Structure and Function of Invertebrates

(22ZOOC11)

Introduction to Invertebrates and Its Organisation

Objectives:

Invertebrata

1. Principles and types of Taxonomy and Nomenclature of species.
2. Animal organization – Protozoa and Metazoa – Representative species.
3. Coelomate and acoelomate organization – examples.

Phylum : Protozoa

Phylum : Porifera

Phylum : Coelenterata / Cnidaria

Phylum : Platyhelminthes

Phylum : Nematoda

Phylum : Annelida

Phylum : Arthropoda

Phylum : Mollusca

Phylum : Echinodermata

Overview

1. Salient features
(General Characters) - Examples

2.Classification
(Evolutionary significance)

3. Physiology of non-chordates and Life cycle

4. Affinities and adaptations

Units

Unit I: Basic concepts – Systematics and Organization

Acellular Organization

Unit II: Cellular Organization

Unit III: Acoelomate and Pseudocoelomate Organization

Unit IV and V: Eucoelomate/ Coelomate Organization

Unit VI: Self Study

Unit I

TAXONOMY:

- Principles of modern taxonomy
- Linnaeus system of classification
- ICN – Bi, Tri nomenclature

ORGANIZATION:

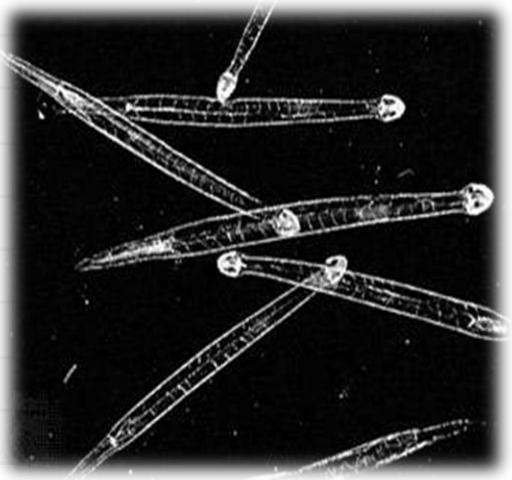
1. SYMMETRY – Types and significance
   - **Asymmetry, radial, biradial and bilateral.**

2. Origin, evolution and types of Coelom
   - **Acoelomate, pseudocoelomate and eucoelomates**

MINOR PHYLA:

Organization and affinities:

Chaetognatha



Sipunculida

Rotifera

Unit I

ACELLULAR ORGANIZATION
(PROTOPLASMIC GRADE OF ORGANIZATION)

SUBKINGDOM I : PROTOZOA (Unicellular)

PHYLUM : PROTOZOA

- General characters of phylum protozoa.
- Classification of protozoa upto orders.

1. **General morphology** – External structure.

2. **Physiology:**
   a. Nutrition and feeding.
   b. Excretion.
   c. Respiration.
   d. reproduction.

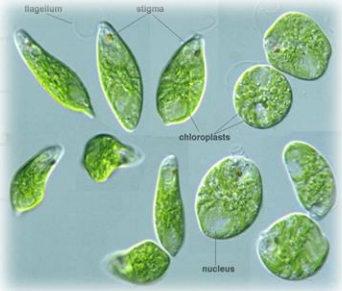
3. **Locomotion**.

4. **Life cycle**.

Example:

1. ***Amoeba proteus***
2. ***Euglena viridis***
3. ***Plasmodium vivax***
4. ***Paramecium caudatum***

Amoeba proteus



Euglena viridis

Unit III

CELLULAR ORGANIZATION

SUBKINGDOM II : METAZOA (Multicellular)

They have three branches as

1. Mesozoa
2. Parazoa
3. Eumetazoa

- General characters, complexities.

PHYLUM : PORIFERA (pore bearers)

- General characters of phylum porifera.
- Classification of porifera upto orders.
- **Regeneration** in porifera.

1. **Parazoa :** Example : **Scypha (Sponges)**

   a. General characters.

   b. Life cycle.

   c. **Canal system**.

   d. Feeding and digestion.

   e. Excretion.

   f. Respiration.

   g. Reproduction- **gemmules**.

   h. Skeletal system – **Spicules.**

Scypha (Sponges)

PHYLUM : COELENTERATA (CNIDARIA)

- General characters of phylum coelenterata.
- Classification of coelenterata upto orders.
- **Polymorphism** in hydrozoa.
- **Coral and coral reefs**.

CLASS : Hydrozoa

CLASS : Scyphozoa

Example :

CLASS : Hydrozoa

1. **Obelia (Sea fur)** - ***Obelia geniculata***
2. **Hydra** - ***Hydra vulgaris***

Obelia geniculata

CLASS : Scyphozoa

3. **Aurelia (Jelly fish) – *Aurelia aurita***

Morphology:

a. General characters.

Physiology:

a. Nutrition and feeding.

b. Excretion.

c. Respiration.

d. reproduction and Life cycle.

Hydra vulgaris

Unit IV

ACOELOMATE ORGANIZATION

PHYLUM : PLATYHELMINTHES (FLATWORMS)

- General characters of phylum platyhelminthes.
- Classification of platyhelminthes upto orders.
- Parasitic adaptations.

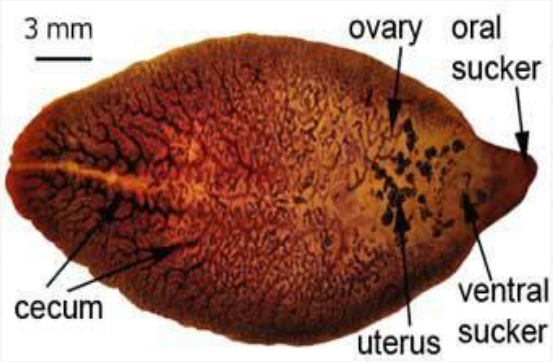
Example :

CLASS : Trematoda

1. ***Fasciola hepatica***

(Sheep liver fluke)

Fasciola hepatica



CLASS : Cestoda

2. ***Taenia solium*** **(Pork tapeworm)**

Taenia solium

SUPERPHYLUM : Aschelminthes

PHYLUM: NEMATODA

(Common Roundworms)

Example :

CLASS : Phasmidia

1. ***Ascaris lumbricoides***

Ascaris lumbricoides

Unit V

EUCOELOMATA ORGANIZATION (COELOMATES)

PHYLUM : ANNELIDA

- General characters
- Classification (upto orders)
- Outline study
- Life cycle and adaptations with ecological significance

Example:

CLASS : Polychaeta

1. ***Neanthes* (*Nereis*) *virens***

(Clamworm)

CLASS : Hirudinea

2. ***Hirudinaria granulosa***

(Indian Cattle Leech)

Neanthes* (*Nereis*) *virens

Hirudinaria granulosa

PHYLUM : ARTHROPODA

- General characters and Classification (upto orders).

CLASS : Crustacea
CLASS : Insecta

- General study and life cycle.
- Crustacean larvae.
- Beneficial and harmful insects.

➢ Connecting link between Annelida and Arthropoda.

Example:

CLASS : Crustacea

1. ***Palaemon* (or) *Macrobrachium malcomsonii***

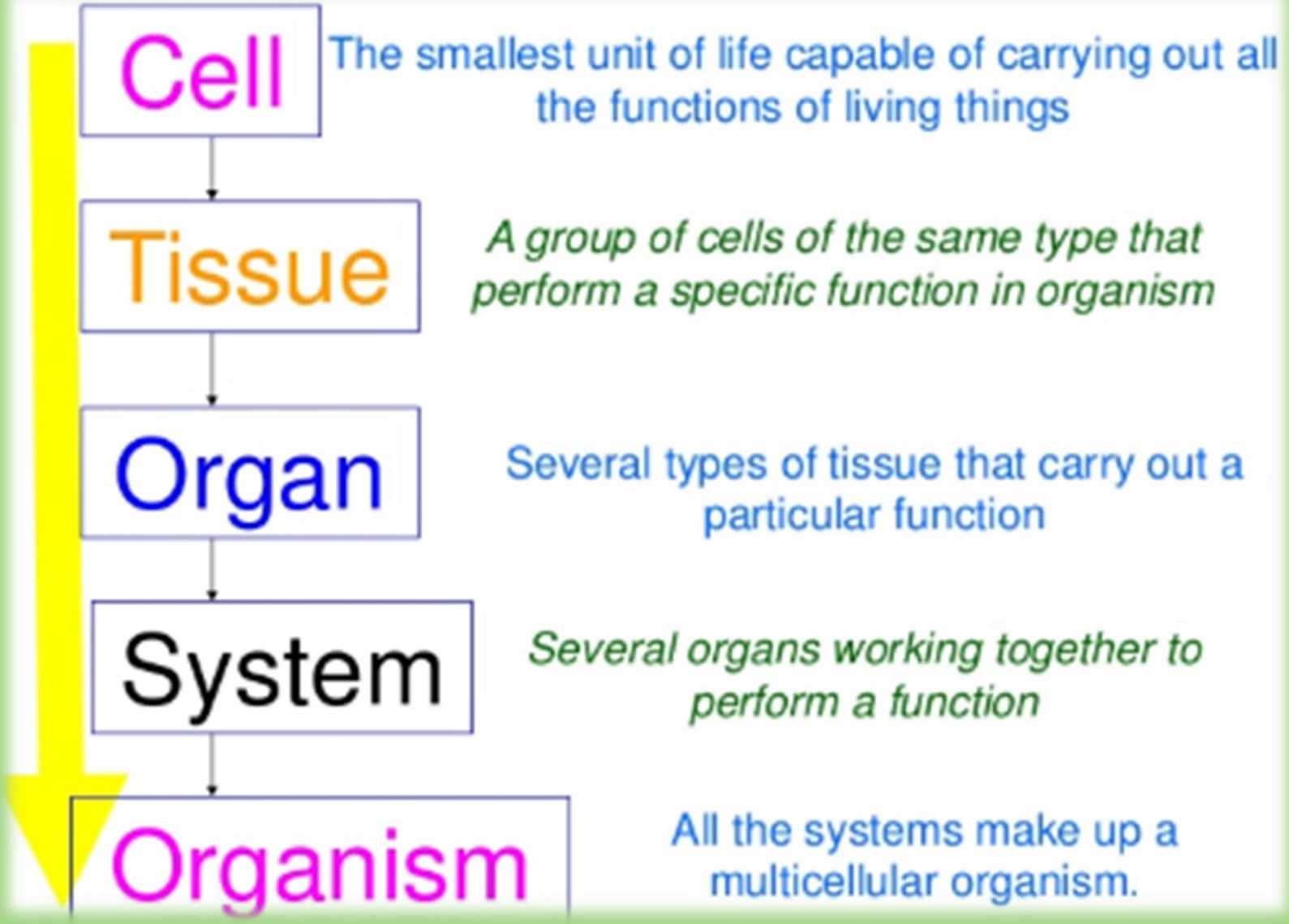
(Indian freshwater prawn)

Macrobrachium malcomsonii

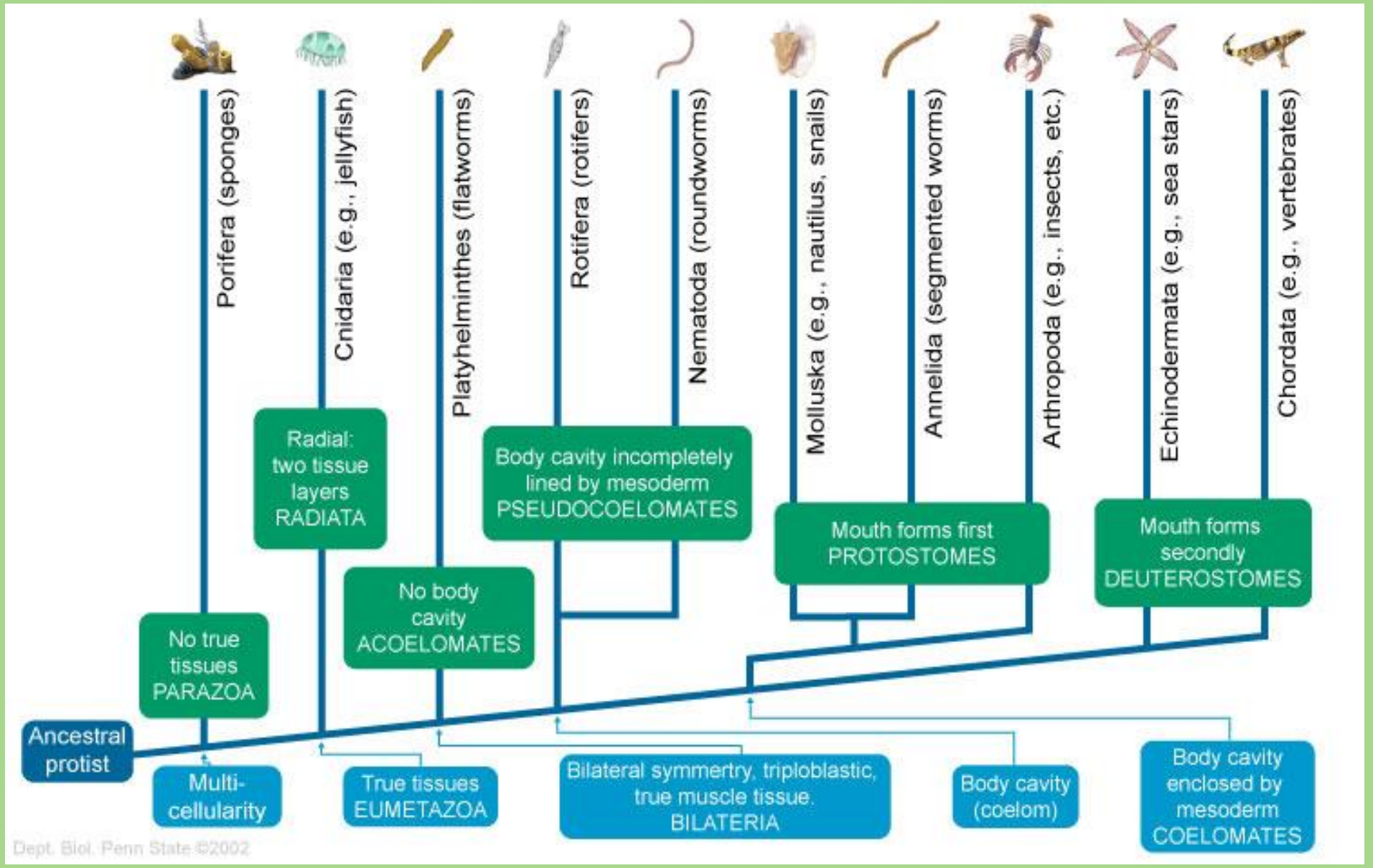
CLASS : Insecta

1. **Grasshopper / Locust**

Grasshopper / Locust


Cell
The smallest unit of life capable of carrying out all the functions of living things
Tissue
A group of cells of the same type that perform a specific function in organism
Organ
Several types of tissue that carry out a particular function
System
Several organs working together to perform a function
Organism
All the systems make up a multicellular organism.

