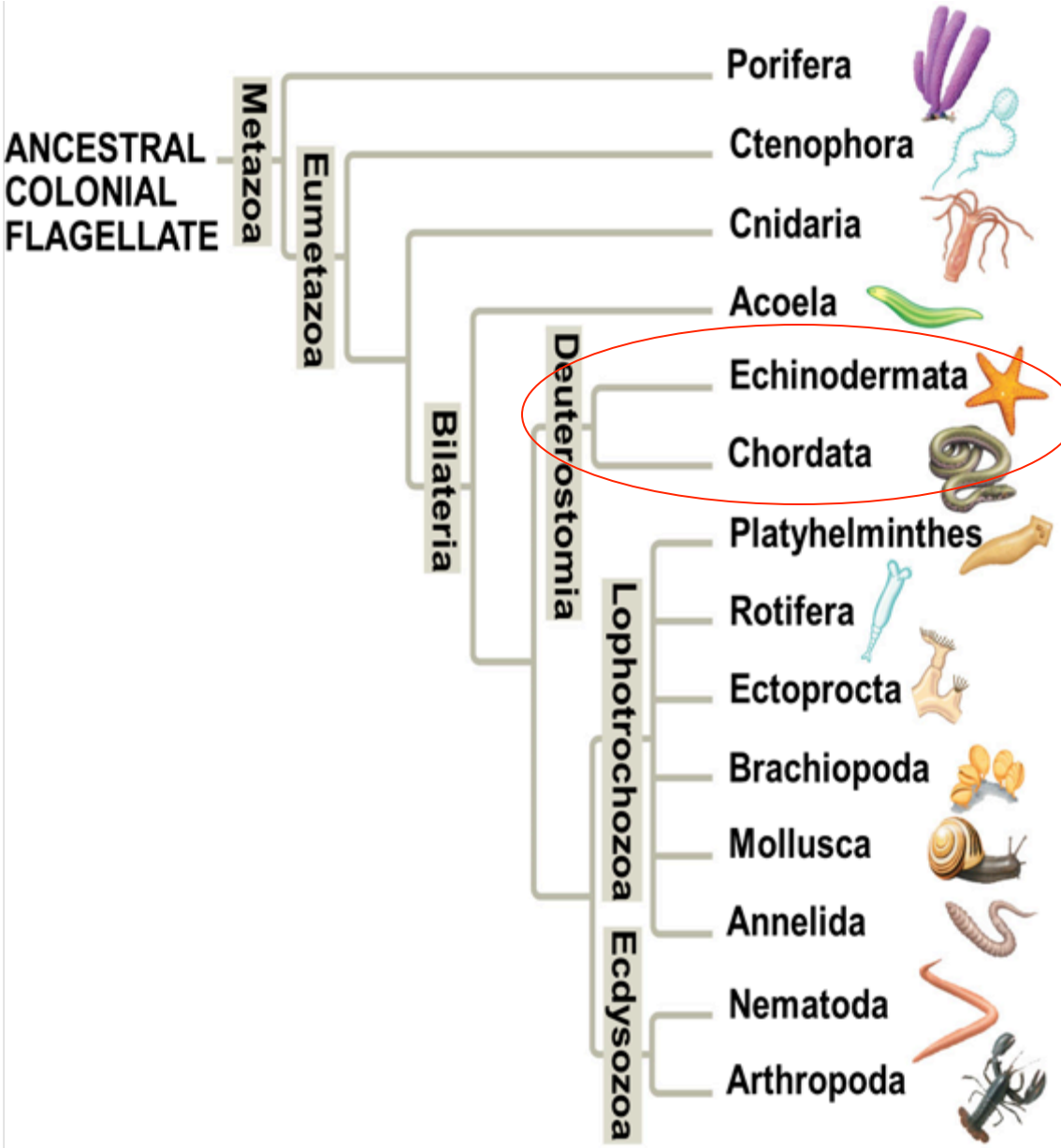
Phyla Echinodermata and Chordata

Deuterostomes!

- Echinoderms and chordates constitute the clade Deuterostomia
- Echinoderms (phylum Echinodermata) include sea stars and sea urchins
- Chordates (phylum Chordata) include the vertebrates



Deuterostome Review

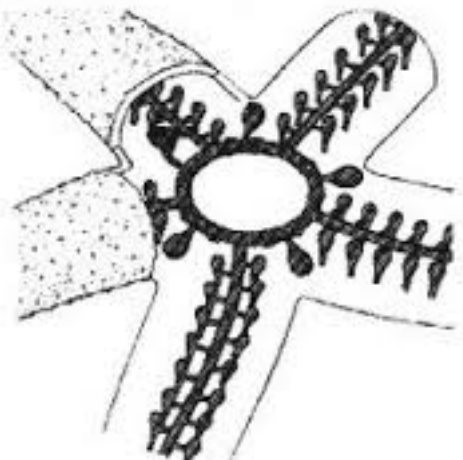
- Deuterostomes share developmental characteristics
  - Radial cleavage
  - Formation of the anus from the blastopore
- Important note
  - Deuterostomes are grouped together primarily on the basis of genomic similarities

Phylum Echinodermata – General Features

- "Spiny skin"; slow-moving or sessile
  - No ability to osmoregulate → exclusively marine
  - Not segmented; no cephalization
- **Symmetry**
  - Bilateral as larvae (defines the group as bilateralians)
  - Radial as adult – body units in multiples of 5 (pentaradial)
- **Skeleton**: **endoskeleton** covered by a thin epidermis

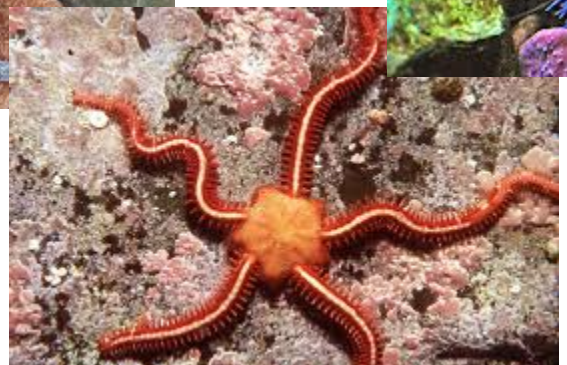
Phylum Echinodermata – General Features cont'd

- **Water-vascular system**
  - Derived from coelom; functions in locomotion, feeding, respiration and excretion
- **Papullae** (skin gills or dermal branchiae)
- **Pedicellariae** (dermal spines)
  - Surface structure with tiny, pincerlike jaws
  - Sometimes born on stalks
  - Various functions, protect papullae, remove debris from body surface, collect food



Echinoderm Taxonomy

- Extant echinoderms are divided into **five classes**
  - **Asteroidea** (sea stars and sea daisies)
  - **Ophiuroidea** (brittle stars)
  - **Echinoidea** (sea urchins and sand dollars)
  - **Crinoidea** (sea lilies and feather stars)
  - **Holothuroidea** (sea cucumbers)



Class Asteroidea: Sea Stars

- Morphology
  - Multiple arms radiating from a central disk
  - Undersurface of each arm bears tube feet, which grip substrate with adhesive chemicals
  - Stomach is on ventral (oral) surface
  - Lost arms can regenerate
- Sea star feeding behavior
  - Feed largely on bivalves by prying open with tube feet
  - Everts stomach
  - Digestion is largely external

Class Asteroidea – water vascular system

- Separate coelomic compartment unique to echinoderms
- System of canals, **tube feet**, and dermal ossicles
- Functions in locomotion, feeding, respiration, excretion
- Opens to outside at **madreporite** on **aboral** side
- Madreporite leads to **stone canal**, which joins **ring canal** that encircles the mouth

