

Lecture 31:

Triploblasts: Protostomes: Ecdysozoans II

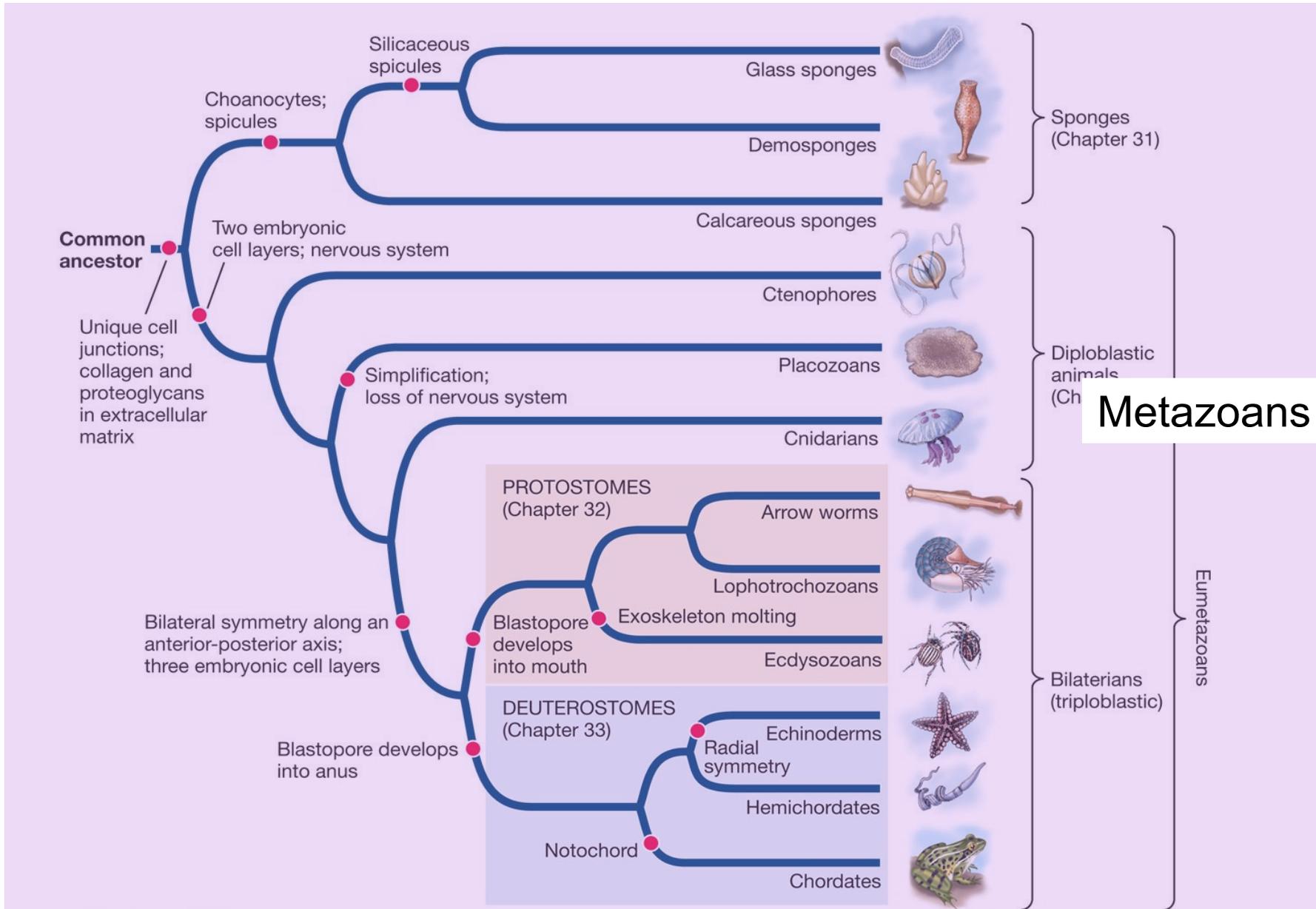
BIS 002C
Biodiversity & the Tree of Life
Spring 2016

Prof. Jonathan Eisen

- Previous lecture:
 - 30: Triploblasts: Protostomes: Ecdysozoans II I
- Current Lecture:
 - 31: Deuterosomes I: Echinoderms & Hemichordates
- Next Lecture:
 - 31: Deuterosomes II: Chordates

- Deuterostome innovations and uses of these innovations
- Major Groups of Deuterostome
- Focus on Echinoderms
 - Innovations
 - Symmetry
 - Tube feet
- Chordate Introduction

Animals - AKA Metazoans



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Figure 31.1 A Phylogenetic Tree of the Animals

- Colonial
- Cell adhesion systems

Common ancestor

Unique cell junctions; collagen and proteoglycans in extracellular matrix

Multicellularity, Blastula

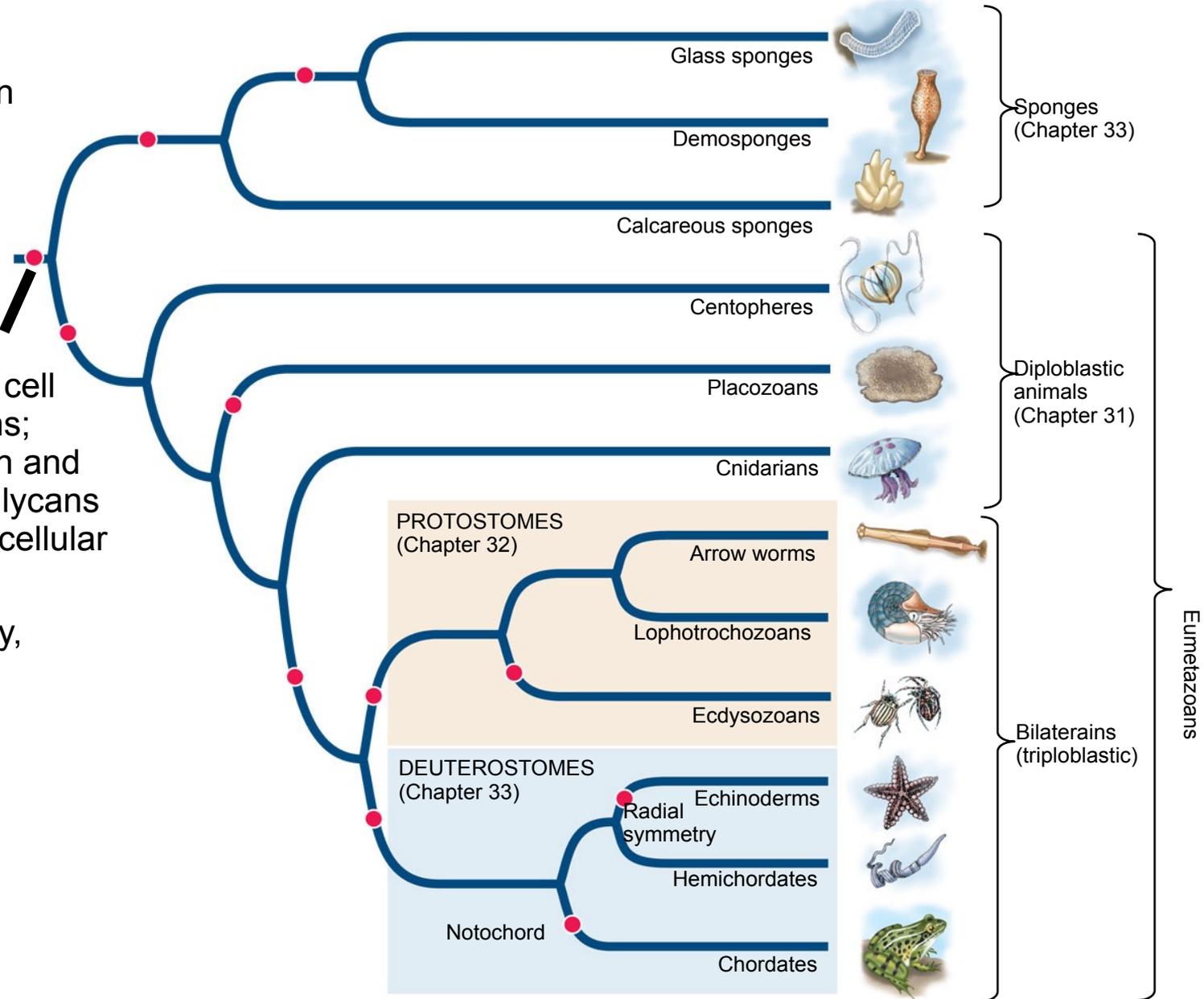


Figure 31.1 A Phylogenetic Tree of the Animals

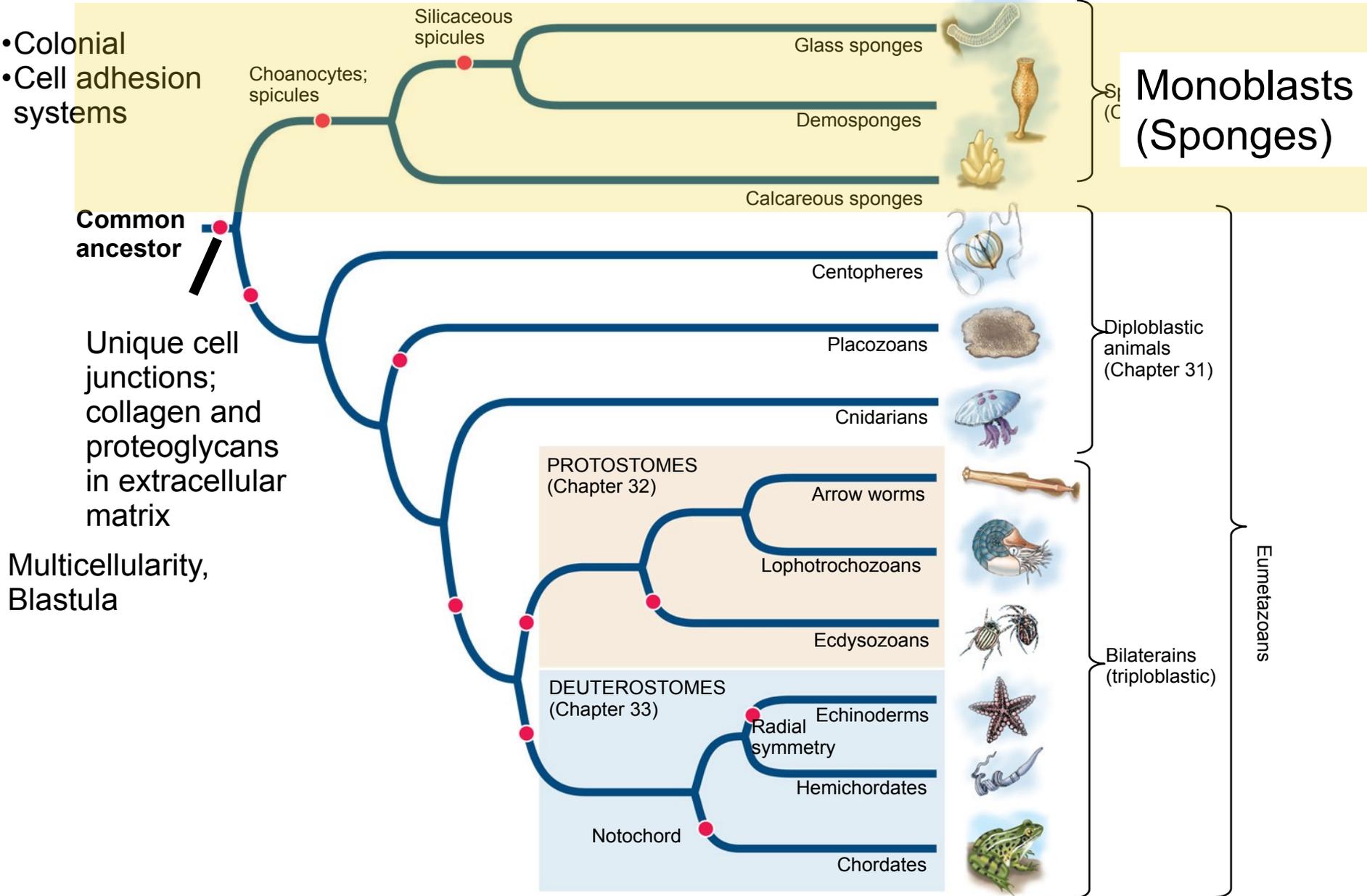
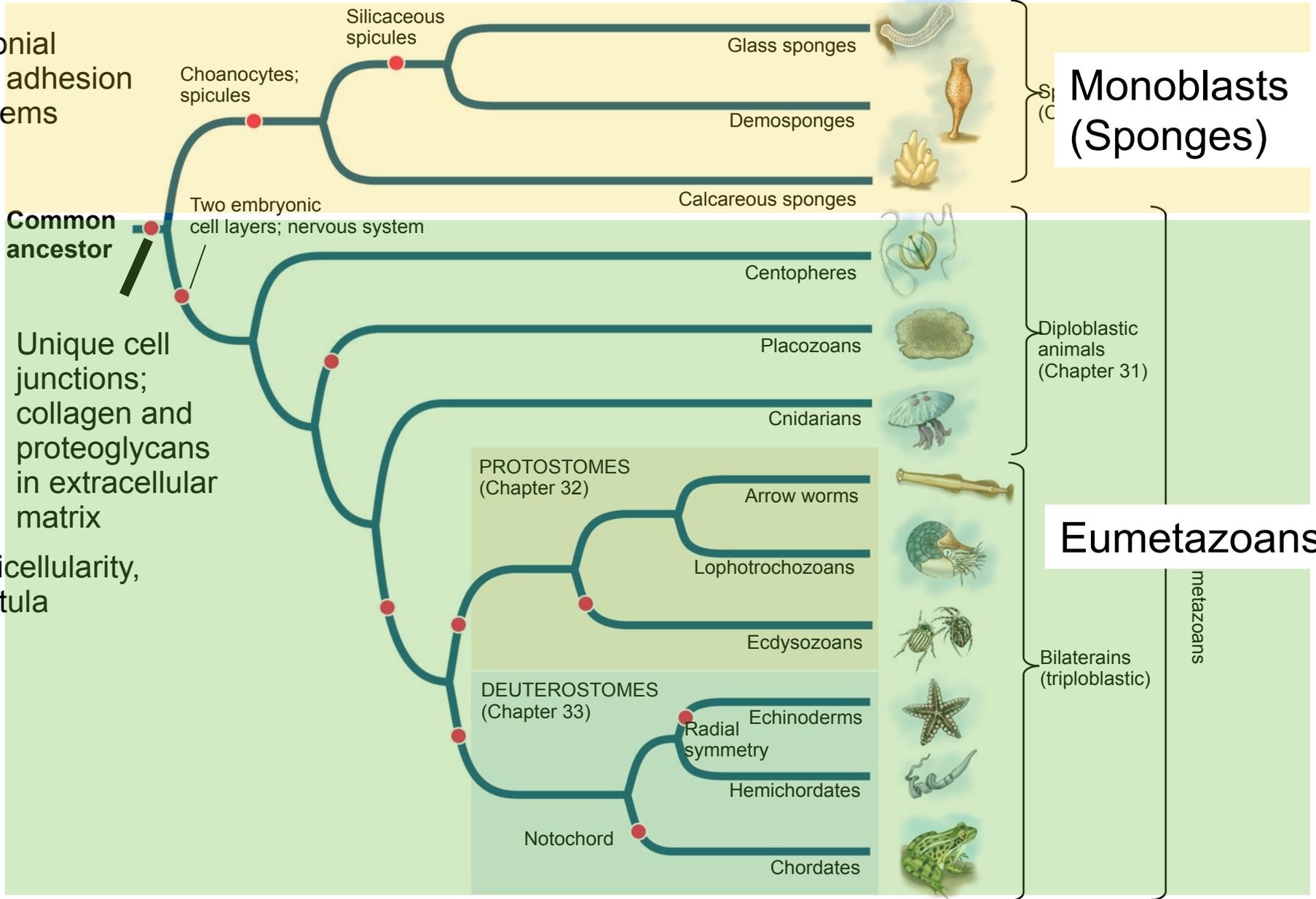


