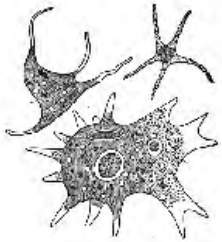
Invertebrates

Chapter 33

Animals without backbones



Protozoa

Annelids

Mollusks

Echinoderms

Crustaceans

Arachnids

Insects

Body plans:

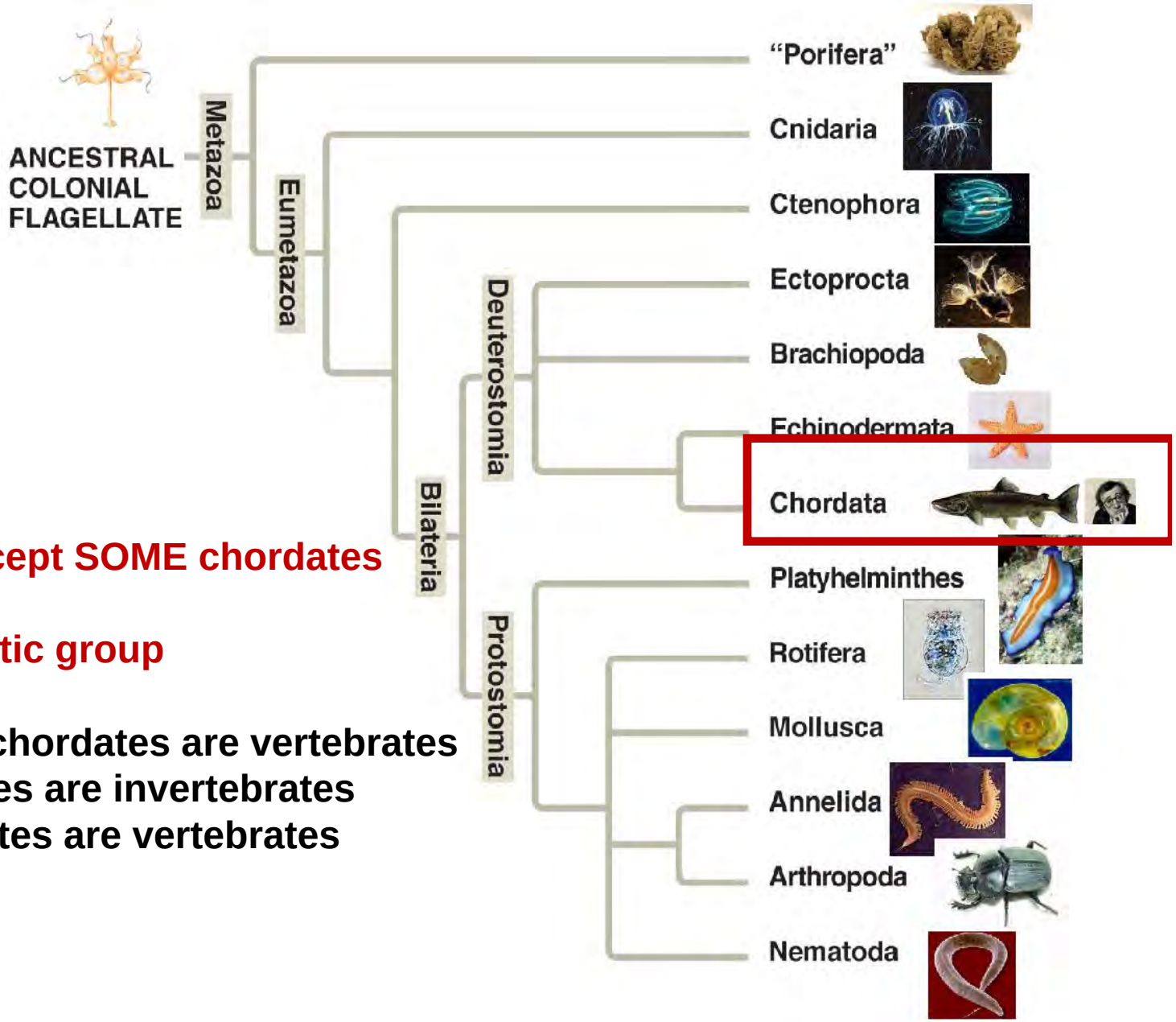
Overview

Main characters used to
categorize animal body plans:

1. Symmetry (none, radial, bilateral)
2. Embryonic germ layers (0, 2, 3)
3. Organization of body cavity (Coelom)
4. Possession of vertebral column

3

WHAT ARE INVERTEBRATES?



Invertebrates are
ALL ANIMALS except SOME chordates

NOT a monophyletic group

Most, but not all, chordates are vertebrates
- **Basal chordates are invertebrates**
- **Higher chordates are vertebrates**

Figure 32.11 (Campbell et al)

Phylum: Porifera (sponges)

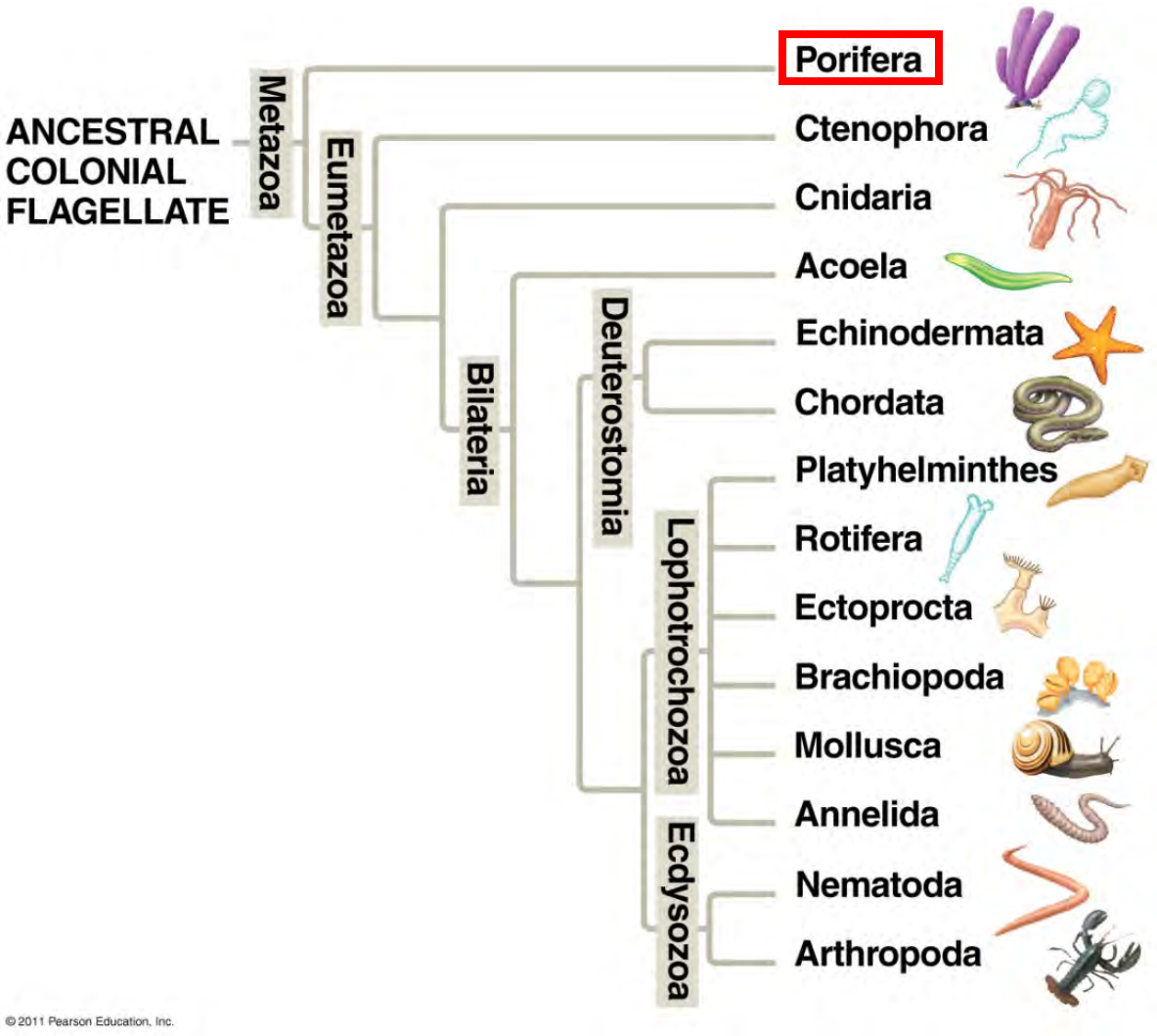


Figure 32.11 (Campbell et al.)

Phylum: Porifera (sponges)

~ 2000 species

- Asymmetric
- Aquatic (mostly marine)
- Sedentary adults (flagellated larvae)
- Suspension feeders (aka filter feeders)
  - Pumps 20,000x own volume of water each day!

Structure & Function

- Body is a “sac with pores”
- No true tissues - cells do not act as functional unit
- 4 Cell types: epidermal, choanocytes, porocytes, amoebocytes

1. Epidermis = outer layer of epidermal cells

2. Porocytes = doughnut shaped cell within epidermis where water enters

3. Spongocoel = inner cavity
   - Water exits at top via osculum

4. Choanocytes = flagellated cells lining spongocoel
   - Moves water in through porocytes
   - Trap and ingest food particles

5. Mesohyl = gelatinous matrix btwn epidermis and choanocytes

6. Amoebocytes = Cells that:
   - transfer nutrients to other cells
   - produce support fibers (spicules)
   - change into other cells

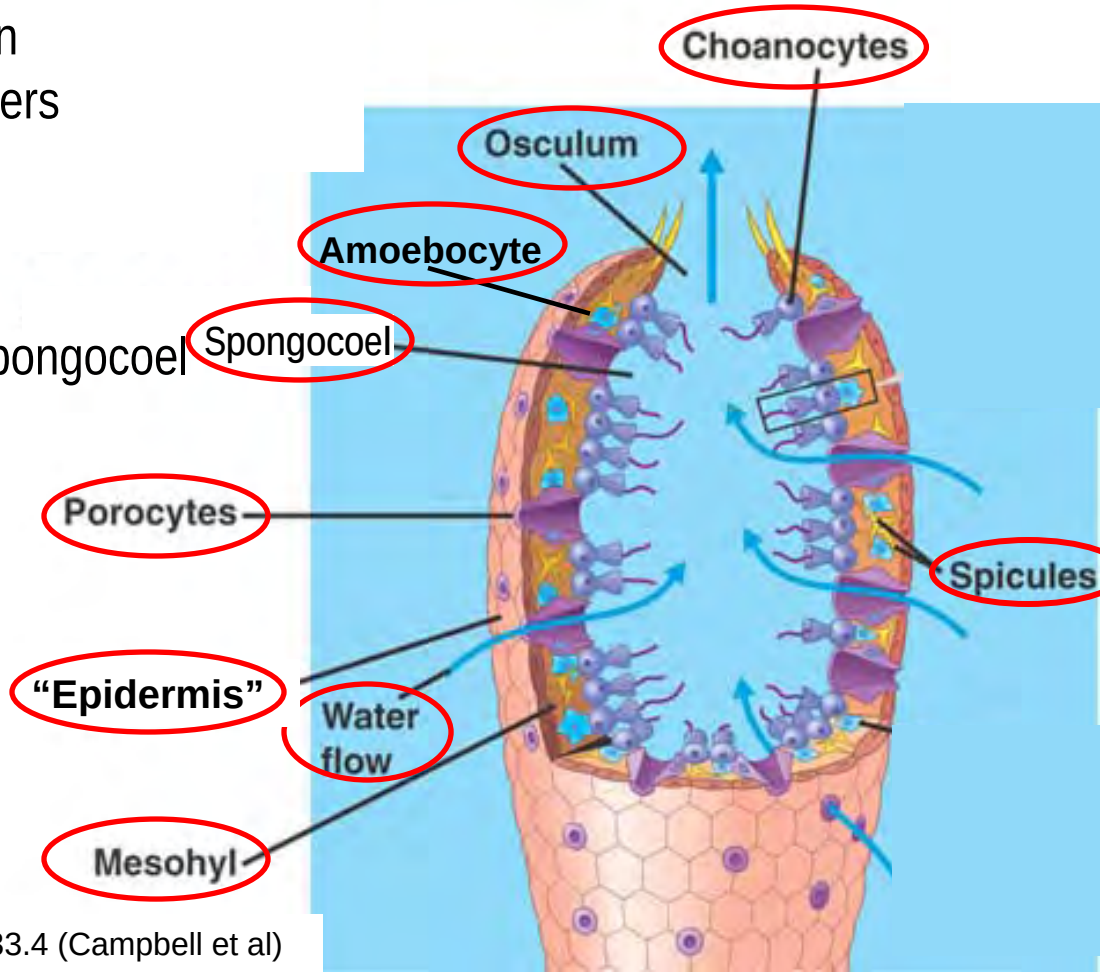


Figure 33.4 (Campbell et al)

Structure & Function

Choanocytes

- Choanocytes flagellum creates a current bringing water and food through sponge
- Food is trapped in sticky collar, ingested via phagocytosis, & transferred to amoebocytes
- H_2O exits via osculum

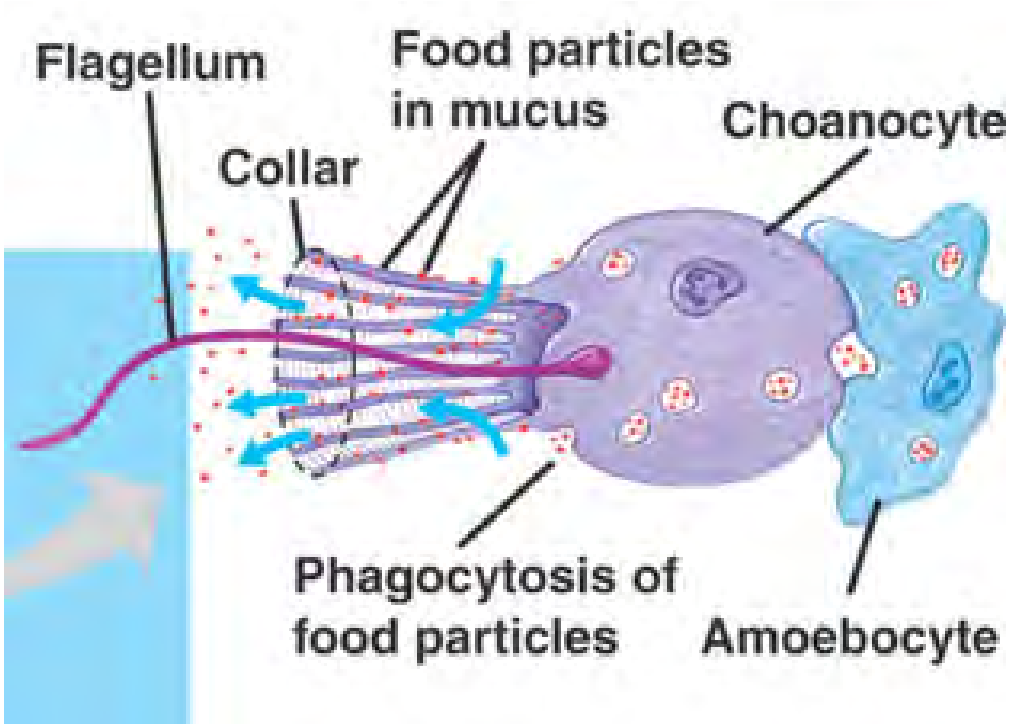
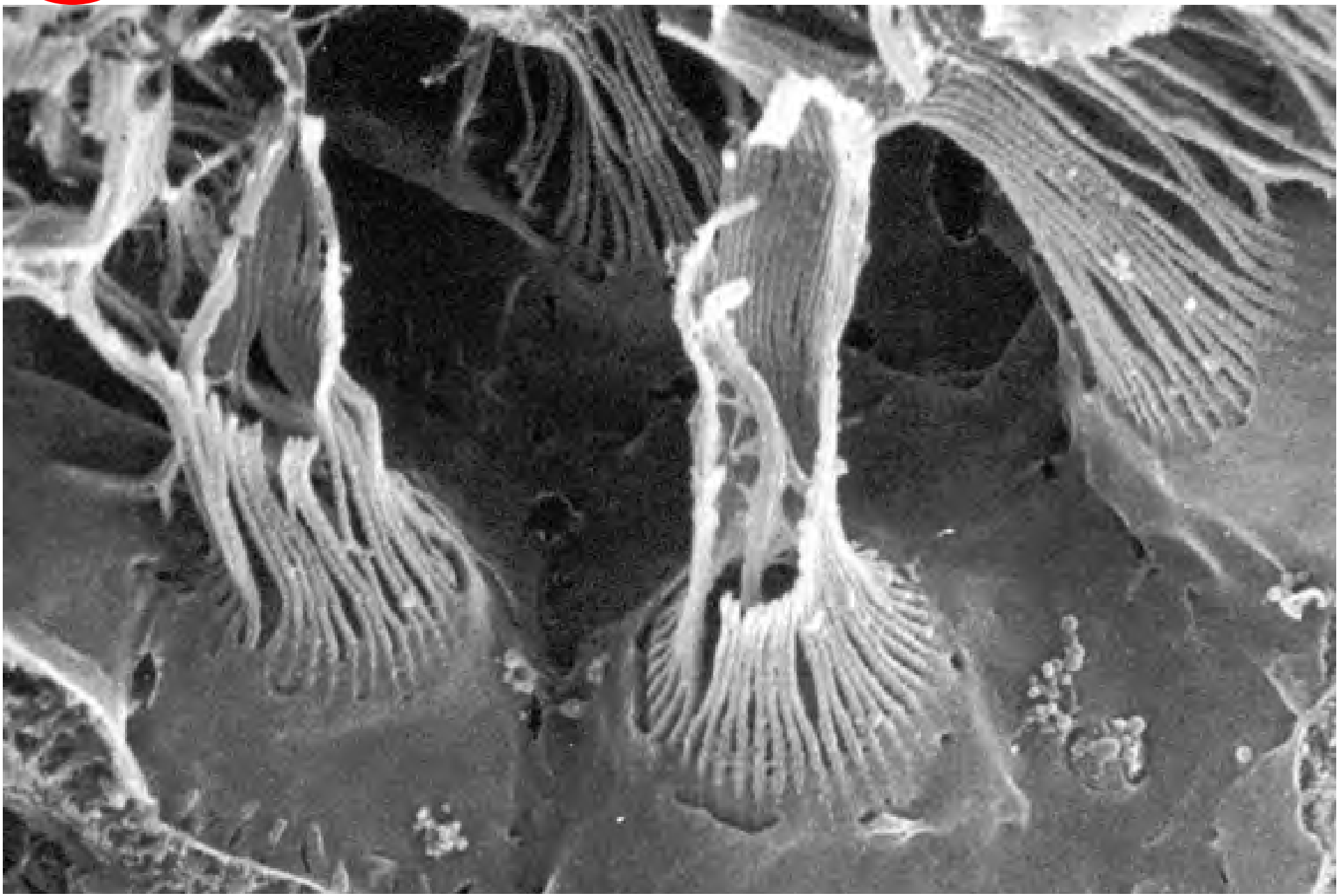


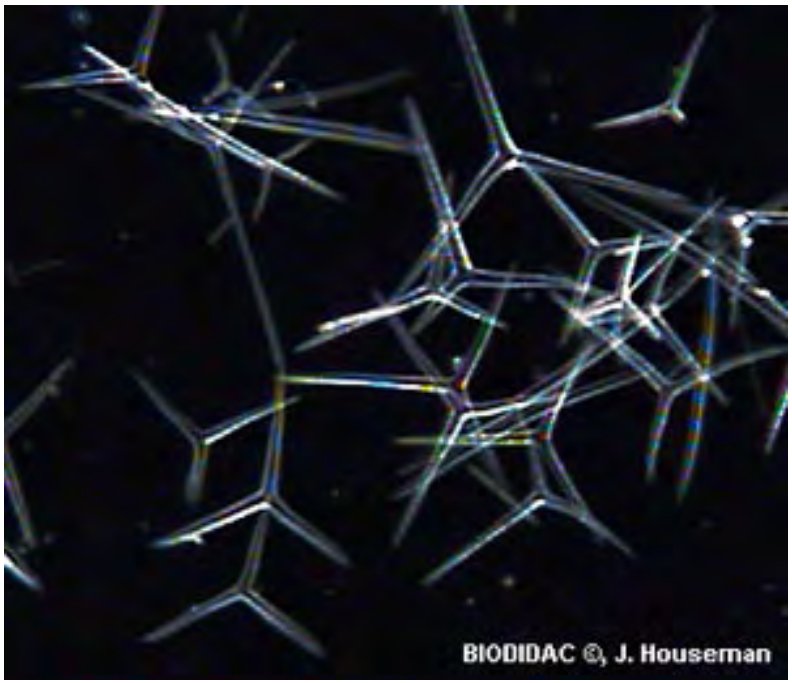
Figure 33.4 (Campbell et al)

Electron microscopic view of choanocytes



Sponge Structure

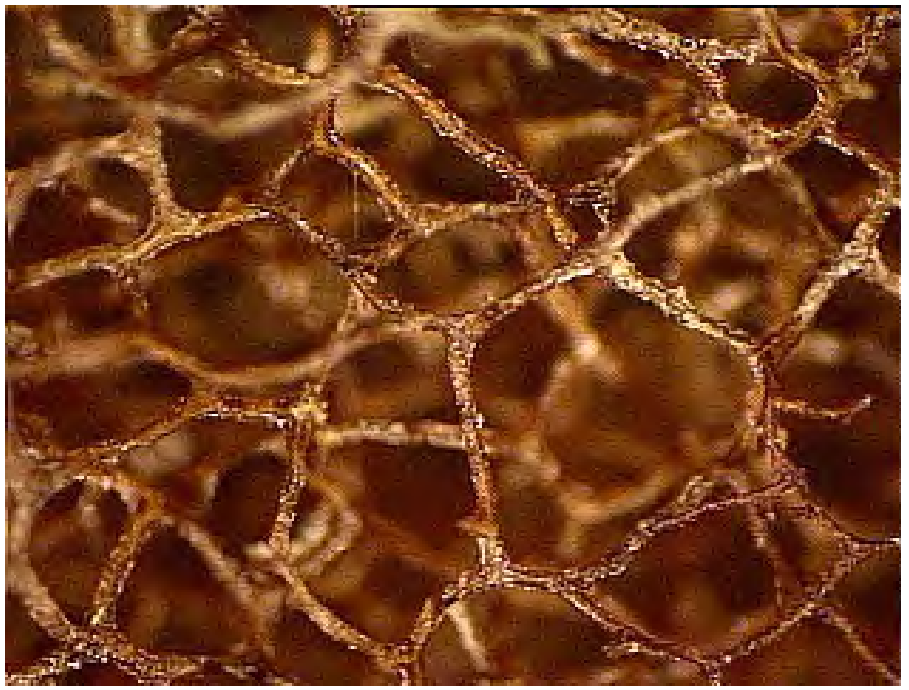
Within mesohyl are hard (**spicules**) or soft (**spongin**) skeletal fibers



Spicules:

Rigid

$CaCO_3$ or SiO_2



Spongin fibers:

Flexible

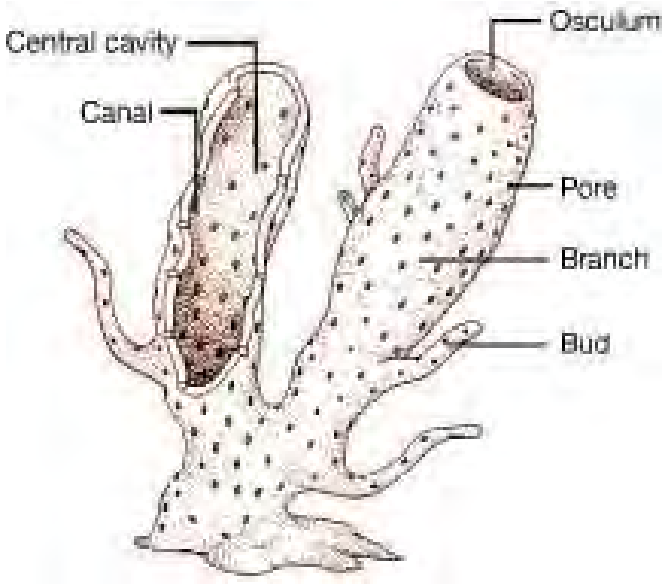
collagen fibers

10

Natural bath sponges are spongin fibers

Precolombian Amazonia clay fired pots with silicaceous sponge (*Cauxi*) spicules to harden ceramic.

Reproduction

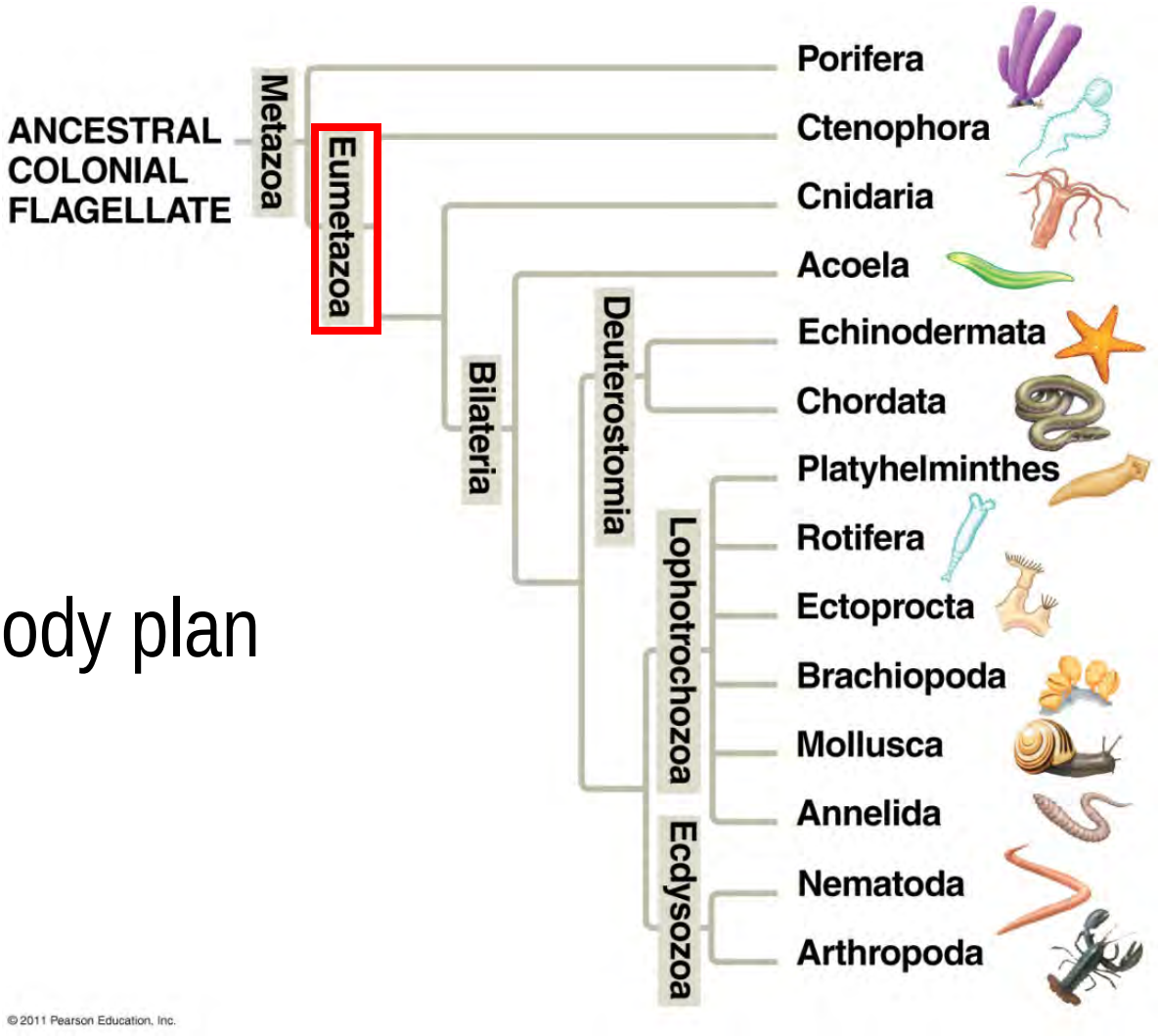


A) Asexual via fragmentation or budding

B) Sexual

- Most sponges hermaphroditic
  - i.e. both ♂ and ♀
- Release sperm into water
- Fertilization usually <u>internal</u>
- Are flagellated larva for hours to weeks

Eumetazoa

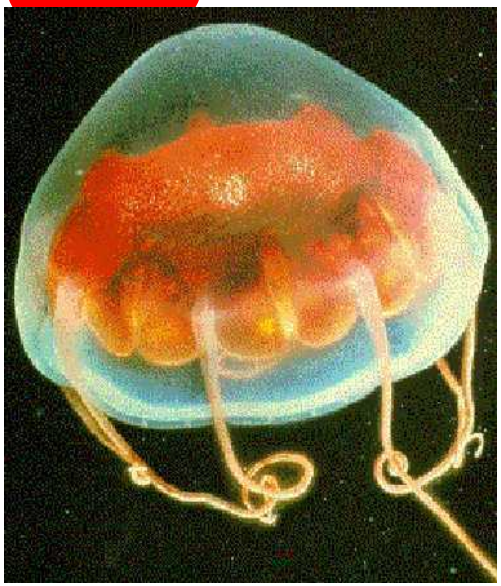


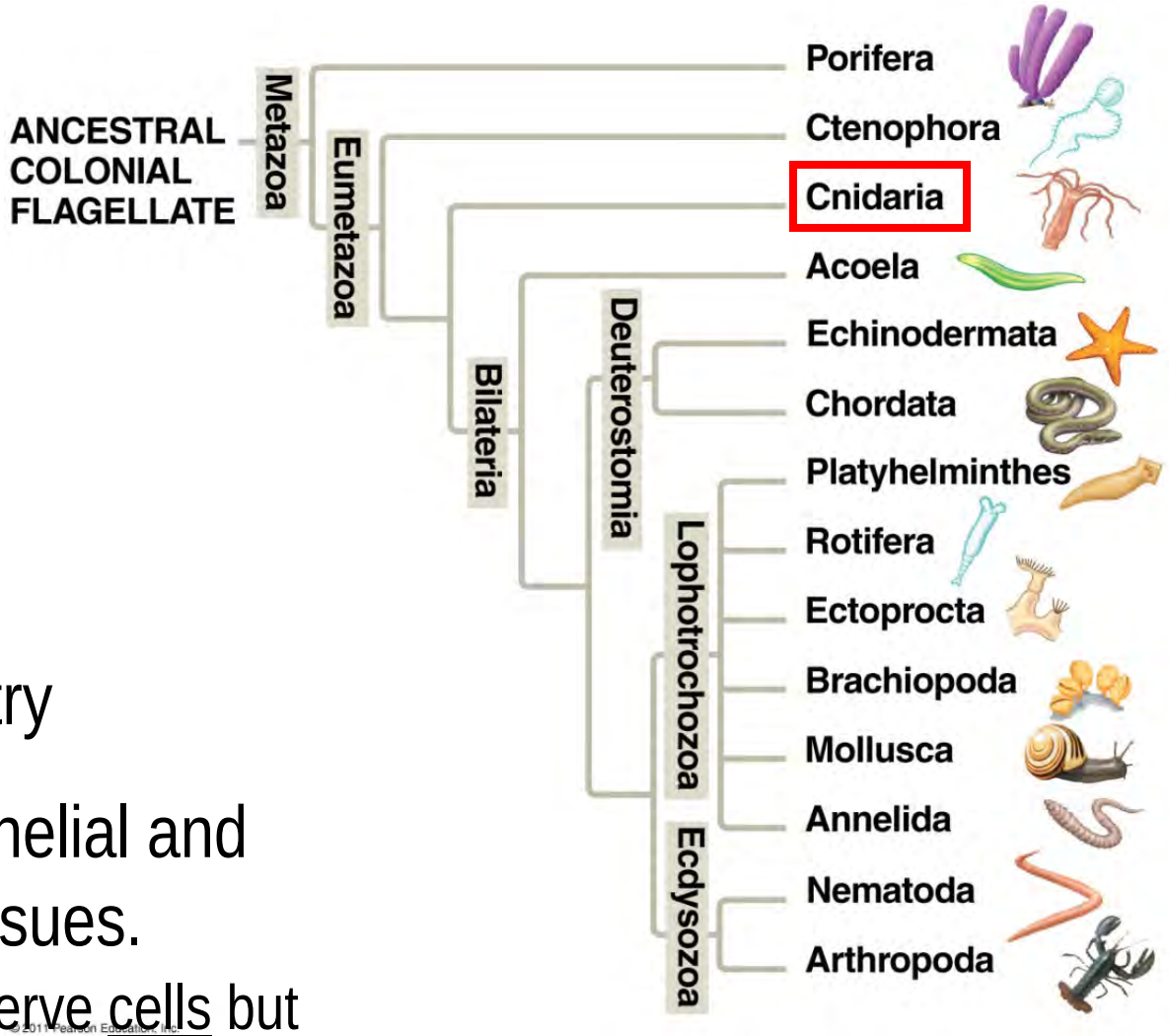
- Diploblastic body plan
- True tissues

Figure 32.11 (Campbell et al.)

