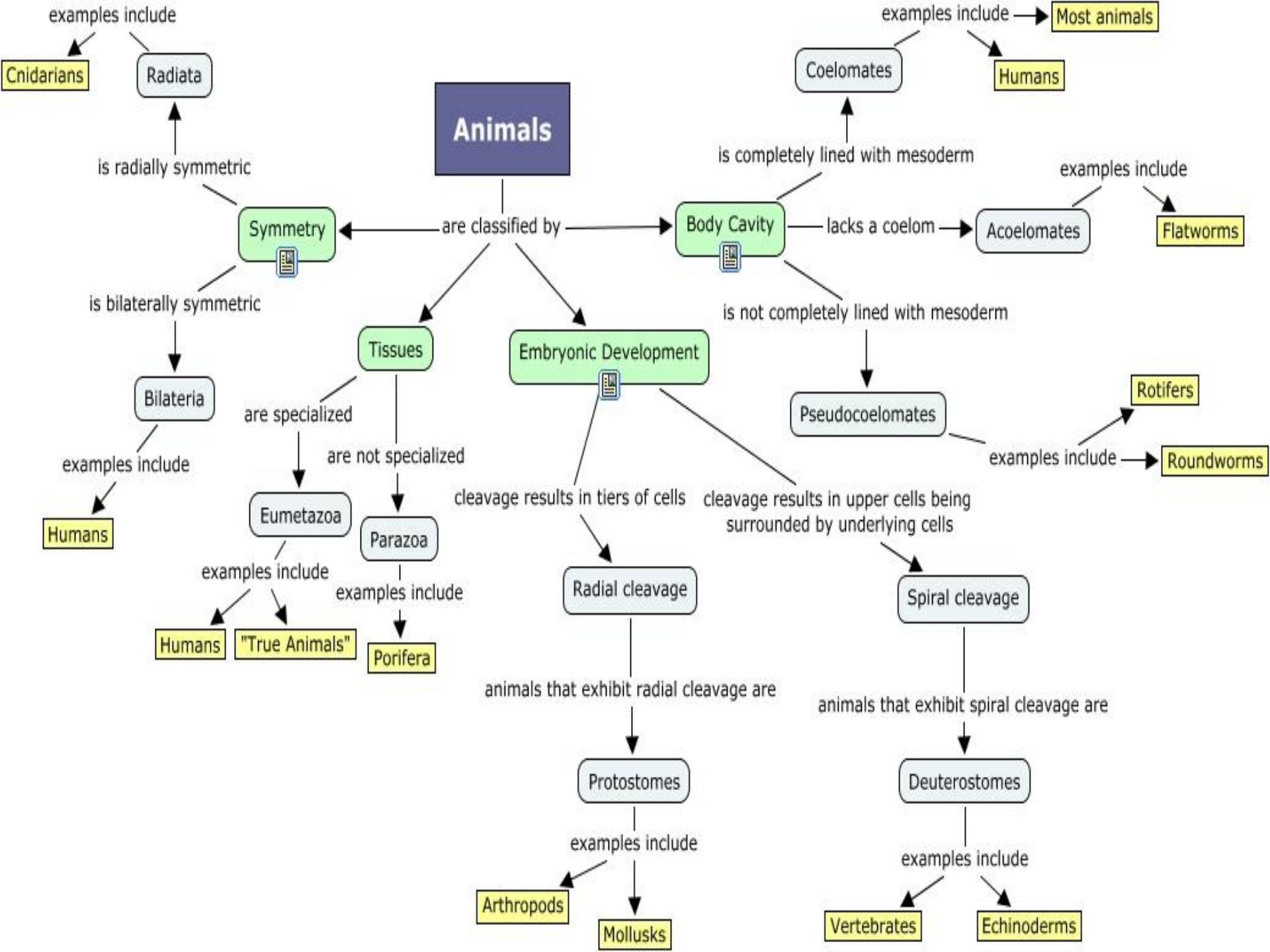
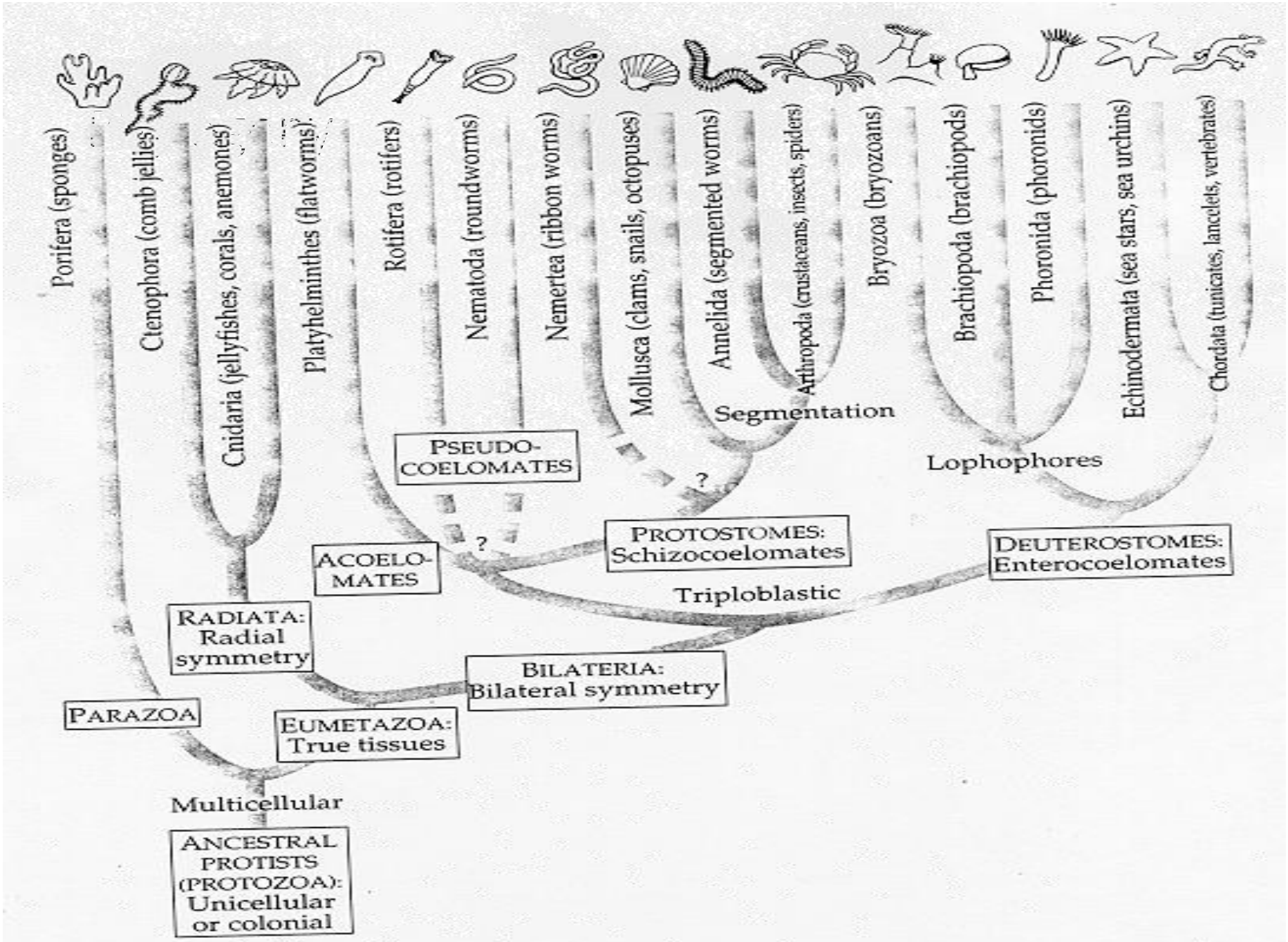
Introductory Biology
Module 3

Invertebrate Zoology/Diversity

Objectives

1. Develop an understanding of the animal kingdom
2. Describe the role of taxonomy and systematics in animal studies
3. Know the structural and functional characteristics of major animal groups
4. Understand the general features of protozoa and animal life cycles and forms of reproduction systems exhibited
5. Describe how the general features such as type of symmetry, number of tissue layers, body cavities, segmentation and cephalization etc, are used in classifying animal groups.
6. Describe the structure and function of animals in general at the cellular, tissue and organ level of structural organization.
7. Describe the distinguishing characteristics of the major animal phyla and intra-phyla differences
8. Develop skill in working with light microscopes and dissecting microscopes and to estimate the relative sizes of objects
9. Be able to prepare wet mounts and manipulate both living and preserved specimens.


Animals
are classified by
Symmetry
is radially symmetric
Radiata
examples include
Cnidarians
is bilaterally symmetric
Bilateria
examples include
Humans
Tissues
are specialized
Eumetazoa
examples include
Humans
"True Animals"
are not specialized
Parazoa
examples include
Porifera
Embryonic Development
cleavage results in tiers of cells
Radial cleavage
animals that exhibit radial cleavage are
Protostomes
examples include
Arthropods
Mollusks
cleavage results in upper cells being surrounded by underlying cells
Spiral cleavage
animals that exhibit spiral cleavage are
Deuterostomes
examples include
Vertebrates
Echinoderms
Body Cavity
is completely lined with mesoderm
Coelomates
examples include
Most animals
Humans
lacks a coelom
Acoelomates
examples include
Flatworms
is not completely lined with mesoderm
Pseudocoelomates
examples include
Rotifers
Roundworms


Porifera (sponges)
Ctenophora (comb jellies)
Cnidaria (jellyfishes, corals, anemones)
Platyhelminthes (flatworms)
Rotifera (rotifers)
Nematoda (roundworms)
Nemertea (ribbon worms)
Mollusca (clams, snails, octopuses)
Annelida (segmented worms)
Arthropoda (crustaceans, insects, spiders)
Bryozoa (bryozoans)
Brachiopoda (brachiopods)
Phoronida (phoronids)
Echinodermata (sea stars, sea urchins)
Chordata (tunicates, lancelets, vertebrates)
Segmentation
Lophophores
PSEUDO-COELOMATES
?
?
ACOELO-MATES
PROTOSTOMES: Schizocoelomates
DEUTEROSTOMES: Enterocoelomates
Triploblastic
RADIATA: Radial symmetry
BILATERIA: Bilateral symmetry
PARAZOA
EUMETAZOA: True tissues
Multicellular
ANCESTRAL PROTISTS (PROTOZOA): Unicellular or colonial

Structural and Functional Diversity in Protists

- Protists exhibit more structural and functional diversity than any other group of eukaryotes
- Single-celled protists can be very complex, as all biological functions are carried out by organelles in each individual cell.

General Characteristics of Protozoa

- **1. unicellular eukaryotes (some multinucleate, a few loosely multicellular), not all have**
- **mitochondria (microspores, many flagellates).**
- **2. up to about 400 micrometer in size (some larger)**
- **3. all have at least one nucleus**
- **4. most are free living, but many parasitic forms including entire phyla**
- **5. motile by a variety of mechanisms but also several non-motile taxa**
  - **Pseudopodia**
  - **Flagella**
  - **Cilia**
- **6. Many have cyst stages secreted by trophic or spore stages**
- **Cysts/spores have four basic functions:**
  - **• protect against unfavorable conditions**
  - **• serve as sites for multiplication**
  - **• assist in attachment to surfaces such as hosts**
  - **• transmission stage from host to host**

7. All types of nutrition are exhibited by protozoans.

- **Autotrophs**: photosynthesis
- **Heterotrophs** (obtain food from outside of the organism)
  - **Phagocytosis**: ingestion of solid particles (e.g., bacteria)
  - **Pinocytosis**: same as phagocytosis but intake of liquid
  - **Saprozoic** or saprotrophy: diffusion or active transport across membrane

Protozoan Reproduction

Protozoan reproduction is asexual or/and sexual

Asexual Reproduction

Binary Fission

- Most common type of reproduction in protozoa

- When parent is larger than progeny with progeny growing to adult size = **budding**
- **Multiple fission** = several nuclear division occur before cytokinesis so that a number of individuals are produced simultaneously

  (**schizogony, merogony and sporogony**)

  - **Schizogony (multiple fission)** is common among apicomplexans and amebas

Sexual Reproduction

- **Syngamy** = fertilization of an individual gamete by another
- **Conjugation** = exchange of gametic nuclei between paired organisms (Paramecium)

Classification

- **KINGDOM -- Protista** (single-celled eukaryotes)

  SUBKINGDOM -- Protozoa (animal-like, single-celled eukaryotes)

  PHYLUM: Sarcomastigophora -- move by pseudopods or flagella

  SUBPHYLUM:
  Sarcodina -- move by means of pseudopods
  Mastigophora -- move by means of flagella
  Class: Phytomastigophora -- photosynthetic
  Class: Zoomastigophora -- non-photosynthetic

  PHYLUM: Ciliophora -- move by means of cilia

  PHYLUM: Apicomplexa -- no locomotion, parasitic

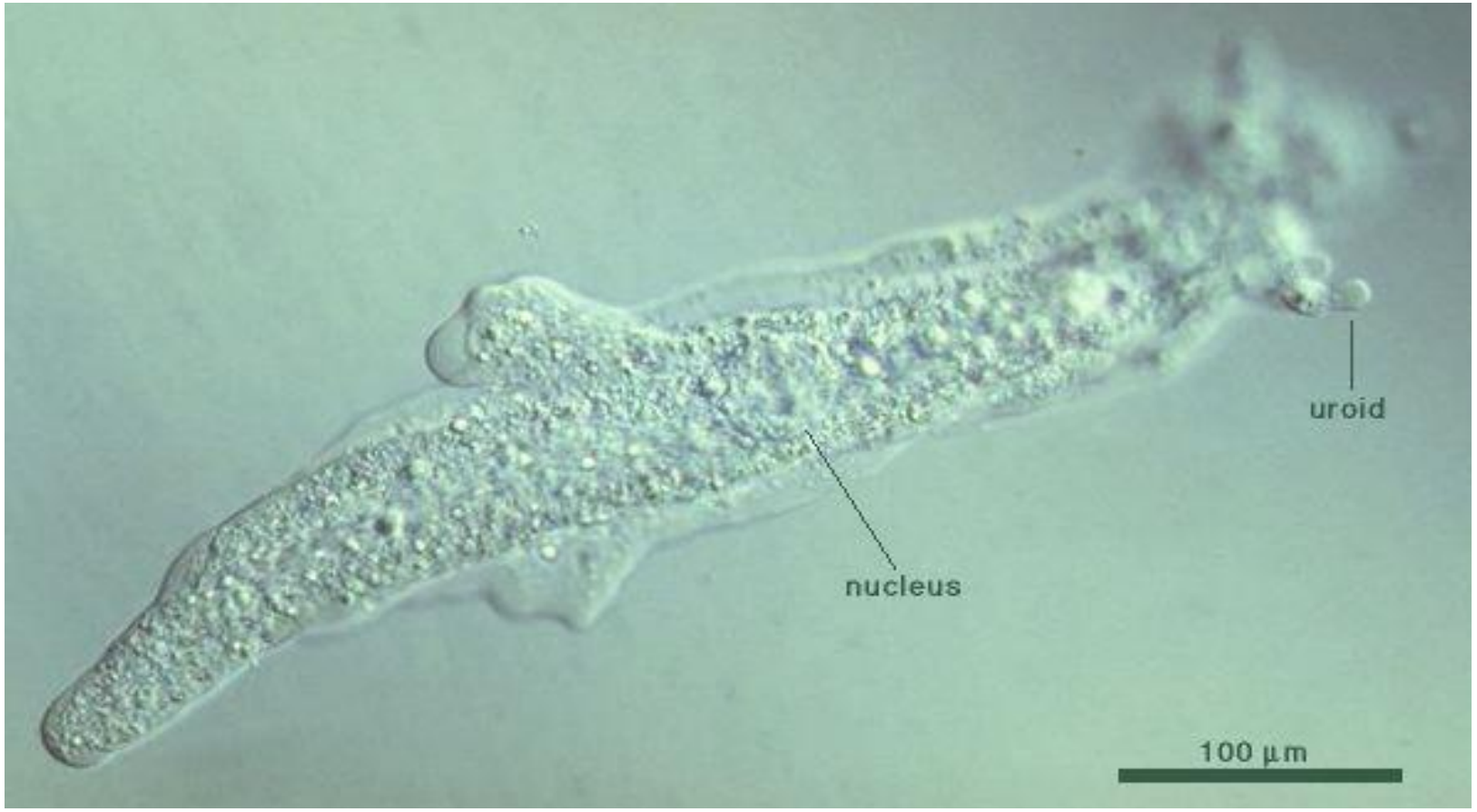
Subphylum Sarcodina.

- Sarcodina consists of **amoebas.** E.g. *Amoeba preteus*
- Has outside membrane called the pellicle.
- Two section of the cytoplasm namely, ***ectoplasm and endoplasm***
- Movement by pseudopodia (cytoplasmic extensions).
- Asexual reproduction occurs by fission (binary) of the cell.
- *Amoeba preteus is* ***free living***
- The food vacuole is formed by the process of **phagocytosis** .
- Osmoregulation is by **contractile vacuole**.
- Sarcodina includes two marine groups known as **foraminiferan**s and **radiolarians**.

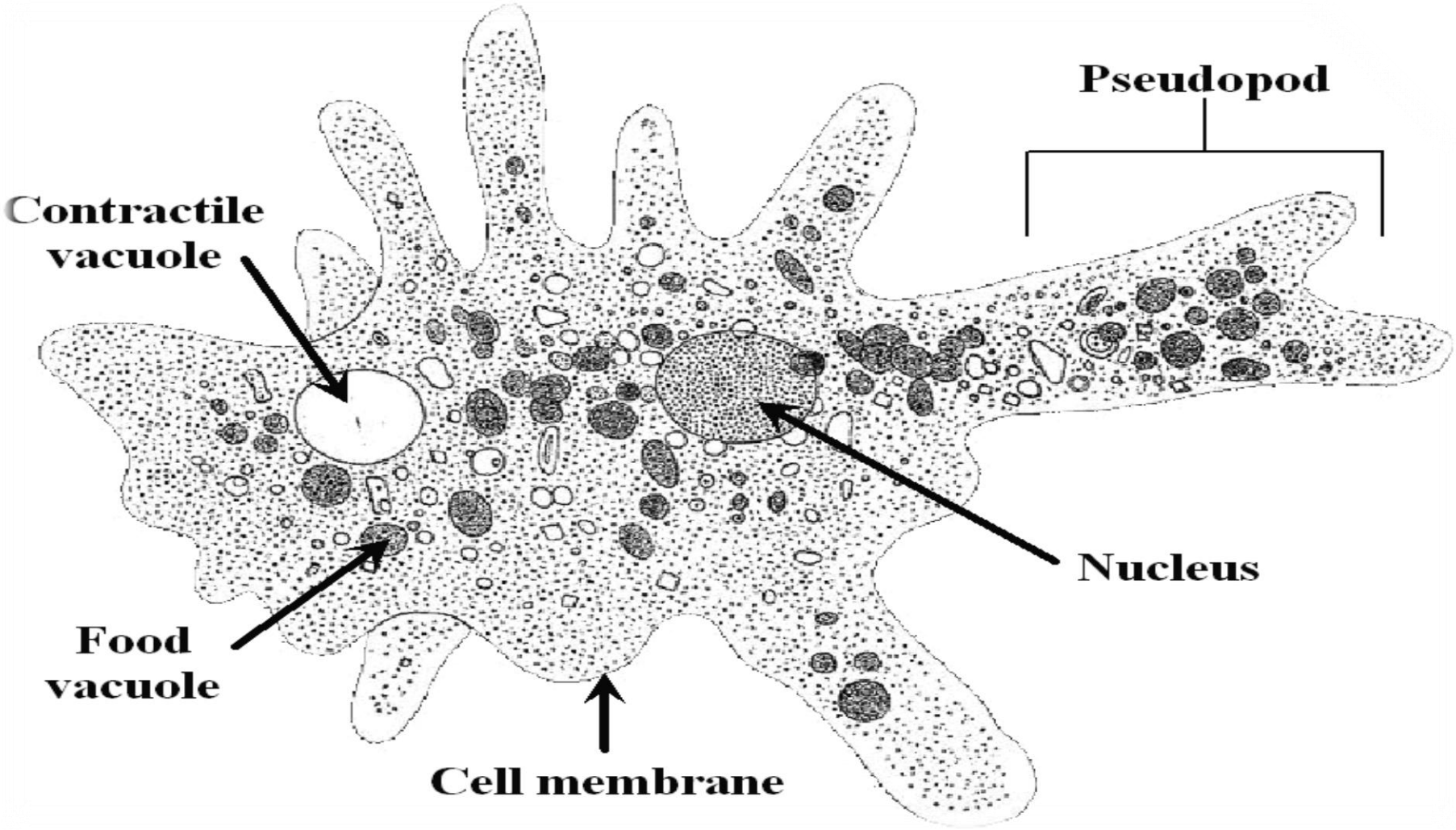
Parasitic

- Another member, ***Entamoeba histolytica***, is the cause of amoebic dysentery (amoebiasis). Extra intesetinal amoebiasis (liver absess)
- This organism can cause painful lesions of the intestine.
- May be contracted from contaminated water.

Sarcodina have Pseudopoda



Amoeba



Phylum Sarcomastigophora – amoebas, flagellates & opalinids

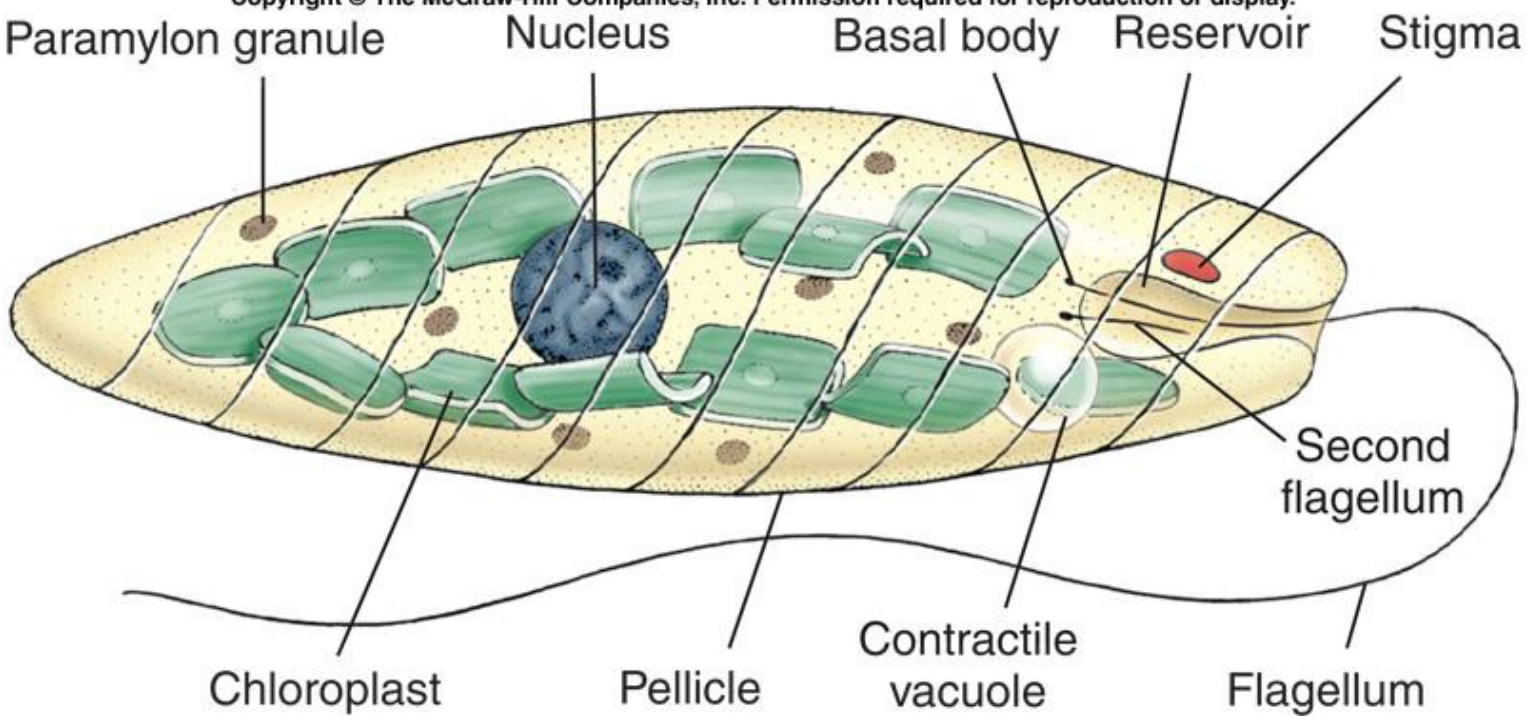
- **Subphylum Mastigophora** – the flagellates
  - They possess 1 flagella or more
  - **Class Phytomastigophorea** – the photosynthetic flagellates
    - Possess a flagella that make a wave-like motion as it goes forward.
    - Reproduction is usually by longitudinal binary fission
    - E.g. Euglena
    - They include Chlamydomonas, Euglenophyta, and Volvox

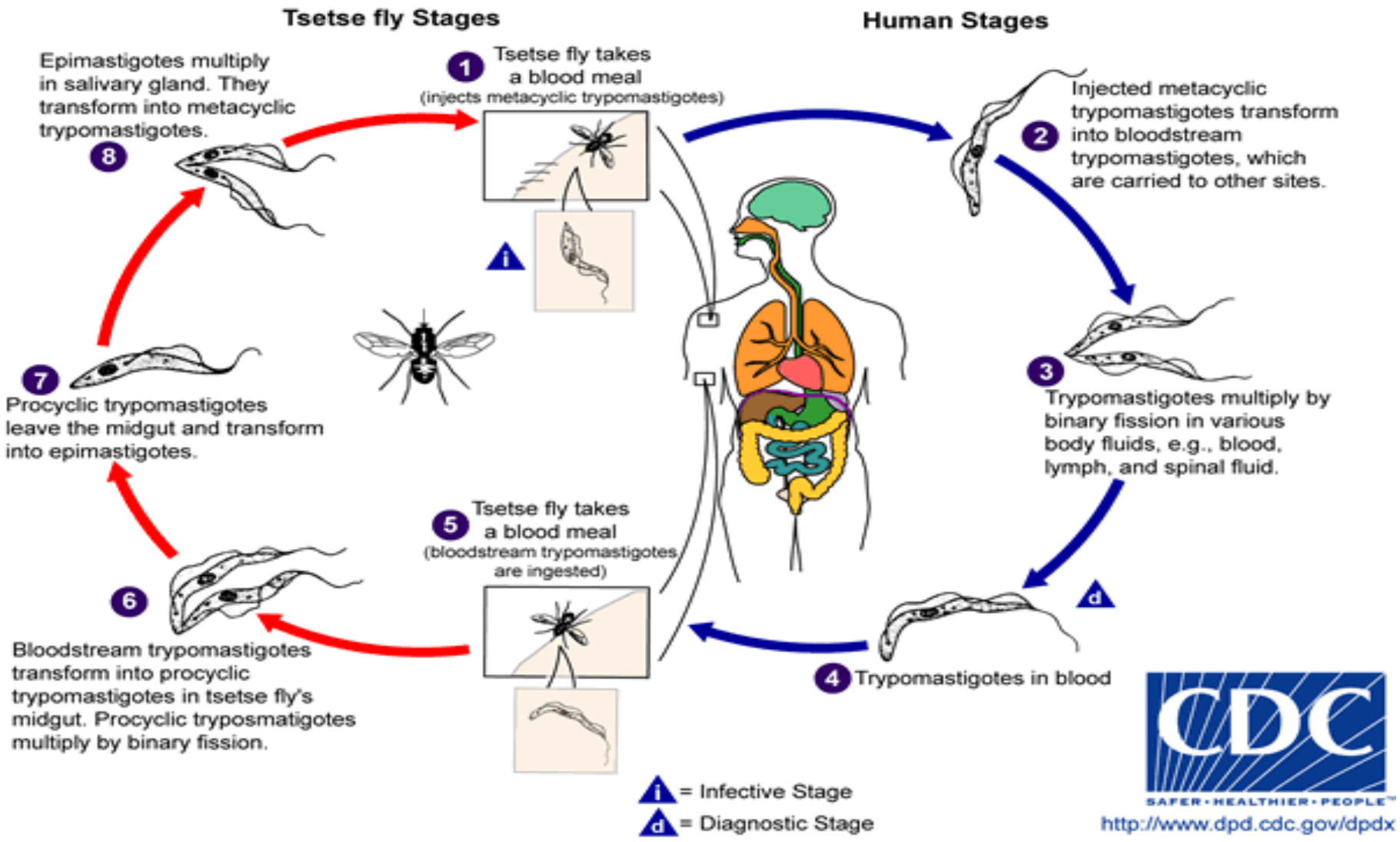
  - **Class Zoomastigophora** – the non-photosynthetic flagellates.

Blood parasites

- ***Trypanosoma brucei*** is common in central Africa causes **African sleeping sickness**/trypanosomiasis
- Disease associated with severe chronic **fatigue, coma, and can be fatal if left untreated.**
- *Trypanosoma brucei gambiense* and *T.b. rhodesiense* transmitted by tsetse fly
- **American sleeping sickness** (*trypanosoma cruzi*) vector riduvid bugs/kissing bugs

Euglena





- Broad and stocky, produced in an intermediate host, and infective for the definitive host.
- Procyclic

Trypanosoma

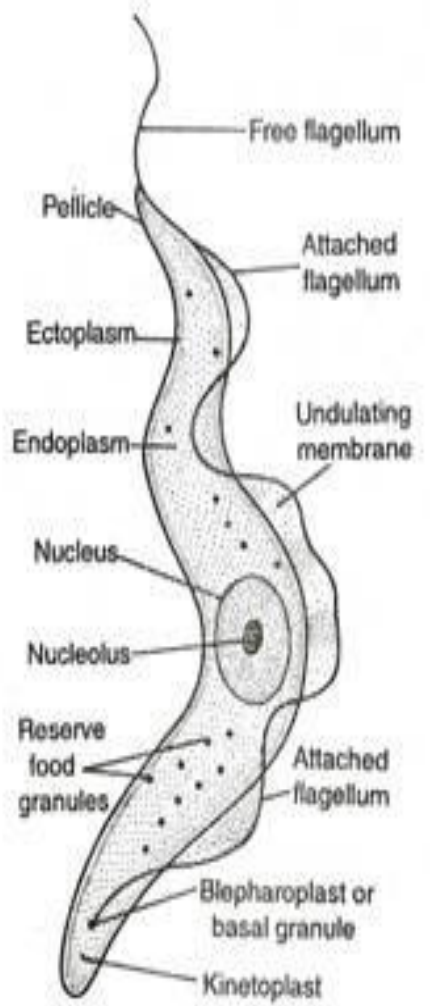
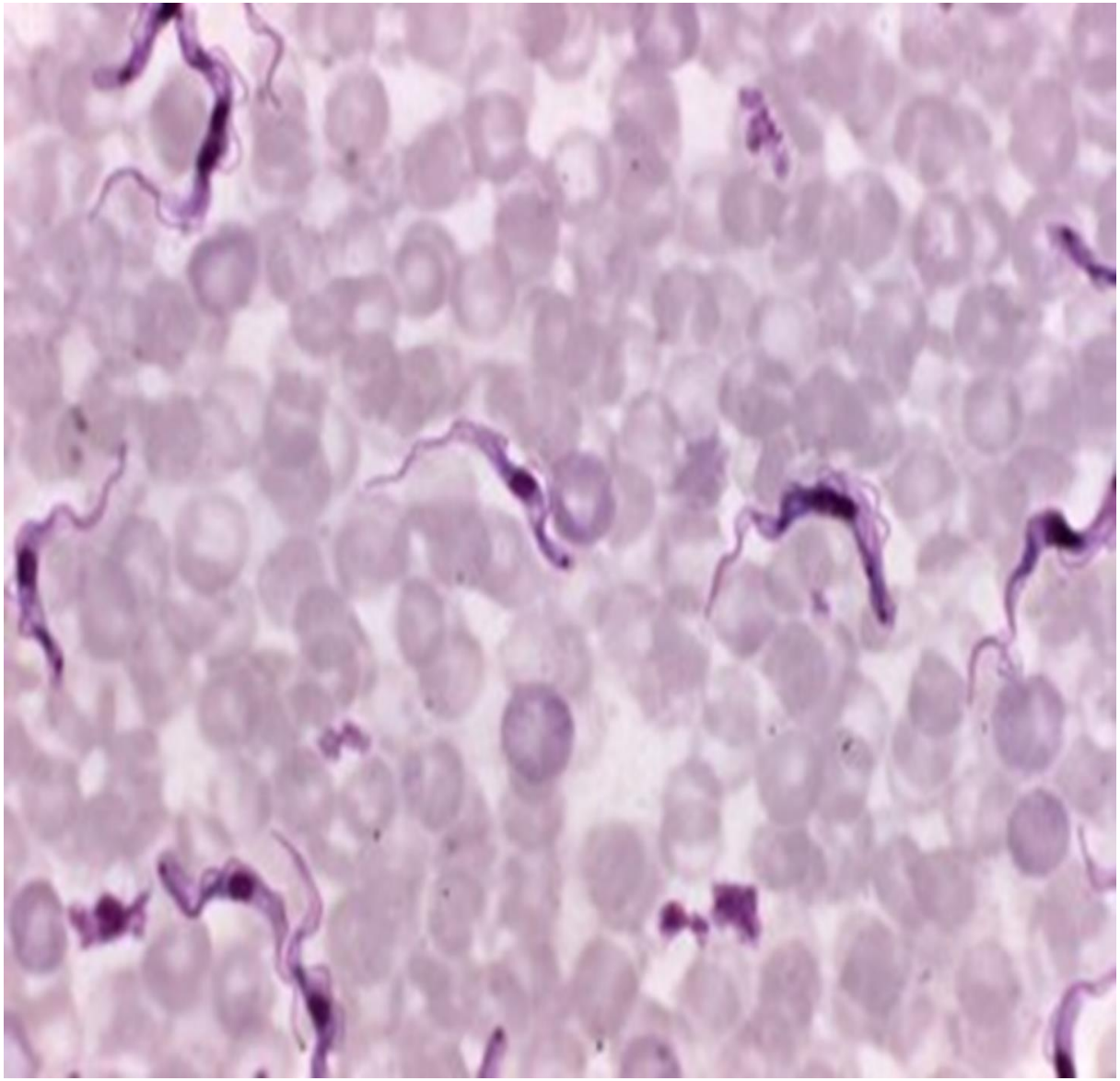
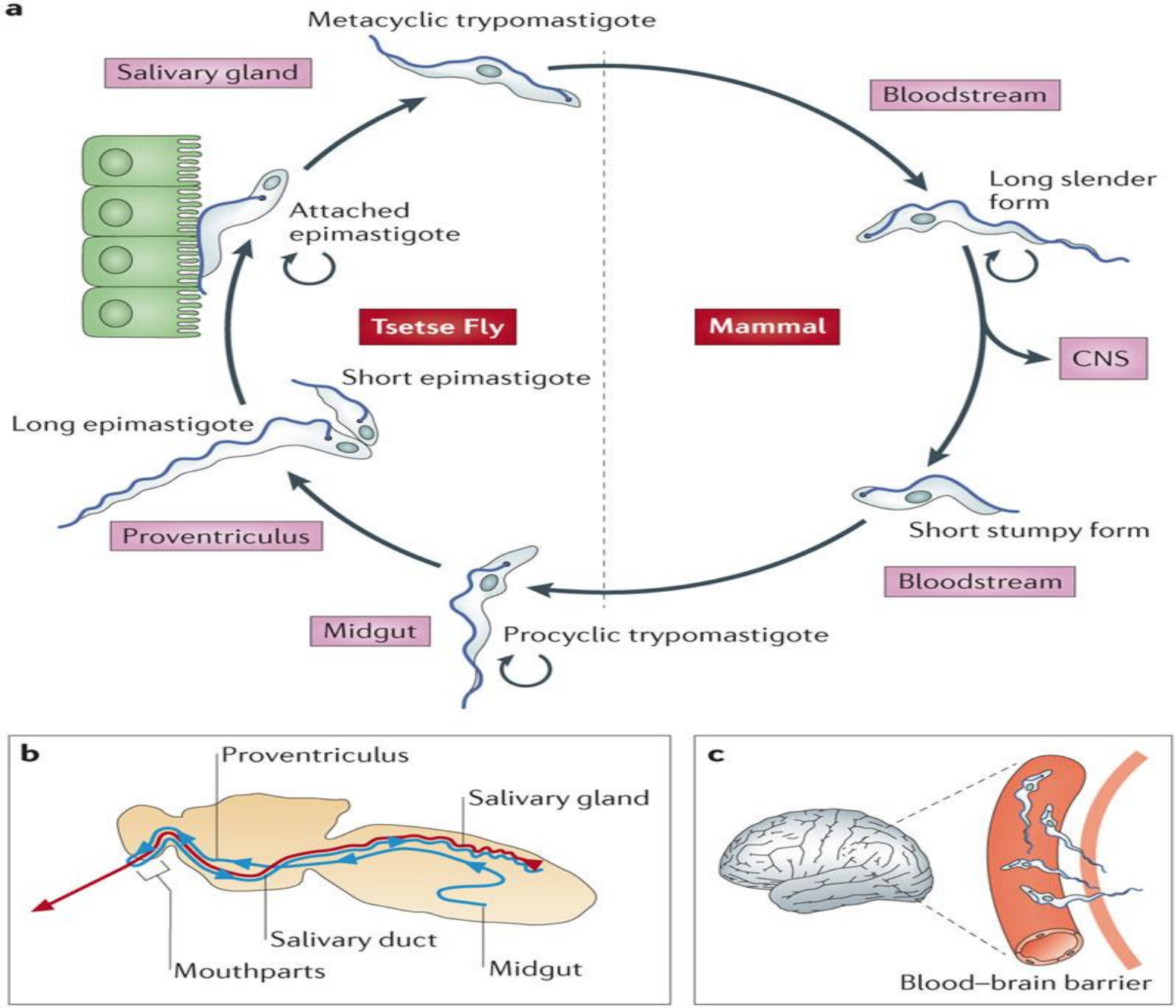


Fig. 183. *Trypanosoma gambiense.*




a
Metacyclic trypomastigote
Salivary gland
Bloodstream
Attached epimastigote
Long slender form
Tsetse Fly
Mammal
CNS
Short epimastigote
Long epimastigote
Short stumpy form
Proventriculus
Bloodstream
Midgut
Procyclic trypomastigote
b
Proventriculus
Salivary gland
Salivary duct
Mouthparts
Midgut
c
Blood–brain barrier

Tissue parasites

- Leishmania,
- Leishmaniasis, Kala-azar/black fever
- Attack the skin, liver, spleen
- Visceral, cutaneous and mucocuteneous leishmaniasis

Intestinal parasites,

- *Giardia lamblia, found in water bodies (contaminated)*
- Symptoms manifest themselves following an incubation period ranging from 3 to 25 days and include:
  - abdominal cramps,
  - stomach bloating,
  - intermittent episodes of diarrhoea, and tiredness.
- Diagnosis is achieved by laboratory examination of a faecal specimen.