Figure 31.1 A Phylogenetic Tree of the Animals

- Colonial
- Cell adhesion systems



Monoblasts (Sponges)

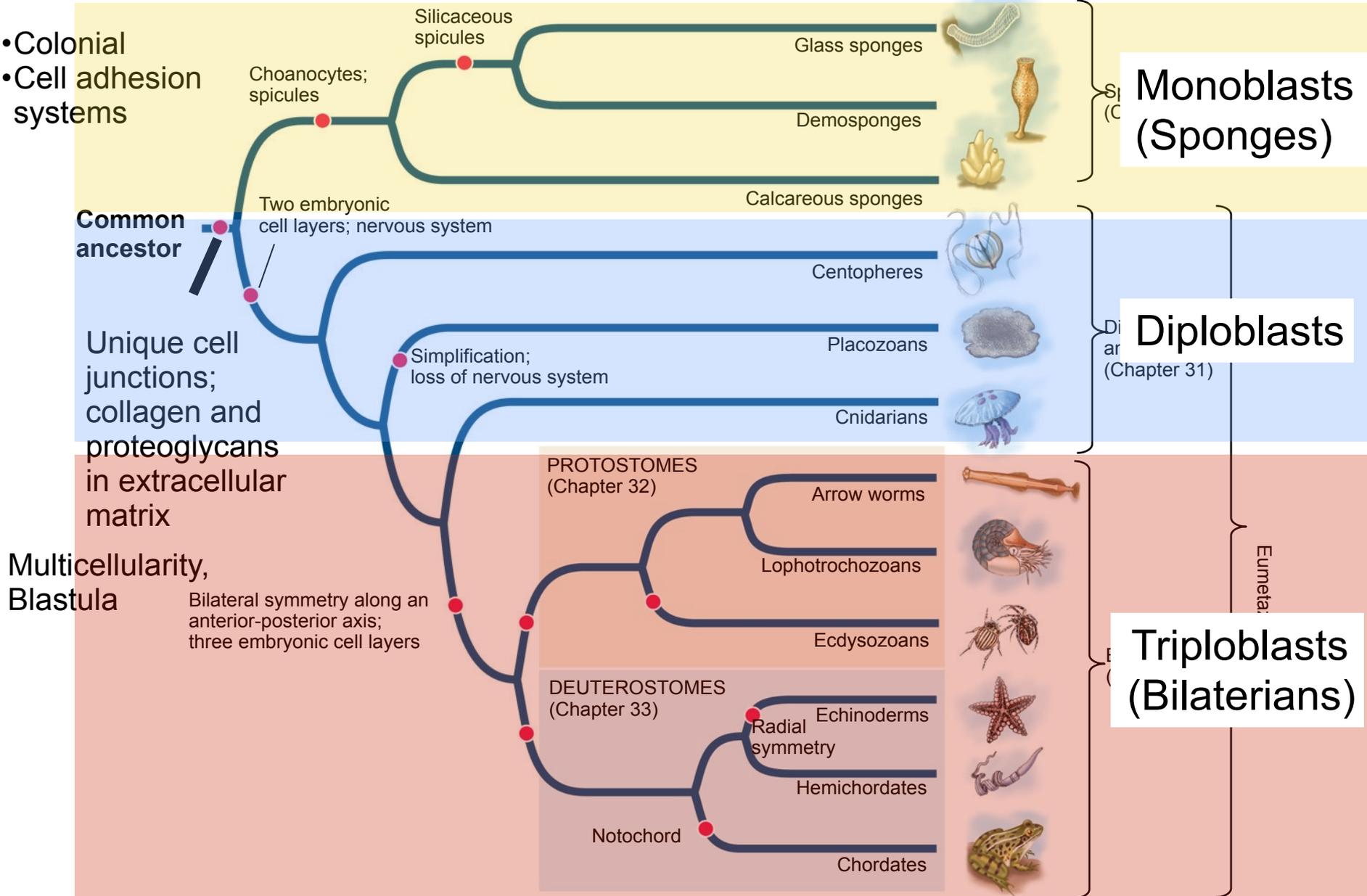
Diploblastic animals (Chapter 31)

Eumetazoans

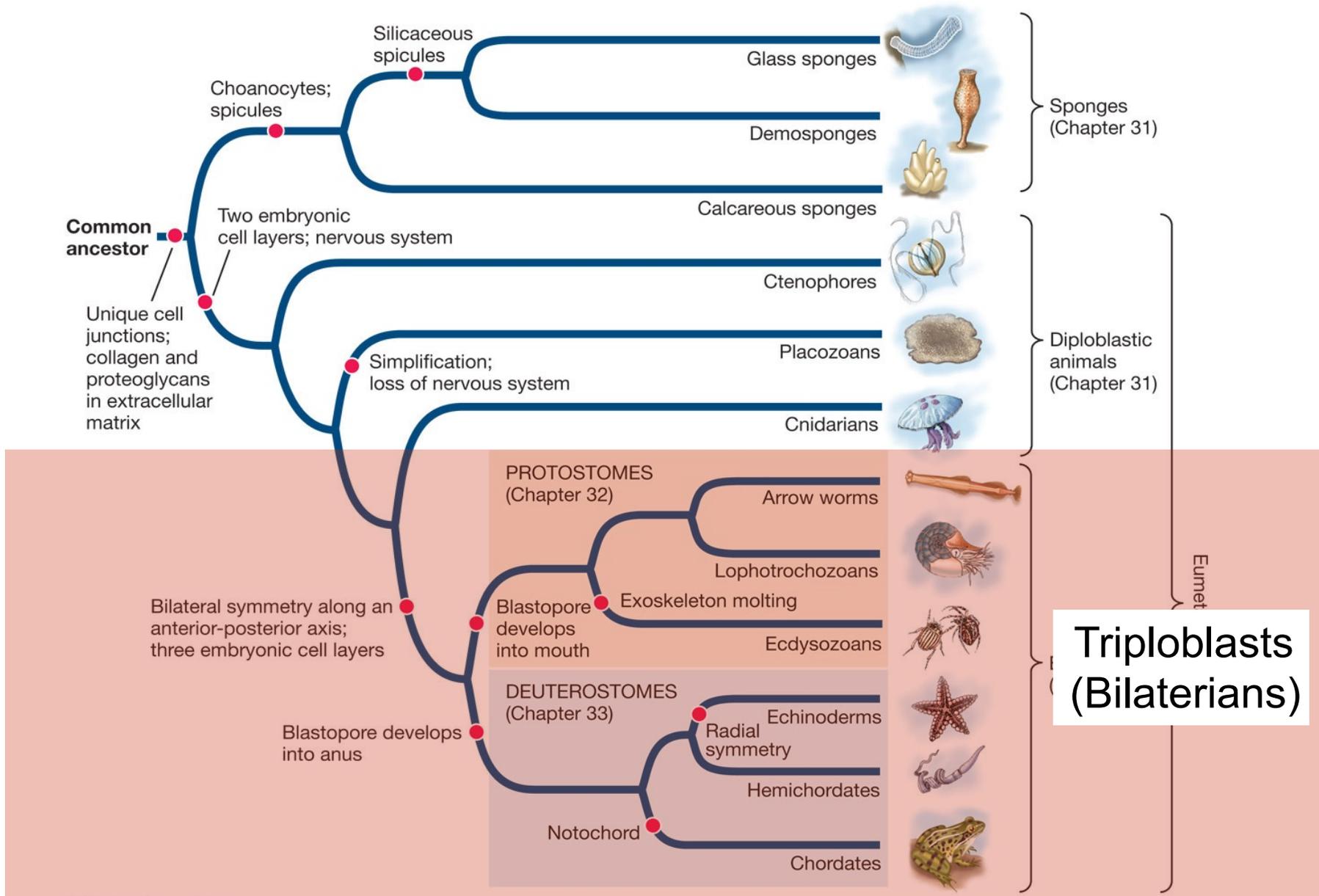
Bilaterains (triploblastic)