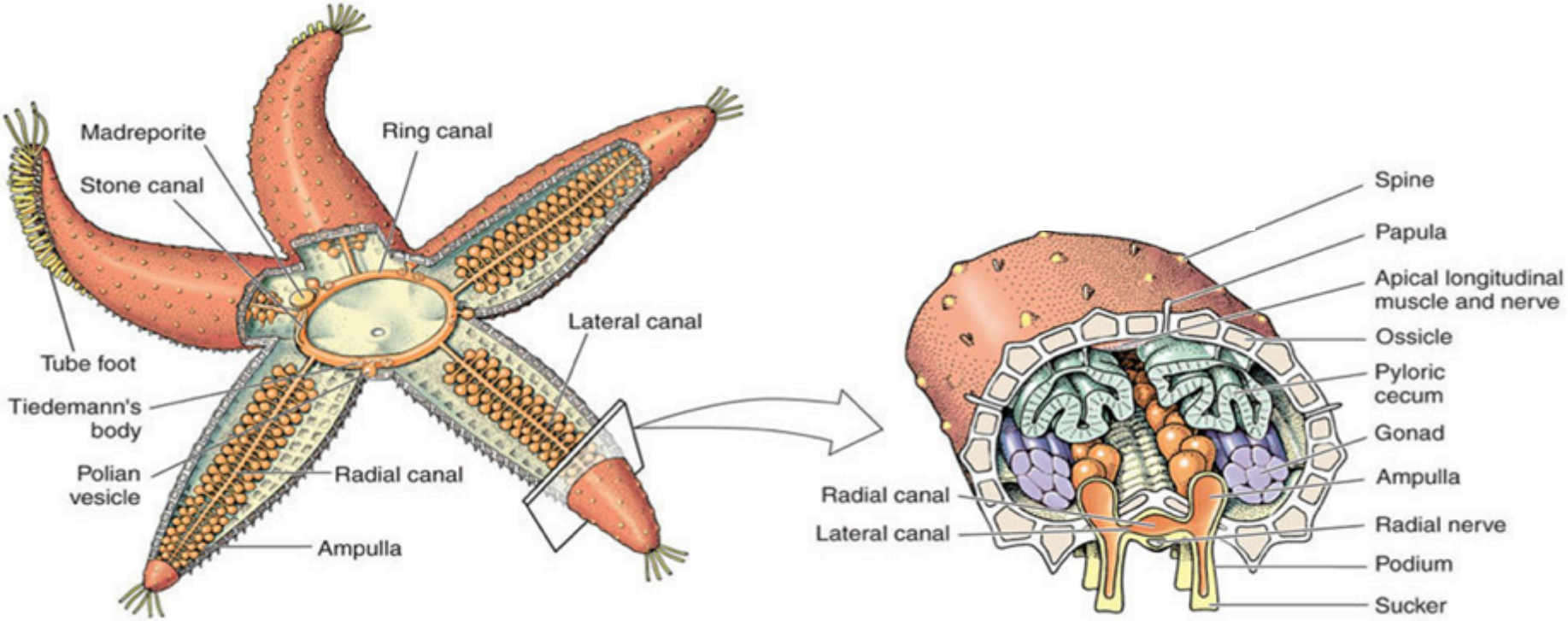
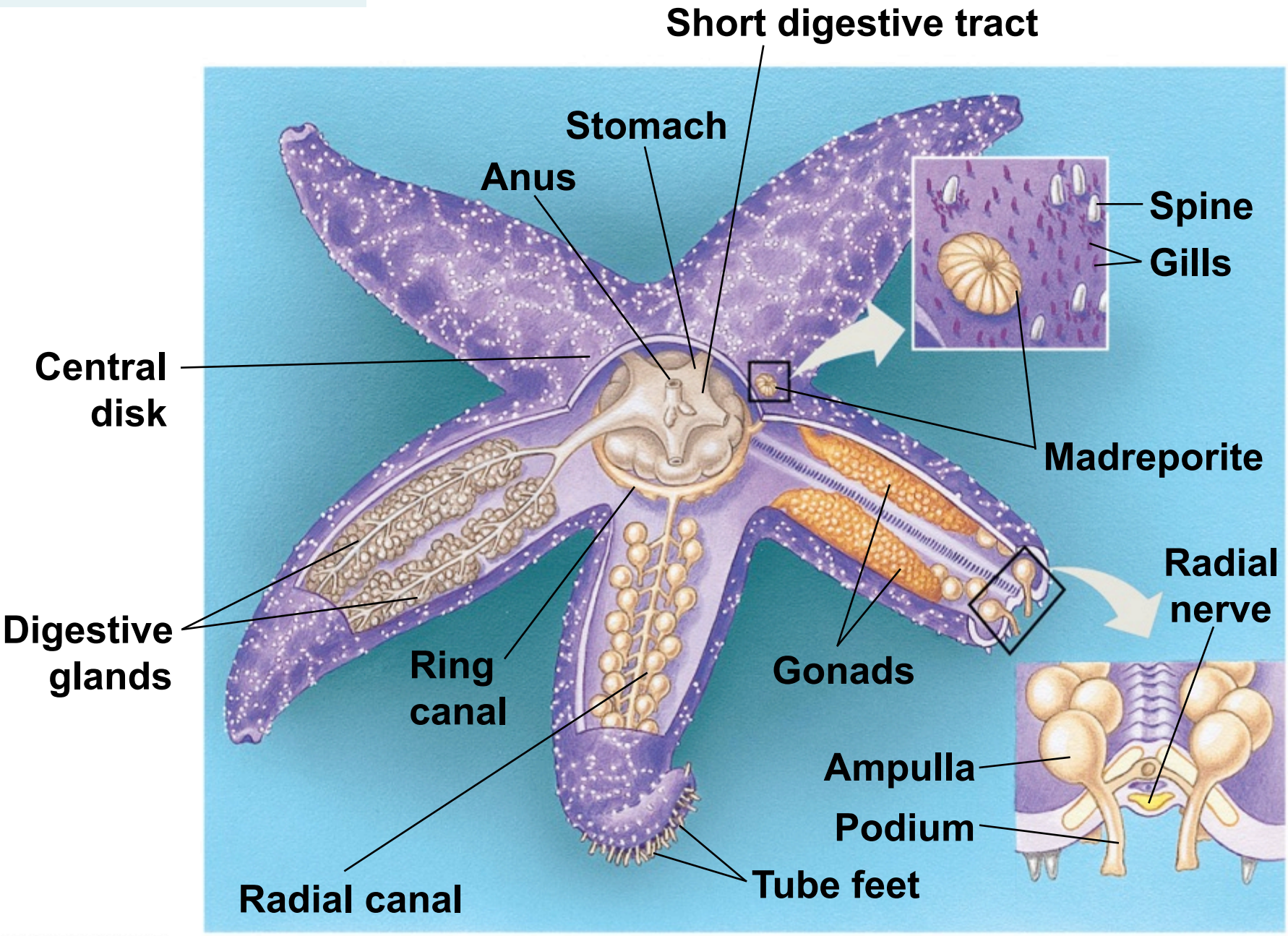


Figure 33.40b



Class Asteroidea - Digestion

- Mouth leads through short esophagus to large stomach
  - Lower part of stomach everted through mouth to feed
  - Upper stomach is smaller and connected by ducts to **pyloric ceca** (digestive gland) in each arm
  - Anus is inconspicuous; some species lack an intestine and anus
  - Consume a wide range of food
    - Sea urchins
    - Molluscs
      - Sea stars pull valves apart and evert stomach through crack
    - Small particles carried up ambulacral grooves to mouth

Class Asteroidea – Excretion & Circulation

- Separate coelom compartment for excretion, circulation
  - Ciliated peritoneal lining of coelom circulates fluid around the cavity and into papulae
  - Respiratory gases and ammonia diffuse across the papulae and tube feet

Class Asteroidea – Nervous System

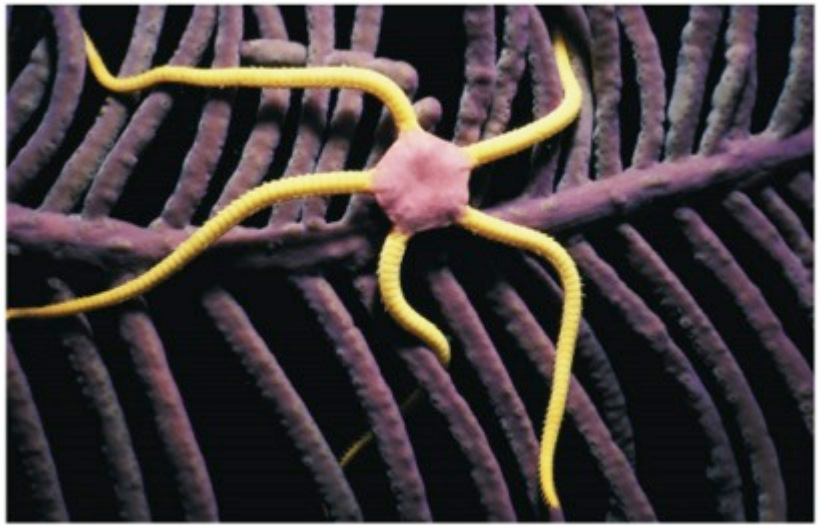
- No Brain
- Central nerve ring and radial nerves coordinate tube feet
- Tactile organs scattered over surface, and an **ocellus** is at tip of each arm
  - React to touch, temperature, chemicals, and light intensity
  - Mainly active at night

Class Asteroidea - Reproduction

- Sexes separate in most sexes
- Pair of gonads in each ray (arm)
- External fertilization
- Eggs and sperm shed into the water in early summer
- Regenerate lost parts
  - Cast off injured arms and regenerate new ones
  - An arm can regenerate a new sea star if at least one-fifth of central disc is present

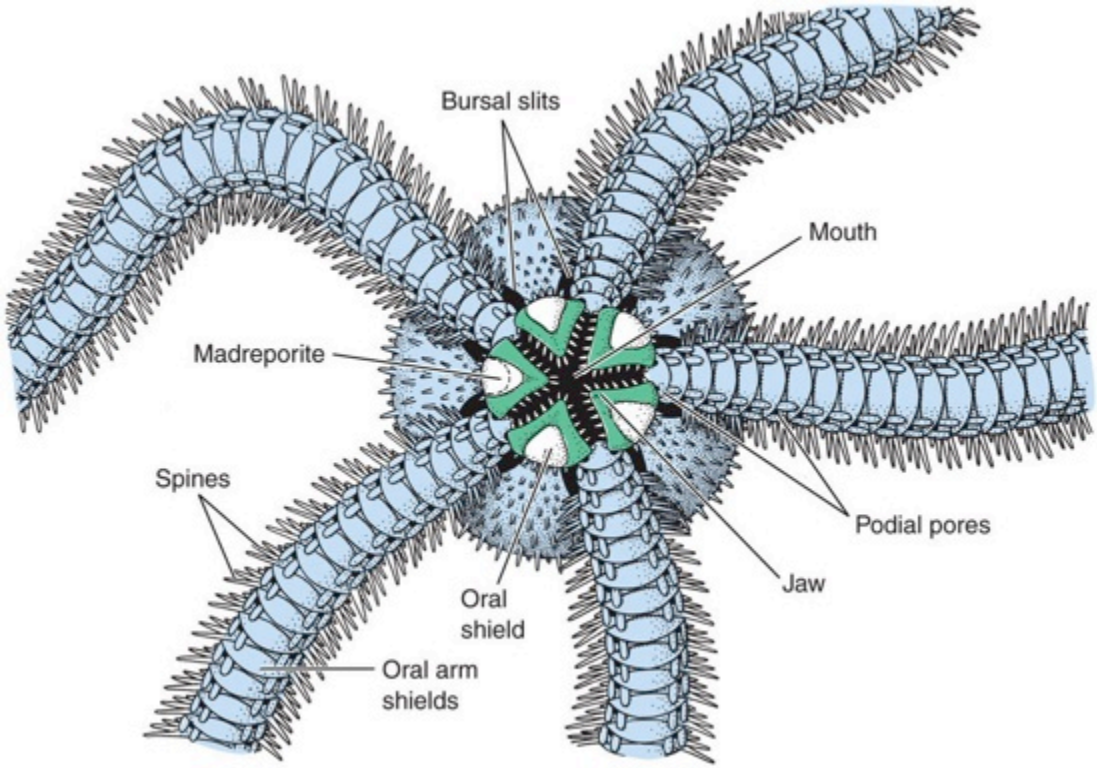
Class Ophiuroidea: Brittle Stars

- Brittle stars have a distinct **central disk** and long, flexible arms, which they use for movement
- Some species are suspension feeders, others are predators or scavengers
- Largest in number of species (over 2000 extant species)
- Lack pedicellariae and papulae
- **Madreporite** is on the **oral** surface
- Tube feet lack suckers and ampullae



