bodies.
- Eg. human, animals and insectivorous plants

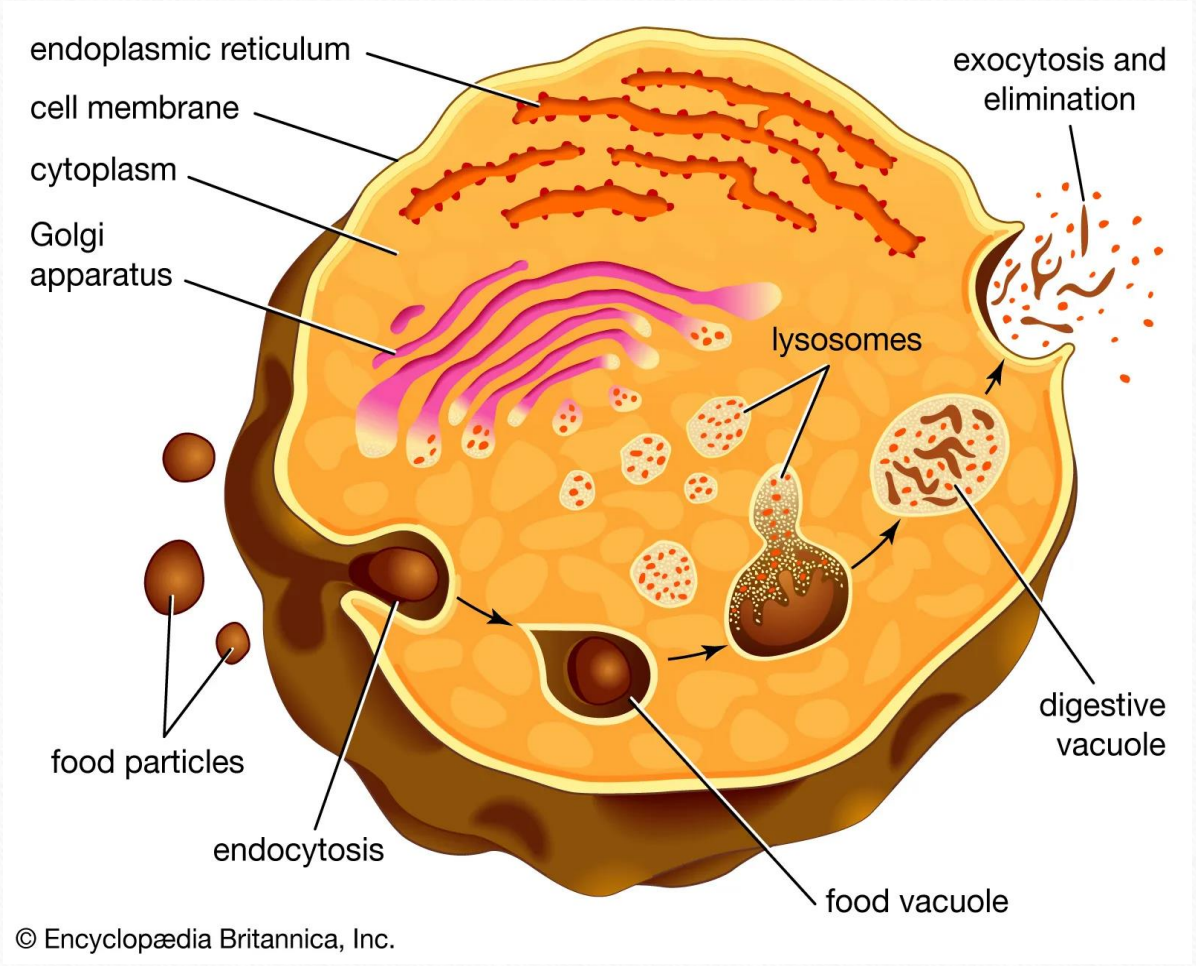
Saprophytism

- Saprophytes.
- Feed on <u>dead and decaying matter</u>.
- Include bacteria and fungi which digest the food externally before the nutrients are absorbed.