Reproductive organs

- *Trichomonas vaginalis four flagellates, forms a trophozoites*

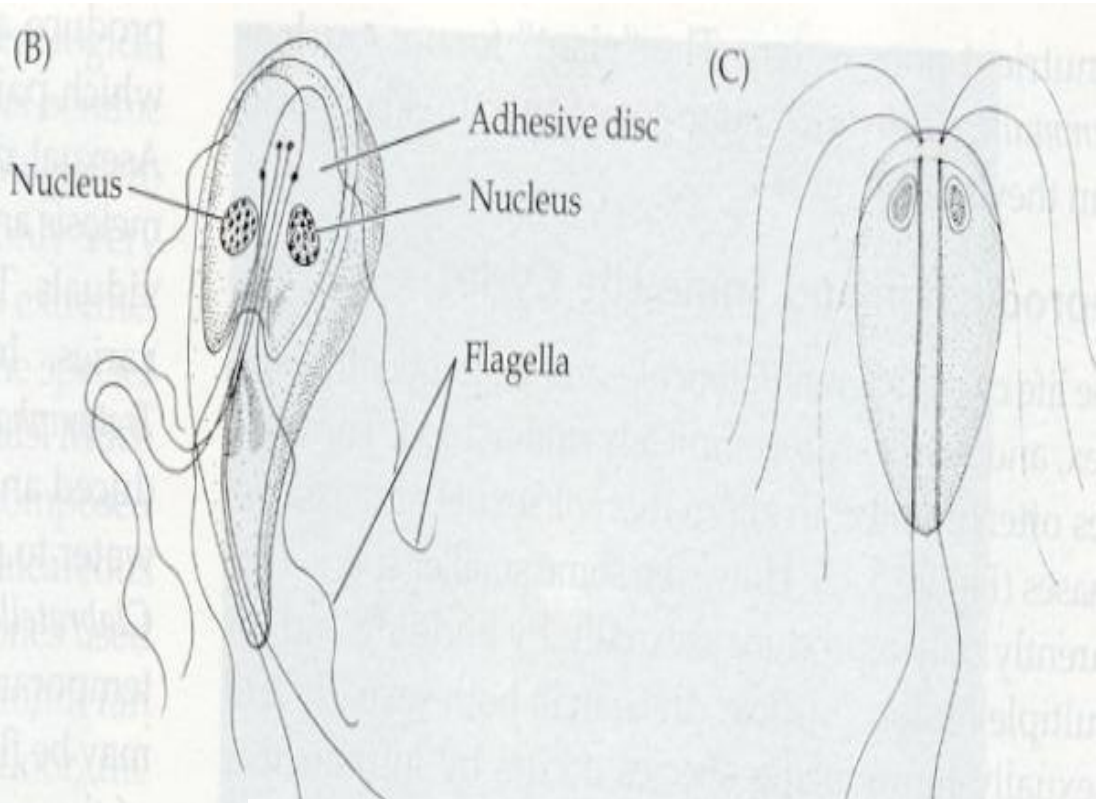


Figure 5.43 Phylum Diplomonadida. (A) *Giardia intestinalis* from human stool (length 12–15 µm). (B) Schematic drawings of *Giardia* and *Hexamita* (C), illustrating the paired nuclei and numerous flagella.

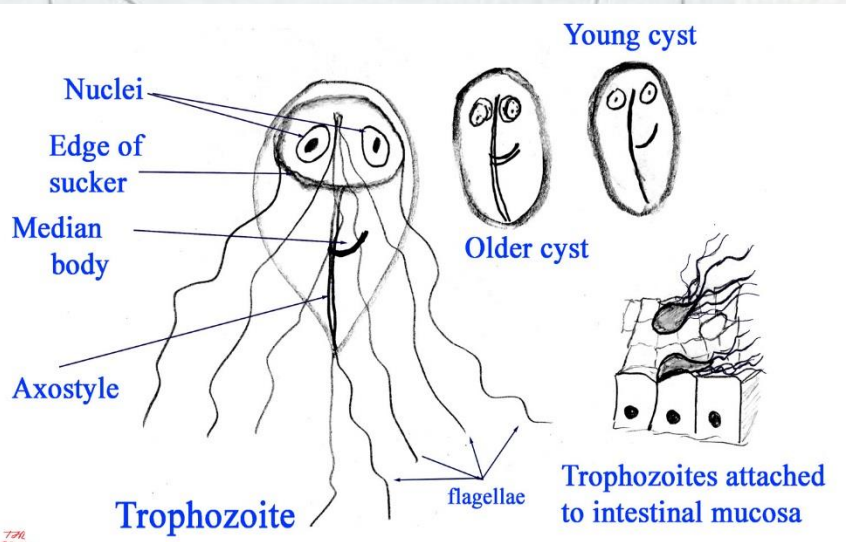
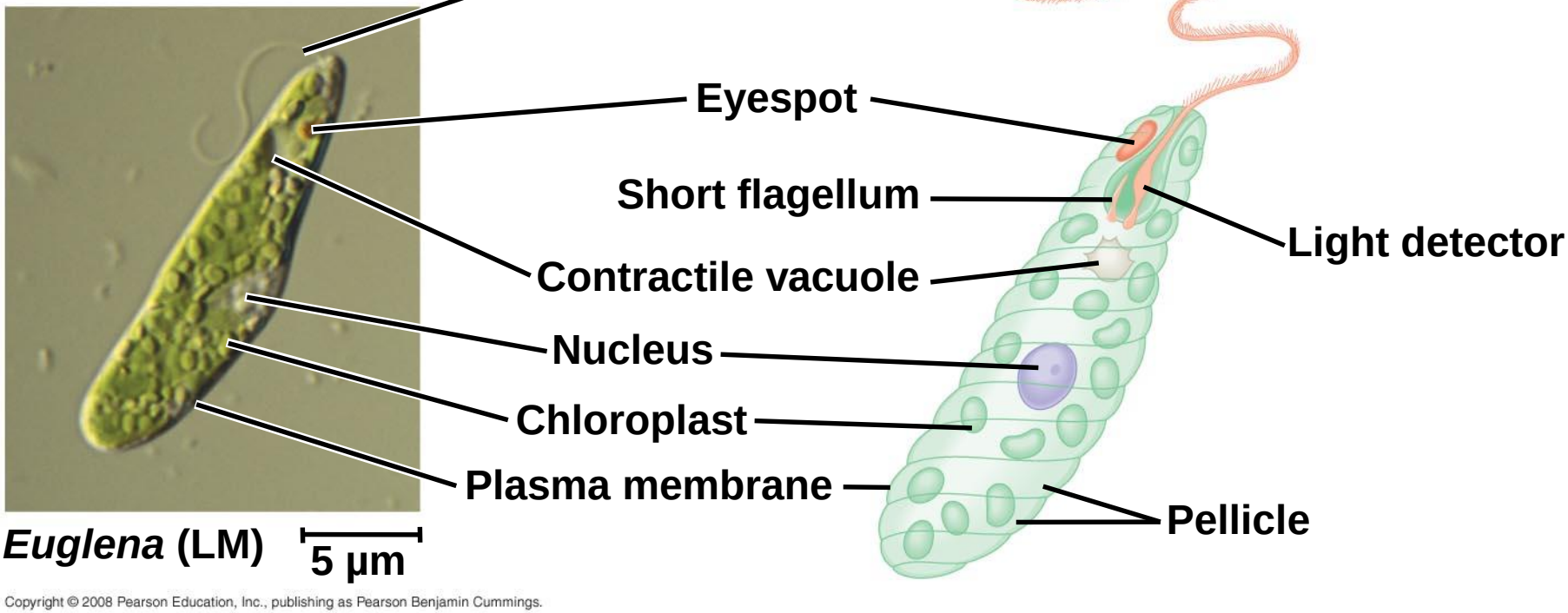
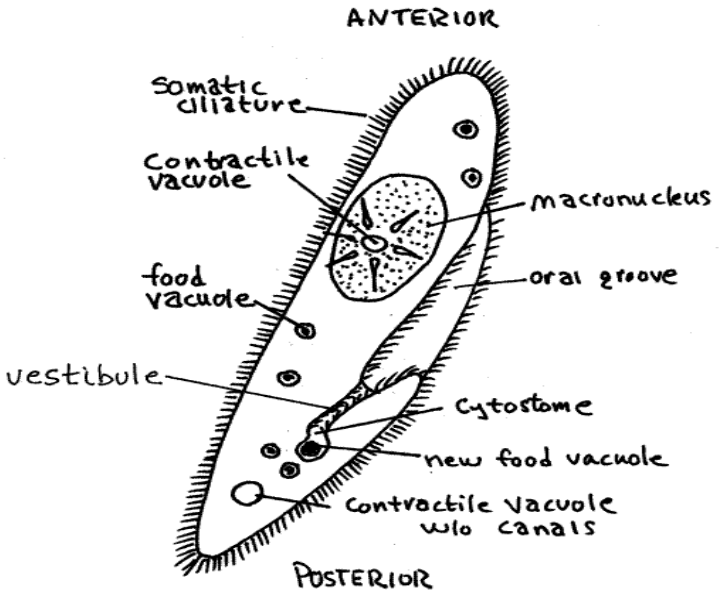


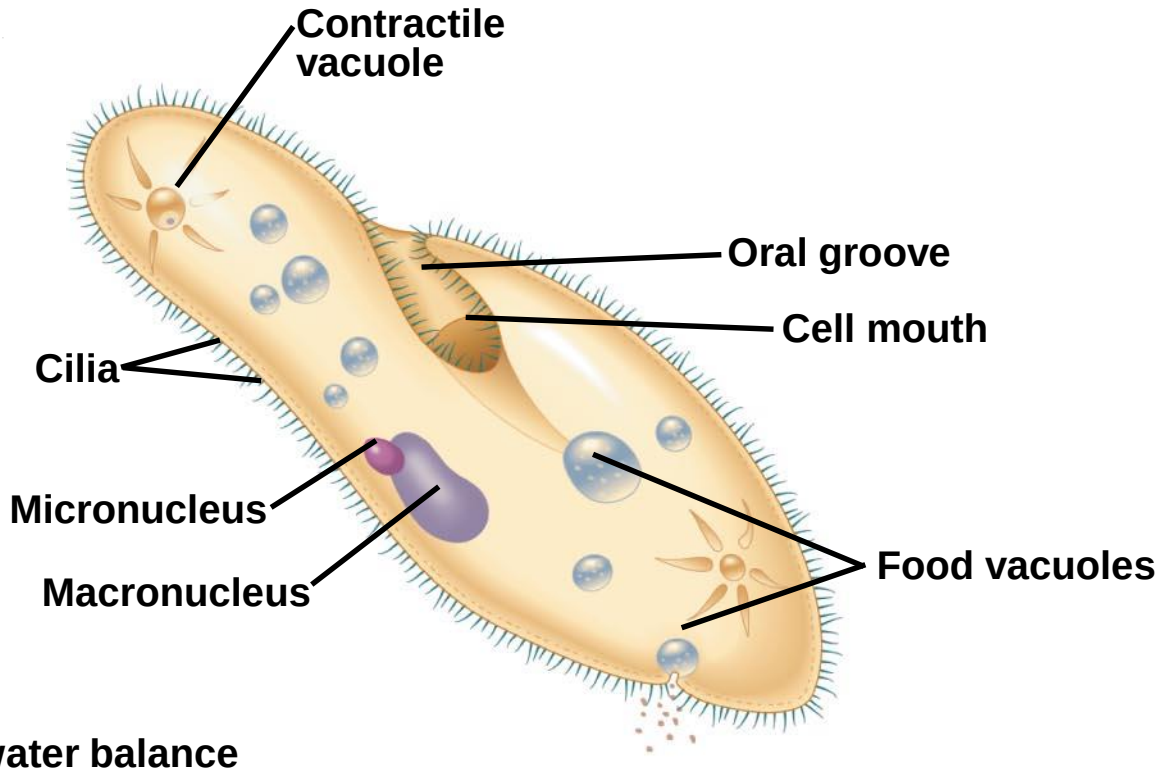
Fig. 28-07



CILIOPHORA
Ciliates

- **Ciliates**, a large varied group of protists, are named for their use of cilia to move and feed
- They have large macronuclei and small micronuclei
- The micronuclei function during conjugation, a sexual process that produces genetic variation
- Macronucleus performs the somatic functions of the organism
- The **pellicle** of *Paramecium* contains trichocysts used in defense
- Cilia of the oral groove move food particles (bacteria, small protozoa, organic particles) to the base of the groove where food vacuoles form in the cytopharynx.





50 µm

(a) Feeding, waste removal, and water balance

Reproduction

- **1. Asexual reproduction**

  a) Paramecium divides by transverse binary fission

  b) Both nuclei (macro and Micronuclei) increase in size

  c) They pull themselves apart

  d) Macronucles divides amitotically (random distribution of chromosomes between the two newly formed macronuclei

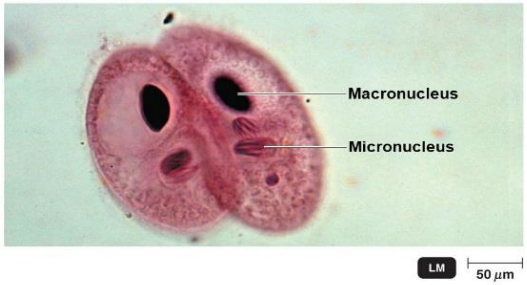
  e) micronucleus divide mitotically (spindle forming sharing of chromosomes done)

  f) Cytoplasmic constriction forms around the middle of the organism and separates into 2 daughter paramecium.

2. **Sexual Reproduction (conjugation)**

- Two compatible mating conjugants adhere to each other at their oral grooves
- the pellicle breaks down and a cytoplasmic bridge is formed
- Respective macronuclei disintegrate
- each micronucleus divides meiotically resulting into 4 daughter micronuclei
- Three micronuclei disintegrate and disappear.
- The surviving micronucleus divides once mitotically to form two identical gametic nuclei.
  - Exchange of the male gametes takes place across the cytoplasmic bridge to opposite conjugant.
  - Male and female fuse forming zygotic nucleus.

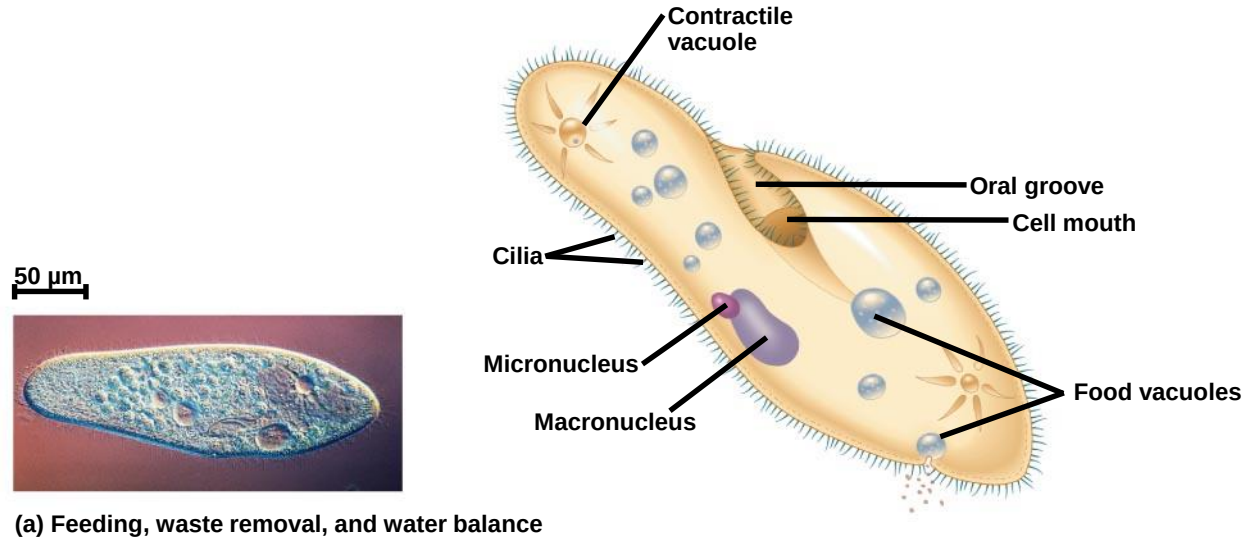
Figure 12.17 Conjugation in the ciliate protozoan *Paramecium*.



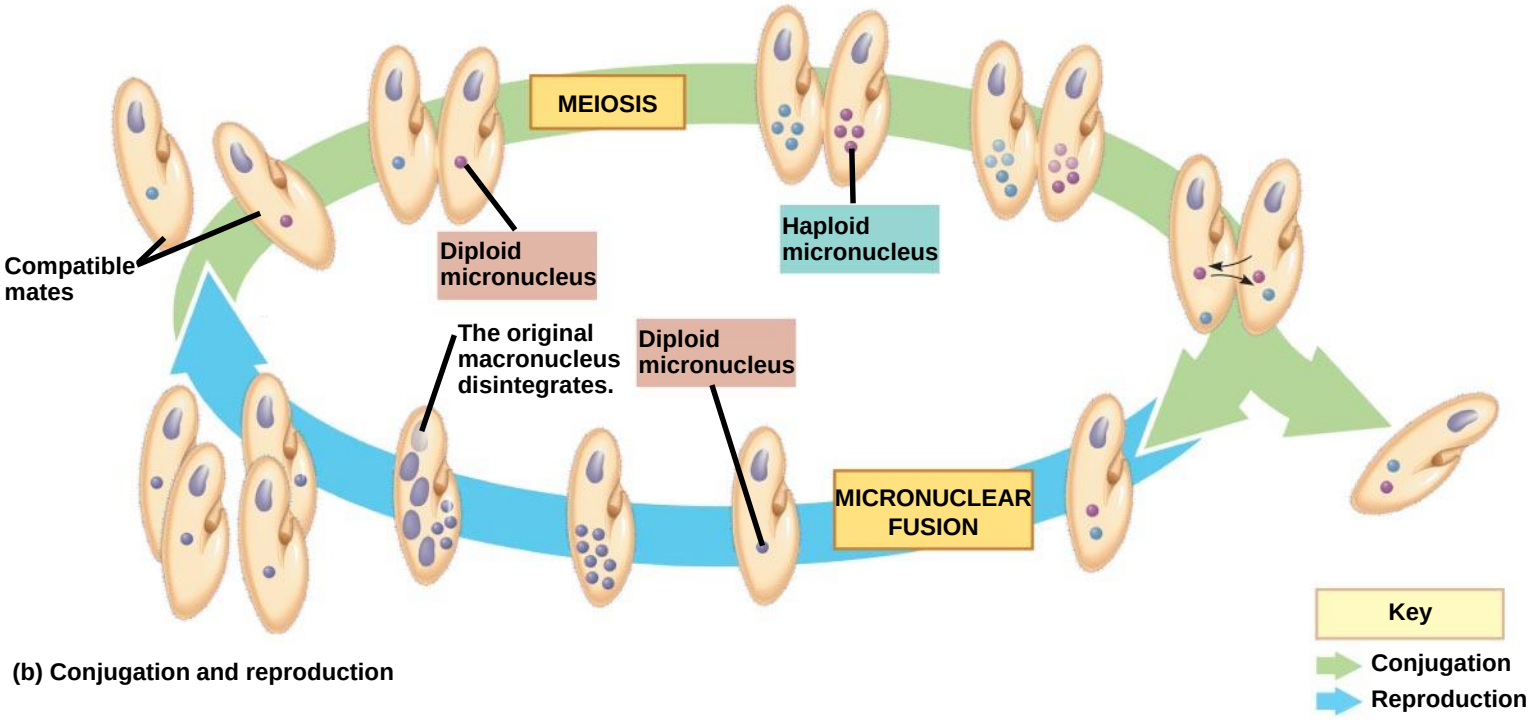
Conjugation cont..

- Conjugants separate and go independently.
  - Zygotic nucleus divides mitotically forming 8 daughter nuclei
  - Four transform into macronuclei and other four into micrinuclei
  - Three daughter micronuclei degenerate leaving only one
- The ex-conjugants undergo binary fission
- two macronuclei enter each new cell and micronucleus divides mitotically
  - further division takes place where the two macronuclei separate one going into separate cell and respective micronucleus dividing.
  - The result is 8 daughter cells from two separated ex-conjugants with four from each.

Fig. 28-11



(a) Feeding, waste removal, and water balance



(b) Conjugation and reproduction

Phylum Apicomplexa

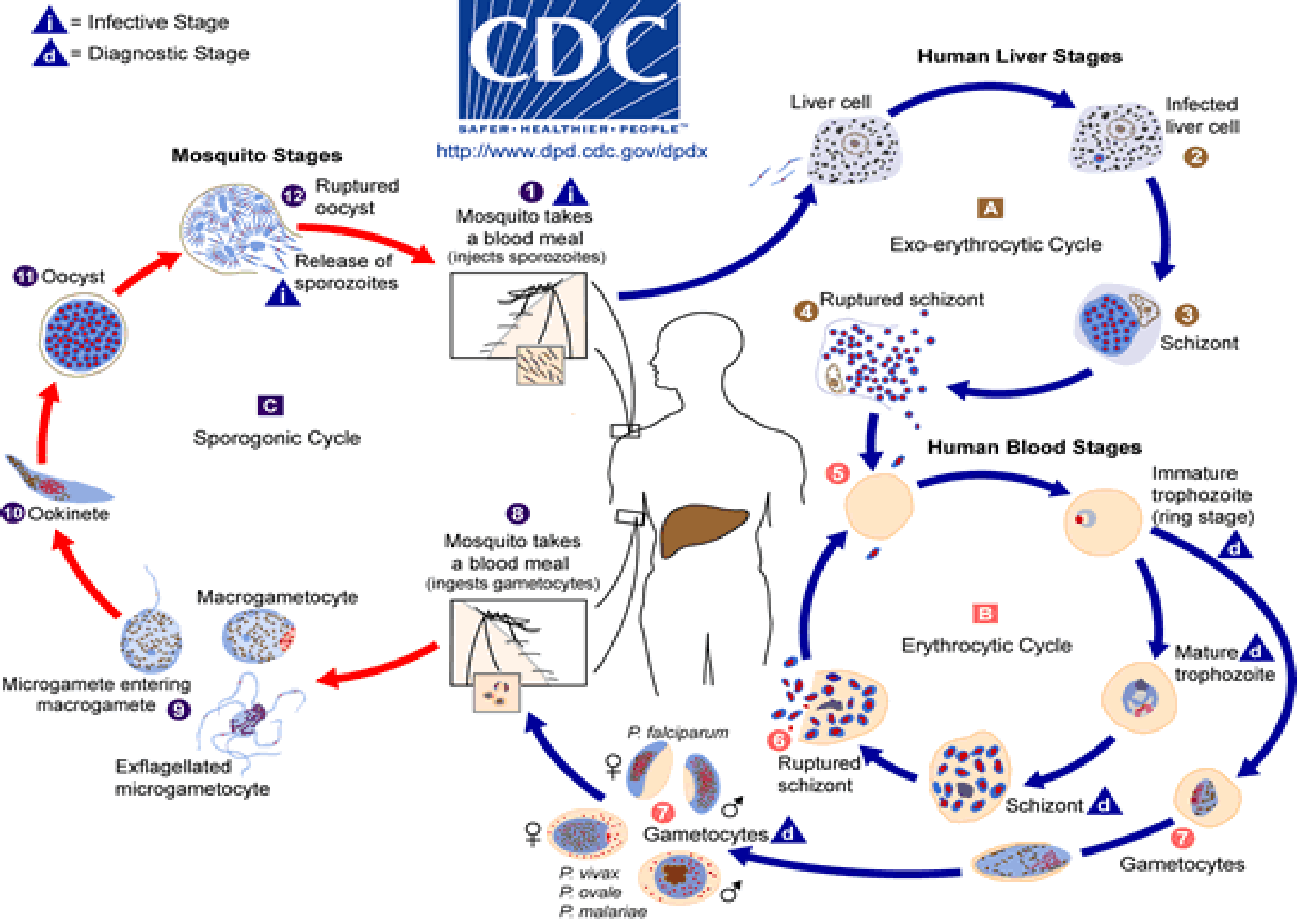
- **Apicomplexans** are parasites of animals, and some cause serious human diseases
- One end, the **apical complex**, contains a complex of organelles specialized for penetrating a host.
- Most have sexual and asexual stages (multiple fission) that require two or more different host species for completion

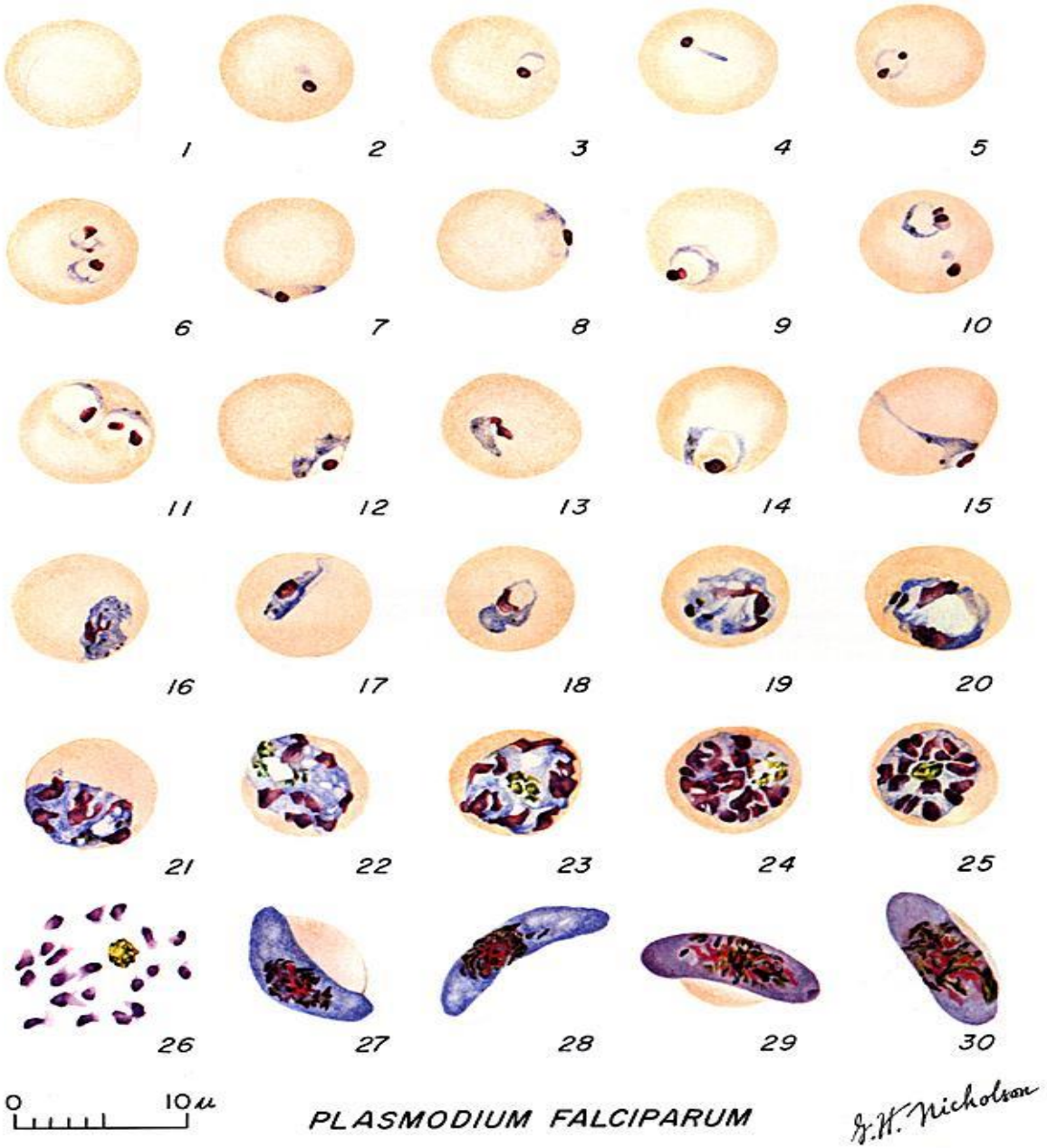
- The apicomplexan *Plasmodium* is the parasite that causes malaria
- *Plasmodium* requires both mosquitoes (female anopheles mosquito) and humans to complete its life cycle.
- Approximately 2 million people die each year from malaria.

Malaria

- Plasmodium mainly infect the liver cells and red blood cells in the human body. Main symptoms are seen with destruction of red blood cells and production of immune system elements in fighting produced merozoites.
- There are 300 to 500 million infected people worldwide, with 1 to 2 million deaths yearly, most in children < 5 yr in Africa.

  - Malaria is characterized by severe intermittent fever occurring every 48 or 72 hours, depending on the species.
  - The 48 hour fever is called **tertian** because it occurs every third day - fever on day 1, no fever on day 2, fever on day 3 and so on.
  - The 72 hour fever is called **quartan**, because it returns on every fourth day.
  - These vary from asymptomatic infections (no apparent illness),
  - the classic symptoms of malaria (**fever, chills, sweating, headaches, muscle pains**),
  - to severe complications (cerebral malaria, anemia, kidney failure) that can result in death.



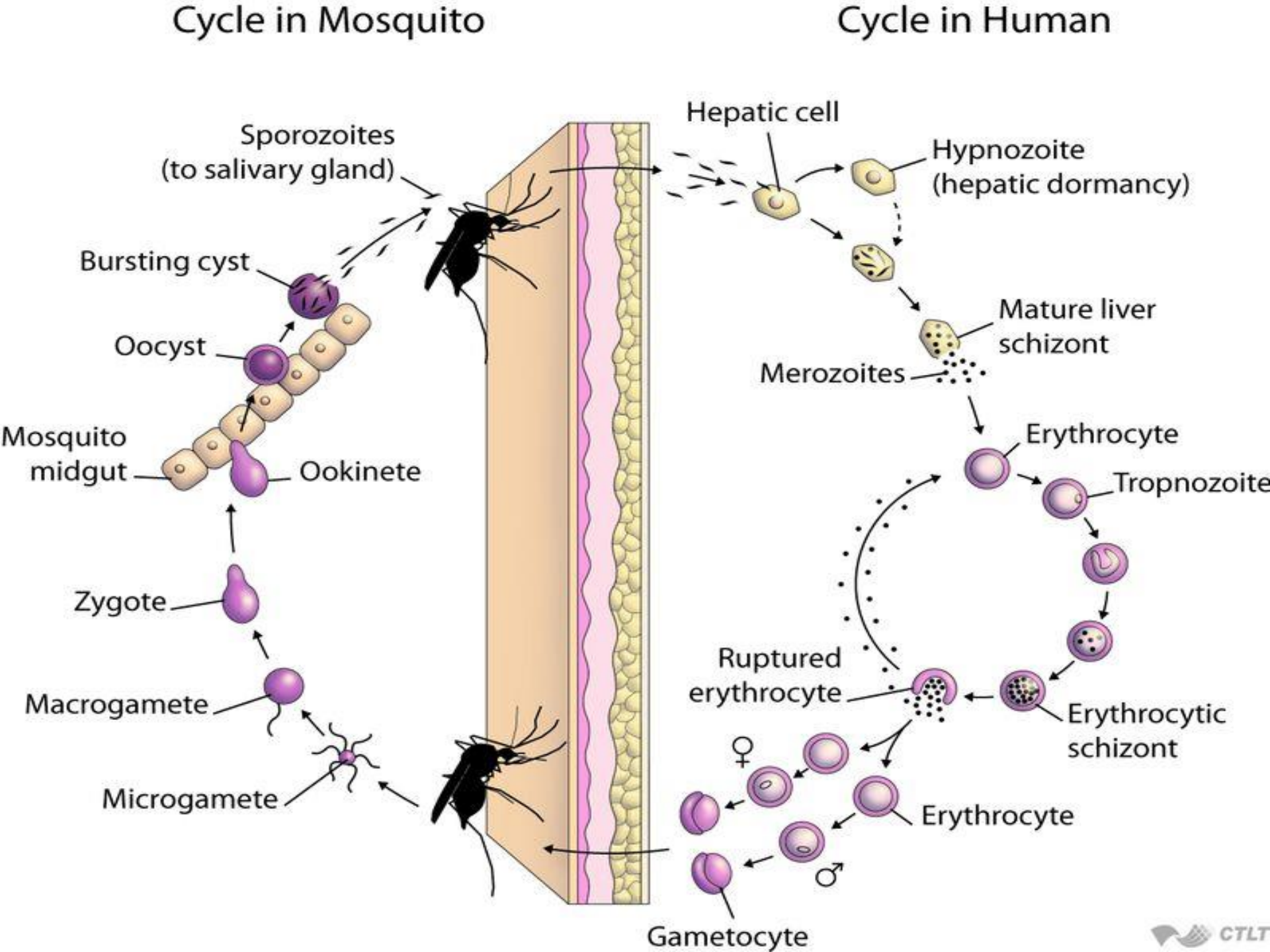


Life cycle of *Plasmodium* (malaria parasite)

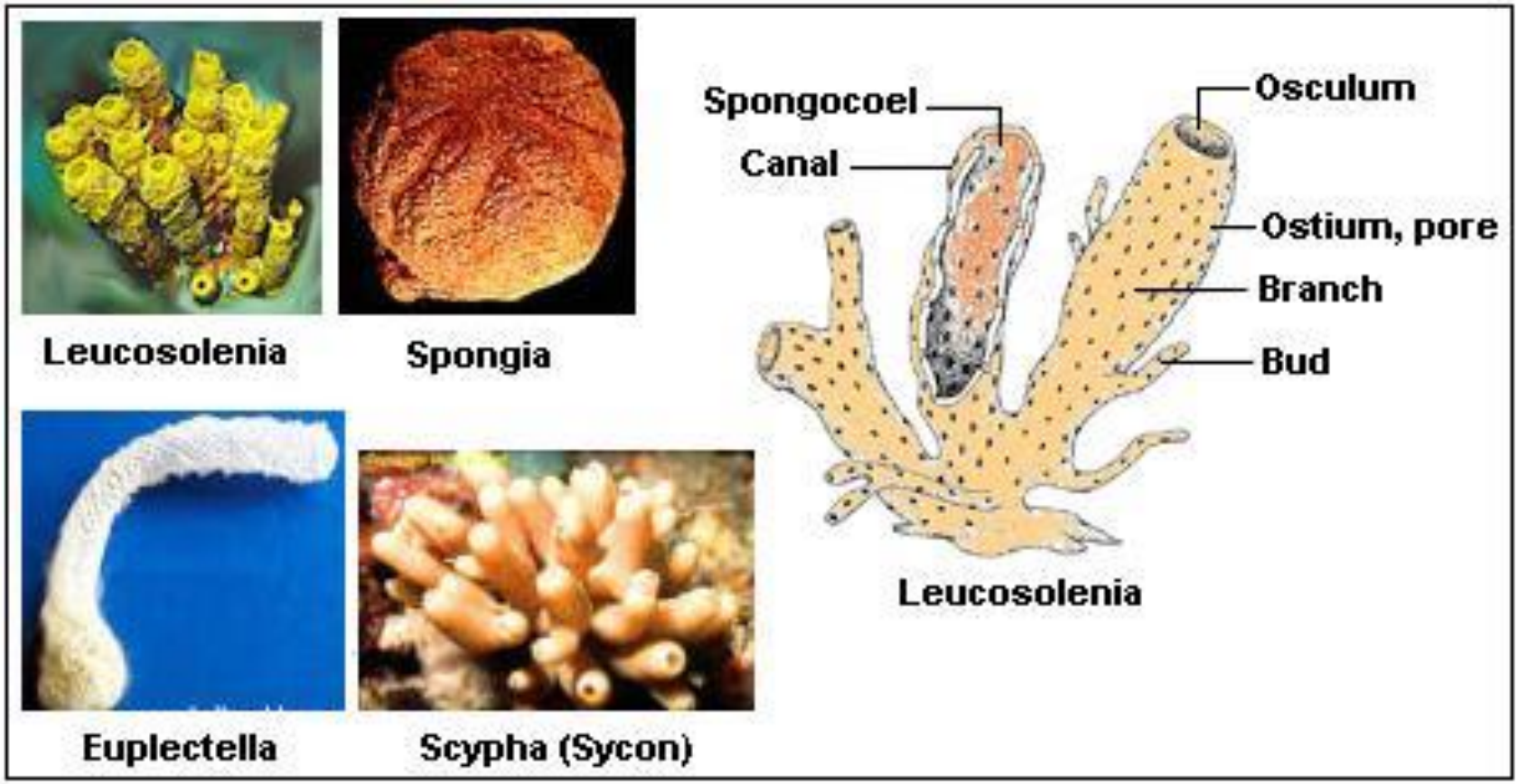
- The malaria parasite life cycle involves 2 hosts.
- During a blood meal, a malaria-infected female Anopheles mosquito injects sporozoites into the human host.
- Sporozoites infect liver cells.
- There, the sporozoites mature into schizonts.
- The schizonts rupture and release merozoites.
- This initial replication in the liver is called the exoerythrocytic cycle.
- Merozoites infect RBCs. There, the parasite multiplies asexually (called the erythrocytic cycle).
- The merozoites develop into ring-stage trophozoites. Some then mature into schizonts.
- The schizonts rupture, releasing merozoites.
- Some trophozoites differentiate into gametocytes.
- During a blood meal, an Anopheles mosquito ingests the male (microgametocytes) and female (macrogametocytes), gametocytes beginning the sporogonic cycle.

Prevention and control of malaria

- Avoid the parasite/ Female anopheles mosquito
  - Wear long sleeved clothes
  - Repellants
  - Screens on doors and windows
  - Being indoors after dusk
  - Using mosquito nets
- Biological
  - Sterile males
  - Viruses that will only attack the mosquitoes
- Chemical control
  - Using chemical/insecticides to kill mosquito population
- Environmental
  - Remove vegetation near settlements
  - Remove stagnant water
- Treatment/prophylaxis
  - Malaria Tablets or injections when going to malaria areas.