Phylum: Cnidaria

Jellies, corals, hydras





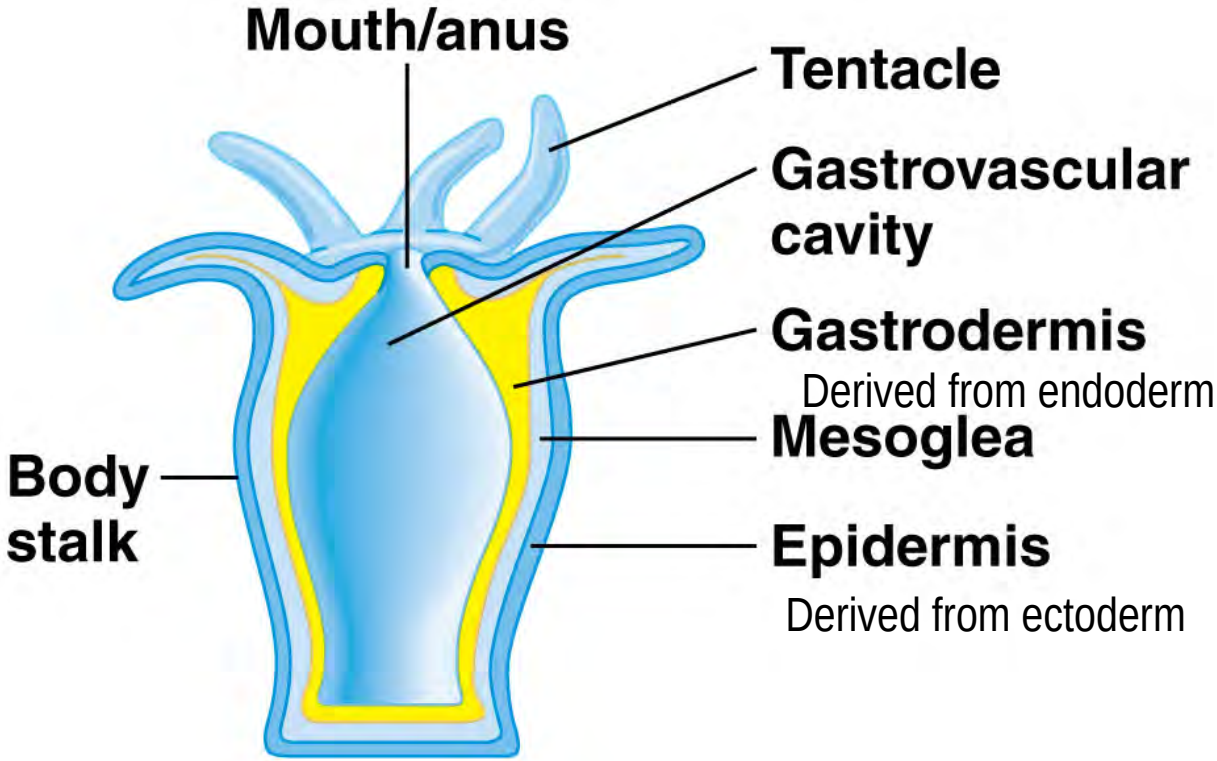
~10K spp

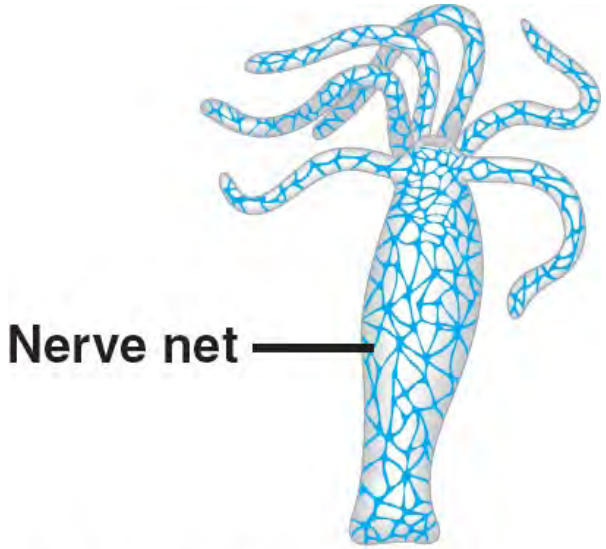
- Diploblastic
- Radial symmetry
- Only have epithelial and connective tissues.
  (muscle and nerve cells but no muscle tissue or nervous tissue)

Figure 32.11 (Campbell et al.)

Structure

- 2 layers of epithelial tissue (epidermis and gastrodermis)
  - separated by gelatenous connective tissue (mesoglea)
  - Muscle cells & nerve cells embedded in epidermis
    - Nerve net = diffuse network of nerve cells
      - No nervous tissue and no brain or other ganglia



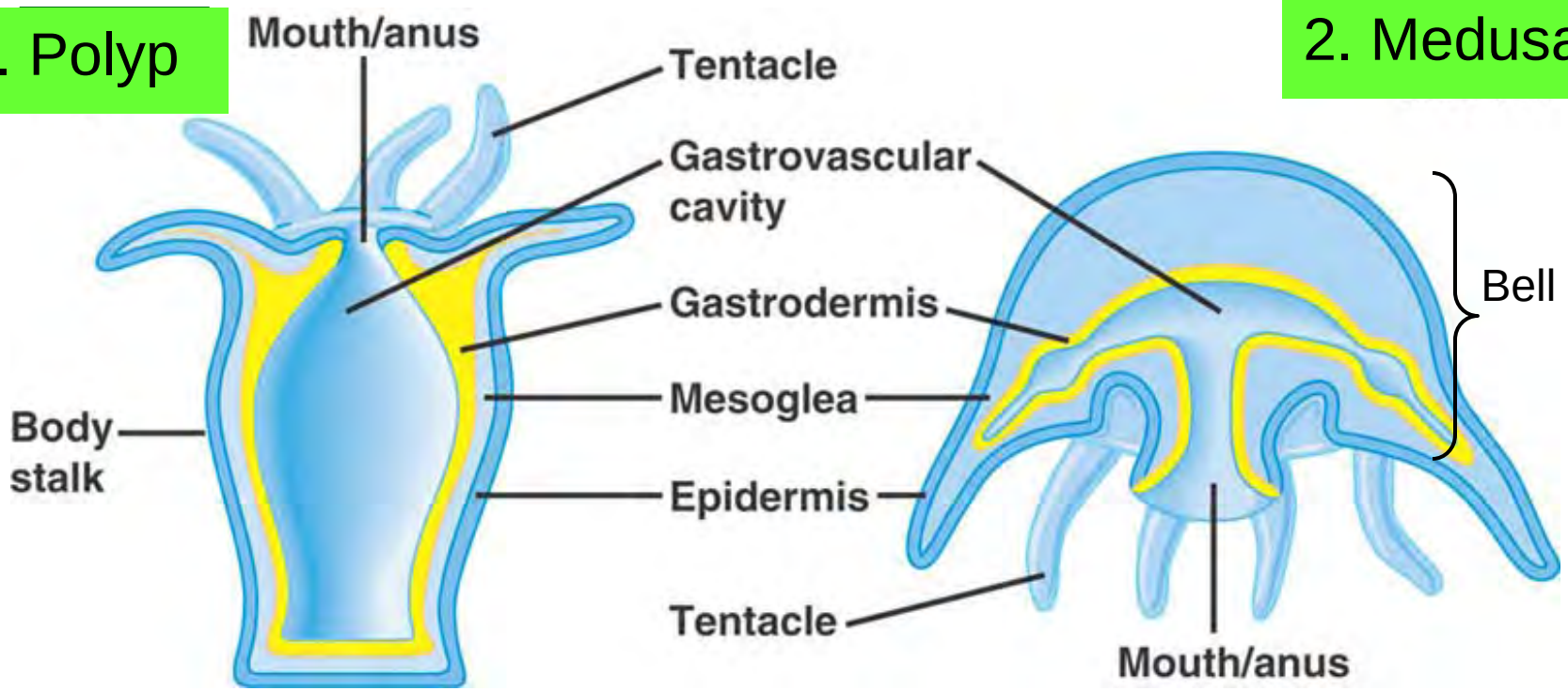


(a) Hydra (cnidarian)

Structure

2 basic body forms:

1. Polyp



2. Medusa

- Sedentary
- Asexual reproduction

- Free-swimming
- Sexual reproduction

- Some species have only 1 form
- Others alternate between forms during life cycle

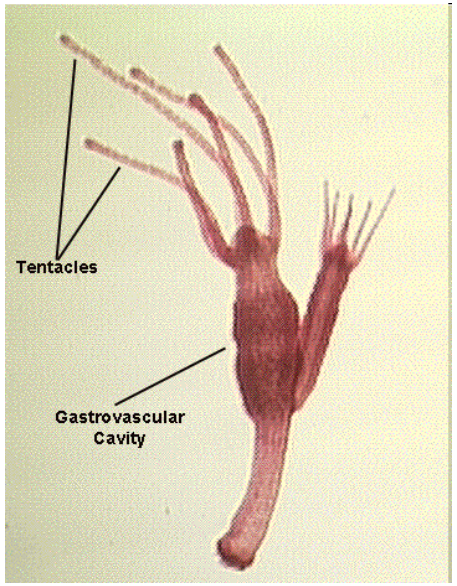
*This is NOT alternation of generations (both diploid)

Figure 33.5 (Campbell et al)

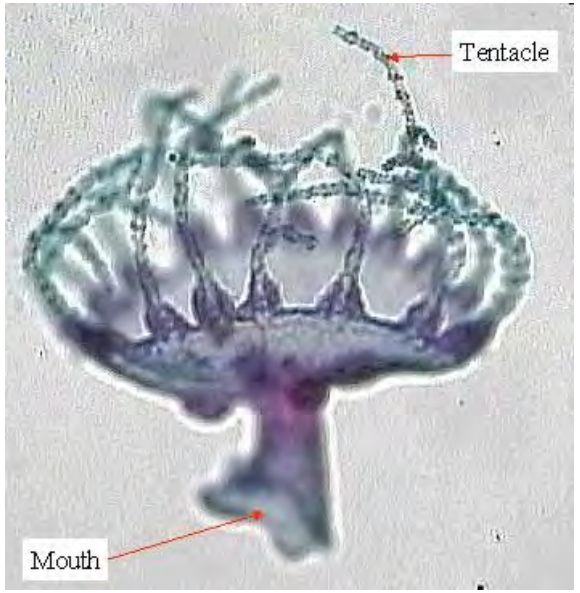
Feeding

Tentacles
- capture prey
- move food to mouth

Mouth leads to gastrovascular cavity
- "Gastro" = Digestion
    - Both extraacellular and intracellular
    - can feed on large prey
- Vascular
    - Delivers food to various parts
    - Removes wastes from various parts
- Incomplete digestive system
    - Only 1 digestive opening
        - i.e. mouth = anus



Hydra polyp

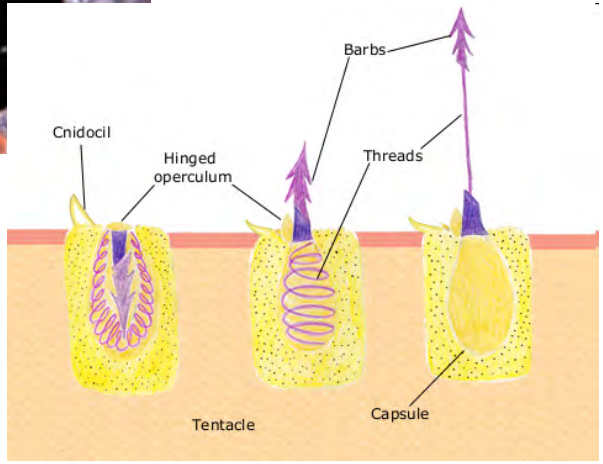


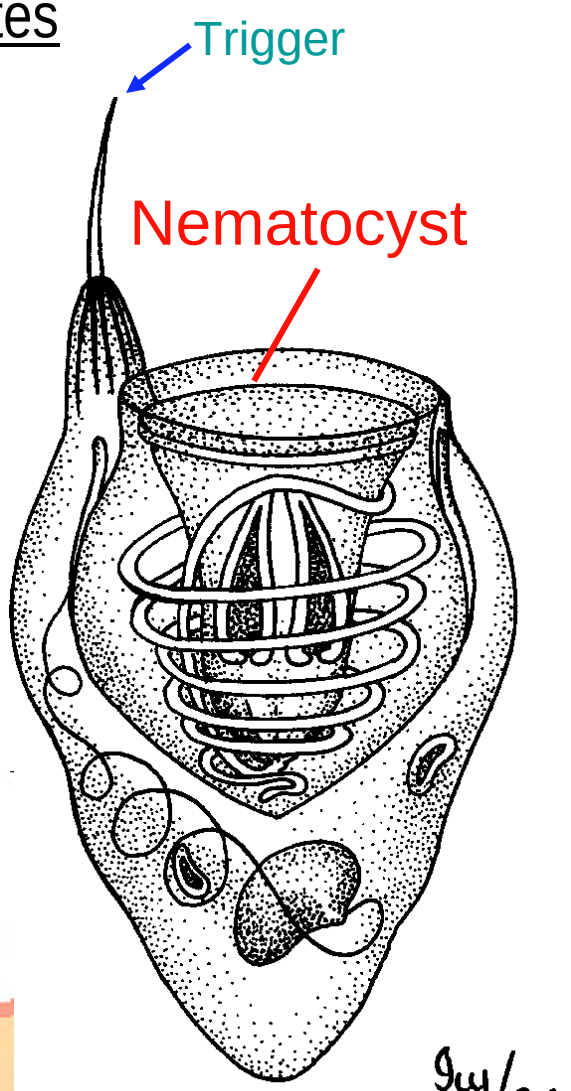
Obelia medusa

Specialized Feeding Cells

- Ring of tentacles around mouth w/ cells called cnidocytes
- Cnidocytes contain explosive organelle called a cnidae
  - Some cnidea have long threads to entangle prey
  - Others cnidea, called nematocysts, have harpoon-like threads

http://www.youtube.com/watch?v=6zJiBc_N1Zk





Cnidocyte

Figure 33.6 (Campbell et al)

Phylum: Cnidaria

4 major clades

(a) Hydrozoa

3,600 spp

(b) Scyphozoa

228 spp

(c) Cubozoa

42 spp

(d) Anthozoa

6,100 spp

Figure 33.7 (Campbell et al)

Phylum: Cnidaria

4 major clades

a) Anthozoa

6,100 spp

b) Hydrozoa

3,600 spp

c) Scyphozoa

228 spp

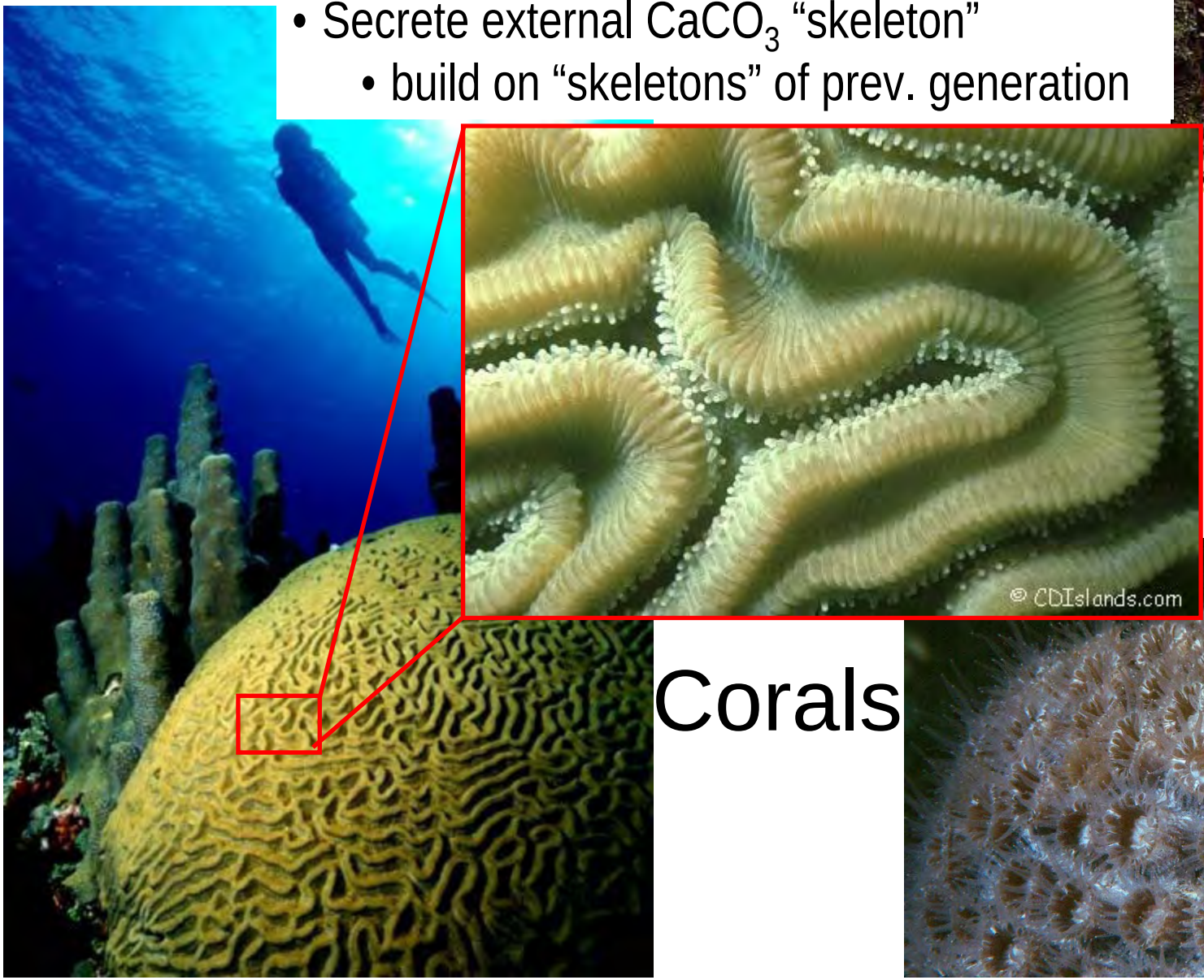
d) Cubozoa

42 spp

Figure 33.7 (Campbell et al)

a) Anthozoa (corals and anemones)

- Polyp stage only, <u>no medusa</u>
- Secrete external $CaCO_3$ "skeleton"
  - build on "skeletons" of prev. generation



Most corals live closely with algae (**Mutualism**)

Corals

a) Anthozoa (corals and anemones)

Sea anemones

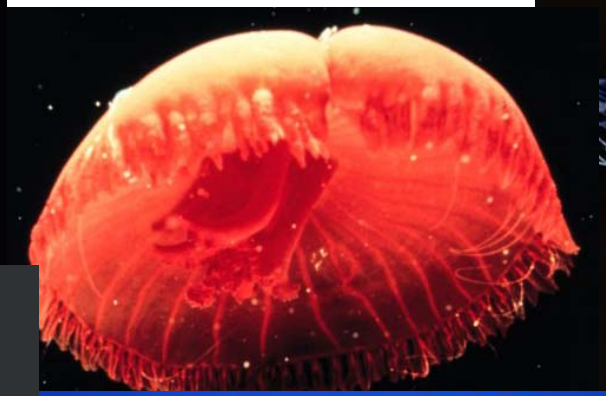
- Polyp stage only, no medusa
- Mutualism w/ clownfish
- Can eat large prey

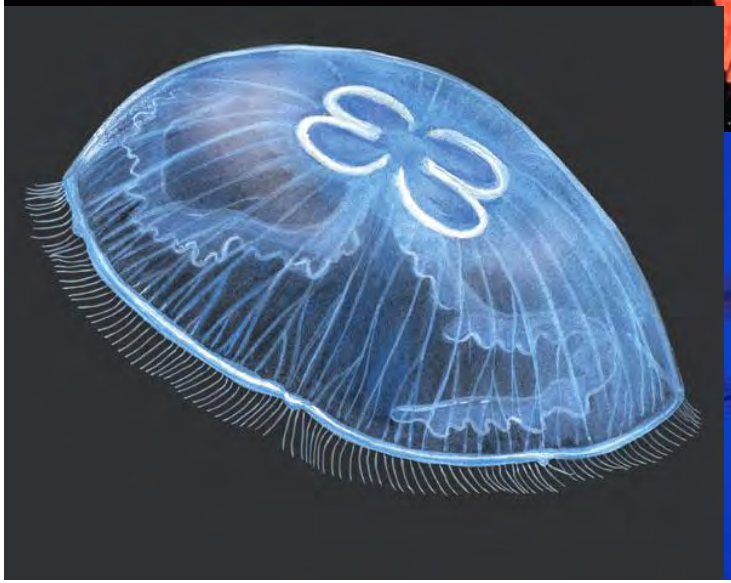
b) Hydrozoa
(Hydras, Man-o-War, etc…)

- Polyps usually colonial and most conspicuous life cycle stage
- Most alternate btwn polyp & medusa but some only 1 or other
  - e.g. hydras only occur as polyps

c) Scyphozoa ("True" jellies)

- Medusa prominent life stage
  - Large and free-swiming
- Polyp long-lived bottom dweller
- Typically 2-40cm (1"-16") w/ max of 2m

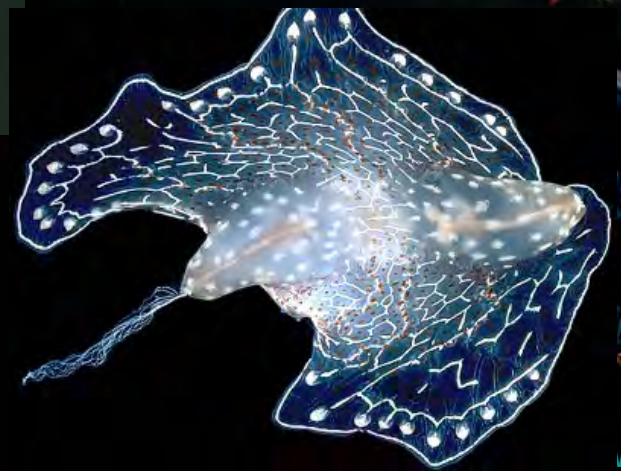




Phylum: Ctenophora

- ~100 species w/ huge biomass
- 3 mm – 1.5 m
- aka “Comb Jellies” - 8 rows of cilia radially arranged
  - Largest organism that moves via cilia
- no medusa/poly stages
- most predatory carnivores
- most hermaphroditic




www.youtube.com/watch?v=ivoSHtOoHuo

Bilateria

- Bilaterial symmetry
- Triploblastic
- Acoelomates, coelomates, and pseudocoelomates
- Most have all 4 animal tissues:
  - epithelial
  - connective
  - muscle
  - nervous
- 3 major clades
  - Deuterostoma
  - Lophotrochozoa
  - Ecdysozoa

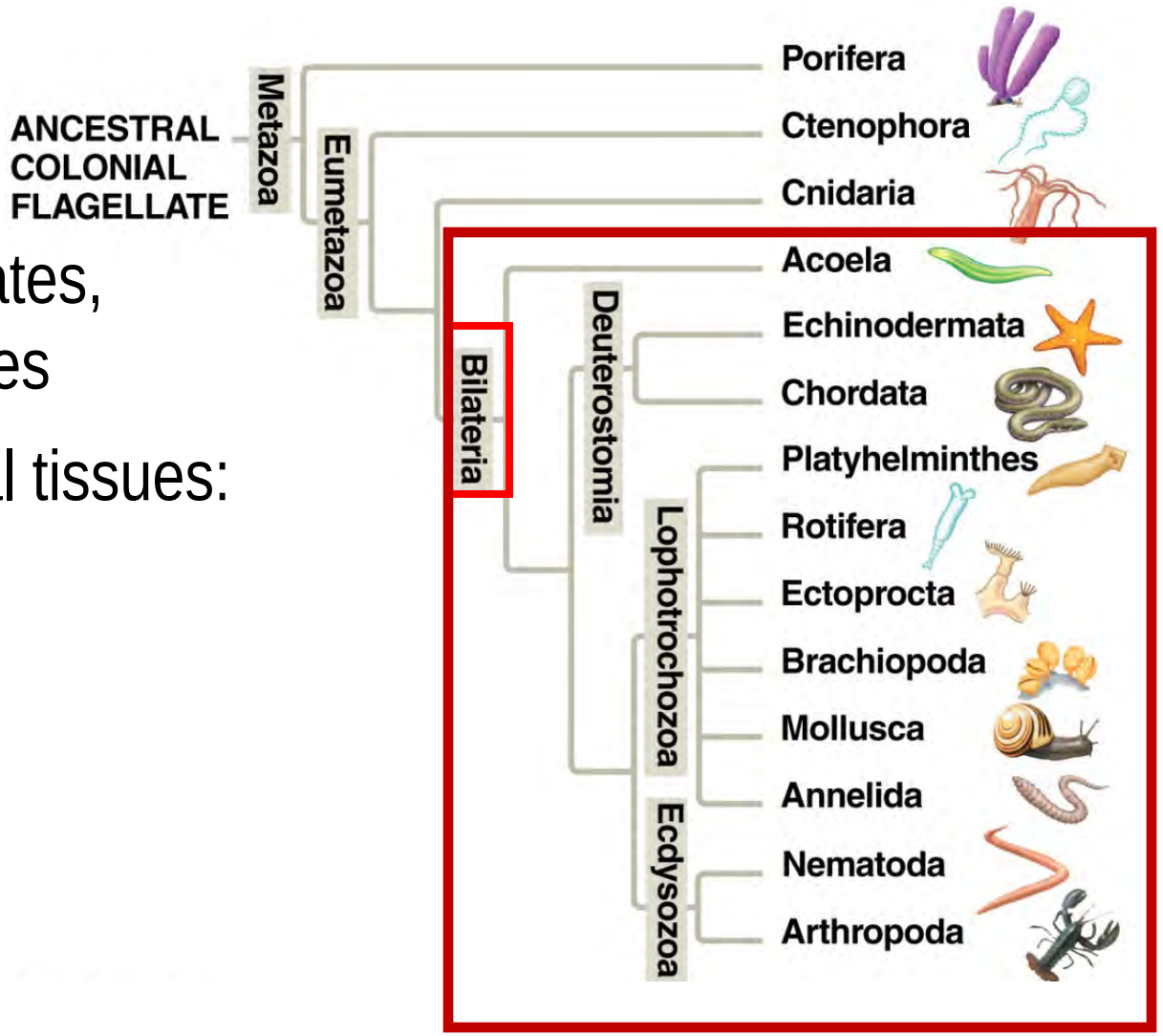


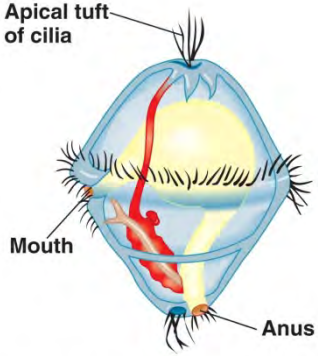
Figure 32.11 (Campbell et al.)

Lophotrochozoa

(a) An ectoproct

Lophophore
(crown of cilia)

OR



(b) Structure of a trochophore larva

Trochophore larva
(tuft of cilia)

Figure 32.11 (Campbell et al.)

Phylum: Platyhelminthes (Flatworms)

- Bilateria, Triploblastic
- Acoelomate
- Many w/ nervous system
  - More complex and cephalized than nerve-net of Cnidaria
- Most w/ Incomplete digestive system (1-opening)
  - Some long species have an anus
- No respiratory or circulatory system
  - Gastrovascular cavity
- Hermaphroditic

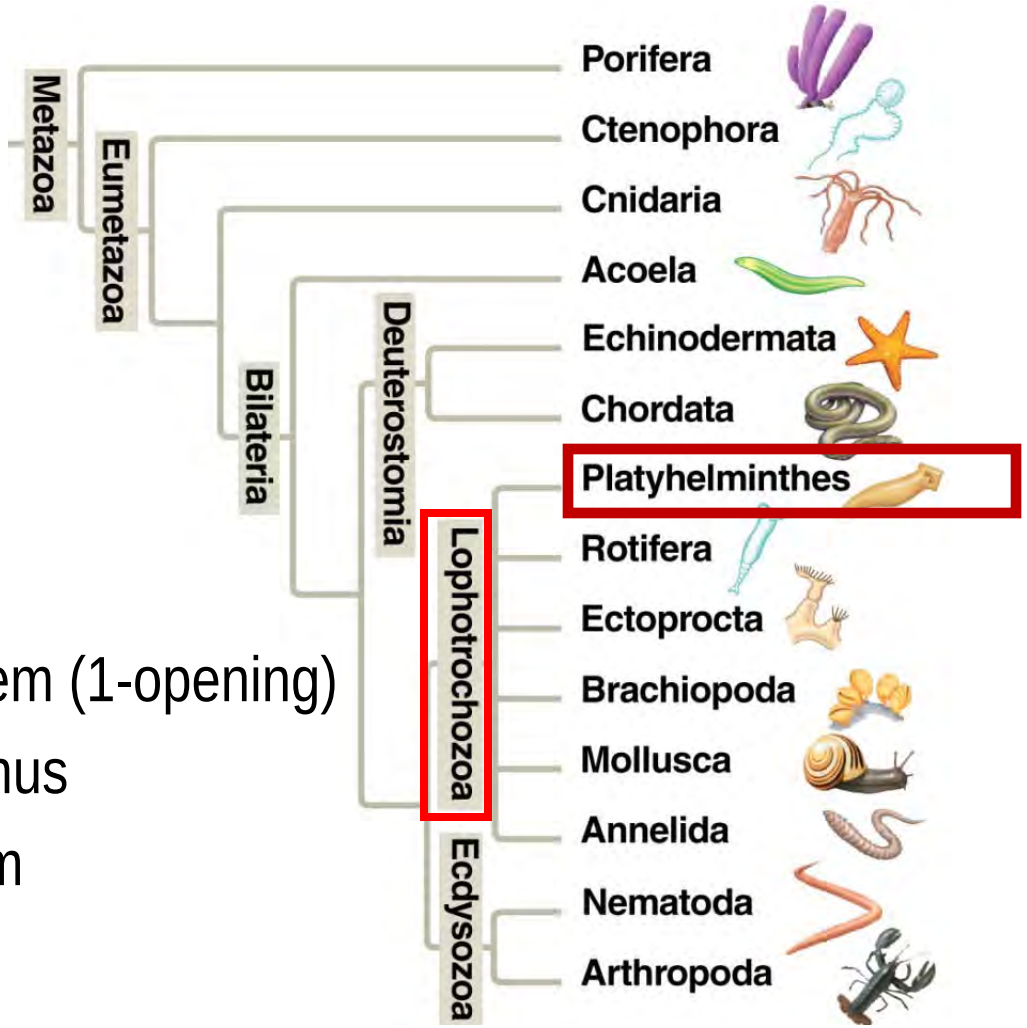


Figure 32.11 (Campbell et al.)

Phylum Platyhelminthes (Flatworms)

~20K spp

Several major clades including:

"Turbellaria" (planarians)
*Not monophyletic

Free living
predators / scavengers

Trematoda
(flukes)

Cestoda
(tapeworms)

Parasites of animals

Phylum: Platyhelminthes

Turbellaria (Planarians)

- NO circulatory or respiratory organs but have many other organs and organ systems.
- Digestive system w/ Mouth, protrusible pharynx, gastrovascular cavity (no separate anus)
- Nervous system w/ cephalized ganglia & VENTRAL nerve cords
- Reproductive system – hermaphroditic (ovary, testes, penis, etc)
- Excretory system – w/ excretory organs (protnephridia)

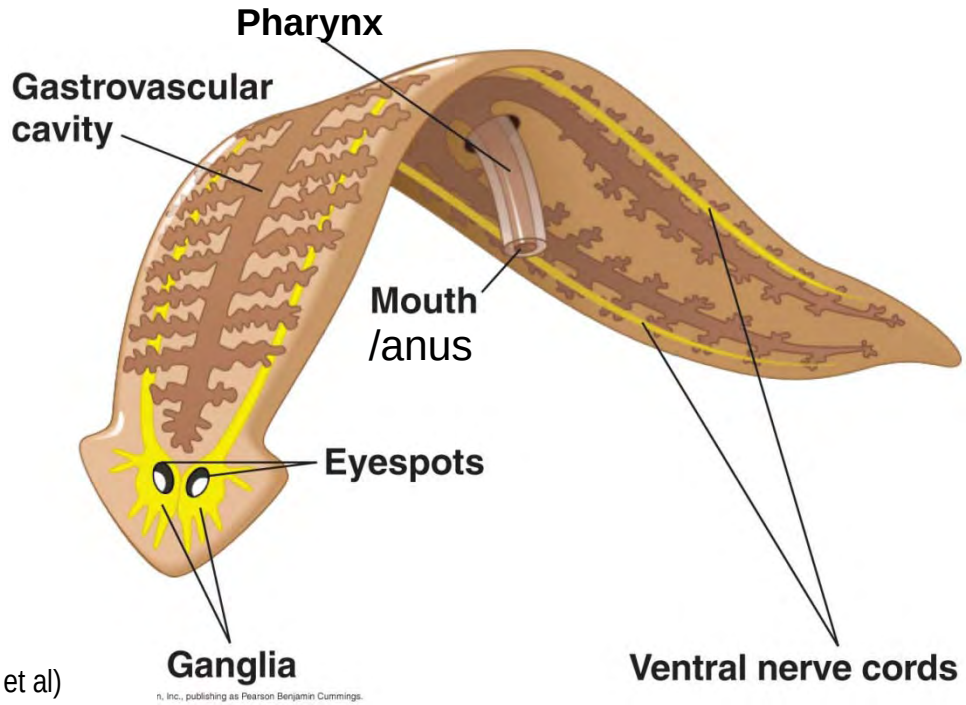
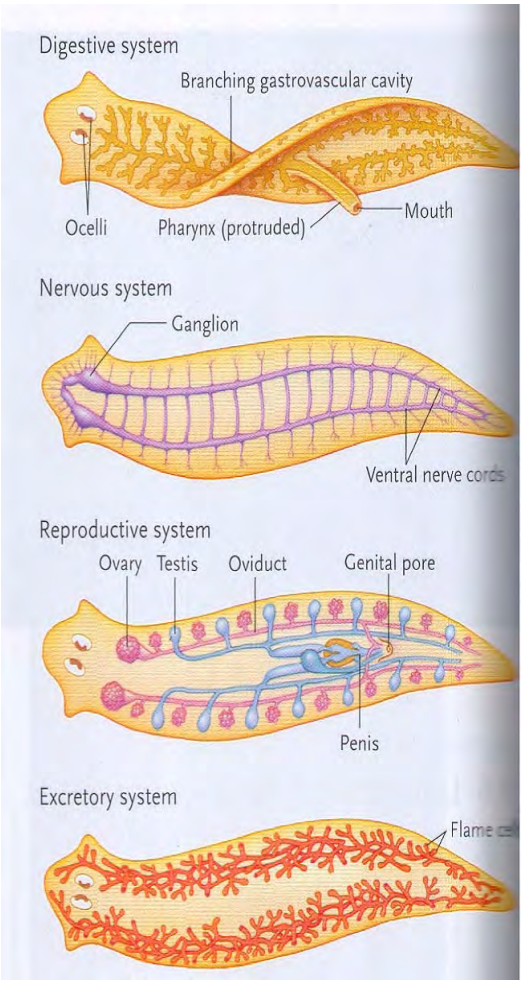


Figure 33.10 (Campbell et al)



Phylum: Platyhelminthes

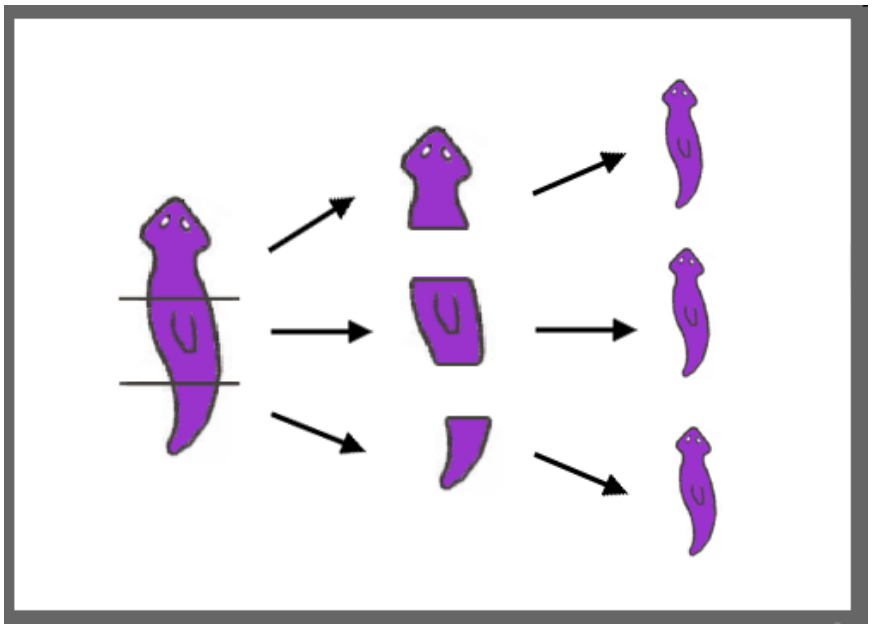
Turbellaria (Planarians)