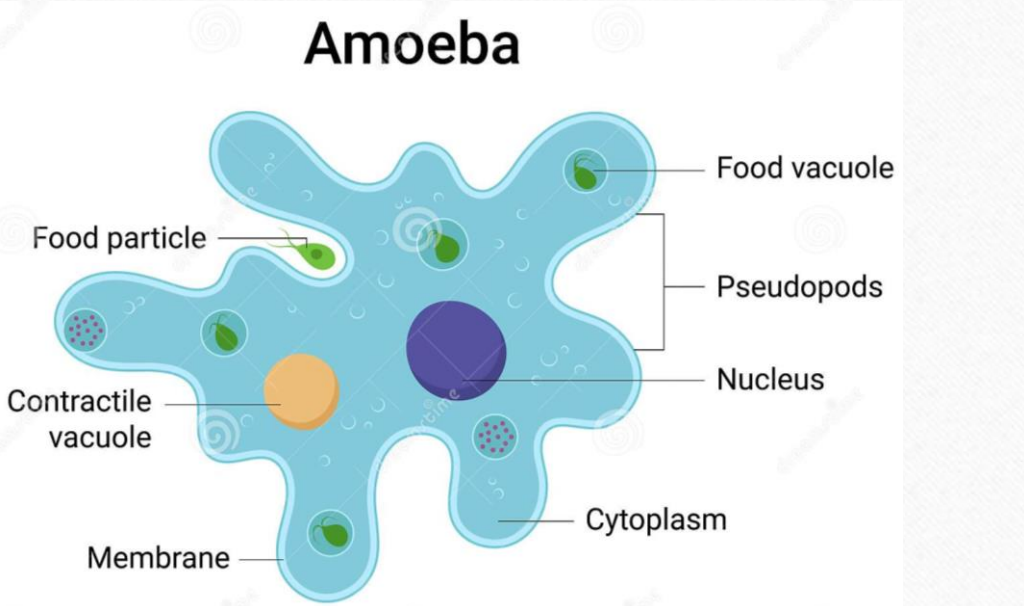
Parasitism

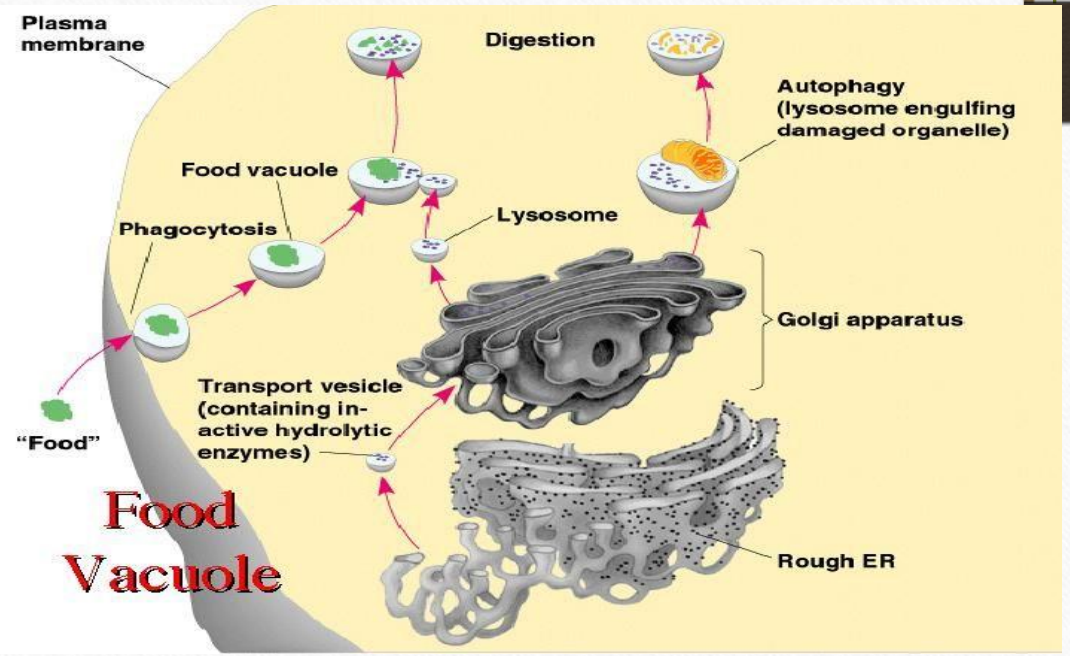
- Obtains nutrients from <u>living organisms</u>
- The parasite obtains nutrients by living on or in the body of the host.
- Eg. fleas, lice and tapeworms

APPARATUS FOR NUTRITION
FOOD VACULOE



Food vacuoles are formed as a result of the fusion of lysosomes and phagosomes. They perform different kinds of functions such as ingestion, storage, and excretion of excess water. It is mainly present in unicellular protozoans which includes plasmodium, amoeba, etc. In biology, a vacuole is termed as a space in a cell that is fully empty of cytoplasm. It is a lined membrane filled with fluid. Vacuoles are usually cytoplasmic organs. In-plant cells large central vacuoles are found. It enables them to attain a large size without accumulating bulk, which makes metabolism difficult.





Structure of Food Vacuole

Food Vacuoles have no specific or basic size or shape. Food Vacuole's structure varies according to the need and requirements of the cells.

In the actively dividing and immature plant cells these vacuoles are quite small. They arise priorly in young dividing cells, generally by progressive fusion of vesicles which are derived from Golgi apparatus.

The vacuole is surrounded by a cell membrane which is called a vacuolar or tonoplast membrane which is filled with the sap of the cell.

Every vacuole is segregated from the cytoplasm with a single unit membrane which is called the Tonoplast. Tonoplast is a cytoplasmic membrane. It separates the vacuolar contents of the cytoplasm from the cells. These vacuoles are functionally and structurally linked to lysosomes in animal cells and they may contain a range of hydrolytic enzymes.

The plant vacuoles' pH may be as high as 10 because of large quantities of alkaline particles and substances or low to 3 because of accumulation of acids.