Cycle in Mosquito
Cycle in Human
Sporozoites
(to salivary gland)
Bursting cyst
Oocyst
Mosquito
midgut
Ookinete
Zygote
Macrogamete
Microgamete
Hepatic cell
Hypnozoite
(hepatic dormancy)
Mature liver
schizont
Merozoites
Erythrocyte
Tropnozoite
Ruptured
erythrocyte
Erythrocytic
schizont
Erythrocyte
Gametocyte

PORIFERA (SPONGES)



Classification of Porifera

i. **Class Calcarea:**
ii. **Class Hexactinellida:**
iii. **Class Demospongiae:**
iv. **Class Sclerospongiae**

Class Calcarea:
1. Calcareous Sponges
2. Skeletons are made-up of $CaCO_3$ spicules.

Class Demospongiae:
1. Natural sponges
2. Skeletons made-up of spongin or siliceous material (or both)

Class Hexactinellida:
1. Glass Sponges
2. Skeletons composed network of silaceous material

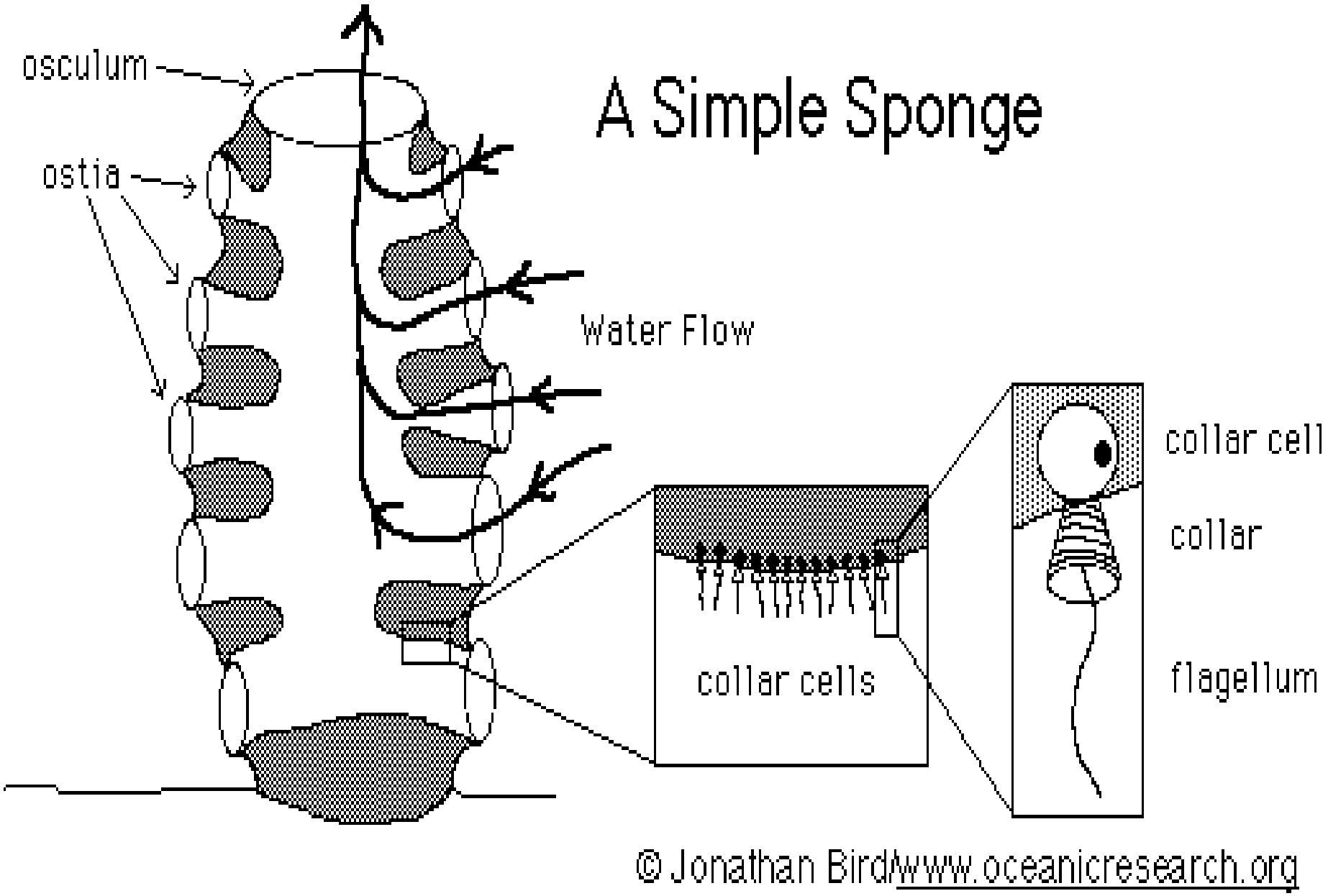
Class Sclerospongiae:
1. Coralline Sponges
2. Skeletons composed of silica, spongin , and $CaCO_3$

The Phylum Porifera/ Sponges

General Characteristics of Porifera:-

- Multicellular animals, body a loose aggregation of cells and body porous
- At cellular level of organisation
- All aquatic, mostly marine
- Body of pores, canals and chambers for water passage
- Radial symmetry or asymmetrical
- Body of two layers separated by a gelatinous mesohyl

- Skeleton of proteinaceous spongin which may or may not be impregnated with calcium or silica
- Filter feeders with intracellular digestion
  - by archaeocytes,
  - by phagocytosis by choanocytes and pinocytosis also present
- Adults sessile, larvae (amphiblastula) motile
- reproduction asexual(fragementation) and sexual
  - Sponges are hermaphroditic -produce egg (ova) and sperm
  - they produce ova and sperm at different times of the year.
  - Eggs and sperm are produced by the amoebocytes .
- **Osmoregulation** -- as in the protozoans, water balance is maintained across the cell membrane by osmosis.
  - Freshwater sponge cells usually have contractile vacuoles.



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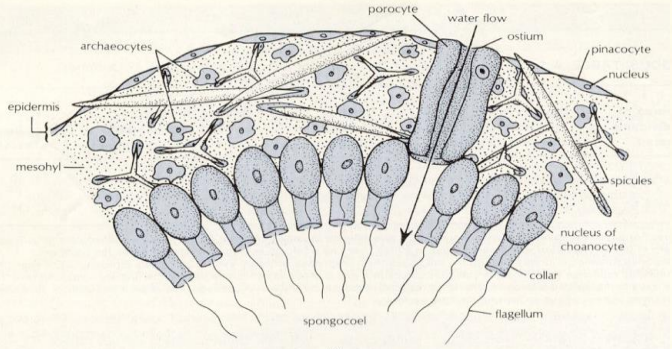
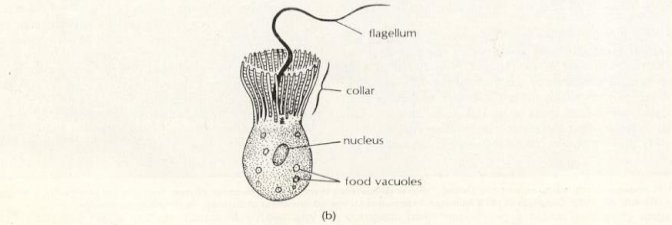
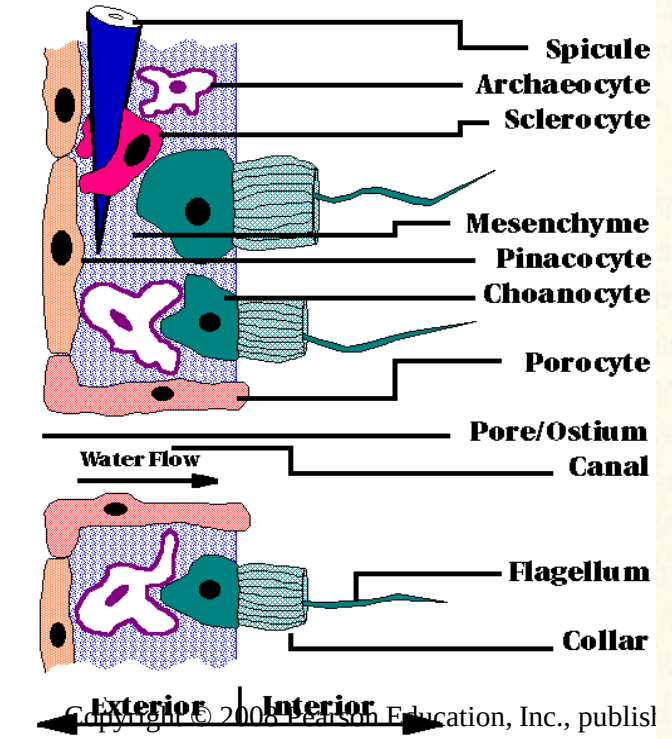
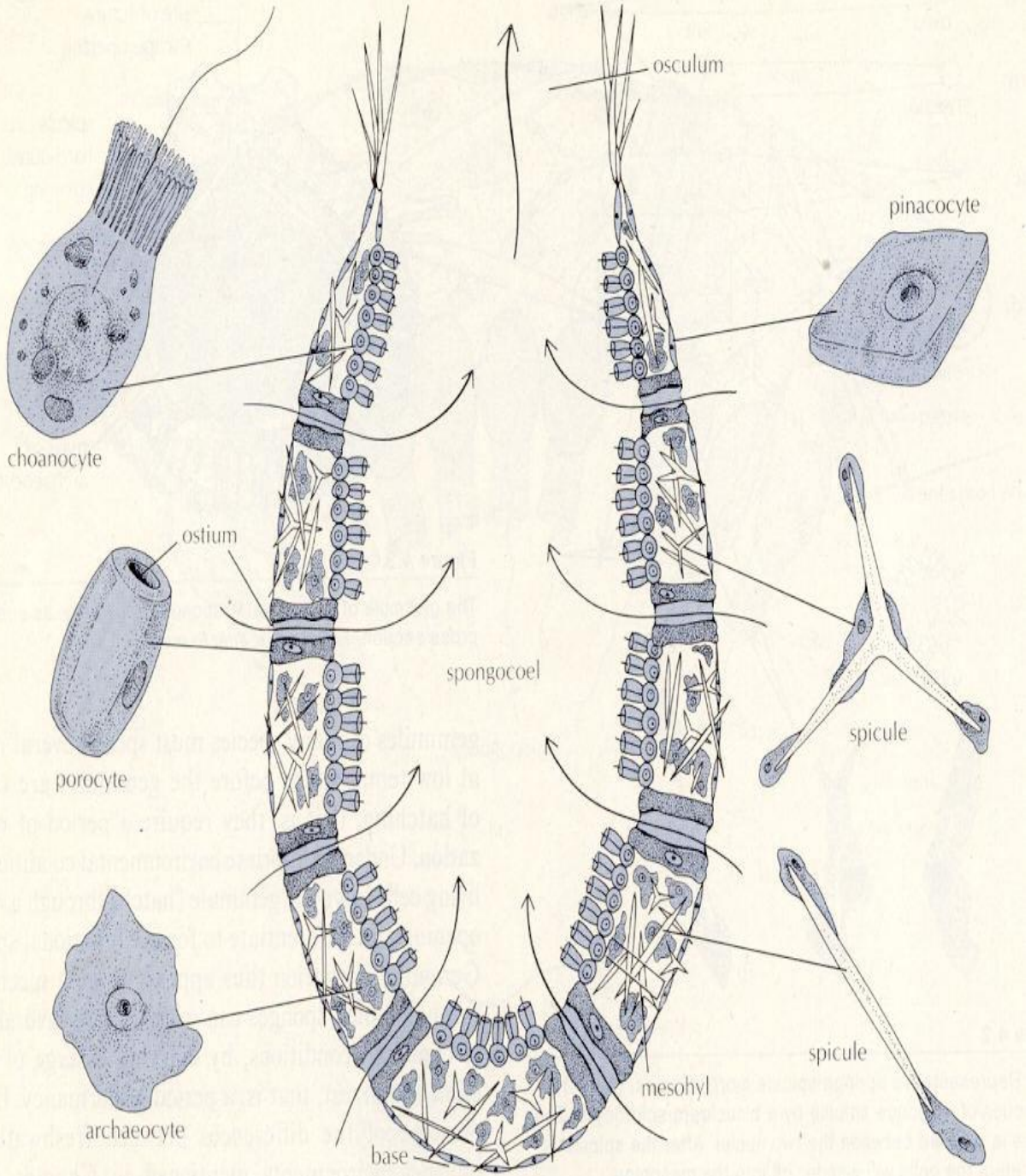




MICROSCOPIC VIEW OF A PORIFERAN WALL





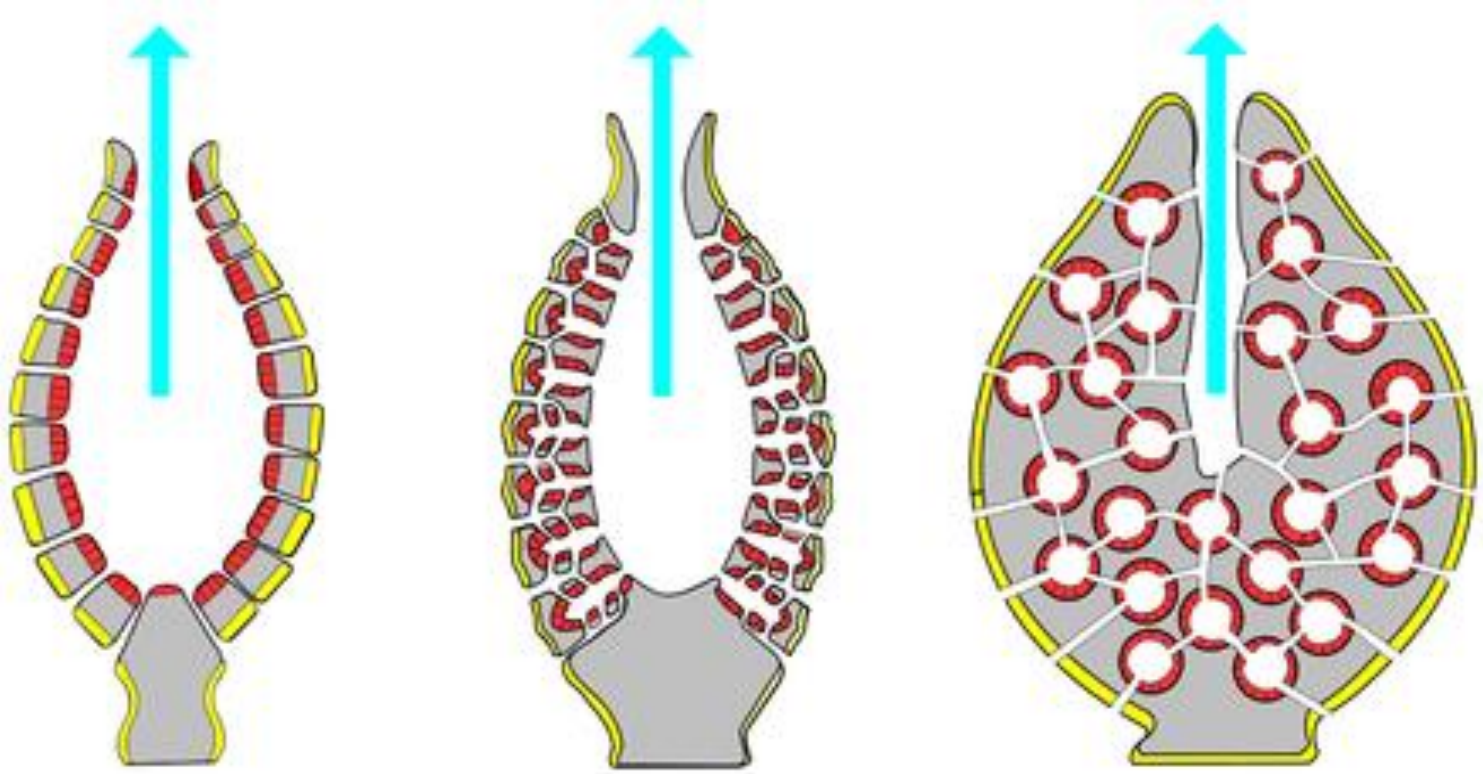
Cell functions in sponges

- **Choanocytes** (collar cells) used to filter particles out of the water. They **function as the sponge's digestive system**, The beating of the choanocytes' flagella creates the sponge's water current.
- **Porocytes** are tubular cells that make up the pores into the sponge body through the mesohyl.
- **Pinacocytes** which form the pinacoderm, the outer epidermal layer of cells. This is the closest approach to true tissue in sponges
- **Myocytes** are modified pinacocytes which control the size of the osculum and pore openings and thus the water flow.

- **Archaeocytes** (or **amoebocytes**) have many functions;
  - they are **totipotent** cells which can transform into ***sclerocytes***, ***spongocytes***, ***or collencytes***.
  - They also have a role in nutrient transport and sexual reproduction.
- **Sclerocytes** secrete calcareous siliceous spicules which reside in the mesohyl.
- **Spongocytes** secrete spongin, collagen-like fibers which make up the mesohyl.
- **Collencytes** secrete collagen.
- **Spicules** are stiffened rods or spikes made of calcium carbonate or silica which are used for structure and defense.

Body types of sponges

- **Asconoid**
  - water passes directly from the outside through the pores into the spongocoel.
  - The spongocoel is lined by cells called choanocytes.
  - The water exits the sponge through the osculum.
- **Syconoid**
  - The walls of the sponge contain canals through which the water must circulate before it enters the spongocoel.
  - Incurrent canals carry water from the outside and are lined with pinacocytes, Pores connect the incurrent canals with the radial canals, which empty into the spongocoel.
  - The radial canals are lined with choanocytes.
- **Leuconoid**
  - the walls are complex, with small chambers connecting the incurrent canals with the spongocoel.
  - The chambers are termed "flagellated chambers" because they are lined with choanocytes.



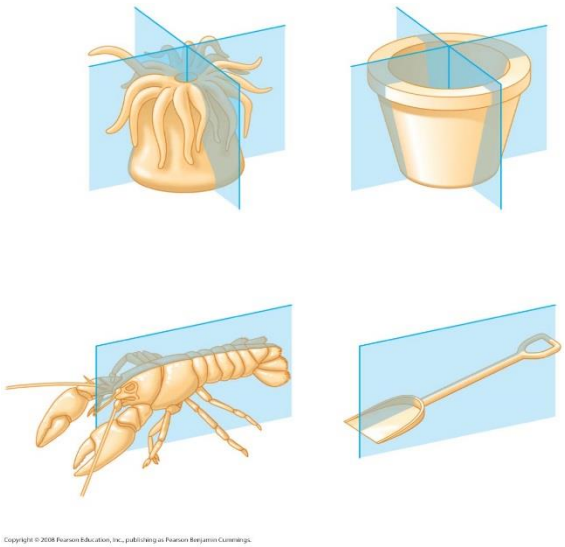
Asconoid **Syconoid** **Leuconoid**

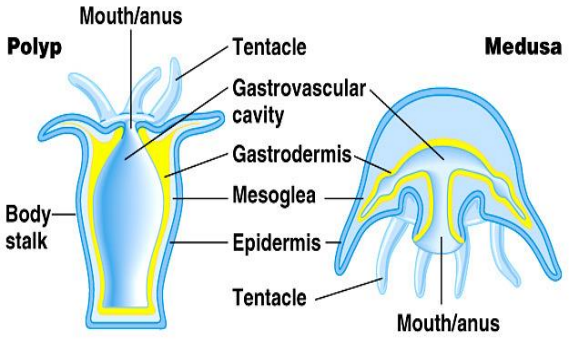
PHYLUM - CNIDARIA
Diploblastic radiata

- The phylum **Cnidaria** - unique stinging cells called **cnidocyte**s
- As a marine group, they are reasonably successful animals.
- The phylum includes such animals as plant like hydroids, **colourful** sea anemones, graceful jellyfish and the **reef forming corals**.
- **There are four main classes of Cnidaria:**
- Class Anthozoa (anemones, corals, etc.)
- Class Scyphozoa (jellyfish)
- Class Cubozoa (box jellies)
- Class Hydrozoa (Obelia, Aequorea, Portuguese Man o' War, etc.)

Phylum General Characteristics

- Multicellular, metazoan animals which are radially symmetrical about an oral - aboral axis.
- Two types of body forms, **medusae and polyps**.
- The animals have reached the **tissue level of organisation**.
- The bodies are derived from two embryonic cell layers (diploblastic), the **ectoderm and endoderm** which are separated by a third gelatinous layer called the mesoglea (this is not the same as "Mesoderm").
- The main body cavity, the gastrovascular cavity has a single opening that serves as both the mouth and anus.





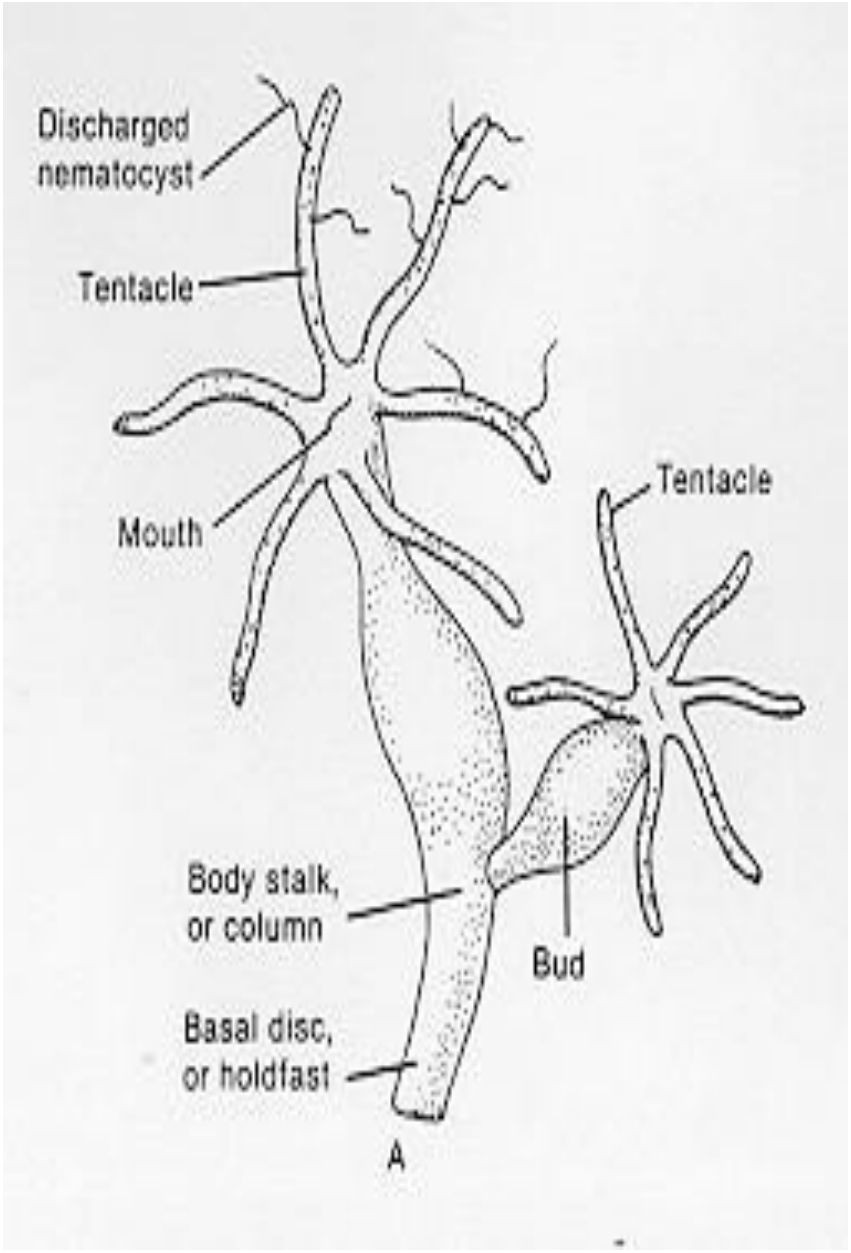
(a) Sea anemone: a polyp

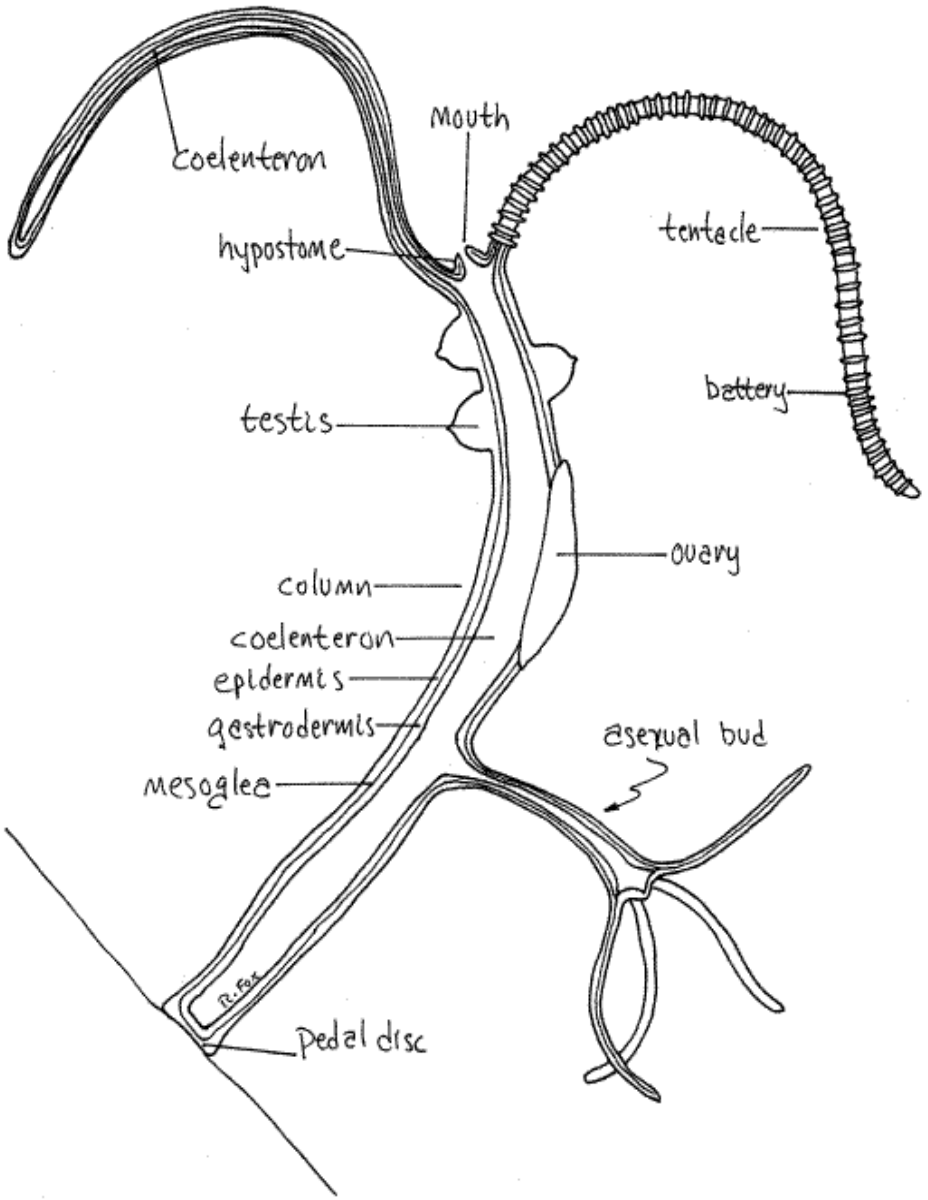
(b) Jelly: a medusa

- Support of the organisms is generated either through a calcareous exoskeleton or through a rudimentary hydrostatic skeleton.
- The inner, outer or both surfaces are possess special stinging cells, cnidocytes.
- Locomotion and co-ordination are generated by epithelio-muscular cells and a primitive nerve net.
- The animals have no excretory, circulatory or respiratory systems.
- They experience **POLYMORPHISM** presence of more than one functionally and structurally different types of individuals
  - -**polyp**- hydroid form, sessile (live single or in colonies)
  - -**medusa**- jelly fish form, floating or free swimming appear quite different but retain sac like structure w/tentacles around mouth
- Reproduction is by asexual budding or sexual reproduction.

Table 33.1 Classes of Phylum Cnidaria

Class and Examples	Main Characteristics
Hydrozoa (Portuguese man-of-wars, hydras, *Obelia*, some corals)	Most marine, a few freshwater; both polyp and medusa stages in most species; polyp stage often colonial
Scyphozoa (jellies, sea nettles)	All marine; polyp stage absent or reduced; free-swimming; medusae up to 2 m in diameter
Cubozoa (box jellies, sea wasps)	All marine; box-shaped medusae; complex eyes; potent venom
Anthozoa (sea anemones, most corals, sea fans)	All marine; medusa stage completely absent; most sessile; many colonial


Discharged nematocyst
Tentacle
Mouth
Tentacle
Body stalk, or column
Bud
Basal disc, or holdfast
A


coelenteron
Mouth
hypostome
tentacle
battery
testis
ovary
column
coelenteron
epidermis
gastrodermis
mesoglea
asexual bud
Pedal disc

NEMATOCYSTS

Functions

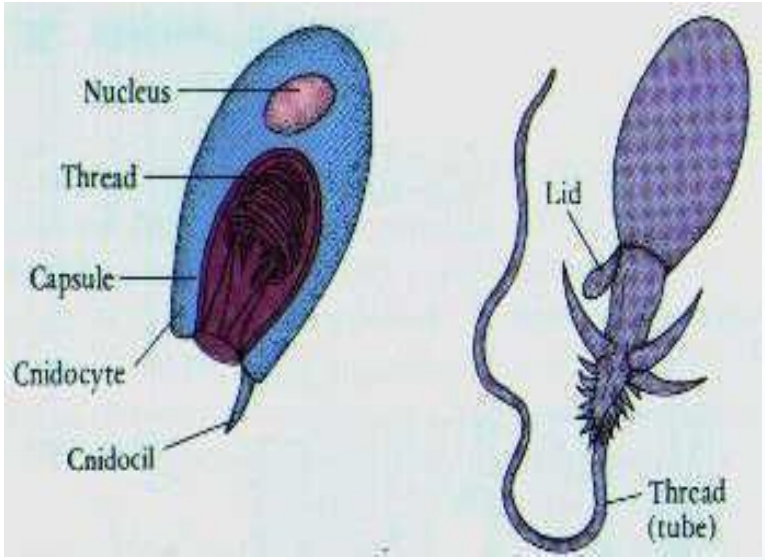
- **anchorage,**
- **defense and prey capture-**

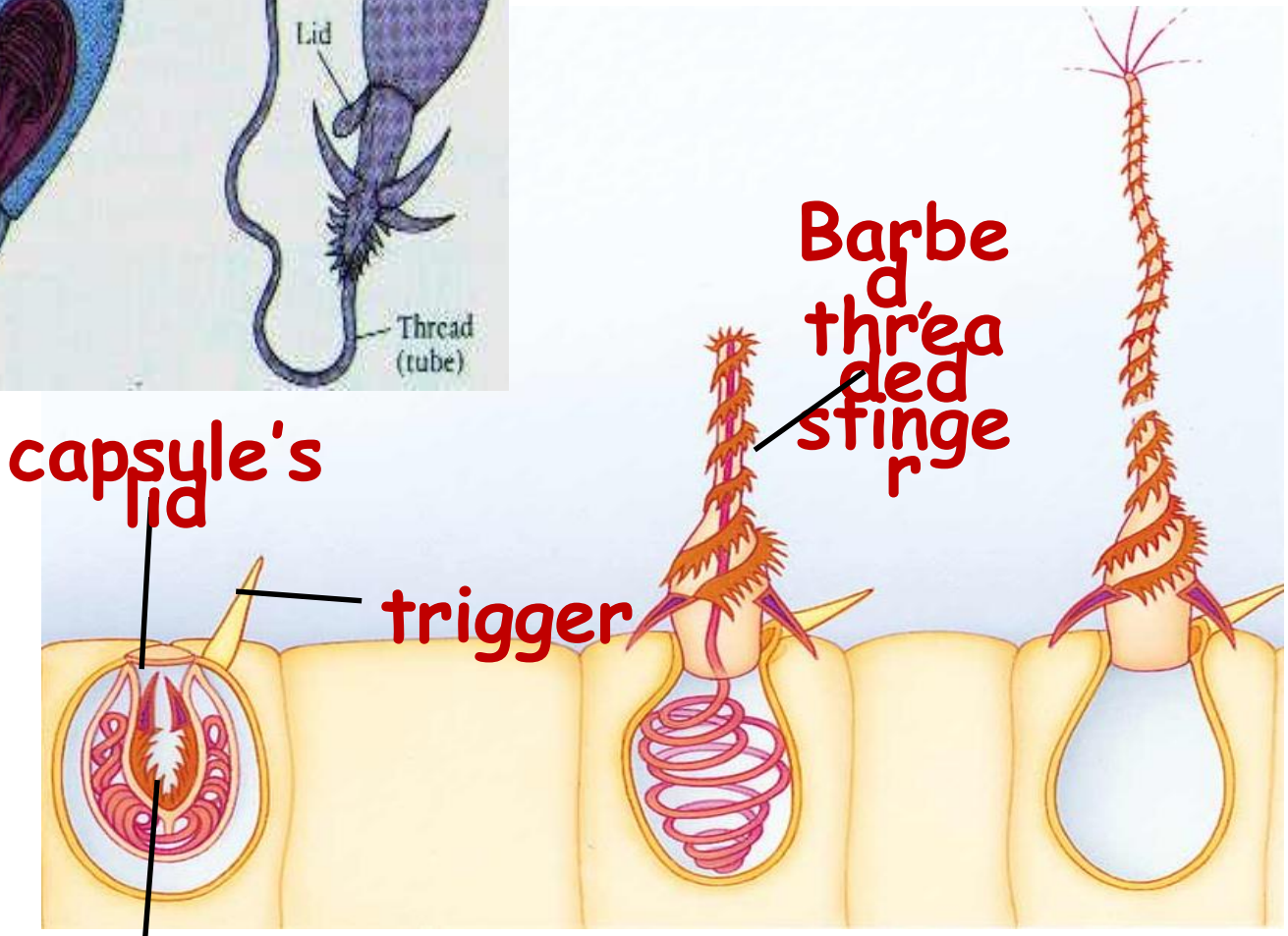
  Nematocyst could also be used as a basis of taxonomy for different species of Cnidaria; predators are also able to use nematocysts for identifying them in the quest for preys

Nematocyst types

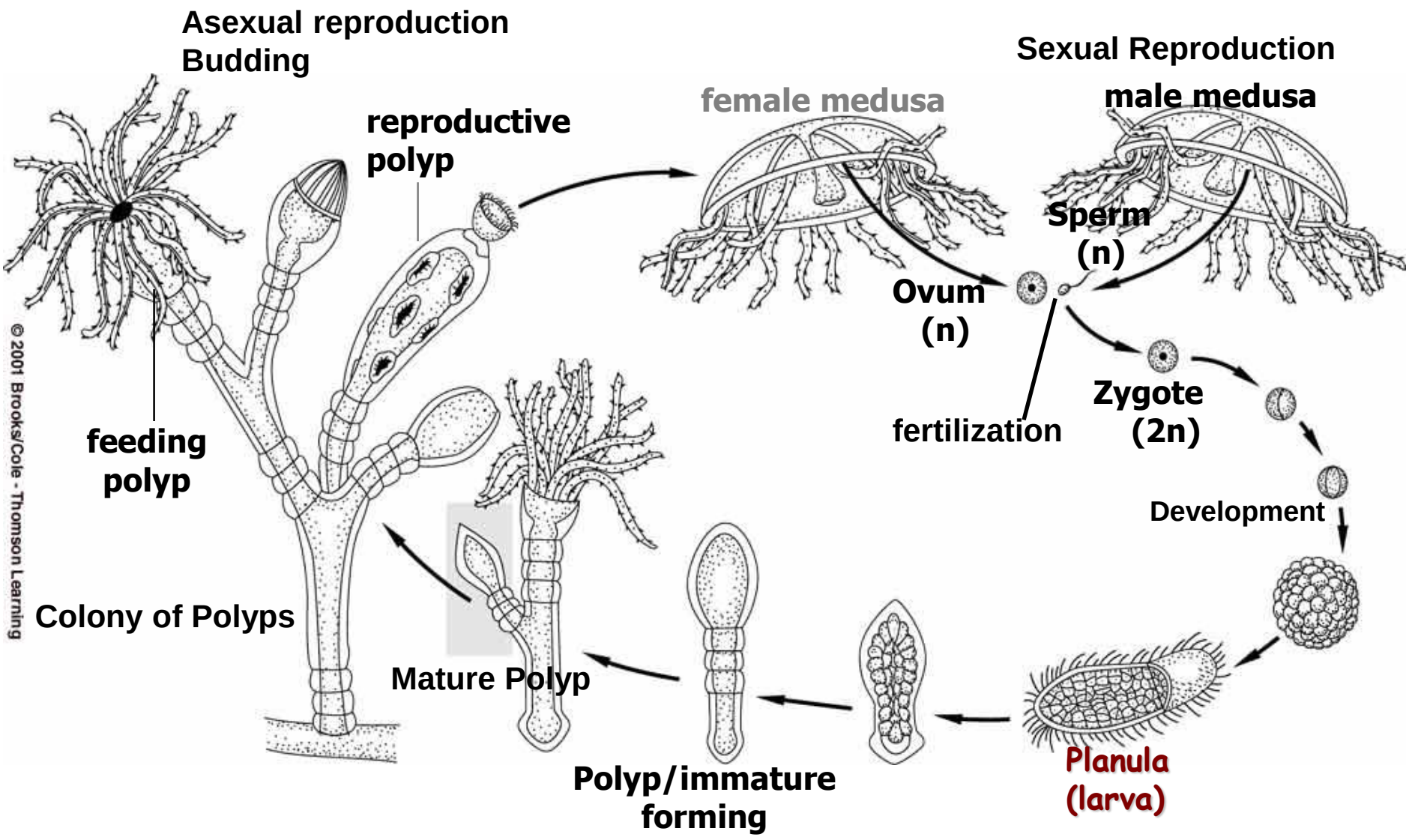
- **Volvent- entangles**
- **Penetrant- penetrates prey, injects toxin**
- **Glutinant- sticky, anchorage**
- **Discharge- chemical or mechanical discharge.**