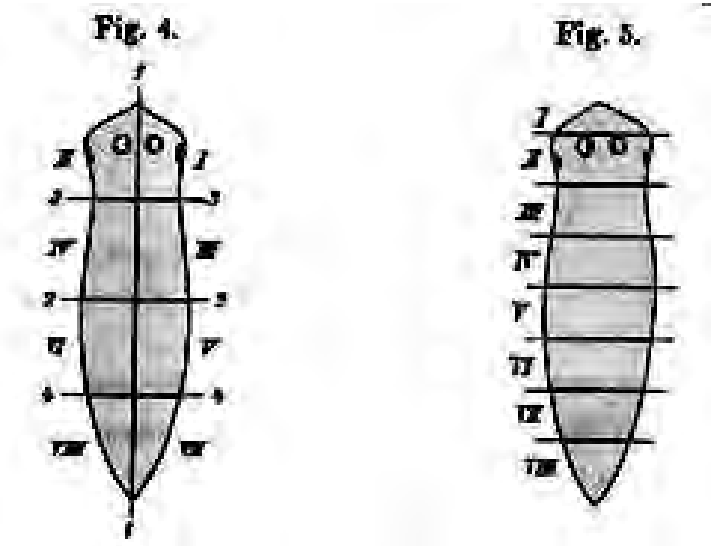
Marine flatworms

Reproduction in planerians

Asexual:

- Fragmentation & regeneration

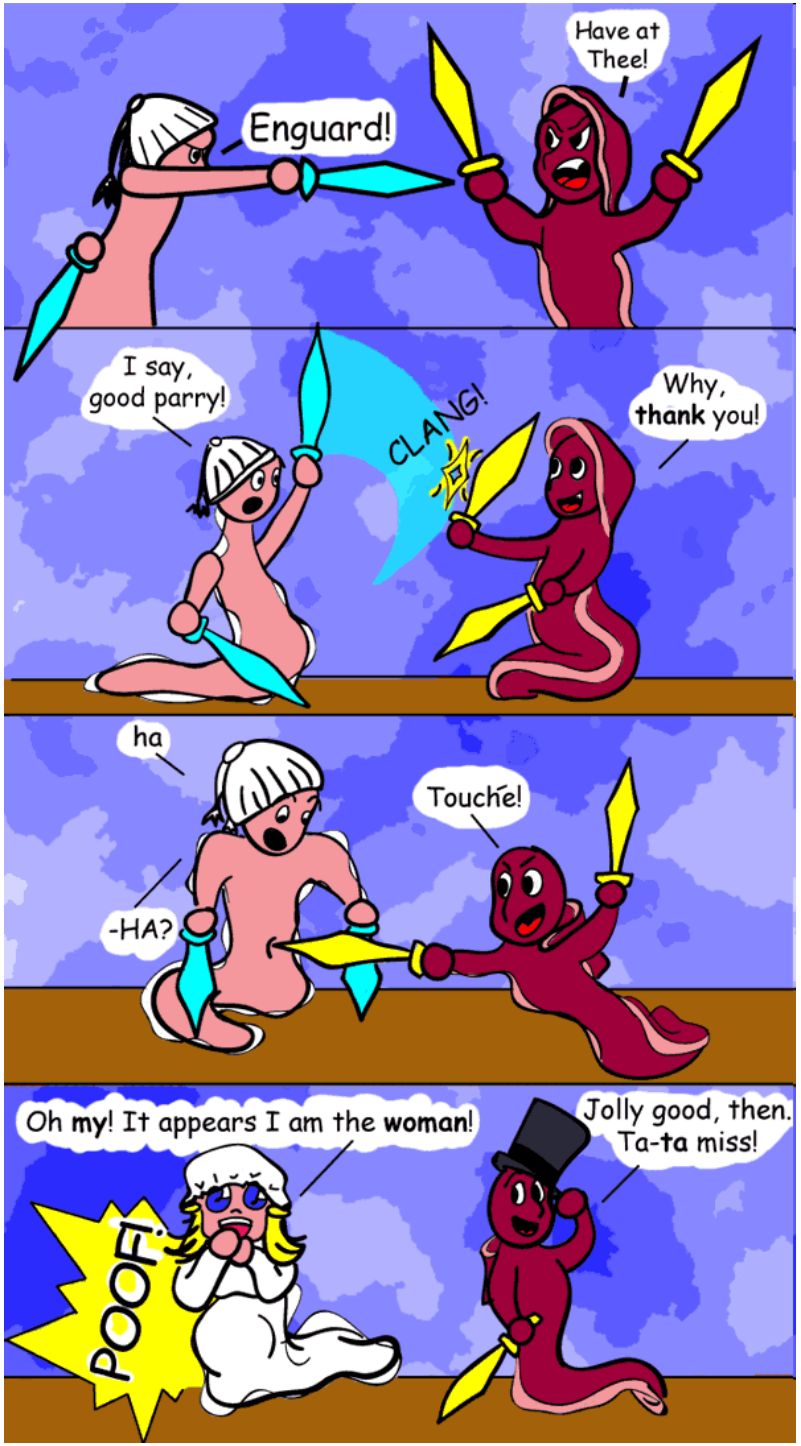




Penis Fencing

Sexual

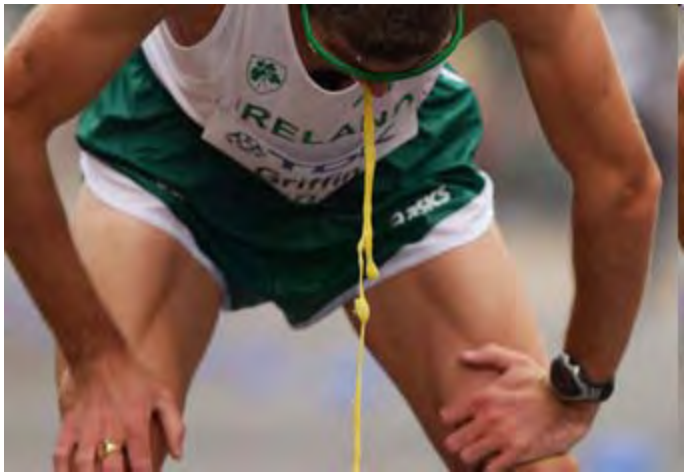
- Hermaphroditic
- Determine which is ♂ and which is ♀ via penis fencing
- "Winner" deposits sperm in "loser" who now acts as the ♀ and carries the eggs.
  - Internal fertilization



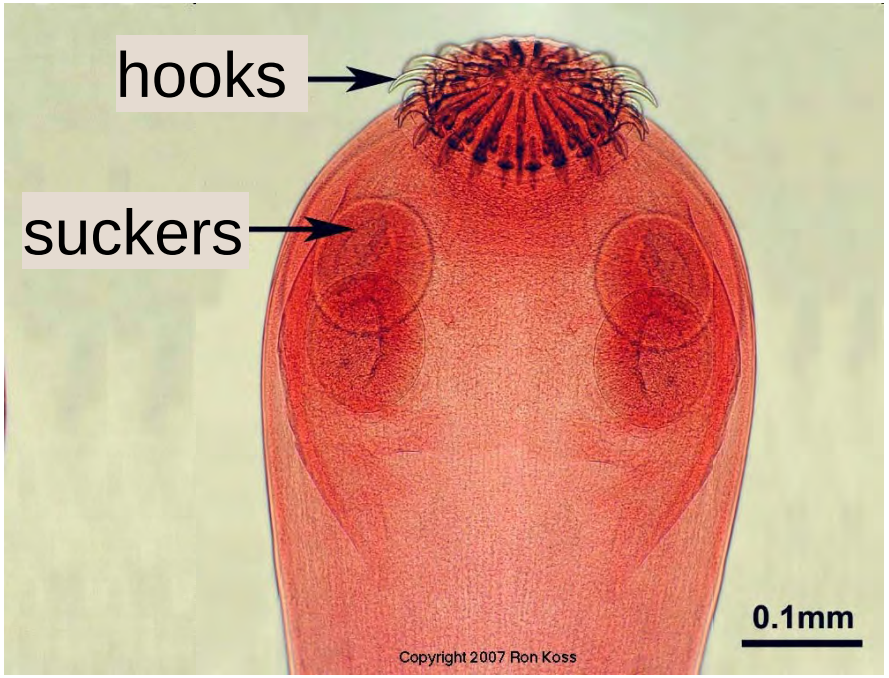
Phylum: Platyhelminthes

Cestoda (Tapeworms)

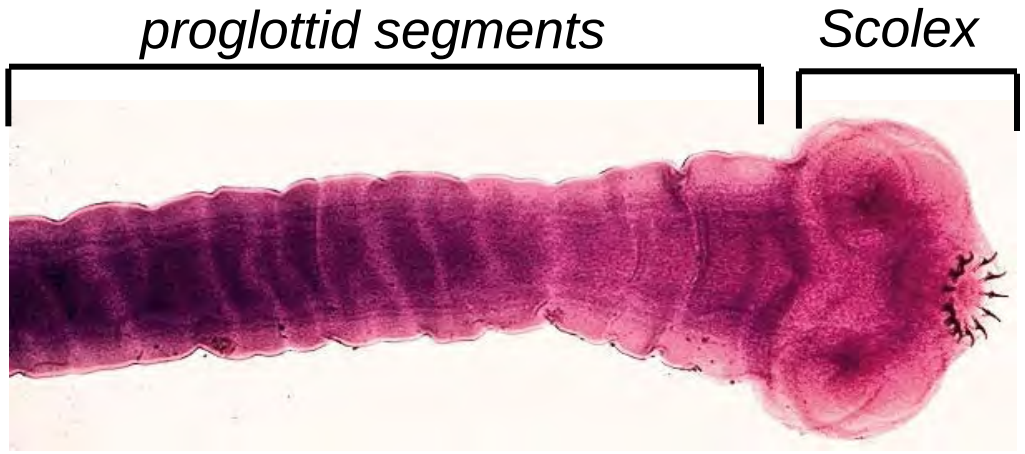
- Intestinal parasites of most vertebrates



Cestoda (tapeworms)



- Highly specialized:
  - no sense organs
  - no brain or nerve cords
  - no mouth or digestive system
- Scolex = end w/ hooks and suckers
  - Attach to intestinal lining
  - Absorbs host's predigested nutrients
- Proglottid segments
  - each w/ reproductive and excretory organs
  - Add new segments behind head as grows



“PARASITOLOGISTS DON’T EAT SUSHI”

8.8 m tapeworm in a Tokyo Museum:

Large cestode ingested by a man who ate uncooked fish

Phylum: Annelida (Segmented worms)

- Bilateria, Triploblastic
- Coelomates
- Segmentation
- Epidermis covered via <u>cuticle</u>
  - Made of collagen
    - vs. chiton “exoskeleton” in ecydysozoa
  - Is not shed (vs. shed in ecdysozoa)
- <u>Complete</u> digestive systems
- <u>Closed</u> circulatory system
- Complex nervous system
- Complex excretory system
- Move via <u>Parapodia</u> and/or <u>Chaetae</u>

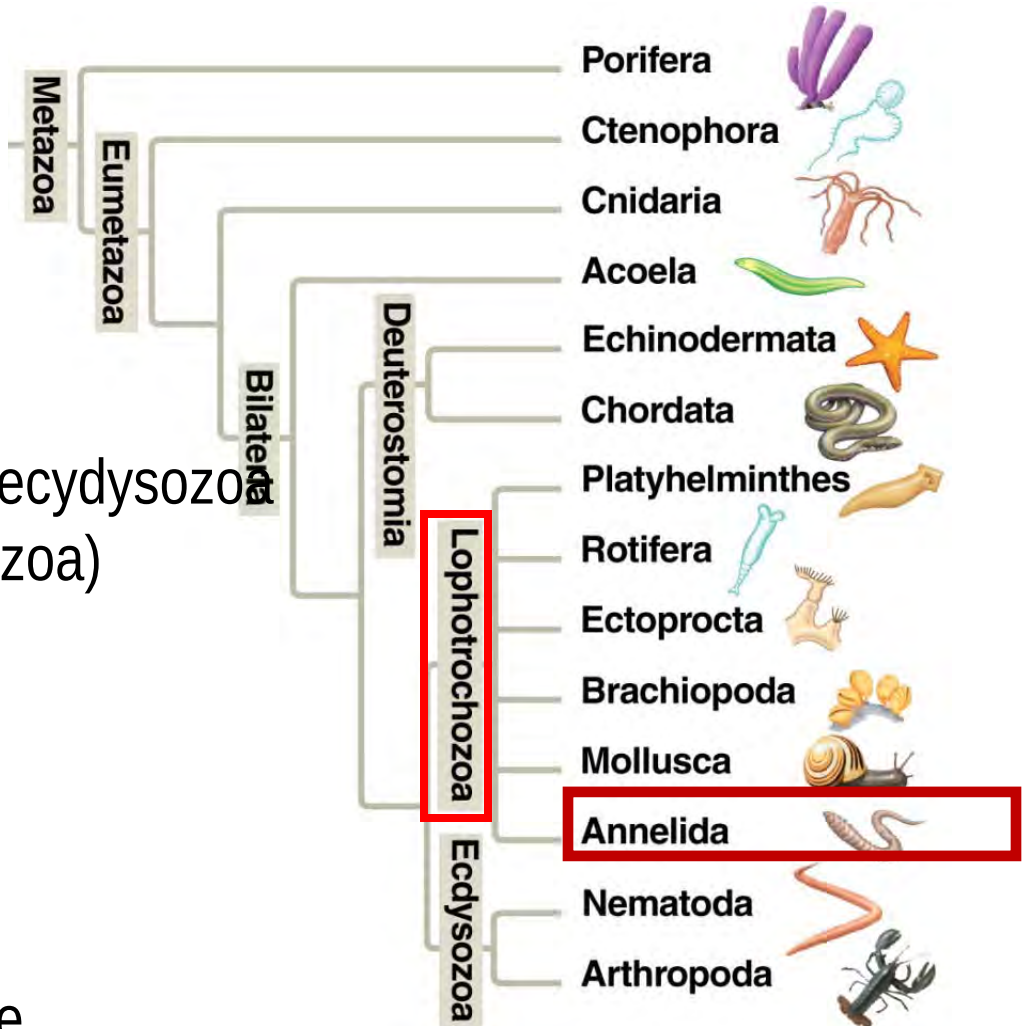
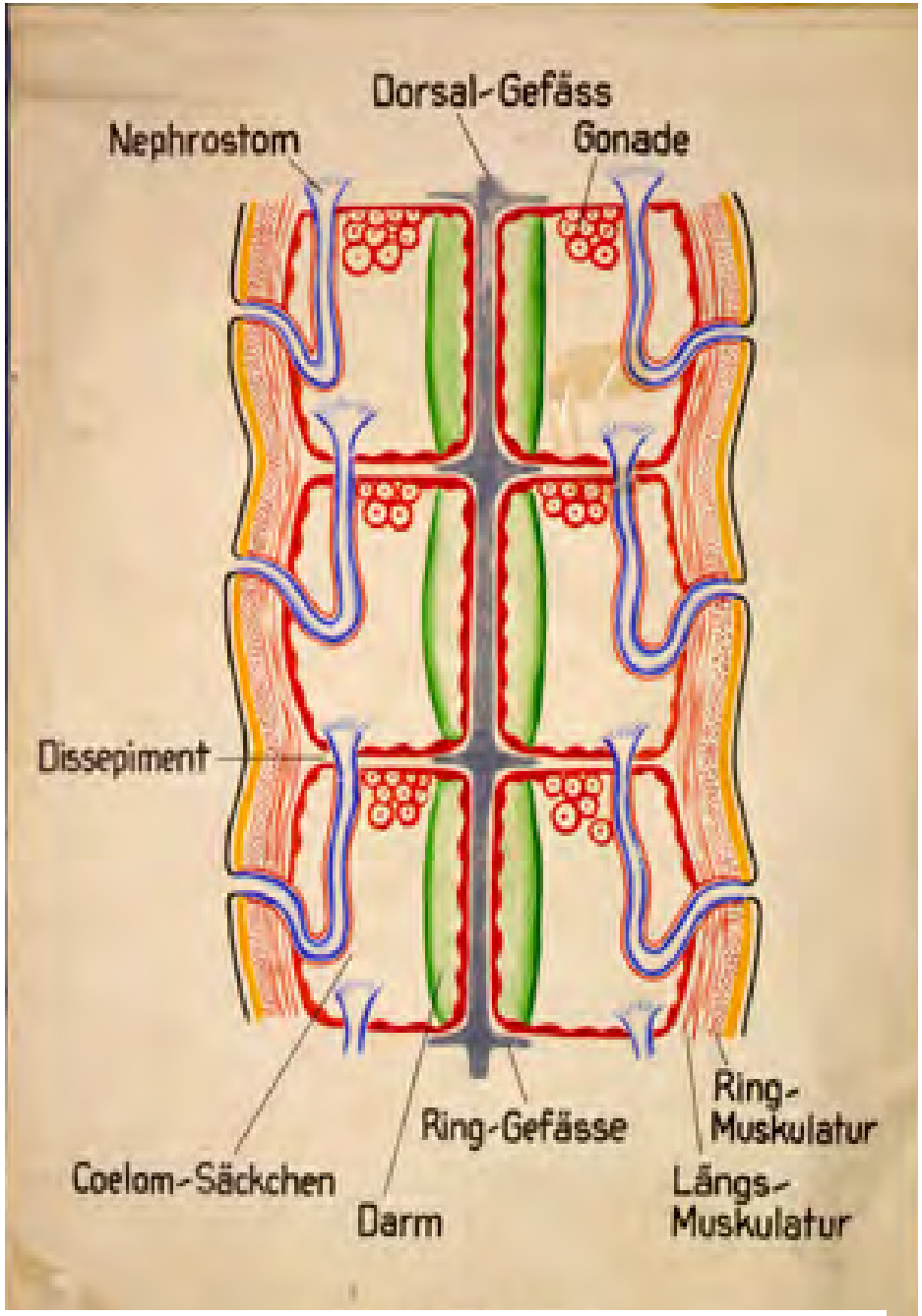


Figure 32.11 (Campbell et al.)

50 Segmentation

- *Septa* between segments partitions coelom
- Some structures repeated, 1 per segment:
  - Coelom
  - Chaetae or parapodia
  - Segmental ganglia
  - Excretory organs (Metanephridia)
  - Excretory pore
- Other structures cross segments:
  - Digestive tract
  - Nerve cords
  - Longitudinal blood vessels
  - Reproductive organs
  - Excretory tubule

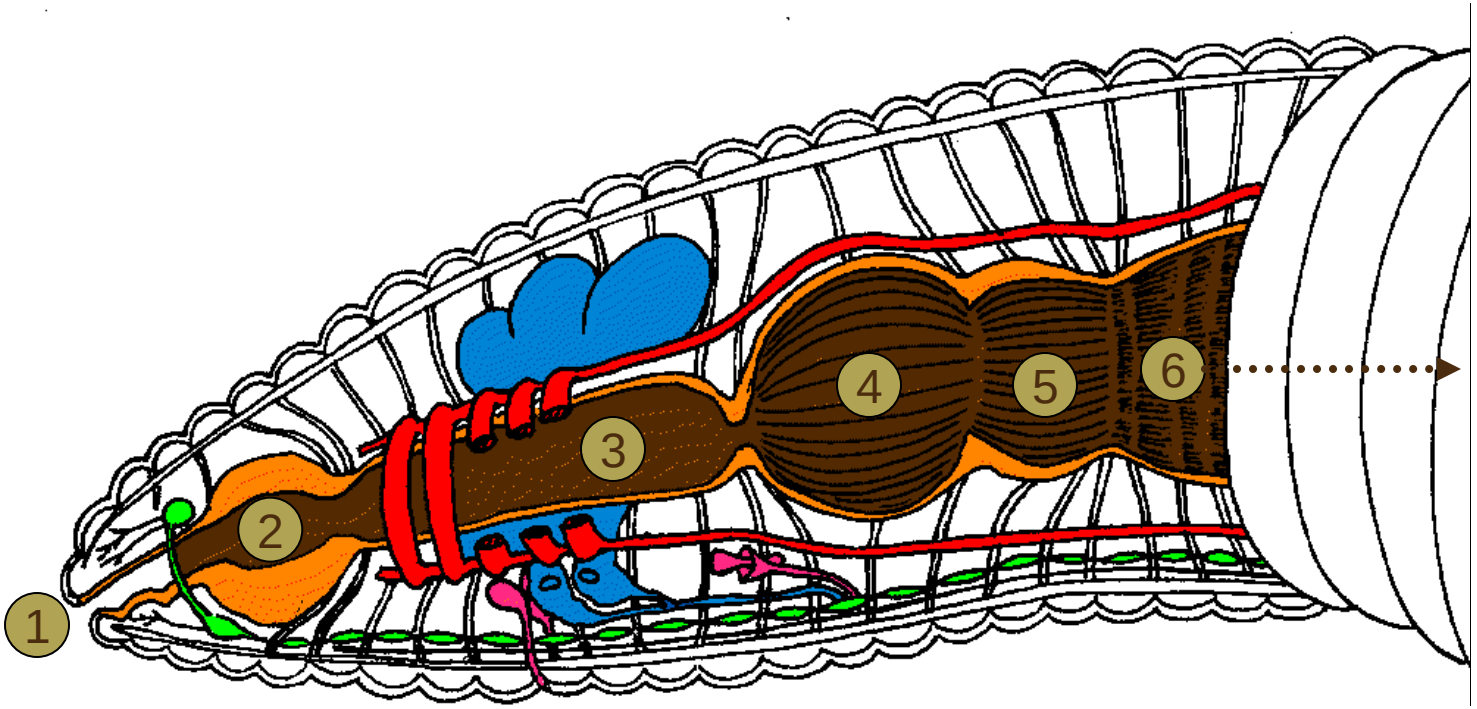
You do not need to remember which structures are repeated and which are not



See Figure 33.24 (Campbell et al)

Feeding

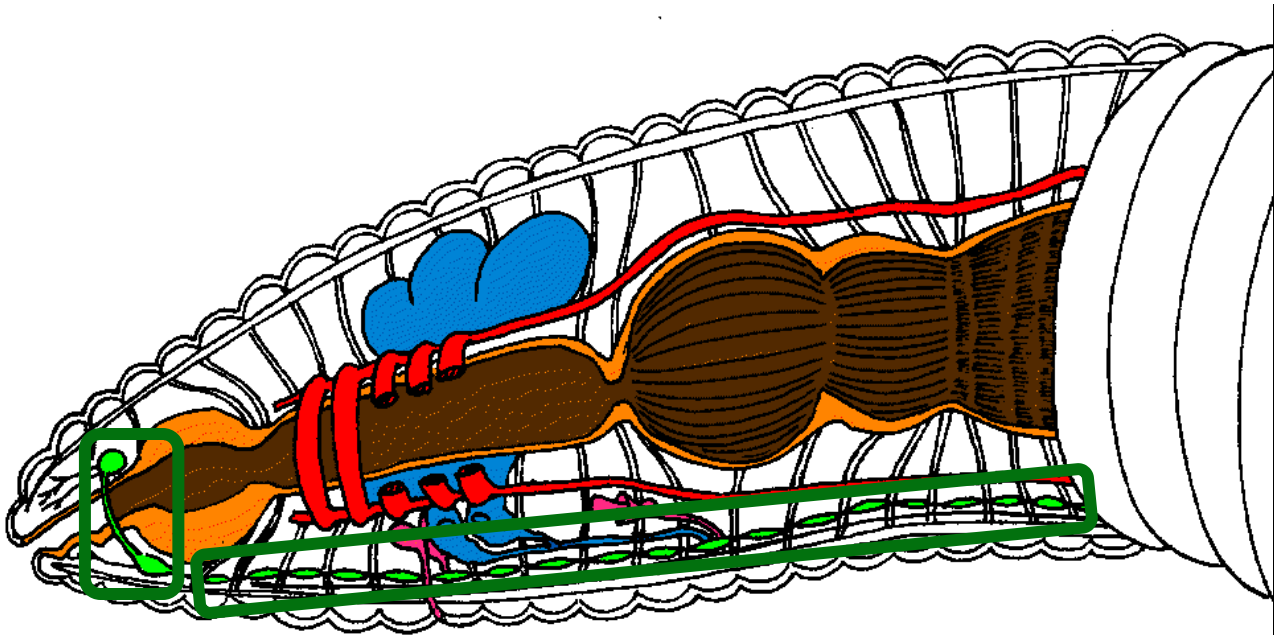
Complete digestive tract with specialized organs



1. Mouth
2. Pharynx: swallowing
3. *Esophagus*
4. *Crop:* storage
5. *Gizzard:* grinding
6. Intestine
7. Anus

See Figure 33.24 (Campbell et al)

Complex Nervous System

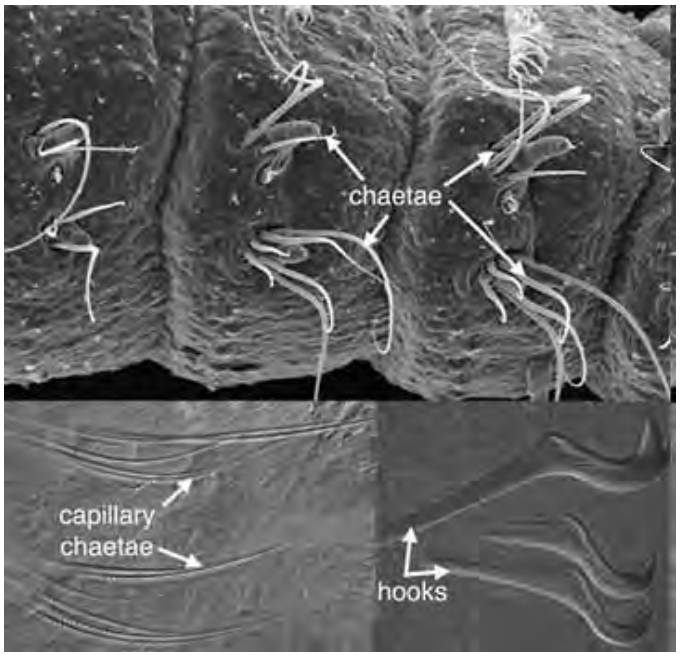


- *Ganglia* (collection of nerves) around pharynx ≈ “brain”
- *Ventral nerve cord*
- *Segmental ganglia*

See Figure 33.22 (Campbell et al)

Movement:

Parapodia and Chaetae

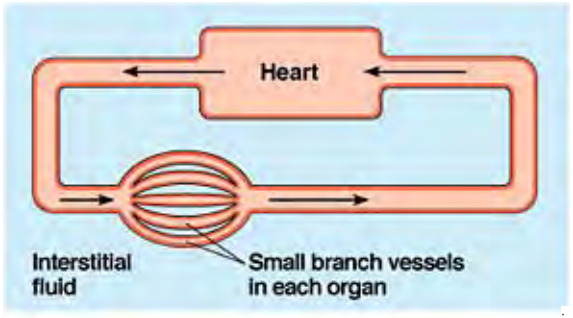


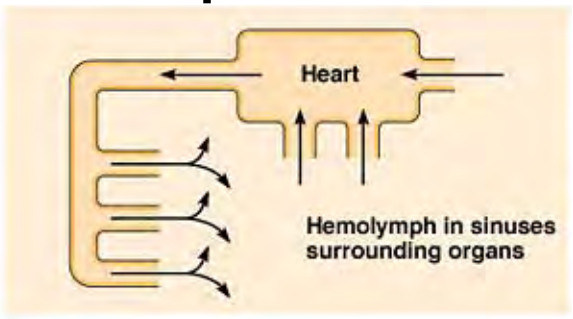
- Parapodia = extensions of body wall (Only occur in polychaetes)
  - help in movement
  - improve cutaneous respiration
- Chetae = bristles (Occur in polychaetes and most oligogochaets except leechs)
  - Grip the ground for movement, burrowing, or reproduction
  - Occur in different amounts on different species (Leeches w/o any).

Most have a CLOSED circulatory System

vs. open in molluscs and arthropods

Closed vs. Open



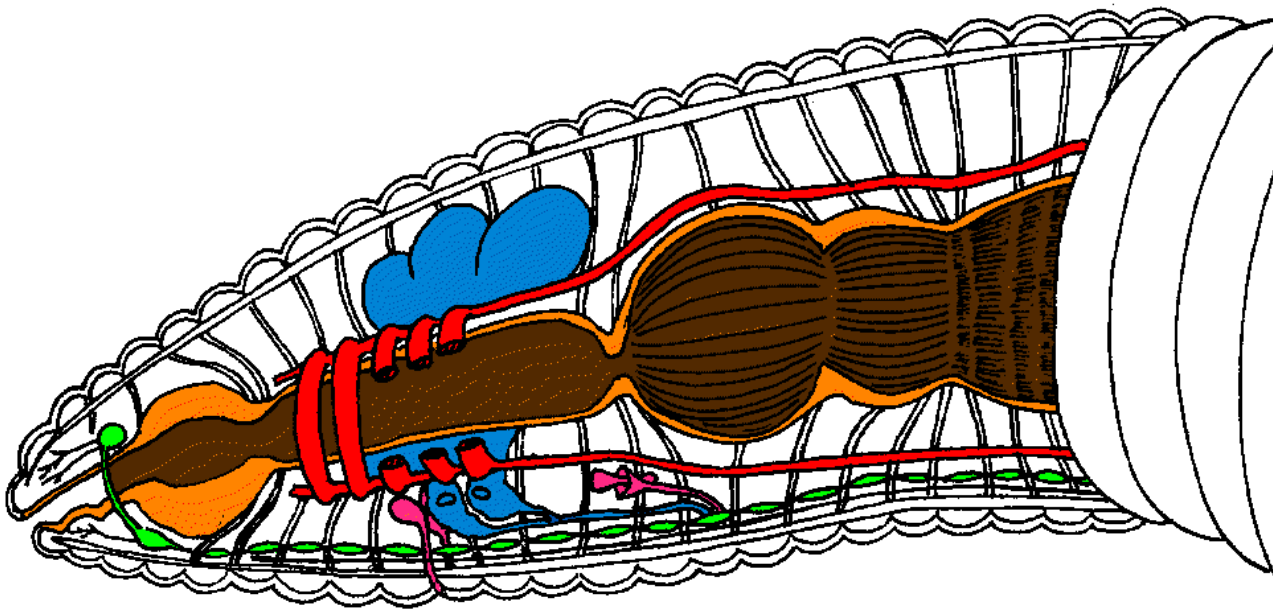


We will talk more about this in another chapter

Varies in complexity in different groups.