Parazoa vz Eumetazoa



- **The first phylogenetic tree of Kingdom Animalia separates organisms that do not have true tissues from those with true tissues.**

  Parazoans lack true tissues, whereas **eumetazoans** have true tissues.

  Eumetazoans -- collections of cells that are arranged for specific purposes.

Presence of true tissues is the first bifurcation in the animal phylogeny.

- **Animal phylogenetic tree separates the eumetazoans with radial symmetry (the radiata) with bilateral symmetry (the bilateria).**

  In organisms that possess radial symmetry, multiple mirror image planes can be drawn across the organism's center. Eg: Asterias

  In organisms that possess bilateral symmetry, only one mirror plane can be drawn along a single axis. Eg: Humans

- **Another characteristic of the radiata are diploblastic.**

Diploblastic organisms only have two embryonic tissue layers: **endoderm** and **ectoderm**.

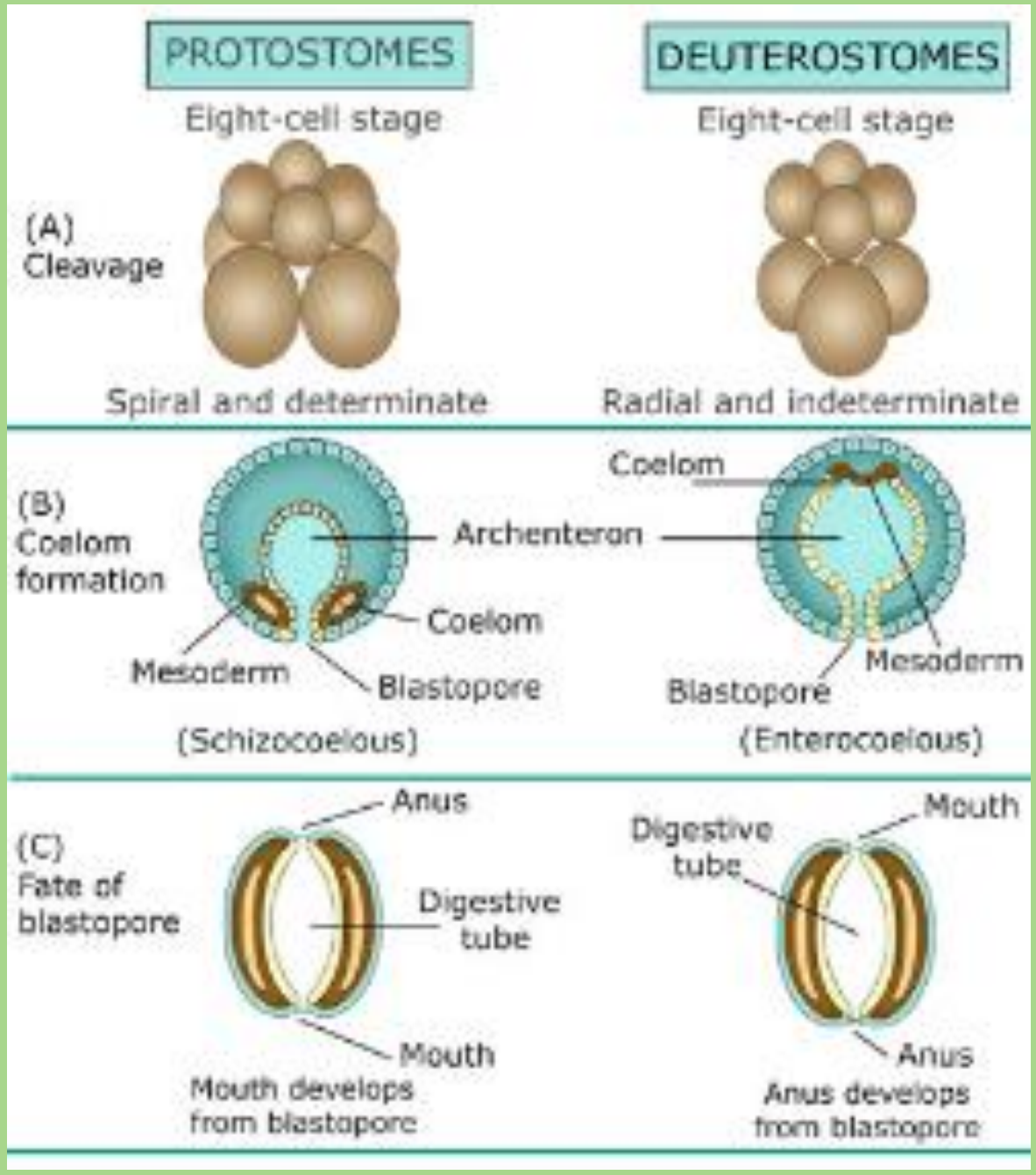
The endoderm - lining of the digestive tract (liver and lungs).

The ectoderm - animal's outer covering and central nervous system.

- **The bilateria are triploblastic** with three distinct tissue layers: Endoderm, Mesoderm and Ectoderm.

- An **adult morphology differ significantly from the larval morphology** of the same animal.

Eg: The radiata tend to be sessile as adults, whereas the bilateria are motile.


PROTOSTOMES
DEUTEROSTOMES
Eight-cell stage
Eight-cell stage
(A)
Cleavage
Spiral and determinate
Radial and indeterminate
(B)
Coelom
formation
Archenteron
Coelom
Mesoderm
Blastopore
(Schizocoelous)
Coelom
Mesoderm
Blastopore
(Enterocoelous)
(C)
Fate of
blastopore
Anus
Digestive
tube
Mouth
Mouth develops
from blastopore
Digestive
tube
Mouth
Anus
Anus develops
from blastopore

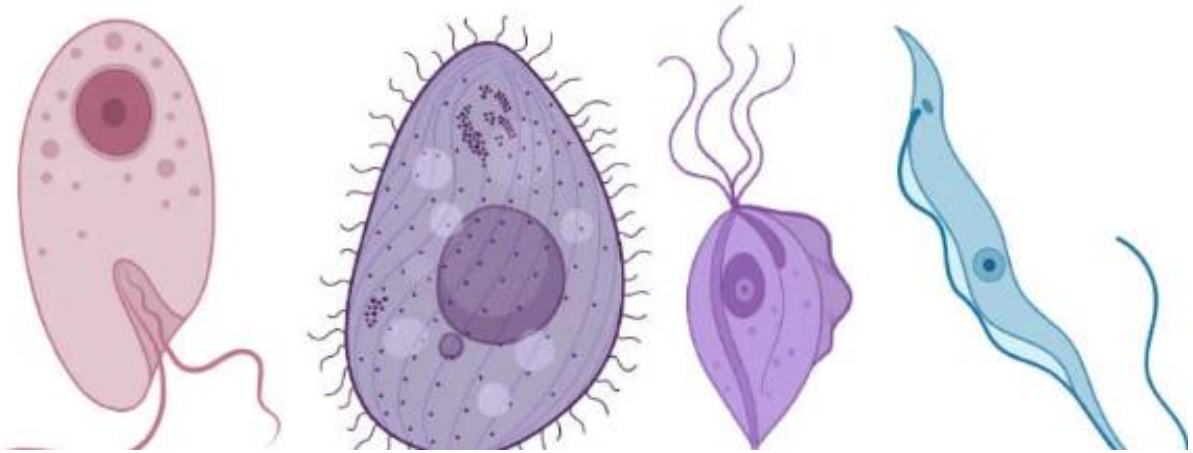
- **The phylogenetic tree of Kingdom Animalia distinguishes animals with a true coelom (body cavity) based on the fundamental aspects of their development – Protostome and deuterostome:**
- The **origin of the openings to their digestive tract**.
  - ✓ In protostomes the mouth develops first,
  - ✓ In deuterostomes the anus develops first.

  Greek : "Stoma" is for "mouth," and

  "protos" are "first" and "deuteros" - "second"
- **Protostome -- coelomates (mollusks, annelids and arthropods),**
- **Deuterostome -- coelomates (echinoderms and chordates).**

Structure and Function of Vertebrates (22ZOO11)

Locomotory Organelles in Protozoa



LOCOMOTORY ORGANELLES IN PROTOZOA

- In protozoans, different modes of locomotion are reported due to presence of different types of locomotory organelles.
- It includes pseudopodia, cilia, flagella and pellicular contractile structure
- Pseudopodia are extruded from body protoplasm of naked protozoa.
- These protozoans do not possess a definite pellicle. Pseudopodia are mainly formed from the ectoplasm although the endoplasm may flow later on.
- According to shape, size, structure and activity, pseudopodia are of following types.

i. Lobopodia: These are broad, lobe like and sometimes branched pseudopodia with rounded tips.

- These pseudopodia consist of both the ectoplasm and the endoplasm.
- Several lobopodia may be given out from the body surface in different directions or single lobopodium may also be given out from body surface. Lobopodia is characteristics of *Amoeba*.

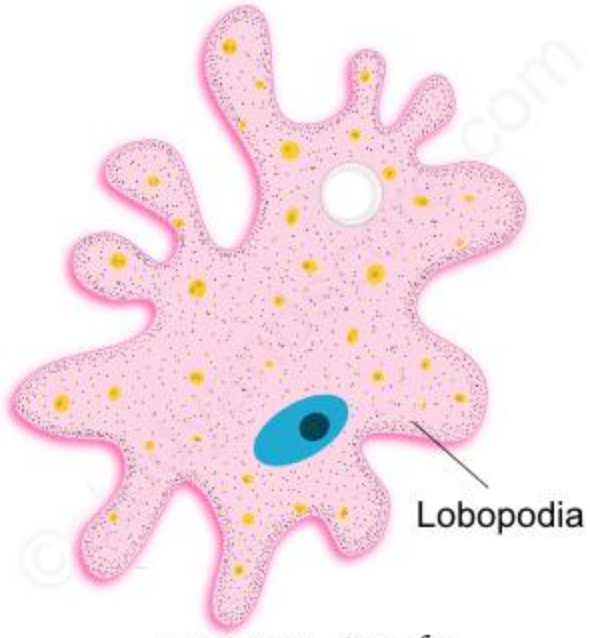
ii. Filopodia: These are thread like hyaline projections with pointed tips and radiate from body in all directions.

- These pseudopodia consist of only ectoplasm. Filopodia is characteristic of ***Euglypha***.

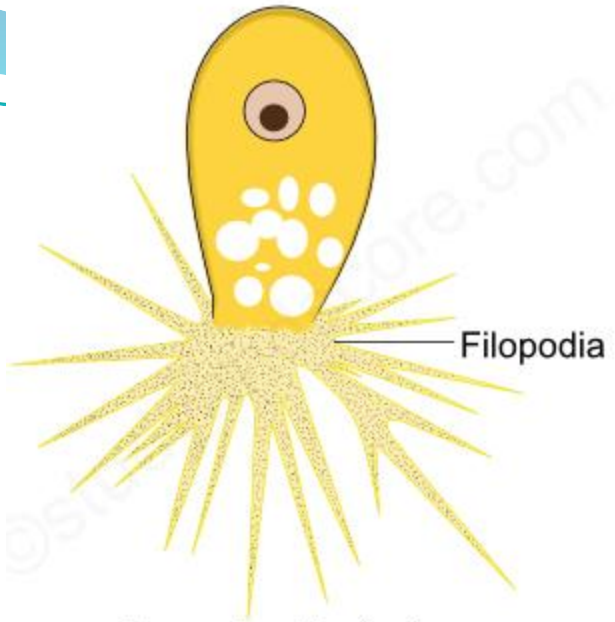
- **iii. Reticulopodia:** These are branched pseudopodia and branches anastomose, often produces large, complex networks which mainly help in food capturing.
- It is characteristic of for aminiferans like *Elphiduim*, *Globigerina* and *Chlamydophyrsetc*.

iv. Axopodia: These are spine like pseudopodia which radiate from the surface of rounded body.

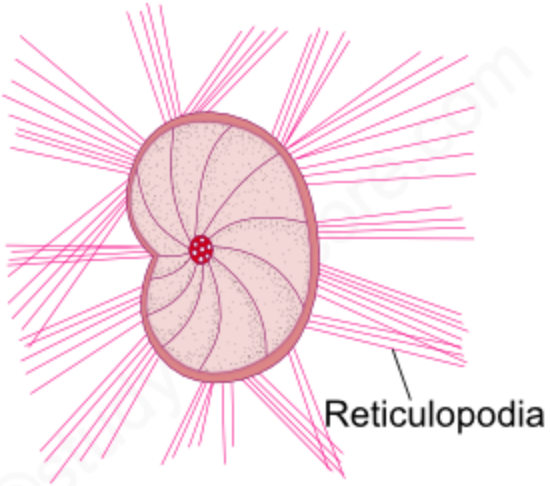
- It is composed of an outer cytoplasmic sheath covering an axial rod



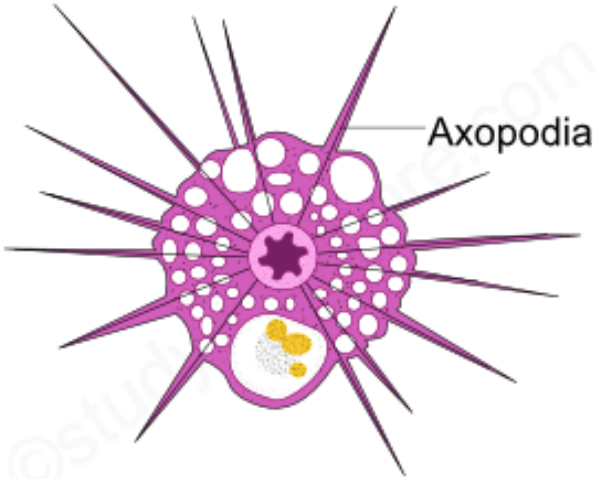
Example: *Amoeba*



Example: *Euglypha*



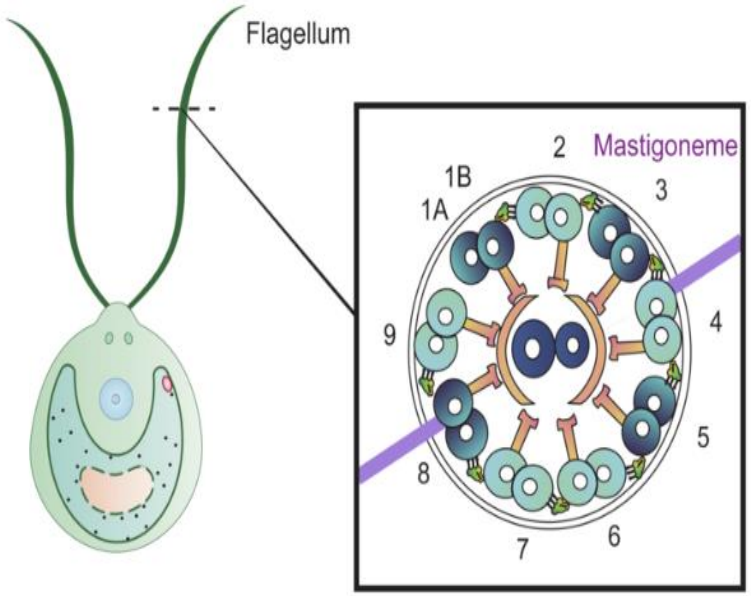
Example: *Elphidium*



Example: *Actinophrys*

FLAGELLA

- These are fine, delicate and thread like extensions of the protoplasm. It consists of axial filament or axoneme surrounded by a protoplasmic sheath.
- The axoneme consists of two longitudinal fibrils and protoplasmic sheath consists of nine doublets of longitudinal fibrils.
- These fibrils lie in a matrix of dense cytoplasm.
- The outer sheath may have laterally frayed out fibrils.
- These fibrils are known as mastigonemes.
- On the basis of the arrangement of mastigonemes, flagella are of following types.