Types of Vacuole

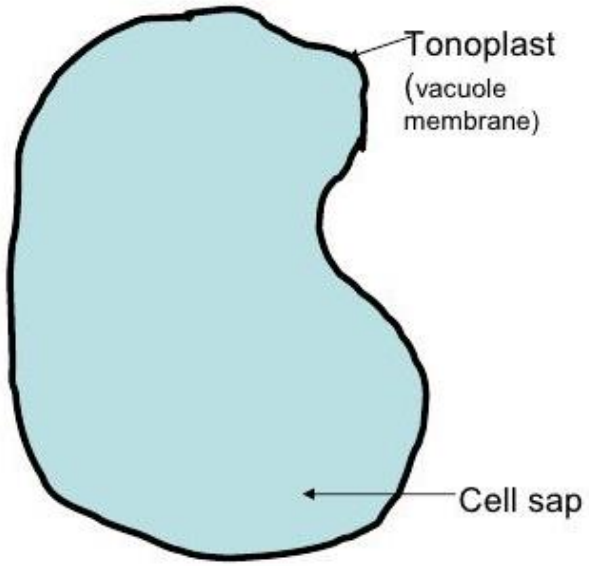
Sap Vacuoles

These are those types of vacuoles that have several transport systems to pass the different substances. Numerous small sap vacuoles are there in animal and young plant cells. In some mature plants, small vacuoles fuse to form a single large central vacuole. It occupies around 90% of the cell. The central vacuole spreads the cytoplasm of a thin peripheral layer. It facilitates rapid exchange and the surrounding environment.

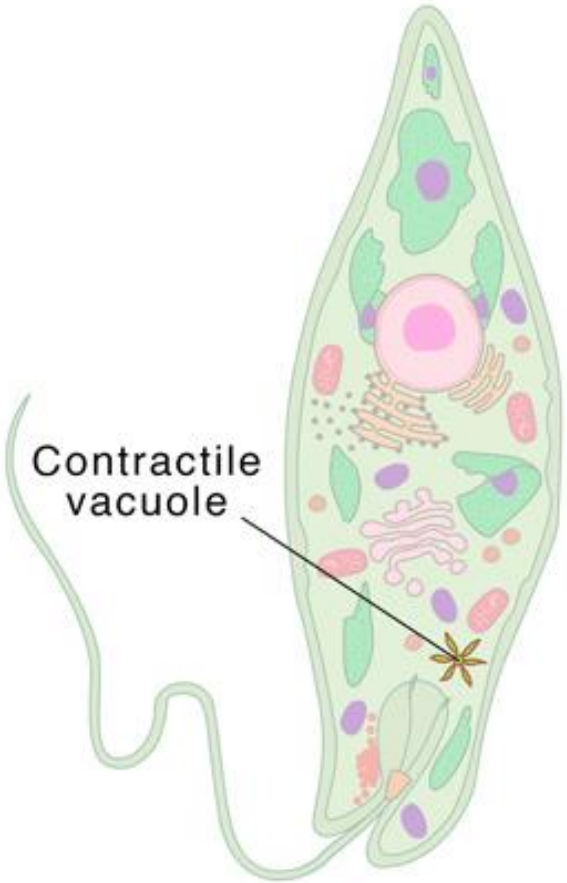
Contractile Vacuoles

These are those kinds of vacuoles that occur in some algae and protist cells which are found mostly in freshwater. These are those types of contractile vacuoles which have a highly collapsible and expandable membrane. These are also connected to a few canals which are for feeding. These canals have water with or without waste products from the cytoplasm surrounding them. It pours the same into the vacuole of the contractile.

Sap Vacuole



- **Large / small**
- **Temporary/ permanent**
- Cell sap contains **starch/ water/ proteins/ sugars/salts/ lipids** (pick 3)
- Stores nutrients **and/or** waste products.
- Water in vacuole presses **outwards/inwards** maintaining turgor



3

Euglena

Food Vacuoles

These kinds of vacuoles are present in protozoan protists cells, in several lower animals, and phagocytes of higher animals. These are formed by the fusion of a lysosome and a phagosome. It has digestive enzymes with which the nutrients are digested. Then these digested materials pass out into the cytoplasm's surroundings.

Air Vacuoles (Gas Vacuoles, Pseudo-Vacuoles)

These kinds of vacuoles are found only in Prokaryotes. This vacuole is not just a single entity, and it is as such surrounded by a common membrane. It has numerous numbers of sub-microscopic vesicles. In this, every vesicle is the one that is surrounded by a membrane of protein and encloses metabolic gases. It does not only store gases but also provides mechanical strength, buoyancy, and protection from harmful radiations.

Functions of Food Vacuole

Food vacuoles contain an enzyme called hydrolyzing enzyme which helps in the digestion of food.

The cell membrane forms a curve to allow the passage of food particles, when the food is captured completely inside the membrane it pushes into the cell.

Food vacuole performs the metabolic function in a way that succulent plants open their stomata and take the carbon dioxide from the atmosphere at night. This will be converted then to malic acid and stored in vacuoles until the next day. In the daytime, light energy can be used to convert it to sugar.

They also perform homeostatic functions in cells of plants that are subjected to wide variations in the environment.

Molecules can be stored in plant vacuoles and act as a storage organelle for both nutrients and waste products.

They also perform functions in fungal cells which include the homeostasis of cell pH and storing of amino acids. In animal cells, they tend to perform by helping in exocytosis and endocytosis.