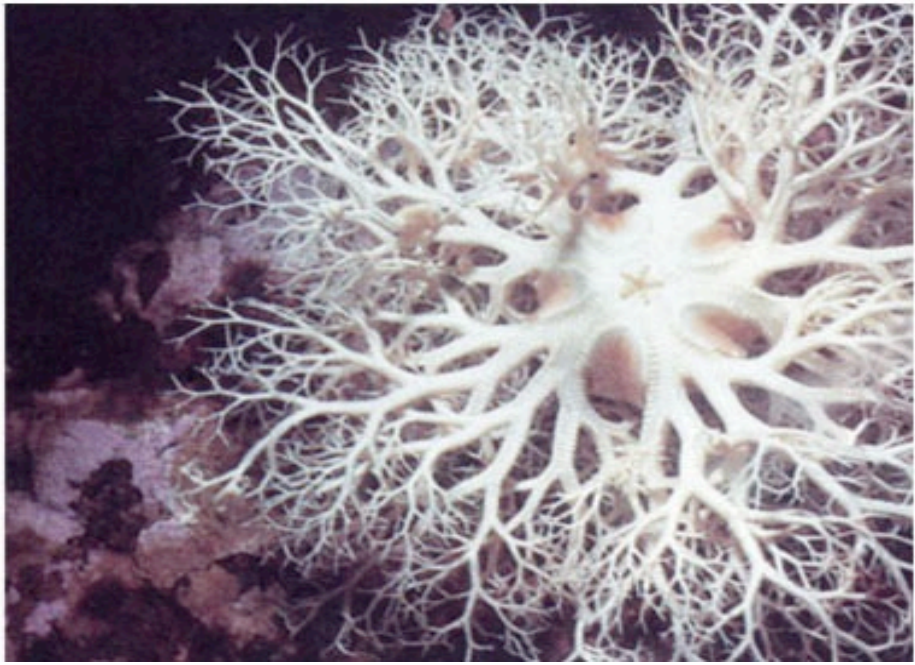
Class Ophiuroidea

- Each jointed arm has a column of articulated ossicles called vertebrae
- Arms are moved in pairs for locomotion
- Five movable plates act as jaws and surround mouth
- No intestine or anus
- Water-vascular, nervous, and circulatory/excretory systems resemble those of sea stars



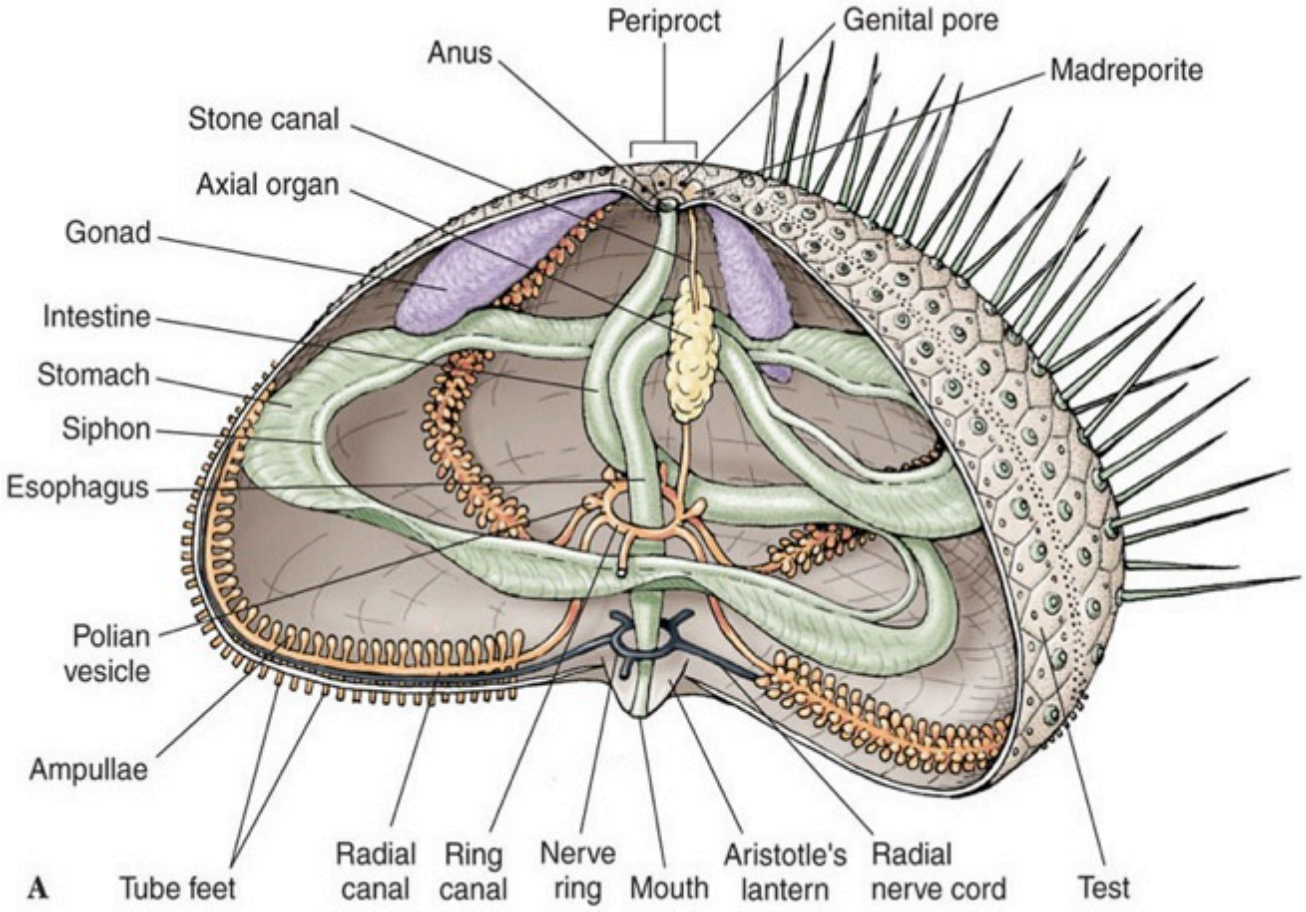
Class Ophiuroidea - Biology

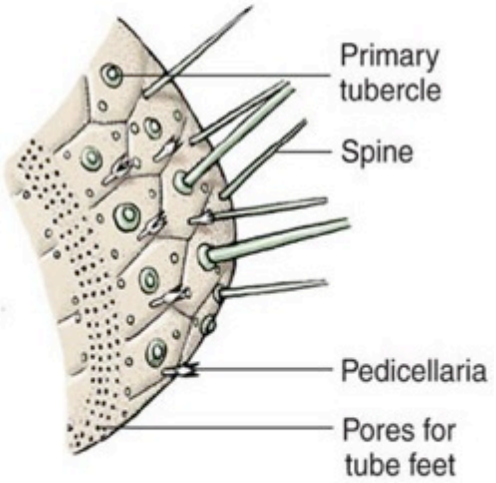
- Brittle stars live on hard or sandy bottoms where little light penetrates (often under rocks or in kelp holdfasts)
- Basket stars perch on corals and extend branched arms to capture plankton
- Regeneration and autonomy are more pronounced than in sea stars - very fragile



Class Echinoidea: Sea Urchins and Sand Dollars

- Sea urchins and sand dollars have **no arms** but have five rows of tube feet
- Their spines are used for locomotion and protection
  - Have a ball-and-socket arrangement
  - Some species have **pedicellariae** with poison glands that secrete a toxin that paralyzes small prey
- Sea urchins feed on seaweed using a jaw-like structure (Aristotle's Lantern) on aboral surface


Periproct
Genital pore
Anus
Madreporite
Stone canal
Axial organ
Gonad
Intestine
Stomach
Siphon
Esophagus
Polian vesicle
Ampullae
Tube feet
Radial canal
Ring canal
Nerve ring
Mouth
Aristotle's lantern
Radial nerve cord
Test
A


Primary tubercle
Spine
Pedicellaria
Pores for tube feet
B

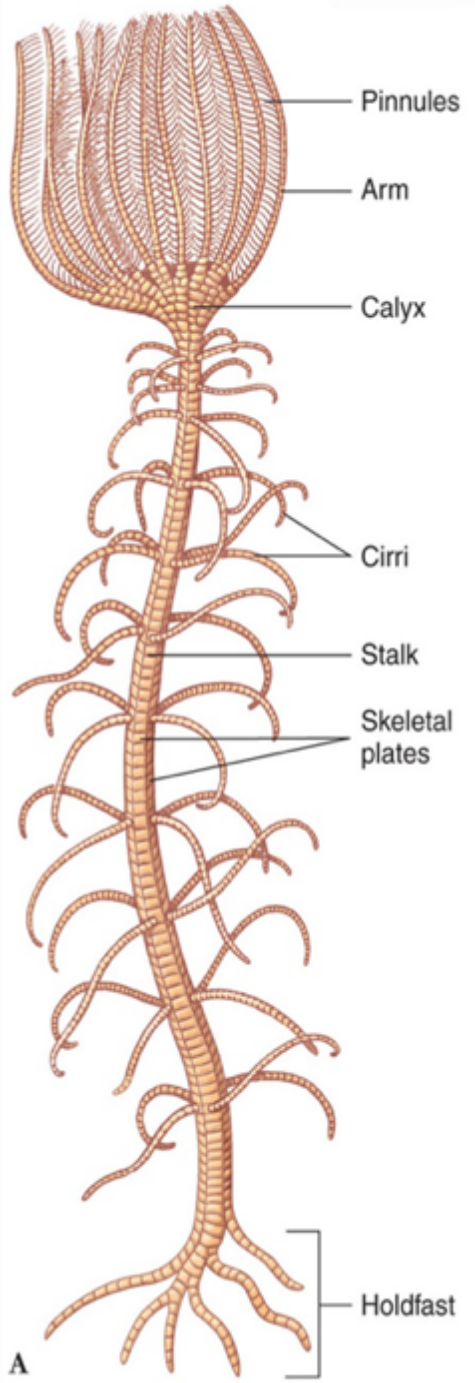
Class Crinoidea: Sea Lilies and Feather Stars