In earthworms:

- 5 parallel "hearts"
  - Fairly weak, uncoordinated



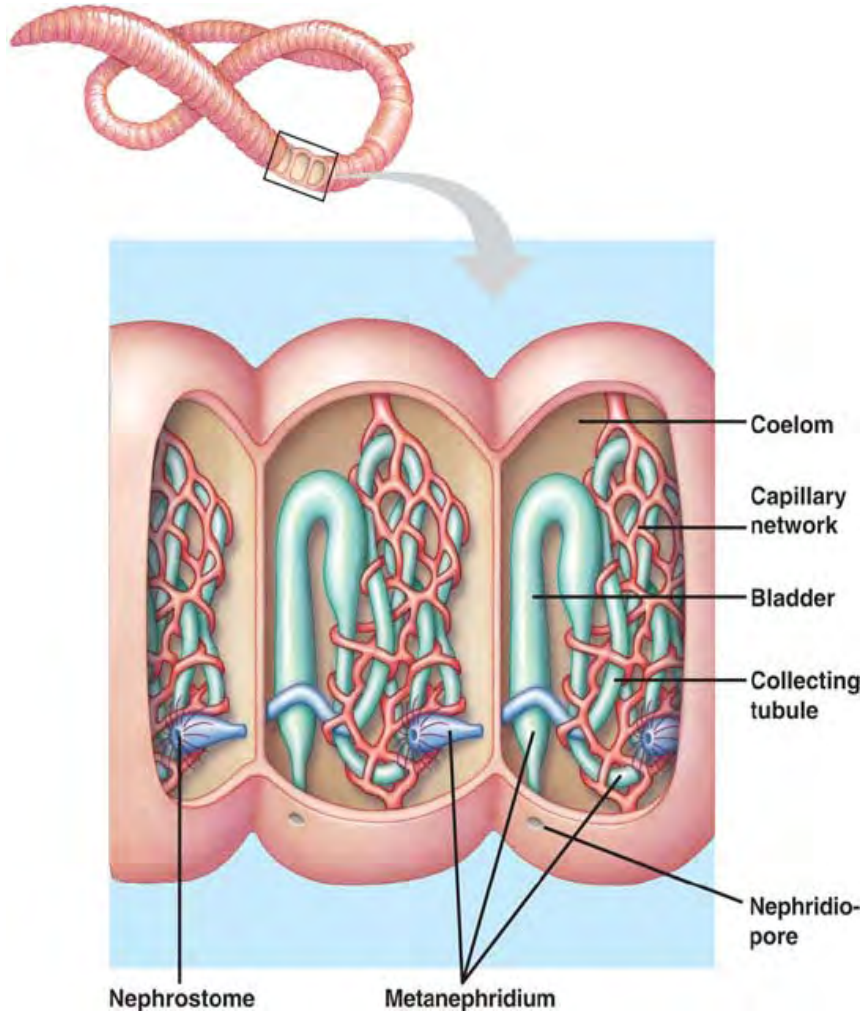
See Figure 33.22 (Campbell et al)

Excretory System

Have advanced organs for removing nitrogenous wastes from blood

Metanephridia

We will talk more about this in another chapter



2 per segment
(only 1 shown)

See Figure 33.22 (Campbell et al)

Annelid Diversity

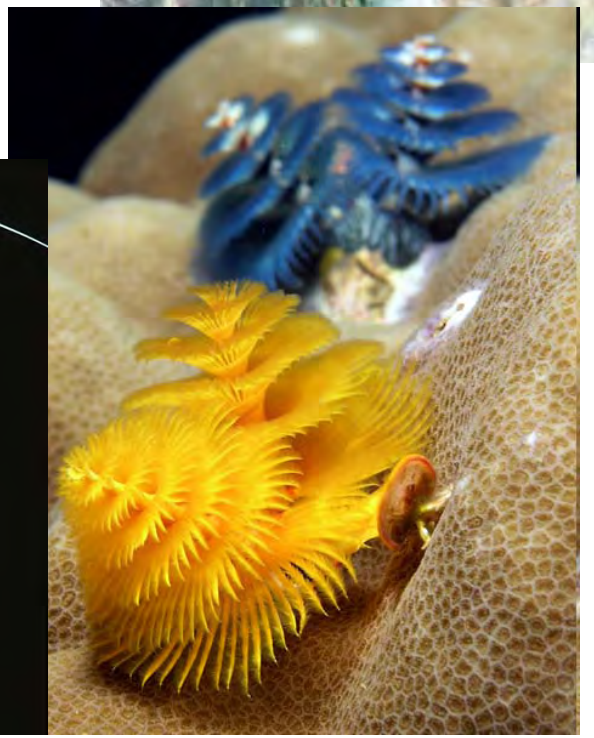
2 Major Clades:

- Polychaeta (polychaetes)
- Oligochaeta (earthworms, leeches, etc…)

Polychaeta:

"many bristles"

- 6-10k species
- Mostly marine
- Mobile or sedentary
- Usually unisexual
- Many w/ large parapodia
- Some w/ cutaneous respiration, others w/ gills



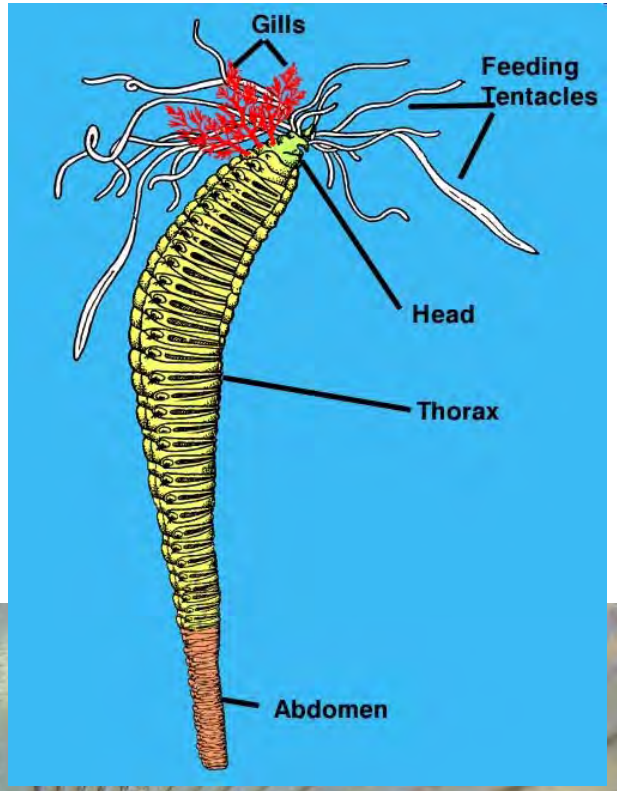
Polychaeta:

Some w/ elaborate gills

Used for:

A) Respiration

B) Filter feeding***



A close-up of a peacock fan worm

Oligochaeta:

"few bristles"

- Earthworms, leechs, etc…
- Terrestrial (subteranean) w/ some freshwater
- No parapodia
- Few chetae
  - None in leeches

Oligochaeta: a) Earthworms

- Scavengers of decomposing materials (substrate feeders)
- Undigested material excreted as fecal “casts” through anus

Earthworm “casts”

Some earthworms get REALLY big

Giant earthworm from Ecuador

See Figure 33.22 (Campbell et al)

Earthworm Reproduction

Simultaneously hermaphroditic with cross-fertilization

vs. sequentially

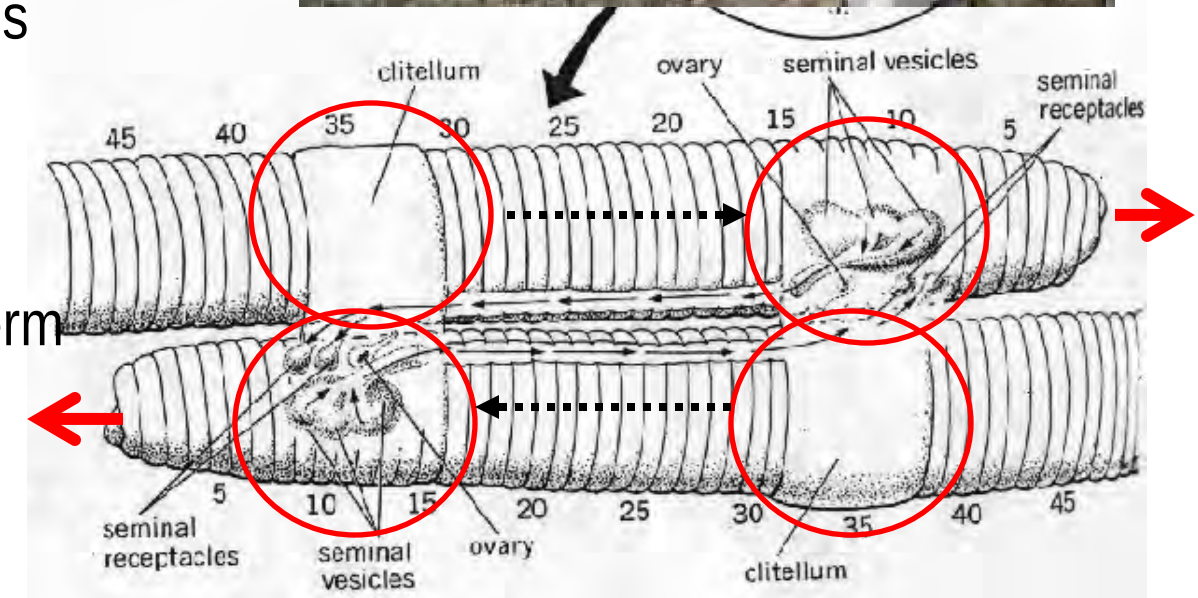
- 2-3 years to reach sexual maturity
- Chaetae hold worms together

1. Exchange & store sperm

2. Clitellum produces a mucous cocoon

3. Cocoon slides forward:
   - picks up eggs & stored sperm
   - slides off head of worm

4. Deposit cocoon in burrow

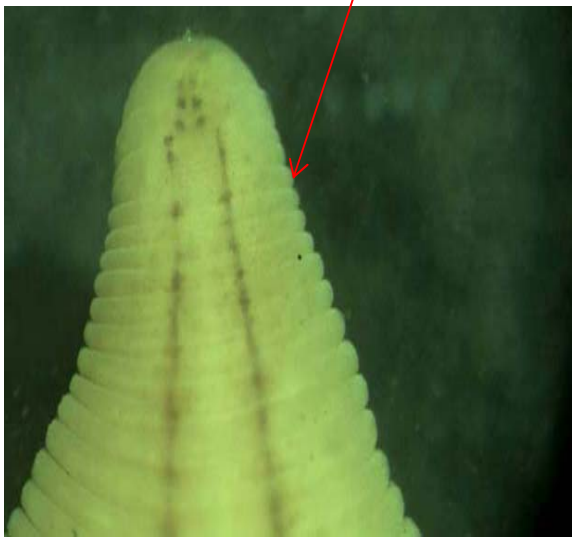


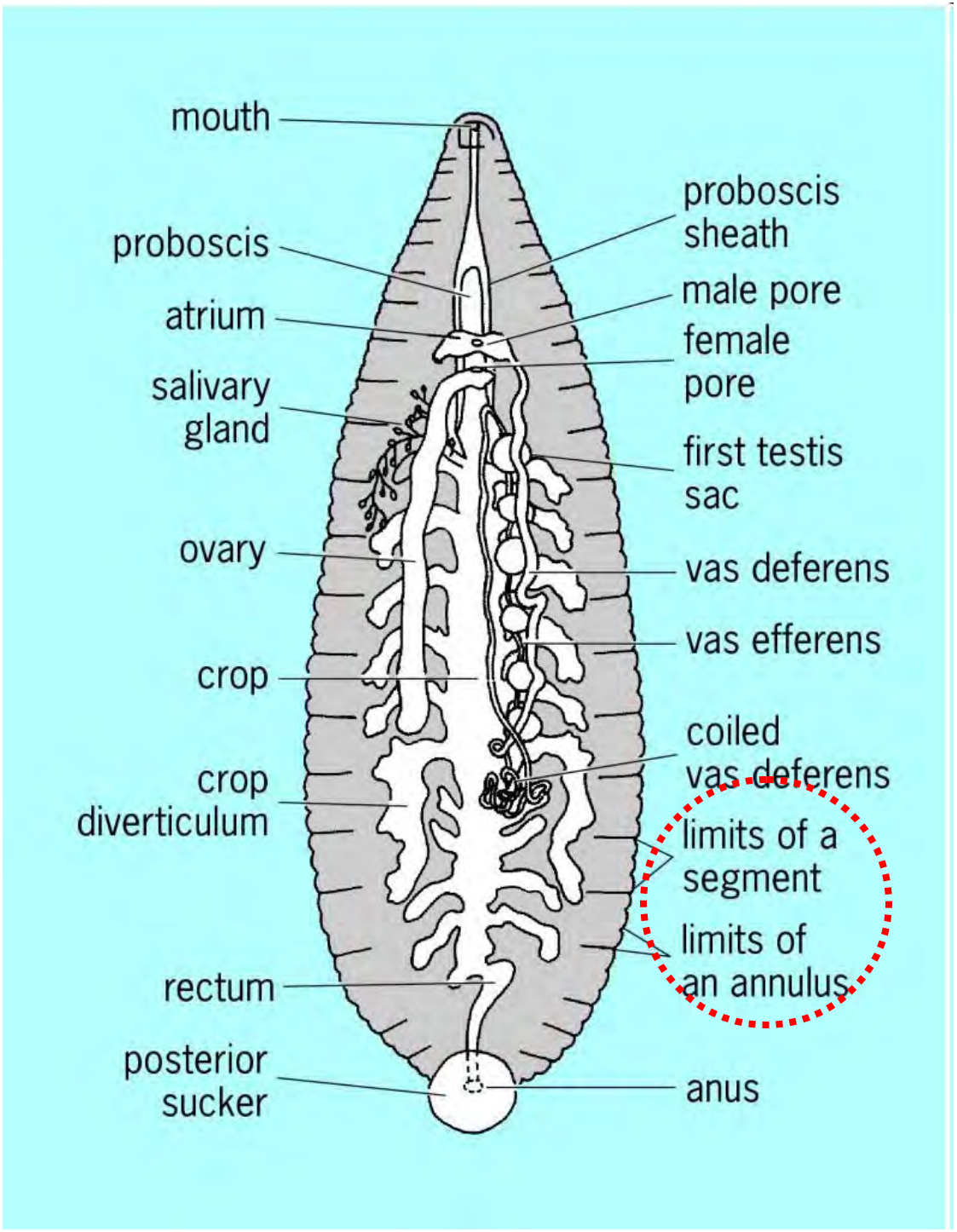
Oligochaeta: b) leeches

- 650 species
- Most freshwater or terrestrial but some marine
- typically 1” to 12” but up to 18”

Leeches

- 34 segments (fixed)
  - each w/ annuli (looks like a segment from outside)
- NO parapodia
- Most w/o chaetae
- 1 to 5+ pairs of eyes

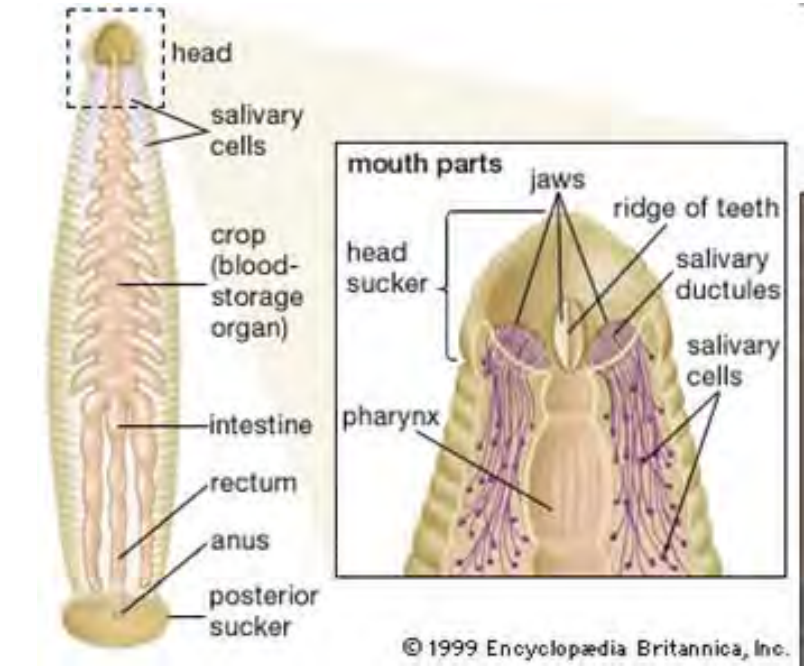




Leeches

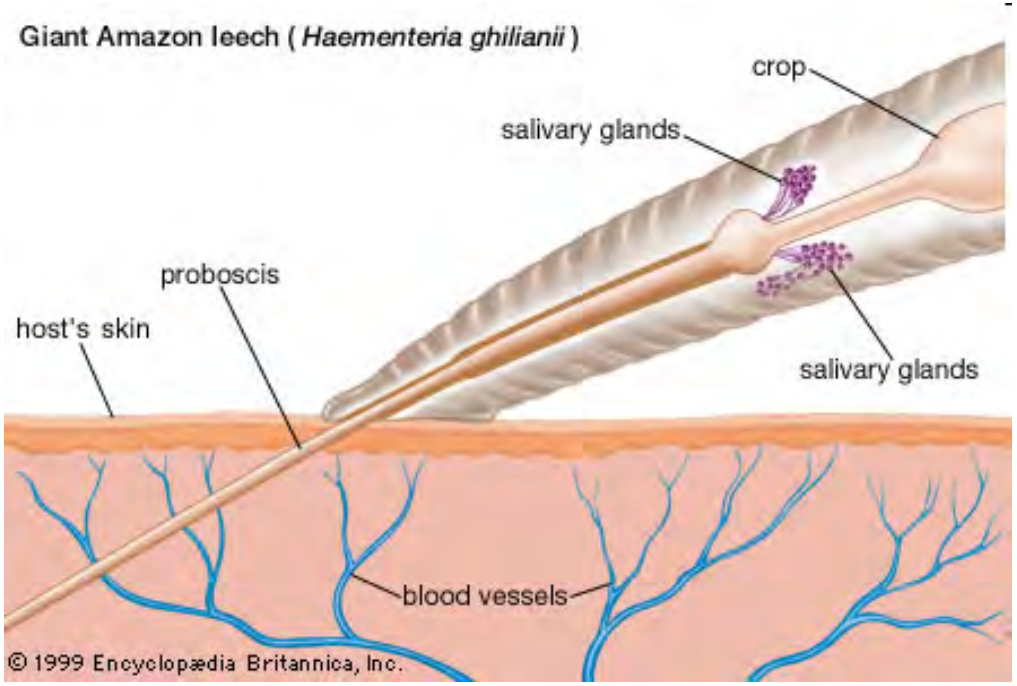
- Most predators of invertebrates

- Some sanguivores
  - 3 jaws w/ teeth → Y-shaped bite
  - Anticoagulant (hirudin)



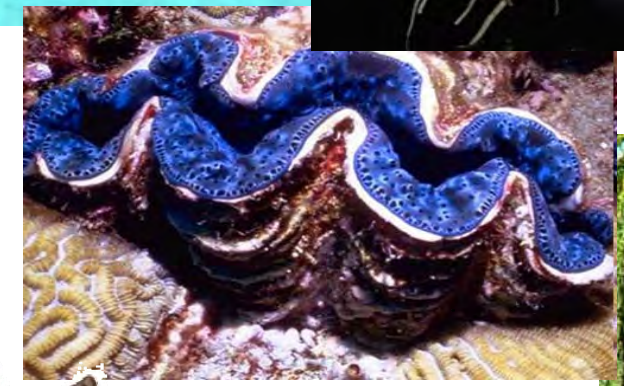
Leeches

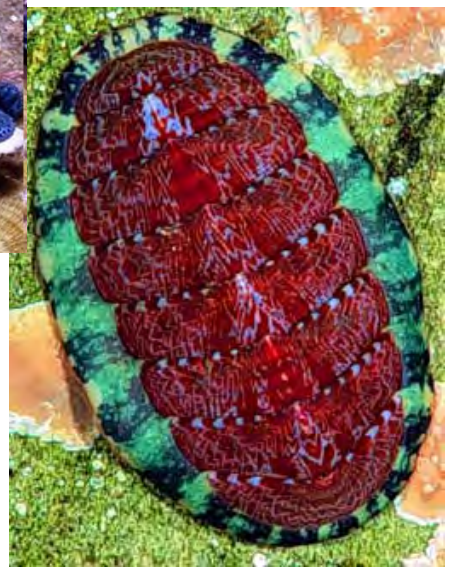
Some have a proboscis (hypodermic needle) for sucking out blood



Phylum: Mollusca

- Bilateria
- Triploblastic
- Coelomates





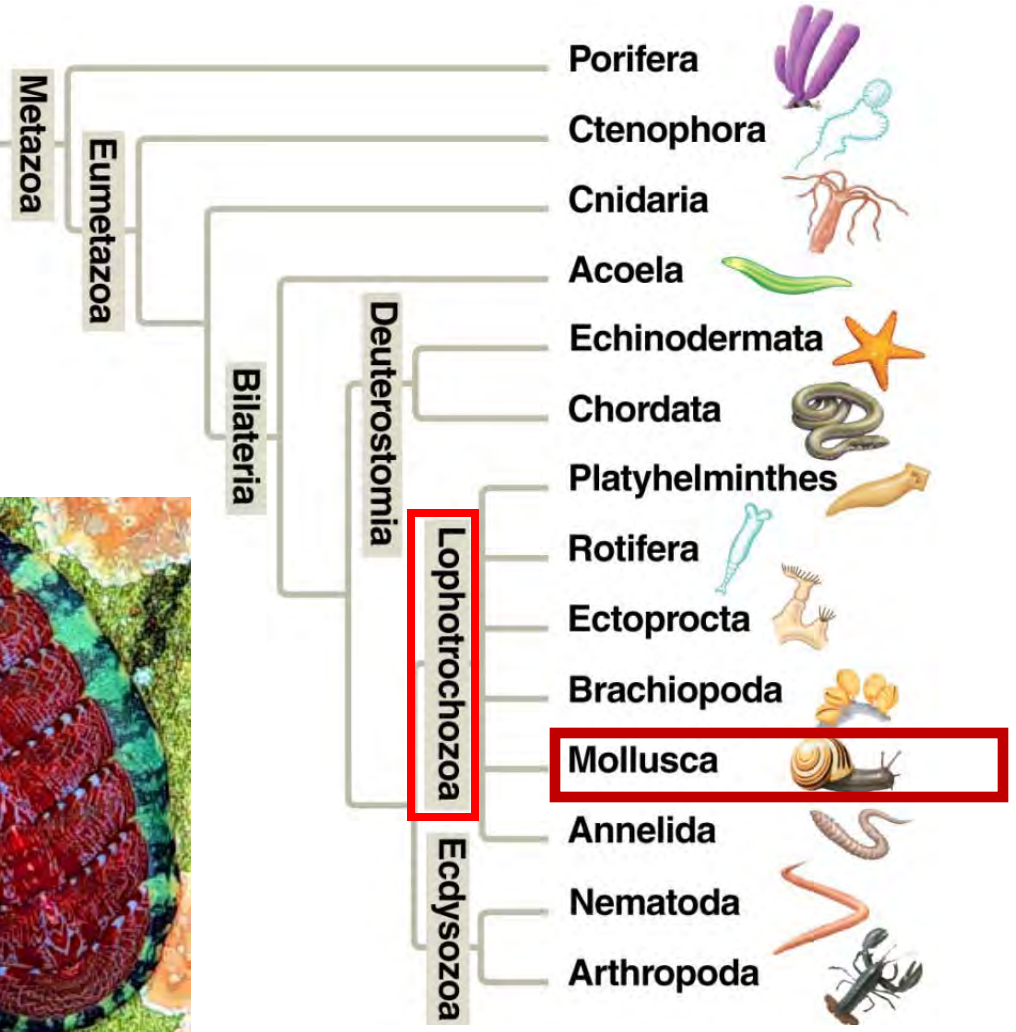


Figure 32.11 (Campbell et al.)

Phylum Mollusca

mollis = soft

- 2nd largest animal phylum
  - ~ 100k spp
- Size
  - most < 5 cm
  - 1 mm – 18m
- Habitat
  - Most marine
  - Some freshwater clams/ snails
  - Some terrestrial snails & slugs
- Reproduction
  - Sexual
  - Most unisexual but some snails/slugs hermaphroditic

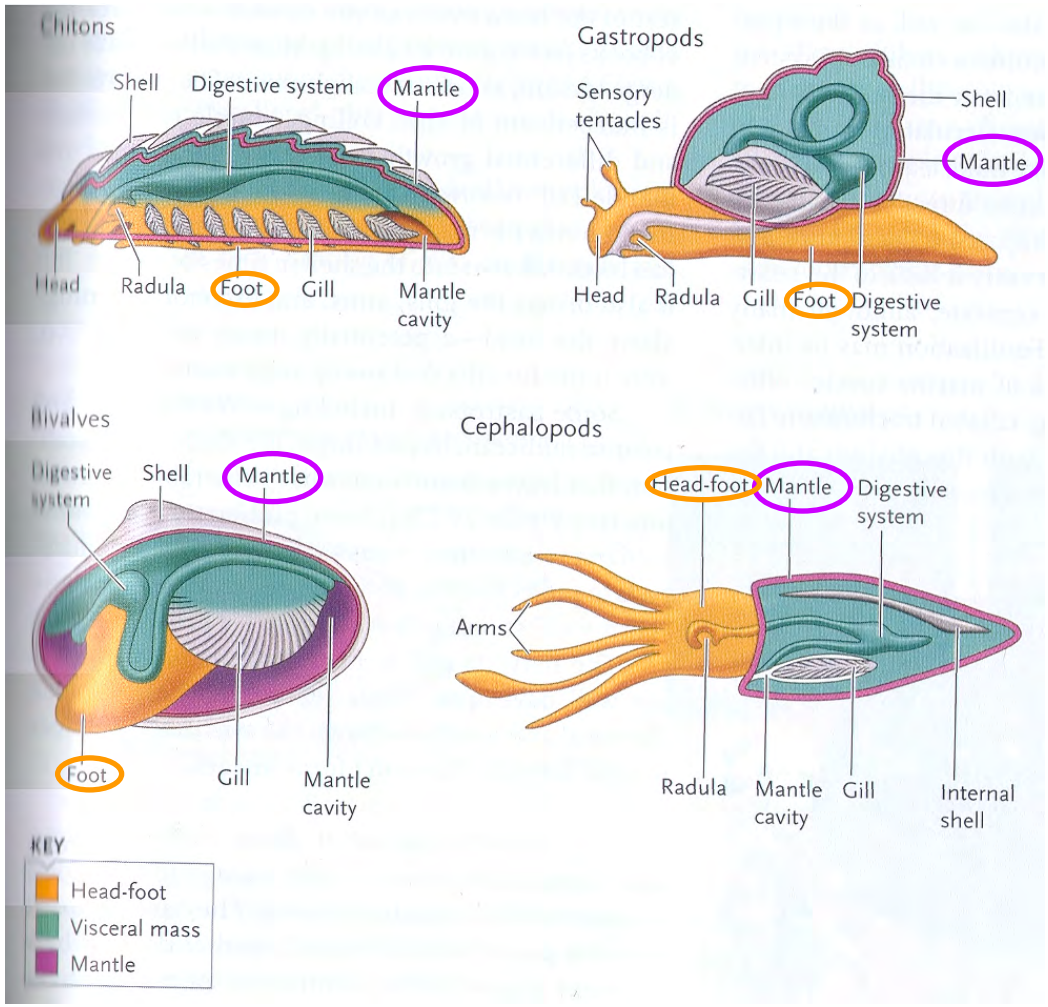
Phylum Mollusca

All have <u>3 parts</u>:

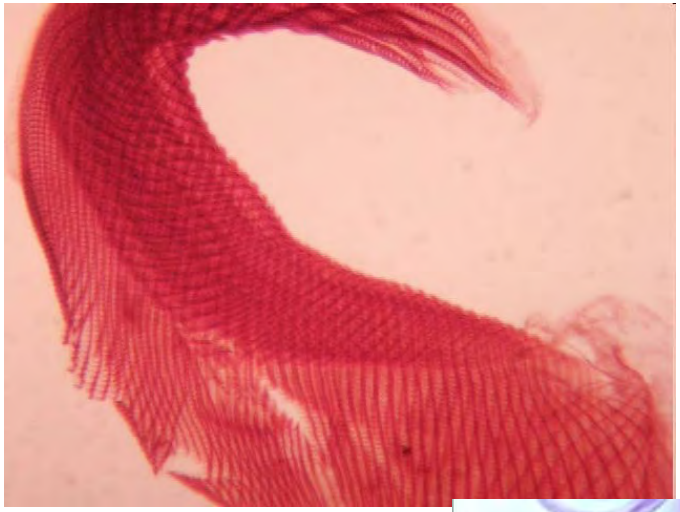
1. Muscular foot

2. Visceral mass
   - contains most organs

3. Mantle
   - Fold of tissue that drapes over visceral mass
   - Secretes $CaCO_3$ shell (if present)



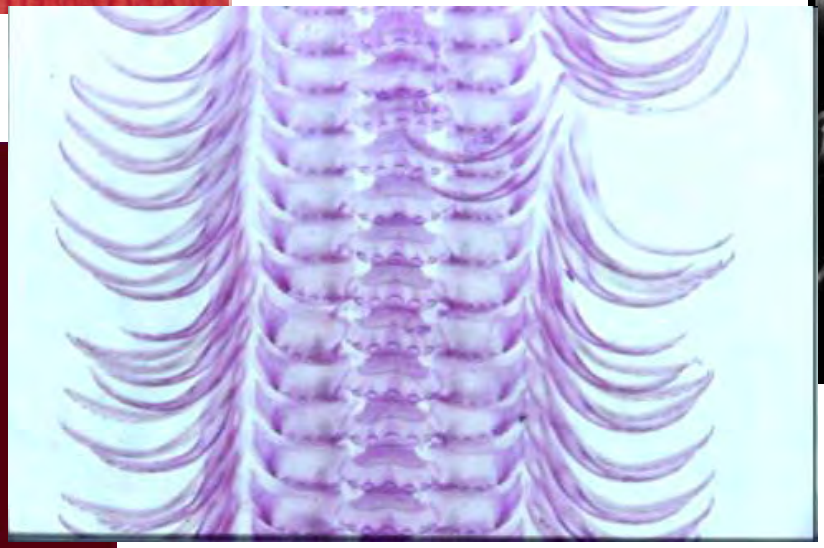
See Figure 33.15 (Campbell et al)

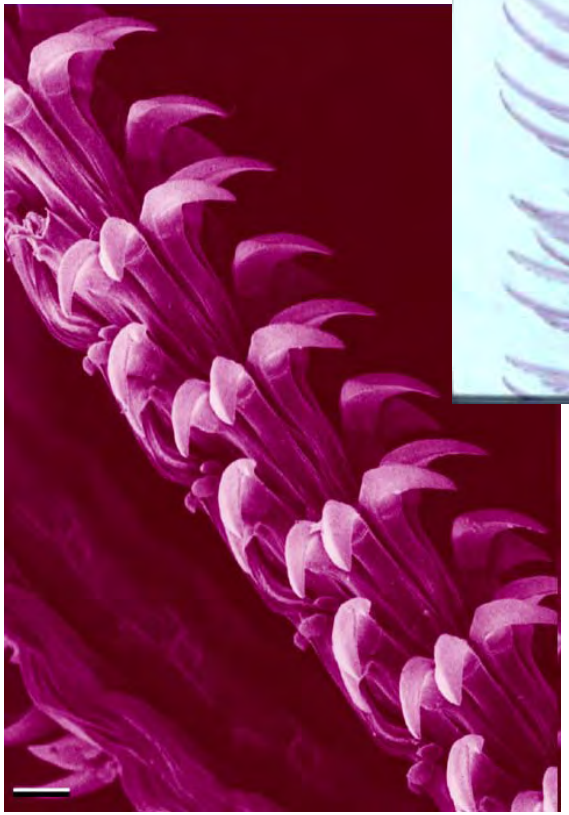


Most have a Radula

Feeding organ

“toungue” w/ teeth





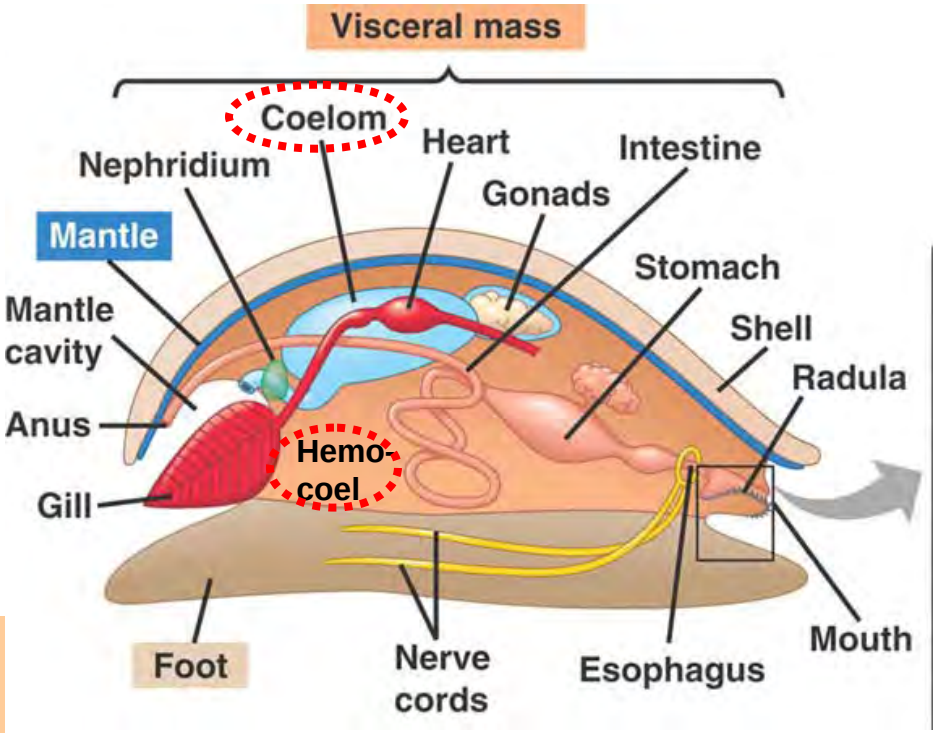
In all but Bivalvia

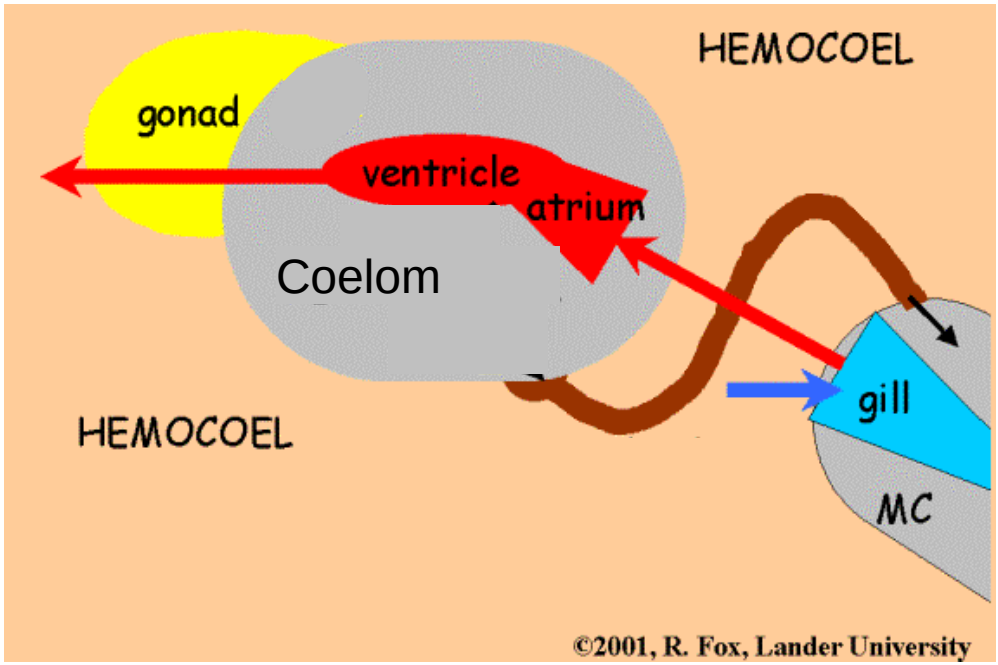
Circulatory System

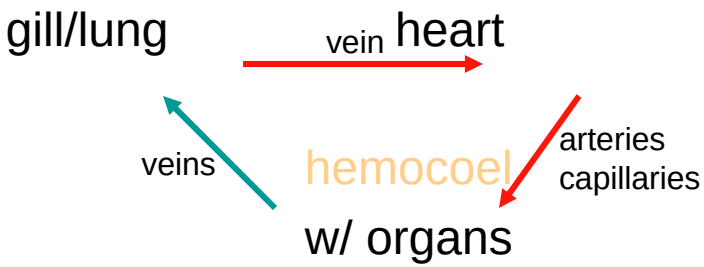
Open except in cephalopods

- small coelom
- *hemolymph* circulates
  - O_2/ CO_2
  - food
  - waste

Don't worry about details as we will talk more about it in another chapter







See Figure 33.15 (Campbell et al)