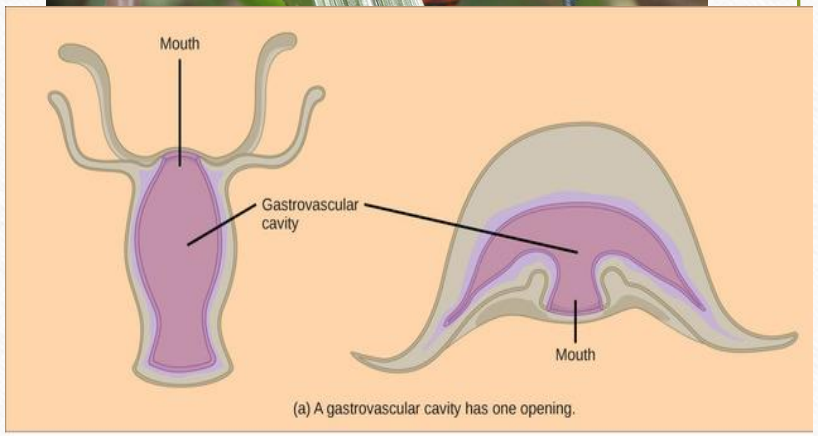
Food vacuoles allow the organs or germinating plants to grow fastly because of the increase in size.

COMPLETE AND INCOMPLETE ALIMENTARY CANAL

Animals have evolved different types of digestive systems to break down the different types of food they consume. Invertebrates can be classified as those that use intracellular digestion and those with extracellular digestion.

Intracellular Digestion

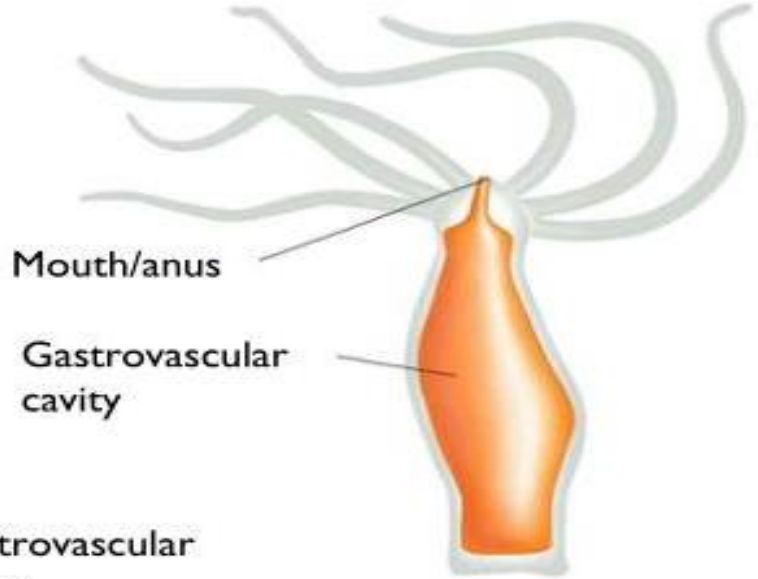
The simplest example of digestion intracellular digestion, which takes place in a gastrovascular cavity with only one opening. Most animals with soft bodies use this type of digestion, including Platyhelminthes (flatworms), Ctenophora (comb jellies), and Cnidaria (coral, jelly fish, and sea anemones). The gastrovascular cavities of these organisms contain one open which serves as both a "mouth" and an "anus".



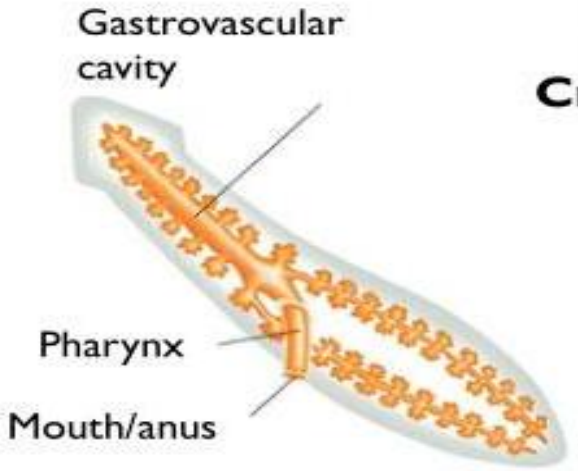
Extracellular Digestion

The alimentary canal is a more advanced digestive system than a gastrovascular cavity and carries out extracellular digestion. Most other invertebrates like segmented worms (earthworms), arthropods (grasshoppers), and arachnids (spiders) have alimentary canals. The alimentary canal is compartmentalized for different digestive functions and consists of one tube with a mouth at one end and an anus at the other.

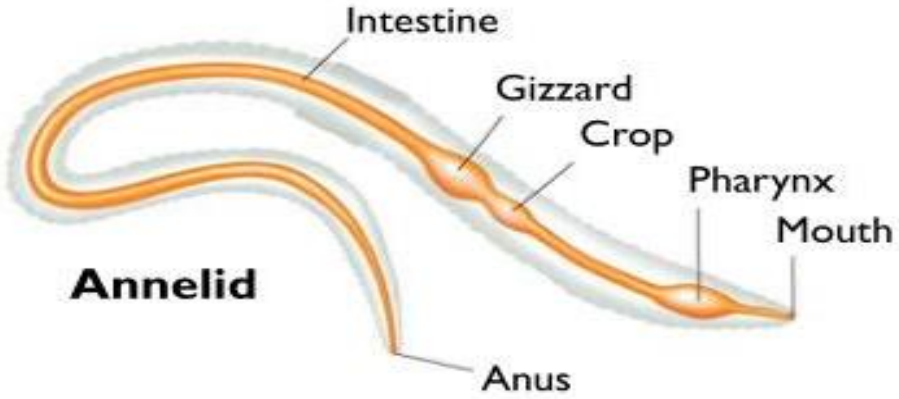
Once the food is ingested through the mouth, it passes through the esophagus and is stored in an organ called the crop; then it passes into the gizzard where it is churned and digested. From the gizzard, the food passes through the intestine and nutrients are absorbed. Because the food has been broken down exterior to the cells, this type of digestion is called extracellular digestion. The material that the organism cannot digest is eliminated as feces, called castings, through the anus. Most invertebrates use some form of extracellular digestion to break down their food. Flatworms and cnidarians, however, can use both types of digestion to break down their food.