metazoans

Figure 31.1 A Phylogenetic Tree of the Animals

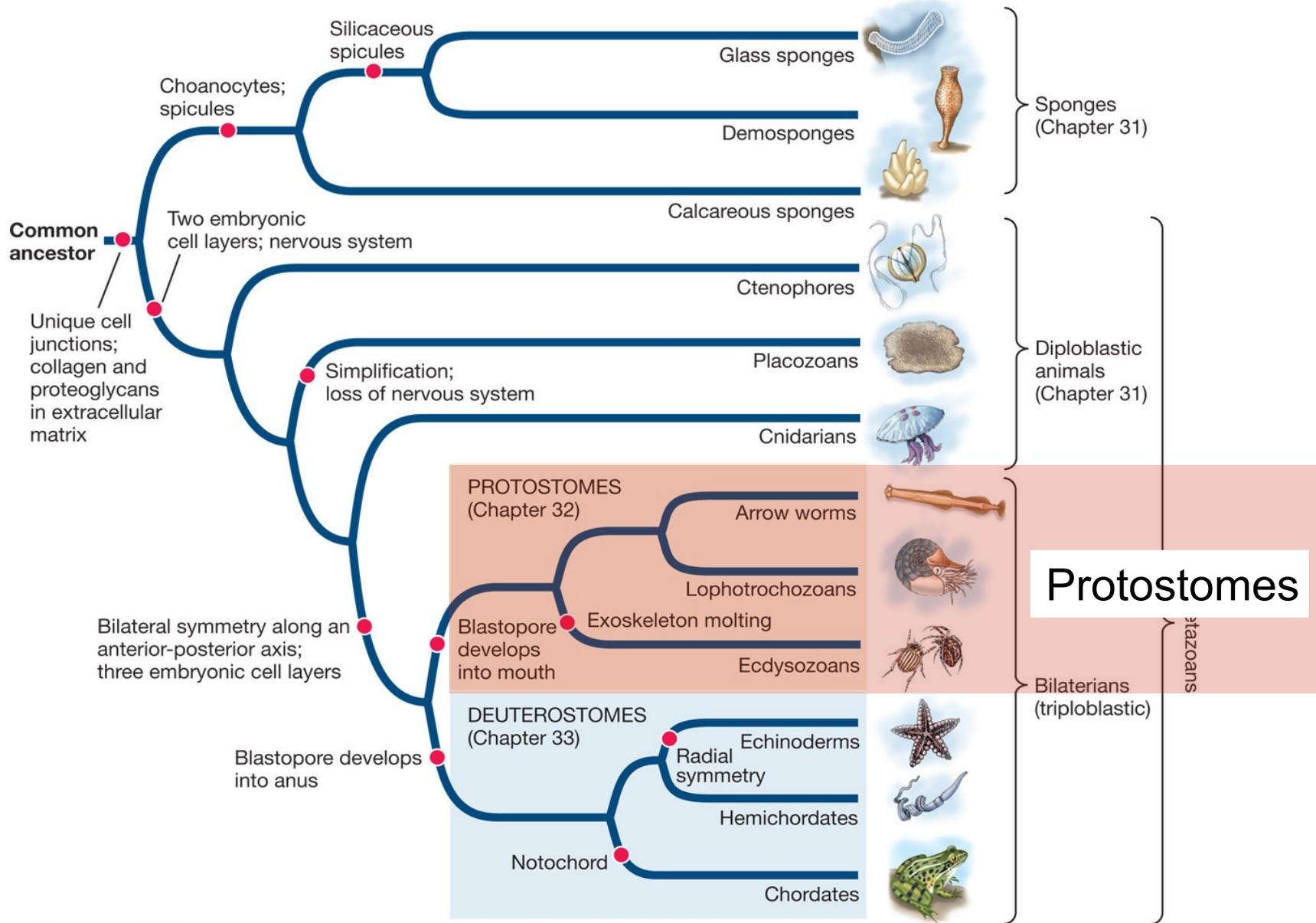


Animal Diversity



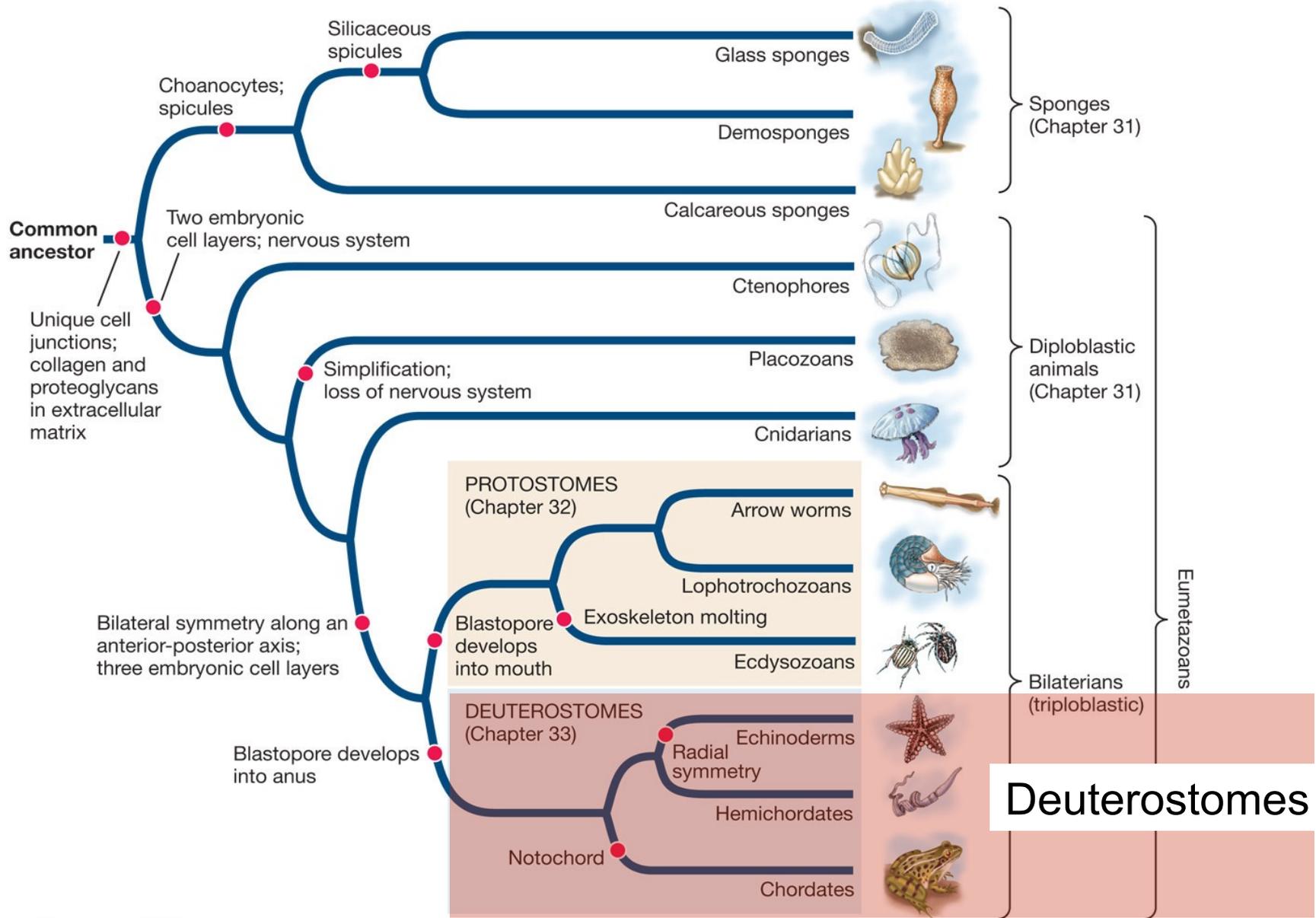
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Protostomes



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Protostomes



Sponges
(Chapter 31)

Diploblastic animals
(Chapter 31)

Bilaterians
(triploblastic)

Eumetazoans

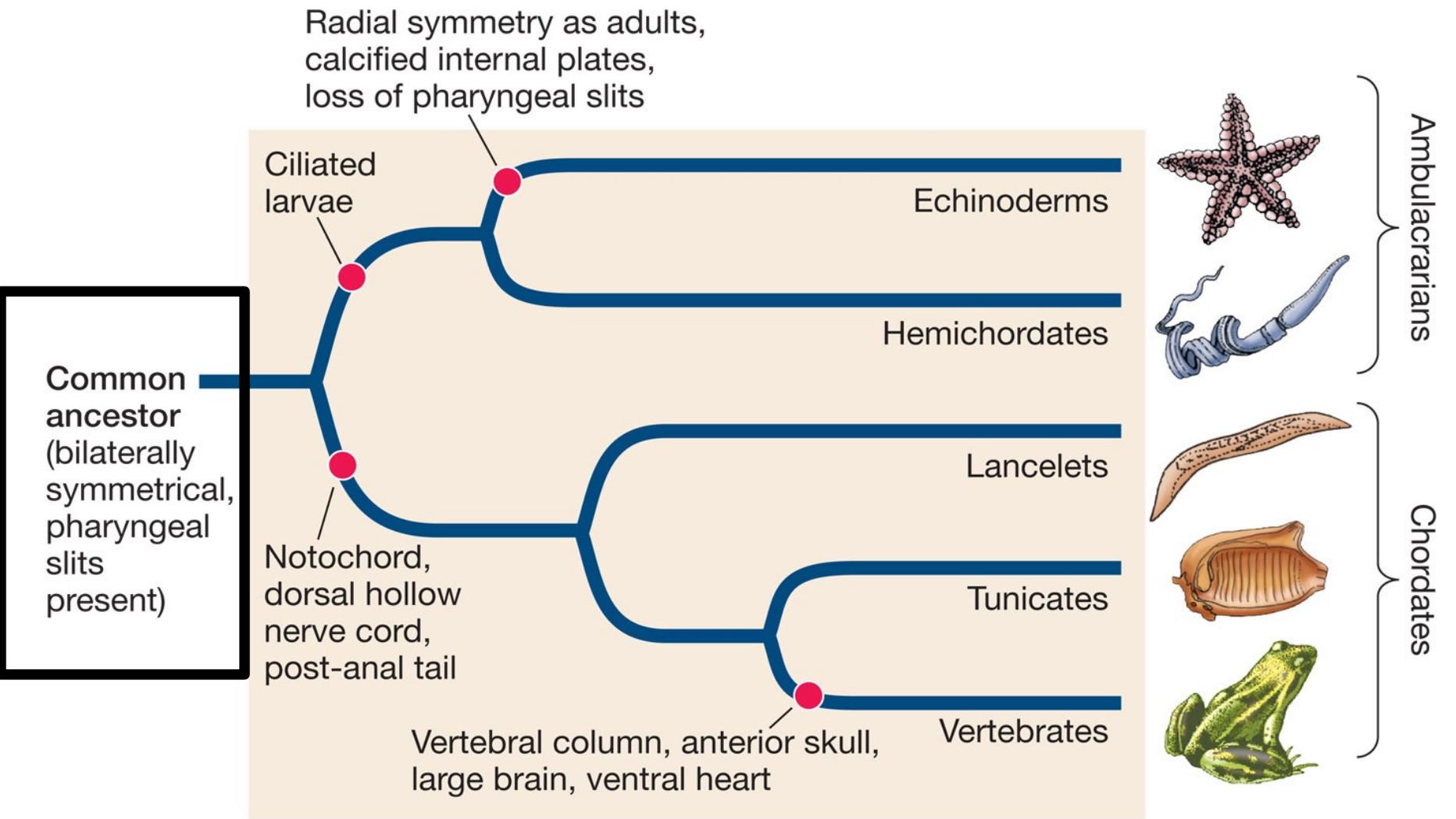
Deuterostomes

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An Overview of the Deuterostomes

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General/Common Features of Deuterostomes Common Ancestor



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General/Common Features of Deuterostomes Common Ancestor

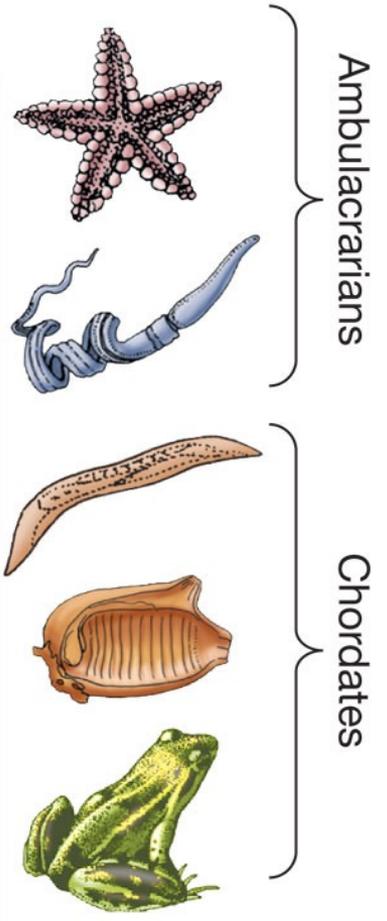
Radial symmetry as adults.

- Development
 - Radial cleavage
 - Blastopore becomes the anus and mouth forms on opposite side
 - Coelom develops from mesodermal pockets that bud off from the gastrula cavity
 - Triploblastic, coelomate animals with internal skeletons
 - Complete gut.
- There are far fewer species of deuterostomes than protostomes.

Common ancestor (bilaterally symmetrical, pharyngeal slits present)

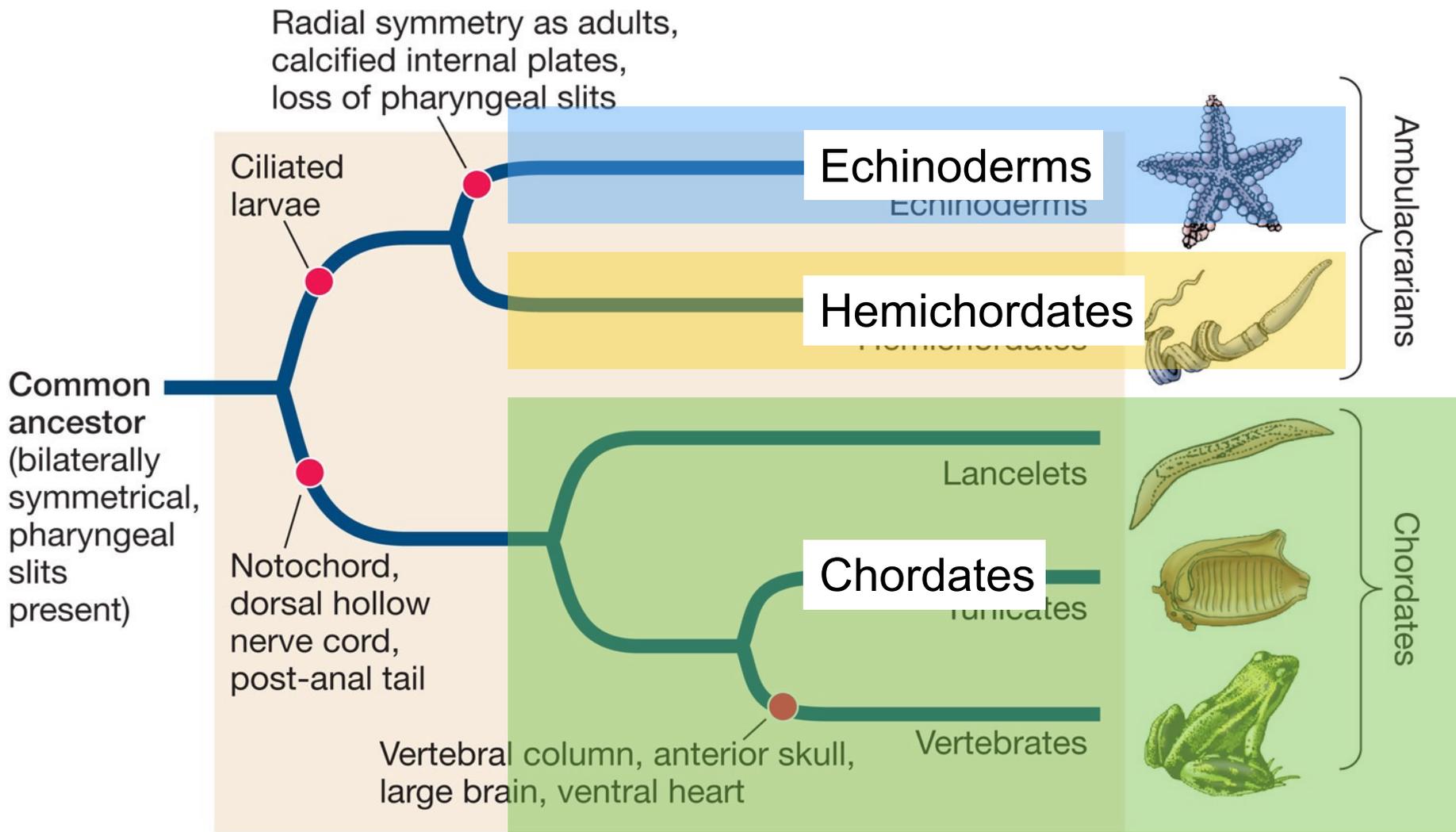
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Three Main Clades