- Have primitive characters, and numerous in fossil record
- Unique in being attached most of their life
- Sea lilies have a flower-shaped body at tip of a stalk
- Feather stars have long, many-branched arms
  - Adults are free-moving but may be sessile
- Many crinoids are deep-water species
- Feather stars are found in more shallow water


Larry S. Roberts

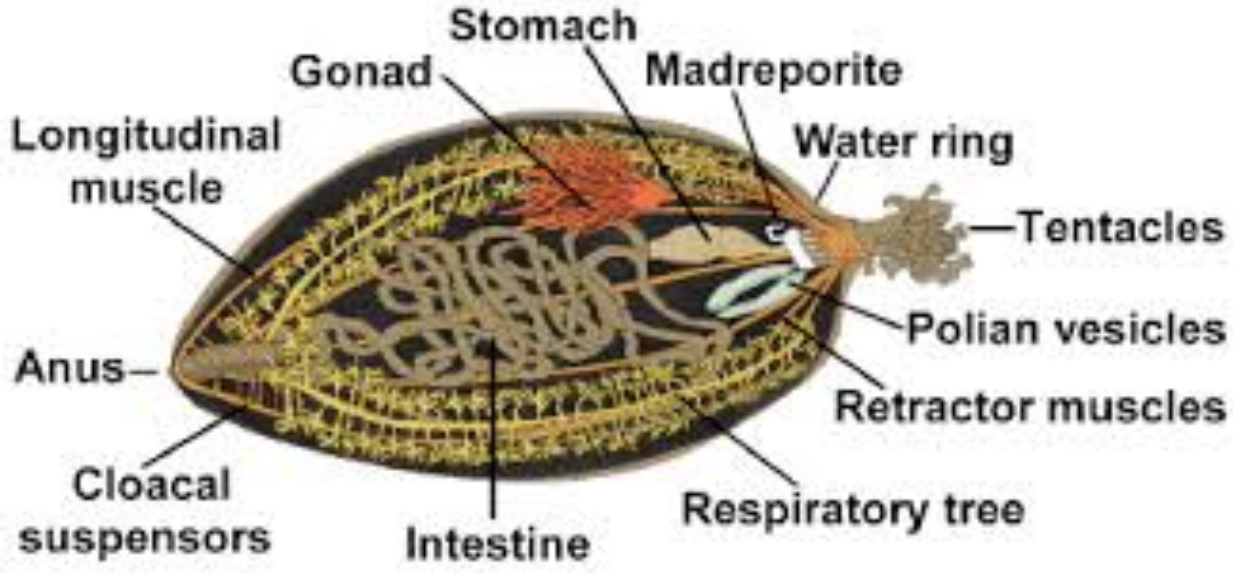
Class Crinoidea - Morphology

- Body disc or calyx covered with leathery skin or calcareous plates
  - 5 arms branch to form more arms, each with lateral pinnules as in a feather
  - Calyx and arms form a crown
- Upper surface has a mouth that opens into esophagus and intestine
  - Tube feet and mucous nets allow feeding on small organisms in ambulacral grooves
  - Water-vascular system, an oral ring, and a radial nerve to each arm
  - Madreporite, spines, and pedicellariae absent



Class Holothuroidea: Sea Cucumbers

- Five rows of tube feet; some developed for feeding
  - ~1150 species
  - Greatly elongated in oral-aboral axis
  - Lack spines, reduced endoskeleton, soft-bodied
  - Some species crawl on ocean bottom, others found under rocks or in burrow



Class Holothuroidea - Morphology

- Possess a **cloaca**
  - All-purpose, pouch-like structure that can play a role in excretion, reproduction, and respiration
  - Digestive system opens into cloaca
  - Respiratory tree also empties into cloaca
- Madreporite lies free in the coelom
- Circulatory and excretory systems better developed than in other echinoderms
- Respiratory tree also serves for excretion
- Gas exchange occurs through the skin and tube feet
- Reproduction
  - Fertilization is external (cloaca doesn't function in reproduction in sea cucumbers)

Class Holothuroidea - Biology

- Some trap particles on mucus of tentacles, ingesting food particles in pharynx by inserting tentacle into mouth
- Others graze sea floor with tentacles
- Cast out part of viscera when threatened
  - Regenerate these tissues
  - Organs of Cuvier are expelled in direction of an enemy
    - Sticky and have toxins
- One small fish, *Carapus*, uses the cloaca and respiratory tree of a sea cucumber for shelter

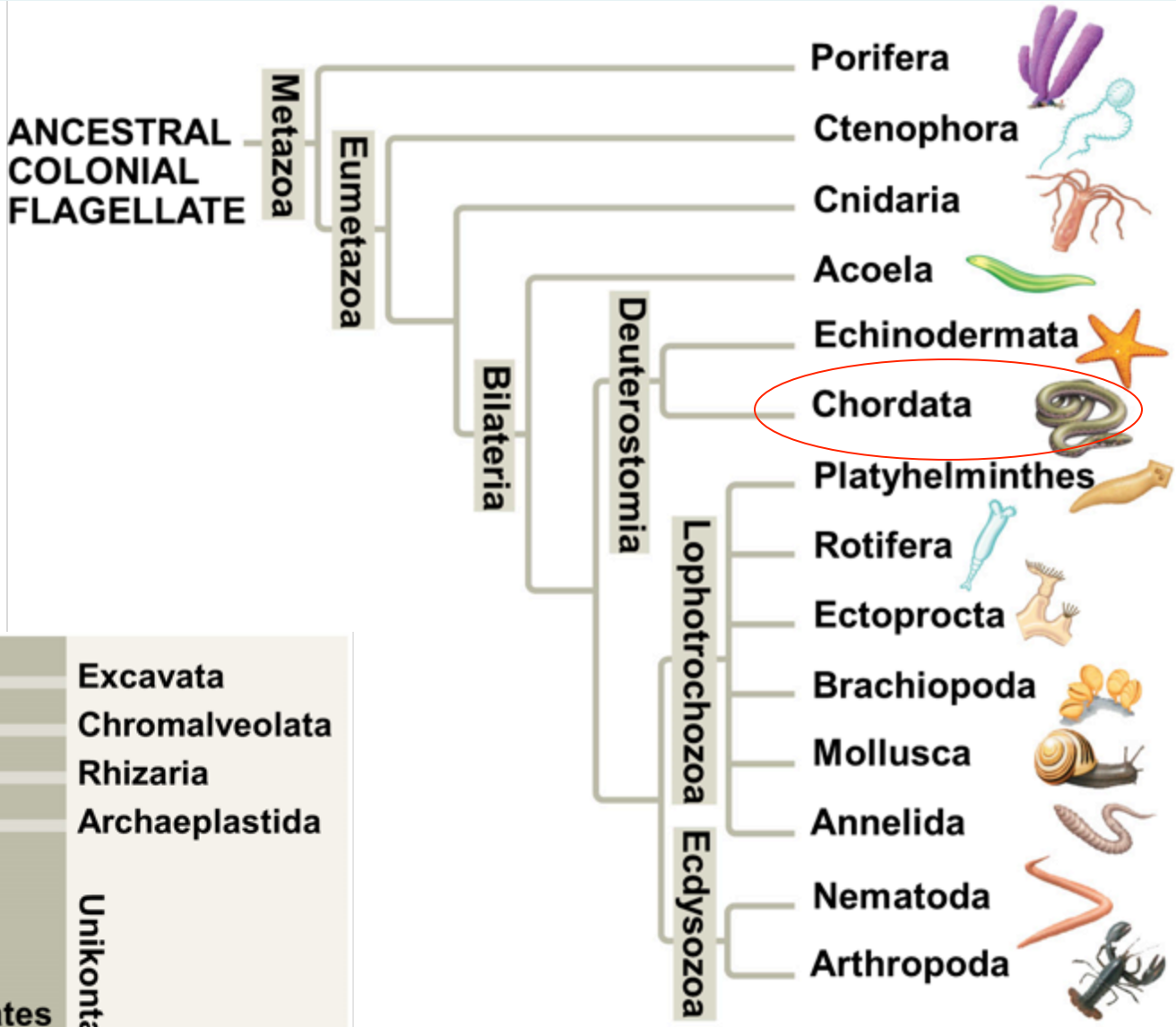
Video resources…

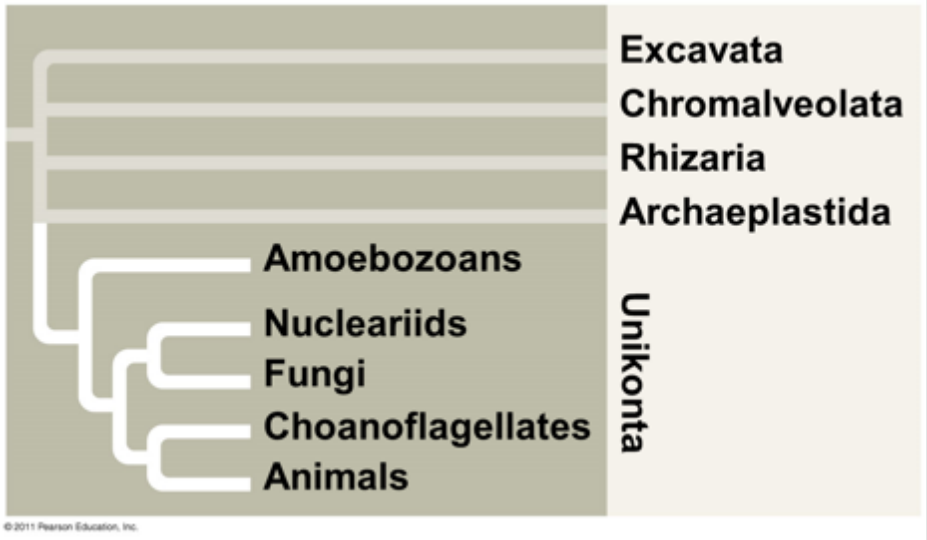
- Ze Frank, True Facts about the Sea Pig: https://www.youtube.com/watch?v=_y4DbZivHCY
- Sea cucumber evisceration: http://video.nationalgeographic.com/video/weirdest-sea-cucumber
- Echinoderms: http://shapeoflife.org/video/echinoderms-ultimate-animal