Phylum Mollusca

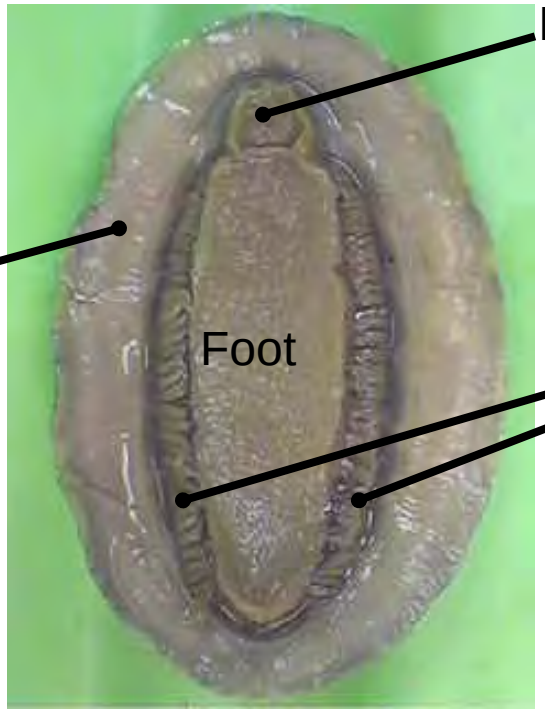
Chiton

Bivalves

Gastropods

Cephalopods

Chiton



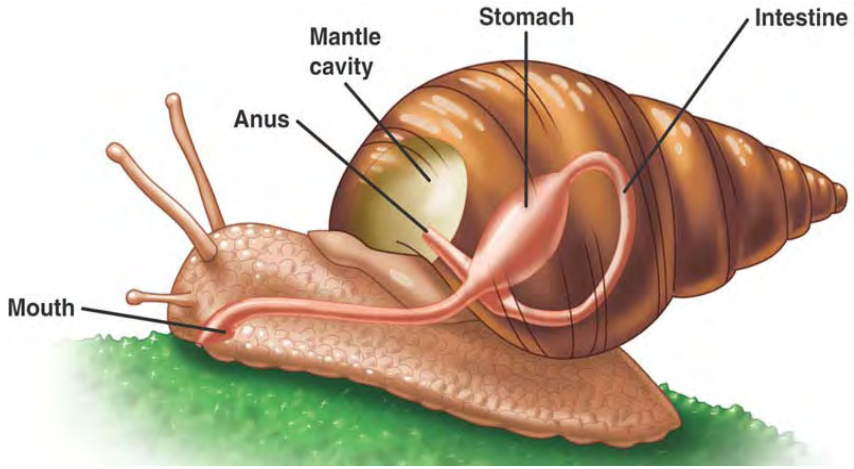
- Have 8 dorsal plates
- Flexible shell and mantle suction cup to substrate
- Scrape algae off rocks w/ radula hardened with iron

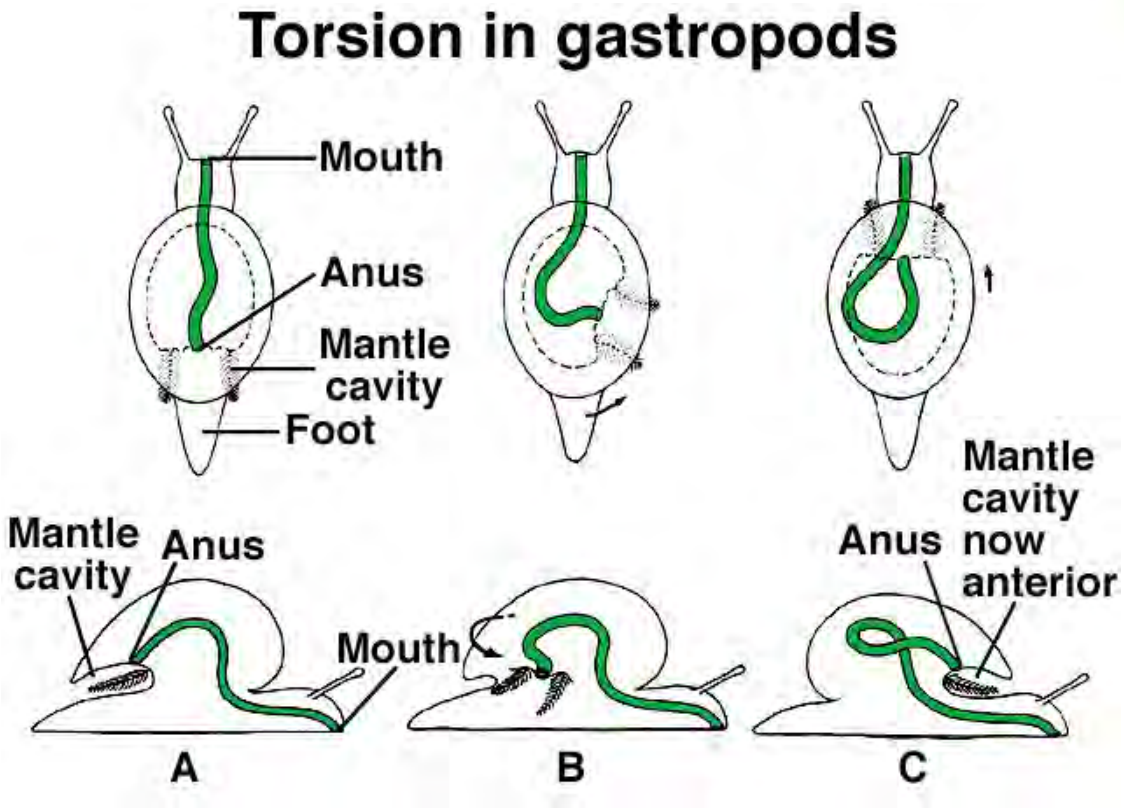
Gastropoda
“stomach-foot”
(snails and slugs)

- 40K spp
- Aquatic or terrestrial (gills or lung)
- Eat algae, plants, or animals
- Some parasites

nudibranch

Slug



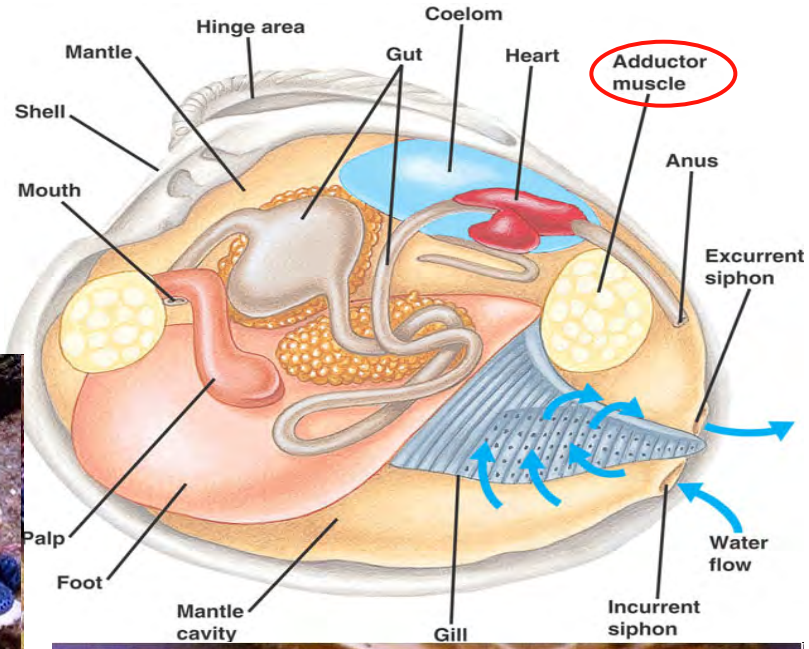


- 180^{o} rotation of visceral mass
- Head room but anus near head

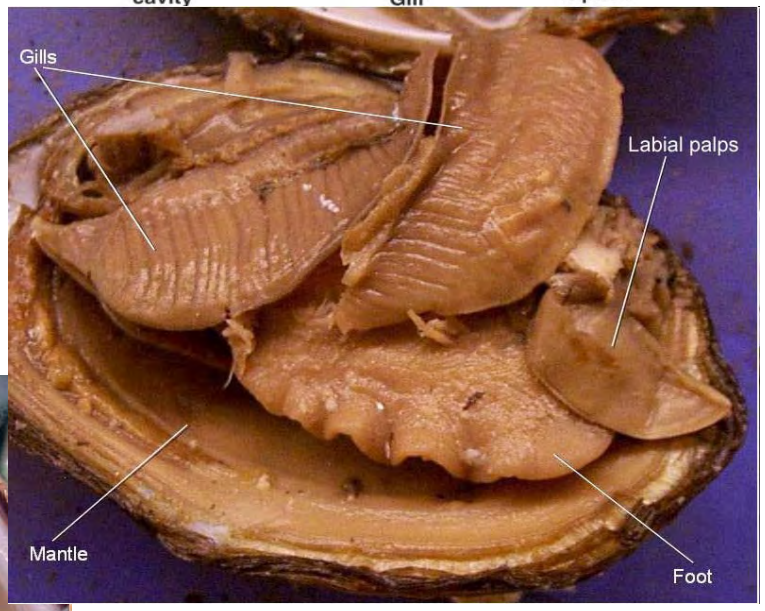
Bivalvia

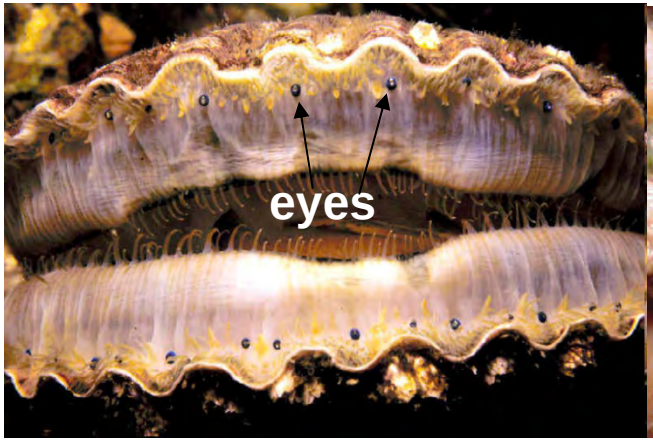
"two folding doors"

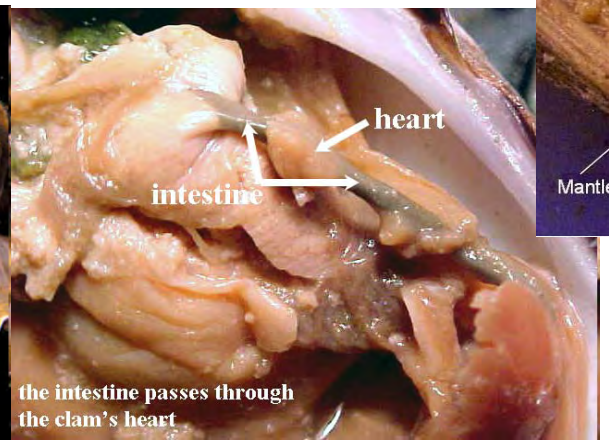
(muscles, oysters, clams, scallops)



- 8000 spp
- No obvious head
- Some have multiple eyes
- most sedentary (scallops can swim)
  - Suspension feed (thus NO radula)
    - *incurrent siphons – gills – palp - mouth*



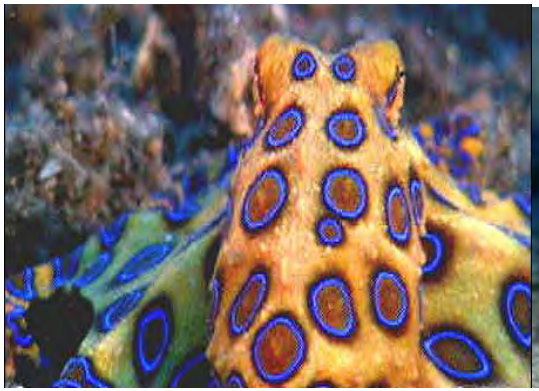




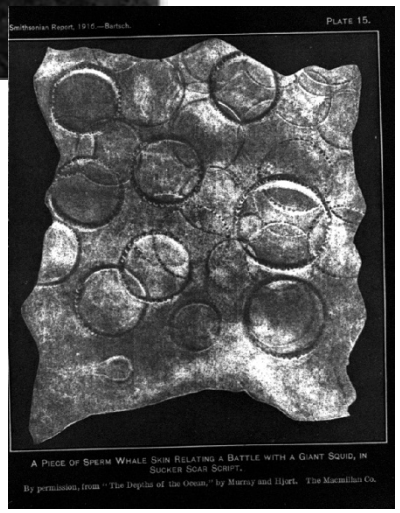
Cephalopoda
"head foot"

(Octopus, squid, cuttlefish, nautilus)

- 600 spp
- Little to no shell (except nautilus)
- Active intelligent predators
  w/ large brain & image-forming eyes
- **closed** circ. system
- radula inside *beak*
- muscular mantle
- jet propulsion via siphon



cuttlefish



Giant Squid:
Largest invertebrate

max size: 13 m (43 ft)

Ecdysozoa

Bilaterians that excrete hard exoskeletons and moult them as they grow

Moulting = Ecdysis

Phylogenetic Tree: Molecular

Figures 32.10 and 32.11 (Campbell et al.)

Phylum: Nematoda (Roundworms)

~25K spp known
- likely 20x more!

•Highly abundant
- 90% of animals on ocean floor
- 80% of all individual animals on earth

•Ubiquitous:
- in soil (terrestrial & under fresh & salt water)
- pole to pole
- harsh desserts
- deep in the earth
- in plant and animal tissues and fluids

• Predators, scavengers, & parasites of animals, plants, fungi, bacteria

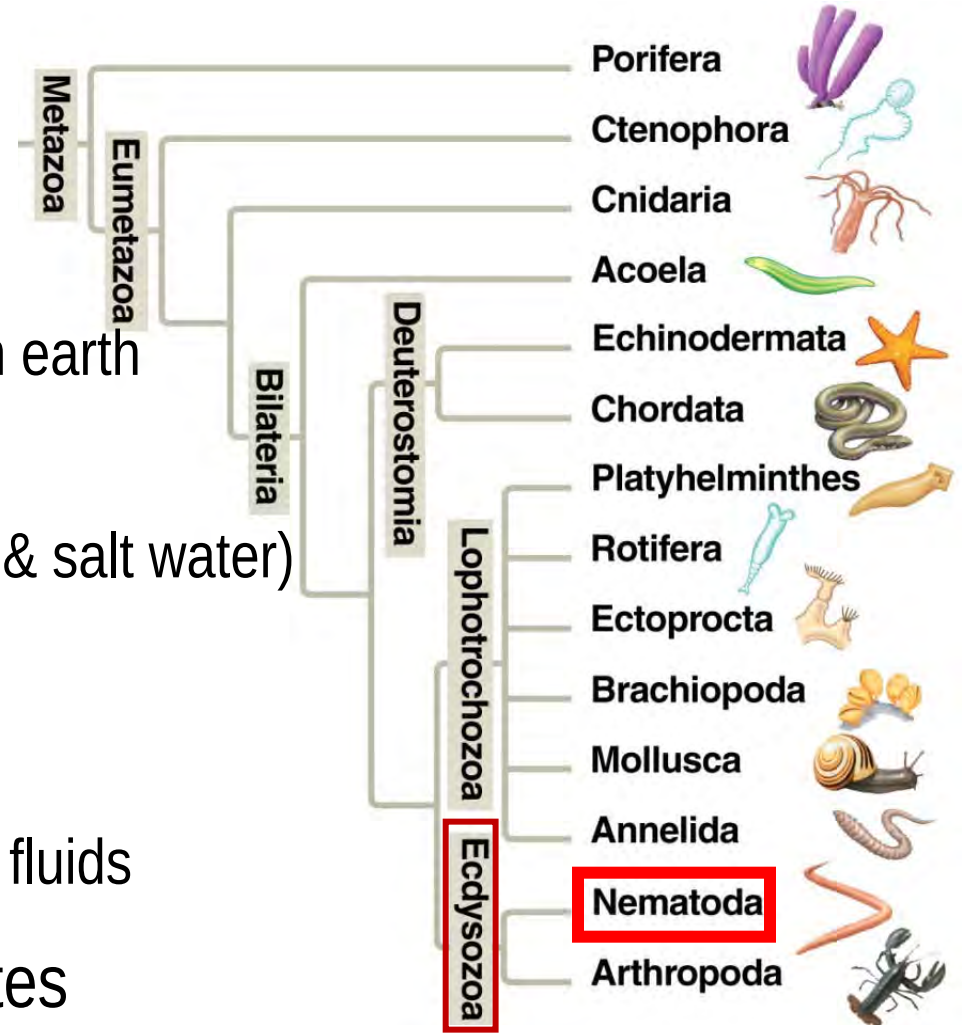
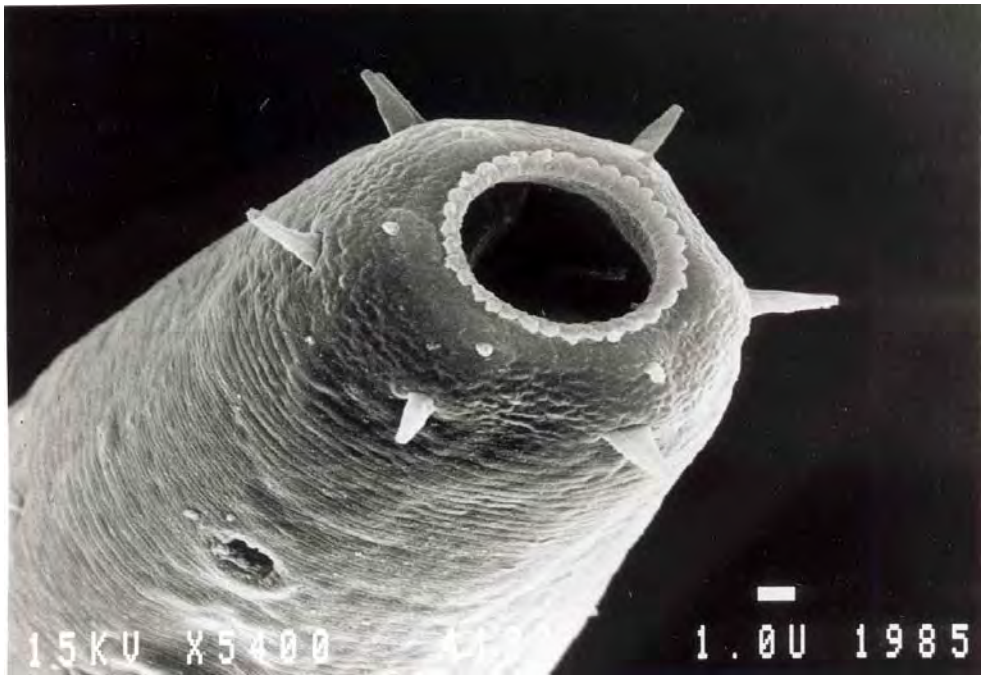
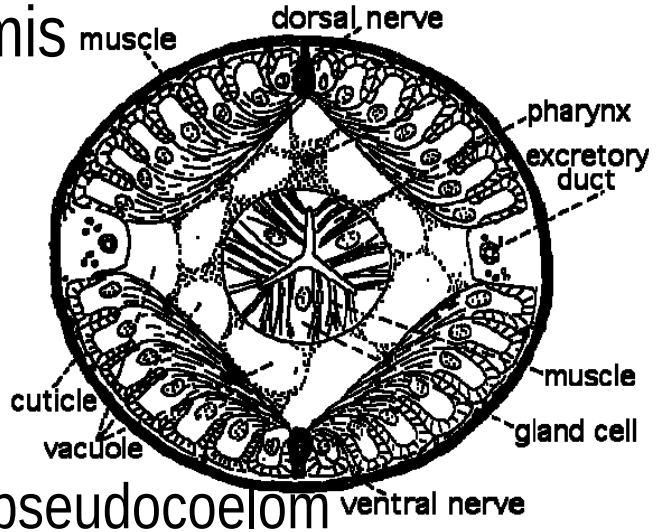


Figure 32.11 (Campbell et al.)

Nematoda Morphology

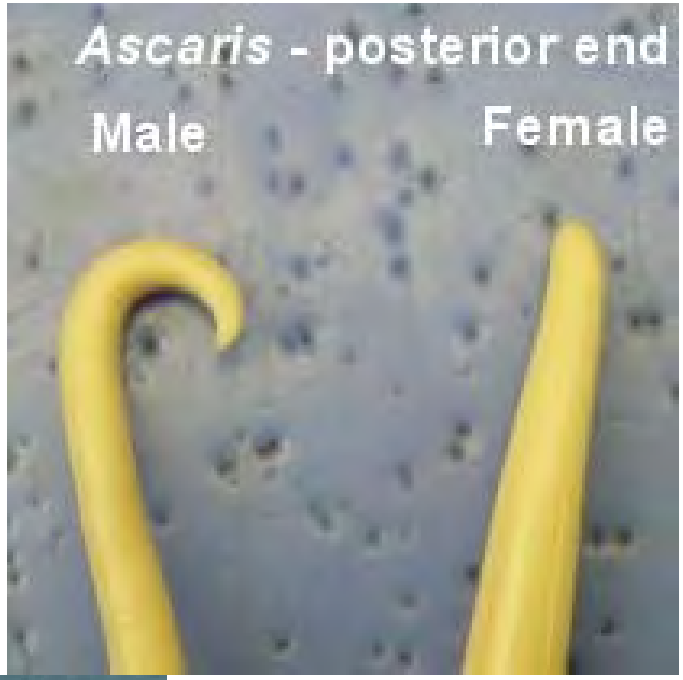


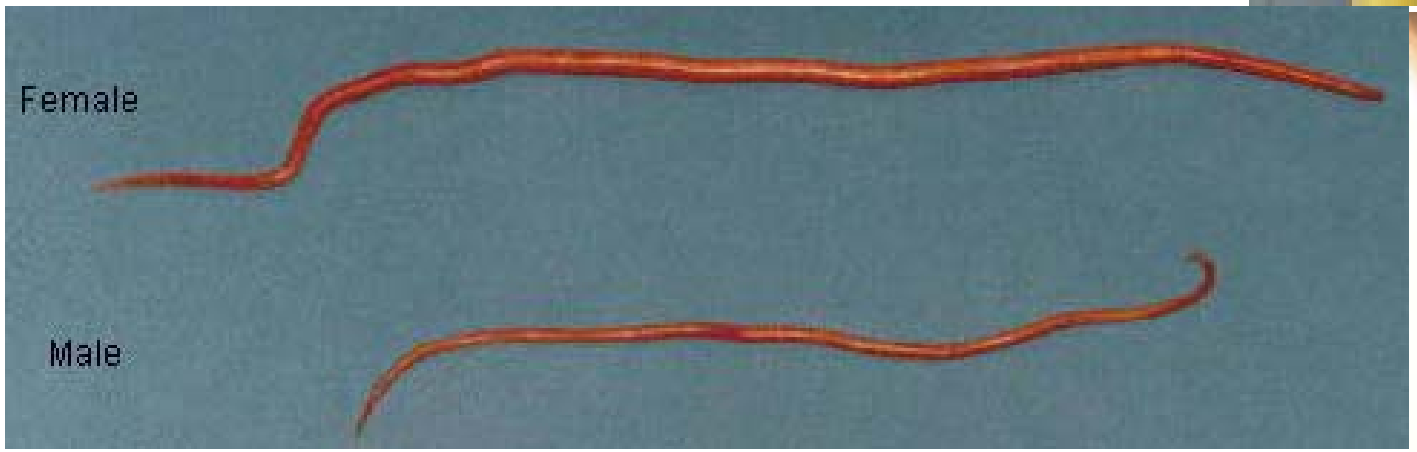
- Pseudocoelomates
- 1 mm – 1m
- Not segmented
- Cuticle
  - External collagen layer
  - Secreted by epidemis
  - Regularly shed (ecdysis)
- Layer of *longitudinal* muscles beneath epidermis only allows thrashing movements
- Dorsal and ventral nerve
- Complete Digestive system
- No respiratory system
  - gasses diffuse across cuticle & move in fluid of pseudocoelom



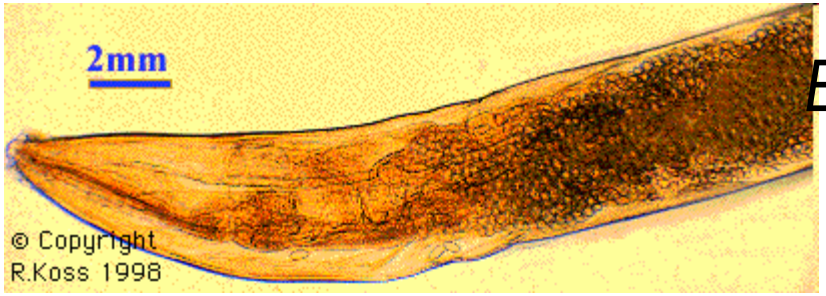
Reproduction

- Usually sexual
- Separate sexes
- Internal fertilization
- Can lay 200K eggs/ day!

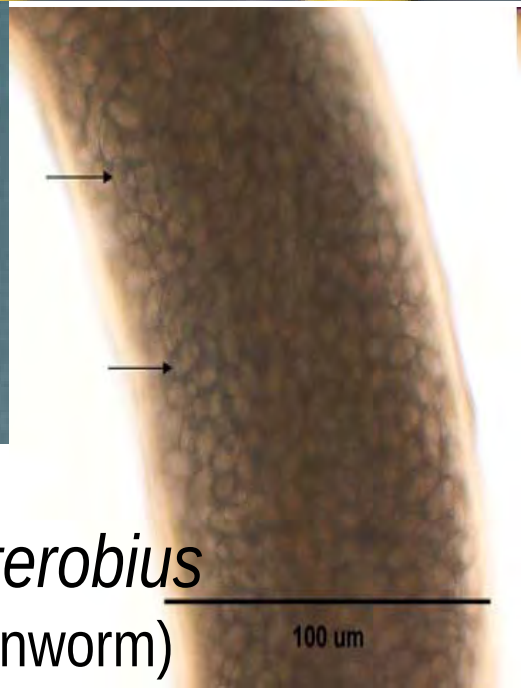




Ascaris spp



Enterobius
(pinworm)

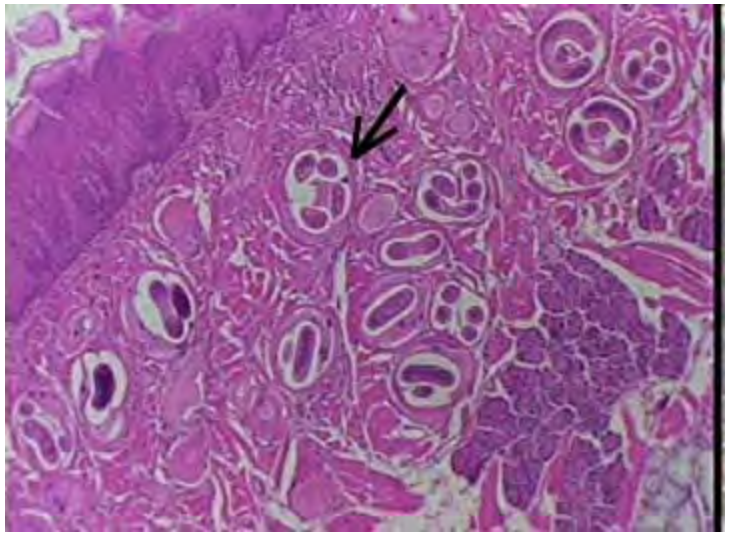


100

Some are parasites of Vertebrates

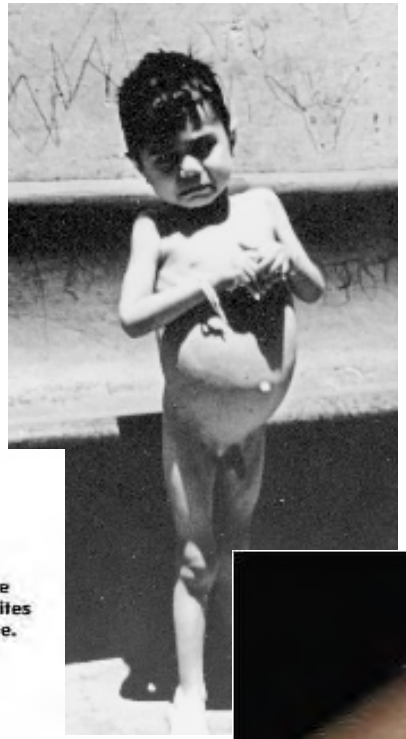
e.g. *Trichinella spp* (trichinosis)

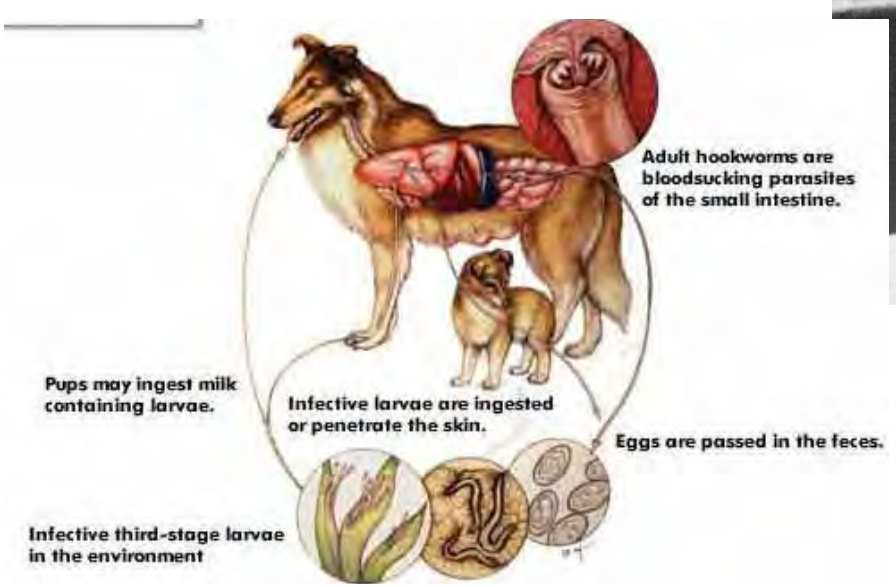
- Mammalian & reptilian parasites
- Cysts live in muscle tissue:
  - hatch when eaten by new host
  - young worms burrow thru intestinal wall & muscles
  - cramping, diarrhea, fever
  - sometimes enter CNS
- In U.S. ~12 cases/ year
  - reduced by not allowing feeding of raw meet to hogs



101 *Necator americanus (hookworm)*

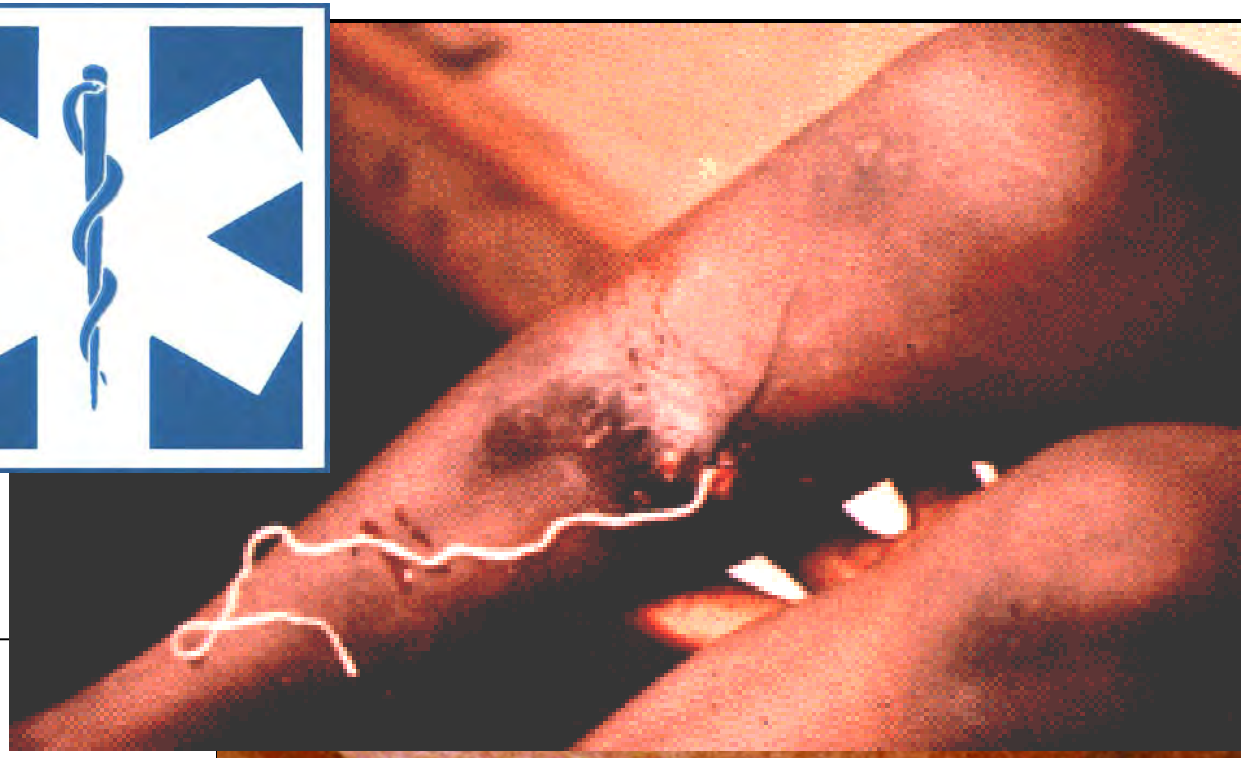
- Mammalian parasites (in soil)
- Penetrate skin, latch onto intestinal lining, & drink blood
- Affect ~2B people
  - anemia & weakness





102 *Dracunculus medinensis (Guinea worm)*

- Ingest in unfiltered drinking water
- Larvae burrow into stomach lining
- Female or offspring emerge from skin blister
- No non-human vector



1986: 3.5 M cases
in 20 African countries

2009: 3185 cases in 4 countries
(85% in S. Sudan)

2010: 1794 cases (95% in S. Sudan)

2011: 1060 (97% in S Sudan)

2012: 542 cases

2013: 148 cases

2014: 80 cases (by 8/31) (vs 121 in 2013)

Filaria (lymphatic filariasis) (Elephantiasis)

~120M people infected in 73 countries

- Spread mainly by biting insects
  (e.g. mosquitoes & blk flies)
- Blocks lymphatic nodes resulting in swelling

Swollen testicles in severe cases

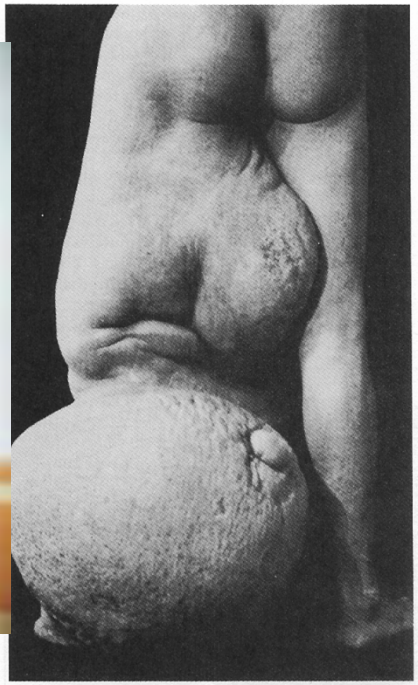
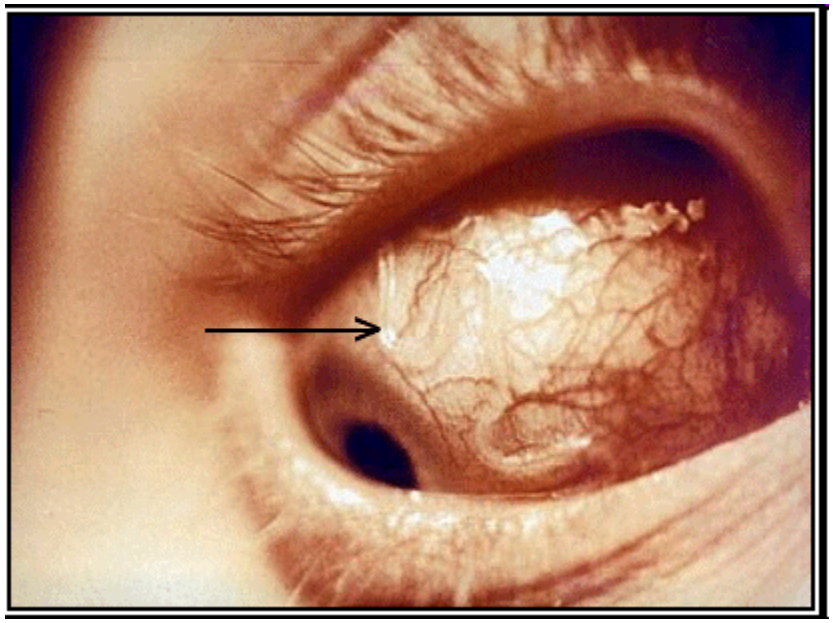
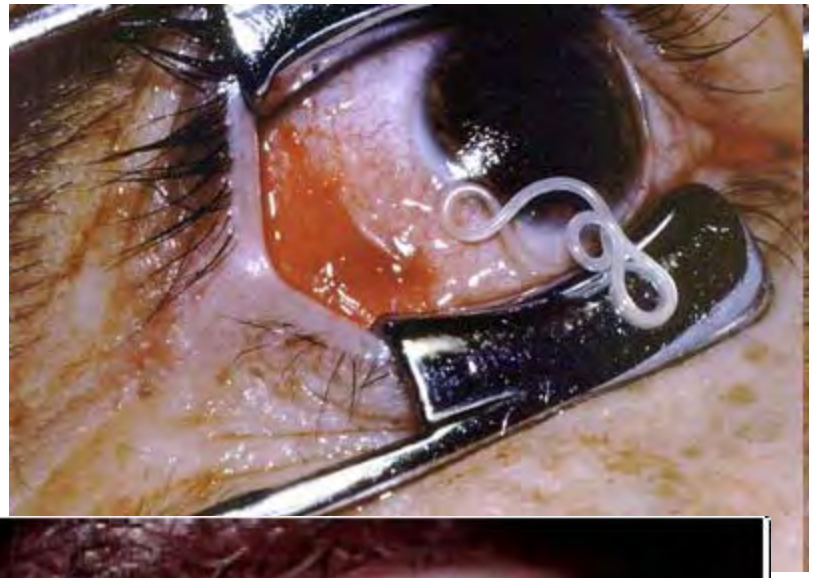


Figure 9–44 A victim of elephantiasis resulting from severe filariasis. (Courtesy of Mayo Clinic.)