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Ambulacrarians

Radial symmetry as adults,
calcified internal plates,
loss of pharyngeal slits

Ciliated
larvae

Echinoderms

Hemichordates

Common
ancestor
(bilaterally
symmetrical,
pharyngeal
slits
present)

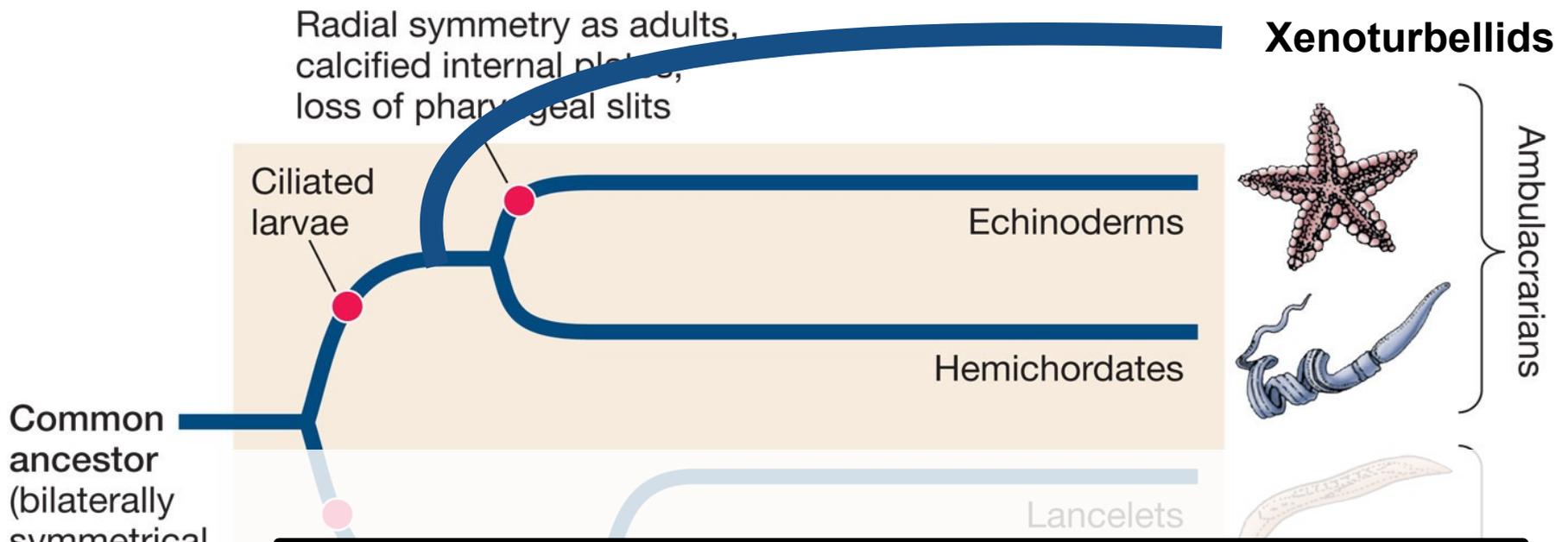


Ambulacrarians

- Two main groups: echinoderms and hemichordates
- Have ciliated, bilaterally symmetrical larvae
- Adult hemichordates are also bilaterally symmetrical.

- Xenoturbellids (two species): wormlike organisms that feed on or parasitize mollusks in the north Atlantic.
- Acoels: also wormlike, live as plankton, between grains of sediment, or on other organisms such as corals.

Ambulacrarians - Others - Xenoturbellids



Xenoturbellids (two species):
 wormlike organisms that feed on or parasitize mollusks in the north Atlantic.

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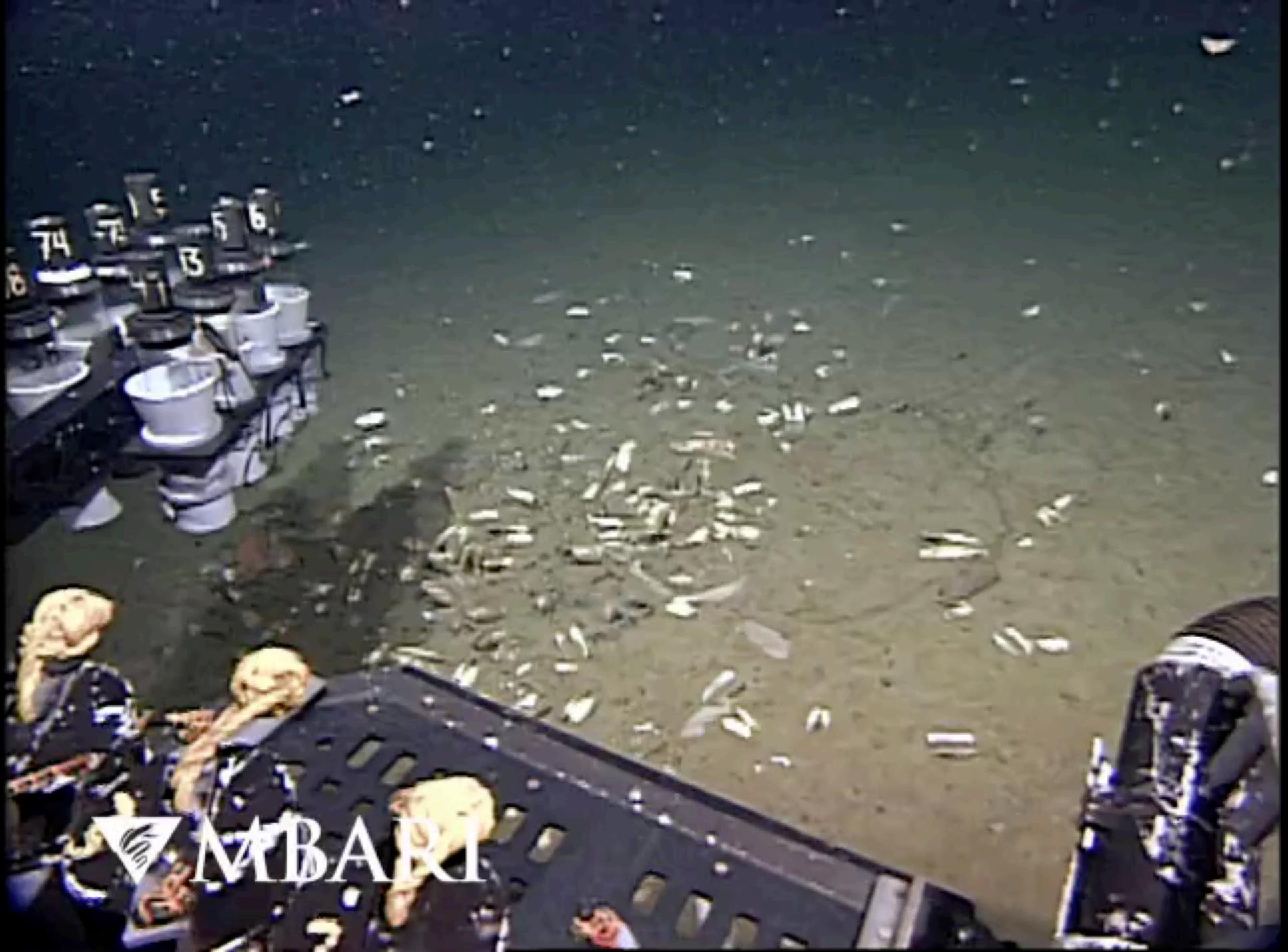
Newly discovered deep-sea worms, including one named 'churro,' could shed light on animal evolution



A California-led team of researchers has discovered four new, pink-hued species of deep-sea worm known as *Xenoturbella* that could shed light on animal evolution.



By **Amina Khan** · Contact Reporter



 MBARI



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New deep-sea species of *Xenoturbella* and the position of Xenacoelomorpha

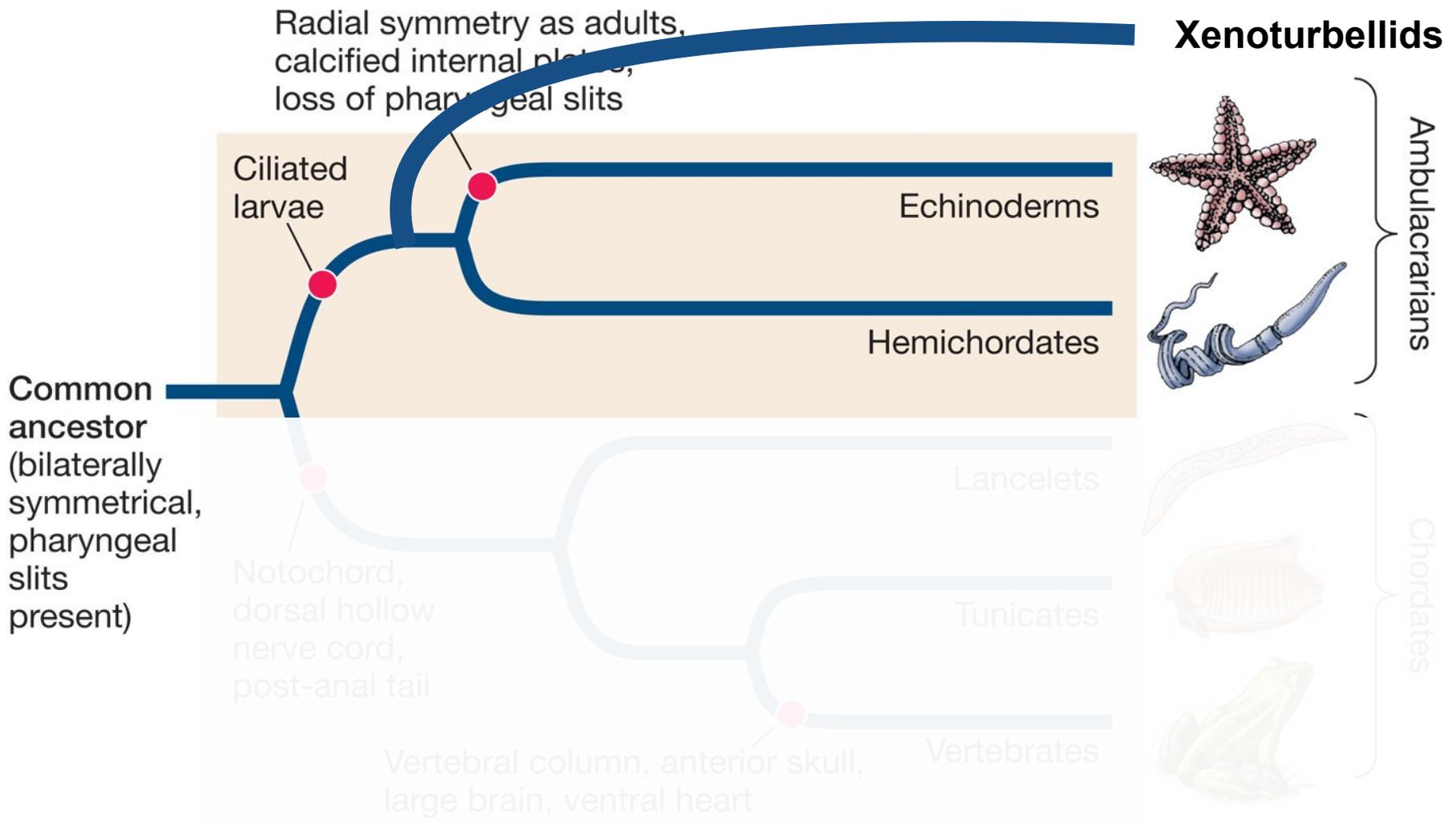
Greg W. Rouse, Nerida G. Wilson, Jose I. Carvajal & Robert C. Vrijenhoek

[Affiliations](#) | [Contributions](#) | [Corresponding author](#)