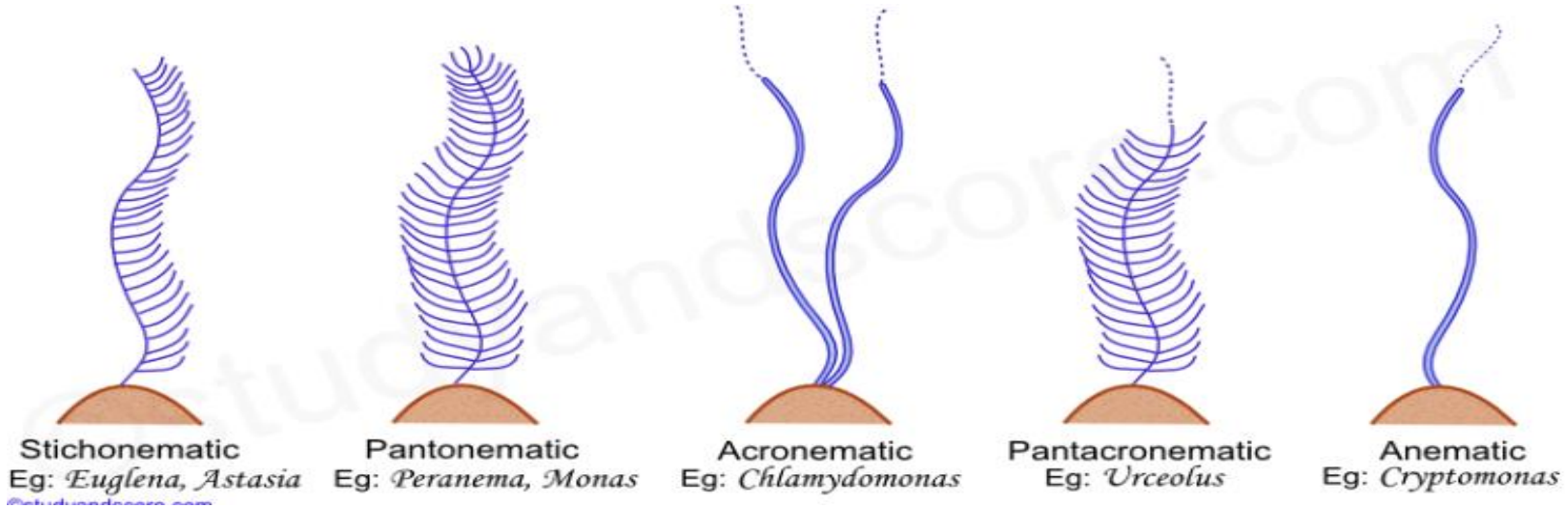
(i). Stichonematic flagella bear only single row of lateral mastigonemes.eg. Flagellum of *Euglena, Astacea.*

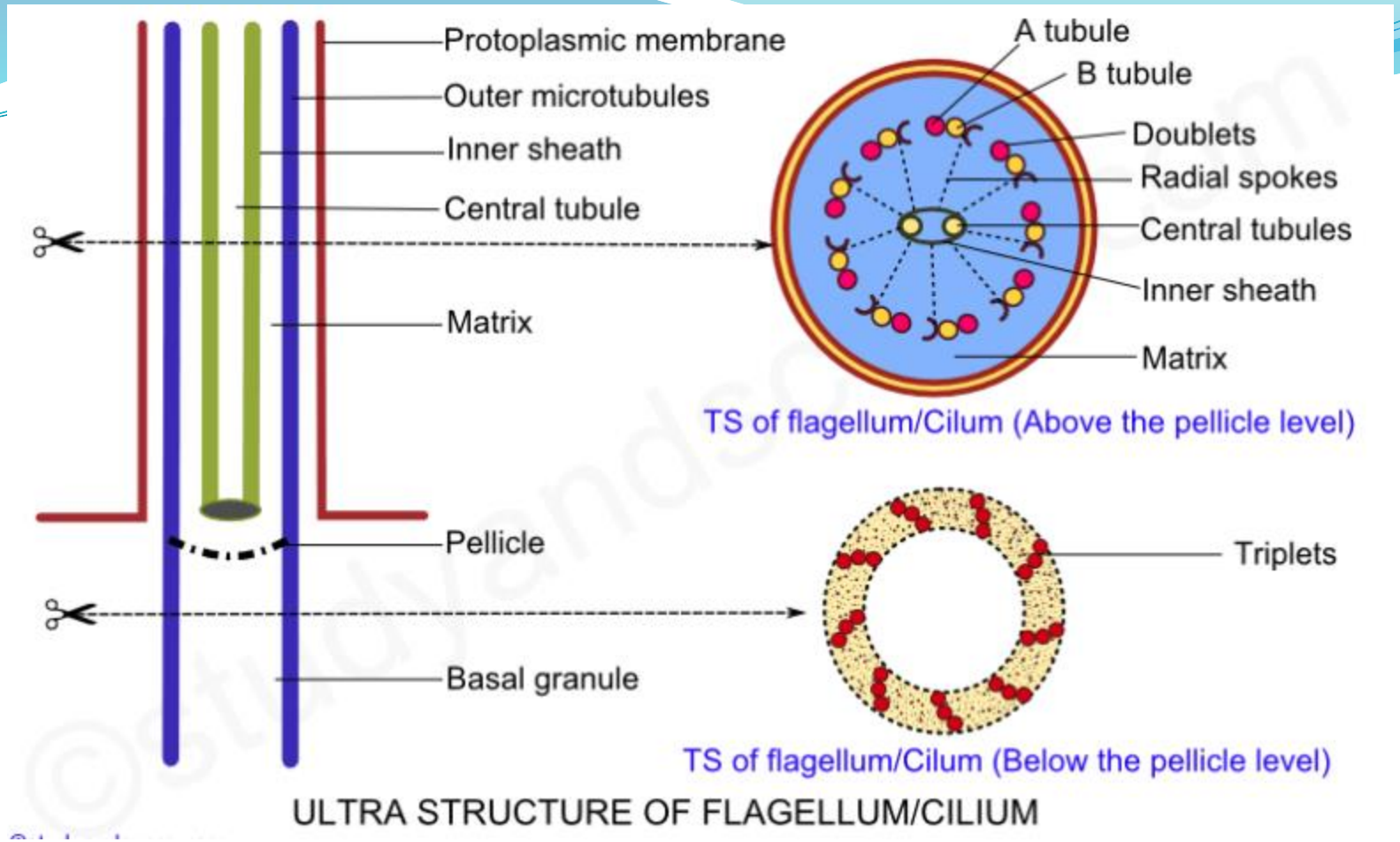
(ii). Panotonematic flagella bear two or more rows of lateral mastigonemes. eg. Flagellum of *Perenema*.

(iii). Acronematic flagella bear a single terminal filament at distal end of the flagellum.eg. Flagellum of *Chlamydomonas*.

(iv). Pentachronematic flagella bear a single terminal filament at distal end of the flagellum and two rows of mastigonemes on the lateral side.eg. Flagellum of *Urcoelus, Monas* and *Polytoma*.

(v). Simple flagella bear neither terminal filament nor mastigonemes. eg. Flagellum of *Trypanosoma*.





a. Number and arrangement of Flagella

The number of flagella varies from species to species. Mostly one or two flagella are present but parasitic forms may have greater number of flagella. Often one of them is the main flagellum and rests are accessory flagella. Mostly flagella originate from anterior end of body but in some cases, it originates from posterior end of body (*Trypanosoma*).

- **Cilia** are slender, fine and more or less short hair like processes of the ectoplasm.
- Cilia resemble in structure with flagella but also differ from flagella in the following respects.

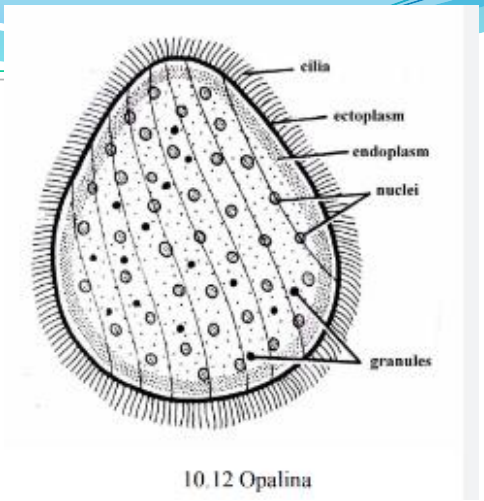
  1. They are relatively much shorter when compared to the size of the body.

  2. They are more in number and cover the entire body.

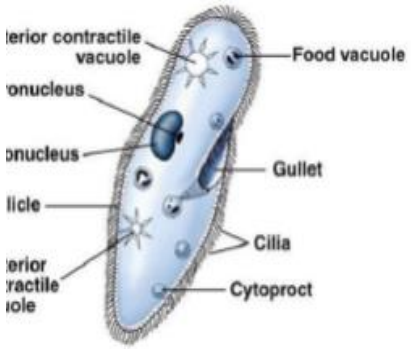
  3.The cilia move in different way from those of the flagella.
- Cilia consist of an axial filament or axoneme surrounded by an elastic sheath continuous with the plasma membrane of the cell surface.
- The axoneme consists of nine doublets of peripheral microfibres and two central fibres.
- The central fibres are enclosed within a delicate inner sheath.
- All fibres are present in a fluid matrix.

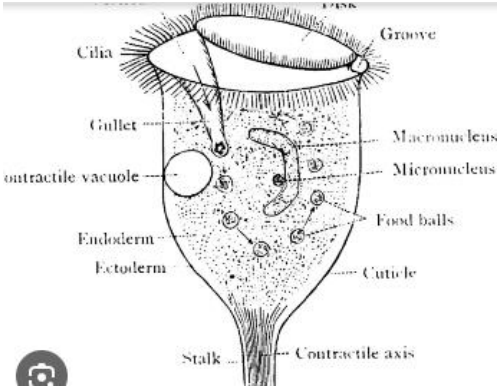
Ciliary arrangement

- The manner of arrangement of cilia is rather constant within a species.
- The cilia may be uniformely distributed all over the body as in *Opalina* and *Paramecium* or may be restricted to certain parts of the body as in *Vorticella*.
- The cilia may be of uniform length as in *Opalina* or may be longer on the extremities of the body as in *Paramecium*.
- In many species, the cilia become fused variously to form composite motile organelle.
- These composite motile organelles are as follows.



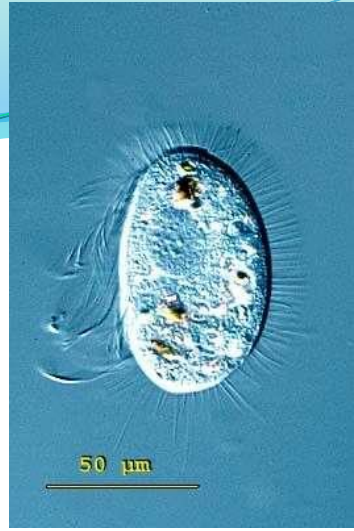
10.12 Opalina





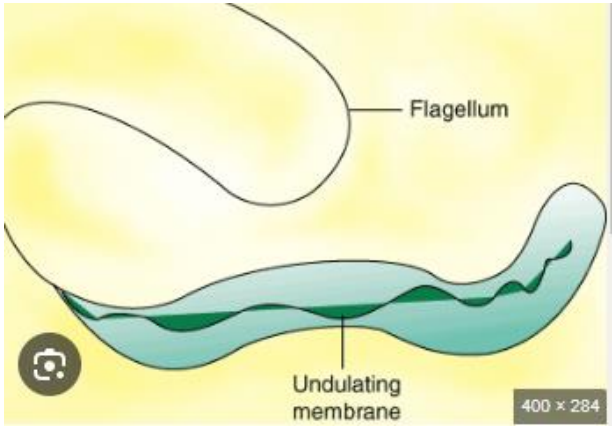
(i) Undulating membranes:

- These are thin, transparent sheet like flaps and made up of one to several longitudinal rows of cilia fused together sidewise.
- These are found in the buccal cavity and are used for food collection.
- In *Pleuronema,* the undulating membrane can be protruded to serve as scoop for food capture.
- These are found in *Holotrichan* and *Heterotrichan*.



(ii) Membranelles:

- The membranelles are paddle like structure and arranged in spiral rows in the peristomial area.
- These are formed by the fusion of two or more transverse rows of cilia which remains free at their edges and make powerful sweeps.
- They help to bring the food particles to the cytostome.
- These are found in Spirotrichans and Peritrichans.



- **(iii) Cirri:** Cirri are found on ventral surface of the body of some ciliates.

➢ These are formed by fusion of two or three rows of cilia.

➢ They can move in all the directions and helps in crawling.

➢ They may also serve as tactile organs.

➢ They are found in *Hypotrichans*.

MYONEMES

- These are contractile fibrils and found in ectoplasm or pellicle of various protozoans like flagellates, ciliates and sporozoans.
- In *Monocystis andPlasmodium* they serve for locomotion.
- In *Paramecium,* metaboly is performed by myoneme fibrils.