Elephantiasis. Tahiti.
W. Peters: A Colour Atlas of Arthropods in Clinical Medicine. 1992

Loa loa filariasis (African eye worm)





- Contracted through biting insects (deer fly, mango fly)
- Human form restricted to the rain forest and swamp forest areas of West Africa

~12-13 million humans are infected with the Loa loa larvae.

Phylum Arthropoda

Greek: Jointed Foot

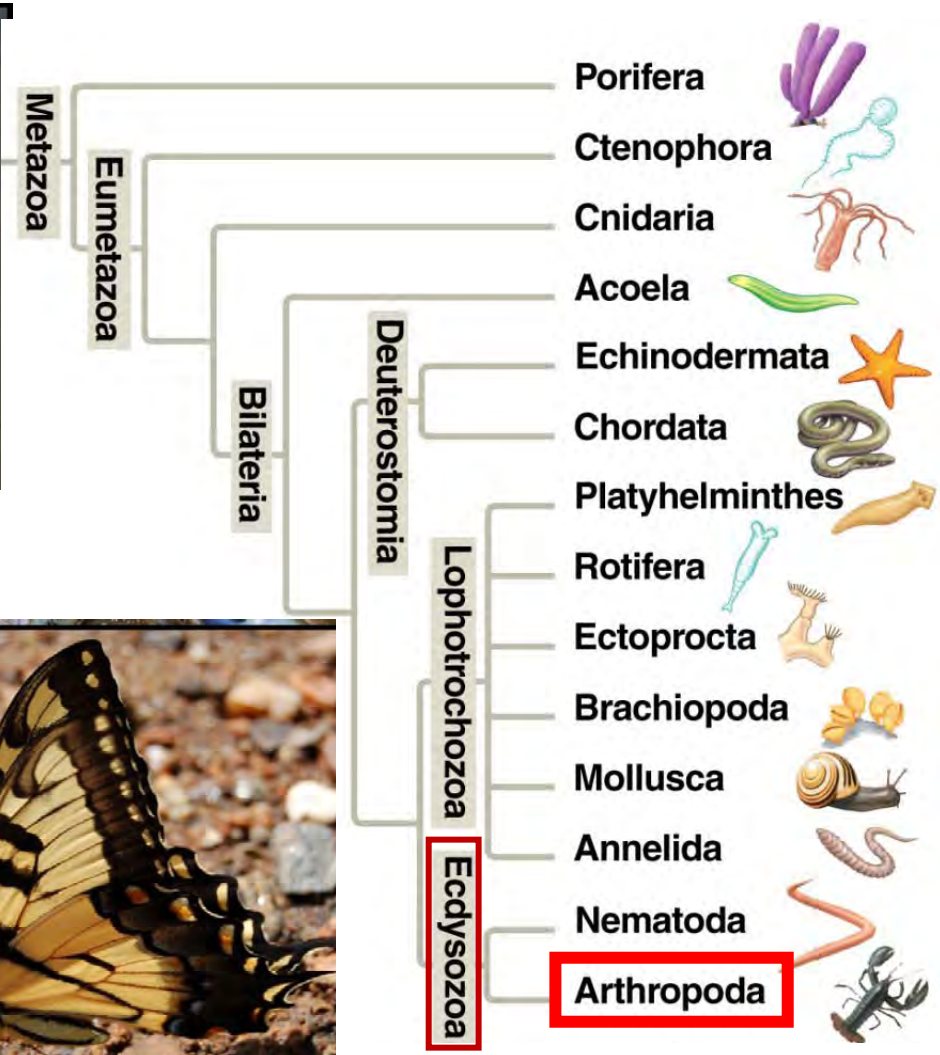
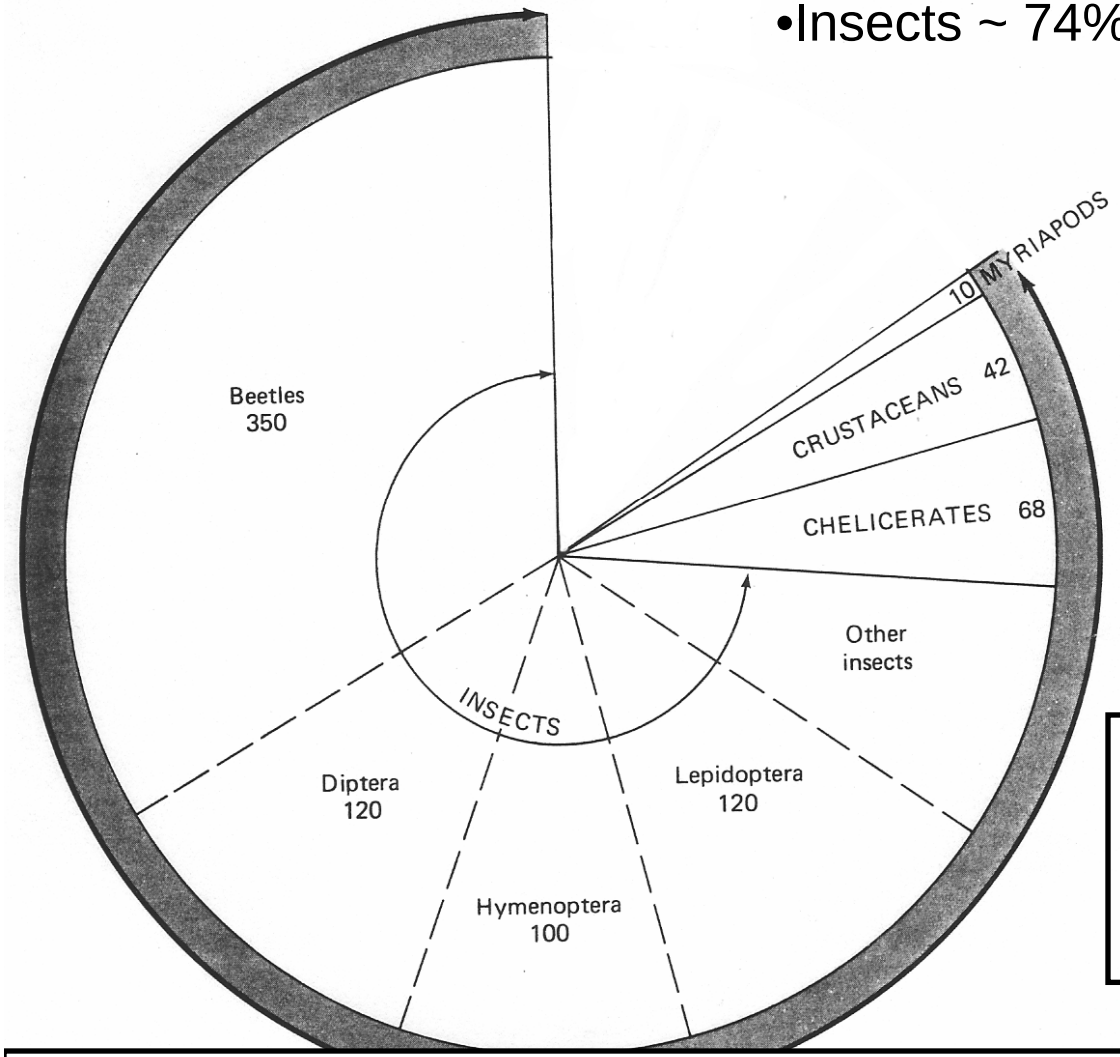


Figure 32.11 (Campbell et al.)

Arthropod Diversity

Arthropods represent **>** **85%** of animal species

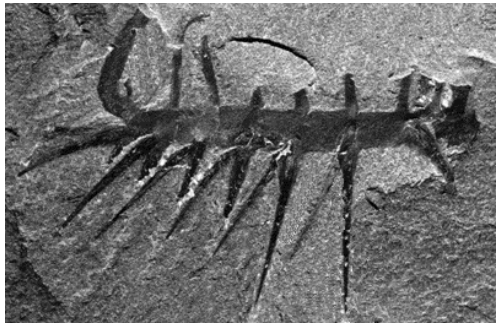
•Insects ~ 74%; Other arthropods ~11%



* 10^{18} individuals (1 quintrillion)
* 1,000,000,000,000,000,000
* 1.6 billion per human

Numbers represent approx. count (in 1,000's) of species per group

Arthropod Success



- Evolved from segmented worms
  - but no internal segmentation i.e. no septa
- Over time segments fused and began to specialize
  - Most w/ 3 segments: head, cephalothorax and abdomen
- Success due to:
  - body segmentation, hard exoskeleton, jointed appendages

Trilobites had little fusing or specialization of segments

Figure 33.27 (Campbell et al)

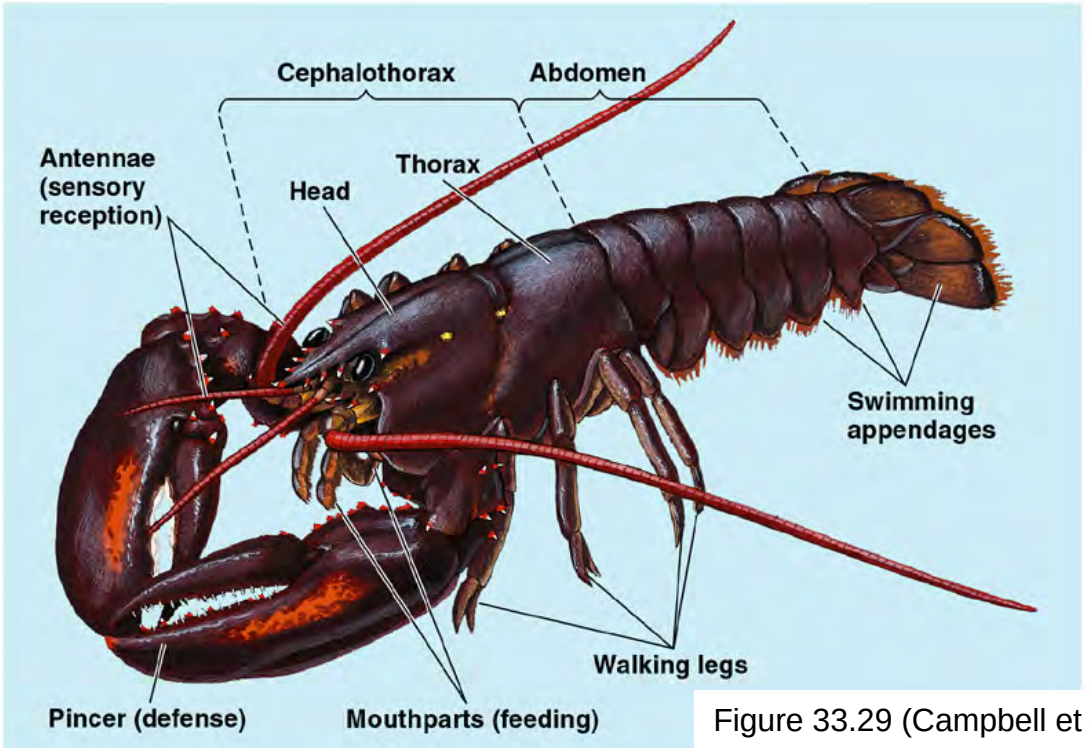
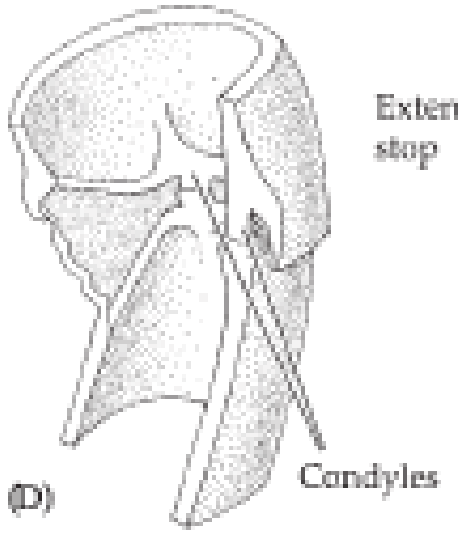


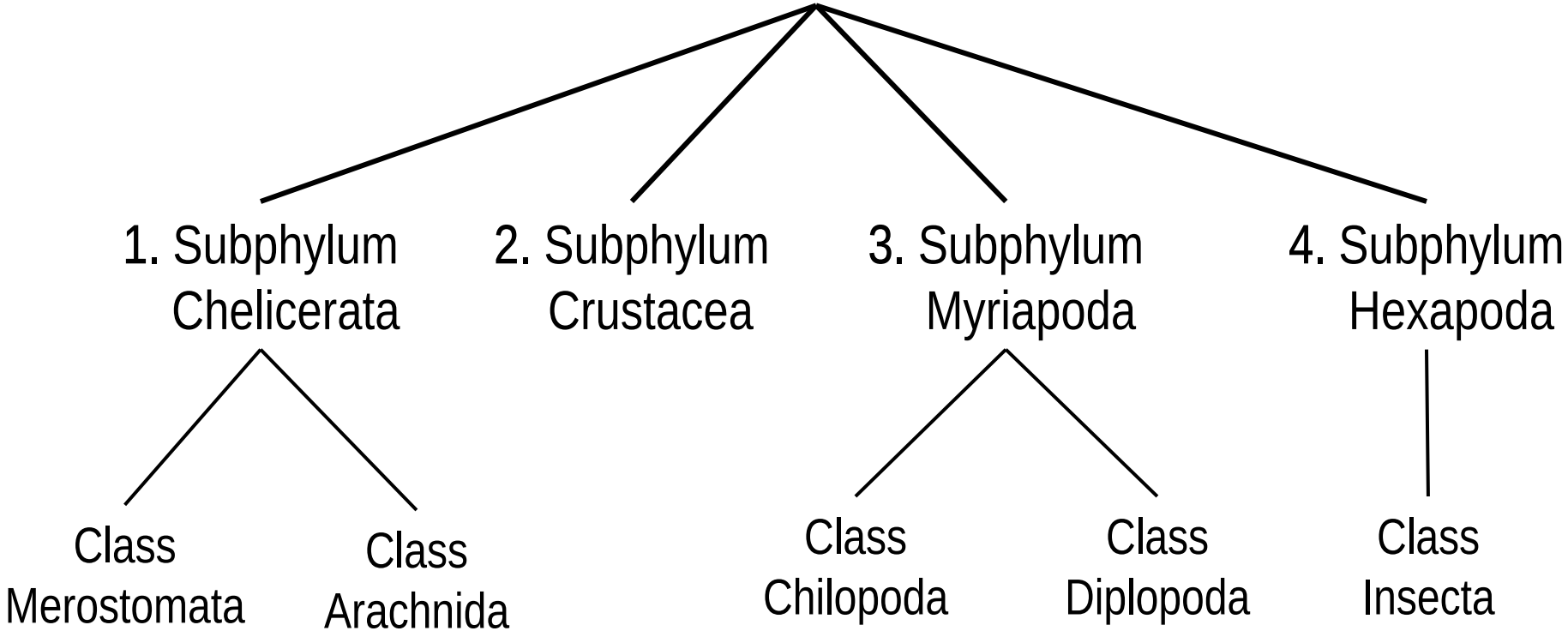
Figure 33.29 (Campbell et al)

Arthropod Structure

- 2-3 segments
- Jointed appendages (many types)
- Cuticle (aka exoskeleton):
  - Made of chitin (= fungi) (vs. collagen in nematodes)
  - Molt (ecdysis)
  - Desiccation resistance
  - Muscle attachments
- Well-developed sensory apparatus:
  - Eyes, olfactory, antennae, setae (hairs)
- Complete digestive tract
- Open circulatory system (will discuss in later chapter)
- Efficient respiration system
  - Gills or tracheal system (will discuss in later chapter)
- Efficient nitrogenous waste removal
  - Coxal gland and malphigian tubules (will discuss in later chapter)
- Sexual reproduction (a few parthenogenic)
  - Usually unisexual (a few hermaphroditic, e.g. barnacles)
  - Fertilization external in many and internal in others (e.g. insects, spiders)



Phylum Arthropoda



Extant subphyla and classes

1. Subphylum Chelicerata

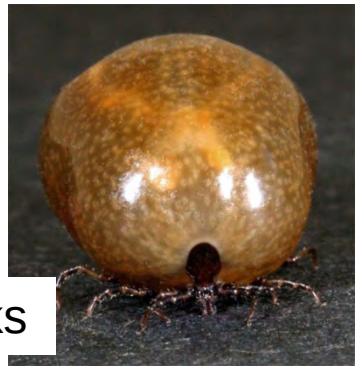
(“bearing pincers”)

2 Classes:

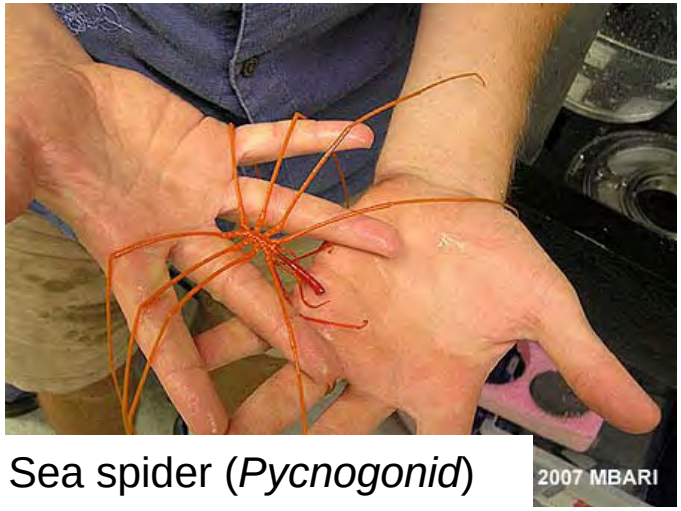
Merestomata (horseshoe crabs) and Arachnida (spiders, ticks, mites, scorpions)

horseshoe crab

Ticks



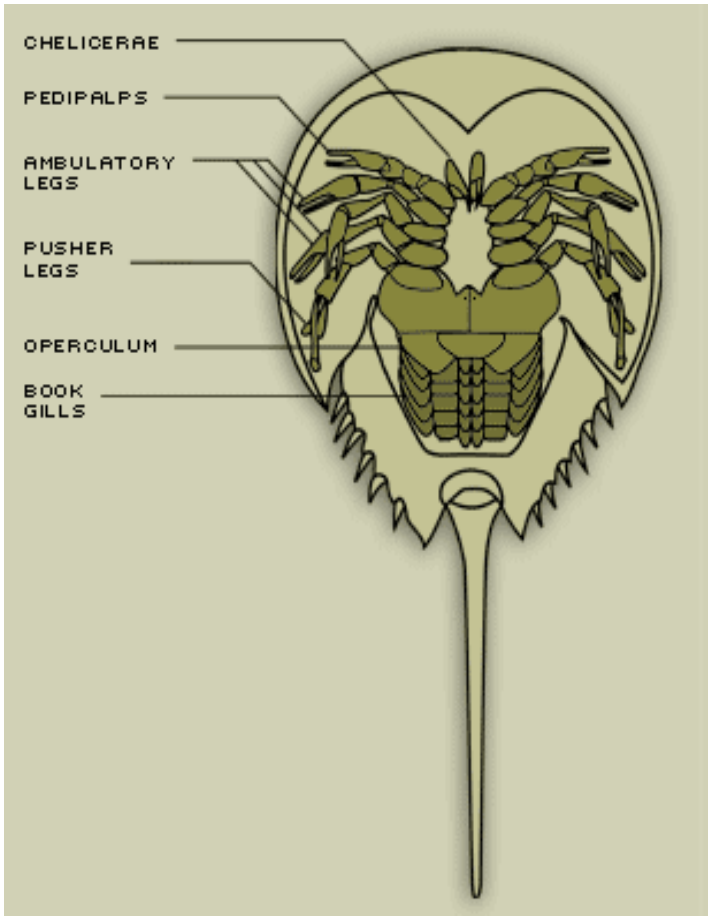
mites



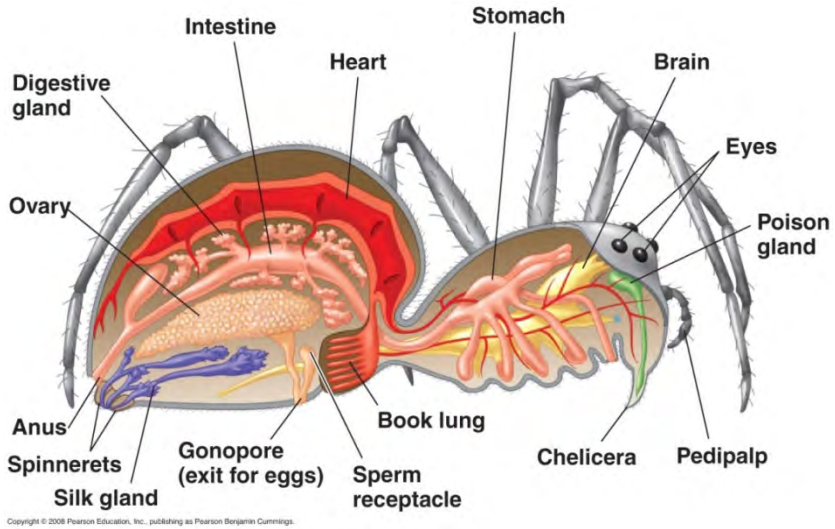
Sea spider (*Pycnogonid*)

spiders

Chelicerata: General Characteristics



- 2 main body parts: Cephalothorax and abdomen
- Appendages: 6 pairs <u>all</u> on thorax
  - 1: Chelicerae (claw-like or fangs)
  - 2: Pedipalps (sensing, feeding, or reproduction)
  - 3-6: 4 pr walking appendages
- No Antennae
- Respiration: Book gills and book lungs
  - well vascularized tissues w/ a lot of surface area



http://www.enchantedlearning.com/subjects/invertebrates/arthropod/Horseshoecrab.shtml

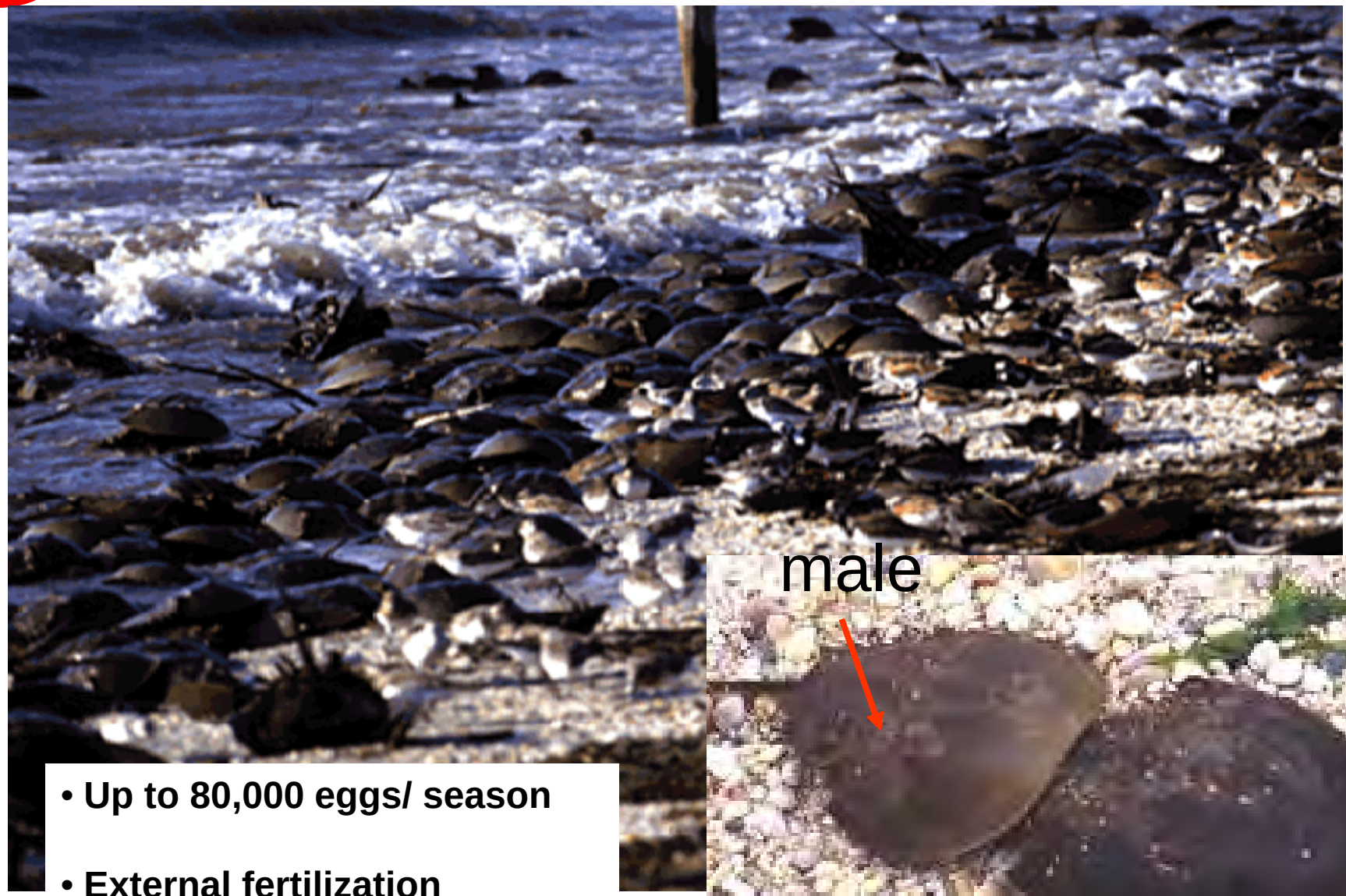
Figure 33.32 (Campbell et al)

Chelicerata: Class Merostomata

- large carapace
- 4 eyes
- Blue blood due to haemocyanin (w/ copper) instead of haemoglobin (w/ iron)

Look similar to extinct subphylum:
Trilobita (extinct in Permian)
but w/ fused and specialized segments

Mating at the shoreline



- **Up to 80,000 eggs/ season**
- **External fertilization**
- **Eggs get buried in the sand**

2. Subphylum Crustacea

lobsters, crayfish, shrimp, barnacles, pillbugs

- Many segments
- 2-3 body regions
- 2 pairs of antennae

- Many appendages (1 per segment) on both thorax and abdomen
  - Modified for sensory, feeding, walking, copulation, swimming…
  - Many are branched (forked)
- Marine and freshwater (a few terrestrial)

Figure 33.29 and 33.38 (Campbell et al)

3A. Subphylum Myriapoda
("many feet")

Unspecialized: many segments, most identical

Class Chilopoda
centipedes

- Flat body (head/trunk)
- Carnivores
- 1 pair legs / segment
- Fangs

3B. Subphylum Myriapoda
("many feet")

Unspecialized: many segments, most identical

Class Diplopoda ("double foot"): millipedes

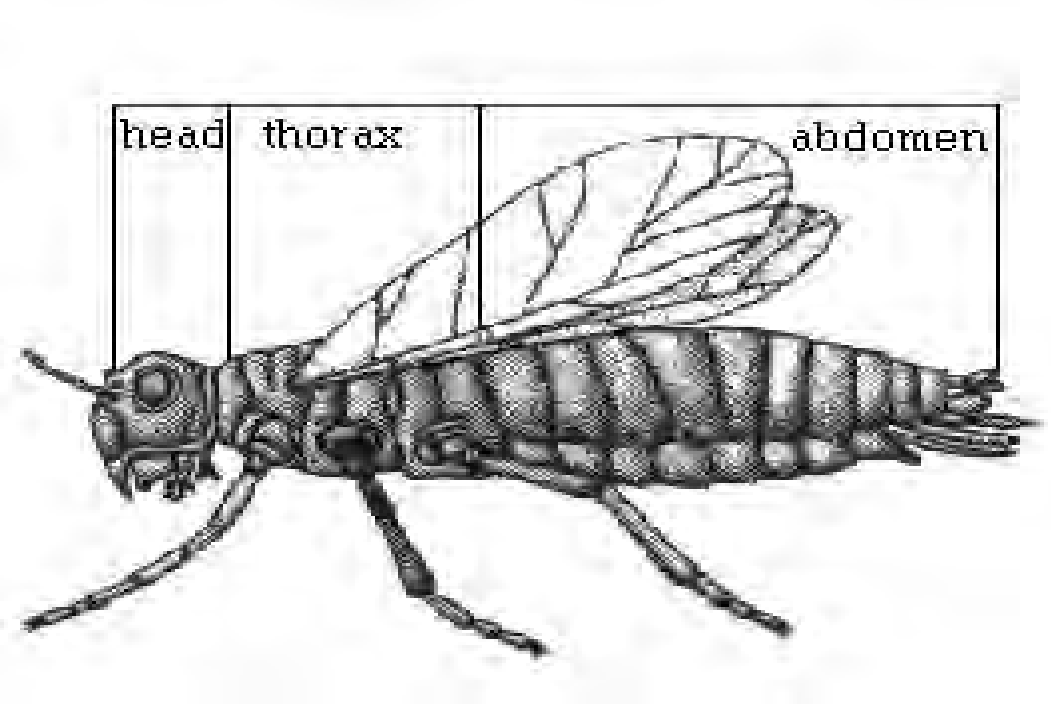
- Rounded body (head/trunk)
- Detritovores
- 2 pairs legs / segment
- Some w/ cyanide on exoskeleton

4. Subphylum Hexapoda

"Six Feet"

Class Insecta + 3 smaller classes

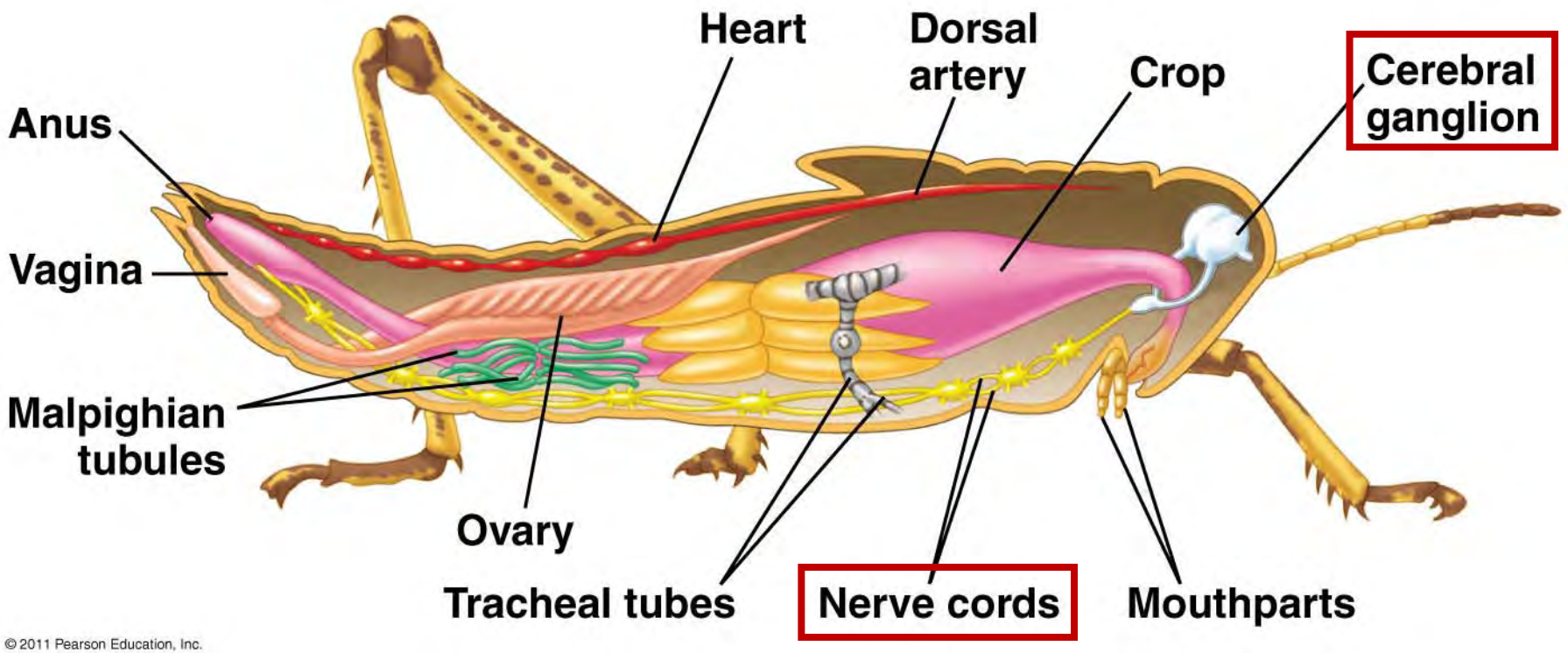
- Mostly terrestrial
- 3 body regions
  a. head
  b. thorax
  c. abdomen
- 3 prs appendages
  <u>all</u> on thorax
- 0-2 pairs of wings
  all on thorax