Nature **530**, 94–97 (04 February 2016) | doi:10.1038/nature16545

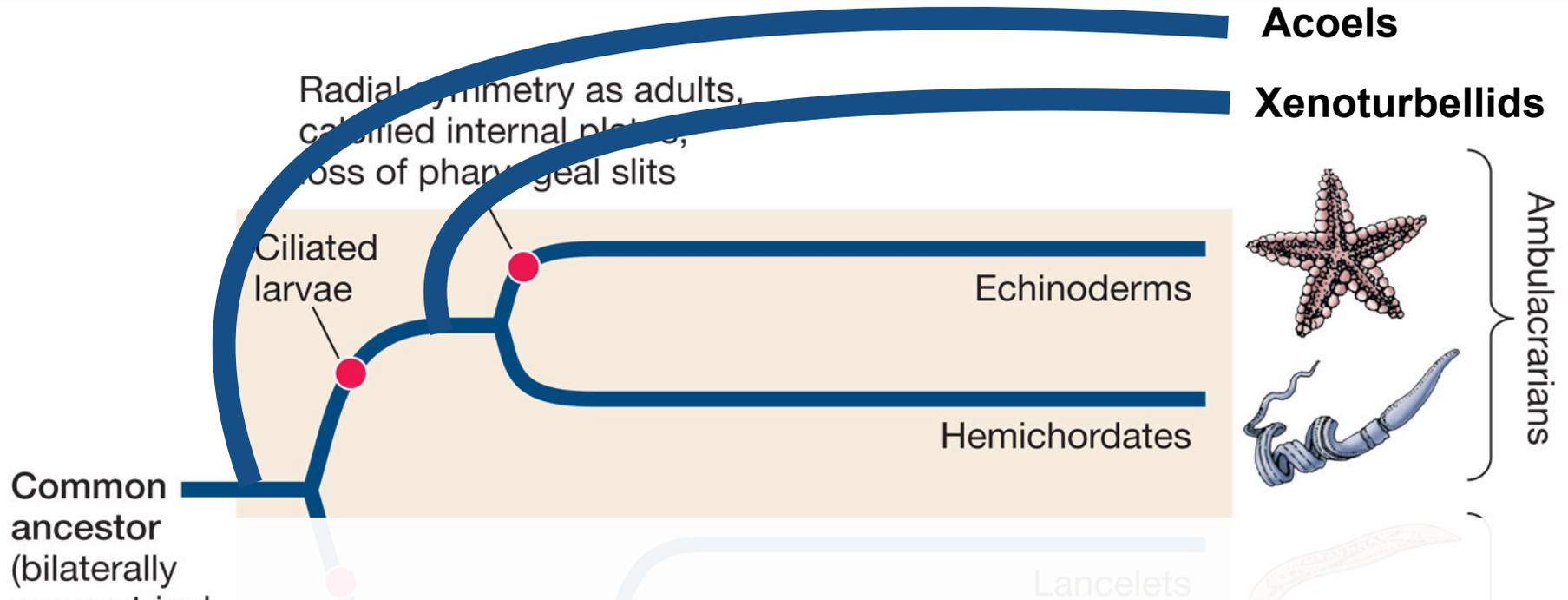
Received 19 September 2015 | Accepted 15 December 2015 | Published online 03 February 2016

Ambulacrarians



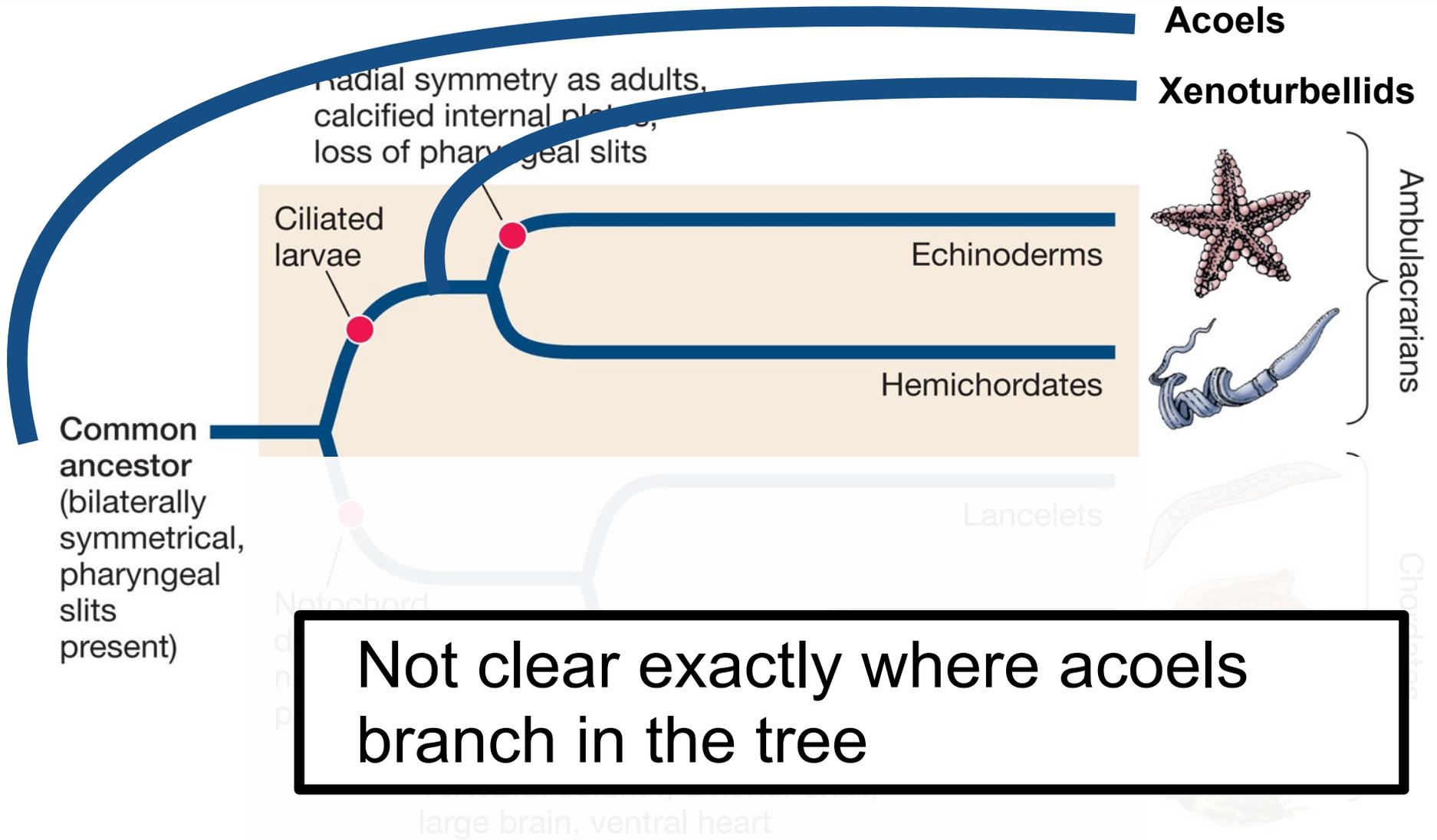
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Ambulacrarians



Acoels: also wormlike, live as plankton, between grains of sediment, or on other organisms such as corals.

Ambulacrarians



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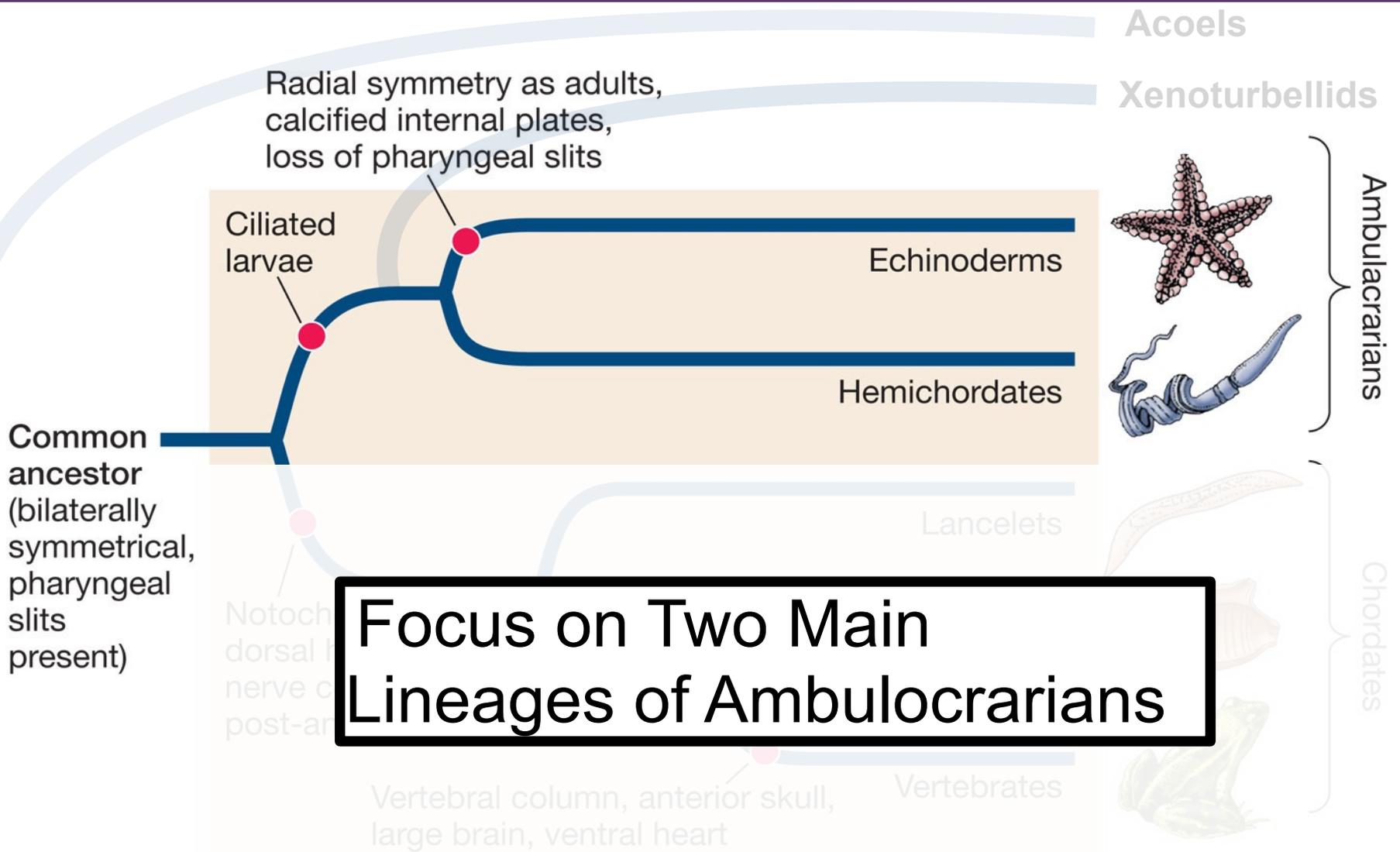
Figure 33.4 Highly Reduced Acoels Are Probably Relatives of the Ambulacrarians

Wamionoa sp.



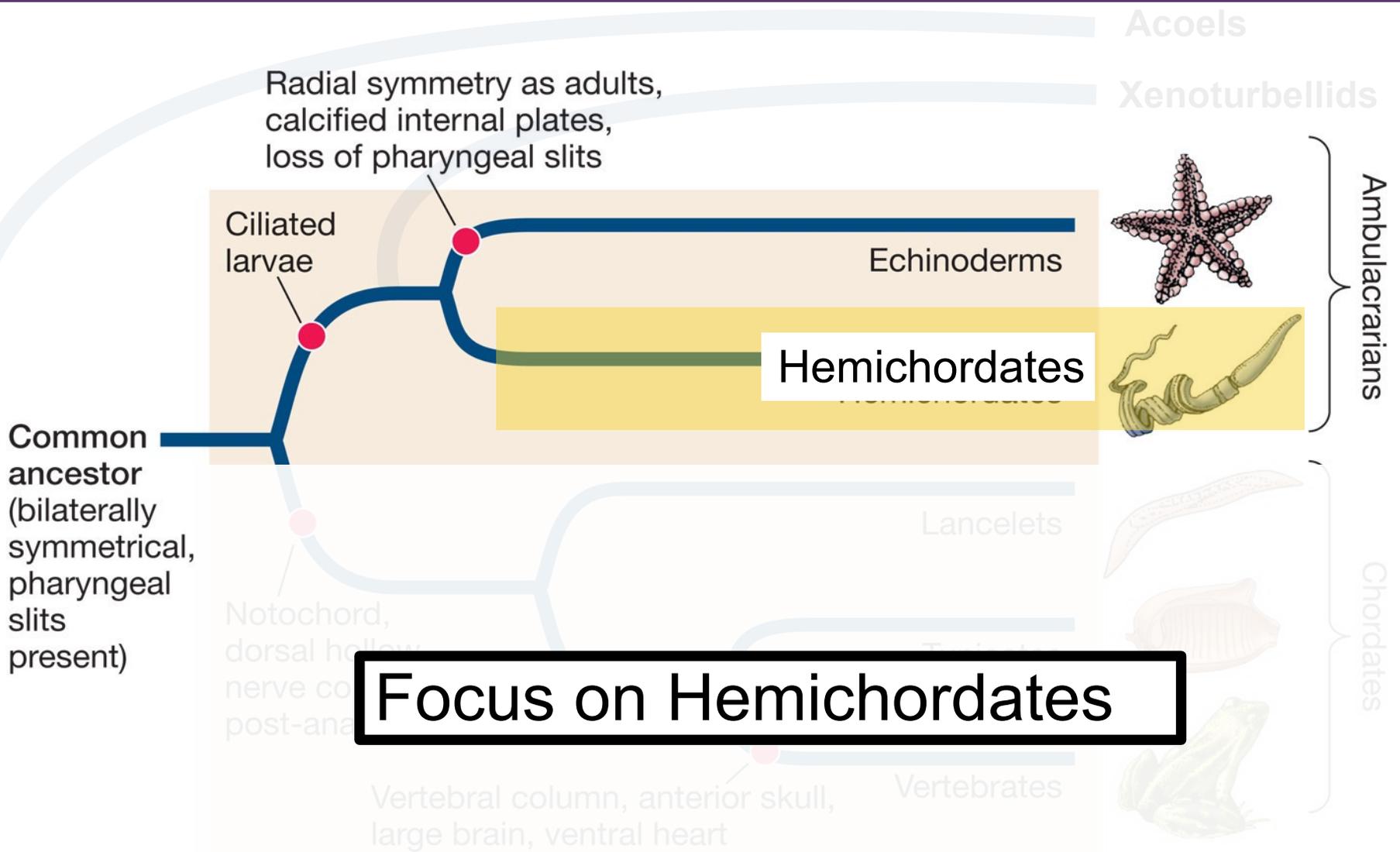
- See <http://www.nature.com/news/2011/110209/full/470161a.html> for discussion of acoels
- <http://www.latimes.com/science/sciencenow/la-sci-sn-churro-sea-worm-bilateria-20160205-story.html>
- <http://www.nature.com/nature/journal/v530/n7588/abs/nature16545.html>