Cnidarian

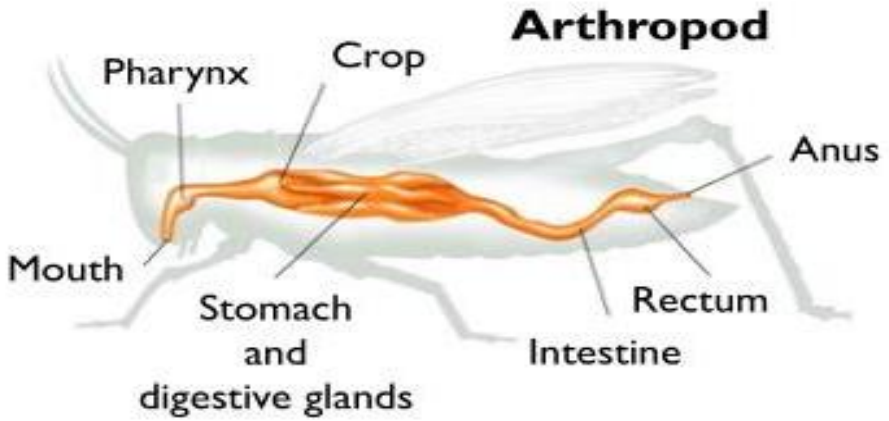


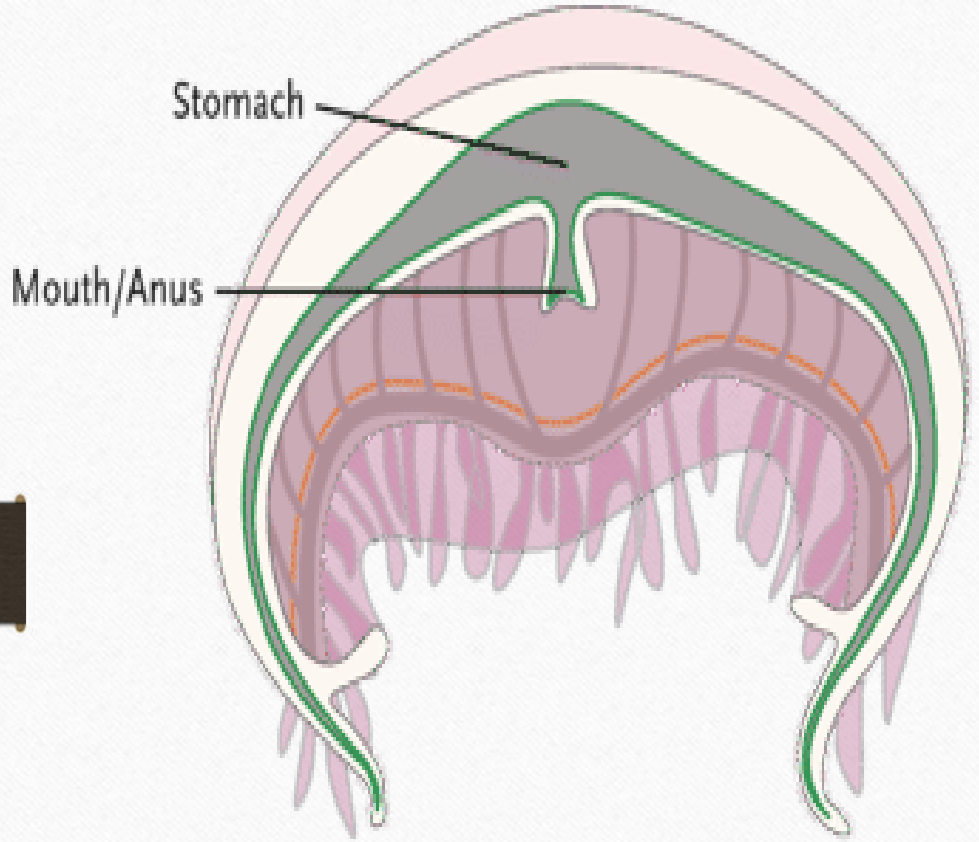
Flatworm



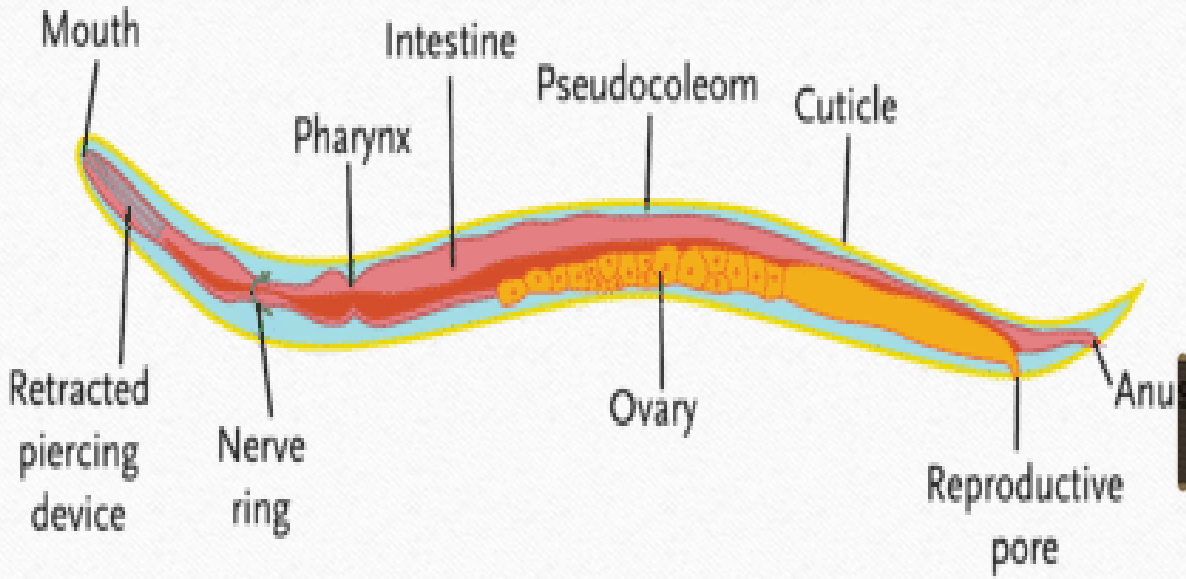
Annelid

Arthropod





Incomplete Digestive System (Jellyfish)



Complete Digestive System (Roundworm)

PHYSIOLOGY OF DIGESTION IN INVERTEBRATES

Digestion by invertebrates is nominally in two phases: extracellular breakdown of food followed by intracellular digestion; protist invertebrates digest foodstuffs by intracellular means. Invertebrate digestion differs from that of vertebrates in that the former lacks digestive glands opening into the hindgut.

Feeding in Invertebrates:

There are various mechanical processes by which invertebrates capture food. The processes are developed in accordance to various kinds of food that a given animal can obtain and utilize.

i. Microphagy:

These are mechanisms for dealing with small food particles. In this process pseudopodia, cilia, tentacles, mucus, setae and muscles are used for obtaining food.

ii. Macrophagy:

These are mechanisms for dealing with large food particles or masses. This involves swallowing of inactive food, scraping, boring, and seizing the prey.

iii. Fluid or Soft Tissue Feeding:

These type of feeders generally suck fluid food. Some pierce and then suck the body fluid of the prey and some simply absorb the liquid food from the substrate through body surface.

Digestive processes, particularly in macrophagous animals, are both mechanical and chemical

i. Mechanical Digestion:

This is achieved with the help of the different components of the mouth parts and different specialised parts of the digestive tracts. In this process large mass of the prey are crushed into smaller parts mechanically.

ii. Chemical Digestion:

In this process smaller masses of prey are broken into simpler organic compounds with the help of different hydrolytic enzymes. The site of enzymatic action varies within the animal body.

According to the site of enzymatic action, chemical digestion is of two types:

(a) Intracellular Digestion:

Here digestion takes place within the cell. The protoplasm of the unicellular animal captures the food, encircles it in a food vacuole, digests it, discharges the wastes and incorporates the digested simple organic components into the protoplasm.