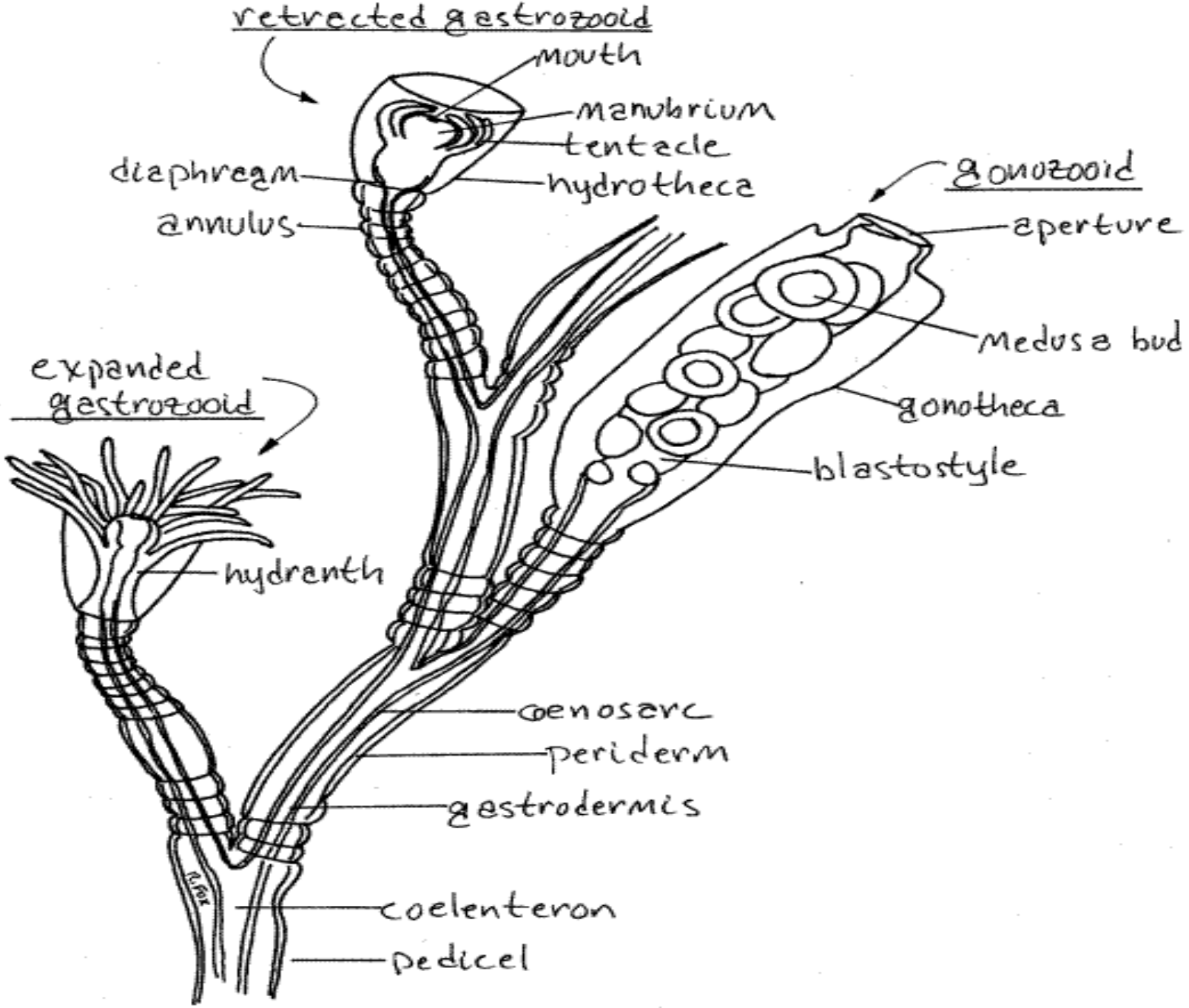
Nematocyst





Obelia Life Cycle (Hydrozoan)




retracted gastrozooid
mouth
manubrium
tentacle
diaphragm
hydrotheca
annulus
gonozooid
aperture
medusa bud
expanded gastrozooid
gonotheca
blastostyle
hydranth
coenosarc
periderm
gastrodermis
coelenteron
pedicel

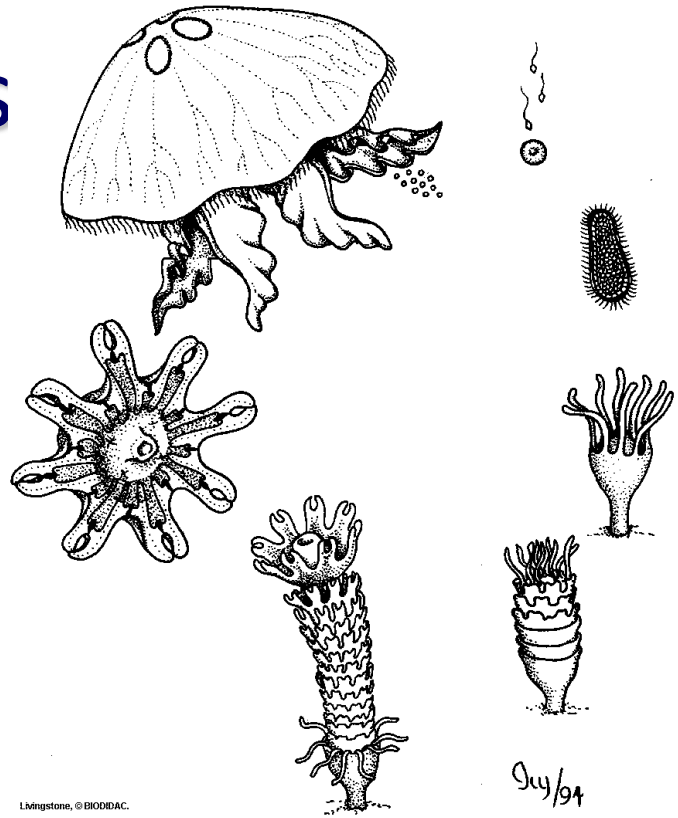
Cubozoans

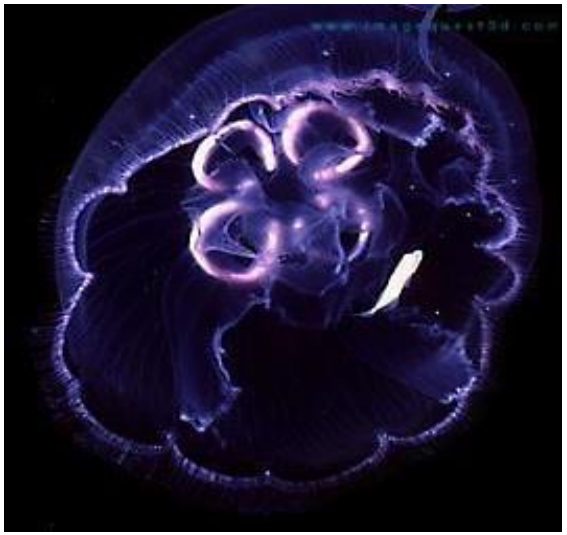
Box JellyFish


Scyphozoans

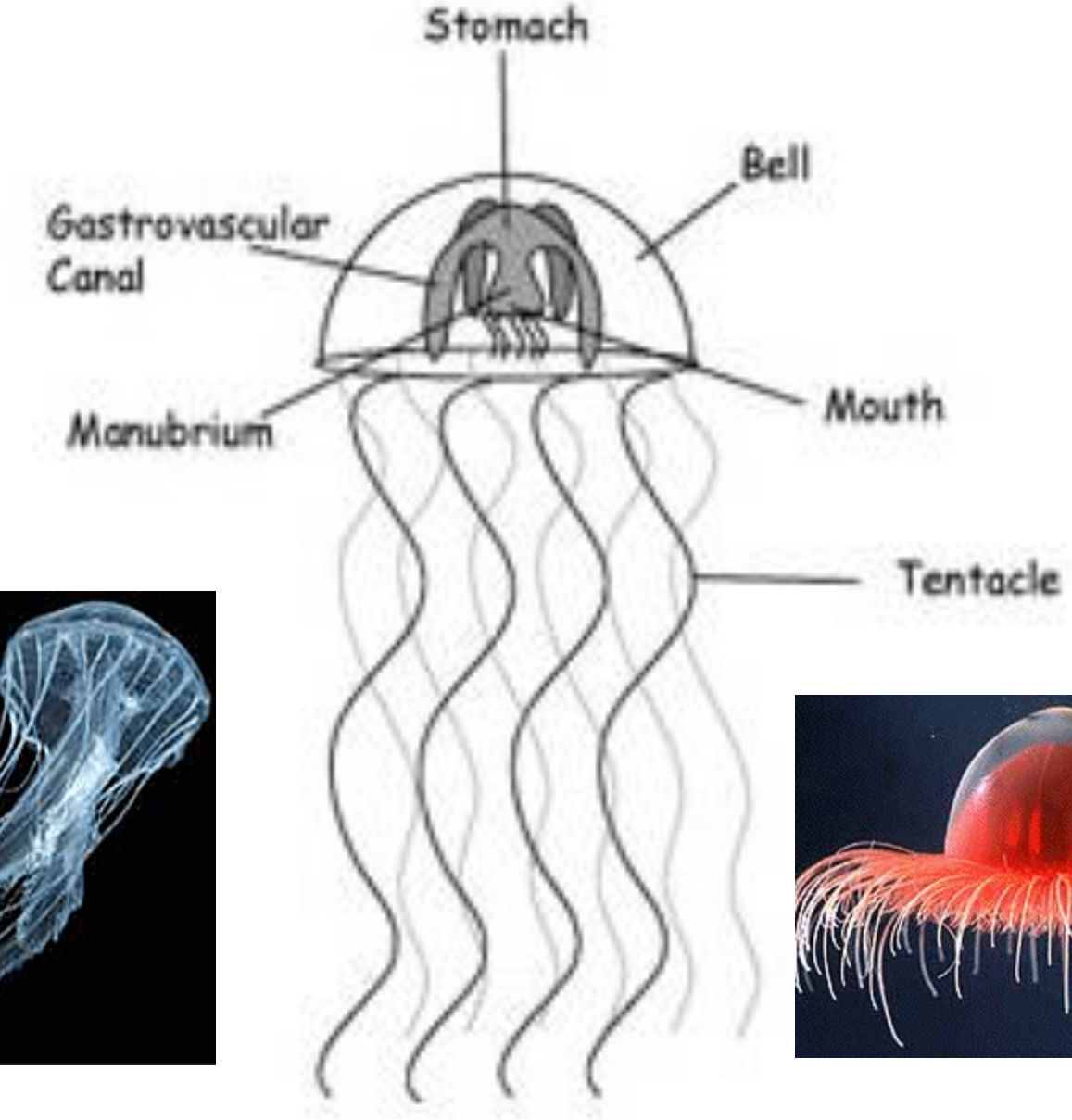
Scyphozoan Characteris

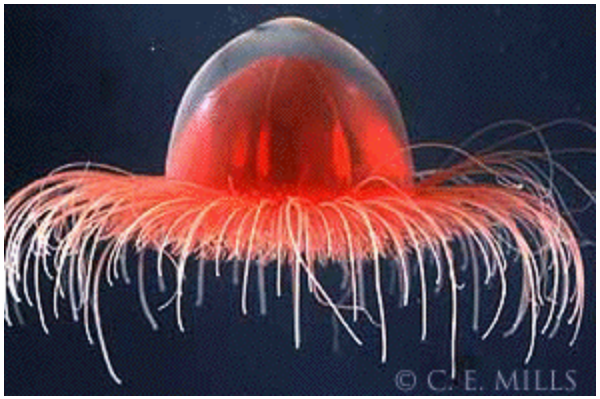
- Jellyfish
  - Medusa is dominant body form
  - Go through small polyp stage during life cycle
  - Stinging tentacles





Parts of a Jellyfish





Phylum Platyhelminthes

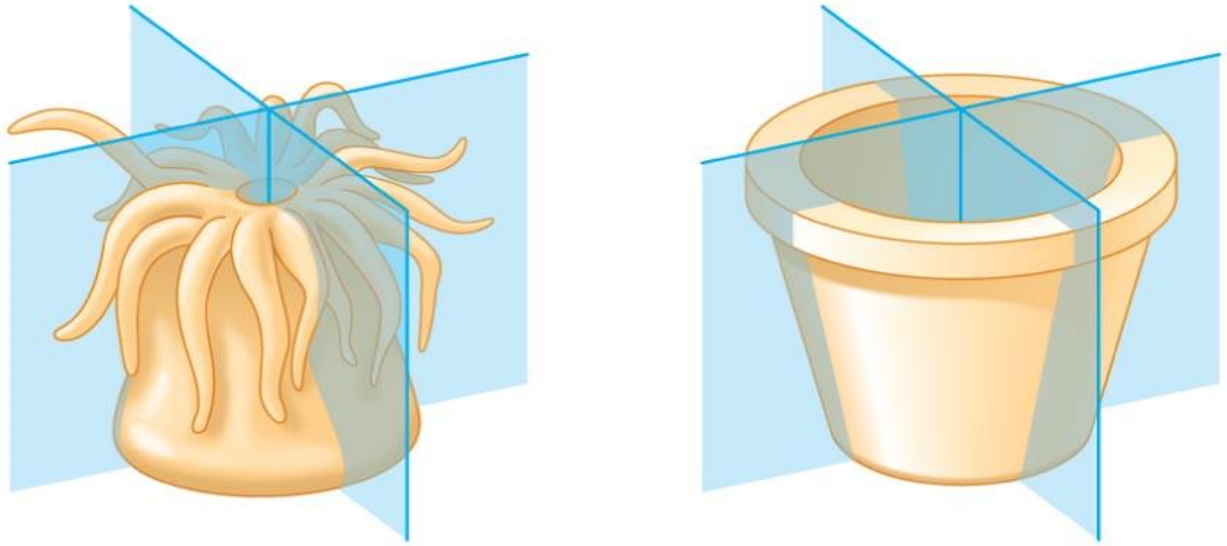
Flatworms

Phylum Platyhelminthes/ FlatwormsFlatworms General Charecteristics

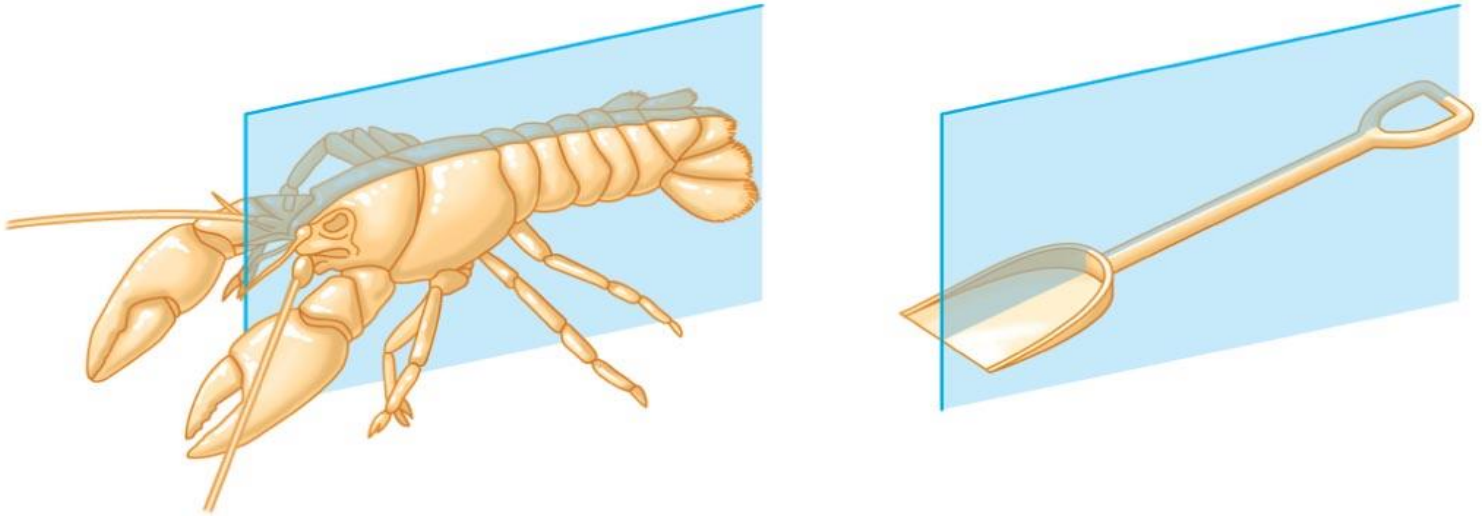
- Members of **phylum Platyhelminthes** live in:
  - marine,
  - Freshwater,
  - damp terrestrial habitats and also exist as
  - Parasites

Flatworms General Charecteristics cont…

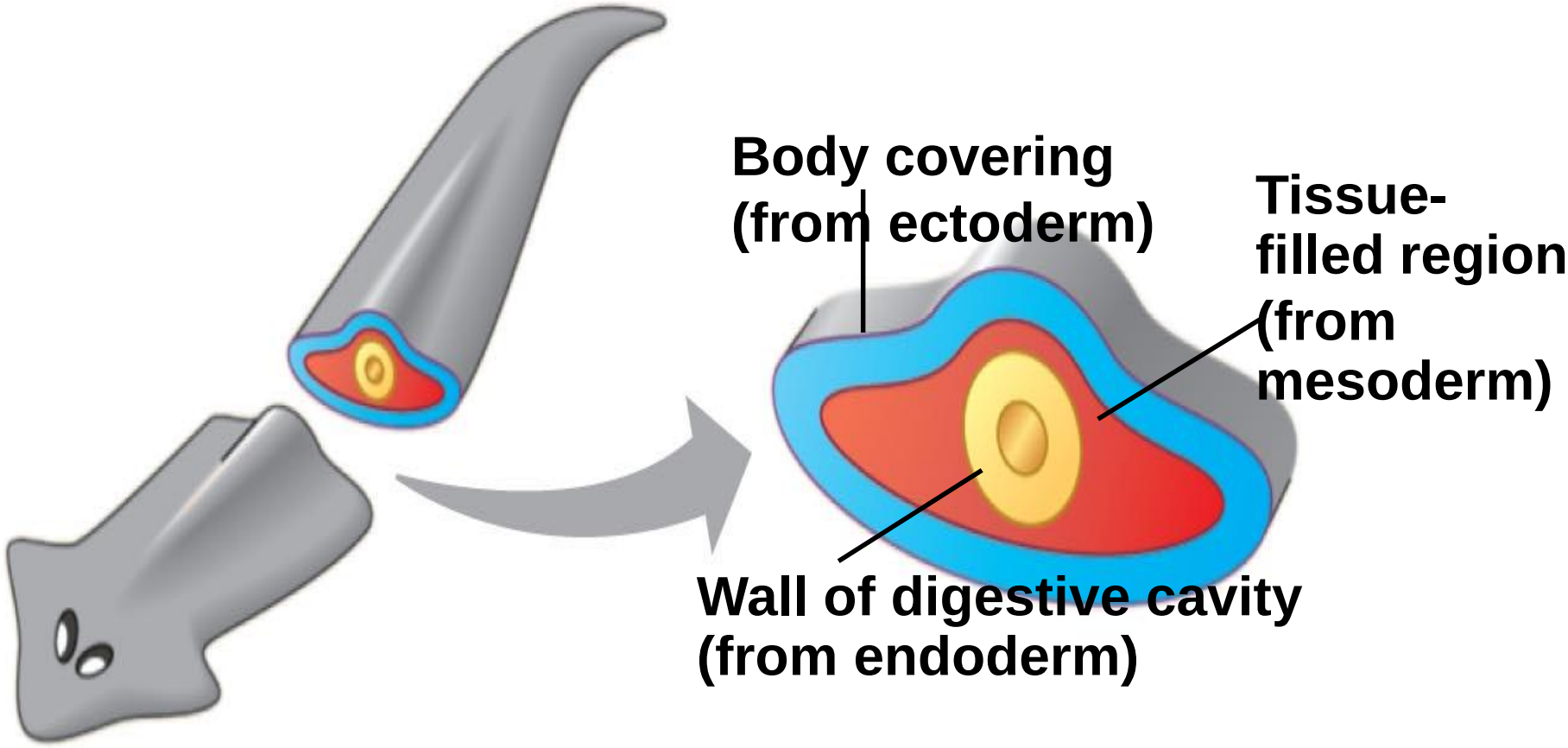
- The platyhelminths, or flatworms are **acoelomates** (no body cavity)
- They are of economic importance, they include the parasitic **tapeworms and flukes**, infecting humans and the livestock
- These animals are **triploblastic** (i.e.: ectoderm, mesoderm, and endoderm during development)
- They are **bilaterally symmetrical**
- Tissues are organized into complex organs (organ level of organization)
- Gas exchange takes place across the surface
- The nervous system is organized and concentrated in the anterior end of the animal (**cephalization**).
- They eliminate nitrogenous wastes (**excretion**) through structures called **flame cells/ protonephridia**. (specialized excretory cells)
- They possess a complex digestive tract with both a mouth and anus.
- There are both hermaphrodites and separate sexes



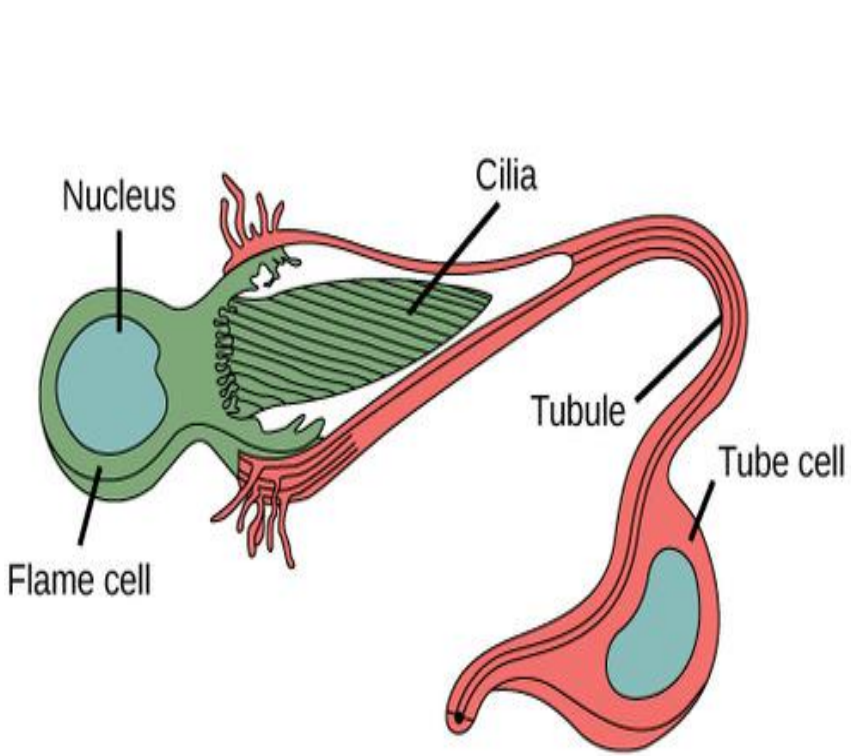
(a) Radial symmetry



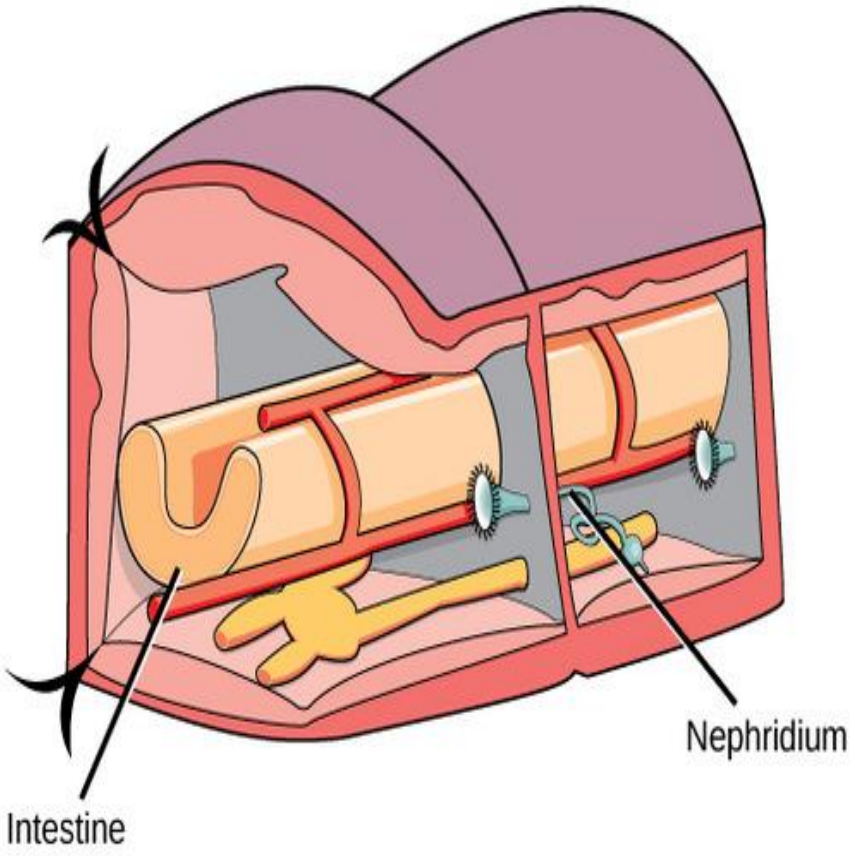
(b) Bilateral symmetry



(c) Acoelomate



(a) Flame cell of a planarian



(b) Nephridium of an earthworm

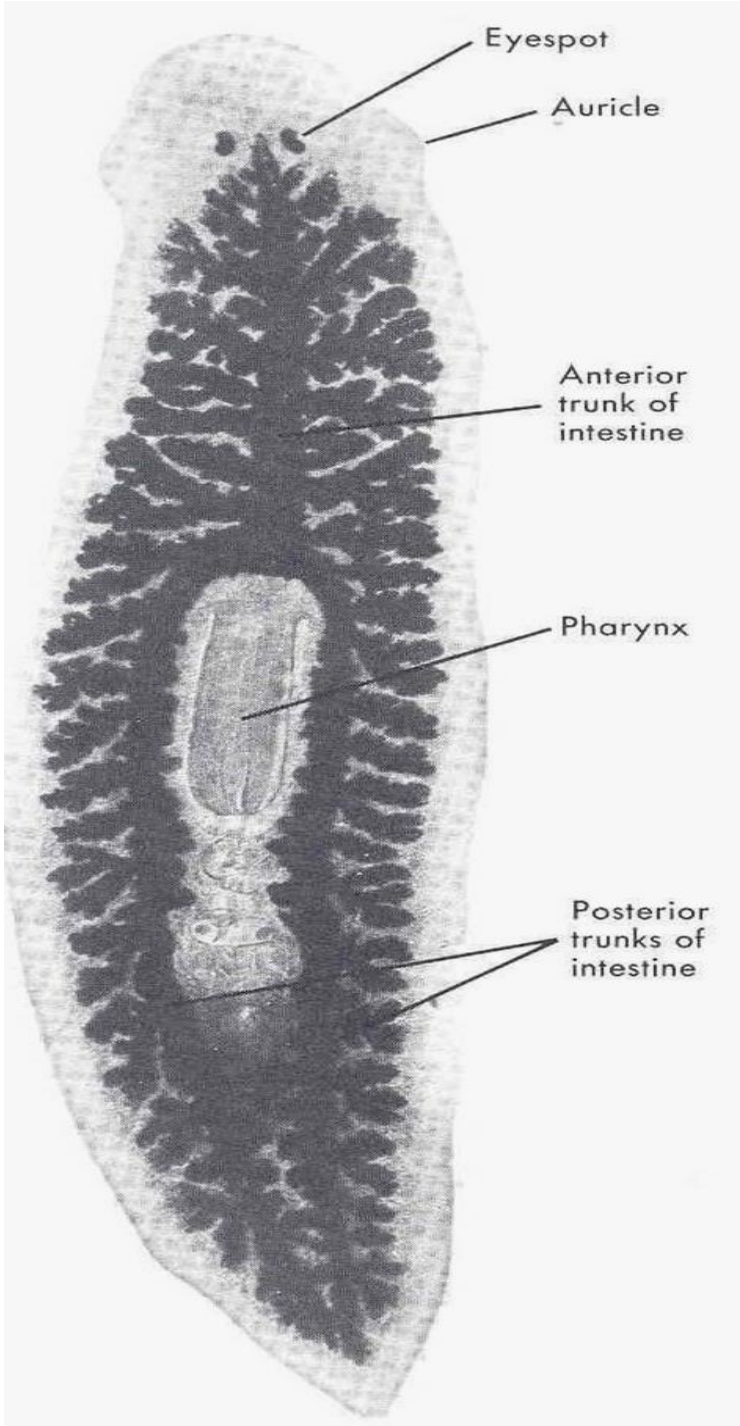
Table 33-2

Table 33.2 Classes of Phylum Platyhelminthes

Class and Examples	Main Characteristics
Turbellaria (mostly free-living flatworms, such as *Dugesia)*	Most marine, some freshwater, a few terrestrial; predators and scavengers; body surface ciliated
Monogenea (monogeneans)	Marine and freshwater parasites; most infect external surfaces of fishes; life history simple; ciliated larva starts infection on host
Trematoda (trematodes, also called flukes)	Parasites, mostly of vertebrates; two suckers attach to host; most life cycles include intermediate and final hosts
Cestoda (tapeworms)	Parasites of vertebrates; scolex attaches to host; proglottids produce eggs and break off after fertilization; no head or digestive system; life cycle with one or more intermediate hosts

Class Turbellaria

- Turbellarians are free-living
- **The best-known turbellarians are commonly called planarians**
- Size up to 50 cm long
- The mouth is located on the ventral side and leads to a gut.
- Planarians have light-sensitive eyespots and centralized nerve nets
- Sense organs are poorly developed.
- Planarians are hermaphrodites and can reproduce sexually, or asexually through fission, by regeneration.



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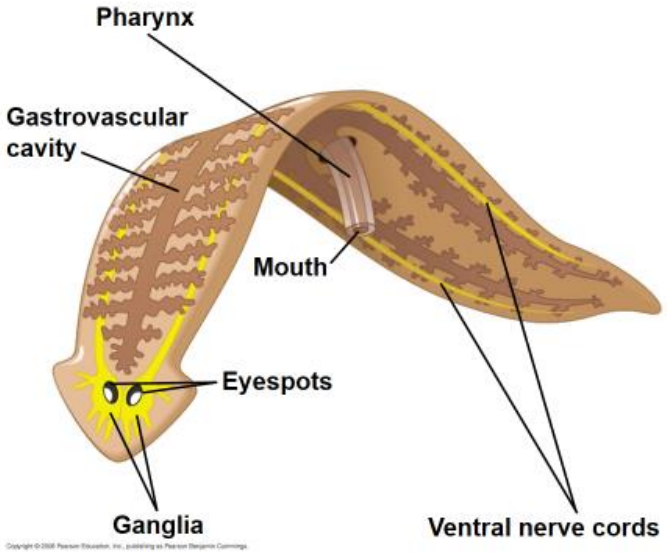
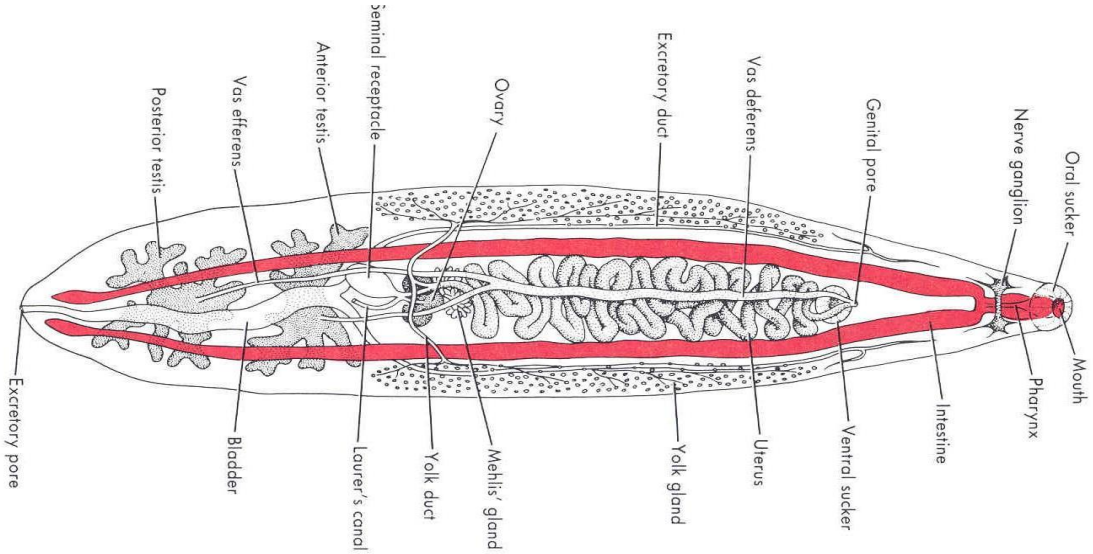
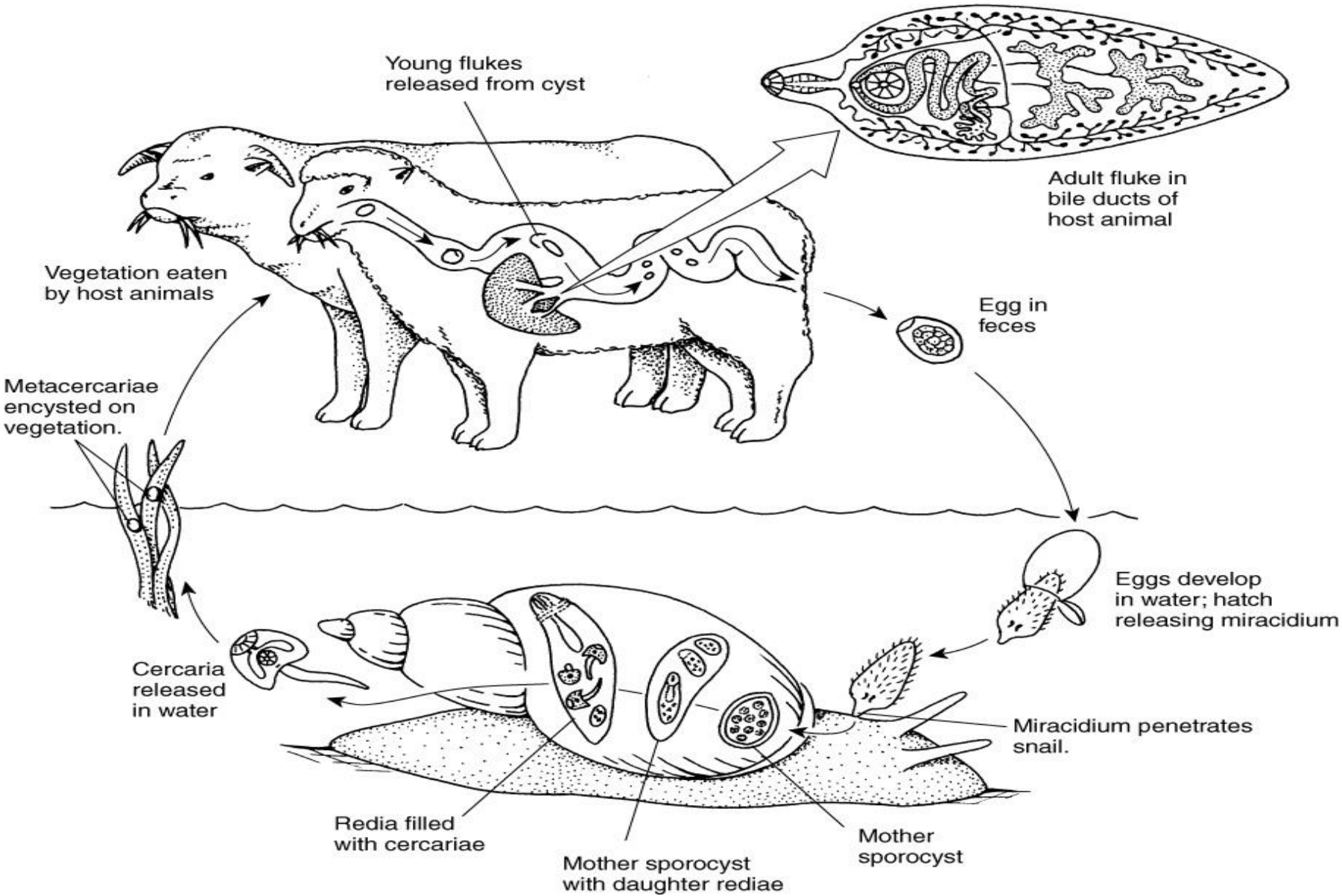