Phylum Chordata!
Part One - Invertebrates

Reference: Chapter 34.1-34.4

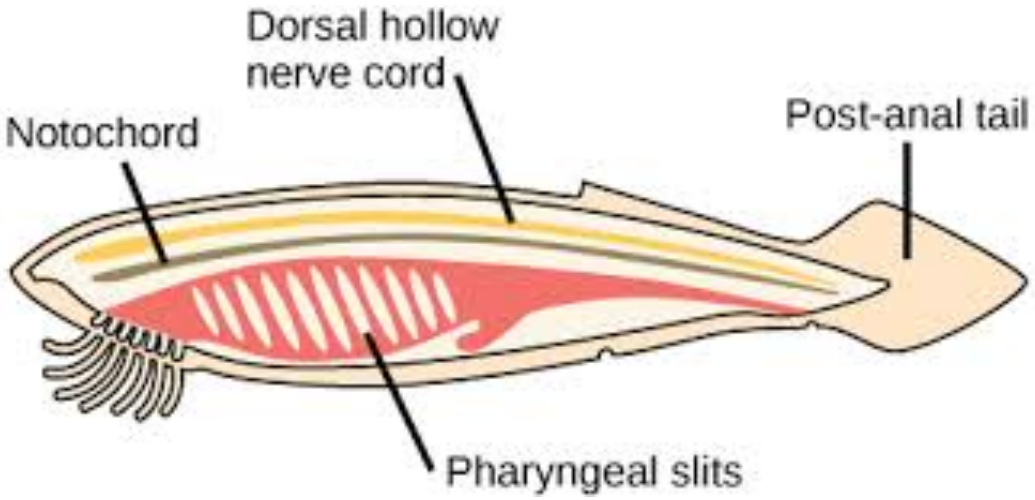
Finally – last stop on our romp through the phyla!





Phylum Chordata

- By the end of the Cambrian period, 540 million years ago, an astonishing variety of animals inhabited Earth's oceans
  - All were invertebrate
  - One group of invertebrates evolved special features that in turn evolved into the early vertebrates



Phylum Chordata

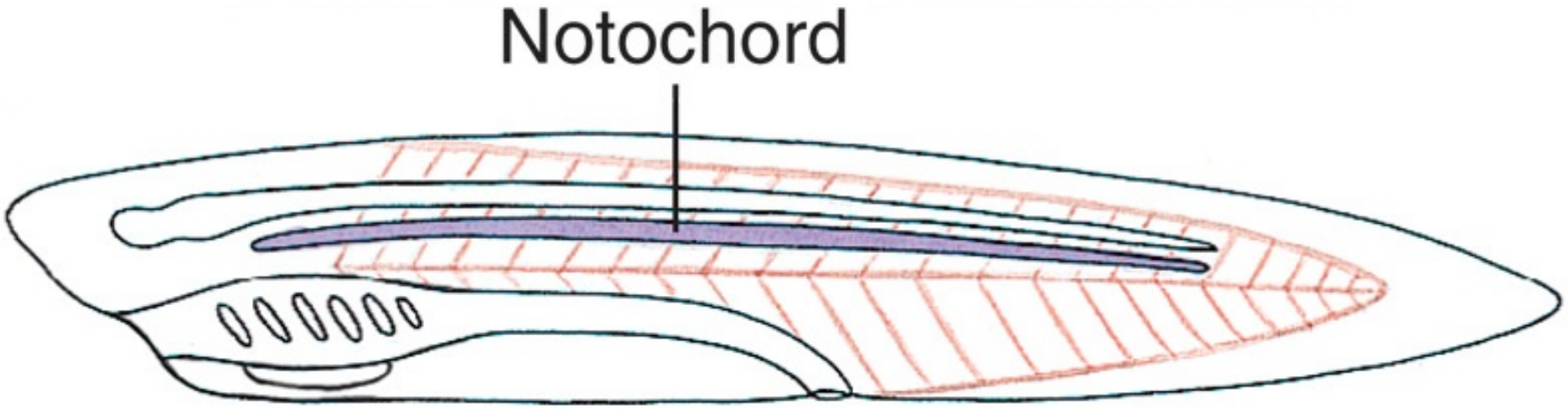
- Chordates have:
  - Bilateral symmetry
  - True coelom
  - **Deuterostome** development
    - Radial, indeterminate cleavage
    - Blastopore becomes the anus
  - **Cephalization**
  - **Metamerism**
    - Body constructed as linear array of segments (somites), groups of which are fused into tagmata for specialized functions
    - What other groups also display metamerism?

Phylum Chordata

- Five distinctive characteristics define the chordates:
  1. **Notochord**
  2. **Dorsal tubular nerve cord**
  3. **Pharyngeal pouches (gill slits)**
  4. **Postanal tail**
  5. **Endostyle**
- All are found at least at some embryonic stage in all chordates, although they may later be lost

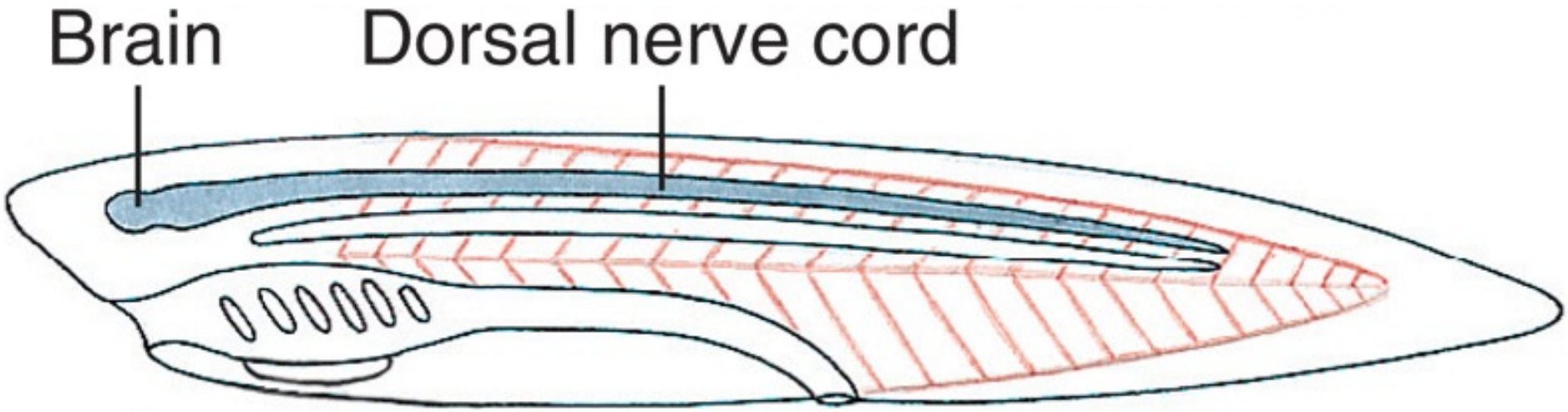
1. The Notochord

- A flexible, rod-like structure **derived from mesoderm**
  - First part of the endoskeleton to appear in an embryo
  - Place for muscle attachment
  - In vertebrates, notochord is replaced by the vertebrae
    - Remains of the notochord may persist between vertebrae in some vertebrates



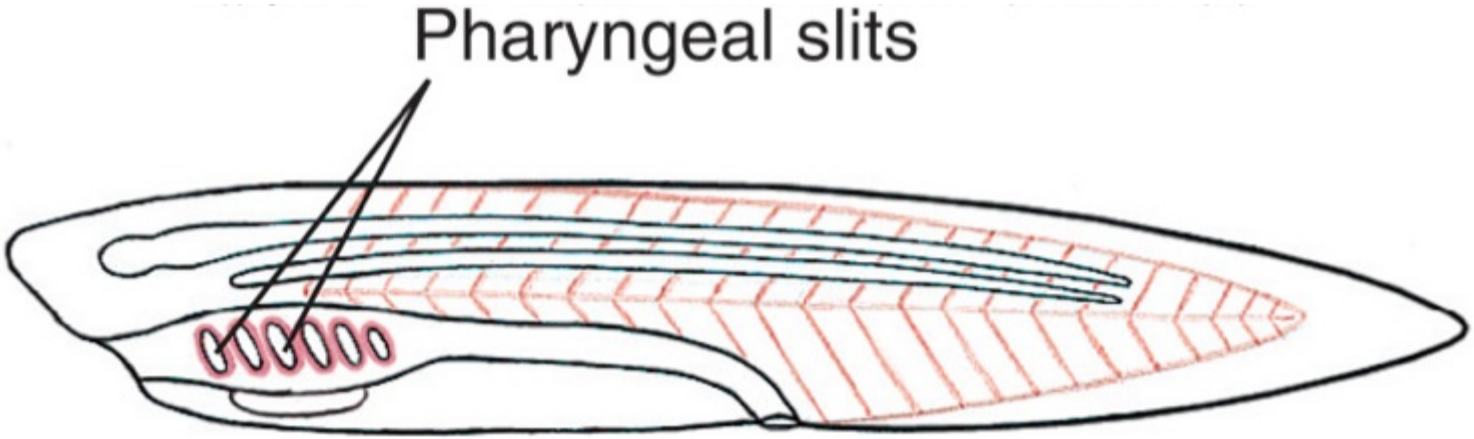
2. Dorsal Tubular Nerve Cord

- In chordates, the **nerve cord** is dorsal to the alimentary canal and is a tube
  - The anterior end becomes enlarged to form the brain
  - The hollow cord is produced by the infolding of embryo ectodermal cells that are in contact with the mesoderm
  - Protected by the vertebral column in vertebrates