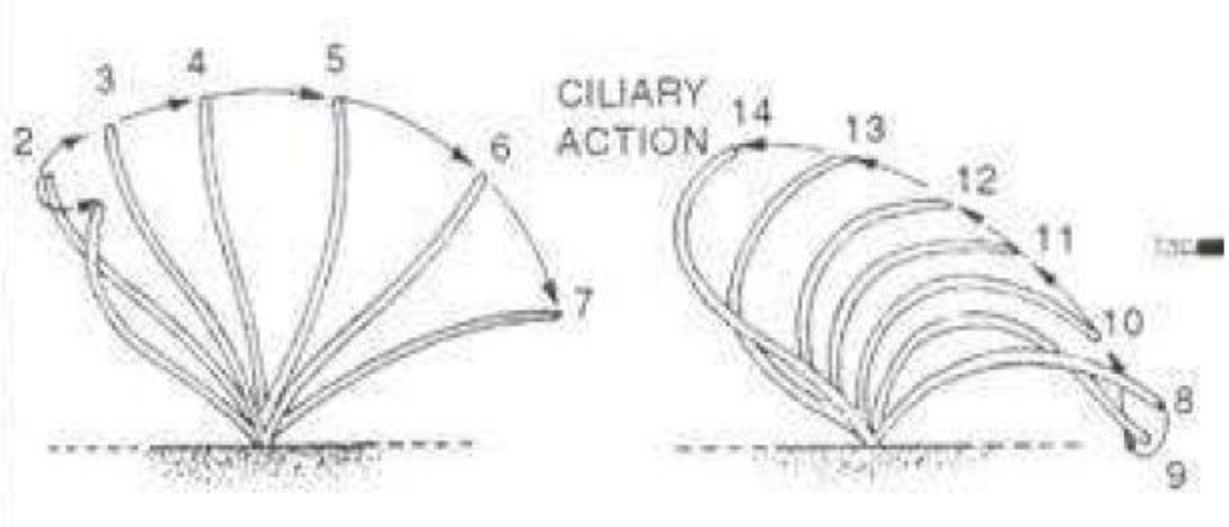


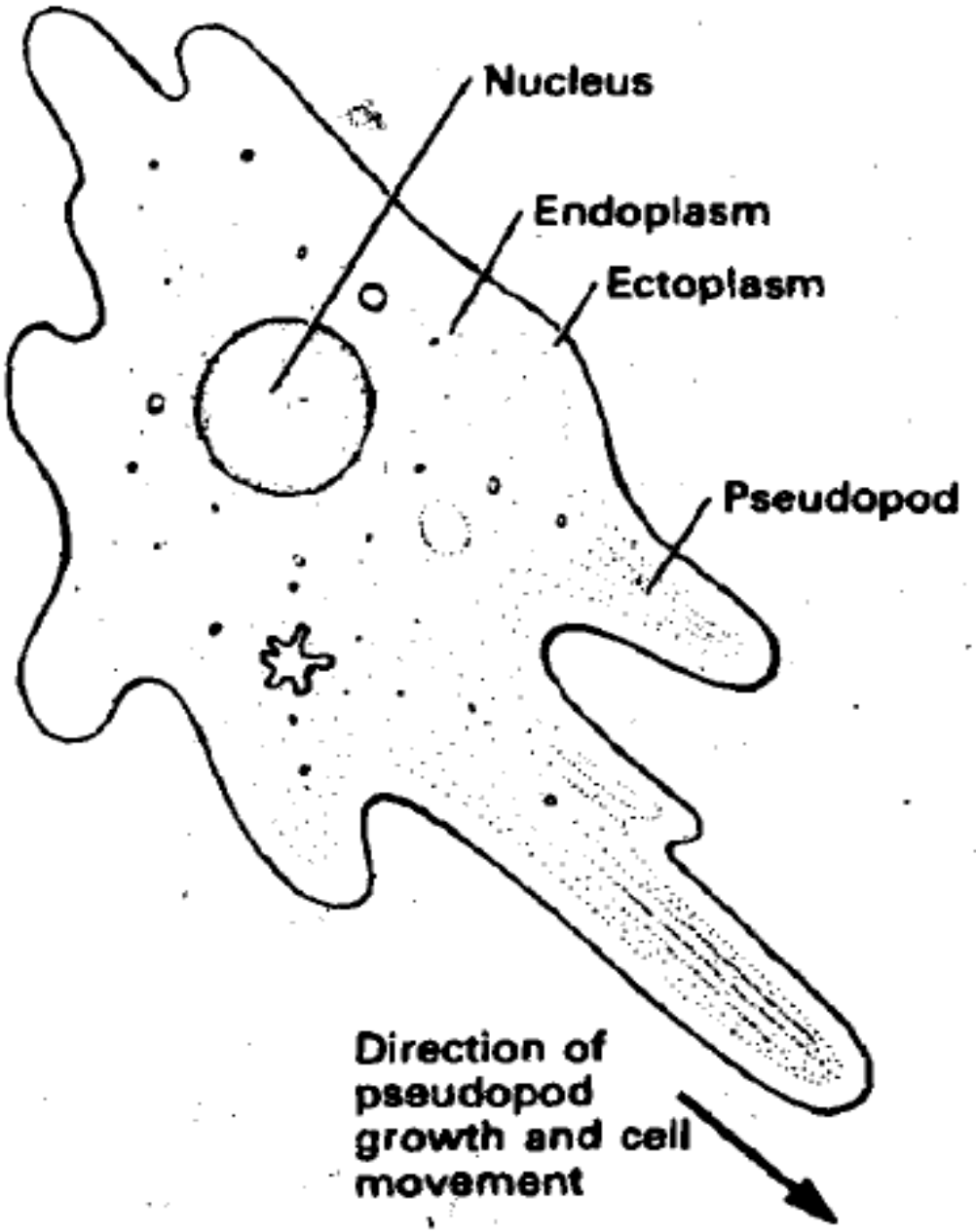
Fig.2.4. Diagram showing flagellar and ciliary movement. A- Effective stroke; B- Recovery stroke

- Amoeboid movement is the characteristic of some protozoans, slime molds and vertebrate white blood cells.
- The movement of these is due to cytoplasmic streaming, change in cell shape and extension of pseudopodia.
- The newly formed pseudopodia gradually extend and enlarge so that the entire cell occupies the space where previously only a small pseadopodium began to form.
- As the cell moves, new pseudopodia are formed in the direction of the movement,
- It appears that there is a transaction of the regions of the cytoplasm from fluid-like sol to semi solid **gel state.**

Under the light microscope, we can find two regions in the-cytoplasm

- i) the central region, the **endoplasm which is fluid like sol**
- **ii) the ectoplasm, the region of the** cytoplasm just beneath the plasma membrane, which is gel-like as **gel end**
- In the phase contrast microscope, the endoplasm contains abundant particles and membranous organellae, found in constant random motion, indicating their freedom of movement in the sol region of the cytoplasm.
- Ectoplasm contains a three-dimensional network of cross-linked **actin fibres, and all other organelle are excluded from the region.**

- It is believed that the ectoplasm contains non-cross-linked actin filaments and probably **myosin filaments also.**
- **As a pseudopodium elongates and the sol-like endoplasm streams into it, the** region of the endoplasm near the tip of the pseudopodium apparently transforms into - gel-like ectoplasm.
- Simultaneously, the ectoplasm transforms into sol-like endoplasm by an uncrossing of linking actin fibres.
- Proteins such as **actin, finabrin and fodrin are involved in the sol-to-gel transition.**
- **They cross-link actin** filaments and bundle them to each other.
- Crosslinking of actin filaments produces a network confining the movement of individual actin molecules and results in the semisolid gel state.


Nucleus
Endoplasm
Ectoplasm
Pseudopod
Direction of pseudopod growth and cell movement

- Both cytoplasmic streaming and the formation of pseudopodia may depend on the interaction between myosin and actin filaments
- amoeboid movement is controlled or regulated the ability of many actin binding poteins to crosslink actin fibres is strongly dependant on both ca2+.concentration and pH.
- Thus, ca2+ and H+ may regulate the sol-to-gel transition
- low molar concentration of ca2+ **when pH is lowered to 6.8, the** cytoplasm of amoeba sets as a gel.

- low molar concentration of ca2+ **when pH is lowered to 6.8, the** cytoplasm of amoeba sets as a gel.
- Conversely, solation of the gel is induced by raising the or ca2+ concentration.
- Involvement of a gelsolin or villin protein in the gel-to-sol transition, because these proteins fragment actin filaments in the presence of micromolar concentration of (**10^6 *moles)* *ca2+*.**
- directed growth of pseudopodia is due to differences in ca2+ or **H+ concentration among** various regions of the cytoplasm

Structure of the Cilia and Flagella

- Cilia and flagella are hair-like cell organelles.
- The diameter (0.2 μm) and internal structure of cilia and flagella is similar to each other but these structures differ in length.
- Cilia are generally less than 15 μm **in length while flagella may be as long as 200 μm.**
- **The internal** structure and the molecular composition of cilia and flagella have been well studied by electron microscopy and biochemical techniques.
- the cilium or flagellum is covering with the plasma membrane of the cell.
- It is actually the evagination of the plasma membrane.
- The cilia is attached to the body of the organisrn by a basal **body or kinetosome.**

- The main **ınternal structures of a cilium are microtubules, which extend from the base to** the tip.
- The licrotubules are arranged in 9 + 2 configuration, consisting of nine outer doublets surrounding two single central microtubules.
- Each microtubuleis a hollow cylinder composed of polymers of the globular proteins-tubulins.
- The outer doublets each consists of a complete tubule (the **A tubule**) with 13 subunits and an attached incomplete B tubule containing only 10 or 11 subunits

- Each A tubule bears two side arms. called dynein arms that project laterally towards the B tubule of the next doublet.
- There is a series of radial spokes which extend from the A sub-tubule to the central pair of microtubules.
- The outer doublets are connected circumferentially by nexin links.
- The entire array of microtubules and associated arms and links is called the akoneme.
- The nine peripheral doublet merge at the base to form a hollow tube that forms the basal body

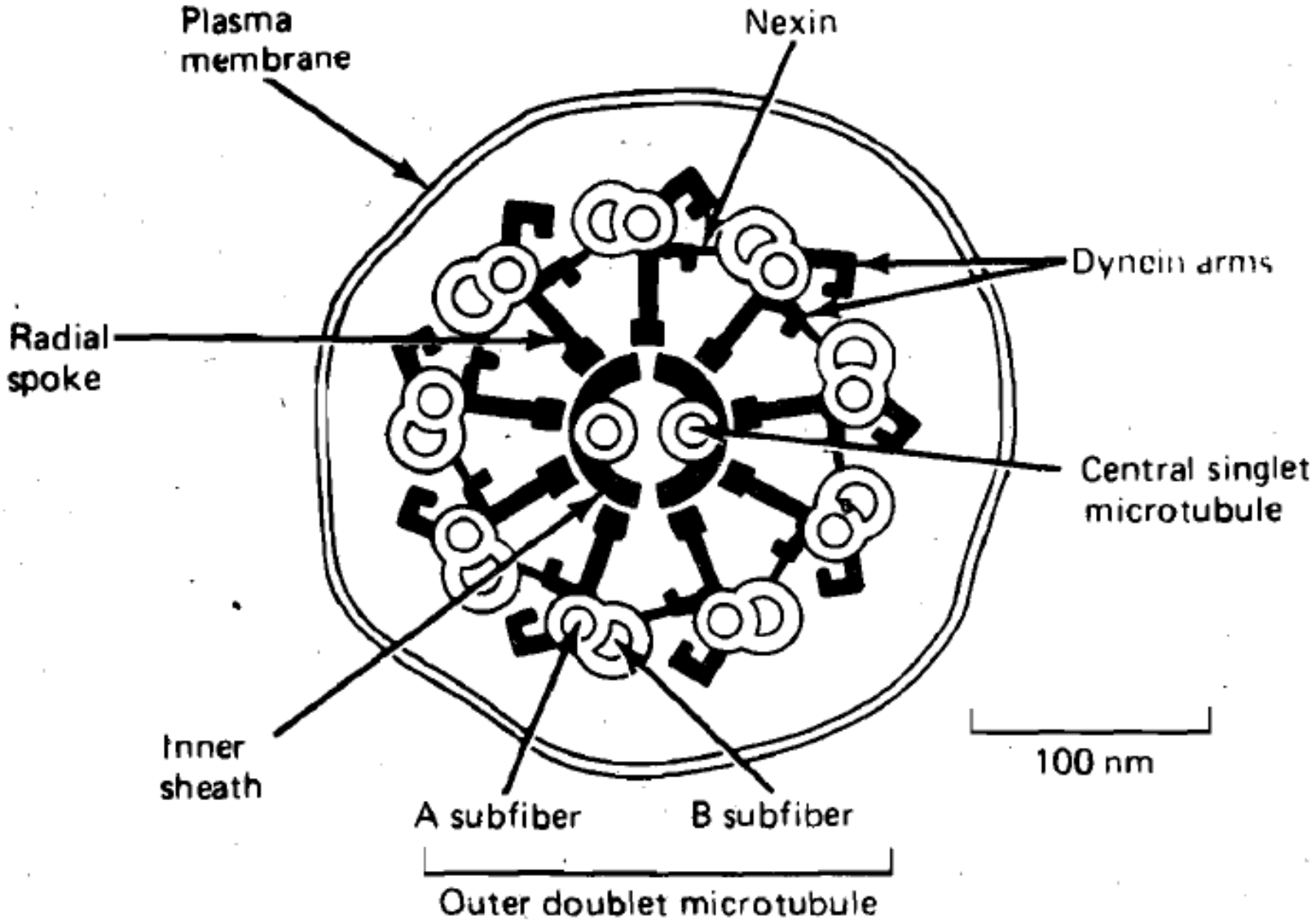


Fig. 6.5 : Diagram showing the internal structure of a cilium in cross-section.

i) the flagellum moves passively, much like a whip, by forces exerted at its base;

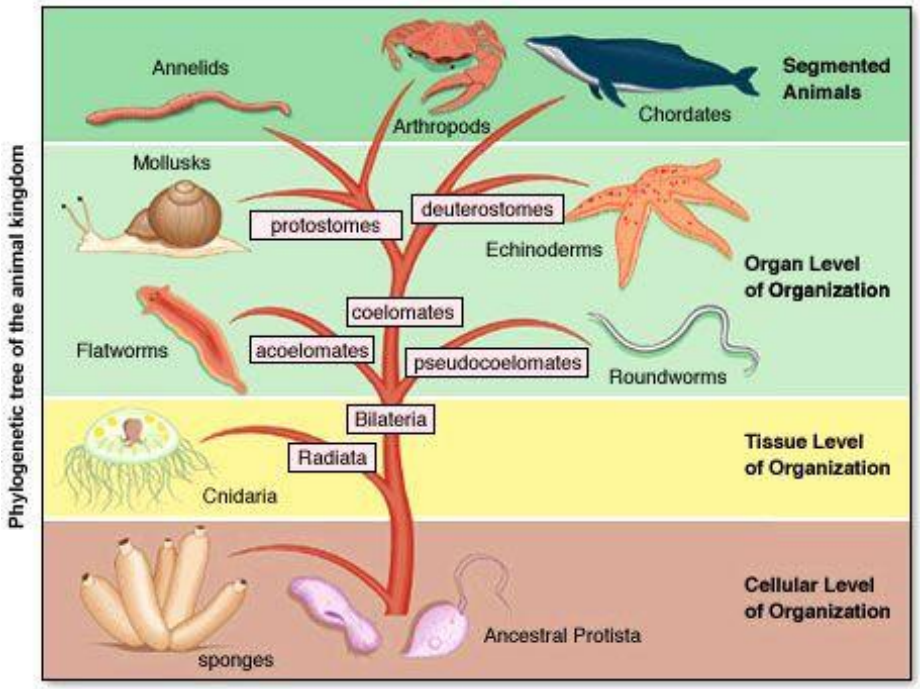
ii) the elements along the inner curvature of a propagating wave contract while the

- opposite side does not. Such a type of contraction takes places alternately on the inner curvature of a propagating wave on opposite side to bend the cilium or flagellum from side to side,
- iii) the thin filaments of the cilium do not change shape, but move past one another to cilium.
- The membrane of the produce a curvature, similar to the sliding filaments during muscle contraction

- During beating, extending dynein arms attach to the neighboring B-tubule, inducing sliding movement.
- The dynein arms seem to "walk" along the cilium, presumably by the attachment of radials pokes to the central microtubule to constrain the sliding.
- The radial spokes and the nexin bending of the cilium and a links are required to convert the sliding movement into typical bending of the cilium or the flagellum.
- The energy for the sliding movement is provided by the hydrolysis of ATP.