Ambulacrarians



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Hemichordates



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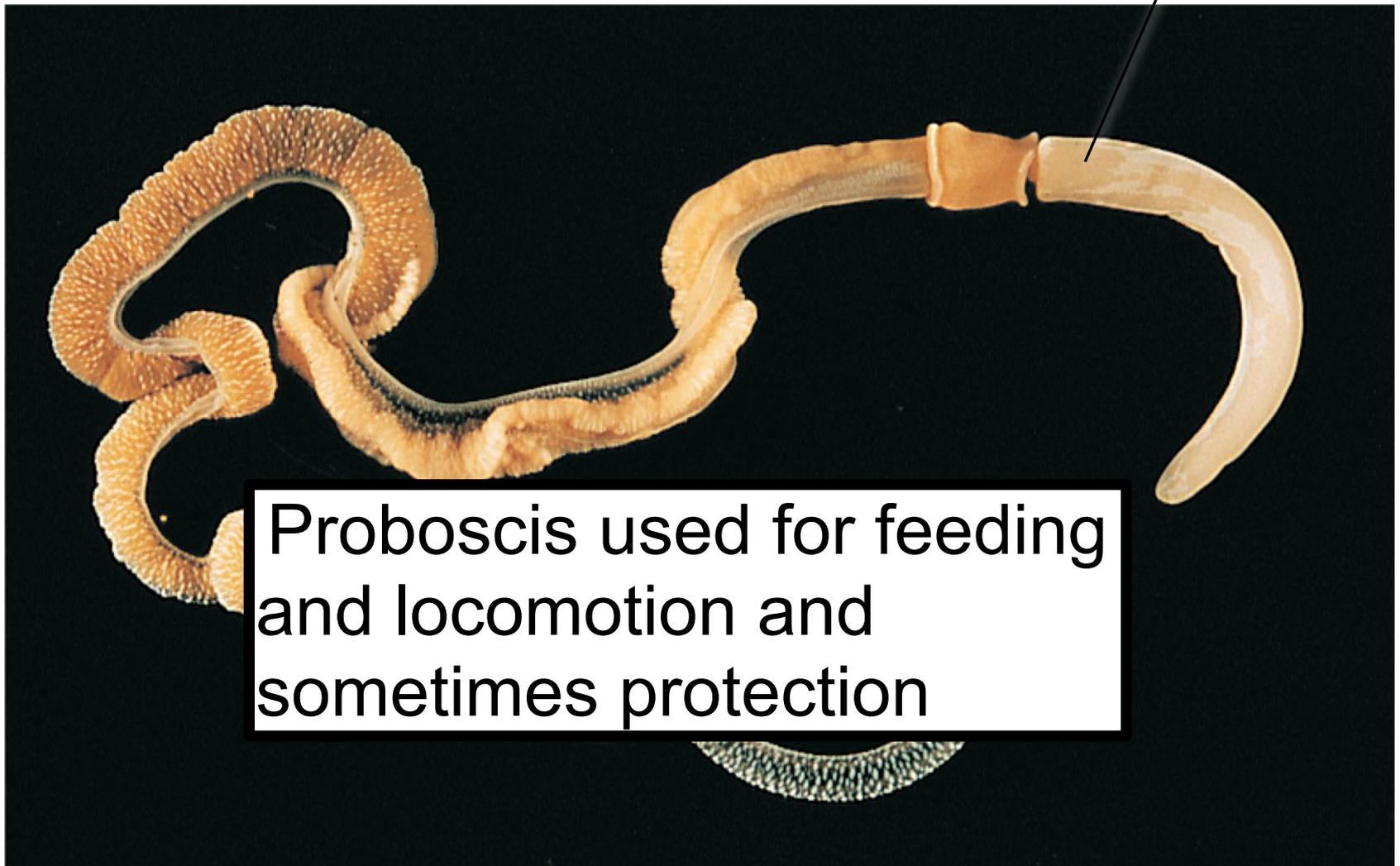
Hemichordates Body Plan



Saccoglossus kowalevskii

(A)

Proboscis

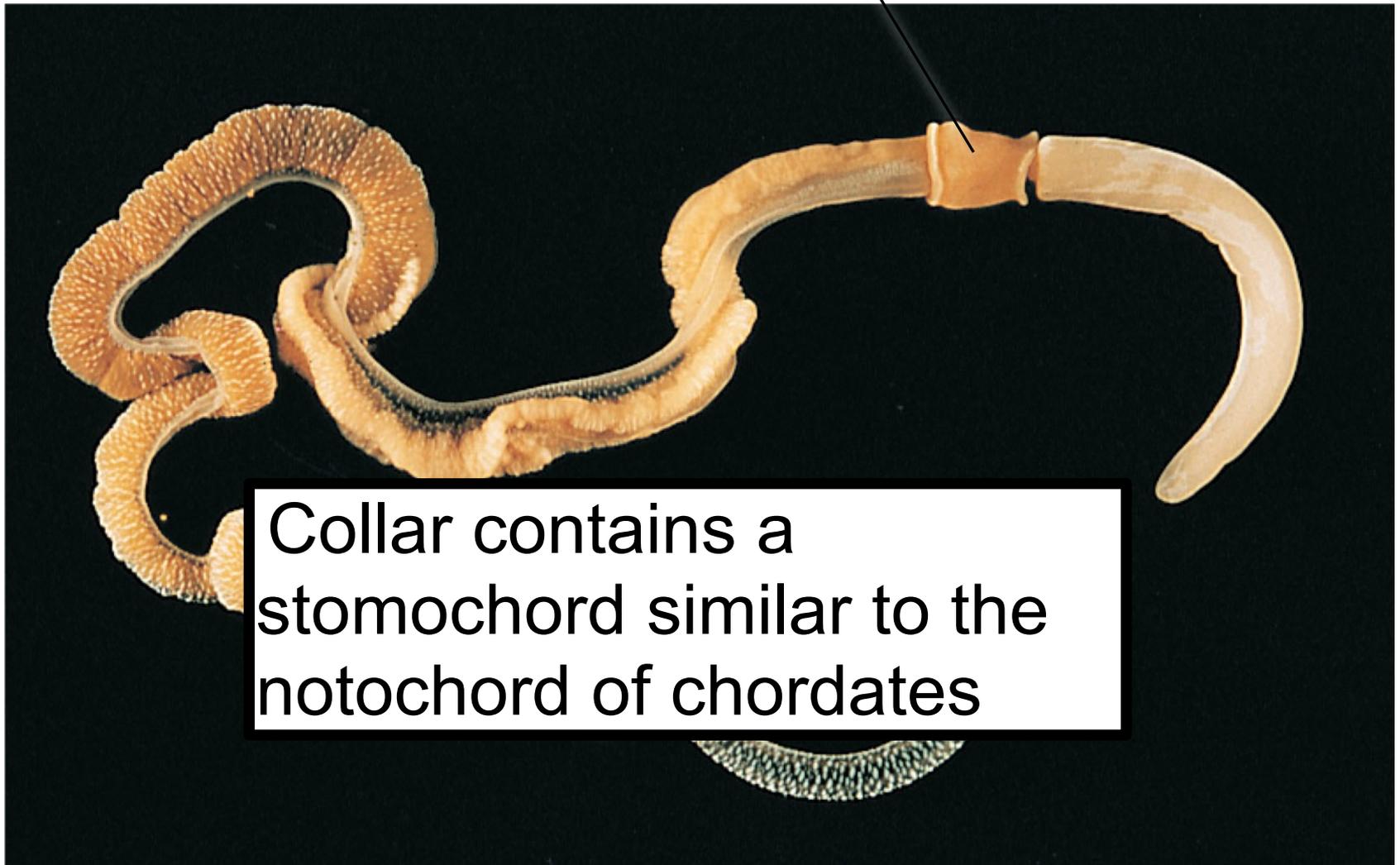


Proboscis used for feeding and locomotion and sometimes protection

Saccoglossus kowalevskii

(A)

Collar



Collar contains a stomochord similar to the notochord of chordates

Saccoglossus kowalevskii

Hemichordates Body Plan

Trunk

(A)



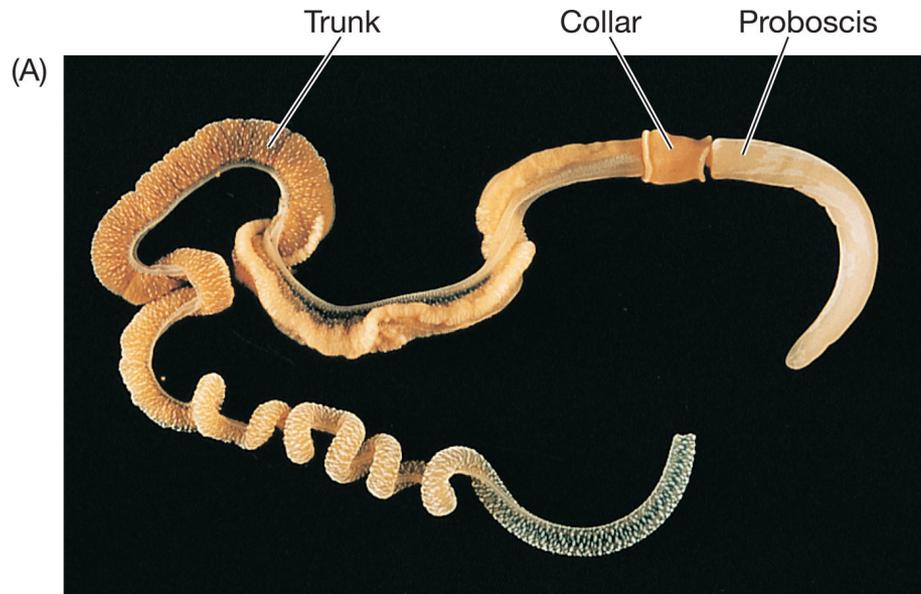
Trunk contains pharynx
and pharyngeal gill slits

Saccoglossus kowalevskii

For Your Personal Enjoyment

Group 1: Acorn worms

- Up to 2 m long, burrow in soft marine sediments
- Digestive tract is a mouth, pharynx, and intestine
- The pharynx opens to the outside via pharyngeal slits.
- Vascularized tissue around the slits is a gas exchange surface.
- Prey is captured with the large proboscis, which is covered in sticky mucus.



Saccoglossus kowalevskii

Acorn Worms



© Nature/OIST



© Nature/OIST

Welcome to the family! Acorn worm is a distant human relative that shares 70% of our genes

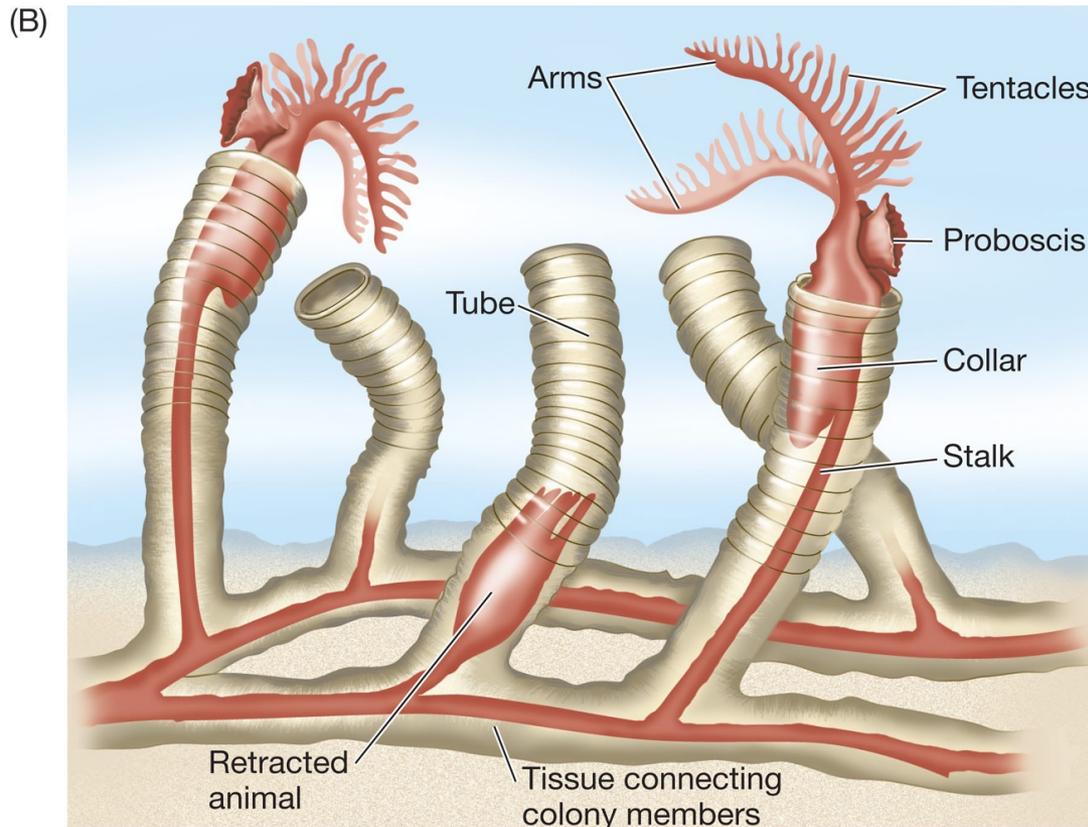
- **Researchers sequenced the genomes of two species of acorn worm**
- **They found 8,600 families of genes are shared across deuterostomes**
- **This is a large animal group that ranges from worms to frogs and humans**
- **14,000 of our genes can be traced back to the original deuterostome**