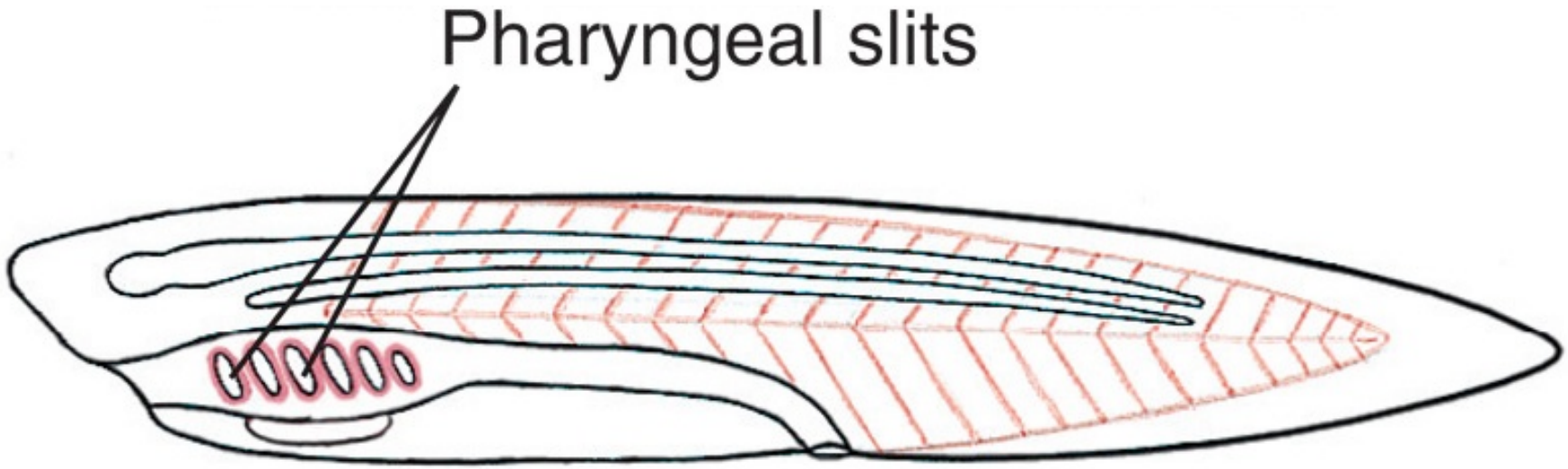
3. Pharyngeal Slits and Pouches

- The perforated pharynx first evolved as a **filter feeding apparatus**
- Later modified into **internal gills** used for respiration.
- **Pharyngeal slits**
  - openings that open from the pharyngeal cavity to the exterior of the body
  - formed during development when pharyngeal clefts and pharyngeal pouches meet to form an opening



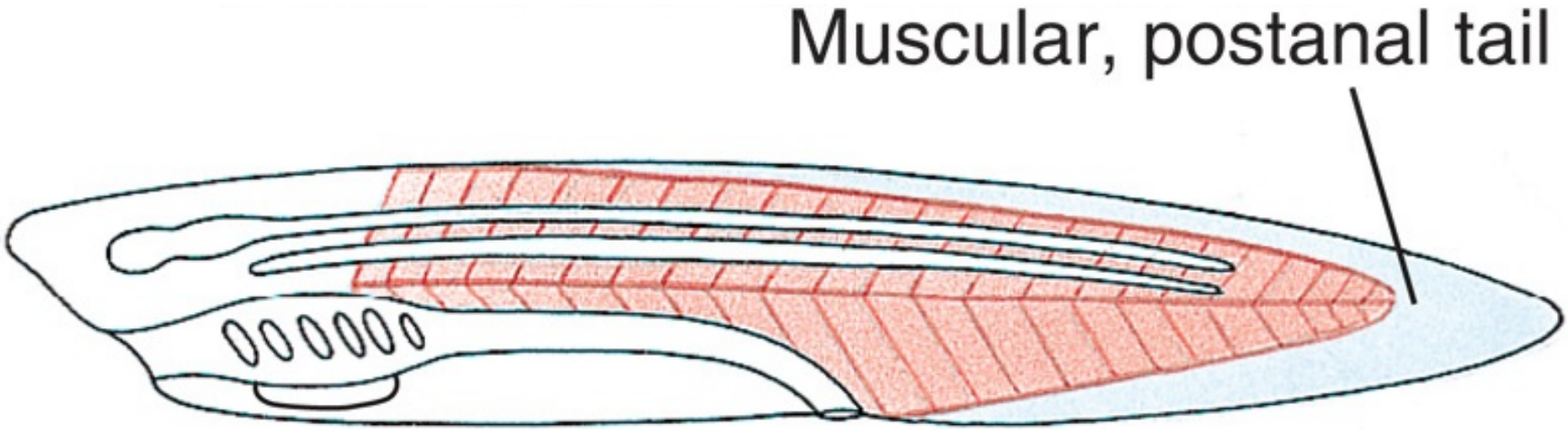
3. Pharyngeal Slits and Pouches

- Function as **filter feeding apparatus** in invertebrate chordates
- Function as **internal gills** in fish
- In tetrapods (vertebrates with limbs), give rise to the Eustachian tube, middle ear cavity, tonsils, and parathyroid glands



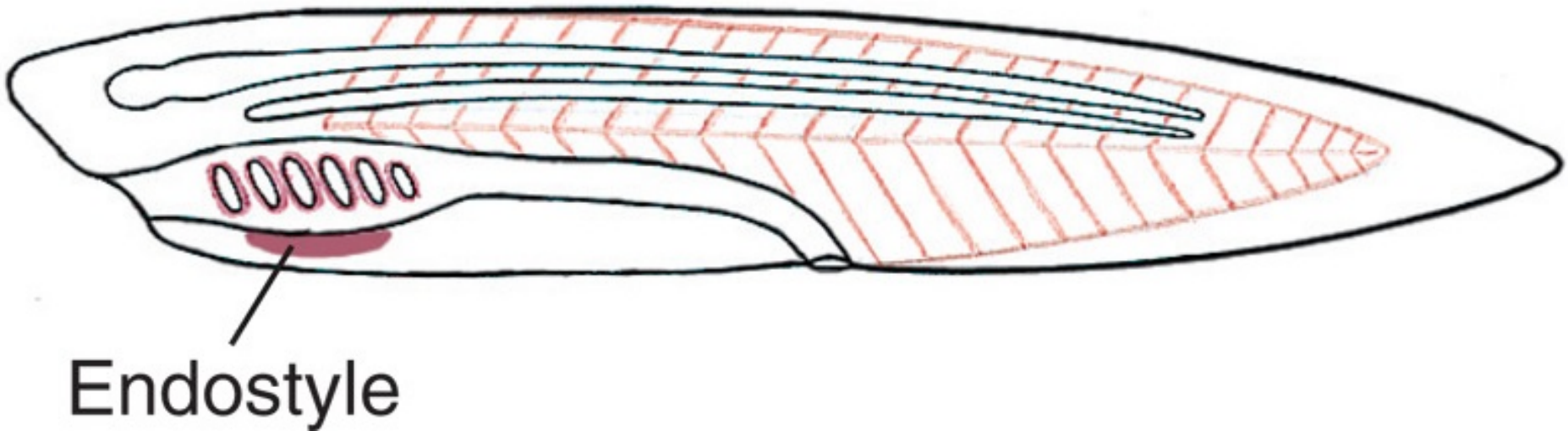
4. Postanal Tail

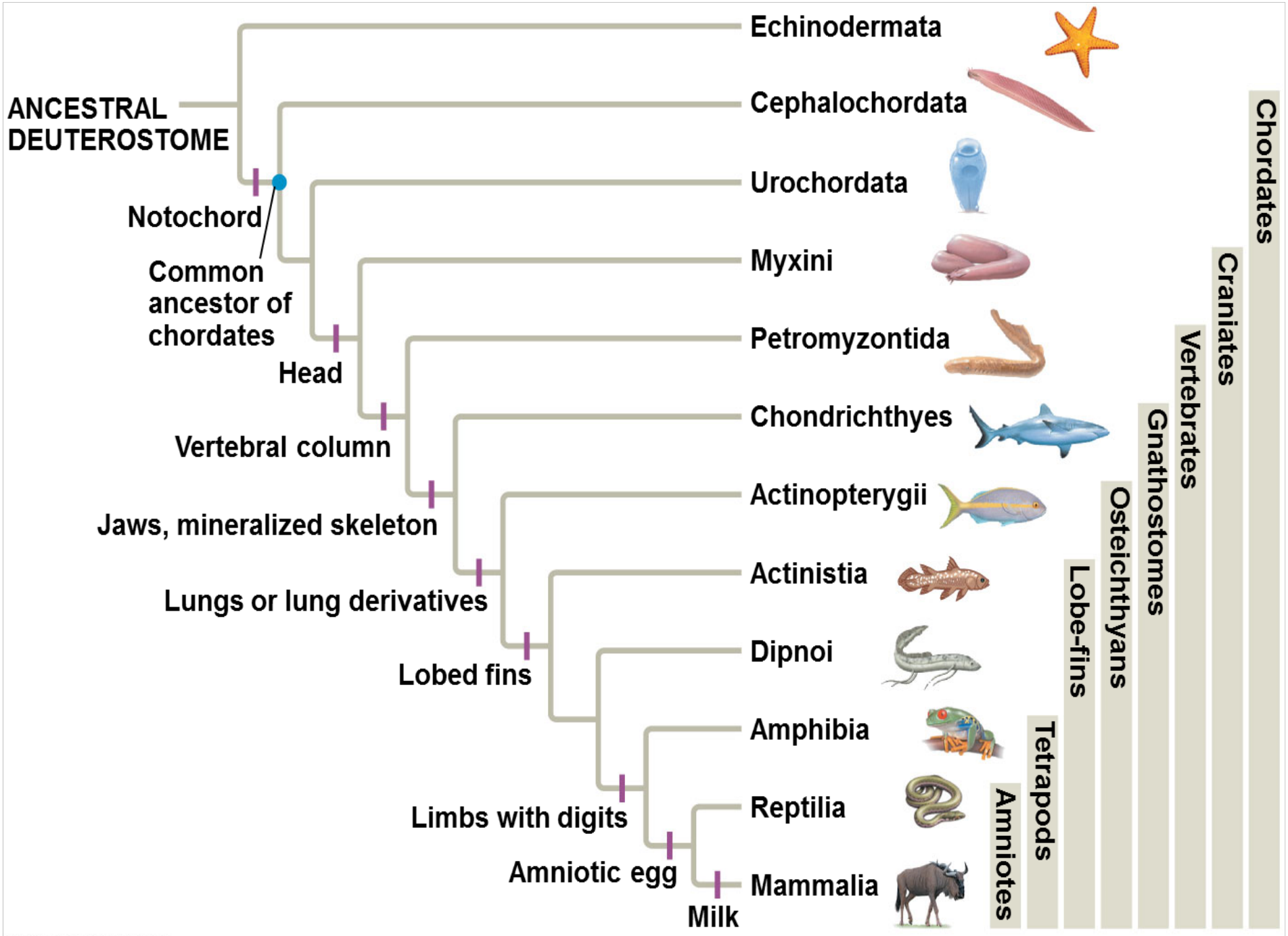
- The **postanal tail**, along with somatic musculature and the stiffening notochord, provides motility in larval tunicates and amphioxus
  - Evolved for propulsion in water
  - Reduced to the coccyx (tail bone) in humans