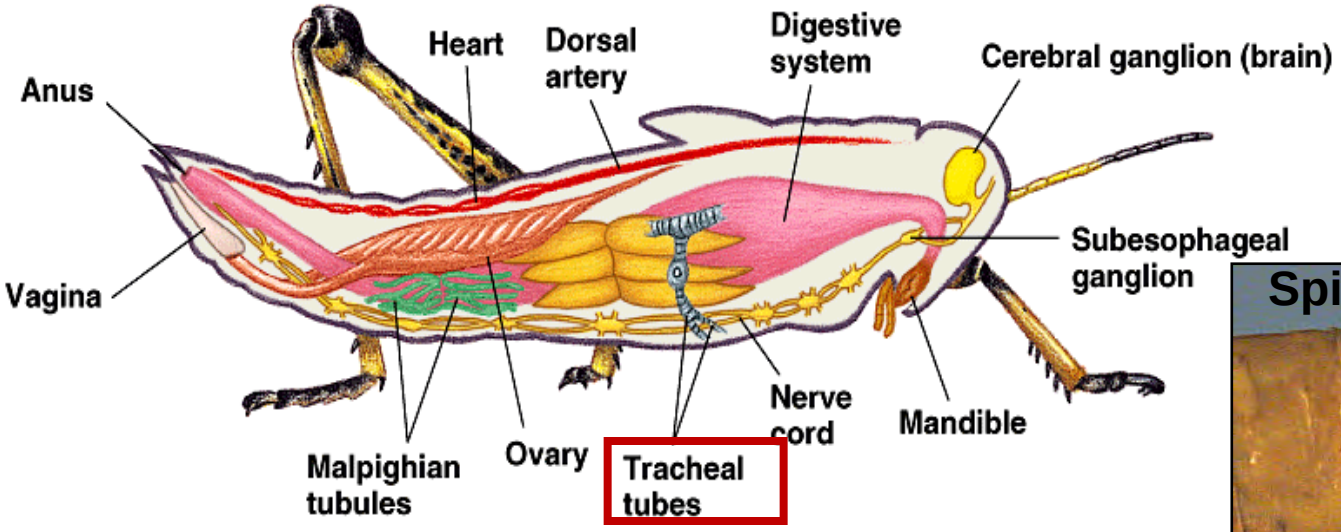
See Figure 33.35 (Campbell et al)

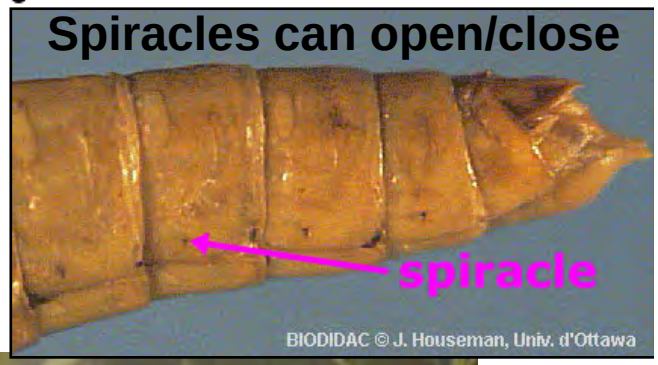
Several complex organ systems

- Circulatory system (will discuss in later chapter)
- Excretory system (will discuss in later chapter)
- Nervous system
  - 2 ventral nerve cords, brain

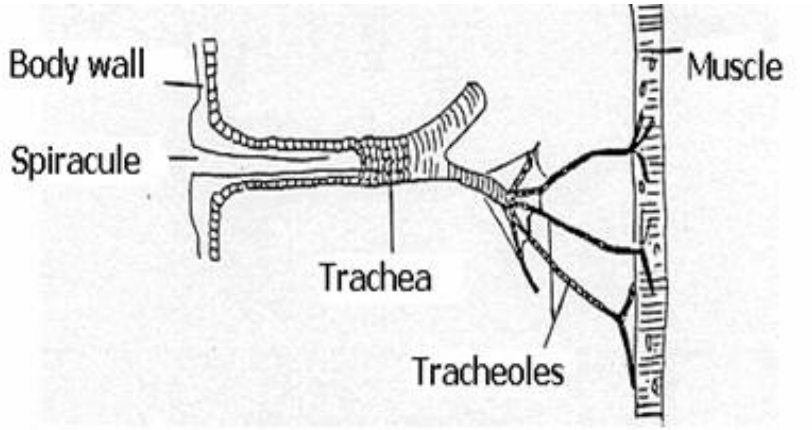


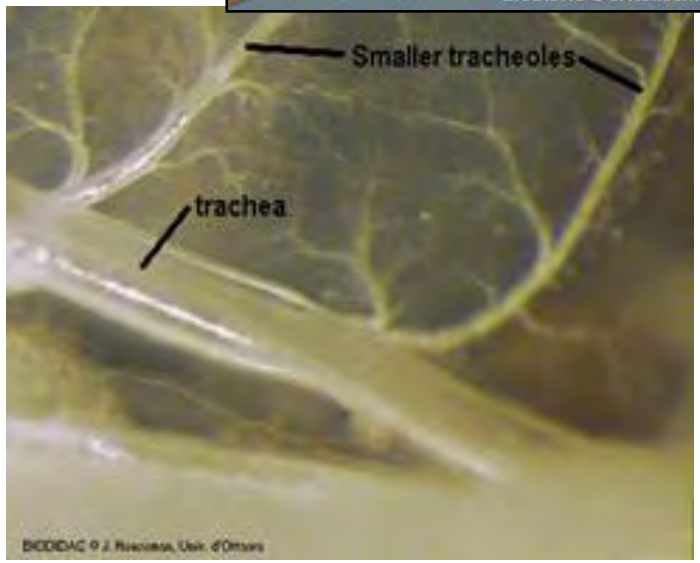
Respiratory system:
spiracles (openings) & tracheae (tubes)





Trachea: branched chitin-lined tubes
take oxygen directly to cells.





Reproduction

- Fertilization internal
- Usually lay undeveloped eggs
  - Some eggs develop internally & hatch upon laying
  - Some develop internally w/o egg

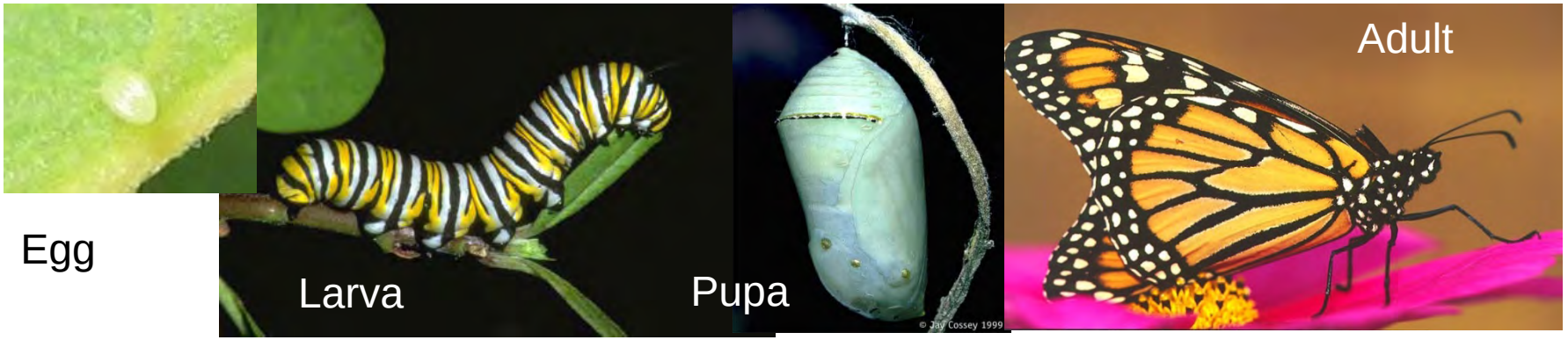
- **2 types of metamorphosis**

A. Incomplete - Younger stages (nymphs) resemble adults.
Final ecydysis (molt): Adult, full size, wings and sexually mature

Usually:
Juveniles= Non-winged
FEEDING STAGE

Adults = winged **DISPERSAL**
& REPRODUCTIVE STAGE

B. Complete - Larval stages completely different in form from adult:

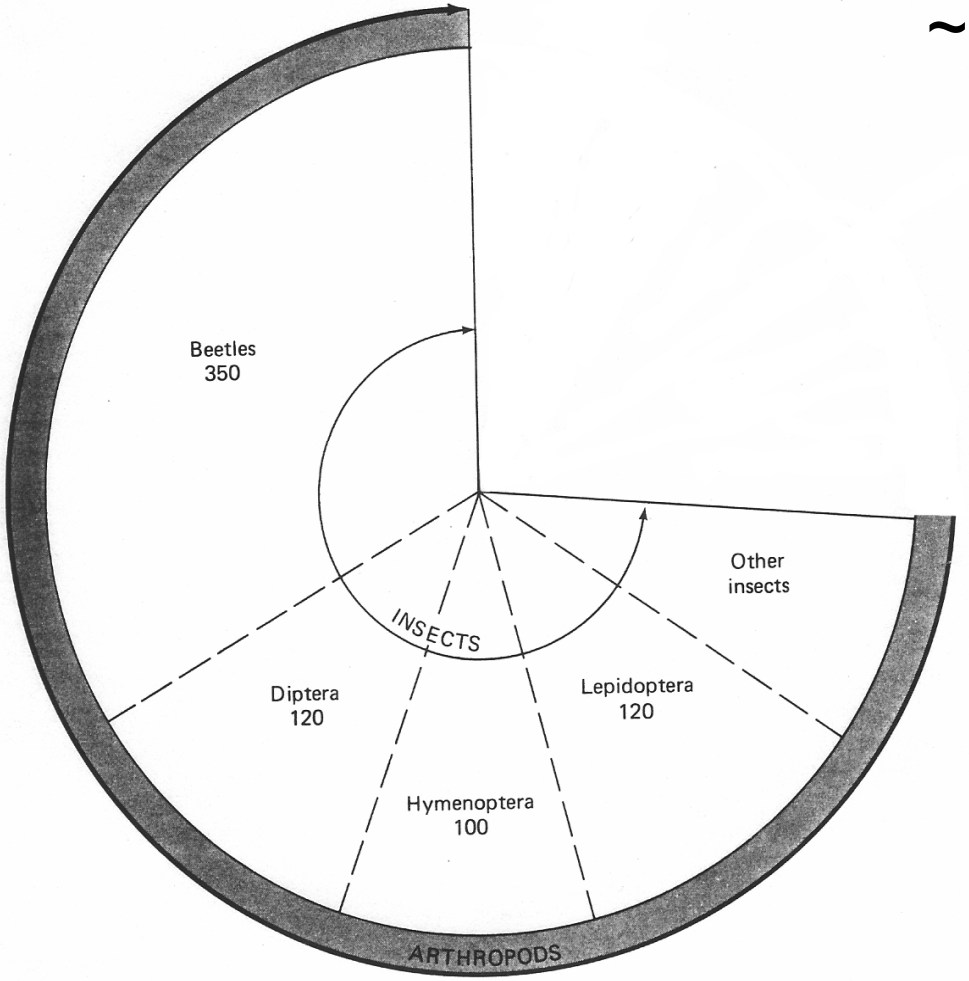


Insect Phylogeny

~ 1 million described species

> 74% of animal species / ~20% of all species

•Estimated to be ~6-10 million species



~30 orders of insects

- Coleoptera (Beetles) (~35%)
- Flies (Diptera)(~10%)
- Butterflies, moths (Lepidoptera) (~10%)
- Bees, ants, wasps (Hymonoptera) (~10%)
- Stink bugs, bed bugs, etc (Hemiptera) (~8%)
- Grasshoppers, crickets, etc. (Orthoptera) (~1%)

Beetles are largest subclass (~30% of all animal spp)

4 General Mouth part Types

Allow for a variety of types of feeding strategies

Sucking

e.g. butterflies

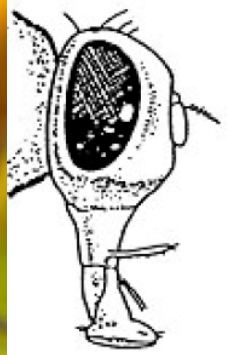
Chewing

e.g. ants,
grasshoppers,
beetles,

Piercing/ sucking

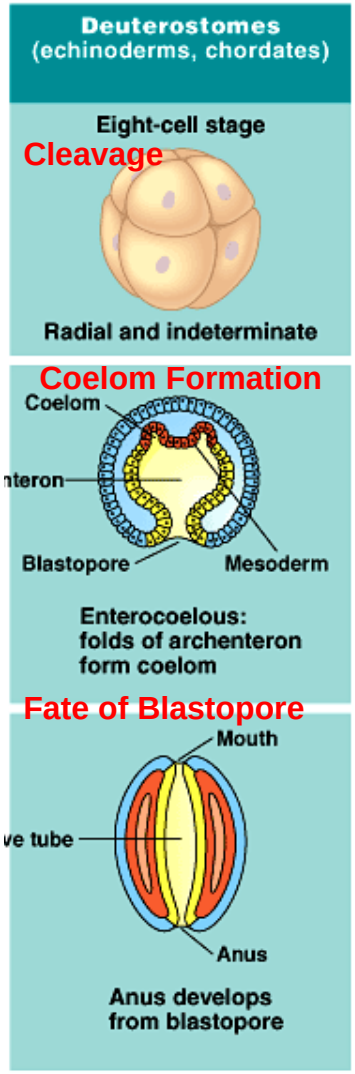
e.g. aphids, mosquitoes

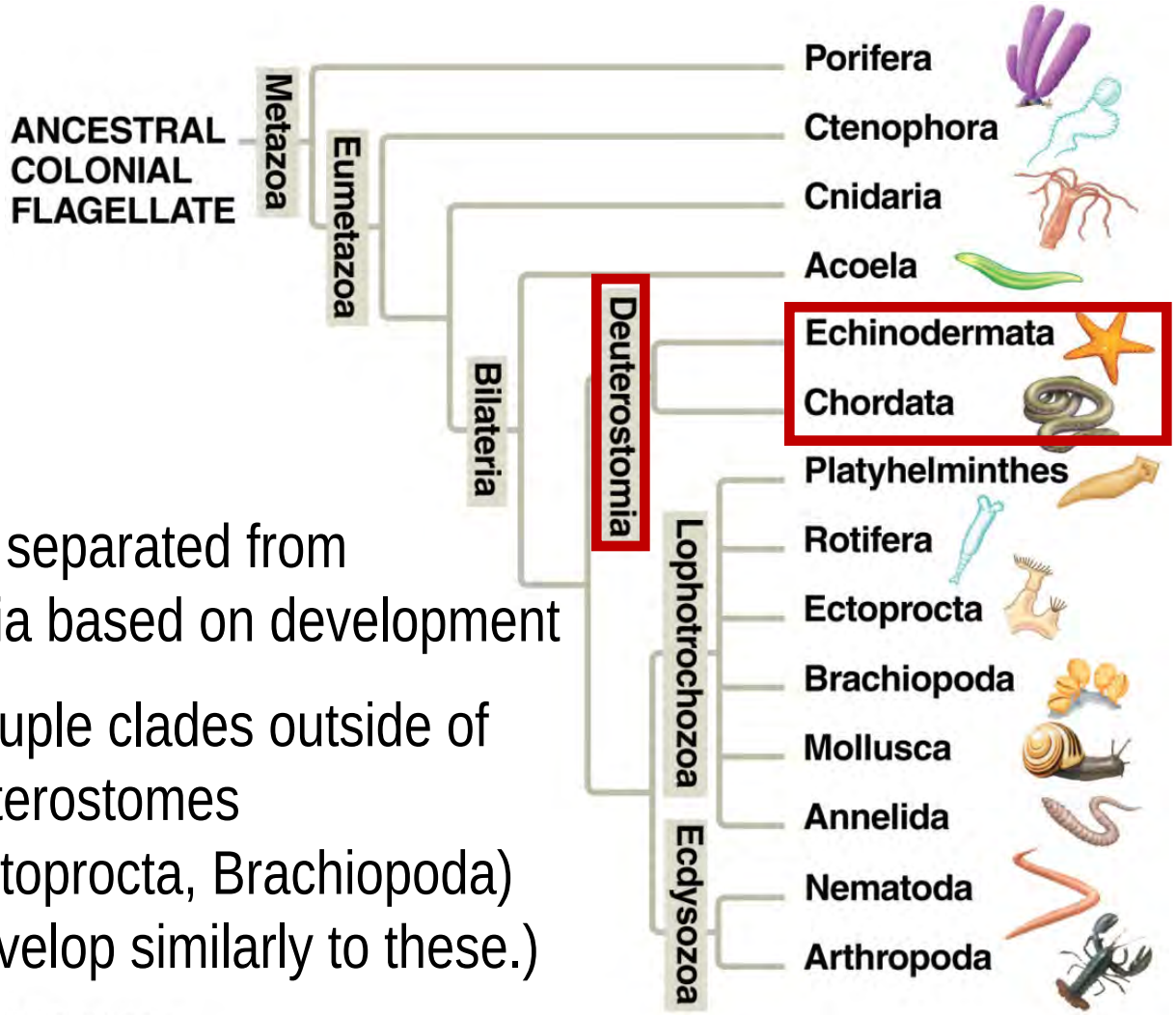
Absorbent



e.g. Flies

Deuterostomes





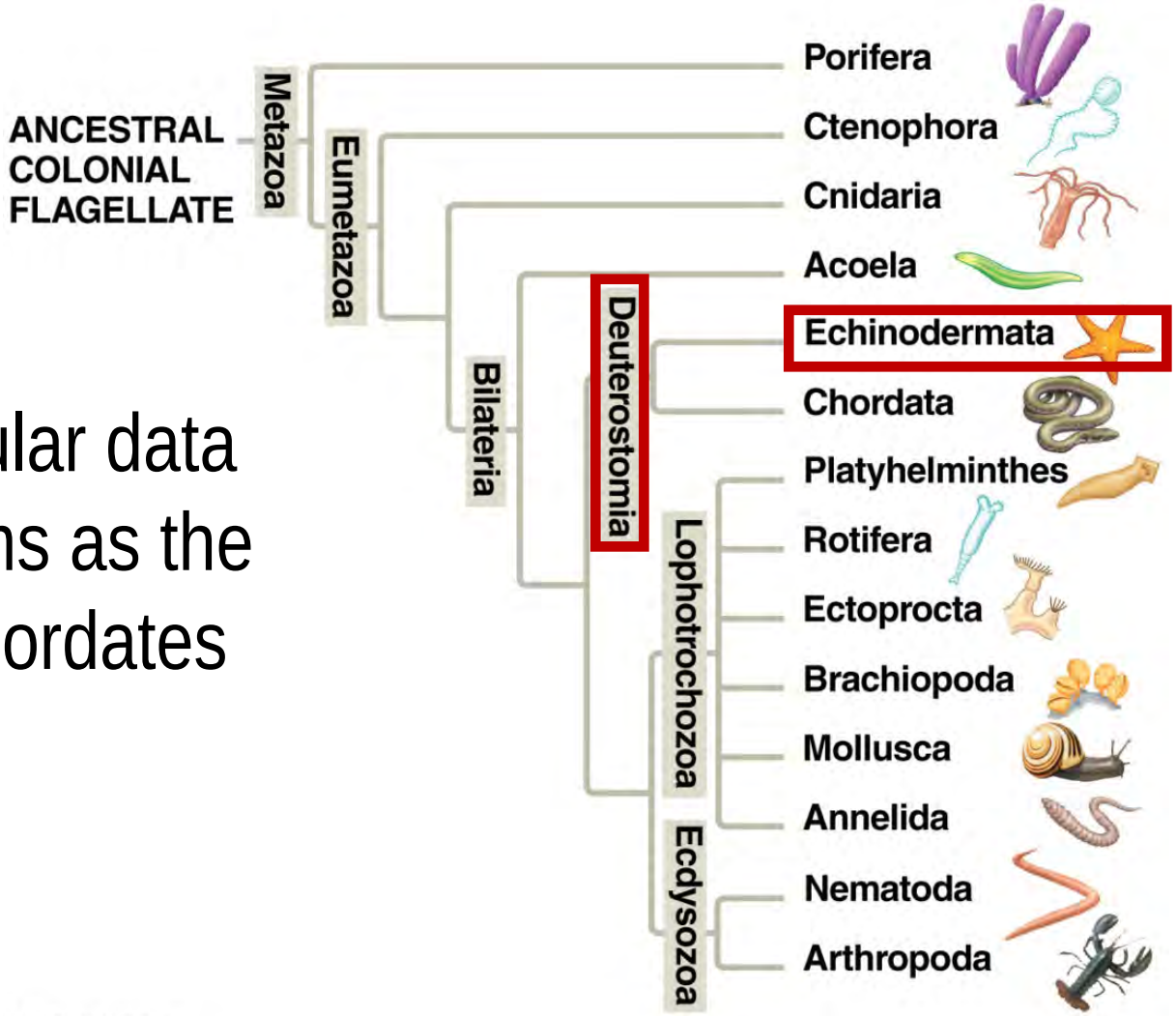
- Traditionally separated from other Bilateria based on development
  - But a couple clades outside of the Deuterostomes (e.g. Ectoprocta, Brachiopoda) develop similarly to these.)
- Thus, Deuterostome monphyly now based primarily on DNA similarities not development

Figures 32.10 and 32.11 (Campbell et al.)

Phylum: Echinodermata

Sea urchins, sand dollars, sea stars, brittle stars, sea cucumbers and crinoids

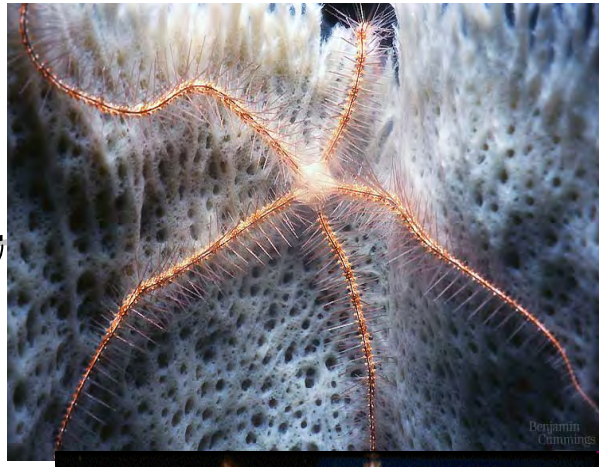
Abundant molecular data places echinoderms as the sister taxon to Chordates



Figures 32.10 and 32.11 (Campbell et al.)

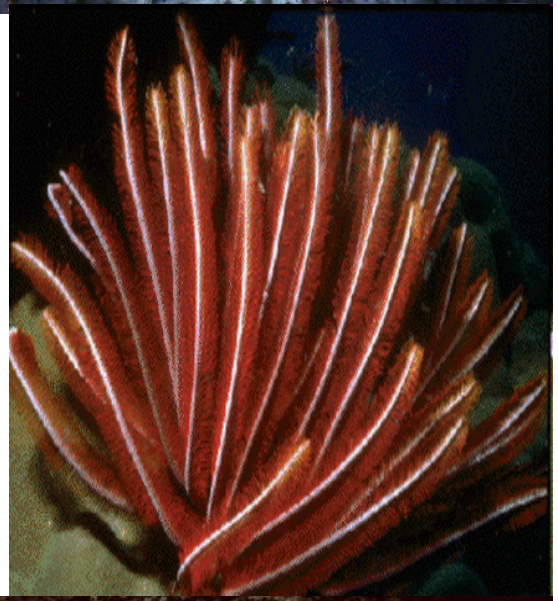
Phylum Echinodermata

spiny skin



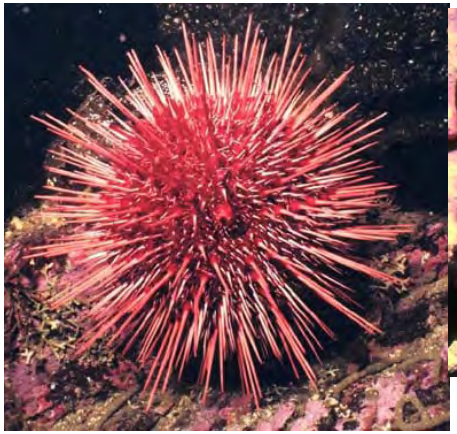
Defining features:

- Marine
- Slow, mobile, bottom dwellers
- Not cephalized
- Endoskeleton of $CaCO_3$ plates
- Water vascular system (tube feet)
- Unisexual w/ external fertilization



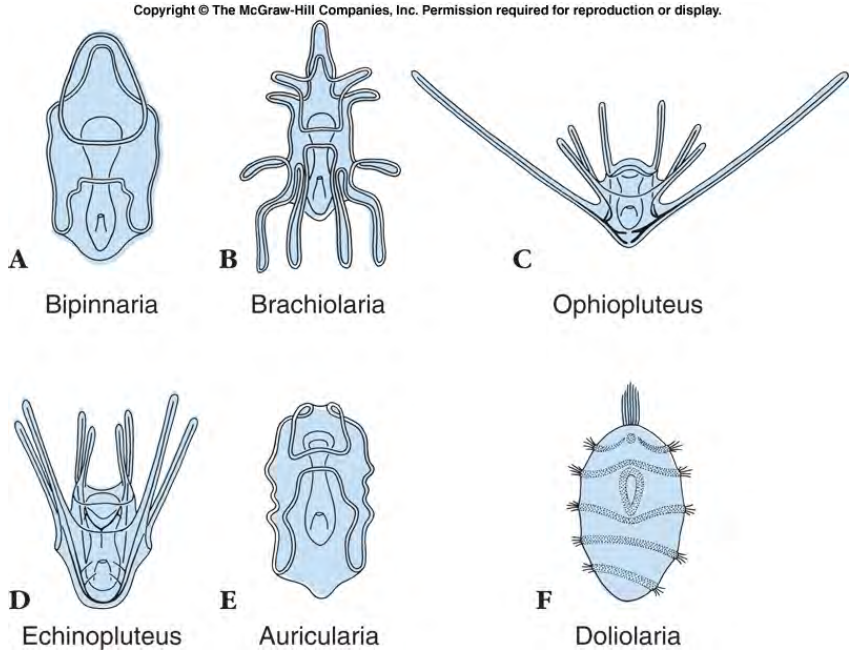
Phylum Echinodermata

Most of the adults have radial symmetry (or close to)…




So why in Bilateria?

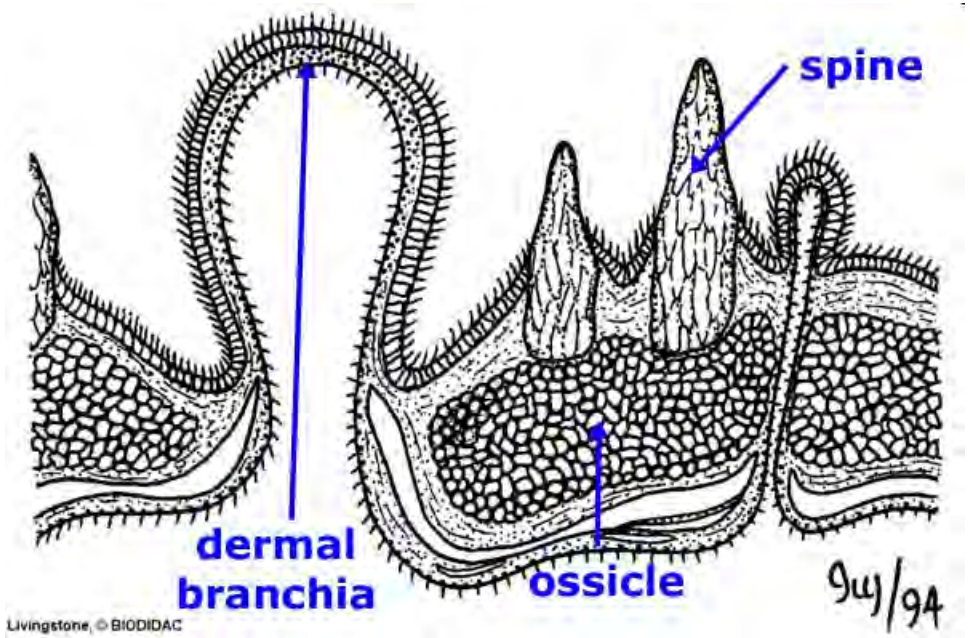
LARVAE
have bilateral
symmetry

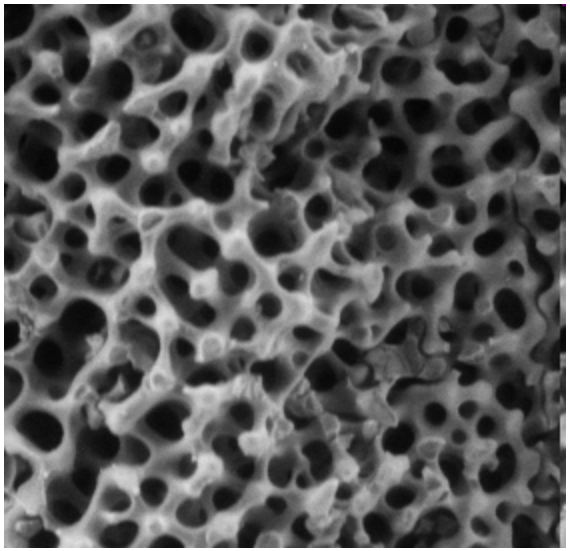


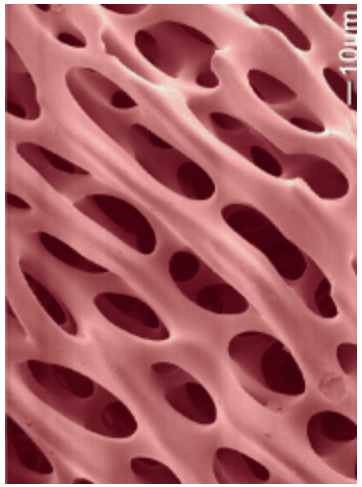
Skeletal support system

- $CaCO_3$ plates *(ossicles)* under a layer of epidermis (i.e. endoskeleton)

- Most w/ spines







Ossicles

A. Separate

- connected by
  - muscle or
  - ligaments

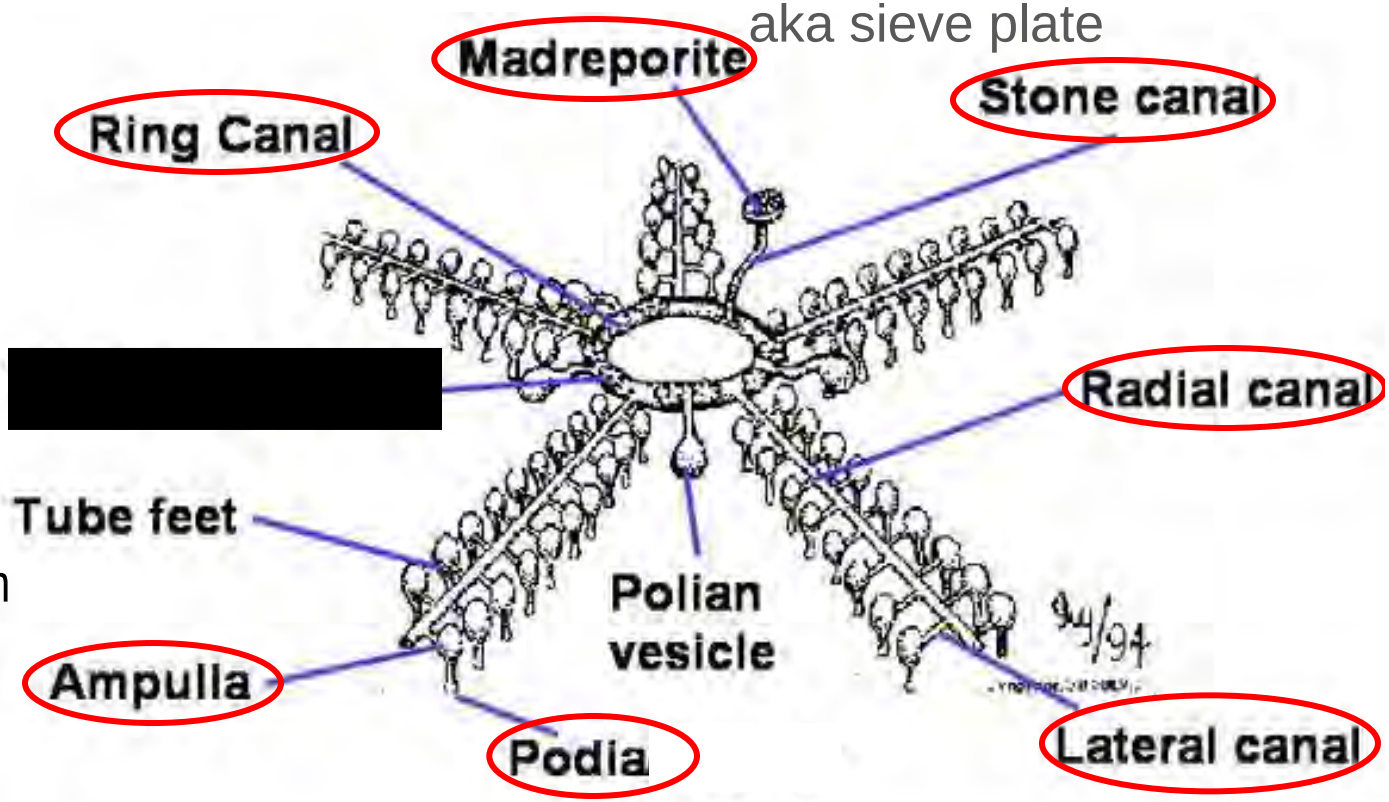
OR

B. Fused

- aka “*test*” *in urchins*

Water Vascular System

aka sieve plate



1. Madreoporite - Water enters or leaves system
2. Stone canal – connects 1 to 3
3. Ring canal
4. Radial Canal
5. Lateral canal
6. Tube foot
   A. Ampula
   B. Podium (podia)