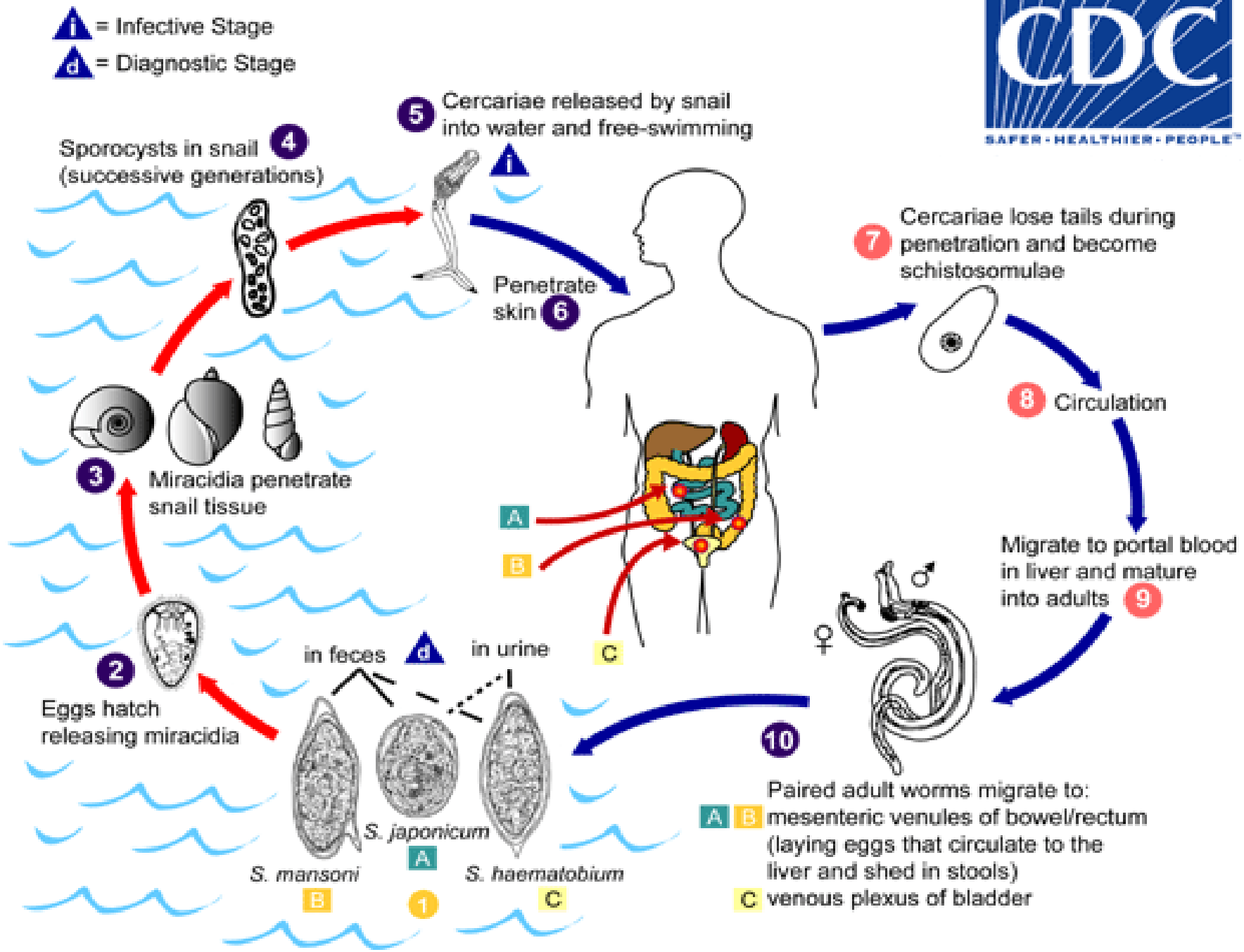
Class Trematoda

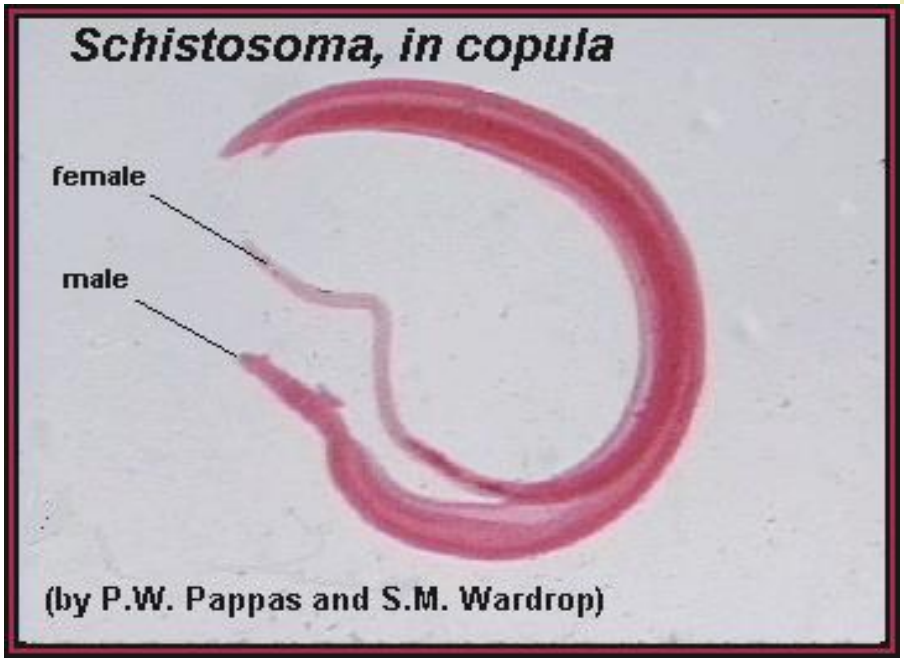
- **Trematodes** are commonly called **flukes**, and they are **parasitic** in tissues and blood vessels.
- Most adults are endoparasites of vertebrates.
- Adaptations for parasitism include:
  - hooks and suckers for adhesion, and
  - increased reproductive capacity (high reproductive potential)
- Possess an excretory and nervous systems.
- Sexual reproduction exhibited
- The life cycles of these parasites are very complex, and comprise of definitive and intermediate hosts.
  - Fasciola hepatica found in bile ducts, causes liver rot/fascioliasis
  - Schistosoma, separate sexes (dioecious, gyenochorific canal) cause schistosomiasis and found in the blood



Life cycle of *Fasciola hepatica,*
Resides in bile ducts, Causes fascioliasis/liver rot





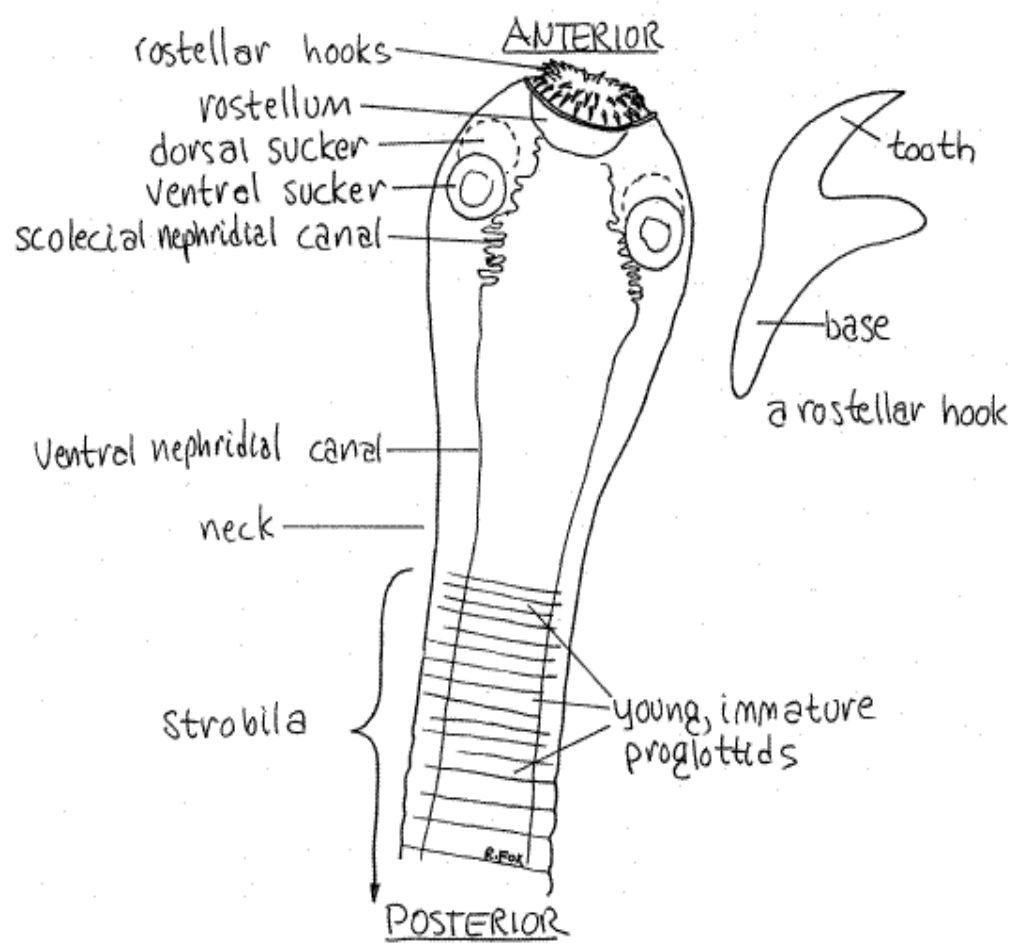


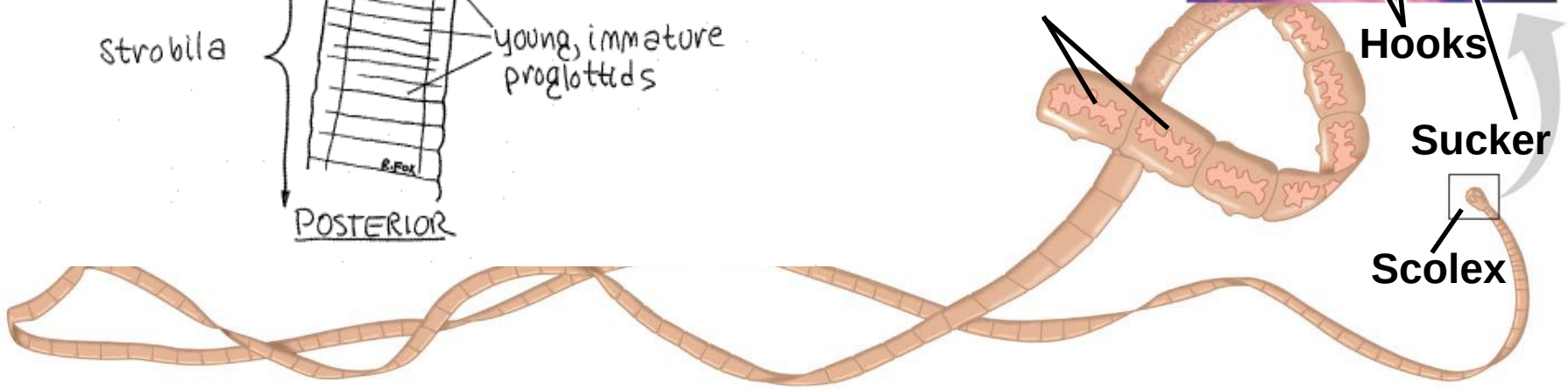
Class Cestoda (Tapeworms)

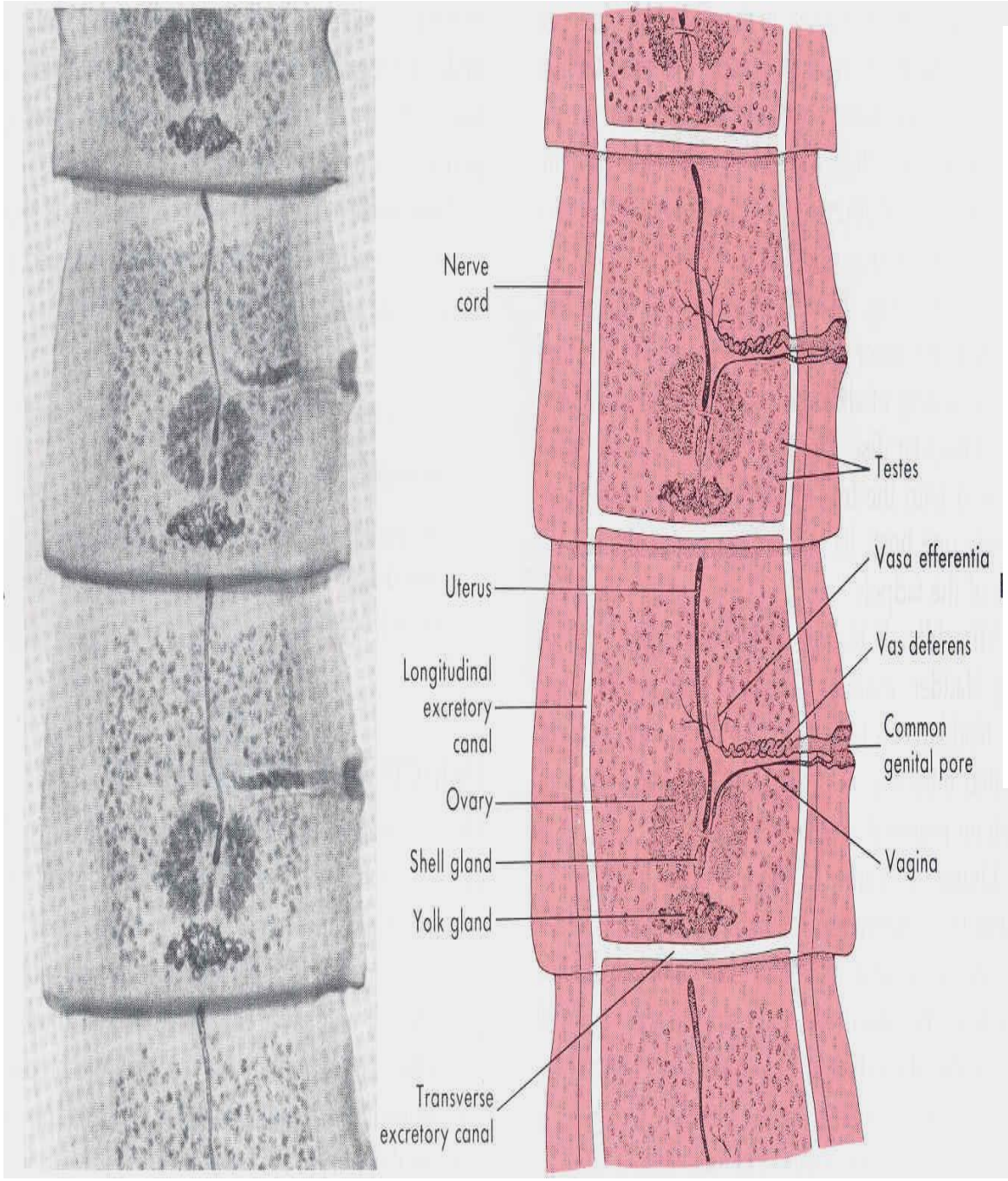
- Tapeworms are all endoparasites **of vertebrates and lack a digestive system**
- **Tapeworms absorb nutrients from the host's intestine through their tegument**
- Most require a single **intermediate host** and a **final host**, where the adult tapeworms resides.
- **Fertilized eggs, produced by sexual reproduction, leave the host's body in faeces**
- Their long bodies are usually made of segments called **proglottids**. Maturest proglottids are found at the posterior end.
- The **scolex** is located on the head and is used for attachment as it has hooks and suckers.
- Since tapeworms are hermaphroditic each proglottid contains both male and female gonads.

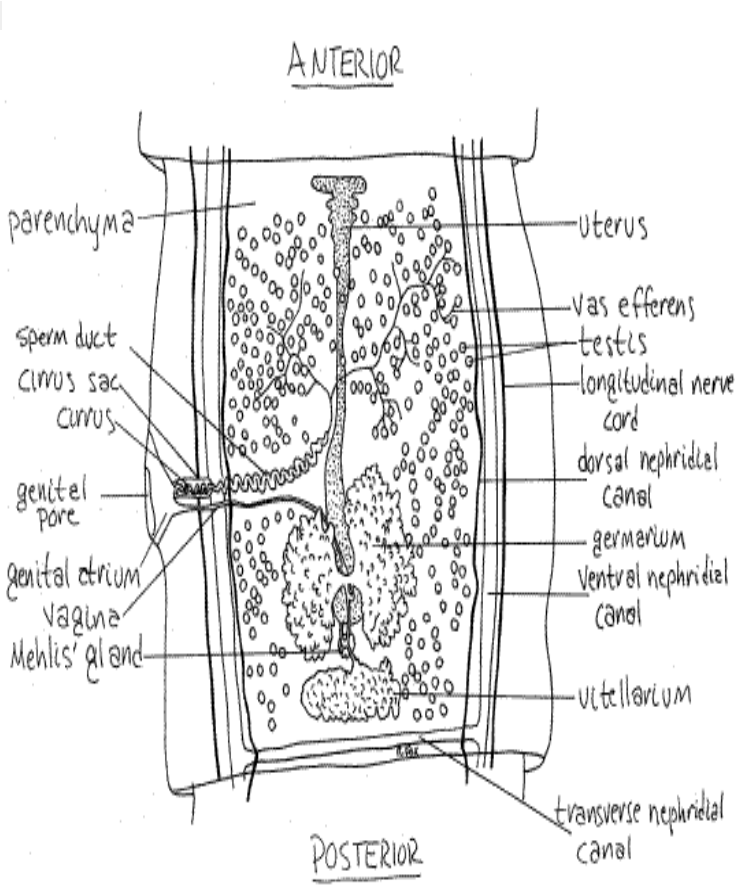
Tapeworms

- Tapeworms are parasites of vertebrates and lack a digestive system
- Tapeworms absorb nutrients from the host's intestine
- Fertilized eggs, produced by sexual reproduction, leave the host's body in faeces









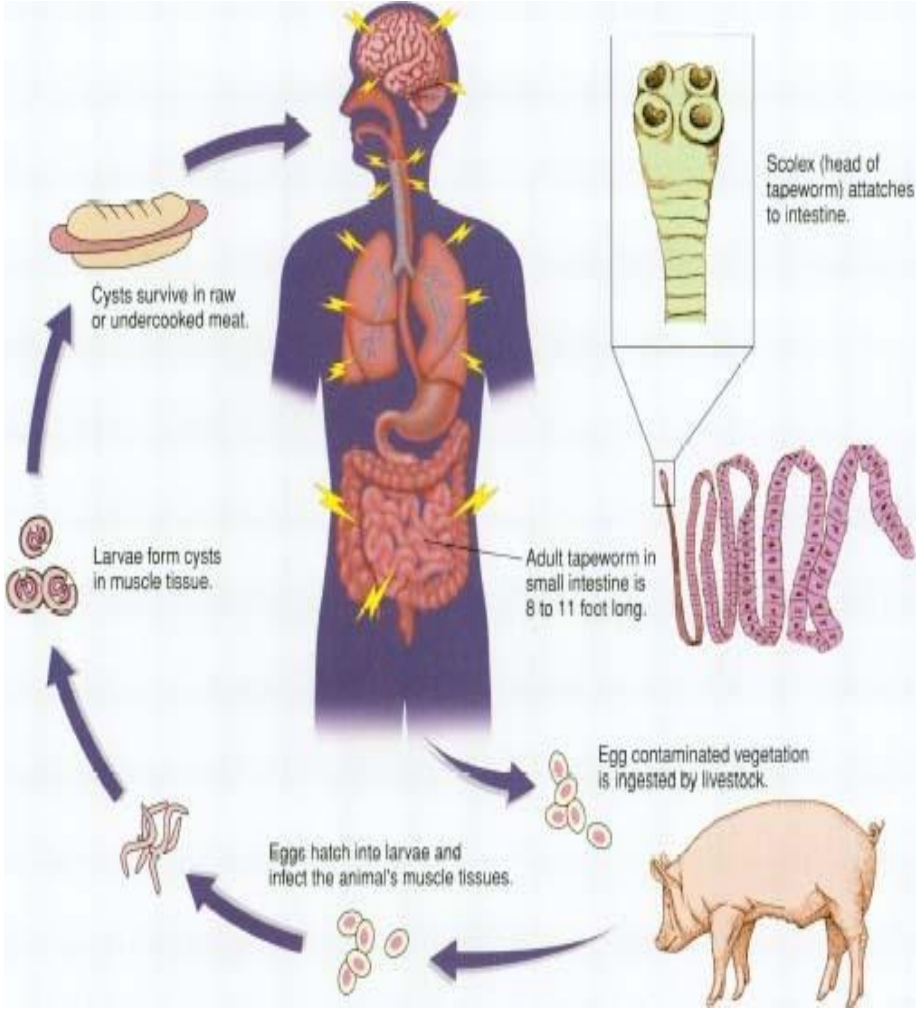
Adaptations Common To Most Parasitic Flatworms:

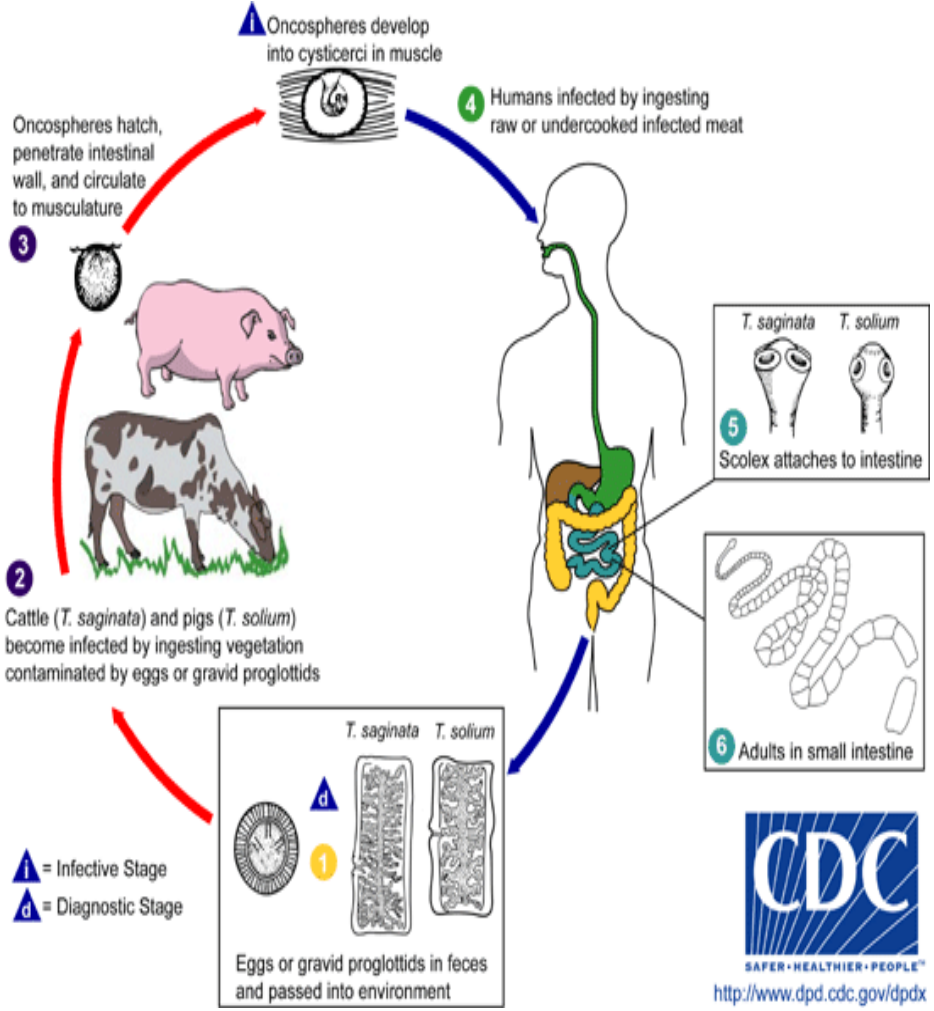
1) Parasitic flatworms often have suckers and hooks for attachments, form a structure called a scolex.

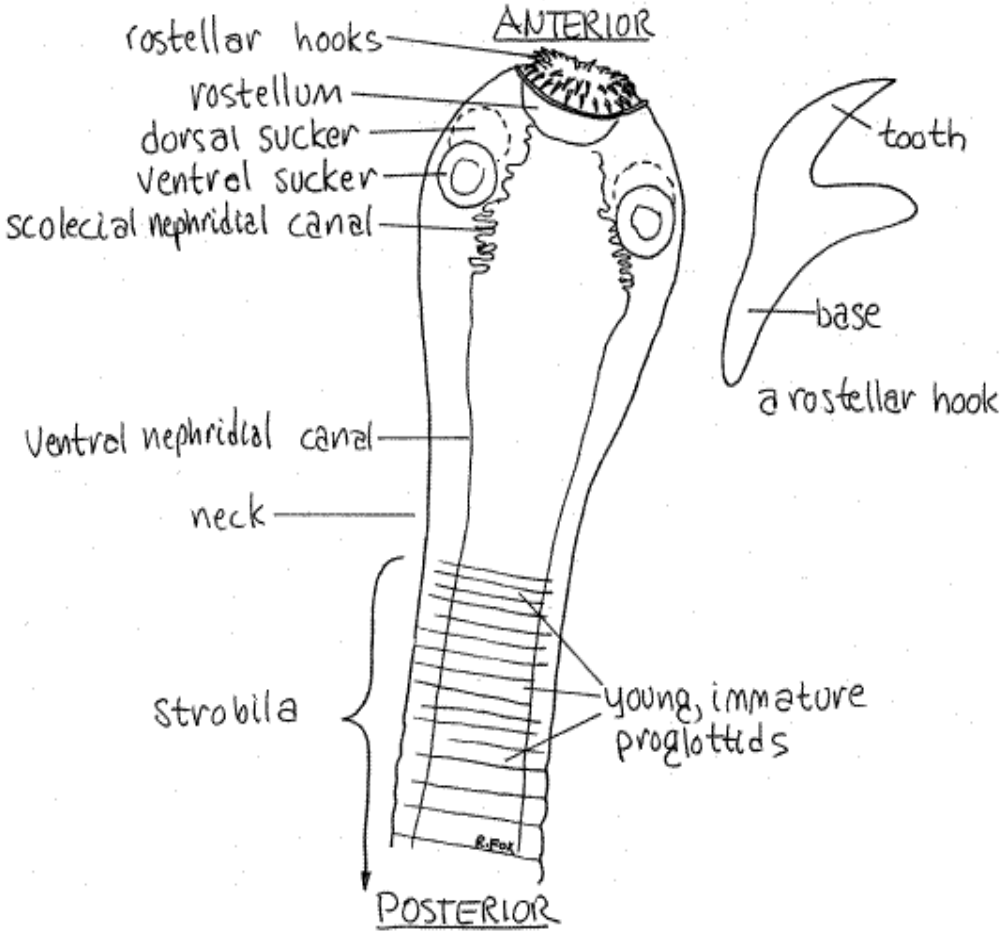
2) Outer cuticle (tegument) for protection so as not to be digested or destroyed by the host's enzymes.

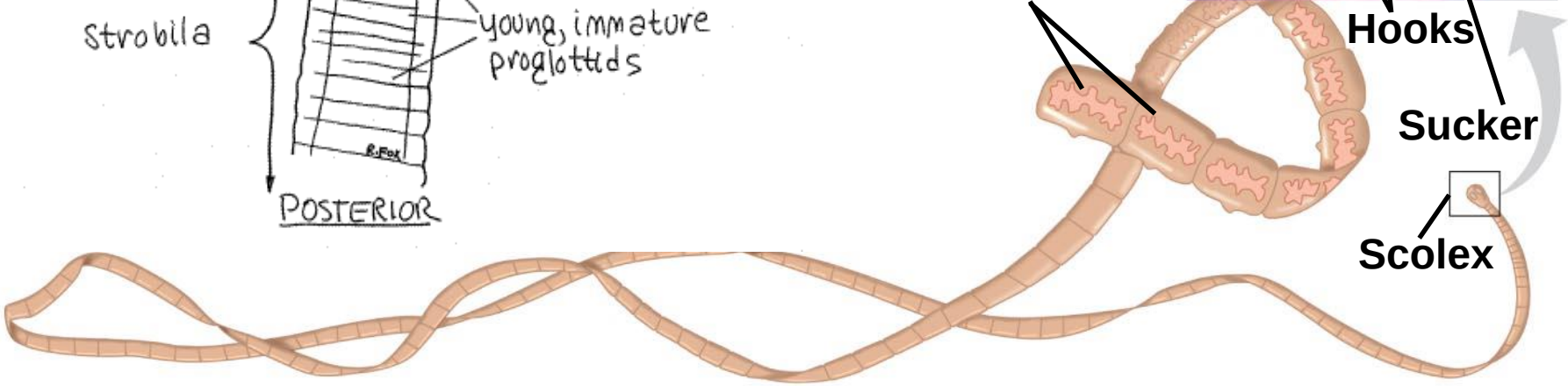
3) Loss of digestive system in some (tapeworms) – these will absorb nutrients through ectoderm.

4) Complicated life cycle with the production of many eggs and/or offspring and use of many hosts to ensure transfer.









PHYLUM NEMATODA

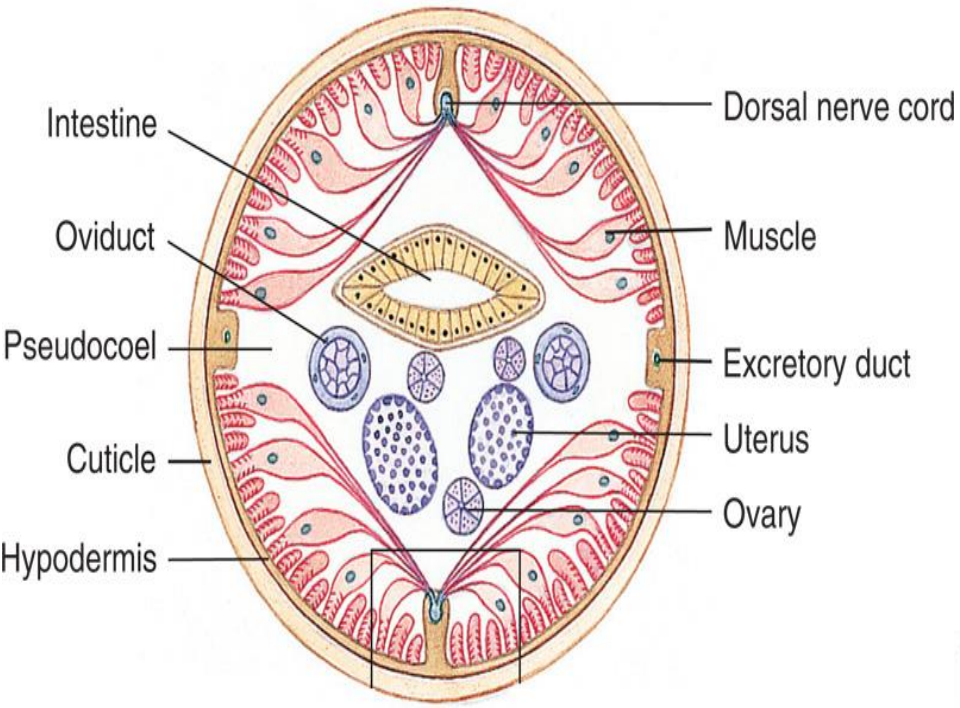
Phylum Characteristics.

- The nematodes are multicellular, cylindrical, bilaterally symmetrical animals.
  - are found in most aquatic habitats,
  - in the soil, in moist tissues of plants, and
  - in body fluids and tissues of animals as parasites
- Their support is generated from an efficient **hydrostatic skeleton** in the **pseudocoelom**
- They are at the organ level of organisation.
- Nematodes are triploblastic, pseudocoelomates.
- They have a complete digestive tract with a **mouth and an anus** and digestion is **completely extracellular**.
- .

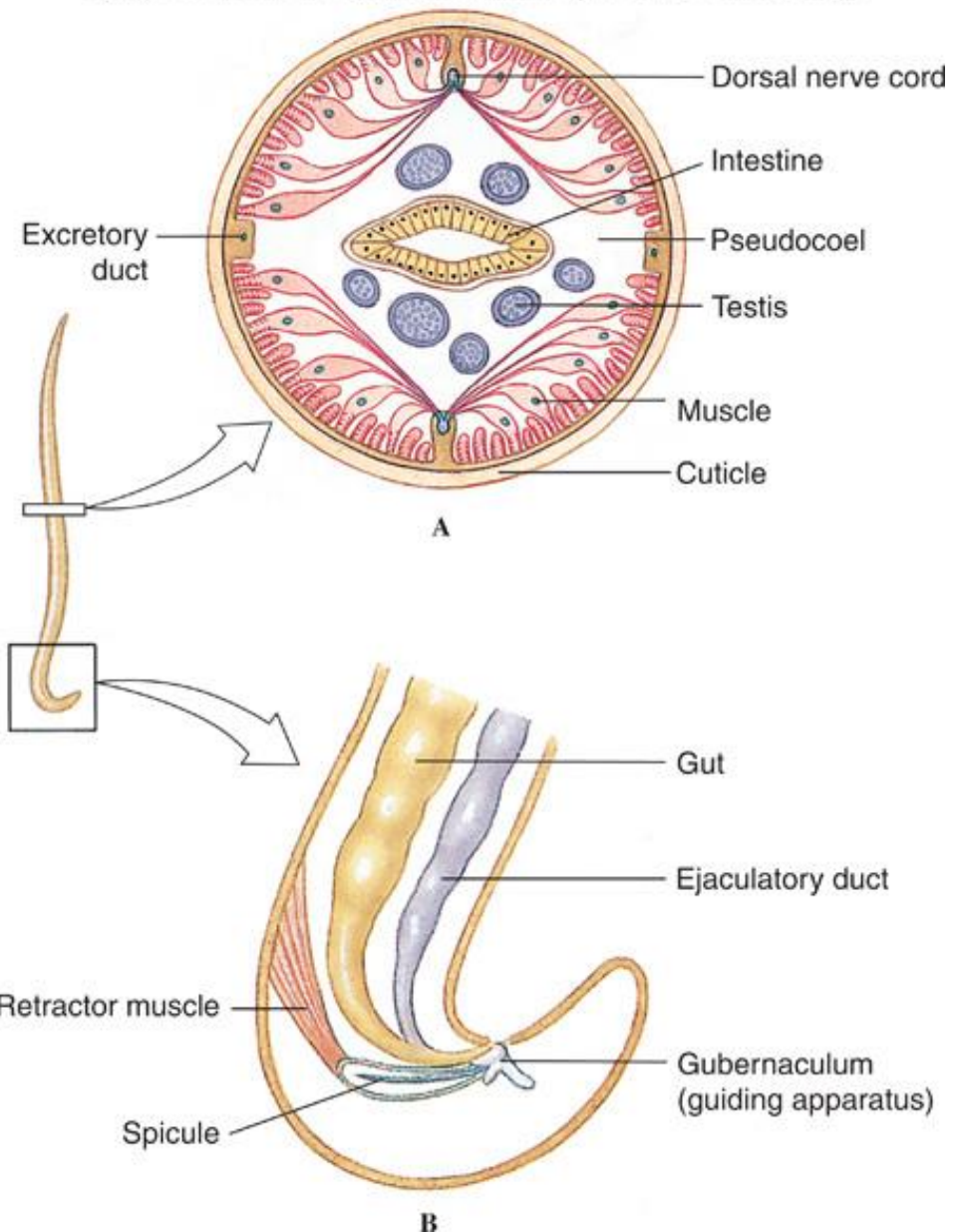
- There are no circulatory, or respiratory systems
- Excretion and osmoregulation are done through **excretory canals and/or renette cells.**
- The nervous system consists of an anterior nerve ring and dorsal and ventral nerve cords.
- Reproduction: sexual, the animals are dioecious and fertilisation is internal.

Parasitic; *Enteobius vermicularis, Ascaris lumbricoides, Necator Americanas Wuchereria bancrofti (elephantiasis) (tissue and body fluids, lymph)*

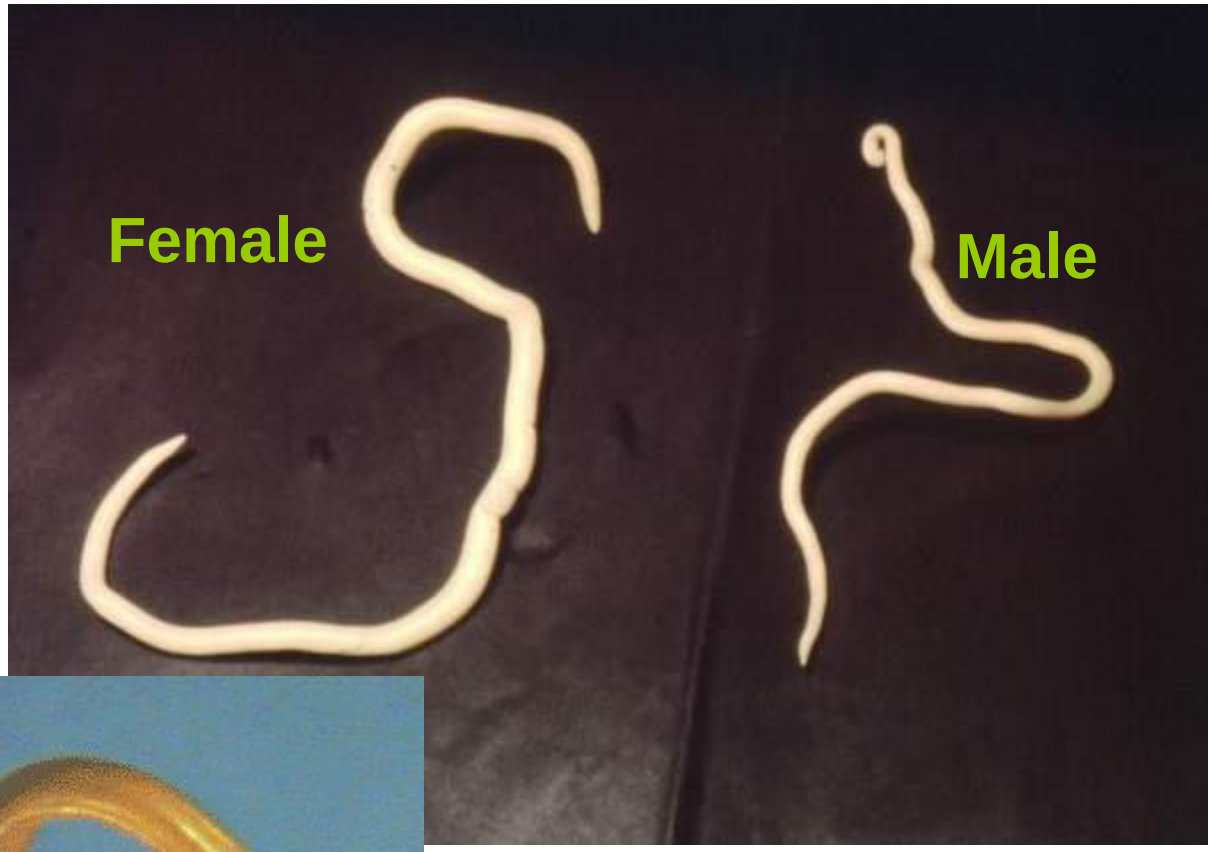
Female Cross-section

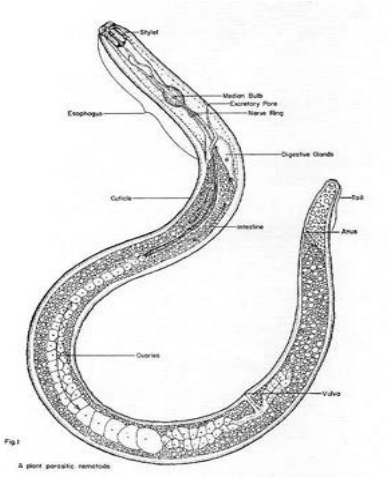


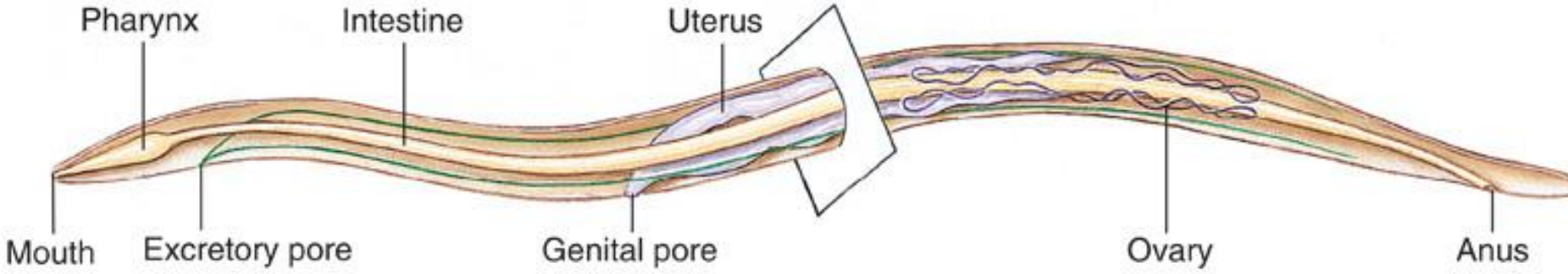
Male Cross-section



Ascaris

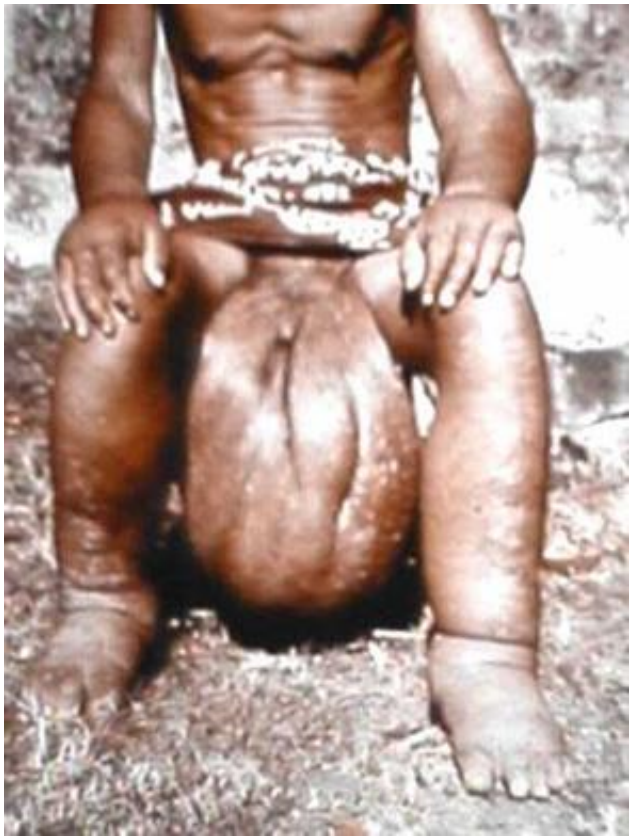






A

Pathology of *Wuchereria bancrofti*

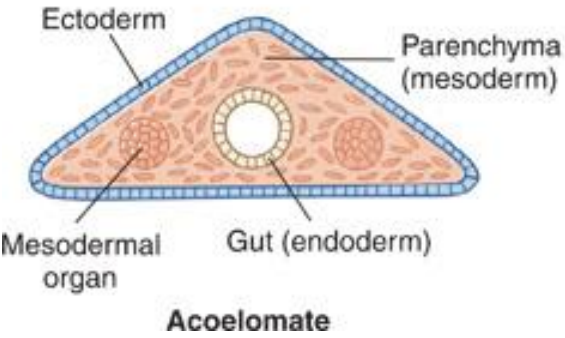


Elephantiasis
Ursache: lymphotrope Filarien (Fadenwürmer)

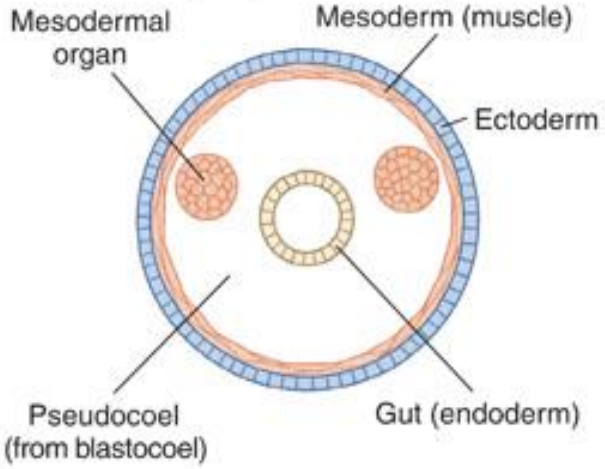
Obstructive phase photos

- Elephantiasis: accumulation of lymph in extremeties, fibrosis, and thickening of skin.