(b) Extracellular Digestion:

Here digestion takes place outside the cell and generally within the digestive tract of the higher animals. Digestion is wholly intracellular in Protozoa and Porifera. In other phyla extracellular digestion either supplements the intracellular mechanisms or completely replaces it. In the following discussion we shall describe the process of feeding and digestion in some invertebrates.

Example: Amoeba

Microphagy in Amoeba:

Amoeba is a member of Phylum-Sarcodina of Sub-kingdom-Protozoa. They are unicellular organisms and are present in marine, fresh water and terresterial habitats. They are entirely heterotrophic. Their food consists of all types of small organisms like bacteria, algae, diatoms, protozoans, and even small multicellular animals, such as rotifers, copepod larvae and nematodes.

Process of Feeding:

Amoeba as a non- ciliate and non-flagellate organism is wholly dependent on its membrane for food intake. The cell membrane acts according to the quality of the food to be consumed.

Permeation

The semi-permeable cell membrane receives the small organic molecules, salts, ions and other molecules in two ways.

Passive Diffusion

In this process the soluble materials like sugars, amino acids etc. diffuse to the concentration gradient and move into the less concentrated protoplasm from the highly concentrated surrounding.

Active Transport:

The protein channels of the cell membrane function as energy-requiring pumps, actively transporting certain molecules or moving ions in or out against their concentration gradient.

Endocytosis:

In this process extracellular materials enter the cell with the invagination of the cell membrane. The invaginated portion ultimately pinches off internally to form food vesicles. There are two basic types of endocytosis — specific and non-specific.

Specific Endocytosis or Receptor Mediated Endocytosis

This process brings in proteins and other macromolecules at a faster rate than predicted by concentration gradient. These substances bind to the specific membrane receptors before they are taken into the vesicles

Non-specific Endocytosis

Any types of dissolved or floating organic materials are taken in by this process. According to the nature of food this process is divided into two types – pinocytosis and phagocytosis.