Structure and Function of Vertebrates (22ZOO11)

Eucellular Plan of Organization

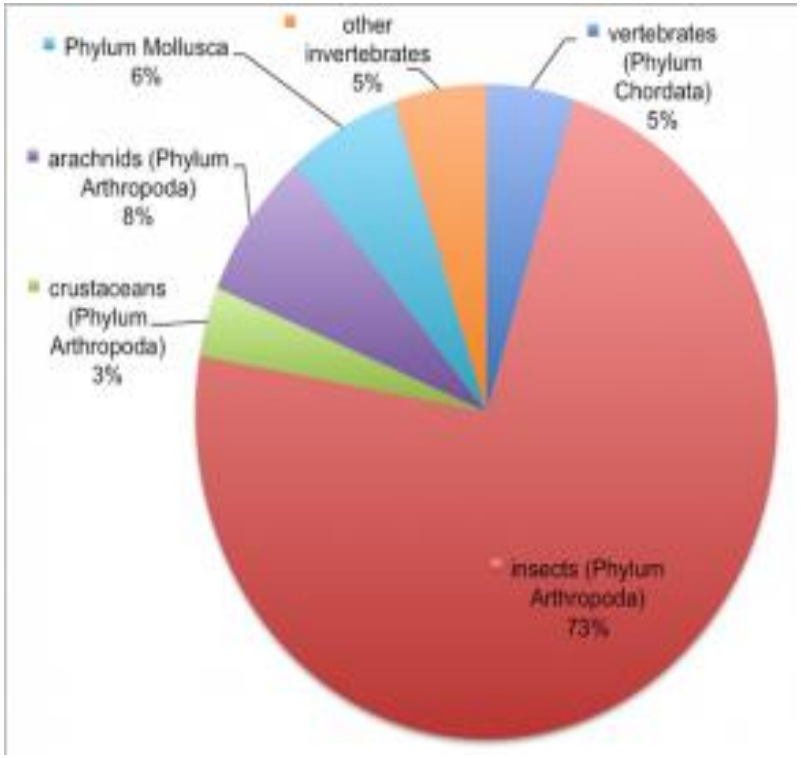


- The invertebrate phyla have been divided into **major and minor**
- **phyla. This concept is based on two factors.**

(i) The number of species and individuals

(ii) Their participation in ecological communities

- On the basis of first factor, phylum Protozoa (50,000 *sp.), Porifera (10,000 sp.),* Coelentrata(11,000 *sp.), Mollusca (112,000 sp.), Annelida (17000 sp.), Arthropoda* (9.00,000*sp.) Ectoprocta (4000 sp.), Rotifera (1500 sp.) and Echinodermata (7,000 sp.)* are major phyla.



- On the basis of second factor, if the phyla are represented in great majority of ecological communities, they would be regarded as major phyla.
- On this basis, in spite of greater in number **Rotifera and Ectoprocta** cannot be considered as major phyla.
- These are included in minor phyla due to their limited participation in animal communities and they form only a fraction of animal communities.

Linnaeus 1735[23]	Haeckel 1866[24]	Chatton 1925[25][26]	Copeland 1938[27][28]	Whittaker 1969[29]	Woese *et al.* 1977[30][31]	Woese *et al.* 1990[32]	Cavalier-Smith 1993[33][34][35]	Cavalier-Smith 1998[36][37][38]	Ruggiero *et al.* 2015[39]
—	—	2 empires	2 empires	2 empires	2 empires	3 domains	3 superkingdoms	2 empires	2 superkingdoms
2 kingdoms	3 kingdoms	—	4 kingdoms	5 kingdoms	6 kingdoms	—	8 kingdoms	6 kingdoms	7 kingdoms
—	Protista	Prokaryota	Monera	Monera	Eubacteria	Bacteria	Eubacteria	Bacteria	Bacteria
					Archaebacteria	Archaea	Archaebacteria		Archaea
		Eukaryota	Protista	Protista	Protista	Eucarya	Archezoa	Protozoa	Protozoa
							Protozoa		
							Chromista	Chromista	Chromista
Vegetabilia	Plantae		Plantae	Plantae	Plantae		Plantae	Plantae	Plantae
				Fungi	Fungi		Fungi	Fungi	Fungi
Animalia	Animalia		Animalia	Animalia	Animalia		Animalia	Animalia	Animalia

- The animal kingdom is divided into two sub kingdoms called **Protozoa and Metazoa.**
- **The protozoans are noncellular organisms *i.e.*** the body of the individual is not divided into cells as in case of metazoans.
- protozoans are described as unicellular eukaryotic protist animals.
- The **metazoans are multicellular and eukaryotic animals.**
- **The metazoans have certain** qualities that must be considered in concert with the basic idea of multicellularity.
- Different structure to form of different animals, there are fundamental characteristics common to various individuals.
- These features are used as the basis of animal classification.
- Some characteristic features of metazoans are as follows.

Diversity in Living Organisms - Part 1

Classification of Organisms

Arranging organism into groups based on similarities and differences.

Advantages

- Identify organisms
- Finds interrelationship between organisms
- Makes studying organisms easy

Types of Classification

Cell Nature

- **Prokaryotic** — Nucleus and cell organelles are not demarcated
- **Eukaryotic** — Clear nucleus and membrane-bound cell organelles

Cell Occurrence

- **Unicellular** — Made up of single cell
- **Multicellular** — Multiple cells in clusters to form specialized tissue and organs

Mode of Nutrition

- **Autotrophs** — Make their own food
- **Heterotrophs** — Depend on others for food

Level of Body Organization

Five Kingdom Classification

*Given by Robert Whittaker

Kingdom Monera
- Prokaryotic
- Unicellular
- Autotrophs/ Heterotrophs
- Some have cell-wall, some doesn't

Bacteria

Kingdom Protista
- Eukaryotic
- Unicellular
- Autotrophs/ Heterotrophs
- Movement – Cilia, Flagella, Pseudopodia

Amoeba

Kingdom Fungi
- Eukaryotic
- Mostly multicellular
- Heterotrophs - Saprophytic
- Cell wall – Chitin
- Some form symbiotic association with blue-green algae

Mushroom

Kingdom Plantae
- Eukaryotic
- Multicellular
- Autotrophs
- Cell wall - Cellulose

Plant

Kingdom Animalia
- Eukaryotic
- Multicellular
- Heterotrophs
- Cell wall - absent

Lion

Binomial Nomenclature

*Introduced by Carl Linnaeus

Genus name + Species name → Scientific name

Rules to follow while naming organism through binomial nomenclature :

1. Names are written in *italicized* form.
2. First letter of genus should be capital.
3. First letter of species should be in lowercase.

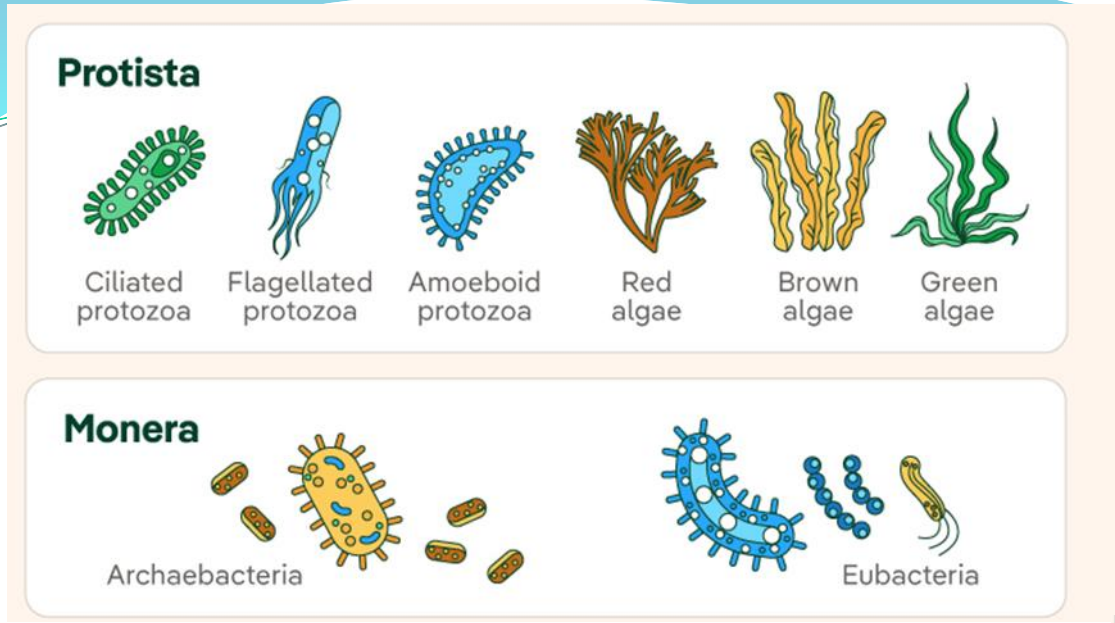
Homo sapiens

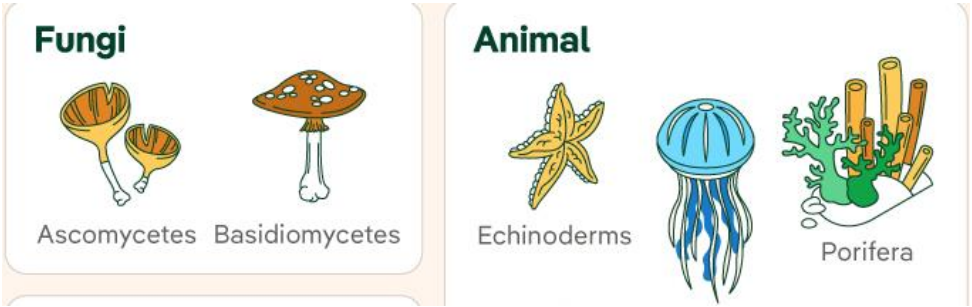
4. If scientific texts are handwritten, they should be underlined.

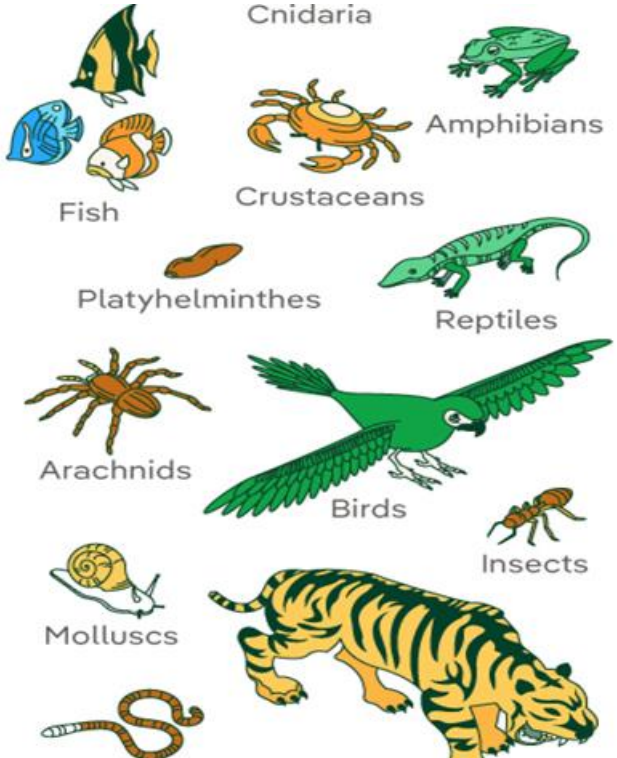
Examples:

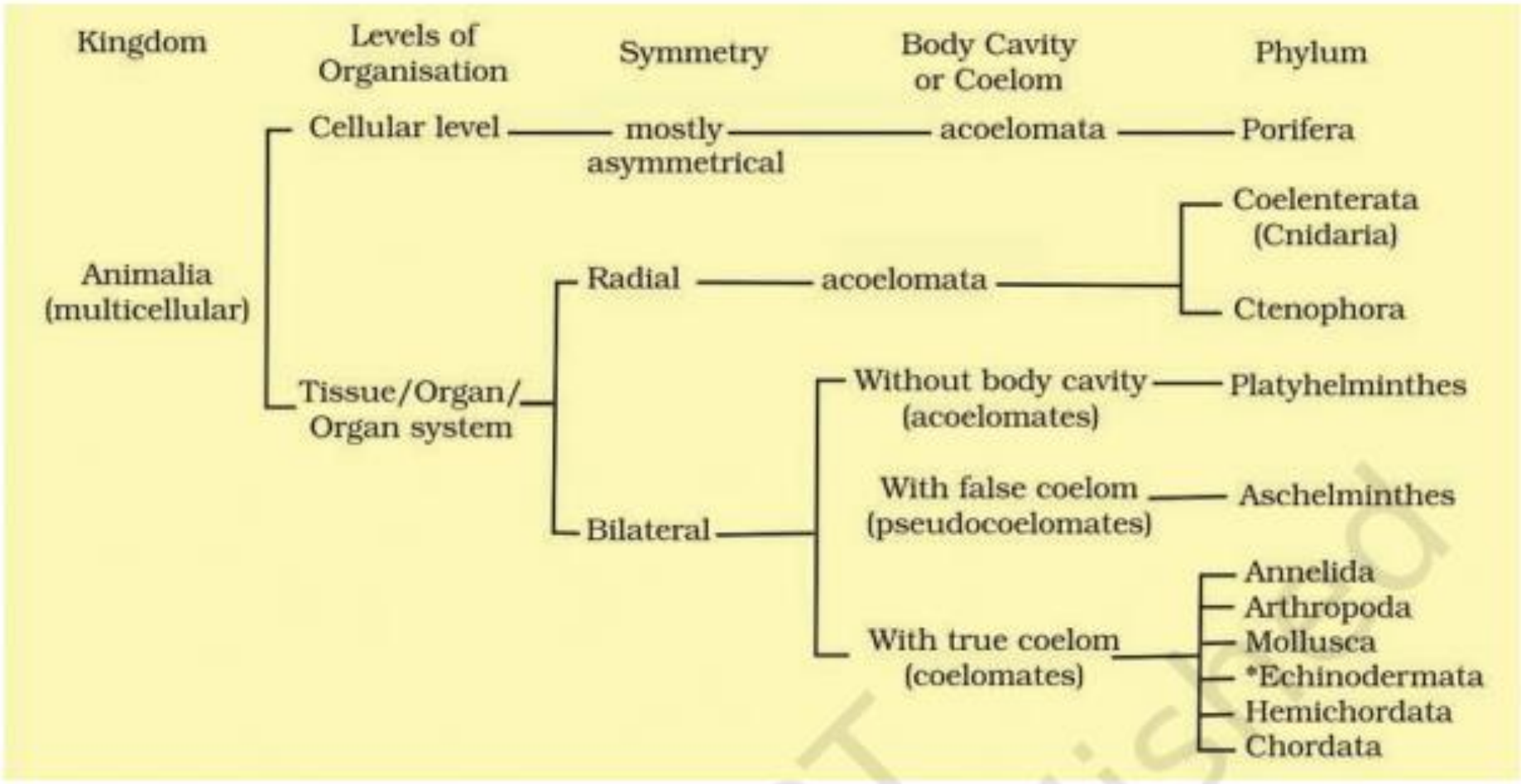
Panthera tigris

Mangifera indica

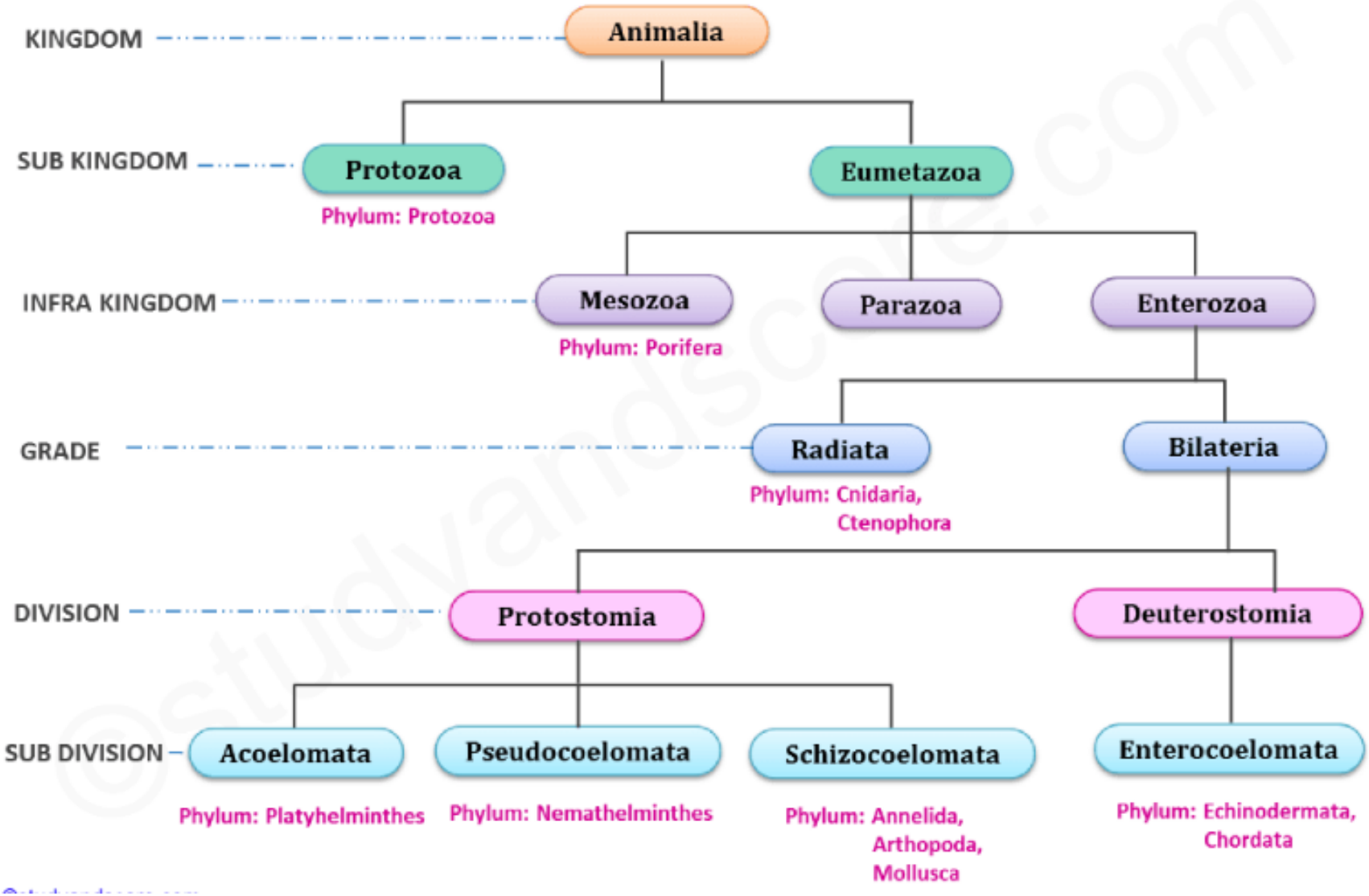

Protista
Ciliated protozoa
Flagellated protozoa
Amoeboid protozoa
Red algae
Brown algae
Green algae
Monera
Archaebacteria
Eubacteria


Fungi
Ascomycetes
Basidiomycetes
Animal
Echinoderms
Porifera


Cnidaria
Amphibians
Fish
Crustaceans
Platyhelminthes
Reptiles
Arachnids
Birds
Insects
Molluscs


Kingdom
Levels of Organisation
Symmetry
Body Cavity or Coelom
Phylum
Animalia (multicellular)
Cellular level
mostly asymmetrical
acoelomata
Porifera
Tissue/Organ/ Organ system
Radial
acoelomata
Coelenterata (Cnidaria)
Ctenophora
Bilateral
Without body cavity (acoelomates)
Platyhelminthes
With false coelom (pseudocoelomates)
Aschelminthes
With true coelom (coelomates)
Annelida
Arthropoda
Mollusca
*Echinodermata
Hemichordata
Chordata

DIVISIONS OF ANIMAL KINGDOM



S.no	Phylum	No. of Species	S.no	Phylum	No. of Species
1	Protozoa	50,000	16	Sipunculida	275
2	Mesozoa	50	17	Mollusca	80,000
3	Porifera	10,000	18	Echiurida	60
4	Coelenterata	11,000	19	Annelida	8,700
5	Ctenophora	90	20	Tardirgada	180
6	Platyhelminthes	15,000	21	Onychophora	65
7	Nemertinea	750	22	Pentastomida	70
8	Acanthocephala	300	23	Arthropoda	900,000
9	Entoprocta	60	24	Phoronida	15
10	Rotifera	1,500	25	Ectoprocta(bryozoa)	4,000
11	Gastrotricha	175	26	Brachiopoda	260
12	Kinorhyncha	100	27	Echinodermata	6,000
13	Nematoda	10,000	28	Chaetognatha	50
14	Nematomorpha	250	29	Pogonophora	80
15	Priapulida	8	30	Hemichordata	80

Characters	Major Phyla	Minor Phyla
1. No. of species	More no. of species.	Less no. of species.
2. Participation in ecological communities	Great Participation.	Less participation.
3. No. of phyla	Eleven.	Nineteen.
4. Examples	Protozoa, Porifera, coelenterates, Platyhelminthes, rotifera, nematodes, annelida, arthropoda, mollusca, Ectoprocta and Echinodermata.	Nematomorpha, Onychophora, Phoronida, Brachiopoda, Pogonophora etc

Characters	Lower Invertebrates	Higher Invertebrates
1. Size	Generally small sized.	Generally large sized.
2. Body organisation	Simple.	Complex.
3. Symmetry	Radial, biradial, asymmetrical.	Bilateral symmetrical.
4. Germ layers	Diploblastic.	Triploblastic.
5. Coelom	Acoelomates or pseudocoelomates.	True coelomates.
6. Gut	Generally incomplete and non-muscular.	Always complete and muscular.
7. Circulatory system	Not well developed, blood vascular system absent.	Well developed.
8. Examples	Protozoa, Porifera, Coelenterata, Platyhelminthes and Nematoda.	Annelida, Arthropoda, mollusca, Echinodermata.

Level of Organization

- the level of organization of cells varies from one animal to another.
- cellular **level of organization. e.g., sponges**
- The cells form poorly defined tissues, and exhibit **tissue level of organization e.g. Cnidarians (=coelenterates),**
- **Phylum** Platyhelminthes and Aschelminthes have **organ level of organization.**
- Annelids, Arthropods, Molluscs, Echinoderms, and Chordates have specialised organ- system for their physiological activities.
- They have the **organ-system level of organisation.**
- **Although these** animals have organ-system levels of the organization, the complexities of organ systems vary in different phyla.

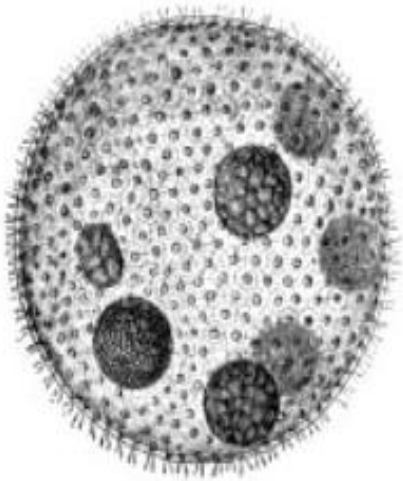
1. Levels of organizations are important in animal classification.
2. Different characters such as cellularity, symmetry, germ layers, segmentation, cephalization etc. Different levels of organization are used to place animals in either; lower or higher categories or groups called as Taxa.

I. Unicellularity vs. Multicellularity:

Sr. No.	Unicellular organisms	Multicellular organisms
1.	They are single celled	Many celled
2.	Prokaryotic or eukaryotic	Only eukaryotic
3.	Protoplasmic grade organization	Cellular, tissue and organ level organization
4.	Single cell performs all function of life as metabolism, growth and reproduction	Single cell can't perform all function of life.
5.	Example: Protozoans	Example: Poriferans to Vertebrates

II. Colonization:

1. Colony means an aggregation of the similar type of individuals.
2. When individuals are identical in a colony then it is called as **monomorphic colony** e.g. Volvox colony.
3. In some colonies the individuals are of different structures known as **polymorphic colony** e.g. Physalia colony.



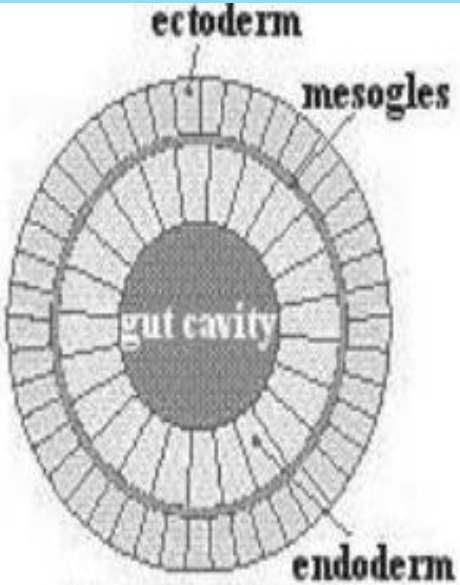
Volvox colony.

Physalia colony.

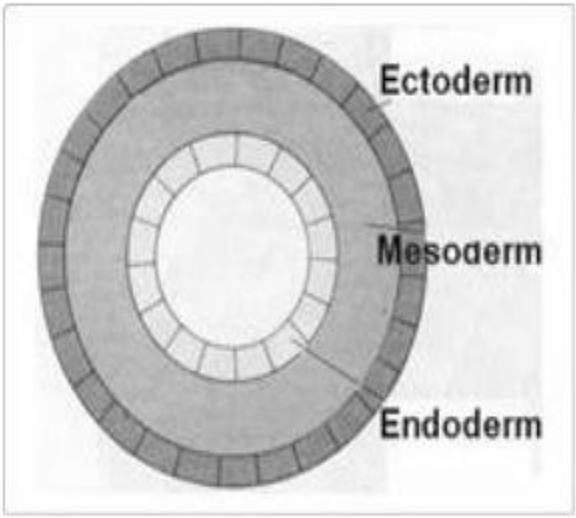
When there is a physiological connection between the members of the colony then it is called as a **true colony** e.g. Volvox, sponges etc.

III. Organization of Germ Layers: Diploblastic and triploblastic organisms

1. In Multicellular organisms at the time of formation of embryo the zygote undergoes cellular division called as cleavage.
2. Further multiplication of the cells forms a hollow single layered **blastula**.
3. Blastula then invaginates to give rise to double layered **gastrula. The outer germ layer is known as ectoderm and the inner one called endoderm.**
4. When animals develop from such double layered gastrula are known as **diploblastic organisms**.
5. All lower organisms are diploblastic in nature.
6. In higher animals the gastrula develops an additional layer between the ectoderm and endoderm called as mesoderm.
7. Thus they are made up of three germ layers called as **triploblastic organisms**.