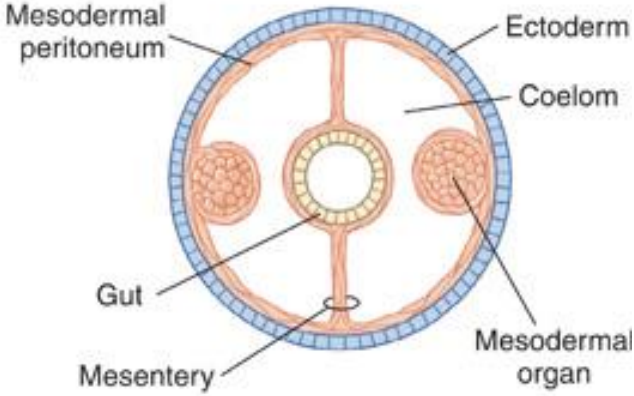
Body Cavities



Acoelomate



Pseudocoelomate



Eucoelomate

Phylum Annelida General Characteristics:

- Three classes of Phylum:
  - **Oligochaeta** (earthworms and their relatives)
  - **Polychaeta** (polychaetes)
  - **Hirudinea** (leeches)

1. Bilaterally symmetrical, segmented worms. Cephalisation or head formation is apparent in some annelids
2. They are at the organ-system level of organisation.
3. Triploblastic, Protostomes, schizocoelomate animals.
4. Annelid worms has chitinous setae (chaetae, bristles).
5. The coelom is separated at each segment by septa.
6. The digestive tract is complete.

8. The body is covered with a moist cuticle secreted by the epidermis.

Osmoregulation and excretion are done by paired nephridia

9. Respiratory gas exchange is through the skin, gills or fleshy appendages, parapodia.

10. Blood is circulated through a closed circulatory system and the oxygen is transported on respiratory pigments.

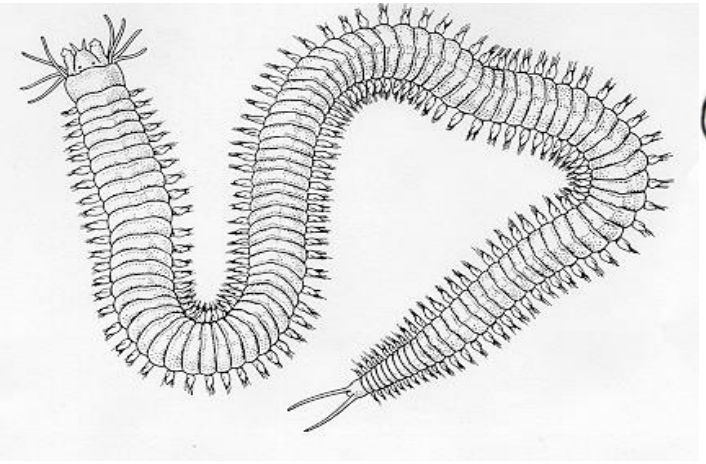
11. The nervous system consists of :
  - a double ventral nerve cord,
  - a pair of ganglia and lateral nerves per segment. The `brain' consists of a pair of dorsal cerebral ganglia,
  - circumpharyngeal connectives and a pair of ventral subpharyngeal ganglia.

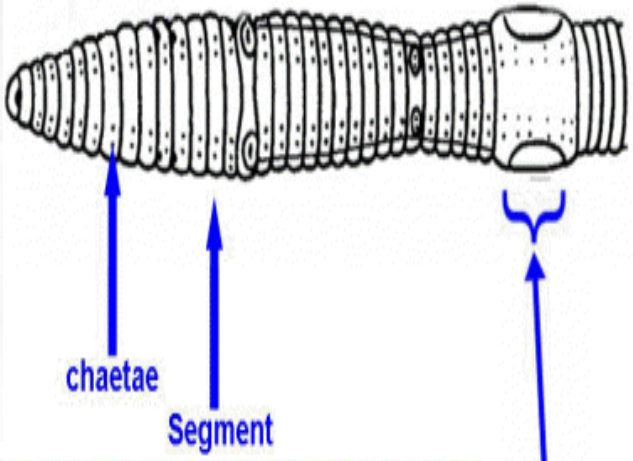
12. The muscles of the body wall and intestinal tract pull against the hydrostatic skeleton of the coelom.

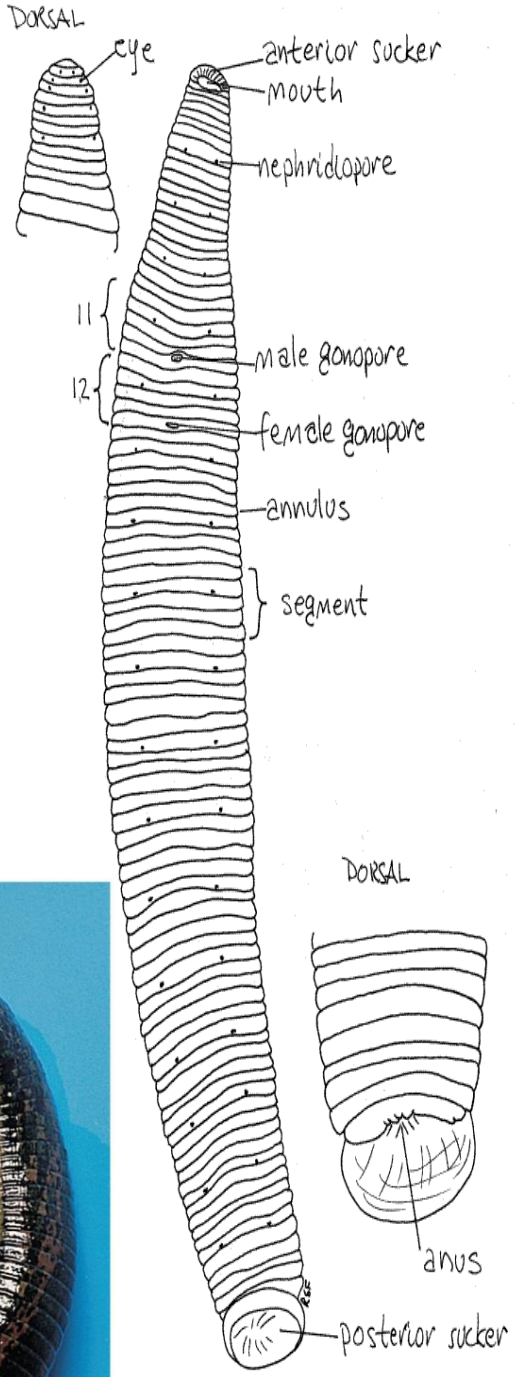
13. The segmented worms are hermaphroditic or with separate sexes. Fertilisation is external and many produce trochophore larvae.

14. The digestive tract into a pharynx, a stomach, and accessory glands

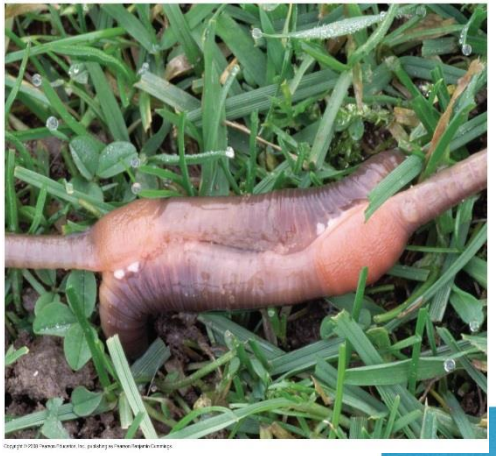
Polychaeta, clam worms, Nereis	Oligochaeta, earthworms	Hirudinea, leeches
1) Mostly marine, few freshwater **2) Mainly filter feeders (Some polychaetes are ferocious predators)** **3) Distinct head with (sense organs) eyes and tentacles, Segments with parapodia and many setae** **4) Parapodia used in locomotion and also serve in gaseous exchange** **5) Dioecious with external fertilization** **e.g. Nereis**	1. Terrestrial and freshwater segmented worms 2. Possess fewer setae 3. Head absent no parapodia, 4. Hermaphrodites Has a clitellum, swollen structure used for reproductive, habours a cocoon eggs 5. Ecological significance: • Aerate the soil • Breakdown organic matter • Thus turn the and keep soils fertile e.g. *Lumbricus terrestis*	1) Marine, fresh water and parasitic 2) Body dorsoventrally flattened 3) Fixed number of segments (33-34) 4) Carnivores, some are blood sucking parasitic 5) Anterior and posterior suckers present. 6) Hermaphrodites similar to Oligochaeta (clitellum temporary) 7) Medicinal use clean wound sucking bad blood and pus e.g. *Hirudo medicinalis*

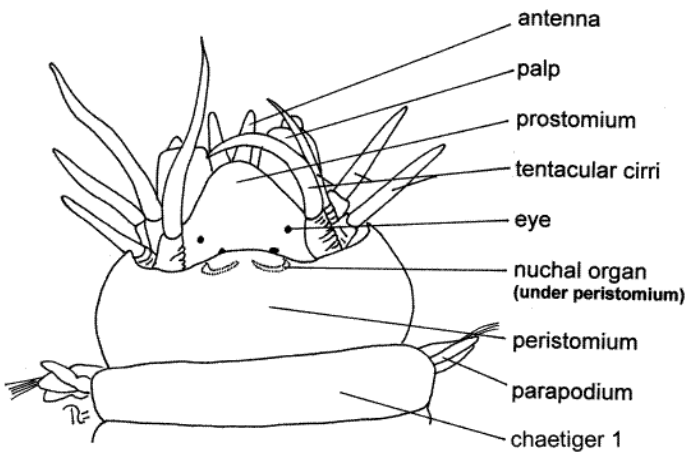


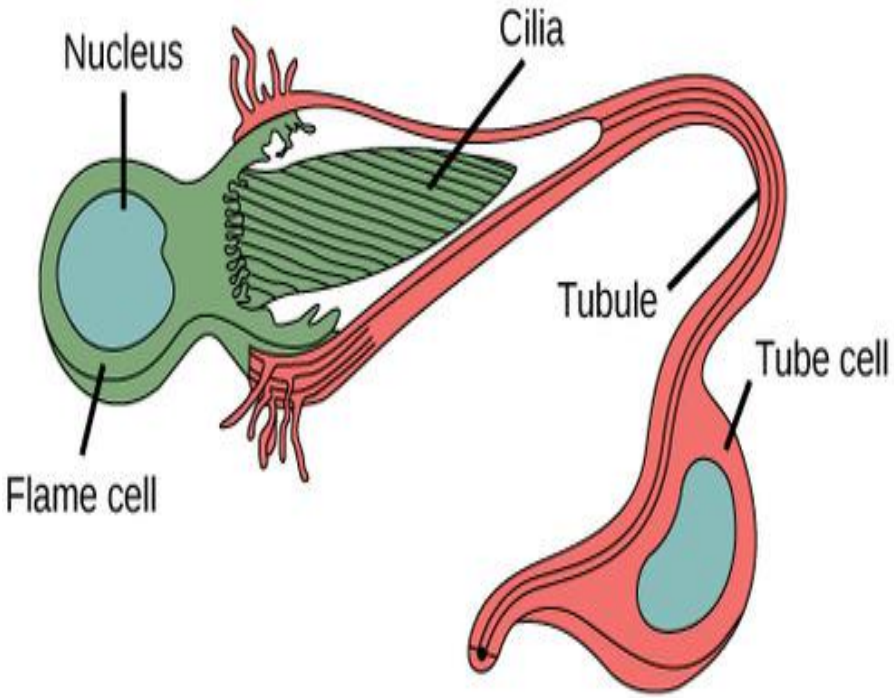




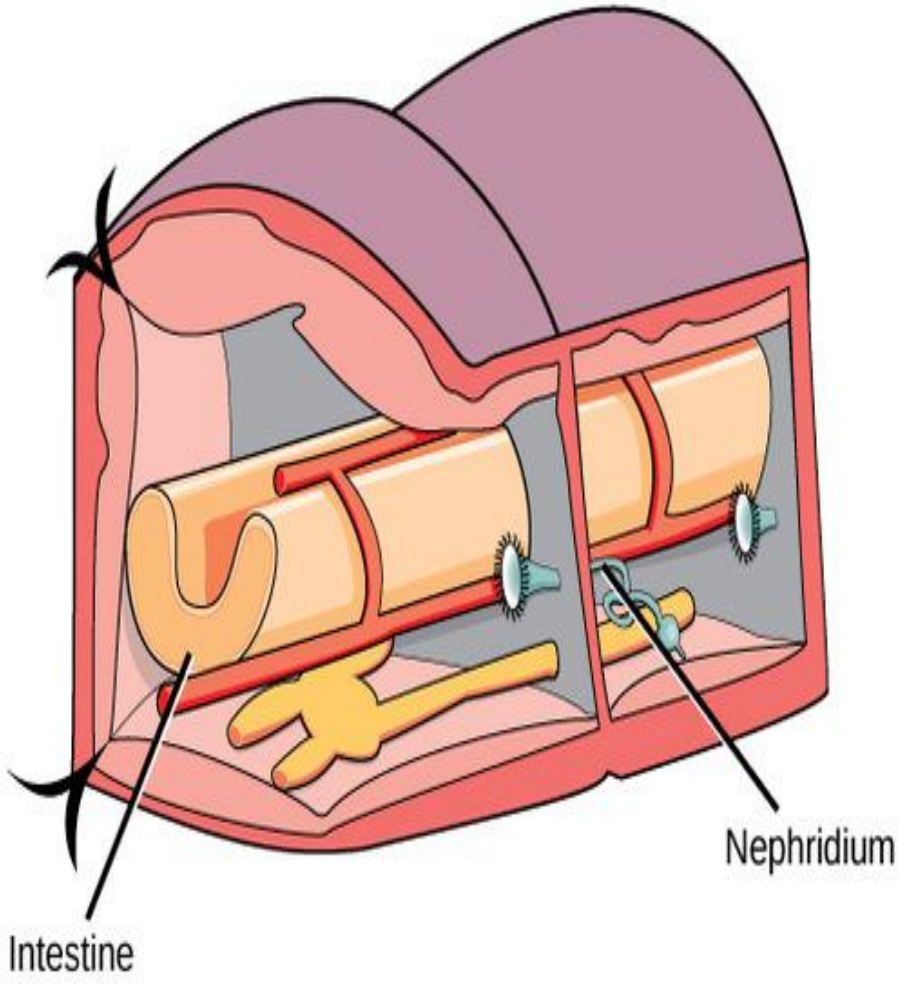
- **Head = prostomium + peristomium**
- **Prostomial appendages**
  - **Palps**
  - **Antennae**
  - **(tentacles)**
- **Peristomial appendages**
  - **Cirri**







(a) Flame cell of a planarian



(b) Nephridium of an earthworm

Giant Australian earthworm

Epidermis
Cuticle
Coelom
Septum (partition between segments)
Circular muscle
Longitudinal muscle
Metanephridium
Anus
Dorsal vessel
Chaetae
Intestine
Fused nerve cords
Ventral vessel
Nephrostome
Clitellum
Metanephridium
Esophagus
Crop
Pharynx
Intestine
Cerebral ganglia
Gizzard
Mouth
Subpharyngeal ganglion
Blood vessels
Ventral nerve cord with segmental ganglia

Phylum Mollusca

- Molluscs have a **soft body** (name from the Latin word *mollus*, meaning "soft")
- which is generally protected by a hard, calcium-containing shell.

Phylum Mollusca

- Divided into 7 classes:
  - **Gastropoda** snails and slugs,
  - **Bivalvia,** oysters and clams, and
  - **Cephalopoda,** octopuses and squids
  - Scaphopoda
  - Aplacophora
  - Monoplacophora
  - Polyplacophora

General Body Organization

1.Head-

- small & poorly defined
- Mouth with radula
- May bear sensory structures

2.Foot (Muscular)

- which contains both the sensory and motor organs
- Highly modified in different classes

3.Visceral mass

- which contains the organs of digestion, excretion, and reproduction;
  - M**antle:** A specialized tissue above the visceral mass that secretes the shell.
  - The **mantle cavity (**Many molluscs also have a water-filled) a space between the mantle and the visceral mass, houses the gills; the digestive, excretory, and reproductive systems discharge into it.

General Characteristics

- Bilaterally symmetrical or asymmetry in some forms (with spiral shells).
- Protostomial schizocoelomates.
- Complete digestive system with extracellular digestion.
  - Many feed using a rasplike **radula (specialized feeding structure)**
- Has open circulatory system with a heart,
  - Several major arteries,
  - Blood sinuses and respiratory blood pigments.
- Gas exchange by **gills, lungs or the mantle wall**.
- Excretion is through metanephridia.

General characteristics cont.....

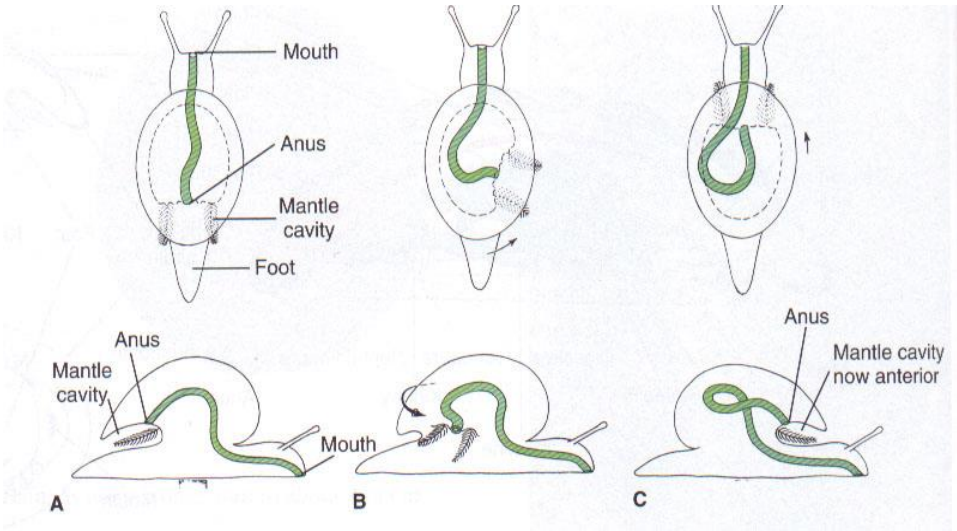
- The muscles pull against the shell or a hydrostatic skeleton.
- Locomotion by
  - foot- snails, slugs,
  - fins,
  - jet propulsion in cephalopods
- The nervous system is typically a circumesophageal nerve ring with multiple pairs of ganglia and two pairs of nerve cords
  - (one pair innervating the foot and another the visceral mass).
  - Many have organs for smell, or touch, or taste. Eyespots or complex eyes present
- The animals are mainly dioecious (separate sexes) and reproduce only sexually fertilization occurs externally or internally.
  - Some hermaphroditic

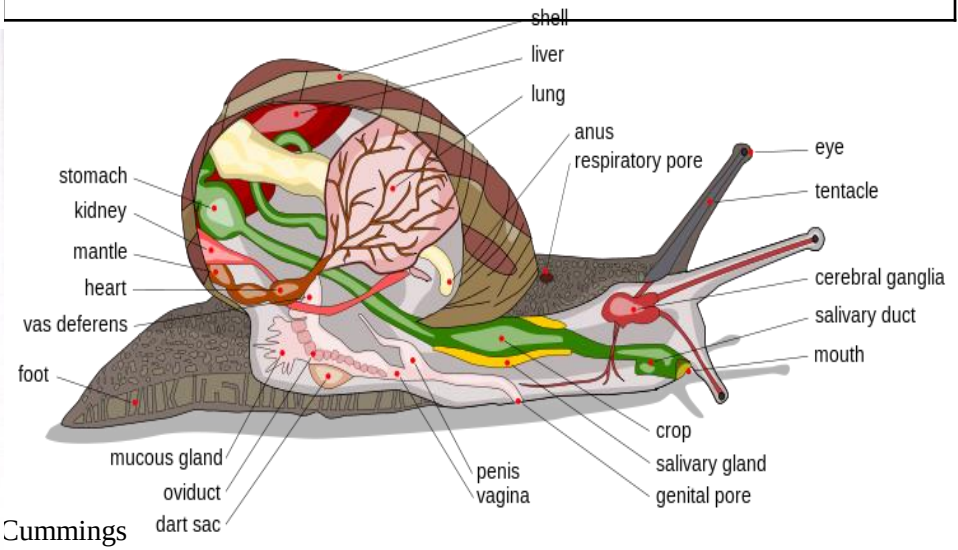
Class Gastropoda (stomach foot)

Slugs and Snails

- Aquatic and terrestrial
- Generally a spirally-coiled shell- body usually asymmetrical,
- with a distinct head
- pair of eyes, and one or two pairs of tentacles;
- foot is broad for locomotion.
- Experience torsion

The most distinctive characteristic of gastropods is torsion, which causes the animal's anus and mantle to end up above its head





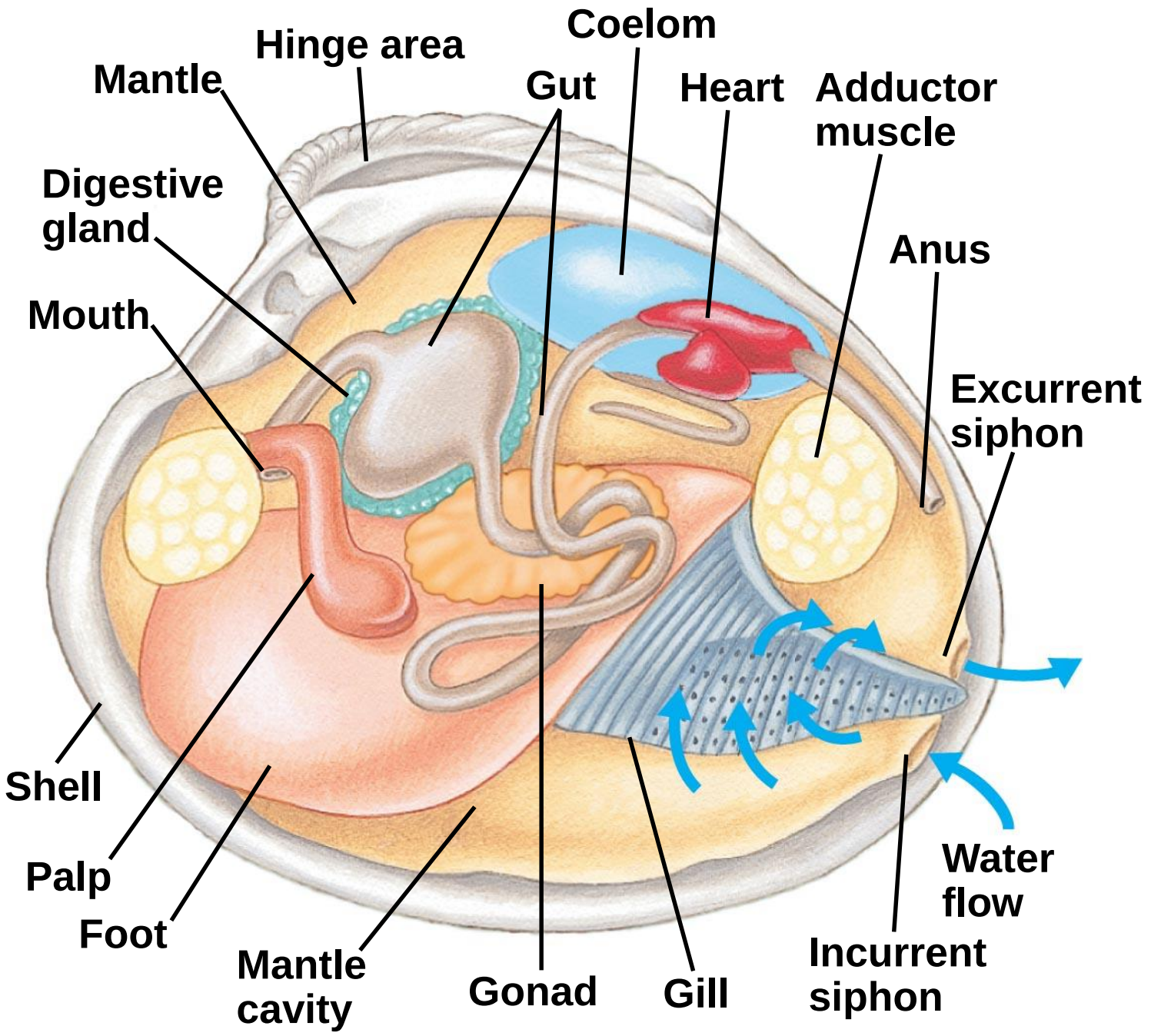
Cummings

Class Bivalvia

= Muscles, Clams, Oysters.

- Shell usually of two valves hinged dorsally;
- foot generally hatchet-shaped;
- head lacking (no cephalization)
- The mantle cavity of a bivalve contains gills that are used for feeding as well as gas exchange
- These valves are joined by a hinge on the dorsal side of the animal

Fig. 33-20



Class Cephalopoda (head–foot)

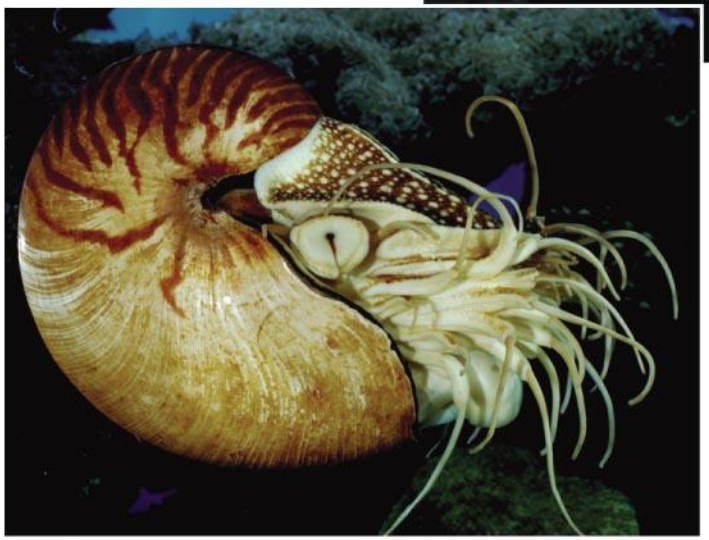
Nautilus, Octopus and Squid

- All marine
- Large head with well-developed eyes,
- horny (chitinous);
- head fused to foot;
- shell (when present) external or internal
- a set of prehensile arms (tentacles) that usually bear rows of suction cups

Squids use their siphon to fire a jet of water, which allows them to swim very quickly. Jet propulsion.

- Octopus

- Squid



- Chambered nautilus

Other important Features of Cephalopods

- For protection, they possess an ink sacs.
- They have well-developed sense organs, including a camera type eye.
- Some have well-developed brains and show a remarkable capacity for learning.
- Cephalopods are the only molluscan class with a closed circulatory system

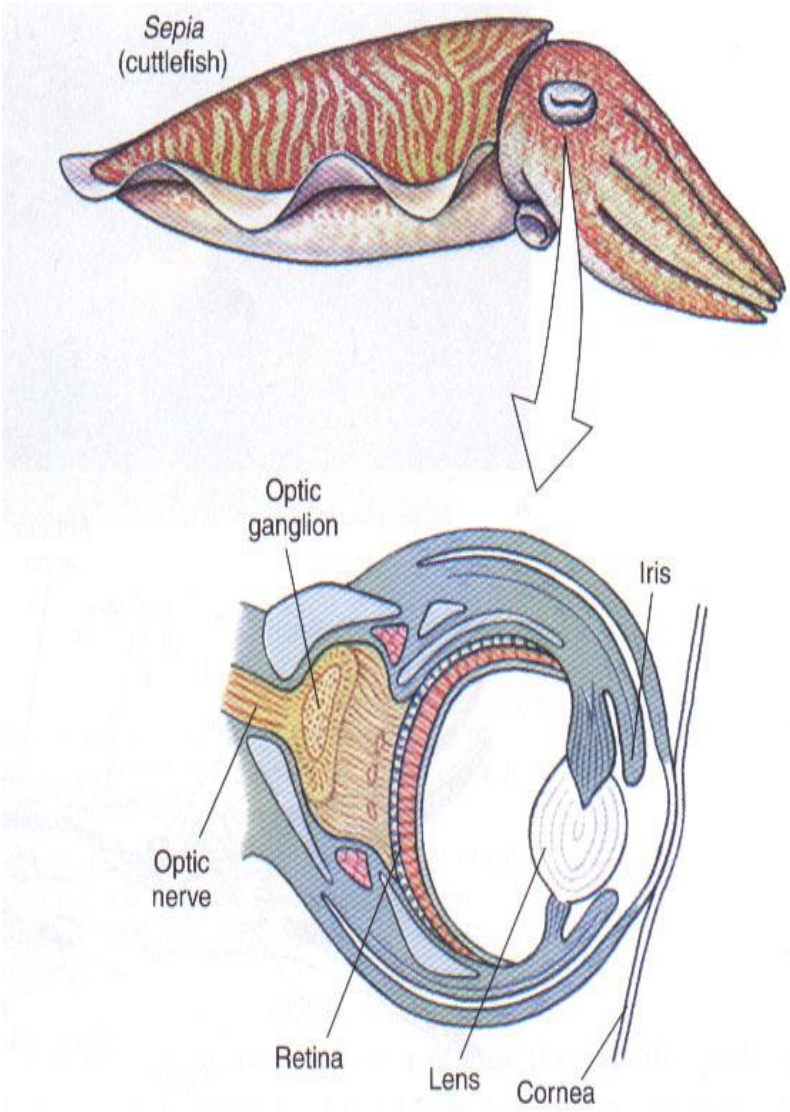


FIGURE 9-33

Eye of a cuttlefish (*Sepia*). The structure of cephalopod eyes shows a high degree of convergent evolution with the eyes of vertebrates.

Sexes are separate

Sperm is transferred to females in packets - **spermatophores**

Male uses a tentacle to reach into its mantle cavity and pick up some spermatophores

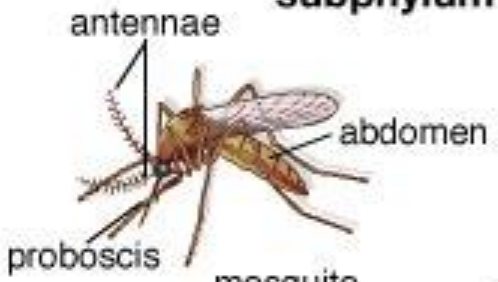
It then inserts the tentacle into the mantle cavity of the female near or within the oviduct

• **A giant squid (3.15-metre-long) has netted off the UK coast; first time in 15 years.**

Phylum Arthropoda

- Phylum Arthropoda (**arthro** = joint; **poda** = foot)
  - These jointed appendages include antennae and mouthparts as well as walking legs.
- It is the most numerous phylum of all living organisms, both in number of species and in number of individuals. Most diverse
  - Conservatively two out of every three (2/3) known species of animals are arthropods
  - Members of the phylum Arthropoda are found in nearly all habitats of the biosphere

subphylum Uniramia

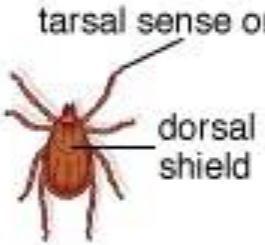


mosquito
class Insecta

moth
class Insecta

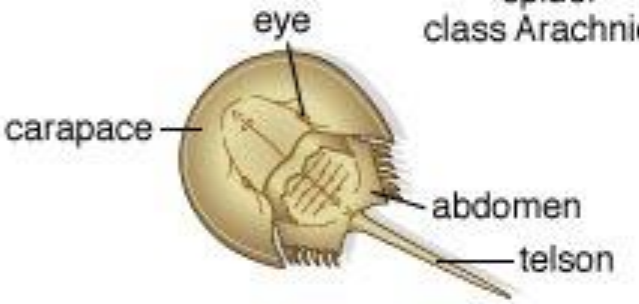
beetle
class Insecta

subphylum Chelicerata

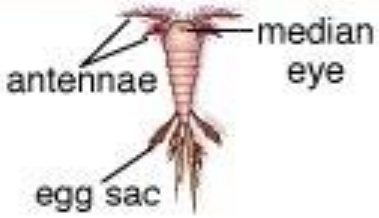


tick
class Arachnida

spider
class Arachnida



horseshoe crab
class Merostomata

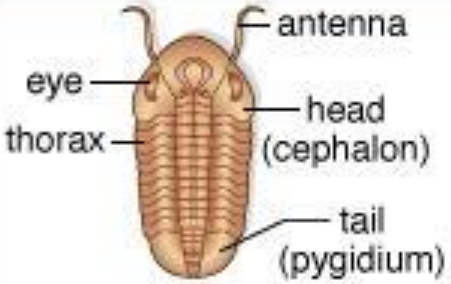


water flea
class Copepoda

shrimp
class Malacostraca

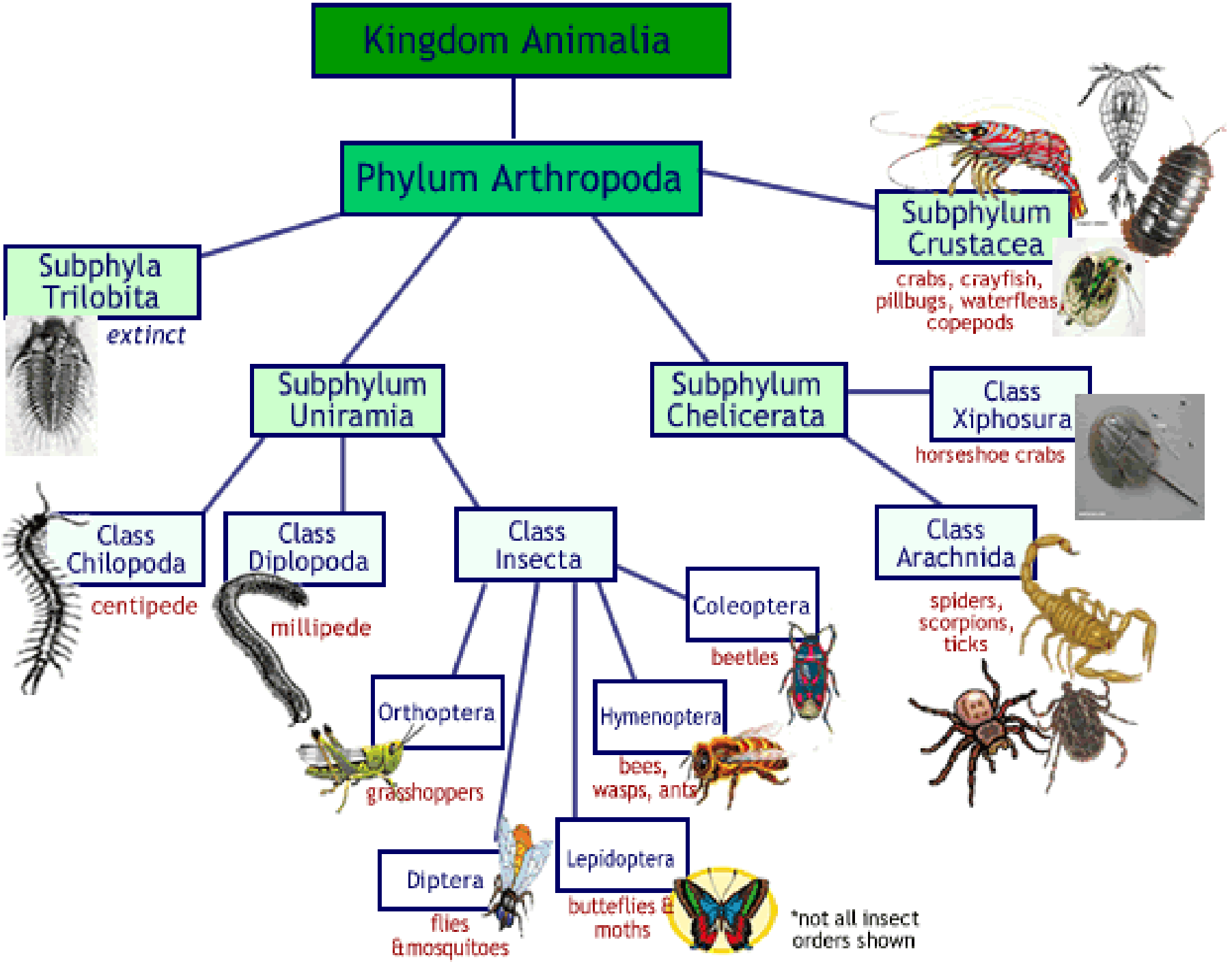
subphylum Crustacea

barnacle
class Cirripeda



trilobite

subphylum Trilobita


Kingdom Animalia
Phylum Arthropoda
Subphyla Trilobita
extinct
Subphylum Crustacea
crabs, crayfish, pillbugs, waterfleas, copepods
Subphylum Uniramia
Subphylum Chelicerata
Class Xiphosura
horseshoe crabs
Class Chilopoda
centipede
Class Diplopoda
millipede
Class Insecta
Class Arachnida
spiders, scorpions, ticks
Coleoptera
beetles
Orthoptera
grasshoppers
Hymenoptera
bees, wasps, ants
Diptera
flies & mosquitoes
Lepidoptera
butteflies & moths
*not all insect orders shown

A hardened exoskeleton is present containing chitin that is secreted by the epidermis. The exoskeleton is moulted at regular intervals to cater for growth.