Pinocytosis in Invertebrates:

Water, ions and small molecules of sugar and protein are absorbed by this process. In this process the cell membrane invaginates into the cytoplasm. The dissolved food with water enters into the invaginated portions. The rate of uptake is in simple proportion to the external concentration of the material being absorbed. The invaginated pit is then pinched off

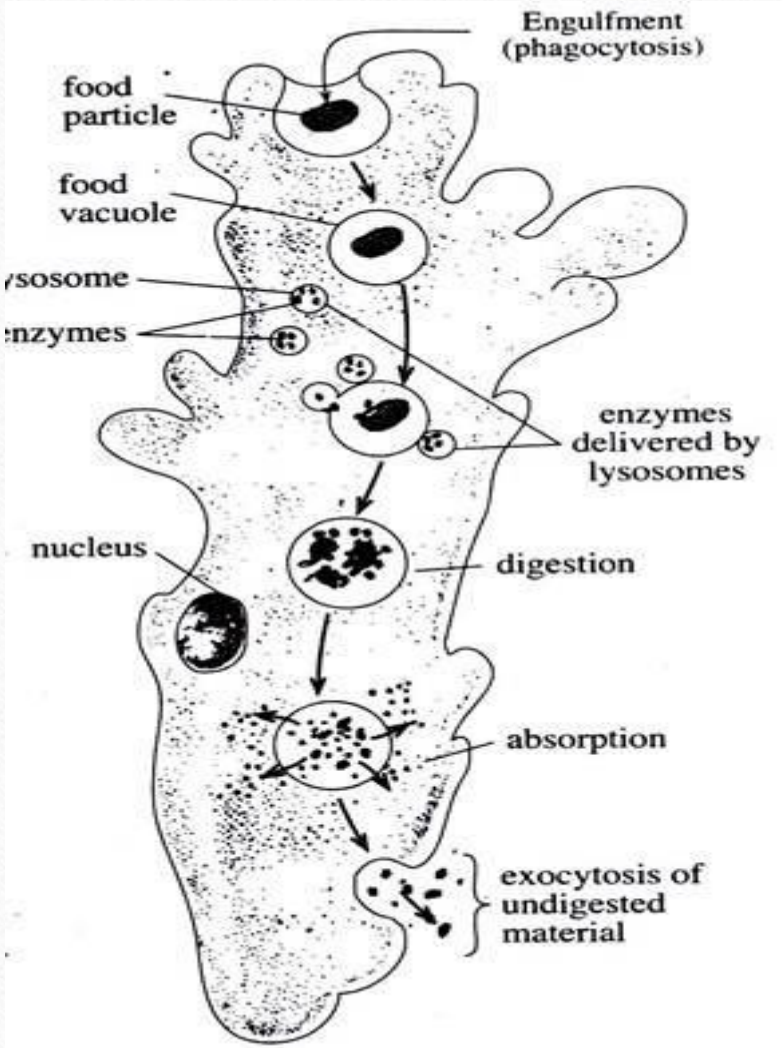
Phagocytosis in Invertebrates

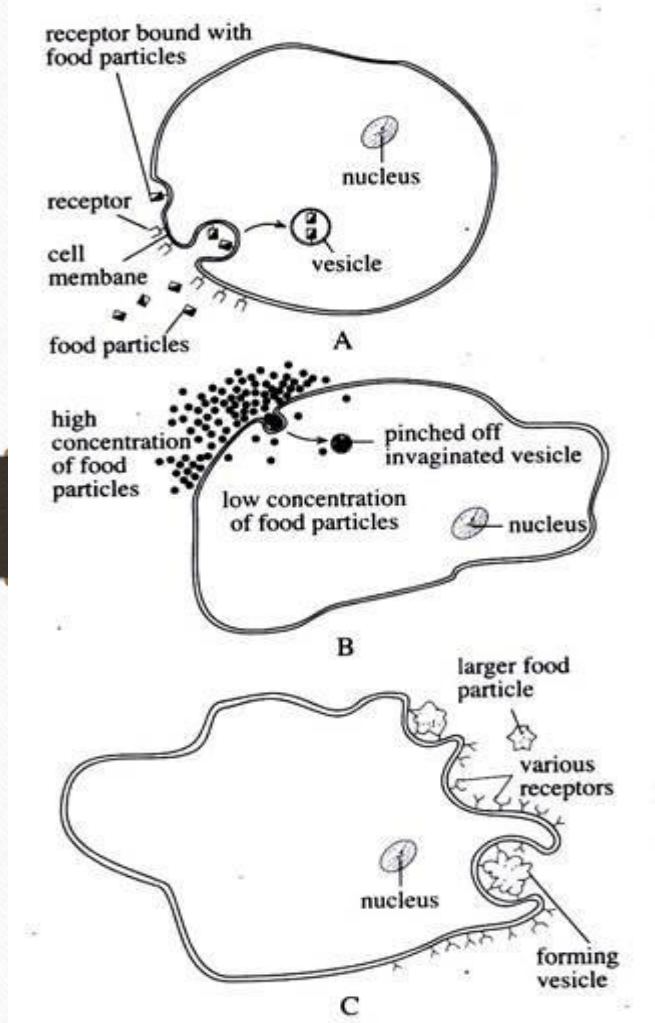
This is the process of engulfment of large particles, such as bacteria, protozoans etc. In this process multiple membrane receptors work synchronously to capture a large mass of food. Dynamic alteration of the cell membrane and cytoplasmic elements help to seize the prey