Diploblastic

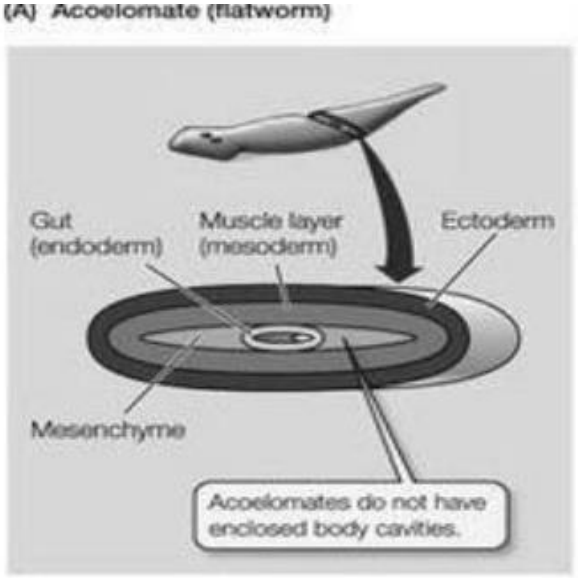


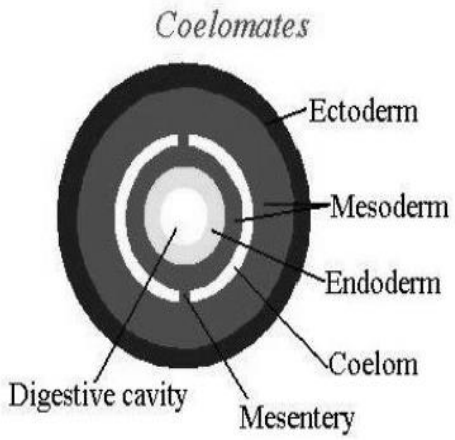
Triploblastic body plan

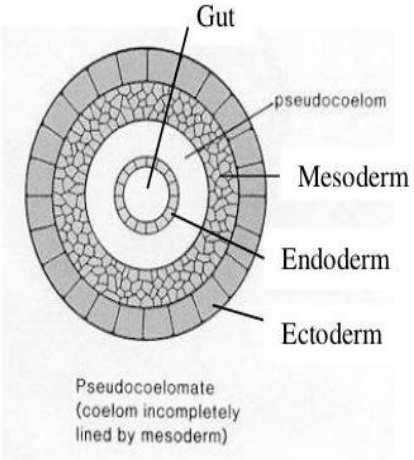
Coelom: **Coelom is a key feature for classification in metazoans. Coelom is a cavity** between the body wall and gut wall, lined by mesoderm. Depending on presence/absence of coelom, animals have been classified into coelomates, pseudocoelomates and acoelomates.

IV. Development of Coelom:

1. Coelom is a body cavity.
2. It is developed in triploblastic animals. In very lower triploblastic organisms there is no body cavity developed therefore they are called as **acolomates**. E.g. Planaria.
3. In sac worms the cavity which is developed is not lined by mesodermal lining called as **pseudocoelomate** condition. E.g. Ascaris.
4. In higher animals the Coelom is lined by mesodermal lining called as peritoneum and These are called as **coelomates** e.g. earthworm, frog, lizard, man etc.







V. Symmetry:

1. Organisms have basically three types of body symmetry namely 1) Asymmetry; 2) Radial symmetry and 3) Bilateral symmetry.
2. Asymmetry: the animals having body which never divides into two equal halves on any plane of their body are **asymmetrical animals**. E.g. the lower animals like Amoeba, and sponges.
3. Radial symmetry: the animals whose body can be divided into two equal halves which are mirror image of each other when cut along any radial plane of body are called as **radially symmetrical** animals.

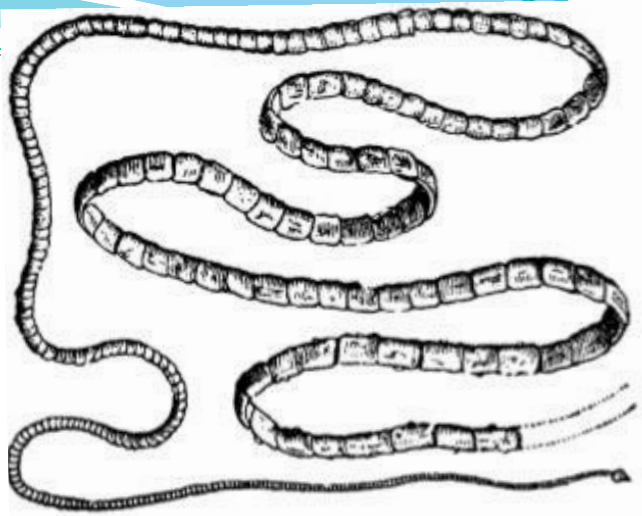
Coelenterates, ctenophores and adult echinoderms show radial symmetry

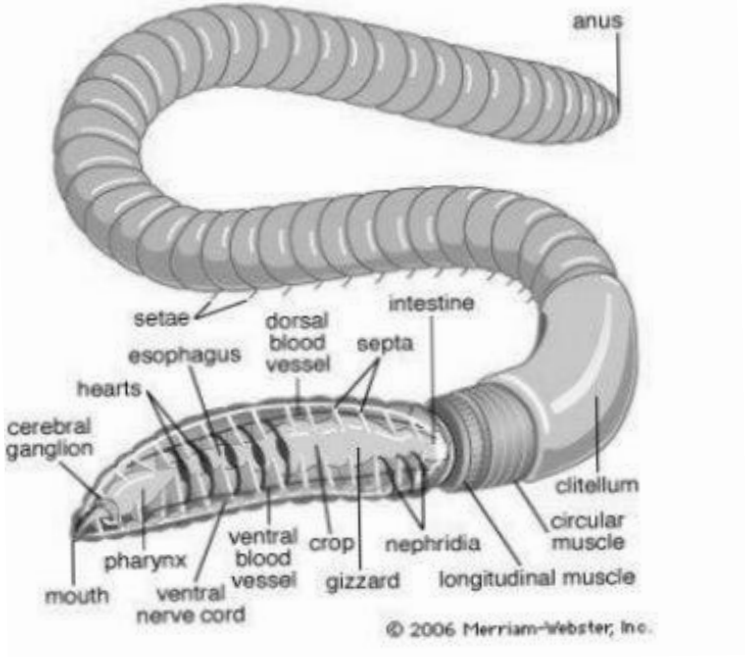
4. Bilateral symmetry: the animals whose body is divisible into two identical halves which are mirror image of each other are known as **bilaterally symmetrical** animals.
5. But the body is divisible along only a single plane.

Annelids, Arthropods and Molluscs etc. show bilateral symmetry

VI. Segmentation:

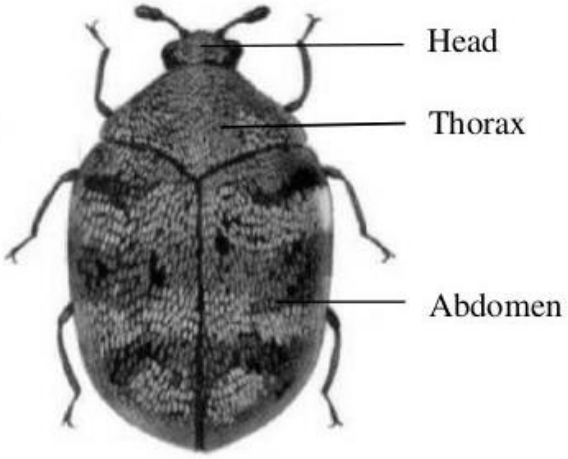
1. Animal body may be divided or not.
2. When body is divided horizontally into segments is called as segmentation.
3. A segment is called as **mere.**
4. The segment may be true or false types.
5. False segments are superficial, incomplete and non-identical. Phenomenon of false segmentation is called as **pseudo-segmentation** e.g. **tapeworm**.
6. True segments are typical, complete and identical.
7. Each true segment contains part of all the systems like reproductive, digestive, excretory, circulatory, nervous etc. and internally divided by septa.
8. Phenomenon of true segmentation is called as **metamerism** e.g. **earthworm** to vertebrates.





VII. Cephalization:

1. Cephalization means **development of head**.
2. In higher animals all important sensory organs are concentrated towards anterior side as they are **highly active**.
3. Active animals move, run, find food, capture prey or attack enemy antriorwards. Therefore they require the sensory organs to locate the objects, enemy, food, or prey which are accumulated at anterior part of the body called as head.
4. Head is movable, capable of attacking or capturing prey, eating food, smelling odors or looking for danger.
5. Head contains sensory organs like eyes, antennae, mouth, nose, ears etc. to perform above functions. In higher animals like insects have head which is basically made up of six segments.



Beetle

Body Plans of Animals: Animals have three types of body plans:

- **Cell Aggregate Plan:** The body consists of a cluster or aggregation of cells. It is found in sponges.
- **Blind Sac Plan:** The body has a single cavity with one opening to the outside. The single opening functions as both mouth for ingestion and anus for egestion. It is found in Cnidarians (=coelenterates) and flatworms.
- **Tube-within-a-Tube Plan:** The body has two tubes i.e., body cavity and gut

  cavity. Gut cavity is a continuous tube-like structure within body cavity and has two openings, a mouth for ingestion and anus for egestion.

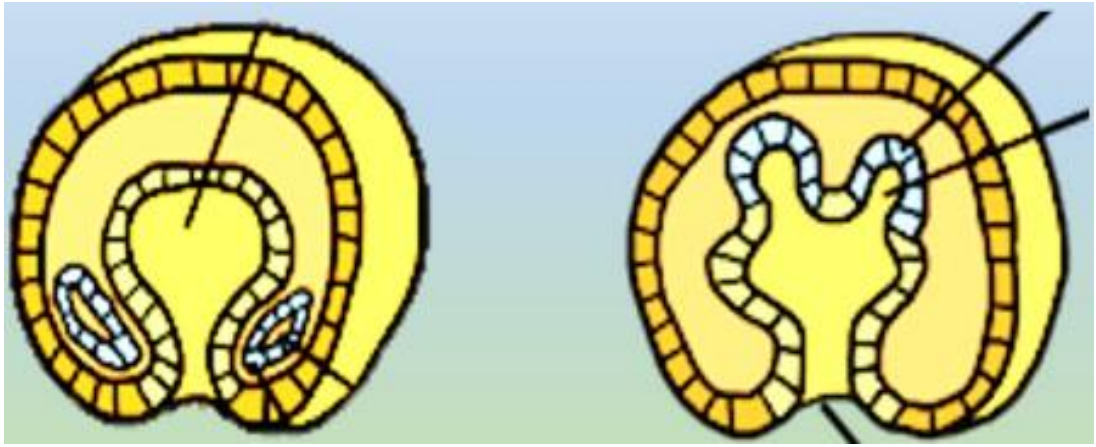
  Tube-within-a tube plan is of two types

- Protostomic plan in which the mouth of the digestive tract develops first in the embryo and anus is formed later and
- Deuterostomic Plan in which the anus of the digestive tract develops first in the embryo and the mouth is formed later.
- The metazoans are subdivided into three branches - Mesozoa,Parazoa and Eumetazoa.
- The mesozoa includes about 50 species of cellular animals, consisting of surface layer of somatic cells and inner reproductive cells.
- The parazoa or porifera include the sponges which are diploblastic and multicellular but have loose aggregations of cells which do not form tissues.

- There is no mouth or digestive tract.
- The body is porous with one or more internal cavities lined by choanocytes.
- The **eumetazoa includes the animals of** tissue or organ-system grade of organization with mouth and digestive tract.
- The eumetazoans include diploblastic animals with radial symmetry (Radiata) and triploblastic animals with bilateral symmetry (Bilateria).
- Bilateria is divided into two divisions - **Protostomia and Deuterostomia**

Structure and Function of Vertebrates (22ZOO11)

Protostomes and Deuterostomes



DEVELOPMENTAL PATTERNS OF INVERTEBRATES

- The bilateral metazoans can be differentiated into two main assemblages based on either the formation of mouth first or the anus.
- Metazoans in which blastopore forms the mouth of the animal and anus is formed secondarily are called 'Protostomes' and in which blastopore forms the anus of the animal and mouth is formed primarily are called "Deuterostomes".
- You will study about these two groups in the following subsections.

PROTOSTOMIA

The metazoans in which mouth is derived from blastopore on the anterior end and anus appears later to complete the alimentary canal are included in Protostomia (Fig. 1.3). As the mouth forms first, there animals are included in 'Protostomia" (Mouth first) division of animal kingdom. Nerve cord is ventral in protostomes.

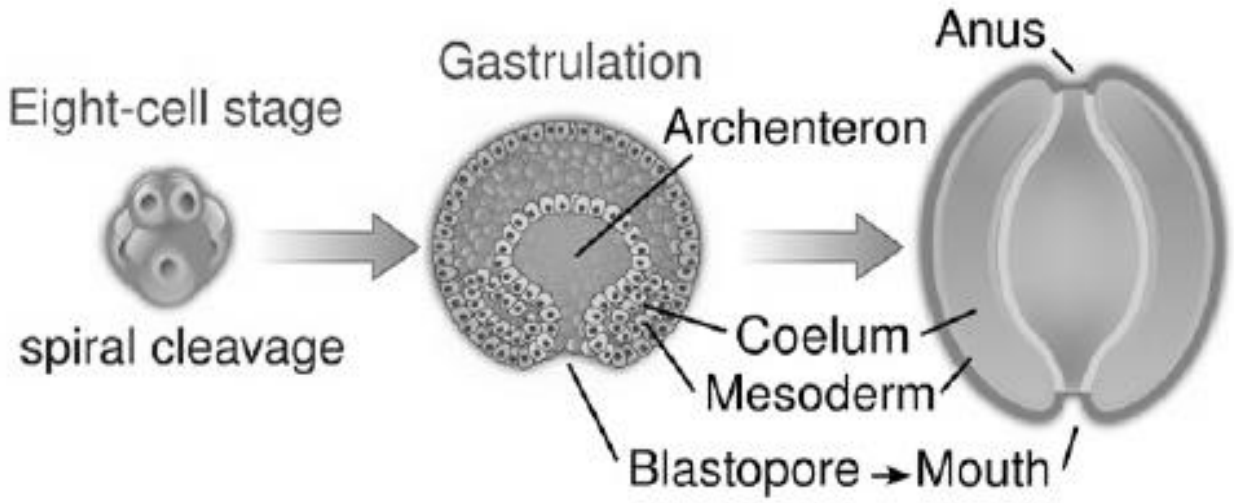


Fig. 1.3 Diagram showing development of mouth from blastopore

The developmental characteristics of protostomes are as follows.

1. **Pattern of embryonic cleavage:** Cleavage is spiral in protostomes, i.e., axis of cleavage plane is oblique, and so that blastomeres have a spiral arrangement in which one tier of cells alternates with the next tier of cells. The spiral cleavage is masked at the 6th cleavages 64-cell stage.

2. Fate of embryonic blastomeres: Fate of blastomeres is determined very early during holoblastic cleavage. This is called determinate or mosaic cleavage, which means blastomeres are destined to form a particular organ in very early stage of cleavage. In Figure 1.4 just after first cleavage ablation of one of the cells takes place which leads to the loss of head structure in embryo that drive from it. Such type of development is said to be mosaic.