- **Advantages of Exoskeleton**
- For support on land
- Provides attachment for the muscles internally to aid movement
- Protection from mechanical/physical damage.
- It prevents desiccation
- Low density – adaptation for flying
- Help in a for formation of jaws modification for piercing, chewing, biting, sucking and grinding

General Charecteristics of Arthropods

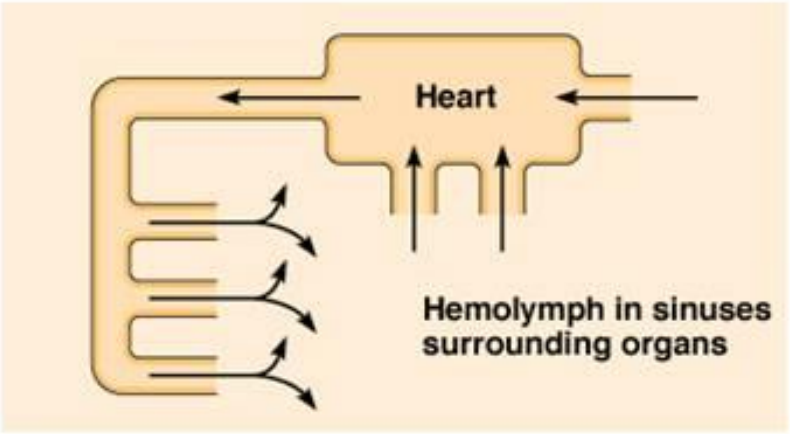
- **Body segmented and joined externally**. **The head, thorax and abdomen** are variously distinct or fused (cephalothorax)
- **There are one pair of jointed appendages per segment or less**.
  - Flexor muscles
  - Extensor muscles
  - Muscle pulling against exoskeleton enables movement
- Excretion occurs either by **coxal/antennal or green glands or maxillary glands**, **Malpighian tubules** that are joined directly to the gut.

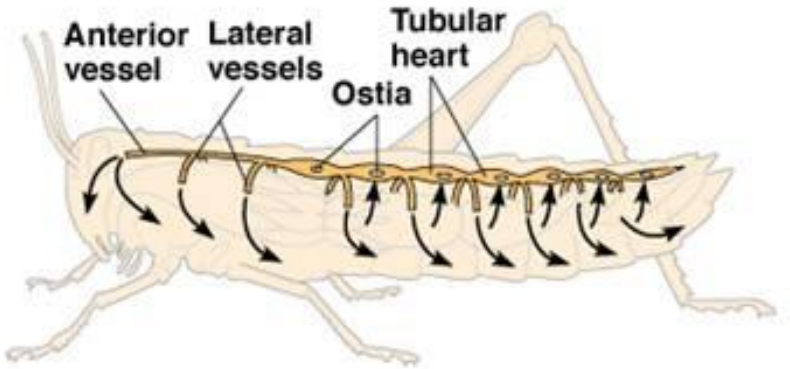
- **Different forms of locomotion in arthropods:** presence of paired **jointed appendages**
    - Swimming for the aquatic
    - Walking, running & crawling
    - Jumping kegs
    - Burrowing or boring into substrate
    - Flight or aerial movement:
        - Insects use wings
        - Spiders use silk to drift in air
    - Cephalization becomes more pronounced, with centralization of fused ganglia and sensory organs in the head.
        - A **nervous system is present with paired dorsal ganglia** and connectives to a pair of ventral nerve cords. The sensory organs include antennae and sensory hairs and simple and compound eyes,
            - Chemoreceptors, taste, smell, pheromones
            - Sound, detect fluctuations in the air (wave)
            - Light, colours
            - Mechanoreceptors, position and direction
- **The sexes are usually separate (dieocious)** and the male and female animals are often unlike. **Fertilization mostly occurs internal.**

Circulation in Arthropods

Open circulatory system

- Blood (haemolymph) moves through a series of sinuses = haemocoel
- Direct contact between blood & organs
- Pumping organ = dorsal vessel = heart
  - heart pumps blood to tissues, sinuses, and cavities but does not return to the heart directly.





(a) Open circulatory system

Respiration

Most arthropods

- **Tracheal tubes**: branching network of tubes that deliver and expel air through **spiracles**

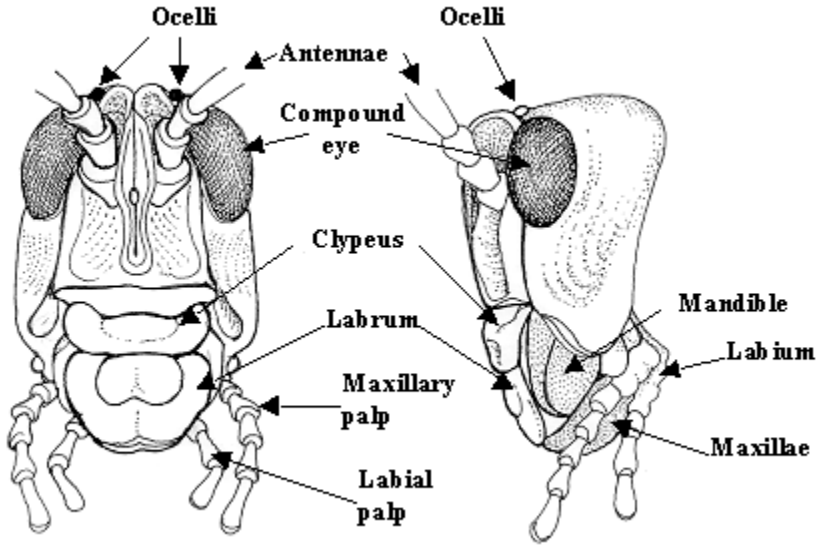
Some arthropods (including spiders)

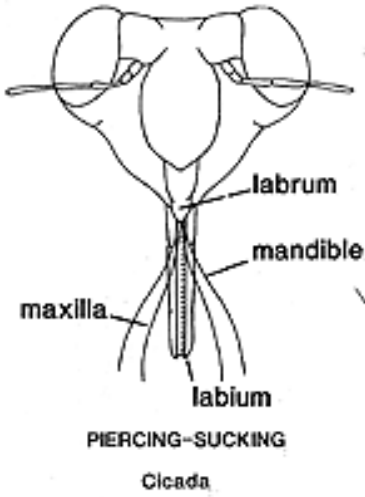
- **Book lungs**: layers of respiratory tissue stacked like pages of a book

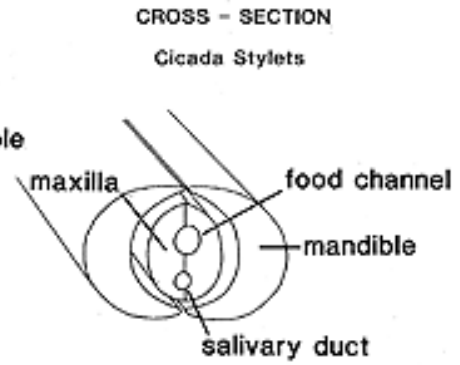
All Crustaceans **have gills**

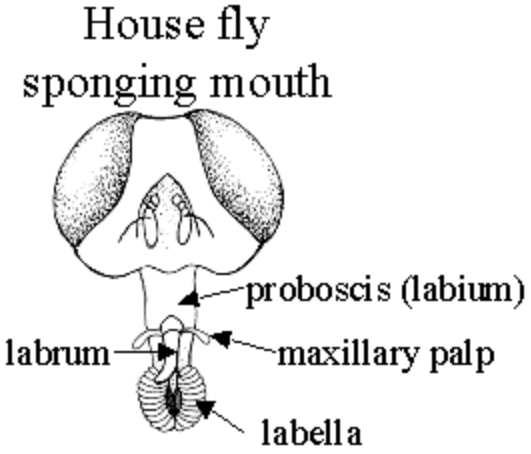
- May be within thoracic cavity or on appendages

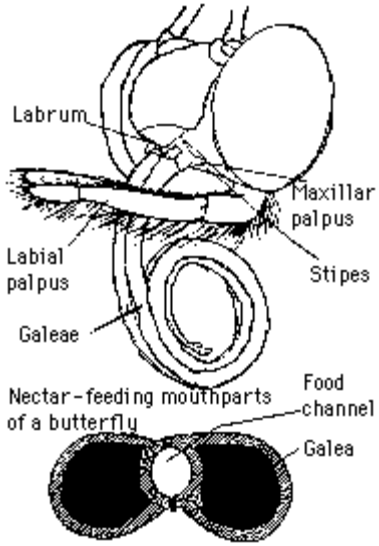
- **A complete digestive canal is present**.
  - The digestive tract has mouth and ends in an anus.
    - Compactments for specialized functions: foregut, midgut and hindgut
- **Feeding behaviours**
  - Herbivores, Locusts
  - Carnivores, e.g. arachnids
  - Parasites,
  - blood suckers (haematophagy), ticks
  - filter feeders/suspension feeders
- **Variety of mouthparts:**
  - That are adapted:
  - for chewing, lapping or sucking.
    - pincers,
    - fangs,
    - Sickle-shaped jaws,
    - feeding tubes





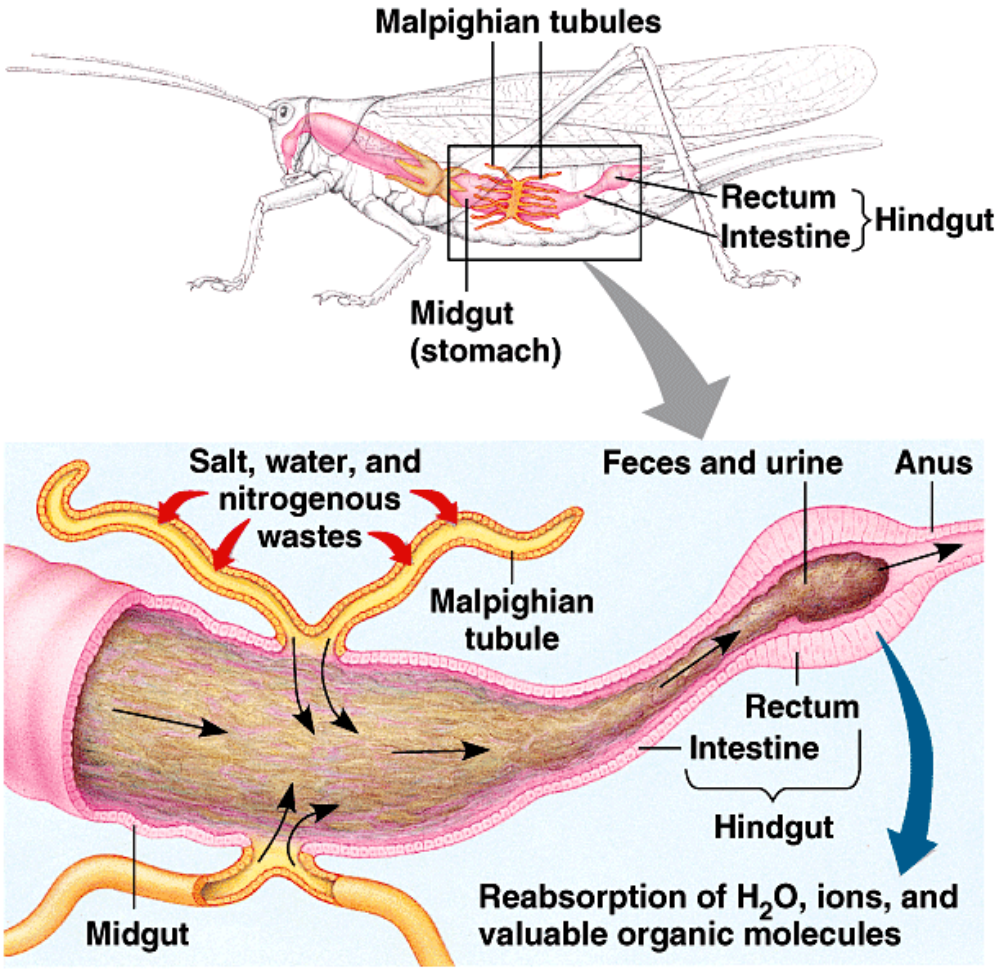






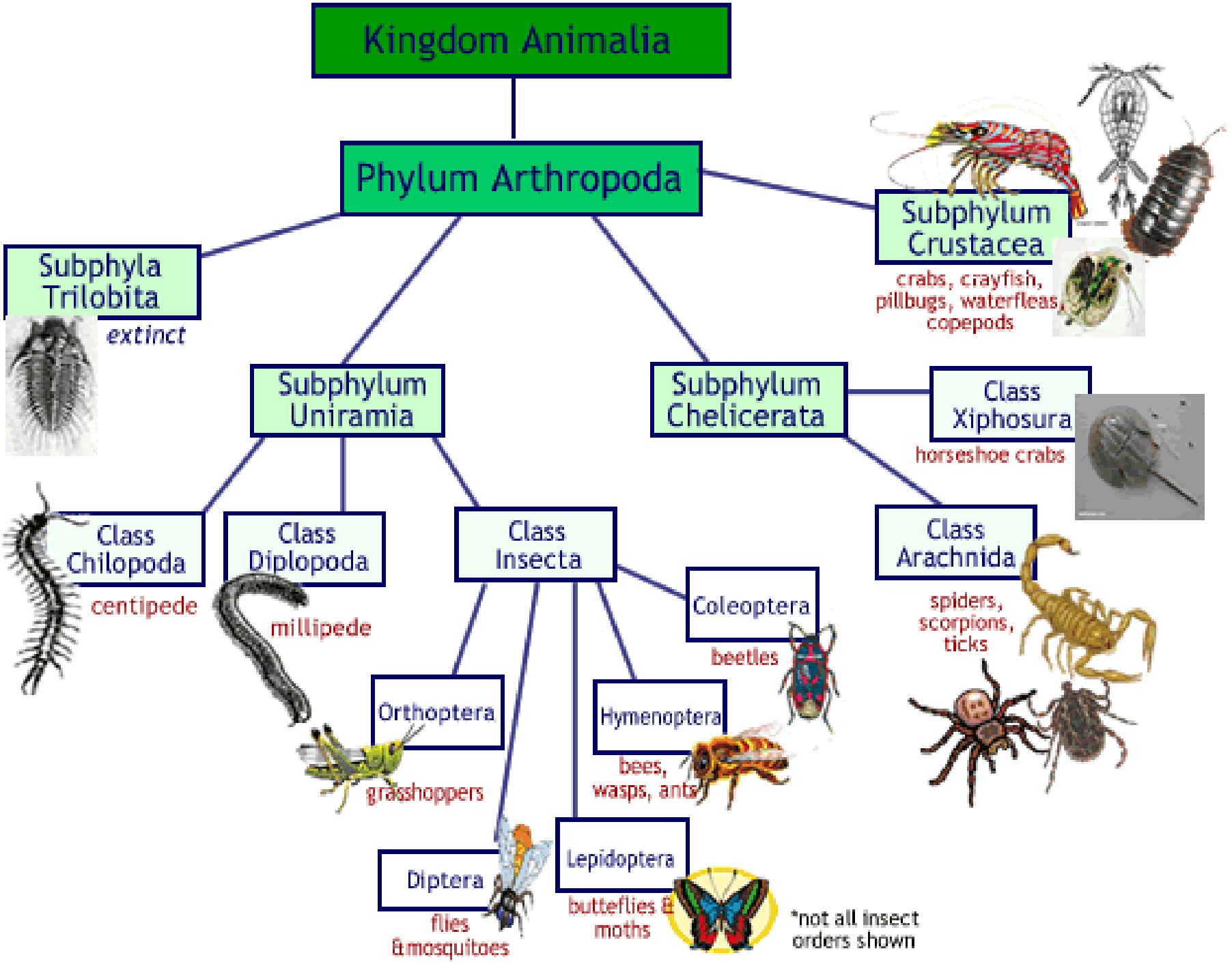
Excretion

Malpighian tubules: saclike organs that extract wastes from blood and then add them to feces to move through the gut



Classification

- Subphylum Trilobitomorpha
- Subphylum Chelicerata
- Sybphylum Uniramia
  - Class Hexapoda
  - Class Myriapoda
- Subphylum Crustacea


Kingdom Animalia
Phylum Arthropoda
Subphyla Trilobita
extinct
Subphylum Crustacea
crabs, crayfish, pillbugs, waterfleas, copepods
Subphylum Uniramia
Subphylum Chelicerata
Class Xiphosura
horseshoe crabs
Class Chilopoda
centipede
Class Diplopoda
millipede
Class Insecta
Class Arachnida
spiders, scorpions, ticks
Coleoptera
beetles
Orthoptera
grasshoppers
Hymenoptera
bees, wasps, ants
Diptera
flies & mosquitoes
Lepidoptera
butteflies & moths
*not all insect orders shown

Subphylum Chelicerata

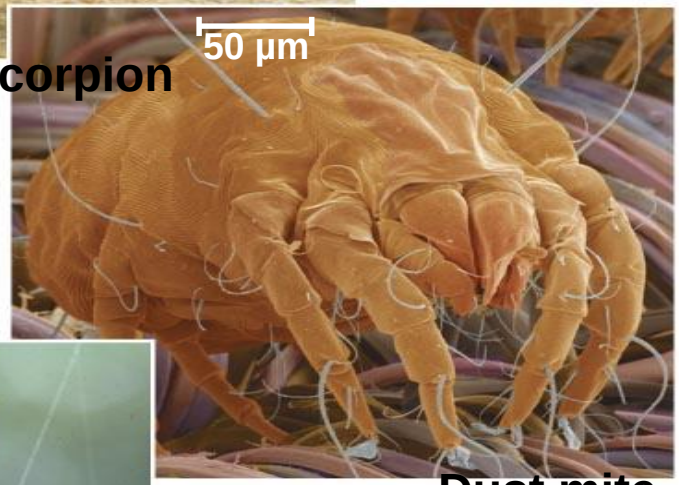
Water scorpions, horseshoe crab, sea spiders, spiders, ticks & mites.

Characteristics

- Chelicerates have six pairs of cephalothoracic appendages including chelicerae, pedipalps and four pair of legs.
- Head and thorax commonly fused together = **cephalothorax**
- Reduced segmentation of the thorax and abdomen
- Breathing typically by book lungs
- They lack mandibles and antennae.
- Most suck liquid food from prey.

Fig. 33-31

Scorpion



Dust mite

Web-building spider

Subphylum Crustacea

- Head of five fused segments including two pairs of antennae, one lateral pair of mandibels for chewing, and two pairs of maxillae.
- Often with a carapace covering the head and parts of the thorax as a dorsal shield or as two lateral valves.
- The appendages are variously modified and some are usually biramous.
- Respiration via gills (rarely by body surface).
- Excretion by antennal or maxillary glands. .
- The sexes are separate

- **The crayfish**:

  a) antennae (2 pair) & antennules for sensing

  b) mandible for crushing food

  d) maxillae & maxilliped for food handling & taste

  e) cheliped for catching food & defense

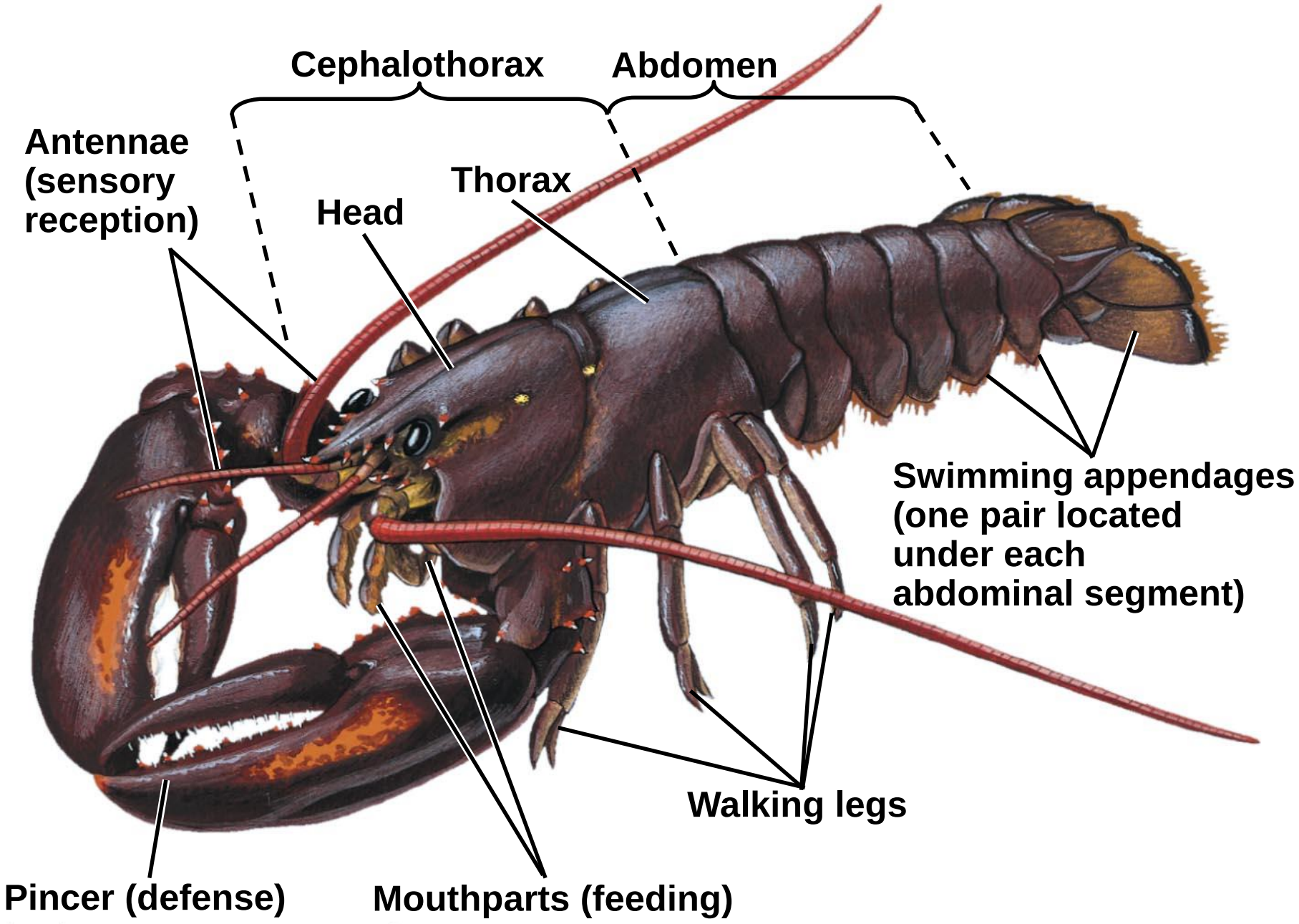
  f) walking legs for walking & gathering food

  g) 1st swimmeret for reproductive function

  h) swimmerets for creating water currents

  i) uropod for swimming

Fig. 33-29



Uniramia characteristics

Have Jaws

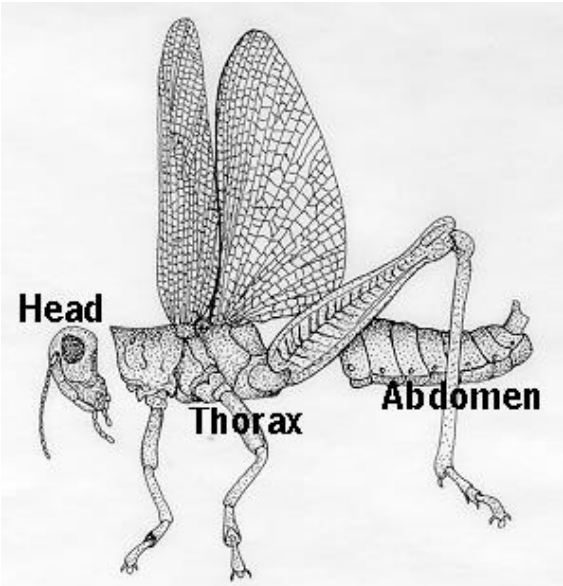
One pair of antennae

Unbranched appendages

Groups: centipedes, millipedes, insects

Class Insecta

- Three distinct head regions:
    - Head, three-segmented thorax (**prothorax, mesothorax, and metathorax**), and abdomen.
- Have both compound and simple eyes;
- One pair antenna,
- One pair of mandibles,
- One pair of maxillae.
- Sensitive taste and smell receptors
- Many insects have **wings**, which are NOT modified appendages, merely flaps of the exoskeleton of the meso- and metathoracic segments
- Three pairs of legs on thorax;
- tracheal respiratory system- composed of tubes, with holes (spiracles) through the body that admit air.



Insect life cycle

Metamorphosis: process of changing shape and form from juvenile to adult stage

- Incomplete: juvenile stage (**nymphs**) appear like adults, just smaller
- Complete: juvenile stage (**larvae**) becomes **pupa**, final stage before becoming an adult

Gradual (Incomplete) Metamorphosis

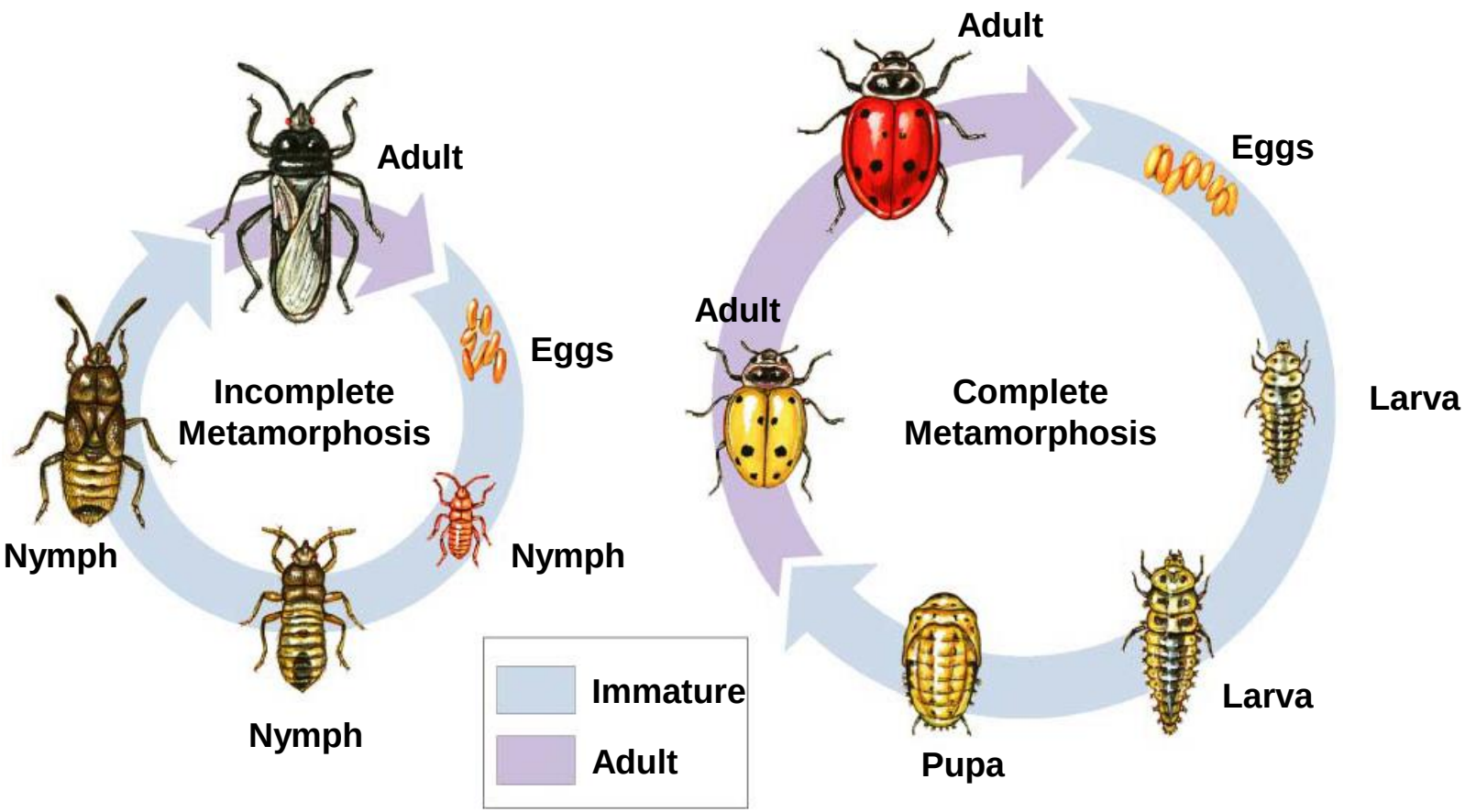
Nymphs (*immature forms are often called nymphs*) **resemble the adult in form** except for being smaller and lacking fully developed wings and sexual organs.

Partial change in wing and external genitalia development with each molt.

Most adults and nymphs have the **same habits** and live in the same environment.

Life Cycle: Egg --> nymphal instars --> adult

Metamorphosis



Complete metamorphosis

Immature forms are called **larvae** (larva, singular).

Larvae are very **different in form** from the adult.

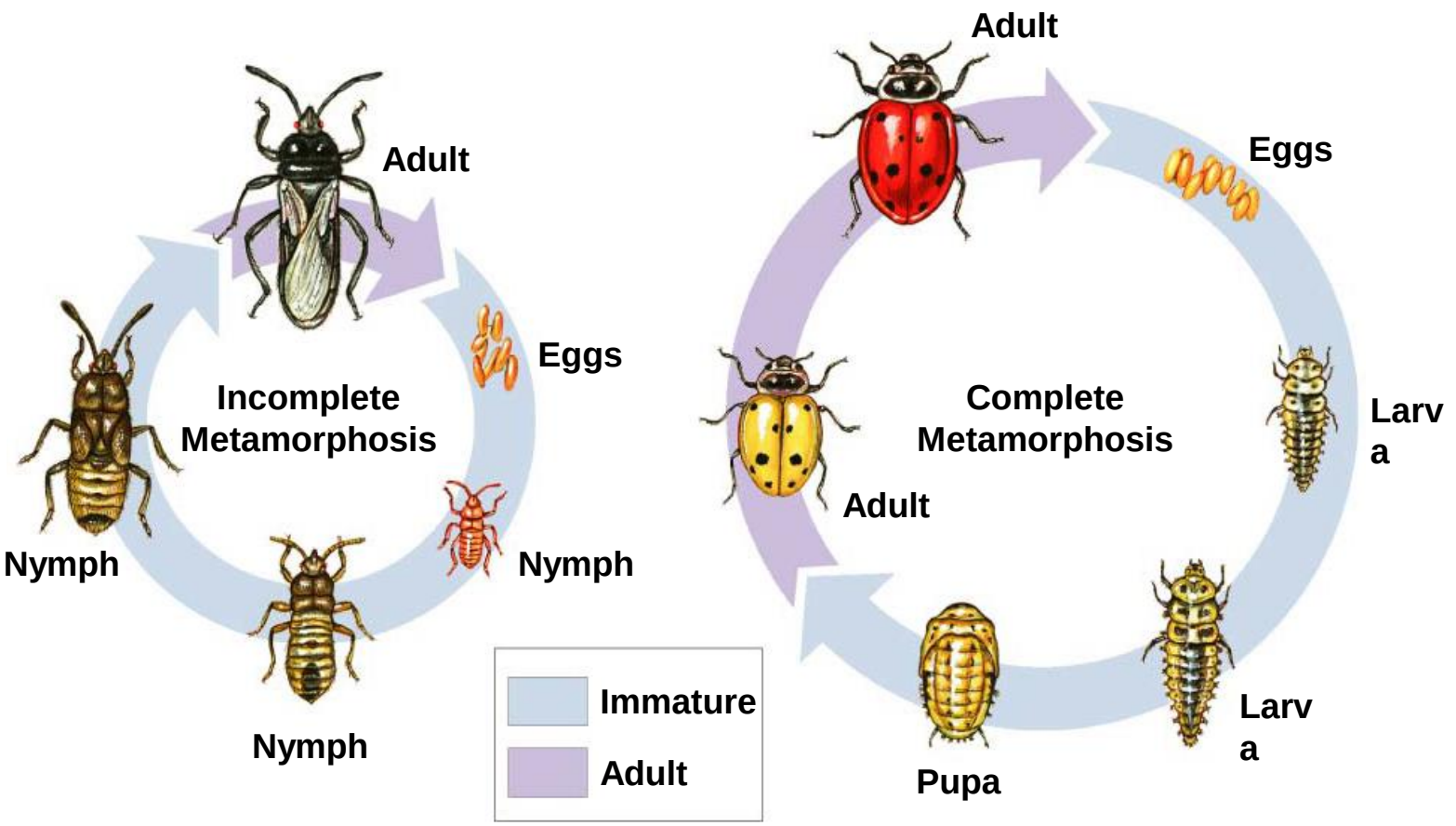
The pupal stage is a transition stage, when the larva is transformed to the adult.

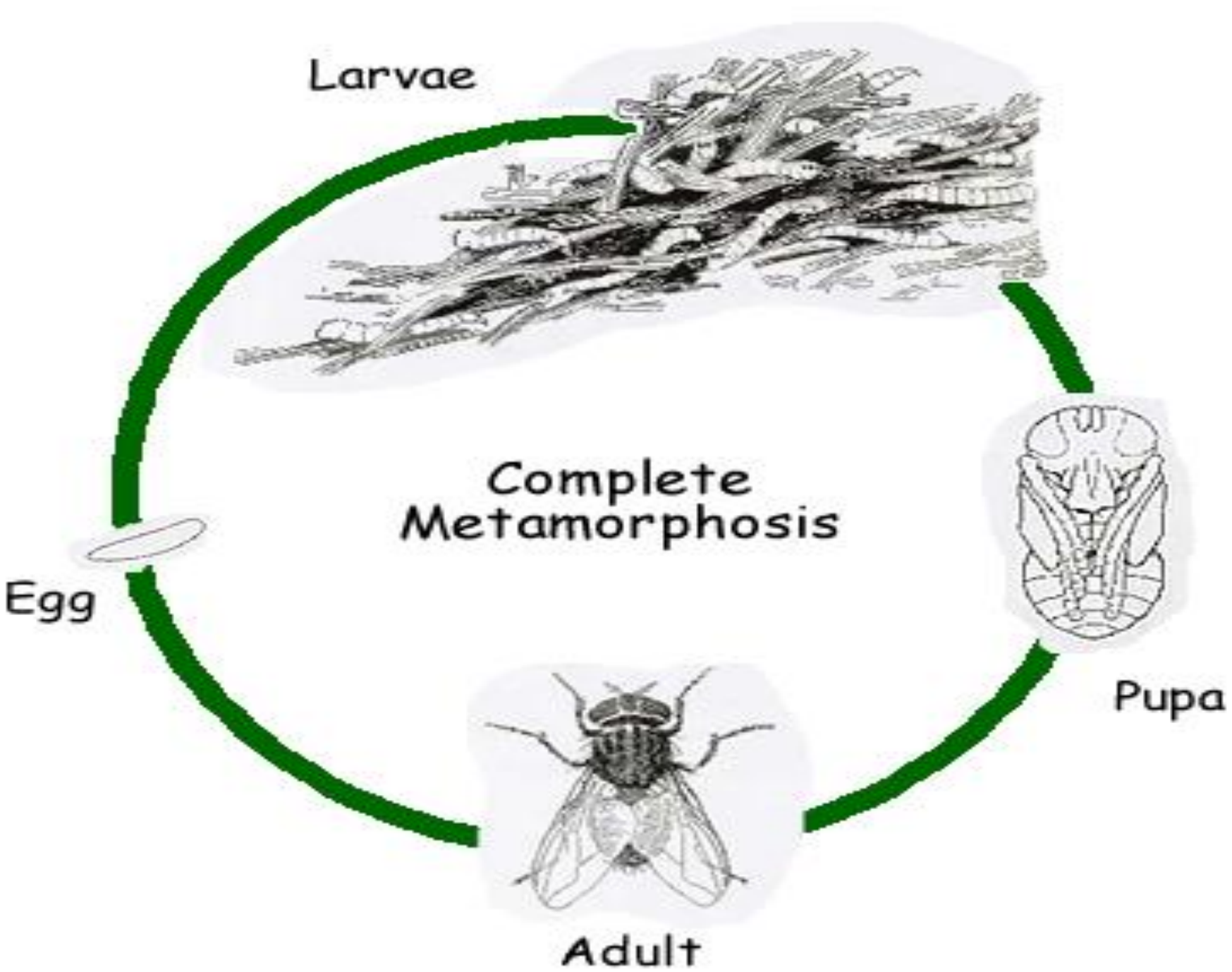
- Pupa does not eat and movement is very restricted.
- Great metabolic changes occur.