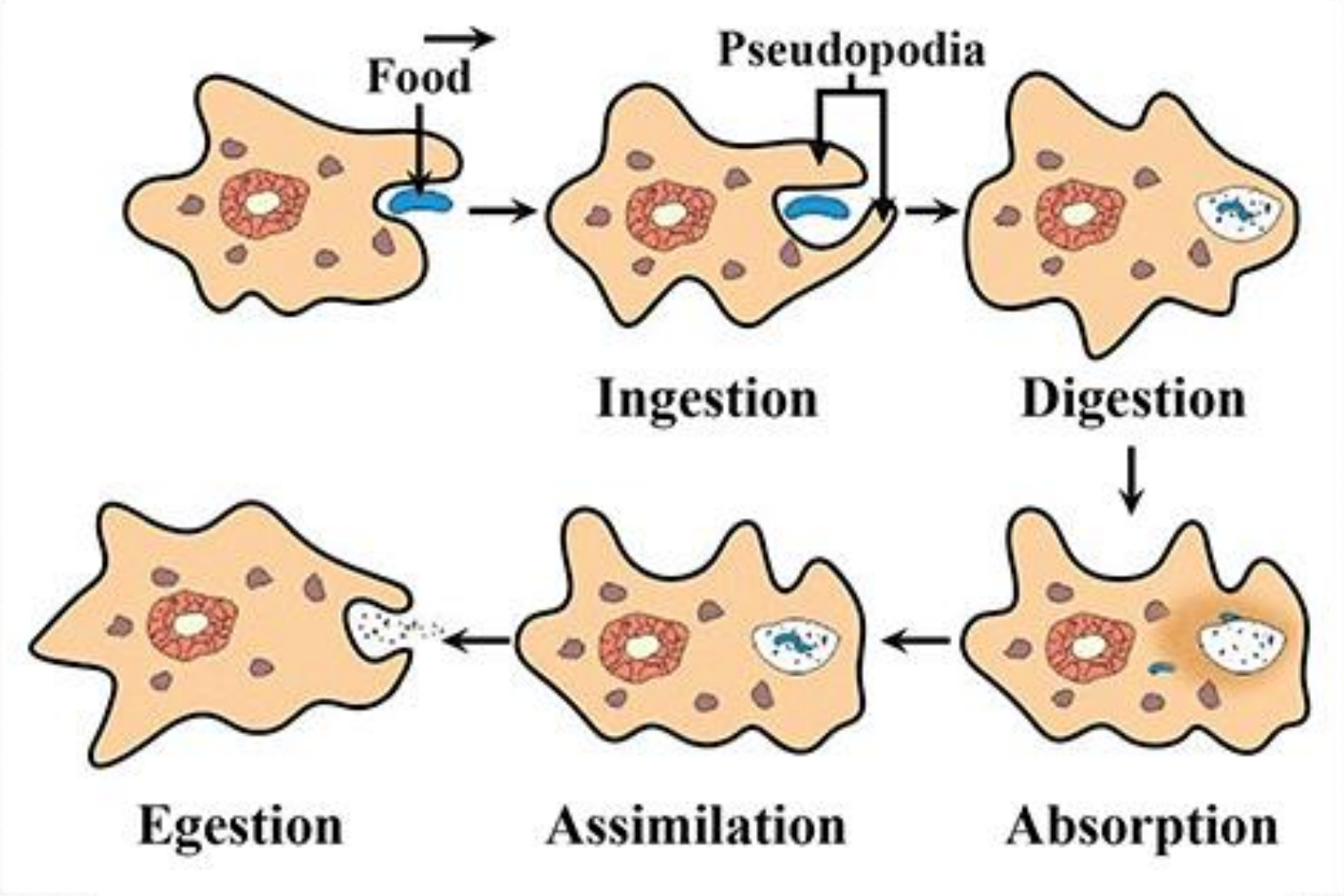
Process of Digestion in Invertebrates

In Amoeba, ingested food occupies a vesicle, called food vacuole, in the protoplasm. The food vacuole initially contains both food and fluid. At the beginning, food vacuoles decrease in size due to diffusion of fluid outwards into the cytoplasm. At this stage, the acidity of the vacuole is nearly at a pH of 5.6. This acidity helps in the death of prey.

After that, the pH of the vacuole increases to about 7.3. This is due to the inflow of fluids from the lysosomes. Lysosomes come in contact with the food vacuole, fuse with it and release its contents within the food vacuole. The lysosomal fluid contains hydrolytic enzymes. These enzymes perform the digestion of the killed prey until there remains only a small residue of un-digestible material. The products of digestion diffuses from the vacuole into the cytoplasm of the cell where they may be used in metabolism by other organelles or stored after undergoing synthesis, into other forms, such as glycogen and lipid. The undigested material is discarded from the body by exocytosis.




receptor bound with food particles
nucleus
receptor
cell membane
vesicle
food particles
A
high concentration of food particles
pinched off invaginated vesicle
low concentration of food particles
nucleus
B
larger food particle
various receptors
nucleus
forming vesicle
C


Food
Pseudopodia
Ingestion
Digestion
Absorption
Assimilation
Egestion

Earthworm

Grasshopper