By [VICTORIA WOOLLASTON FOR MAILONLINE](#)

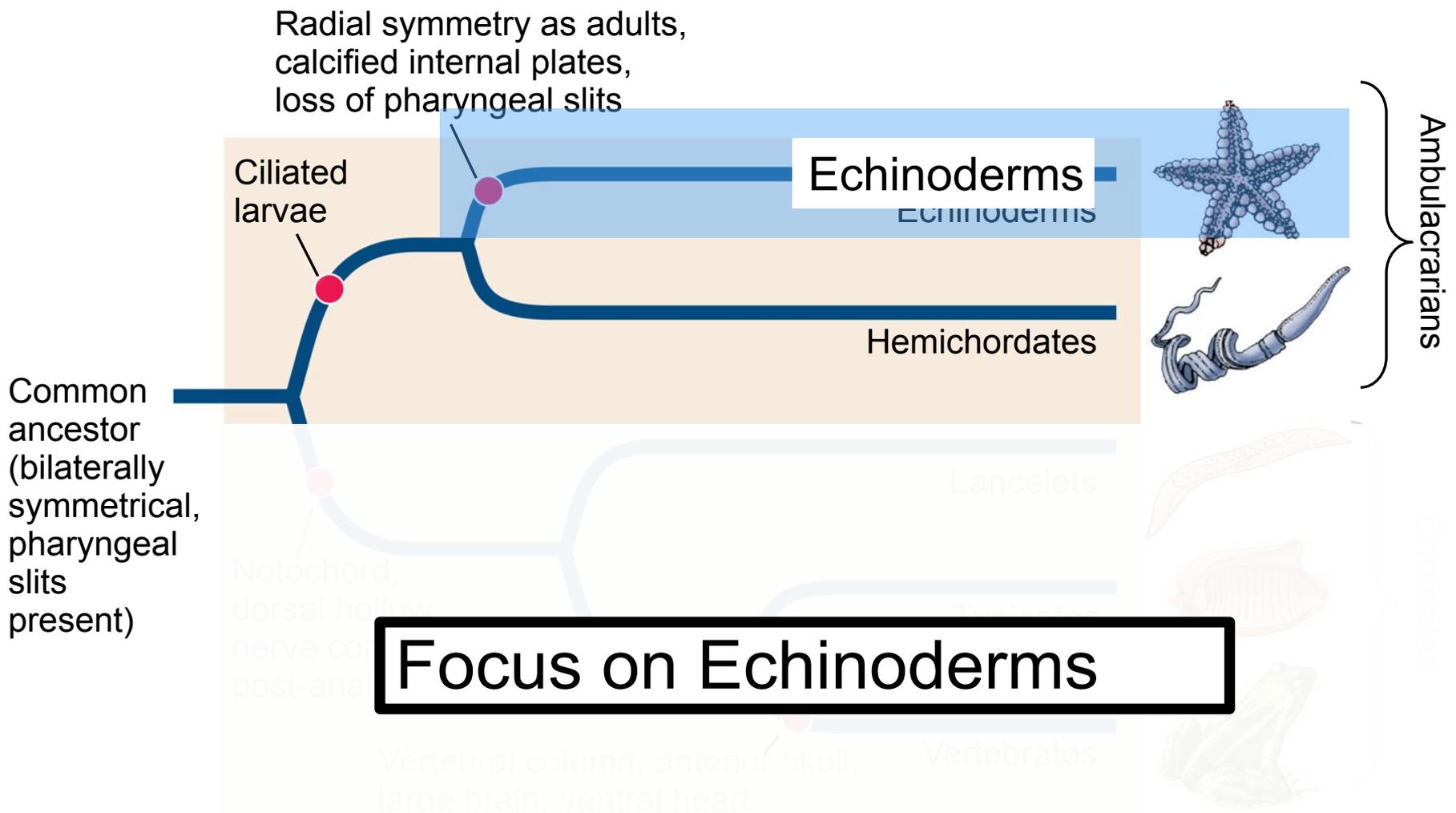
PUBLISHED: 10:01 EST, 19 November 2015 | **UPDATED:** 10:24 EST, 19 November 2015

Group 2: Pterobranchs

- Sedentary marine animals that live in tubes secreted by the proboscis.
- Some are solitary, others form colonies.
- The collar has one to nine pairs of arms with tentacles for prey capture and gas exchange.



Ambulacrarians



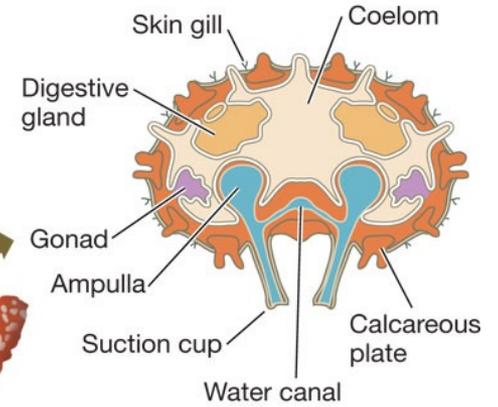
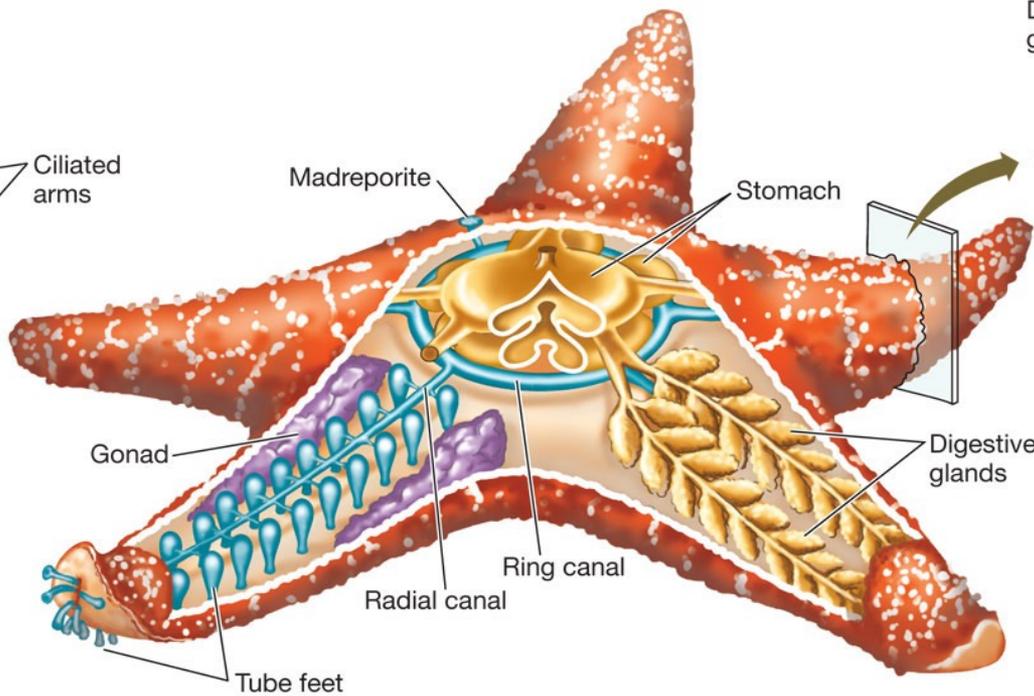
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~7,500 species

(A) Sea star larva
(bilateral symmetry)



(B) Adult sea star
(pentaradial symmetry)

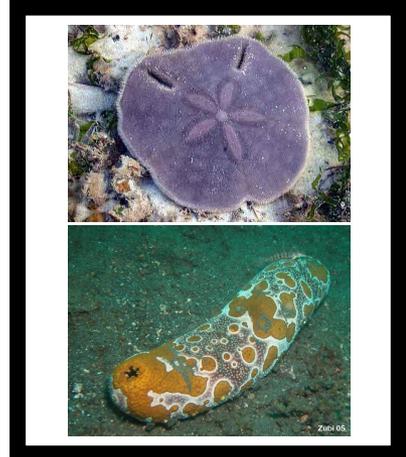
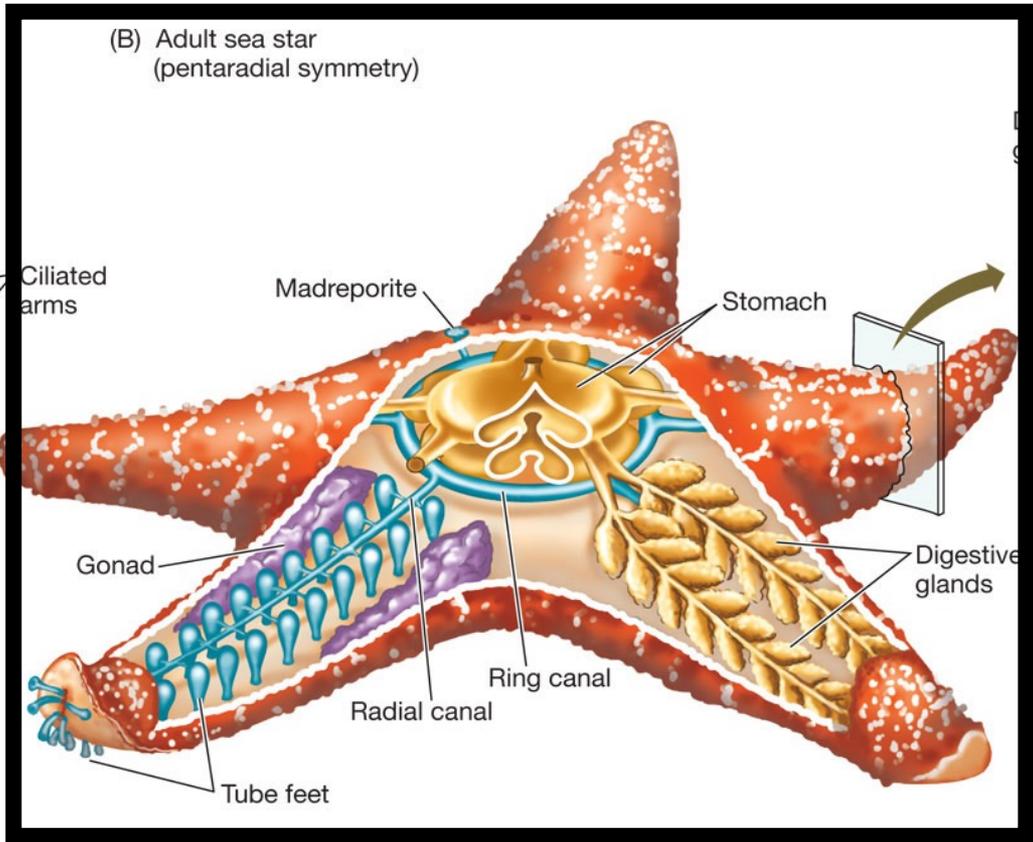