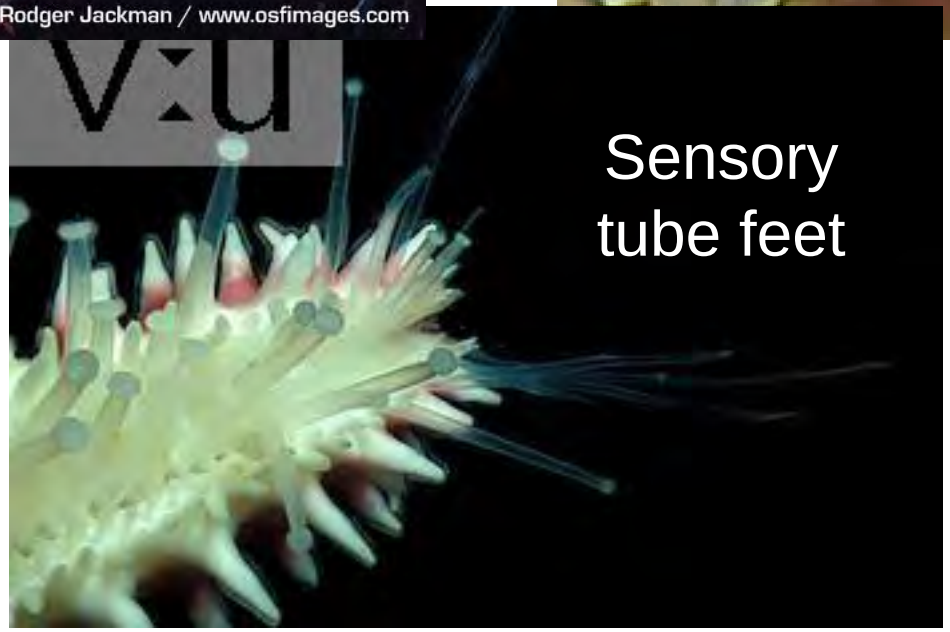
Functions of water vascular system

Locomotion, sensory, feeding, respiration, food & waste transport, excretion

Figure 33.39 (Campbell et al)

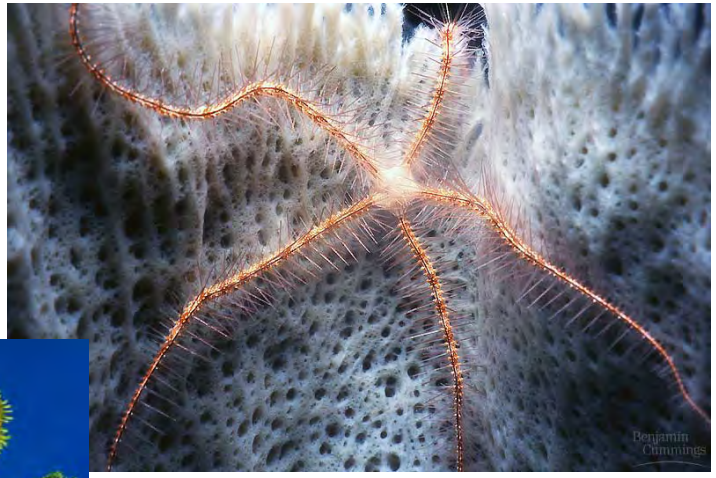
Tube Feet

No suckers – move by applying a cement which can be biochemically reversed as it moves



1. Asteroidea

3. Crinoidea



2. Ophiuroidea

Echinoderm

Diversity

5 Major Classes
+ a few others
= ~7000 spp

4. Echinoidea

5. Holothuroidea

1. Class Asteroidea:

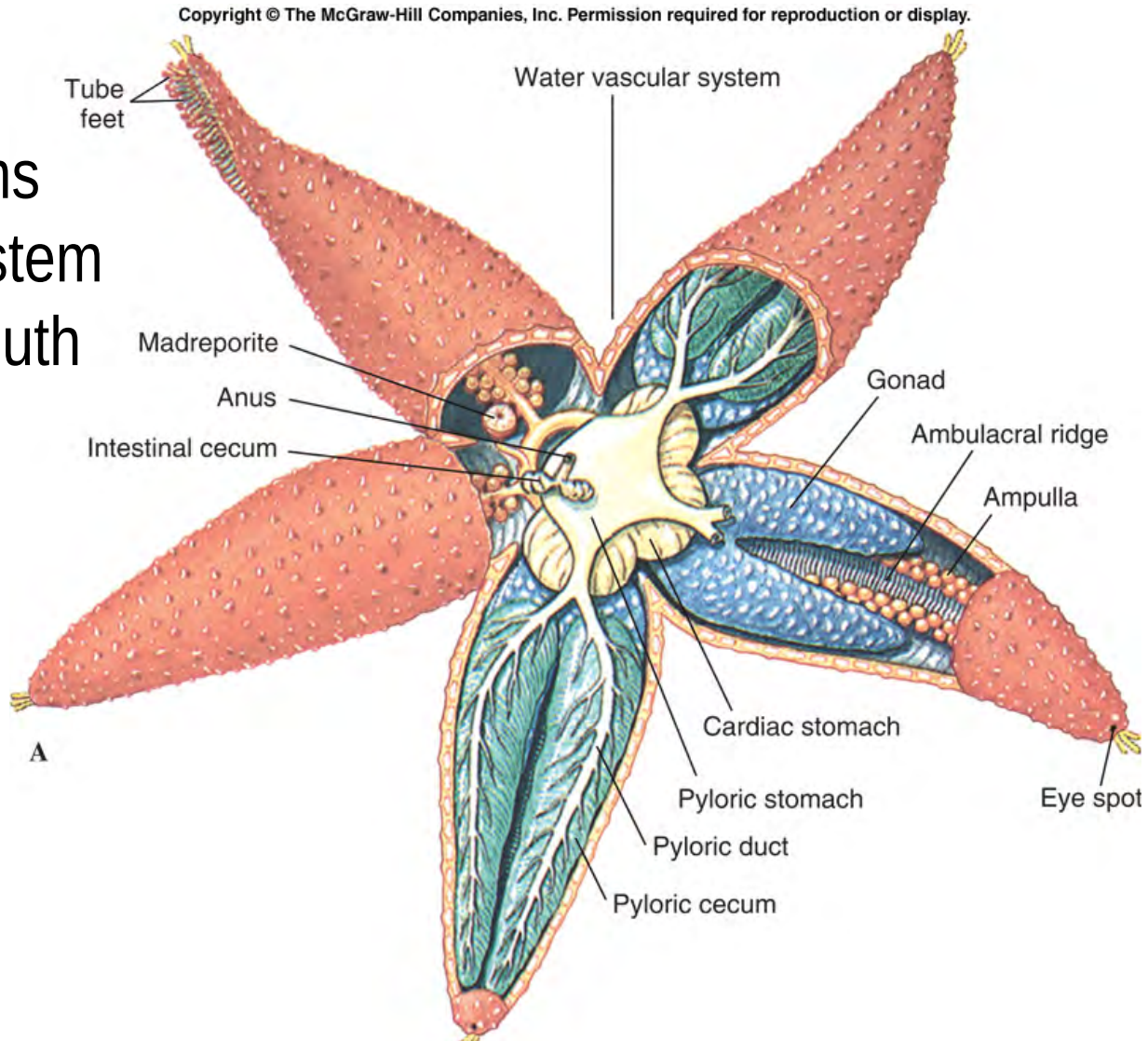
sea stars

"star-like"

- Large central disk
- Thick arms (usually 5)

1. Class Asteroidea

- Organs in disk and arms
- Complete digestive system
  - Downward facing mouth
  - Upward facing anus & madreporite



http://www.biog1105-1106.org/labs/deuts/media/echinowatervasc.jpg

1. Class Asteroidea

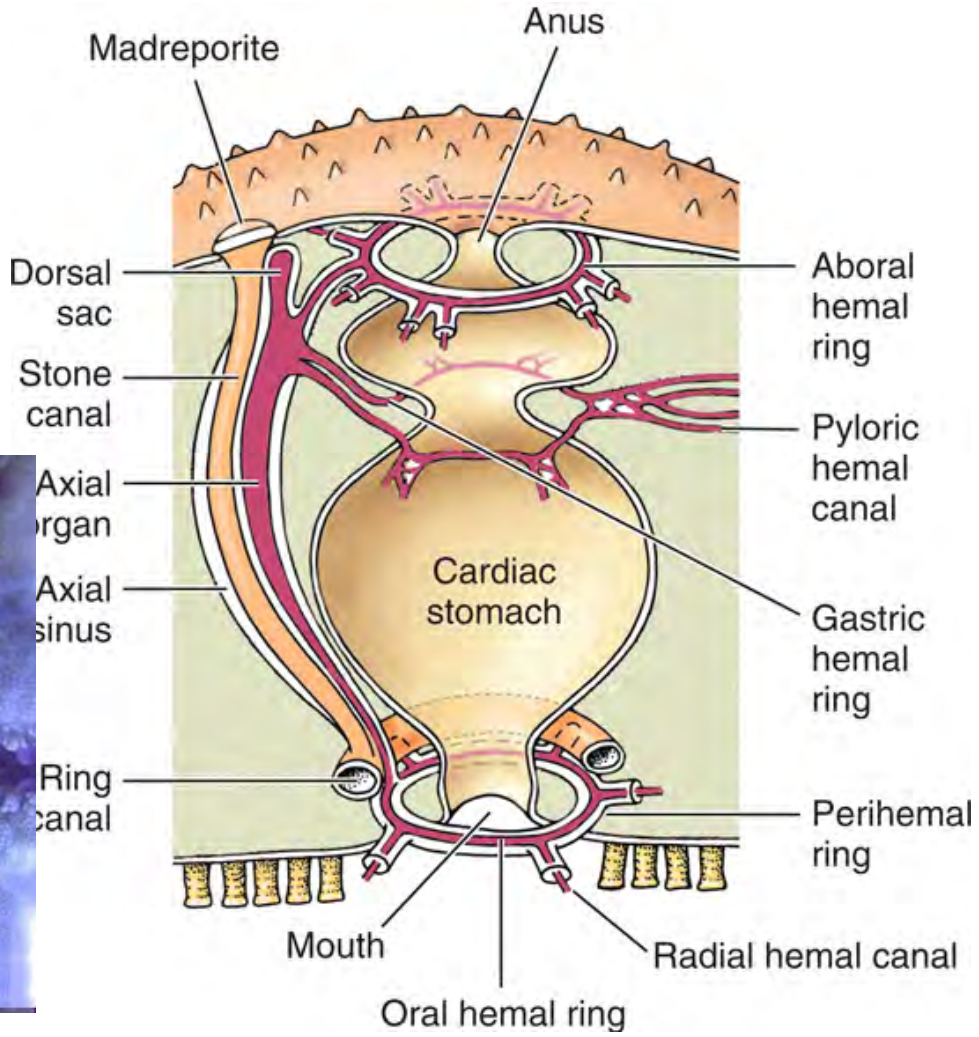
Feeding:

- Active predators

1. Class Asteroidea

Feeding:

- Some e*vert stomach* onto or into prey
  e.g. into a bivalve



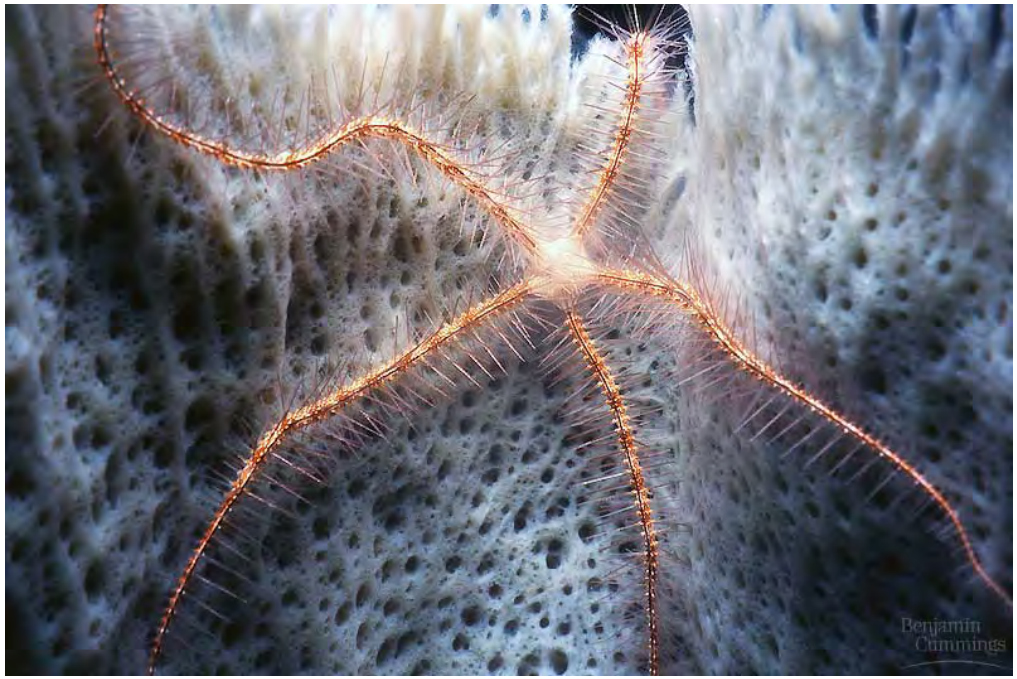
http://www.youtube.com/watch?v=HG17TsgV_qI&feature=player_embedded

2. Class Ophiuroidea:

brittle stars

"snake-like"

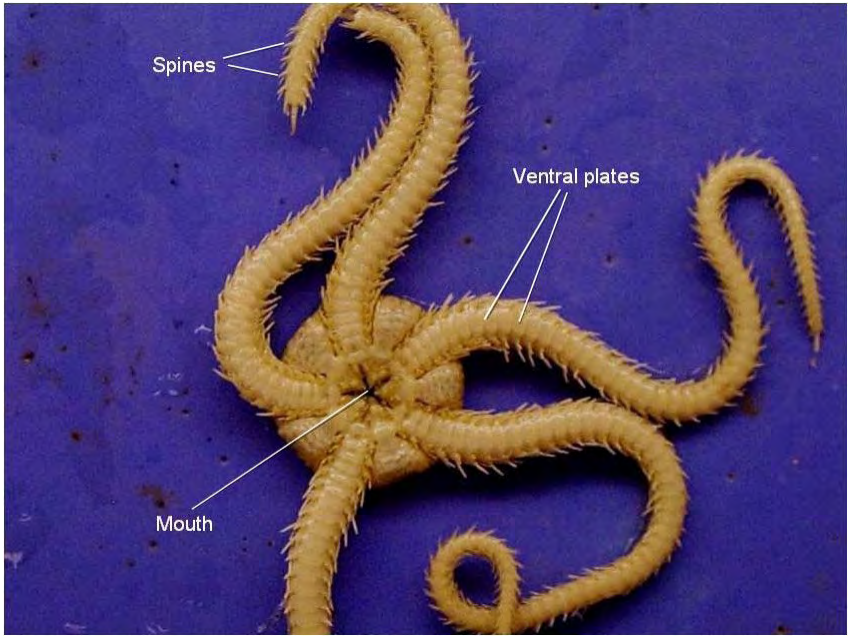
- Small central disk
- Thin, fragile arms
- Organs NOT in arms

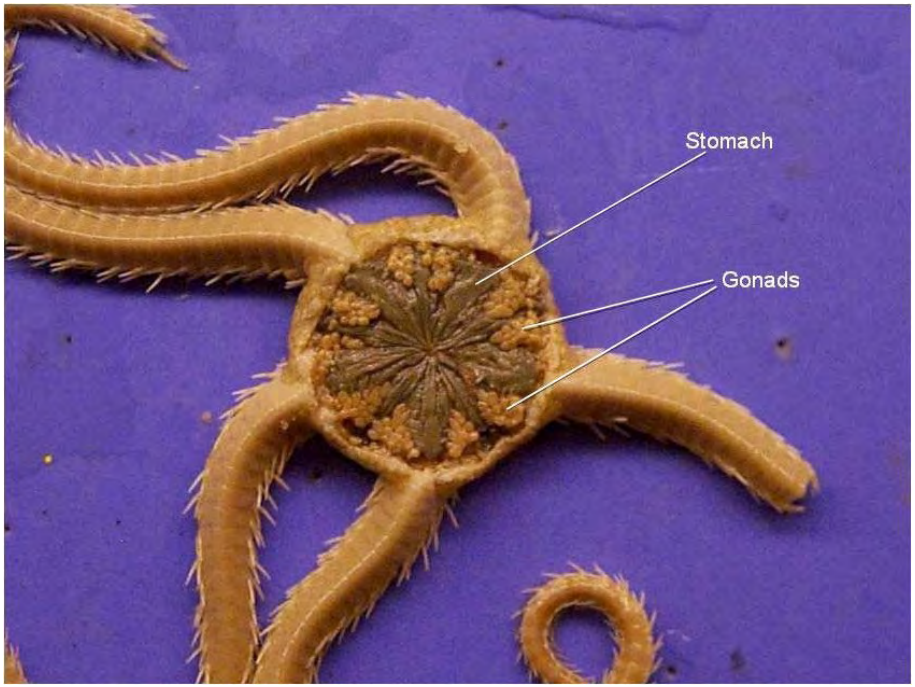


- Incomplete digestive system
  (i.e. No separate anus (mouth=anus))
- Madreporite on bottom side near mouth/anus
- Suspension feeders, predators, & scavengers

2. Class Ophiuroidea:

brittle stars





- Organs NOT in arms

3. Class Crinoidea:

sea liles & feather stars

"lily-like"

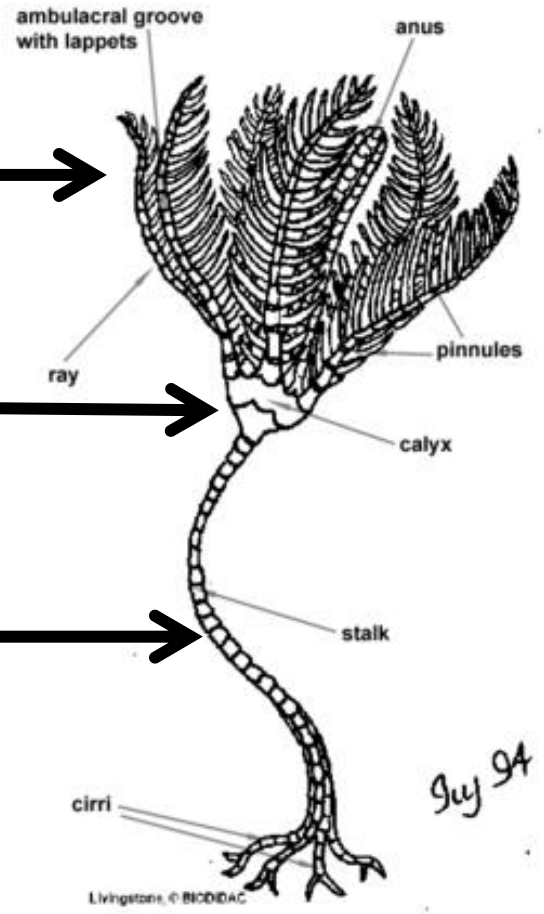
- Feather-like arms used for feeding
- Complete digestive system
  w/ upward-facing mouth and anus

All are suspension feeders (eat plankton)

3. Class Crinoidea:

sea liles & feather stars

- Arms (many)
  - w/ tube feet, feeding groove & cilia
- Calyx
  - organs, mouth, anus
- Stalk
  - sometimes muscular

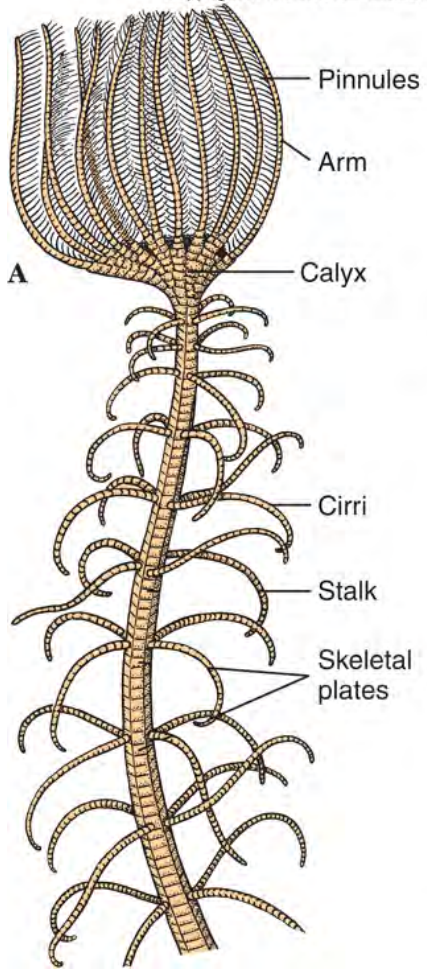


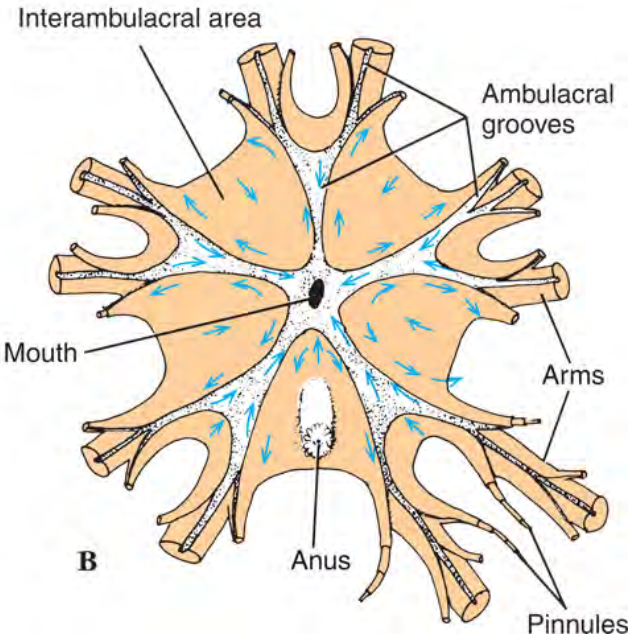
http://animaldiversity.ummz.umich.edu/site/resources/biodidac/crin001.gif/medium.jpg

3. Class Crinoidea

Feeding

- Arms w/ tube feet
- Mucous secretion
- Move food to feeding grooves
- Cilia pass to mouth





4. Class Echinoidea:

sea urchins & sand dollars

"spine-like"

- No arms
- Complete digestive system
  w/ downward-facing mouth and upward-facing anus
- Ossicles fused into a "test"

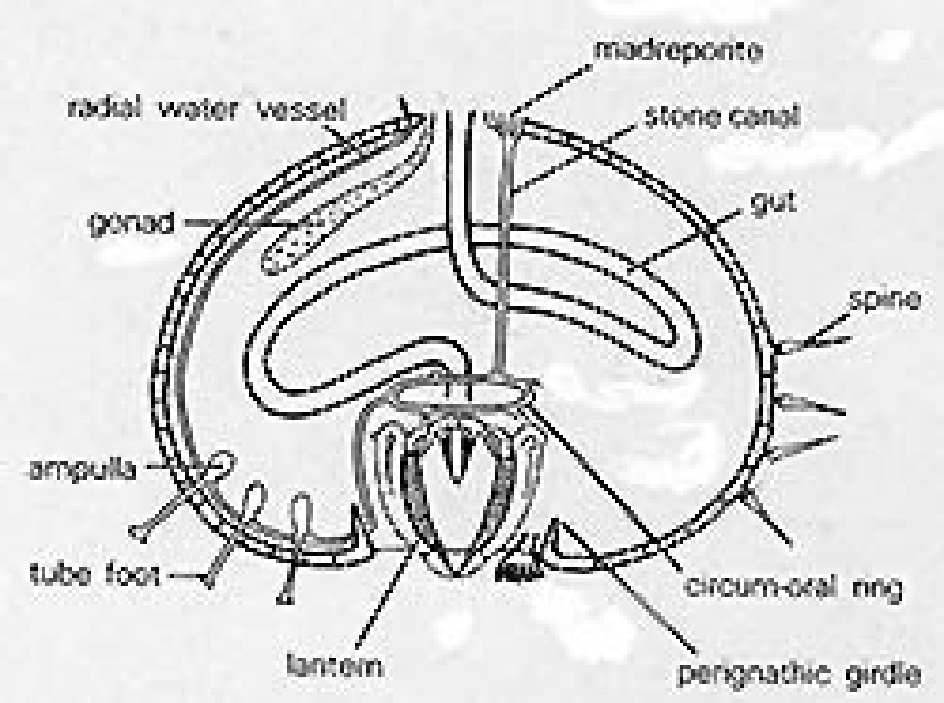
Herbivore

Substrate feeder

4. Class Echinoidea:

sea urchins & sand dollars

- In urchins tube feet stick out between spines

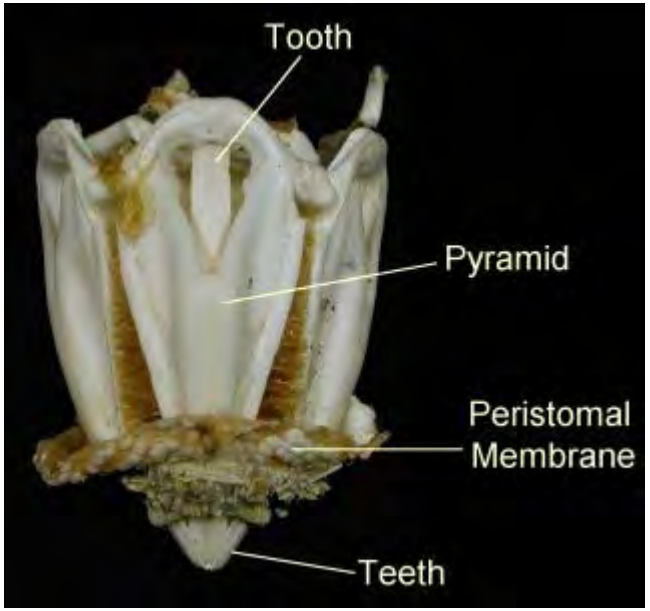


4. Class Echinoidea:

sea urchins & sand dollars

- Mouth surrounded by specialized feeding apparatus known as "Aristotle's lantern"
- Has 5 teeth (replaced regularly)

http://virtual.yosemite.cc.ca.us/randerson/Marine%20Invertebrates/Aristotle%27s%20lantern.jpg



http://www.chalk.discoveringfossils.co.uk/images/LanternBooth.jpg

5. Class Holothuroidea:

sea cucumbers

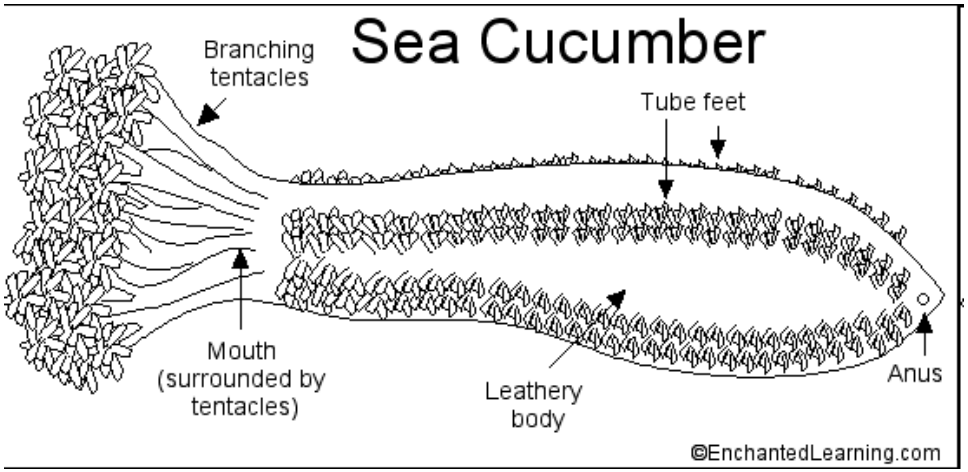
"whole, worm-like"

- No arms
- No spines
- Microscopic ossicles

5. Class Holothuroidea:

Feeding

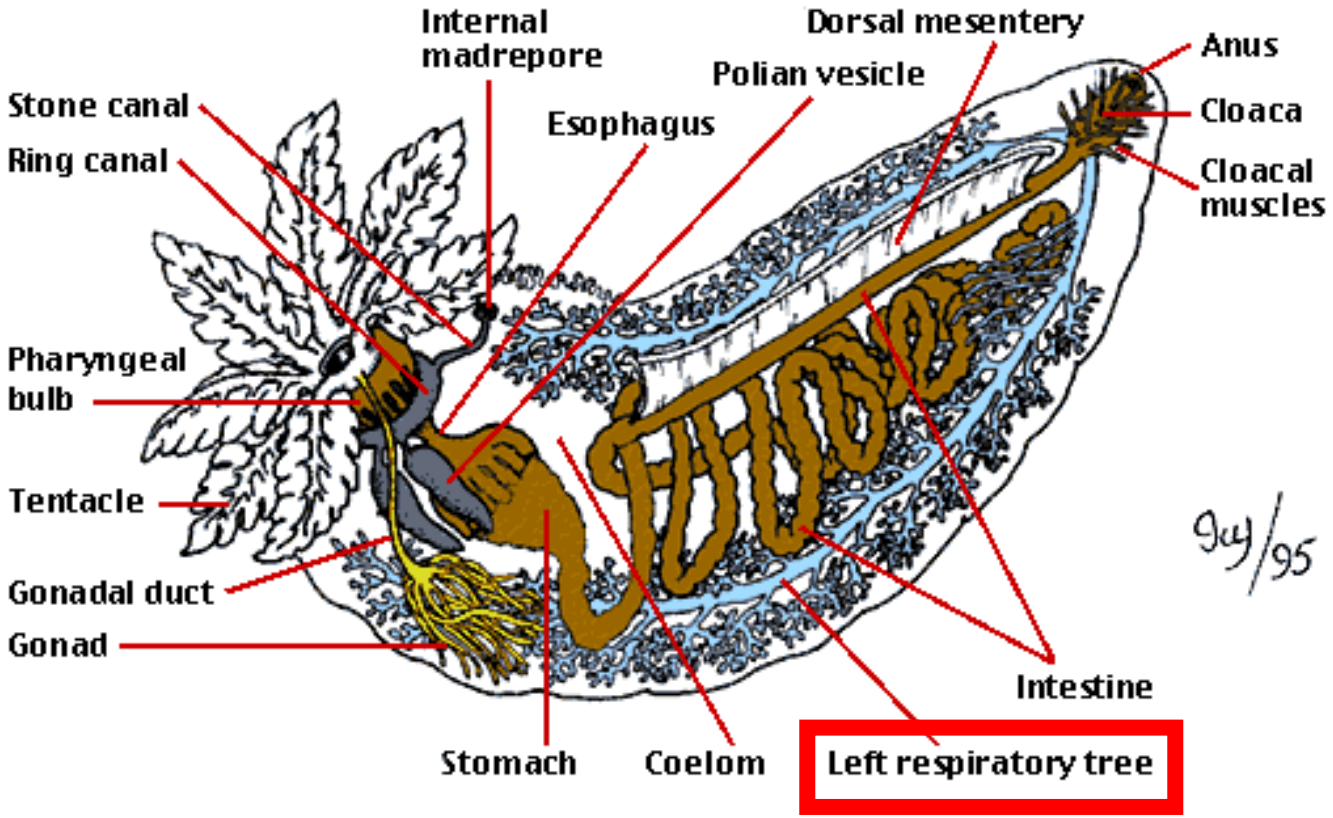
- Complete digestive system
- Imobile
- Suspension feeders / substrate feeders
- Mouth surrounded by tentacles (special tube feet)
    - insert into mouth to remove food



5. Class Holothuroidea:

Respiration

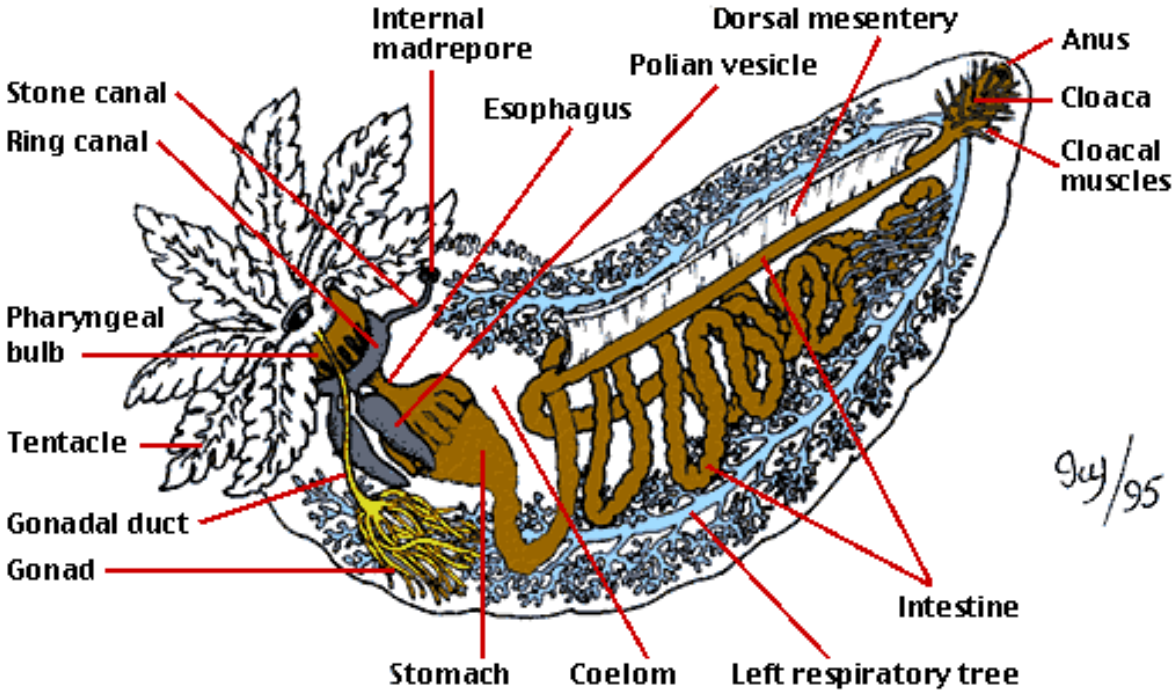
- Breathe through Anus!
- Large internal respiratory trees that branch off anus



5. Class Holothuroidea:

Defense

Some sea cucumbers spp defend themselves by expelling parts of their respiratory tree to entangle potential predators (some also expel a toxin)



http://www.youtube.com/watch?v=aCxKFc3XtJs

Readings on which you will NOT be tested

- Figure 33.3 – You only need to know the groups discussed in class
- Figure 33.8
- Trematodes and Figure 33.11
- Rotifers
- Brachiopods
- Figure 33.22 – Impact (Though worth a quick read!)
- Figure 33.29 – Inquiry
- Details of Circulatory systems in any of the groups (Is in later chapter)
- Details of Excretory systems in any of the groups (Is in later chapter)

In general:

  - You are NOT responsible for definitions of terms or sections included in the text but which were not discussed in lecture
  - You are not responsible for the details of examples used in the text but not discussed in lecture. HOWEVER, these additional examples will help your understanding of concepts discussed and may be used on exams to test if you understand the general concepts.
  - You ARE responsible for material covered in lecture but not included in the readings

Next Chapter

Chapter 34 – The Origin and Evolution of Vertebrates