5. Endostyle or Thyroid Gland

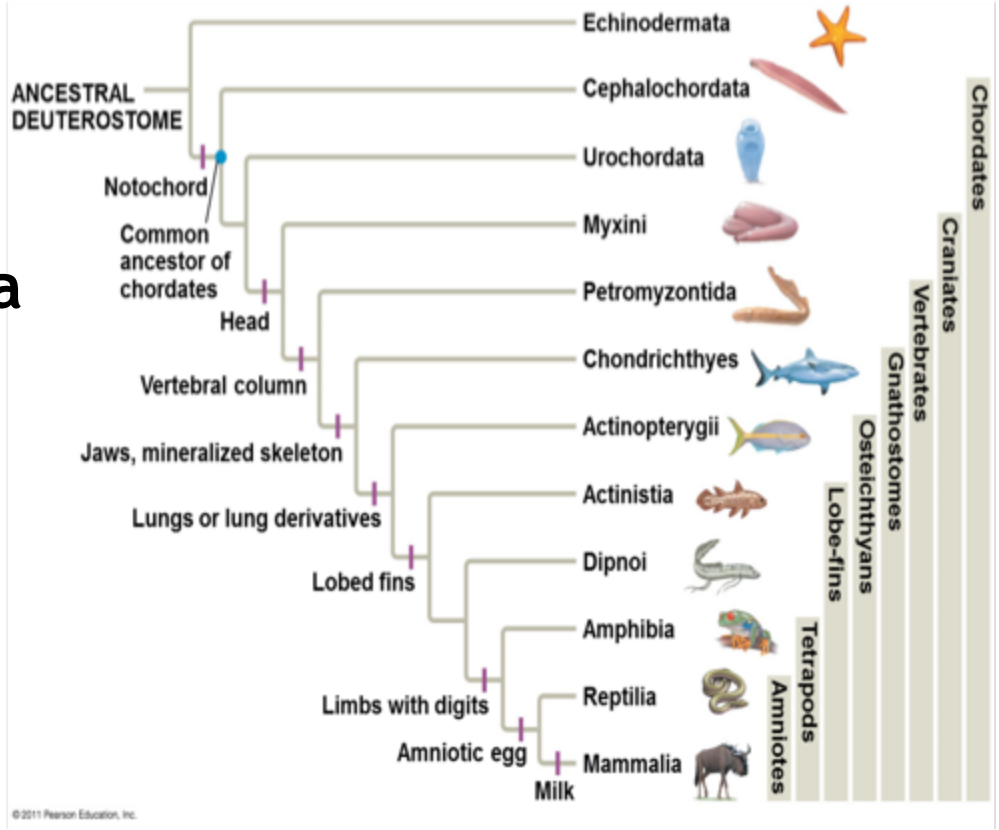
- Situated in the pharyngeal floor
- Secretes mucus that traps food particles
  - Found in protochordates and lamprey larvae
  - Secretes iodinated proteins
- Homologous to the **thyroid gland** in vertebrates





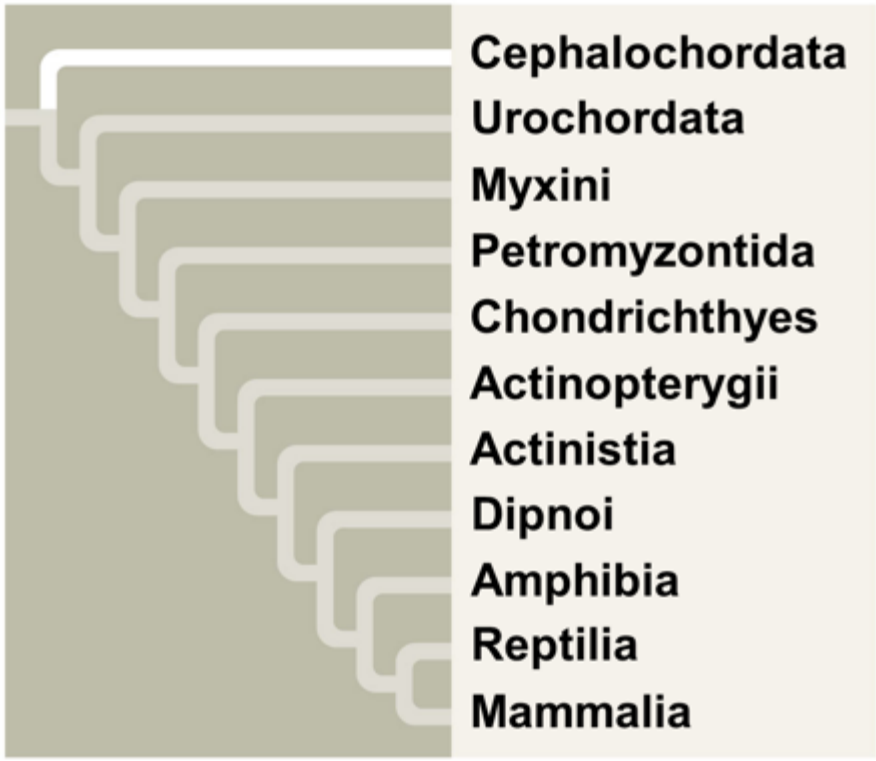
Phylogenetic tree of the Chordata

- Protochordata (**Acraniata**) are separated from Vertebrata (**Craniata**) that have a skull
- Vertebrates divided into superclasses **Agnatha** (jawless) and **Gnathostomata** (having jaws)
- Vertebrates are also divided into **Amniota**, having an amnion, and **Anamniota** lacking an amnion
- Gnathostomata is subdivided into **Pisces** with fins and **Tetrapoda**, usually with two pair of limbs



Phylum Chordata

- Two **protochordate** subphyla
  - **Subphylum Cephalochordata**
    - Most basal group of living chordates
  - **Subphylum Urochordata**

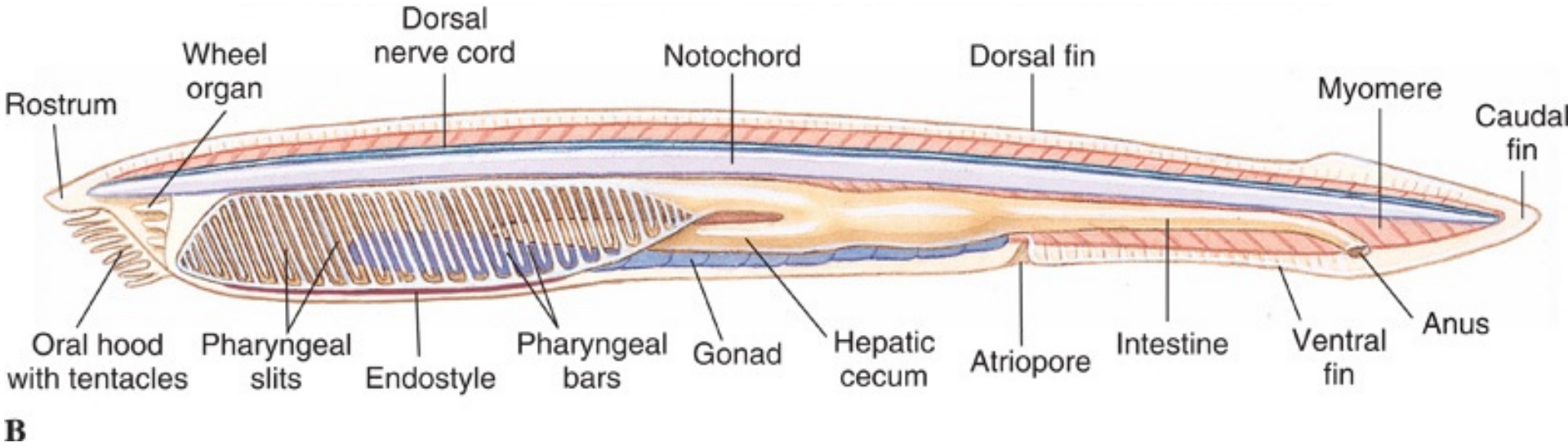


Subphylum Cephalochordata

- **Cephalochordates** are the **lancelets**, also called **amphioxus**
- Named for their bladelike shape