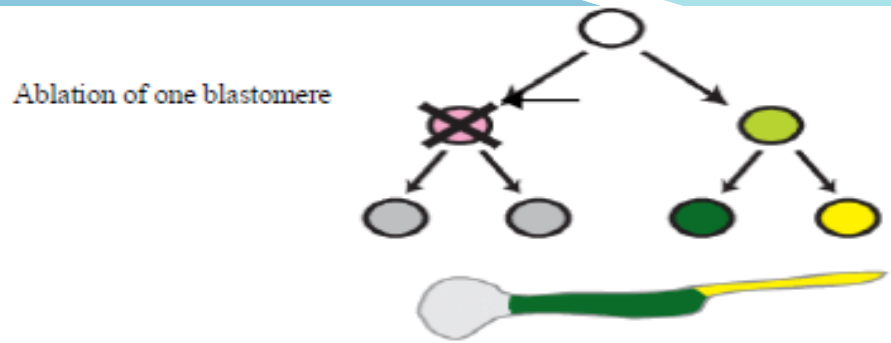


Fig 1.4 Development of mosaic embryo

3. Fate of blastopore:

The blastopore either becomes mouth (e.g., Mollusca) or gives rise to both mouth and anus (e.g., some molluscs, polychaetes and onychophorans) in adult.

4. Formation of mesoderm:

Mesoderm originates from the fourth cell, named as mesentoblast (also called as '4d' cell) which increases in number by proliferation.

5. Formation of coelom:

Coelom originates by the splitting of the mesodermal cell mass. This proess of coelom formation is known as**schizocoely**and coelom is called schizocoelom ('schizo' means'split').

Examples:

Coelomate protostomes include Sipuncula, Echiura, Annelida, Pogonophora, Mollusca, Onychophora, Tardigrada, Pentastomida and some groups of arthropods.

DEUTEROSTOMIA

The metazoans in which anal opening are derived from blastopore during embryonic development and represents the posterior end of body and mouth is formed later are included in deuterostomia (Fig. 1.5). As the anus forms first and mouth is formed secondarily, these animals are grouped in deuterostomia (Mouth second). Nerve cord is dorsal in deuterostomes.

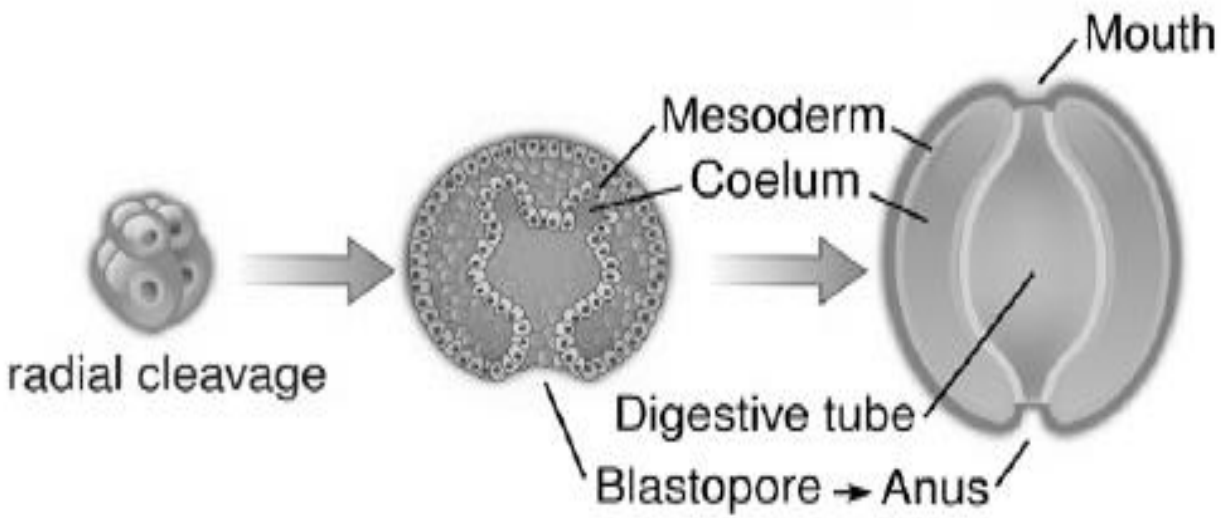


Fig. 1.5 Diagram showing development of anus from blastopore

- The developmental characteristics of deuterostomes are as follows.
- **1. Pattern of embryonic cleavage:** Radial pattern of embryonic cleavage occurs in which the cleavage plane is either parallel or at right angle to the polar axis. Blastomeres are arranged directly above or below one another.
- **2. Fate of embryonic blastomeres:**
- Cleavage is indeterminate and if blastomeres are separated at 4 cell stages, each one will develop into a complete individual.
- Cleavage is regulative because each of the blastomeres, if separated can regulate its development
- if ablation of one cell takes place, then the descendants of the remaining cell can give rise to the structure in embryo that would have developed from the lost cell.
- In this case green cell is able to regenerate head structure as well as trunk region. Such development is said to be regulative.

3. Fate of blastopore:

Blastopore becomes the adult anus and then the formation of mouth takes place from a second opening on the dorsal surface of the embryo.

4. Formation of mesoderm: Mesodermal tissue is formed by the outgrowth of endodermal wall of the archenteron.

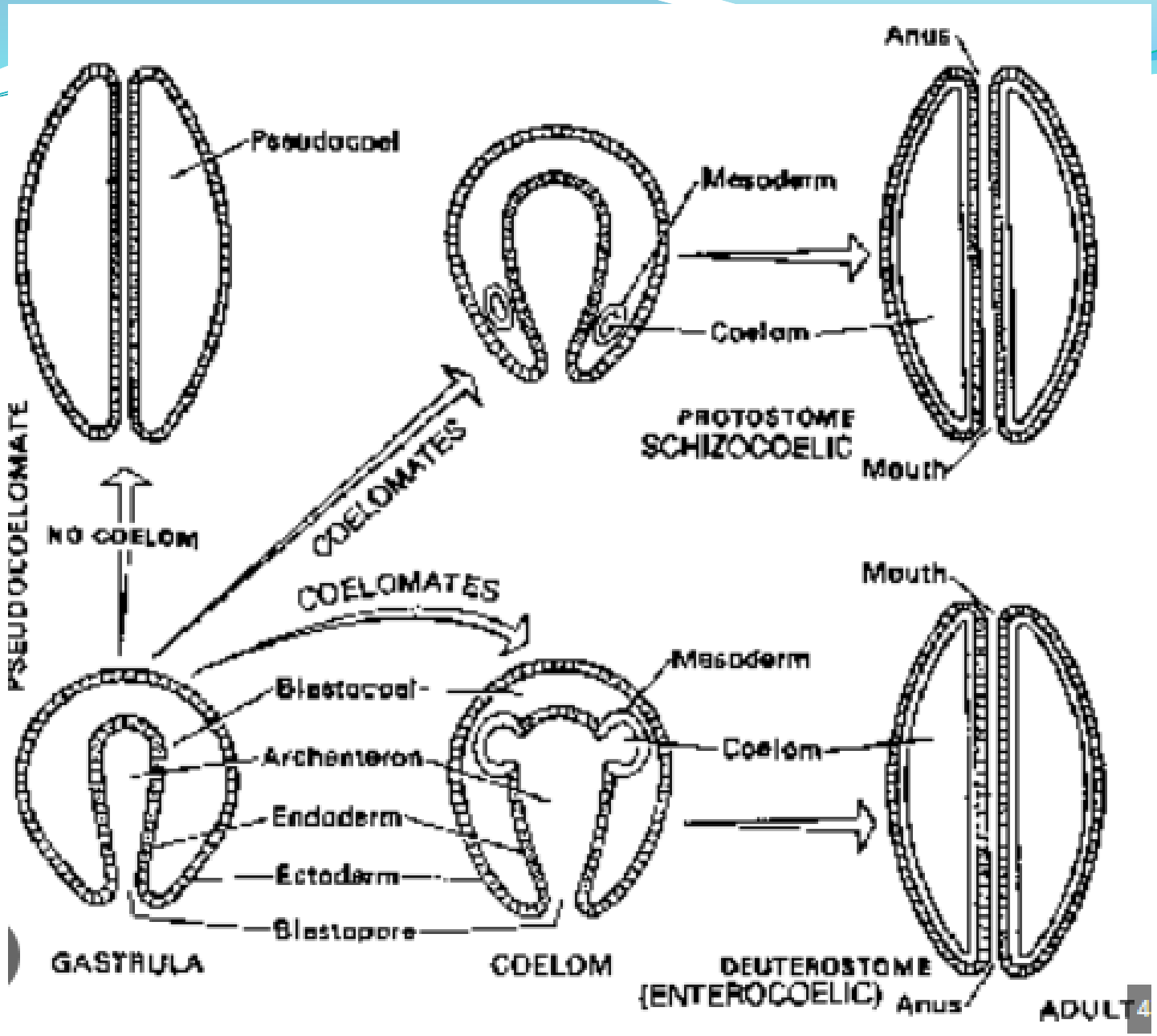
5. Formation of coelom:

Coelom is formed by evagination of pouches from the wall of archenteron and each diverticulum becomes separated from the archenteron and develops independent coelomic pouch.

This process of formation of coelom is called as **enterocoely and coelom is called asenterocoelom.**

Examples: Deuterostomes include echinoderms, chordates, pogonophores, hemichordates and some minor phyla.

- The eucoelomates are classified into two types : **I. Schizocoelomates :**
- Animals in which the body cavity is formed by .splitting of mesoderm. are called schizocoelomates.
- Annelids, arthropods and molluscs are schizocoelomates in the animal kingdom.
- All the schizocoelomates are protostomians and they show. holoblastic., .spiral and .determinate. cleavage.
- The 4d blastomere or mesentoblast cell of the early emrbyo divides to form mesodermal blocks between the ectoderm and the endoderm and replaces the blastocoel.
- The split that appears in each mesodermal block leads to the formation of Schizocoelom.


Anus
Pseudocoel
Mesoderm
Coelom
PROTOSTOME
SCHIZOCOELIC
Mouth
PSEUDOCOELOMATE
NO COELOM
COELOMATES
COELOMATES
Mouth
Mesoderm
Blastocoel
Archenteron
Coelom
Endoderm
Ectoderm
Blastopore
GASTRULA
COELOM
DEUTEROSTOME
(ENTEROCOELIC)
Anus
ADULT

II. Enterocoelomates :

- Animals in which the body cavity is formed from the mesodermal pouches of archenteron are called enterocoelomates: Echinoderms, hemichordates and chordates are the enterocoelomates.
- In these animals, mesodermal pouches that evaginate from the wall of the archenteron into the blastocoel are fused with one another to form the enterocoelom.
- All the enterocoelomates are deuterostomes and they show radial and indeterminate cleavage.

Table 1.2: Differences between Protostomia and Deuterostomia

S. No.	Protostomia	Deuterostomia
1.	Mouth originates from blastopore	Anal opening originates from blastopore
2.	Coelom is formed from schizocoely	Coelom is formed from enterocoely
3.	Cleavage is spiral and determinate	Cleavage is radial and indeterminate
4.	Composed of a solid ventral nerve cord	Composed of hollow dorsal nerve cord

Protostome VS Deuterostome

Protostome	Deuterostome
Formation Of Blastopore	
The blastopore forms the mouth in a protostome.	The blastopore forms the anal opening in a deuterostome.
Nervous System	
Their nervous system consists of a ventral nerve cord that is solid from inside.	Their nervous system consists of a hollow nerve cord.
Mesoderm Formation	
The mesoderm forms with the migration of the Mesenchymal cells.	The mesoderm in deuterostome forms from the ingrowths of the archenteron.
Zygote Cleavage	
The zygote cleavage in the protostome is considered determinate and spiral. The four embryo cells experience an oblique cleavage and the fate of resultant cells is determined.	The zygote cleavage in the protostome is indeterminate and radial. The four embryo cells experience a perpendicular and parallel cleavage to the body axis and the fate of resultant cells is not determined.
Origin Of Coelom	
The solid mesoderm masses split to develop coelom in a protostome. This splitting process is known as Schizocoelous.	The archenteron fold develops coelom in a deuterostome in the form of a pair of primitive gut's mesodermal pouches. The process is known as Enterocoelous.
Ciliary Bands	
The larval ciliary bands of protostomes have multi-ciliated cells.	The larval ciliary bands of deuterostomes carry single cilium per cell.
Phyla	
Arthropoda, Annelida, and Mollusca phyla are classified as protostomes.	Chordata, Echinodermata, and Hemichordata phyla are classified as deuterostomes.
Examples	
Insects, squid, and snails are some organisms considered as protostomes.	Humans, sea urchins, and starfish are some organisms considered as deuterostomes.

Animal Phyla	*Symmetry*	*Grade of Organisation*	*Coelom/ Germ layers*	*Respiratory Surface*	*Excretory structures*	*Modes of Reproduction*
Protozoa	—	Protoplasmic level	-	Plasma-Lemma	Plasma-lemma	Asexual/ Sexual
Porifera	—	Cellular Grade	Diploblastic	Body wall	Body wall	Asexual/ Sexual
Cnidaria	Radial/ Biradial	Cell Tissue grade	Diploblastic	Body wall	Body wall	Asexual/ Sexual
Ctenophora	Biradial	Cell Tissue grade	Diploblastic	Body wall	Body wall	Only sexual
Platyhelminthes	Bilateral	Organ grade	Acoelomate /Triploblastic	Mostly anaerobes	Flame cells	Asexual/ Sexual
Aschelminthes	Bilateral	Organ system grade	Pseudocoelomate/ Triploblastic	Mostly anaerobes	Glandular-organs & Canals	Sexual
Annelida	Bilateral	Organ-system grade	Eucoelomate (Schizocoelic)/ Triploblastic	Gills and Skin	Nephridia	Asexual/ Sexual

Arthropoda	Bilateral	Organ-system grade	Eucoelomate (Schizocoelic)/ Triploblastic	Gills, Tracheal tubes, Book Lung	Malpighian tubules, Green Gland	Asexual/ Sexual
Mollusca	Bilateral	Organ system grade	Eucoelomate (Schizocoelic) / Triploblastic	Gills/Ctenidia Pulmonary Sac	Keber's organ, Organ of Bojanus	Asexual/ Sexual
Echinodermata	Bilateral	Organ-system grade	Eucoelomate (Enterocoelic) /Triplobastic	Dermal bran-chiae, Gills	Amoebocytes	Sexual
Hemichor data	Bilateral	Organ-system grade	Eucoelomate (Enterocoelic)/ Triplobastic	Gills	Proboscis gland	Sexual
Chordata	Bilateral	Organ-system grade	Eucoelomate (Enterocoelic)/ Triploblastic	Gills, Lungs, Skin, bucco-pharyngeal cavity,	Neural glands, Paired kidneys	Sexual