Pupa molts to the adult form.

Life Cycle: Egg --> larval instars --> pupa --> adult

Metamorphosis




Larvae
Complete
Metamorphosis
Egg
Pupa
Adult

Insect communication and societies

Chemical cues: **pheromones**

Visual cues: light, flight patterns

Some insects form societies where **castes**, groups of individuals, perform specific tasks.

Why insects are evolutionarily successful

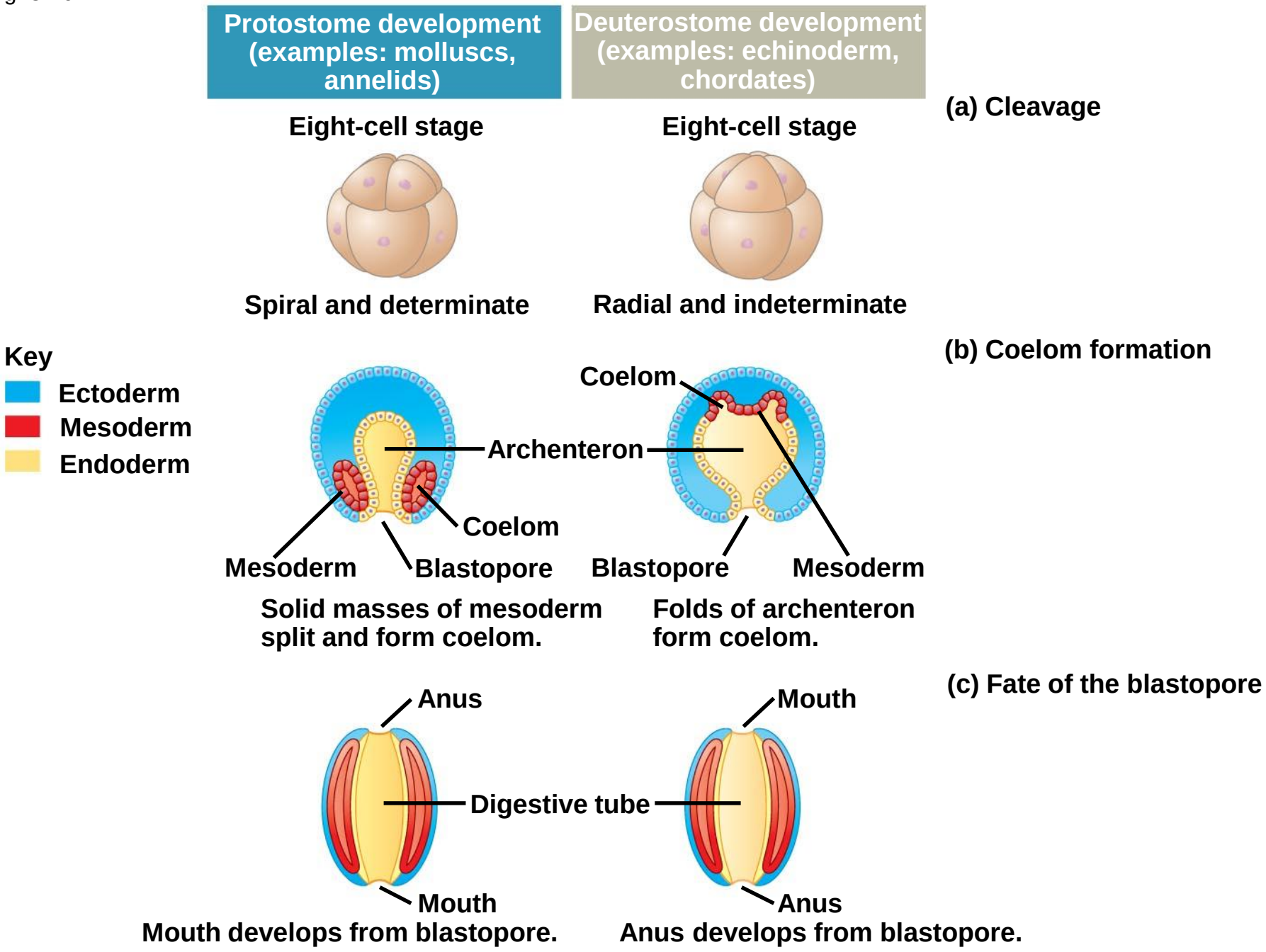
Flight

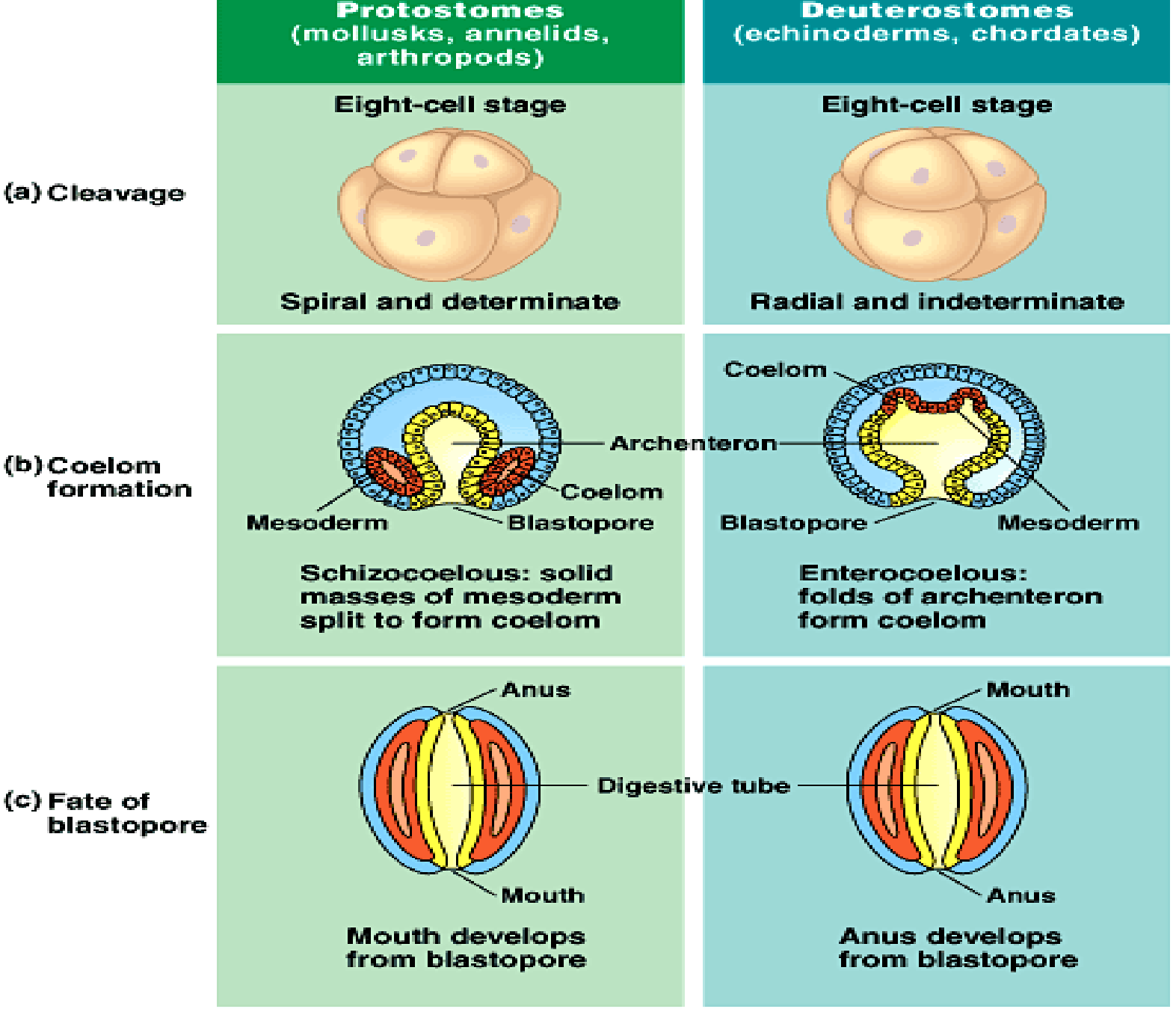
Variety of stimuli responses

Differential feeding methods between young and adult

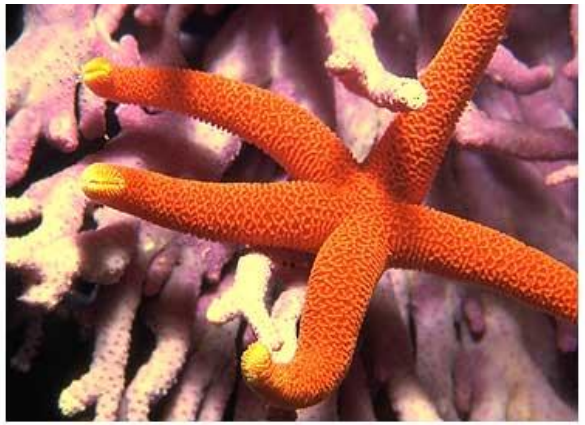
Different morphology between young and adult

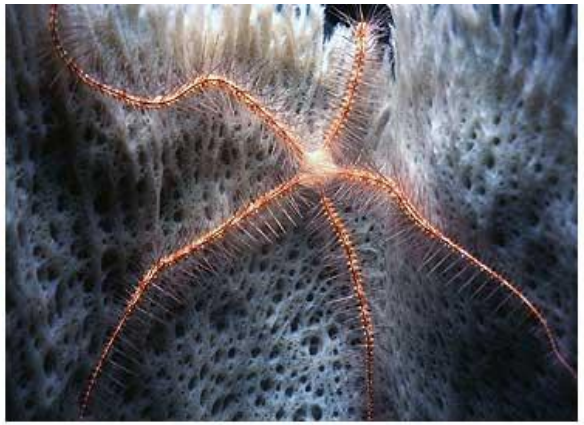
Fig. 32-9





Echinodermata

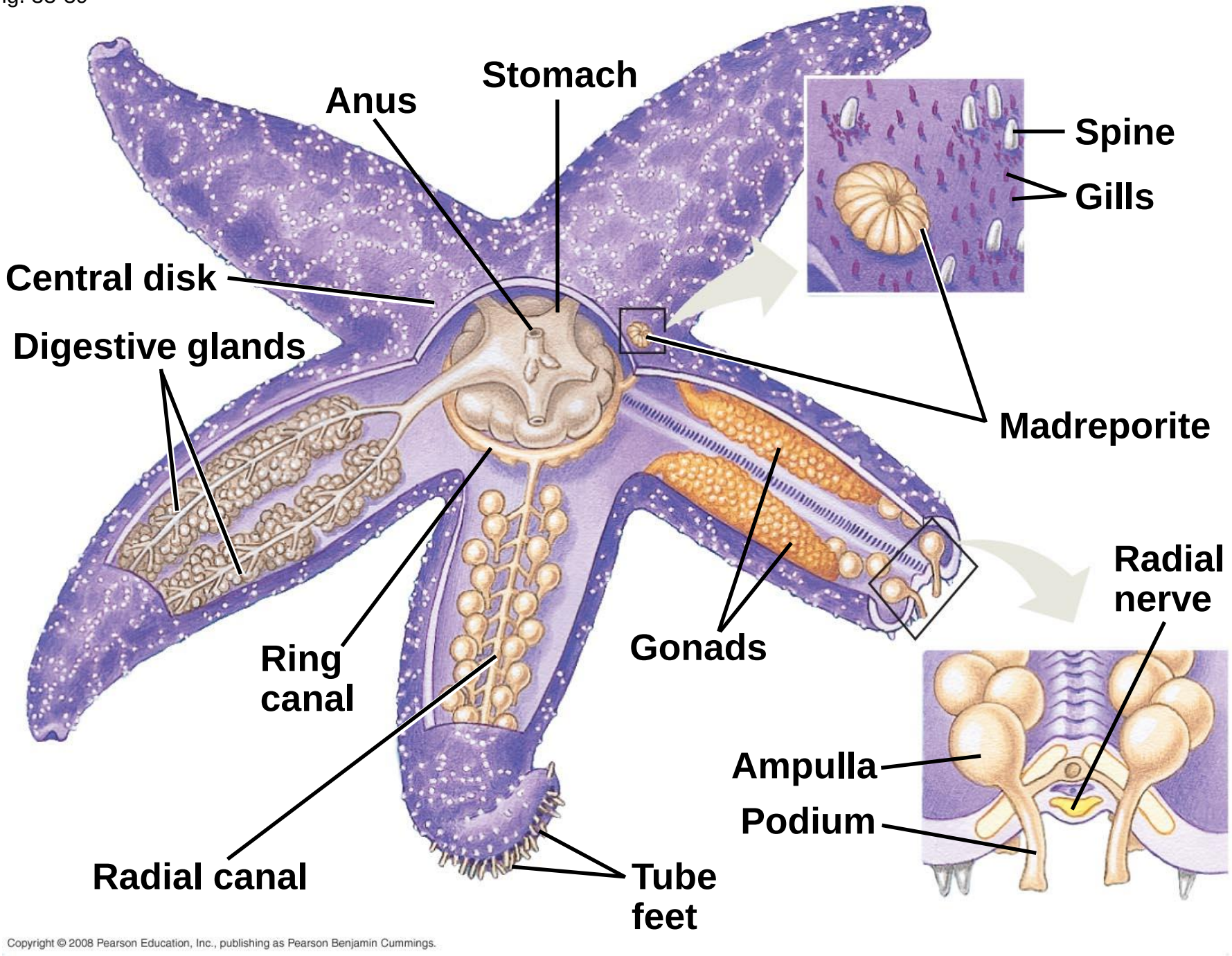




Phylum Characteristics:

- Non-segmented animals with secondary pentaradial symmetry.
- The animals show no cephalization and no head or brain.
- They are at the organ system level of organisation.
- The echinoderms are enterocoelomic, triploblastic deuterostomes.
- They have a complete digestive system.
- They have an endoskeleton of dermal calcareous ossicles covered by an epidermis.
- The echinoderms possess a water vascular system and tube feet.
- The coelom is extensive, involving the water vascular system and a large perivisceral cavity.

Fig. 33-39



The circulatory and excretory systems are reduced or absent.

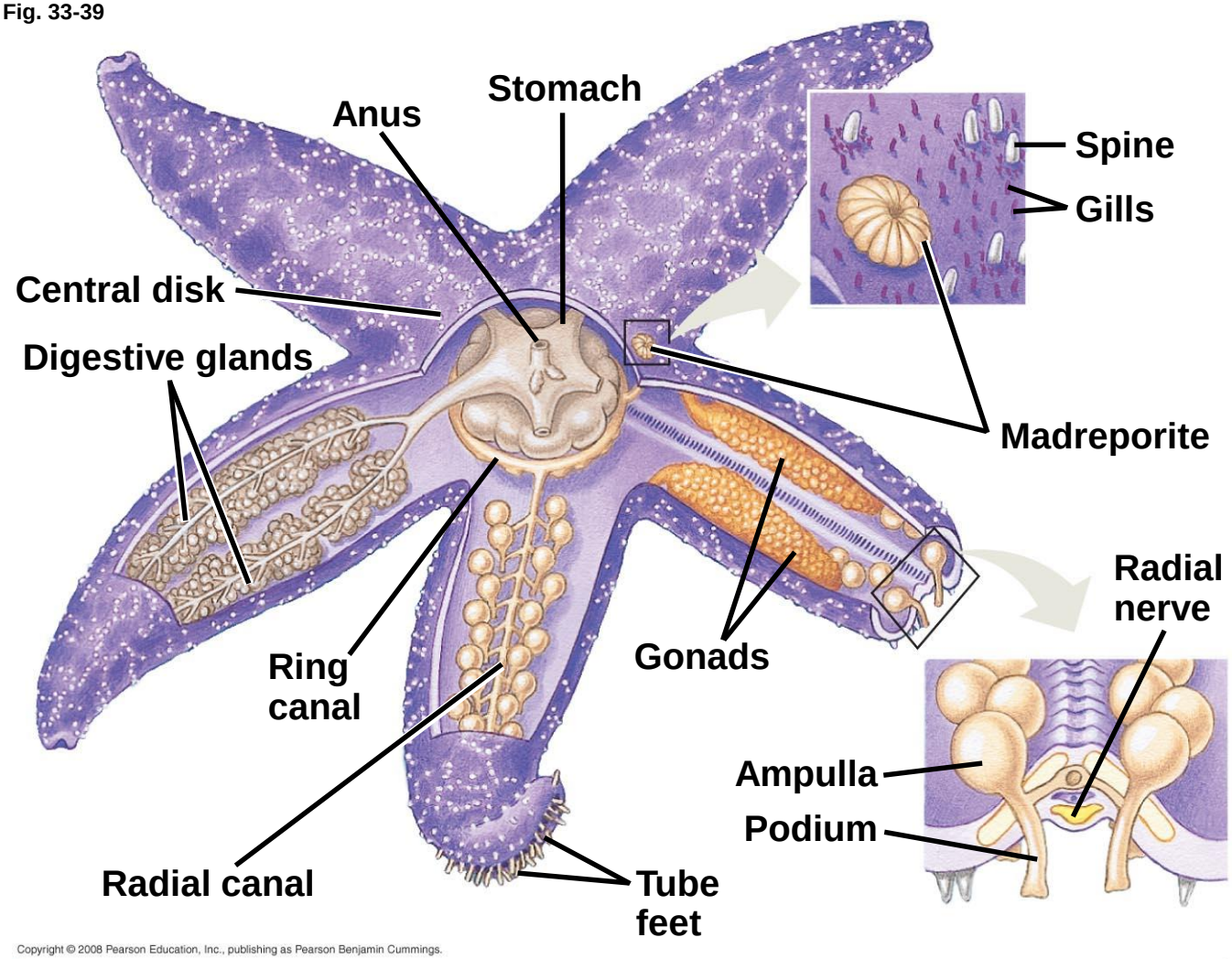
Respiration is by dermal branchiae or tube feet.

The nervous system consists of a nerve ring and 5 radial nerve cords.

Locomotion is by tube feet, spines or arm movement.

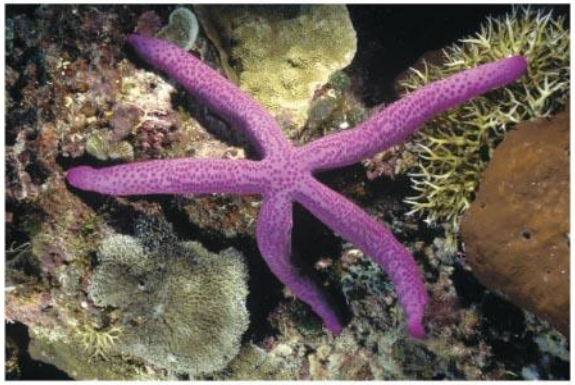
Sexes are separate, fertilisation external and.

Fig. 33-39

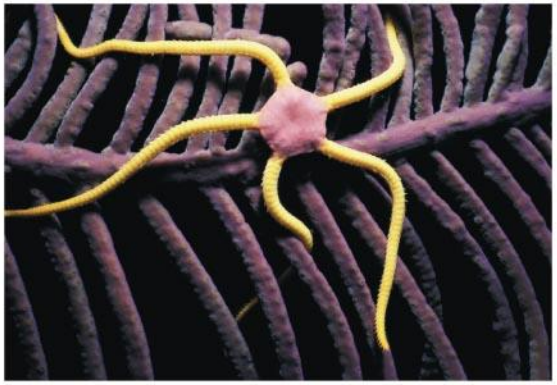


Living echinoderms are divided into six classes:

1. Asteroidia (sea stars)
2. Ophiuroidea (brittle stars)
3. Echinoidea (sea urchins and sand dollars)
4. Crinoidea (sea lilies and feather stars)
5. Holothuroidea (sea cucumbers)
6. Concentricycloidea (sea daisies)



(a) A sea star (class Asteroidea)

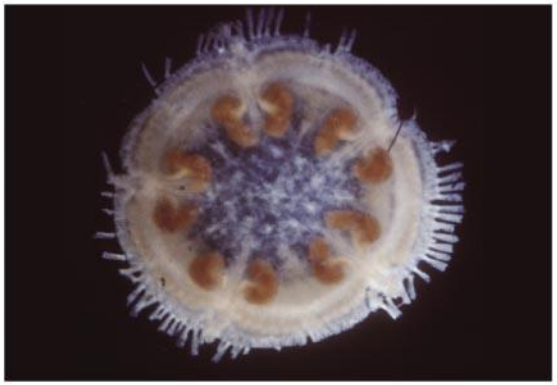


(b) A brittle star (class Ophiuroidea)

(c) A sea urchin (class Echinoidea)

(d) A feather star (class Crinoidea)

(e) A sea cucumber (class Holothuroidea)

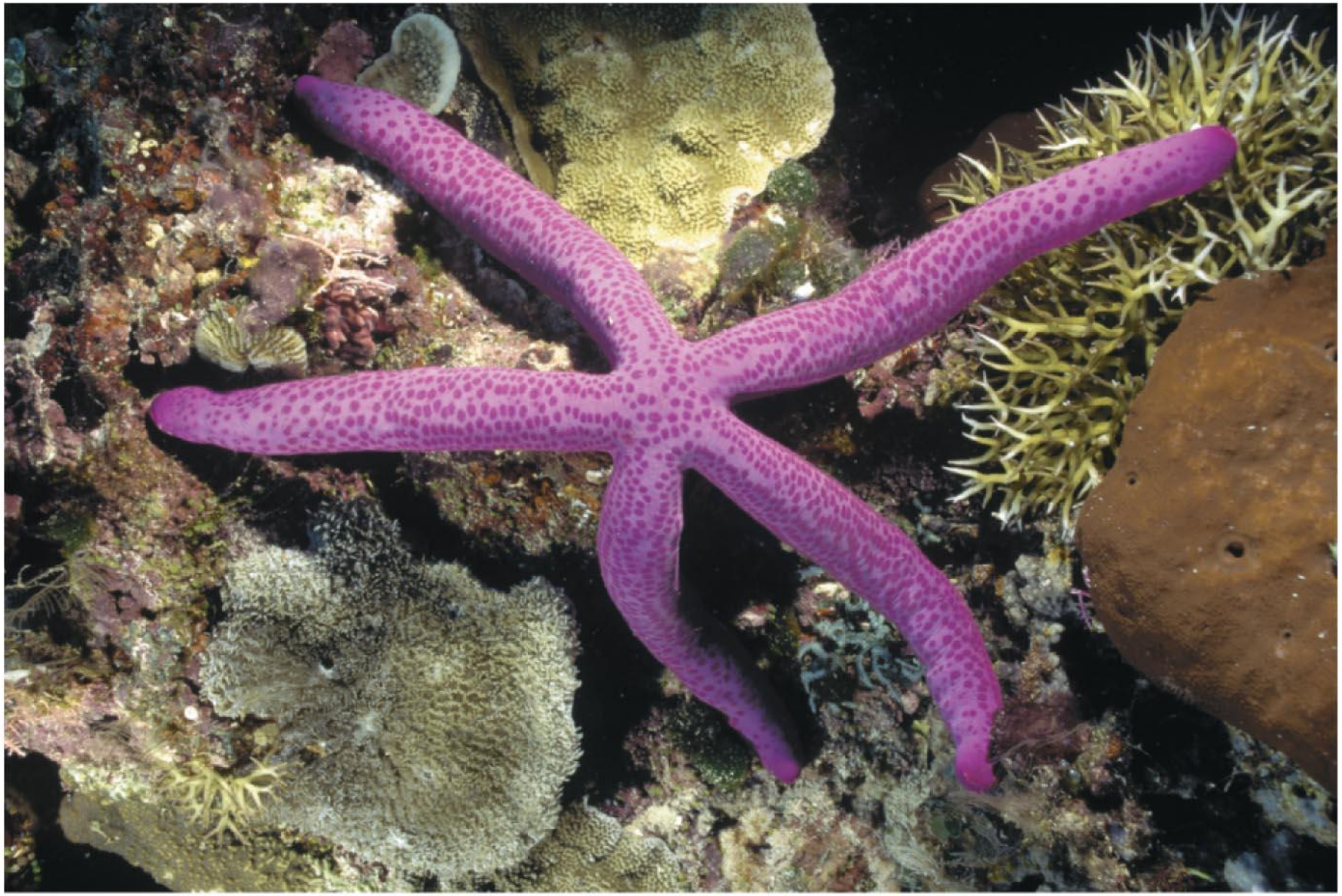


(f) A sea daisy (class Concentricycloidea)

Table 33.6 Classes of Phylum Echinodermata

Class and Examples	Main Characteristics
Asteroidea (sea stars)	Star-shaped body with multiple arms; mouth directed to substrate
Ophiuroidea (brittle stars)	Distinct central disk; long, flexible arms; incomplete digestive system
Echinoidea (sea urchins, sand dollars)	Roughly spherical or disk-shaped; no arms; five rows of tube feet; mouth ringed by complex, jaw-like structure
Crinoidea (sea lilies, feather stars)	Feathered arms surrounding upward-pointing mouth
Holothuroidea (sea cucumbers)	Cucumber-shaped body; five rows of tube feet; reduced skeleton; no spines
Concentricycloidea (sea daisies)	Armless, disk-shaped body ringed with small spines; incomplete digestive system

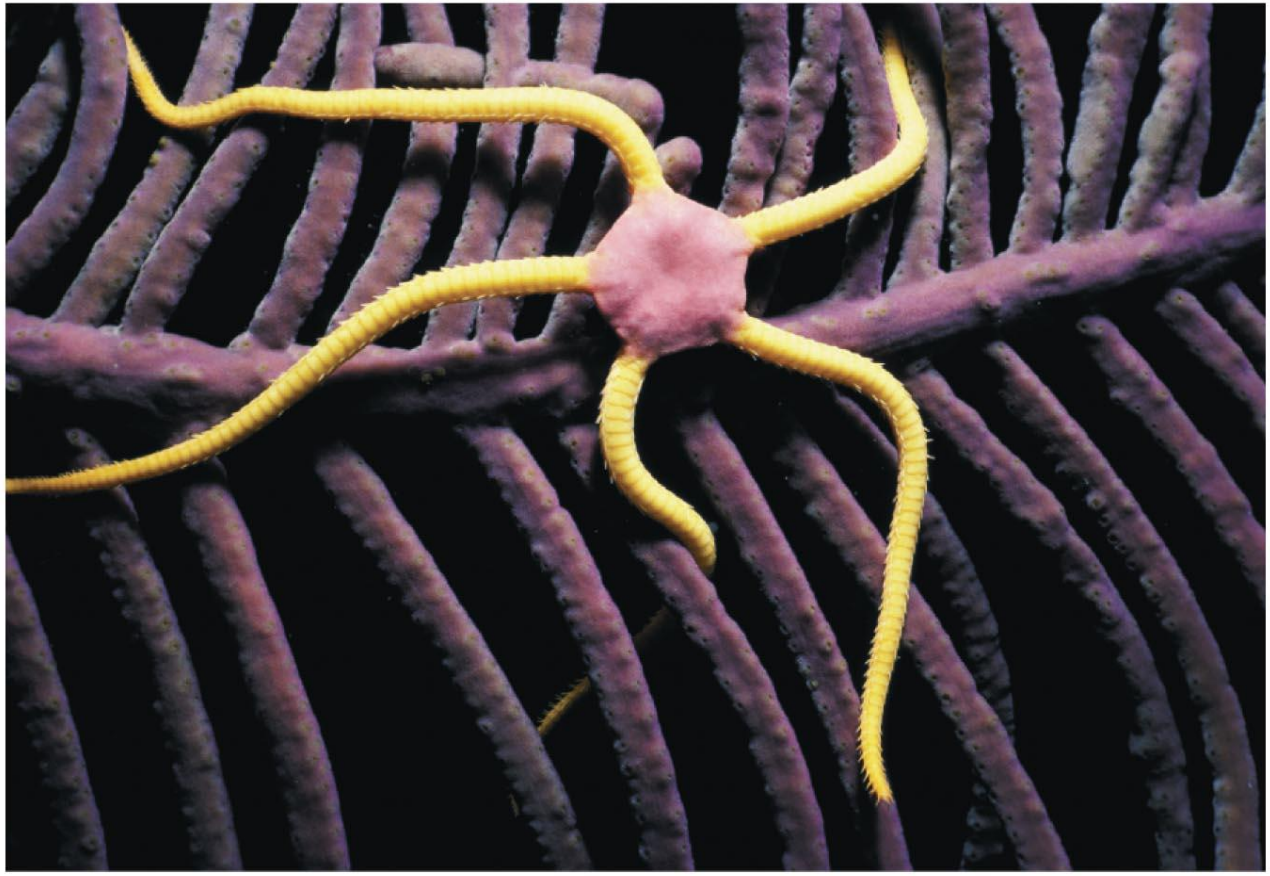
Fig. 33-40a



(a) A sea star (class Asteroidea)

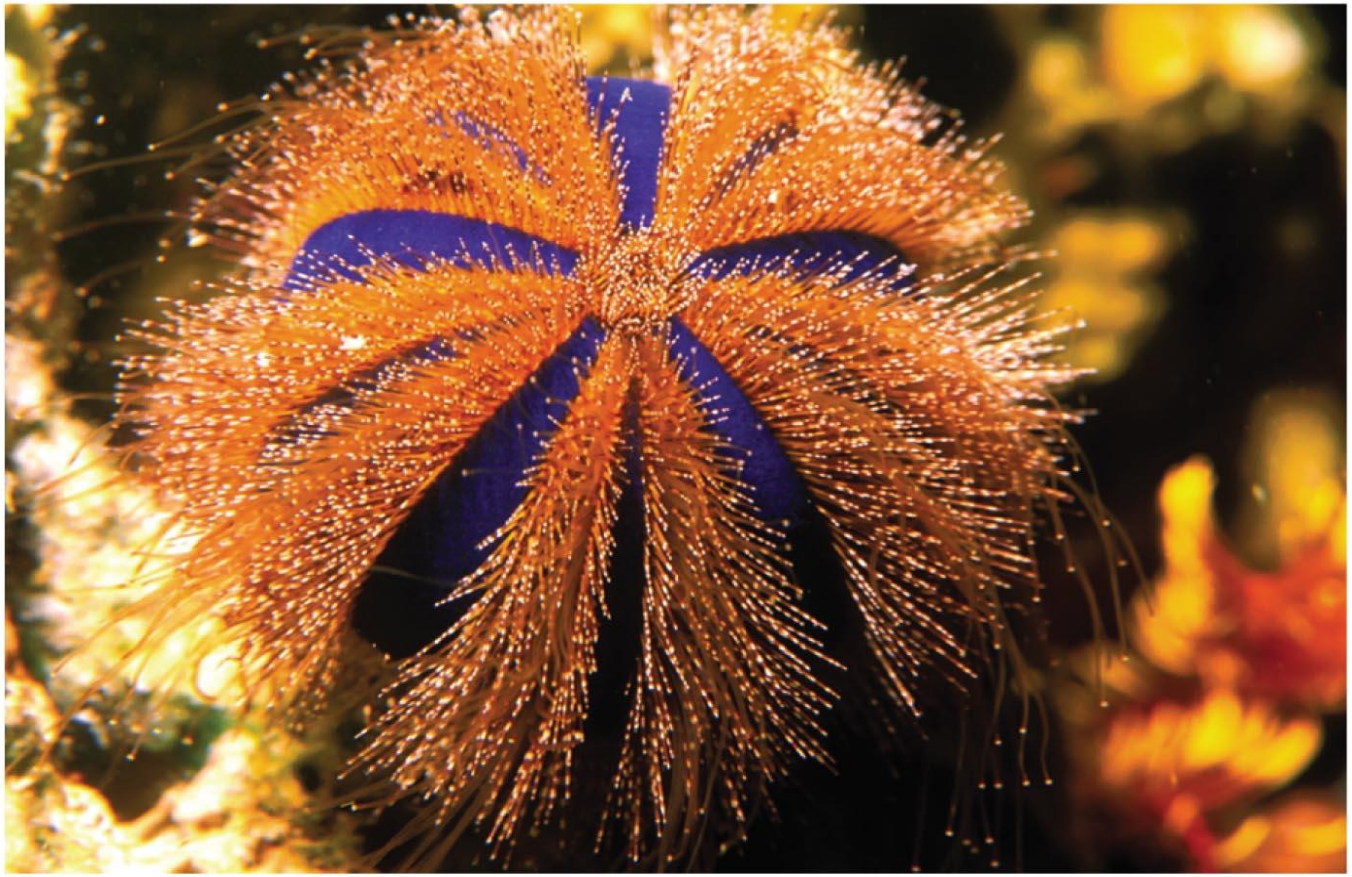
Brittle Stars

- Brittle stars have a distinct central disk and long, flexible arms, which they use for movement



Sea Urchins and Sand Dollars

- Sea urchins and sand dollars have no arms but have five rows of tube feet



Sea Lilies and Feather Stars

- Sea lilies live attached to the substrate by a stalk
- Feather stars can crawl using long, flexible arms

(d) A feather star (class Crinoidea)

Sea Cucumbers

- Sea cucumbers lack spines, have a very reduced endoskeleton, and do not look much like other echinoderms
- Sea cucumbers have five rows of tube feet; some of these are developed as feeding tentacles

Sea Daisies

- Sea daisies were discovered in 1986, and only three species are known

(f) A sea daisy (class Concentricycloidea)

Fig. 33-UN6

Key Concept	Phylum		Description
Concept 33.1 Sponges are basal animals that lack true tissues	Calcarea, Silicea (sponges)		Lack true tissues; have choanocytes (collar cells—flagellated cells that ingest bacteria and tiny food particles)
Concept 33.2 Cnidarians are an ancient phylum of eumetazoans	Cnidaria (hydras, jellies, sea anemones, corals)		Unique stinging structures (cnidae), each housed in a specialized cell (cnidocyte); diploblastic; radially symmetrical; gastrovascular cavity (digestive compartment with a single opening)
Concept 33.3 Lophotrochozoans, a clade identified by molecular data, have the widest range of animal body forms	Platyhelminthes (flatworms)		Dorsoventrally flattened, unsegmented acoelomates; gastrovascular cavity or no digestive tract
	Rotifera (rotifers)		Pseudocoelomates with alimentary canal (digestive tube with mouth and anus); jaws (trophi) in pharynx; head with ciliated crown
	Lophophorates: Ectoprocta, Brachiopoda		Coelomates with lophophores (feeding structures bearing ciliated tentacles)
	Mollusca (clams, snails, squids)		Coelomates with three main body parts (muscular foot, visceral mass, mantle); coelom reduced; most have hard shell made of calcium carbonate
	Annelida (segmented worms)		Coelomates with segmented body wall and internal organs (except digestive tract, which is unsegmented)
Concept 33.4 Ecdysozoans are the most species-rich animal group	Nematoda (roundworms)		Cylindrical, unsegmented pseudocoelomates with tapered ends; no circulatory system; undergoes ecdysis
	Arthropoda (crustaceans, insects, spiders)		Coelomates with segmented body, jointed appendages, and exoskeleton made of protein and chitin
Concept 33.5 Echinoderms and chordates are deuterostomes	Echinodermata (sea stars, sea urchins)		Coelomates with bilaterally symmetrical larvae and five-part body organization as adults; unique water vascular system; endoskeleton
	Chordata (lancelets, tunicates, vertebrates)		Coelomates with notochord; dorsal, hollow nerve cord; pharyngeal slits; post-anal tail (see Chapter 34)

Metazoa
Eumetazoa
Bilateria
Lophotrochozoa
Ecdysozoa
Deuterostomia

Fig. 33-UN6a

Key Concept	Phylum	Description
Concept 33.1 Sponges are basal animals that lack true tissues	Calcarea, Silicea (sponges)	Lack true tissues; have choanocytes (collar cells—flagellated cells that ingest bacteria and tiny food particles)

Fig. 33-UN6b

Key Concept	Phylum	Description
Concept 33.2 Cnidarians are an ancient phylum of eumetazoans	Cnidaria (hydras, jellies, sea anemones, corals)	Unique stinging structures (cnidae), each housed in a specialized cell (cnidocyte); diploblastic; radially symmetrical; gastrovascular cavity (digestive compartment with a single opening)

Fig. 33-UN6c

Key Concept	Phylum	Description
Concept 33.3 Lophotrochozoans, a clade identified by molecular data, have the widest range of animal body forms	Platyhelminthes (flatworms)	Dorsoventrally flattened, unsegmented acoelomates; gastrovascular cavity or no digestive tract
	Rotifera (rotifers)	Pseudocoelomates with alimentary canal (digestive tube with mouth and anus); jaws (trophi) in pharynx; head with ciliated crown
	Lophophorates: Ectoprocta, Brachiopoda	Coelomates with lophophores (feeding structures bearing ciliated tentacles)
	Mollusca (clams, snails, squids)	Coelomates with three main body parts (muscular foot, visceral mass, mantle); coelom reduced; most have hard shell made of calcium carbonate
	Annelida (segmented worms)	Coelomates with segmented body wall and internal organs (except digestive tract, which is unsegmented)

Fig. 33-UN6d

Key Concept	Phylum	Description
Concept 33.4 Ecdysozoans are the most species-rich animal group	Nematoda (roundworms)	Cylindrical, unsegmented pseudocoelomates with tapered ends; no circulatory system; undergoes ecdysis
	Arthropoda (crustaceans, insects, spiders)	Coelomates with segmented body, jointed appendages, and exoskeleton made of protein and chitin

Fig. 33-UN6e

Key Concept	Phylum	Description
Concept 33.5 Echinoderms and chordates are deuterostomes	Echinodermata (sea stars, sea urchins)	Coelomates with bilaterally symmetrical larvae and five-part body organization as adults; unique water vascular system; endoskeleton
	Chordata (lancelets, tunicates, vertebrates)	Coelomates with notochord; dorsal, hollow nerve cord; pharyngeal slits; post-anal tail (see Chapter 34)