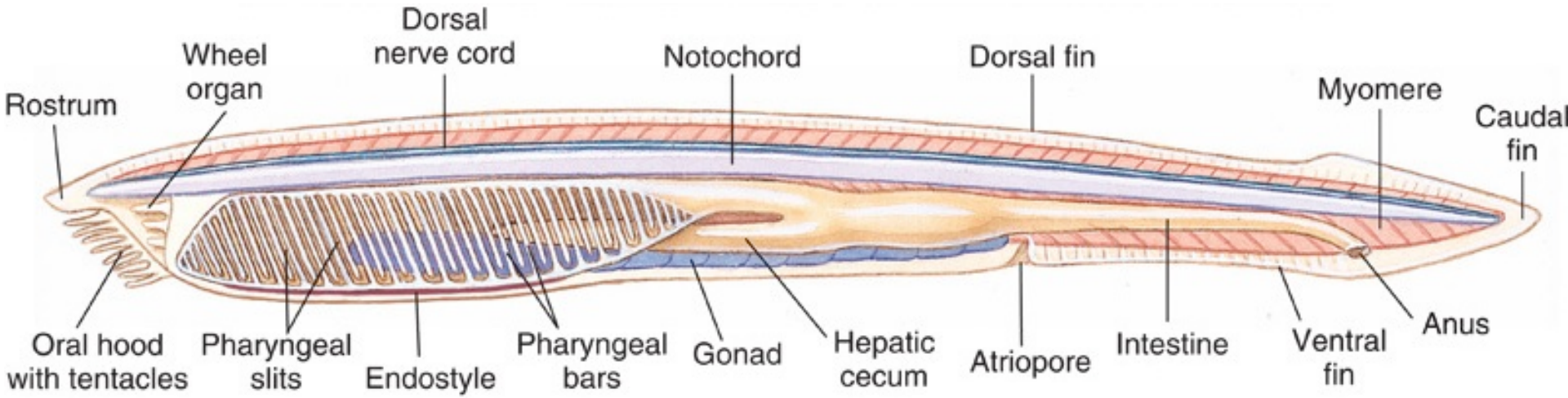
Subphylum Cephalochordata

- Retain the four major chordate characters as adults
- Filter feeding accomplished using **pharyngeal slits**



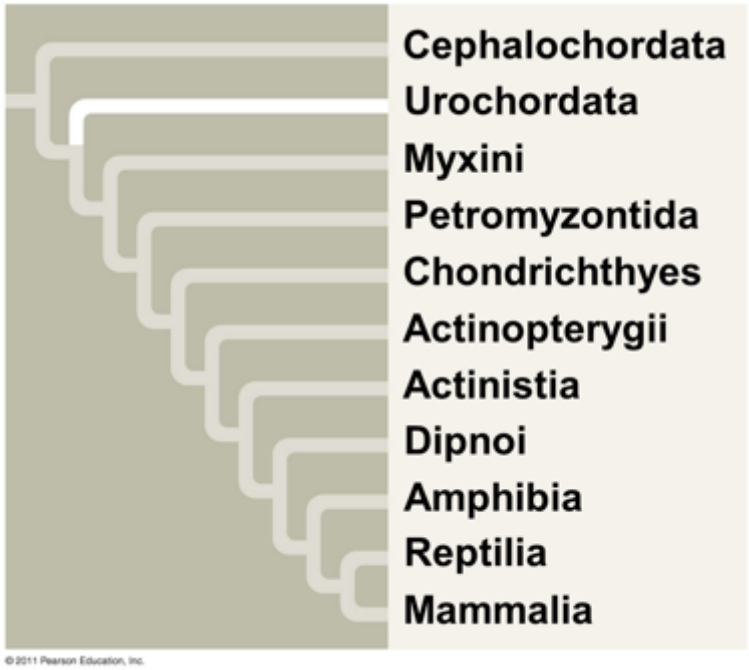
Subphylum Cephalochordata

- The **dorsal, hollow nerve cord** lies just above the notochord
- Circulatory system is closed, but no heart
  - Blood functions in nutrient transport, not oxygen transport
- **Segmented trunk musculature** is also shared with vertebrates
  - Chevron-shaped muscles flex notochord and produce side-to-side movement



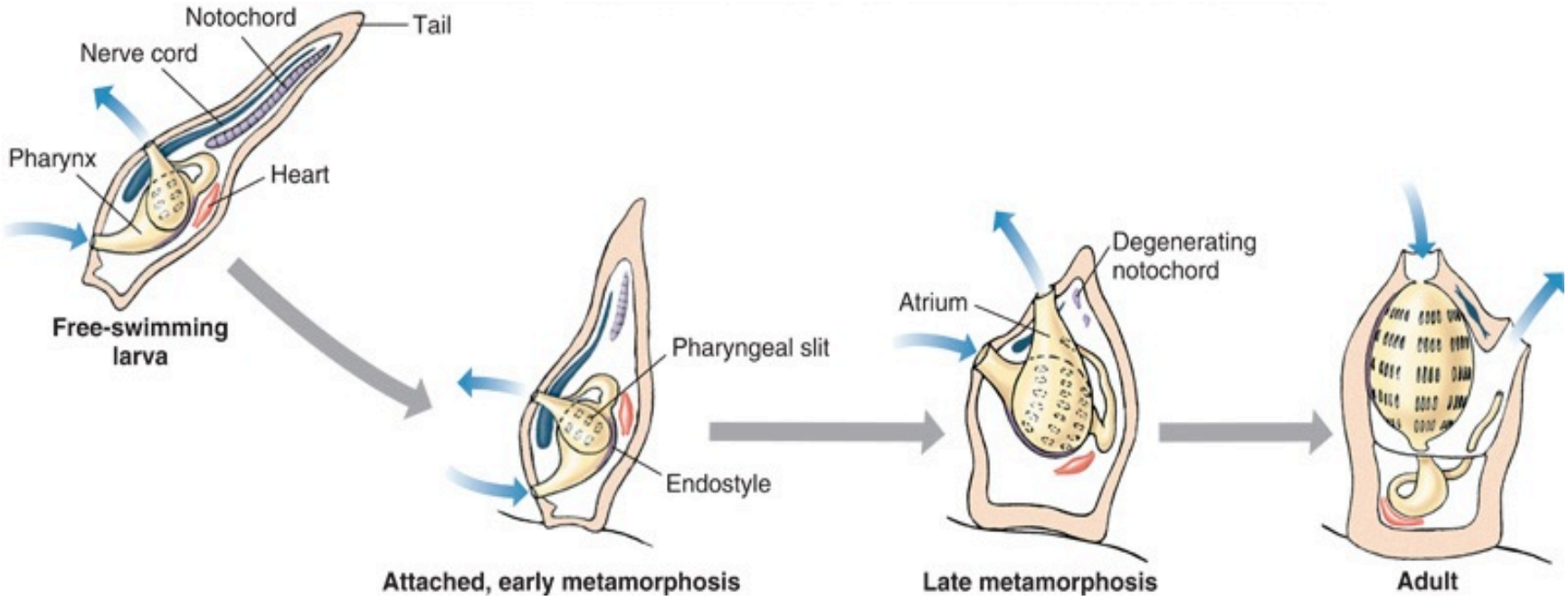
Subphylum Urochordata

- **Tunicates** are marine, with global distribution
- Most are sessile and highly specialized as adults



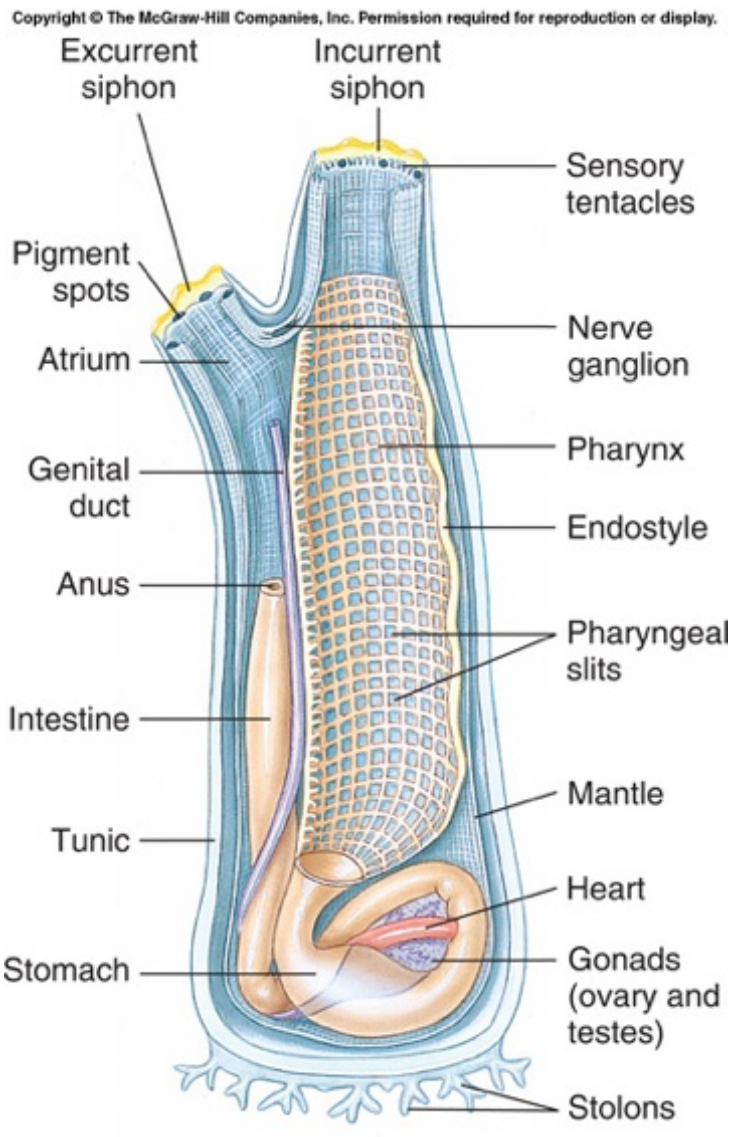
Subphylum Urochordata

- In most species, only the larvae show all of the chordate features
  - Tadpole-like larva



Subphylum Urochordata

- Tunicates filter feed using the pharyngeal slits and a mucous net secreted by the endostyle



Subphylum Urochordata

- Some tunicates are colonial.

Video resources…

- Chordates: http://shapeoflife.org/video/chordates-we%E2%80%99re-all-family