Symmetry

Larvae are bilateral

Adults are pentaradial with exceptions

Sand dollars and sea cucumbers are trending towards bilateral



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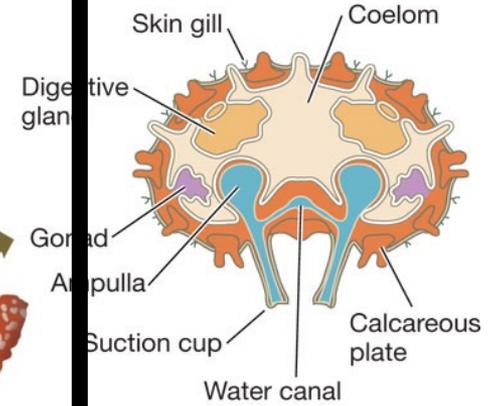
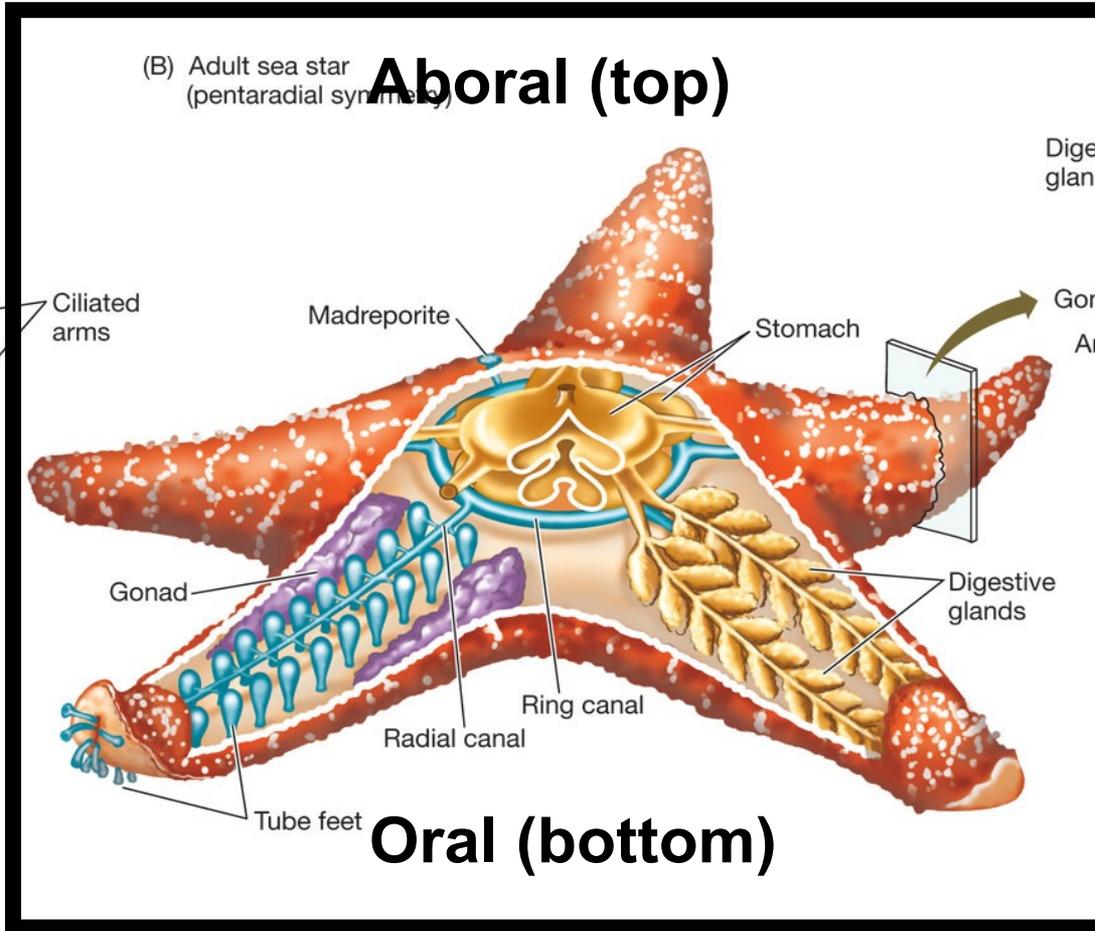
Echinoderm Symmetry

No head or brain

(A) Sea star larva
(bilateral symmetry)



(B) Adult sea star
(pentaradial symmetry)



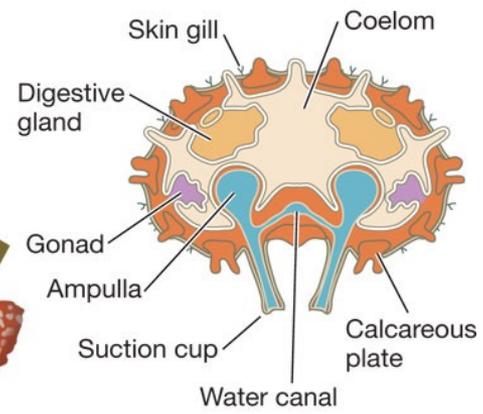
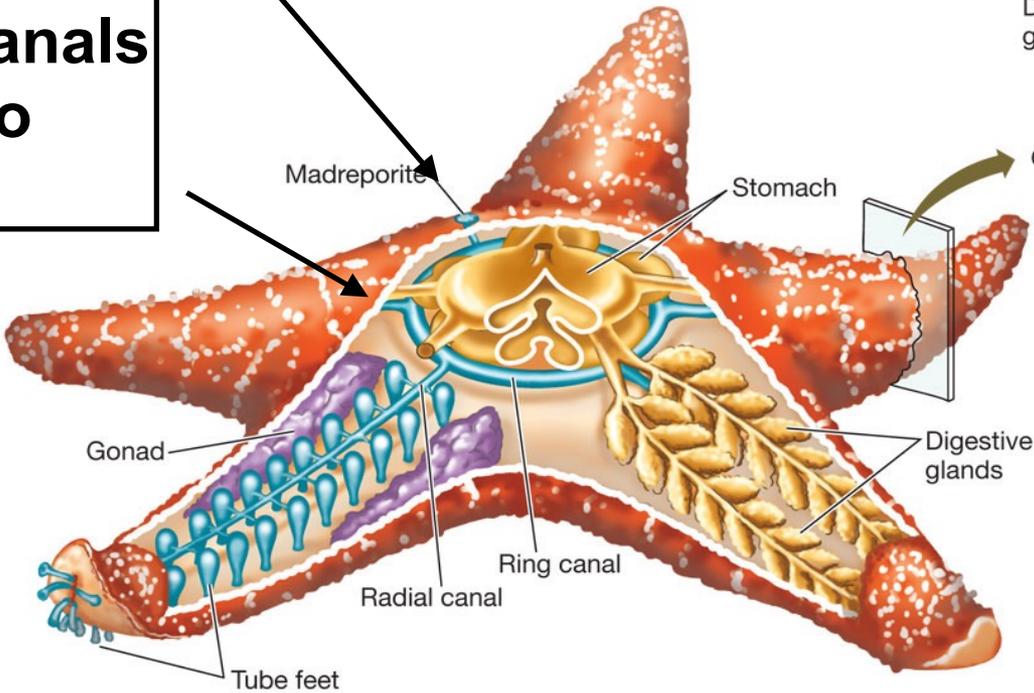
Water Vascular System

Water enters through pores known as madreporites

Hydraulic system used for locomotion, feeding, waste transport, respiration

Circulates through canals that lead to tube feet

(A) Cross section of a sea star (pentaradial symmetry) (B) Adult sea star (pentaradial symmetry)



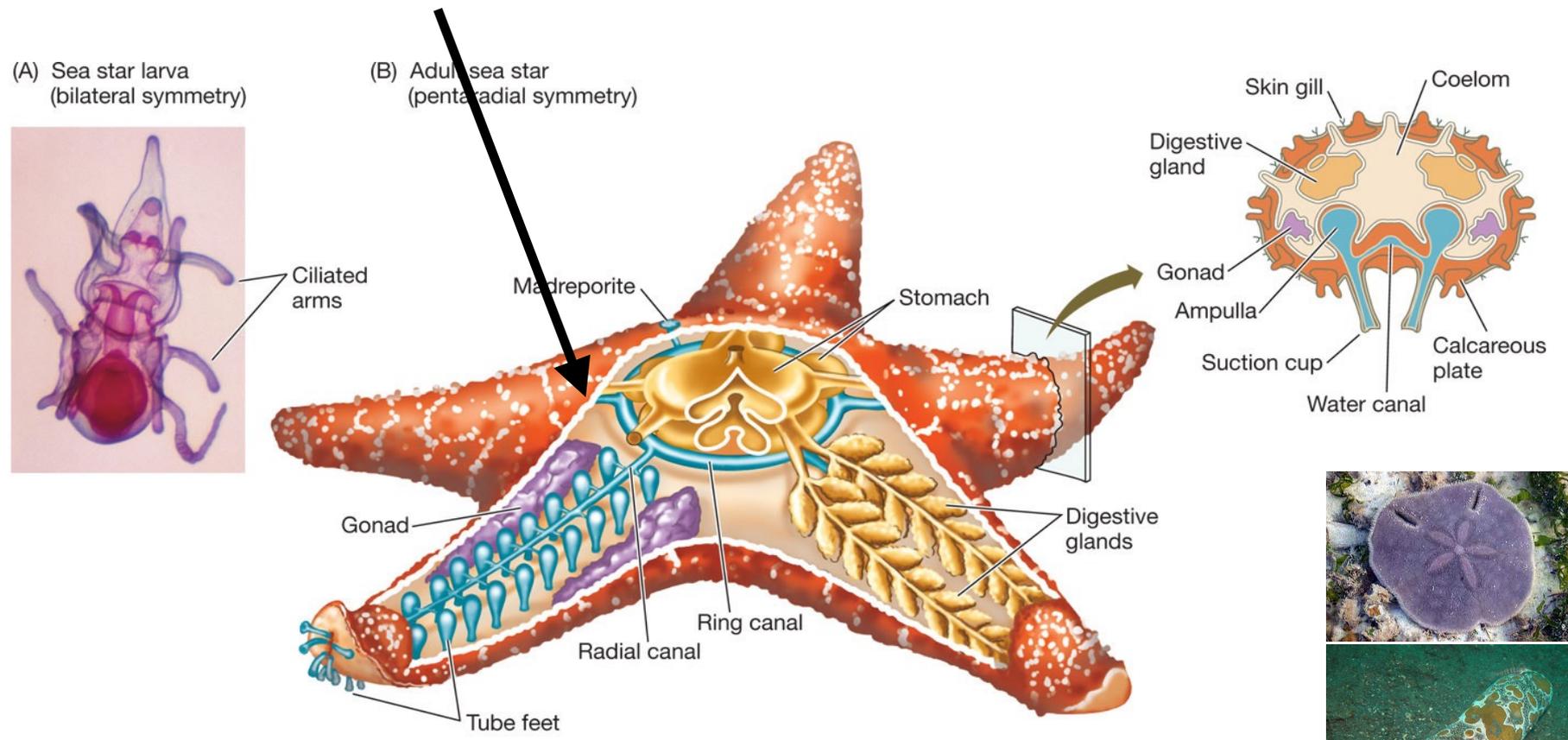
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Echinoderm Video



Endoskeleton

- Endoskeleton derived from mesoderm
- The endoskeleton is covered in epidermis
- The skeletal plates are connected by collagen which can be stiff or flexible which controls body tone without muscle



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Echinoderm Endoskeleton



Crinoidea- Sea Lily's and Feather Stars

- 600 described extant species, many more in the fossil record
- Both shallow water and deep trenches
- Oral surface in **dorsal**, aboral surface is **ventral**
- Sea Lily's are attached to the surface by a stalk

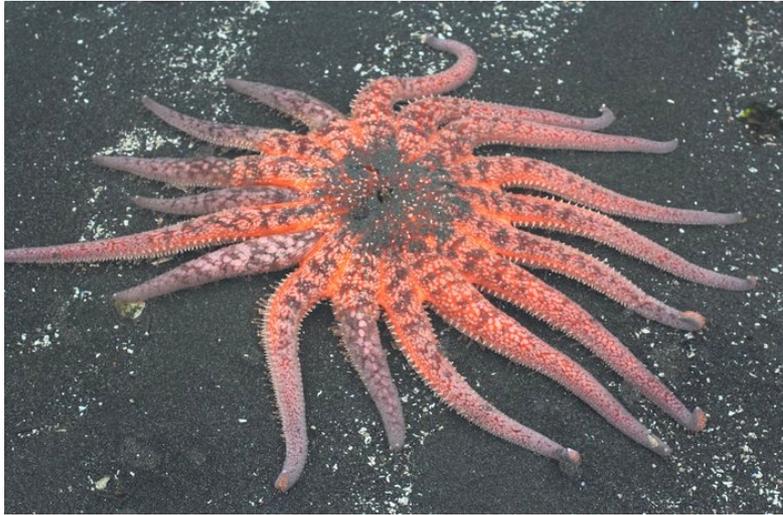


Feather Star

Fossil Sea Lily's, 330 mya

Asteroidea- Sea stars

- 1500 described species, both shallow and deep habitats
- Mostly predaceous with an **evertable stomach**
- Remarkable capacity for **regeneration**



Pycnopodia- sunflower star



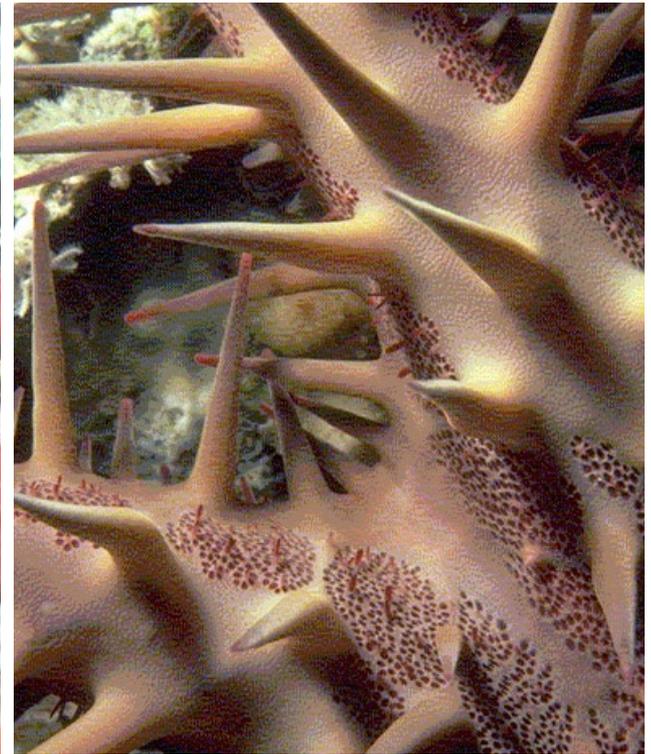
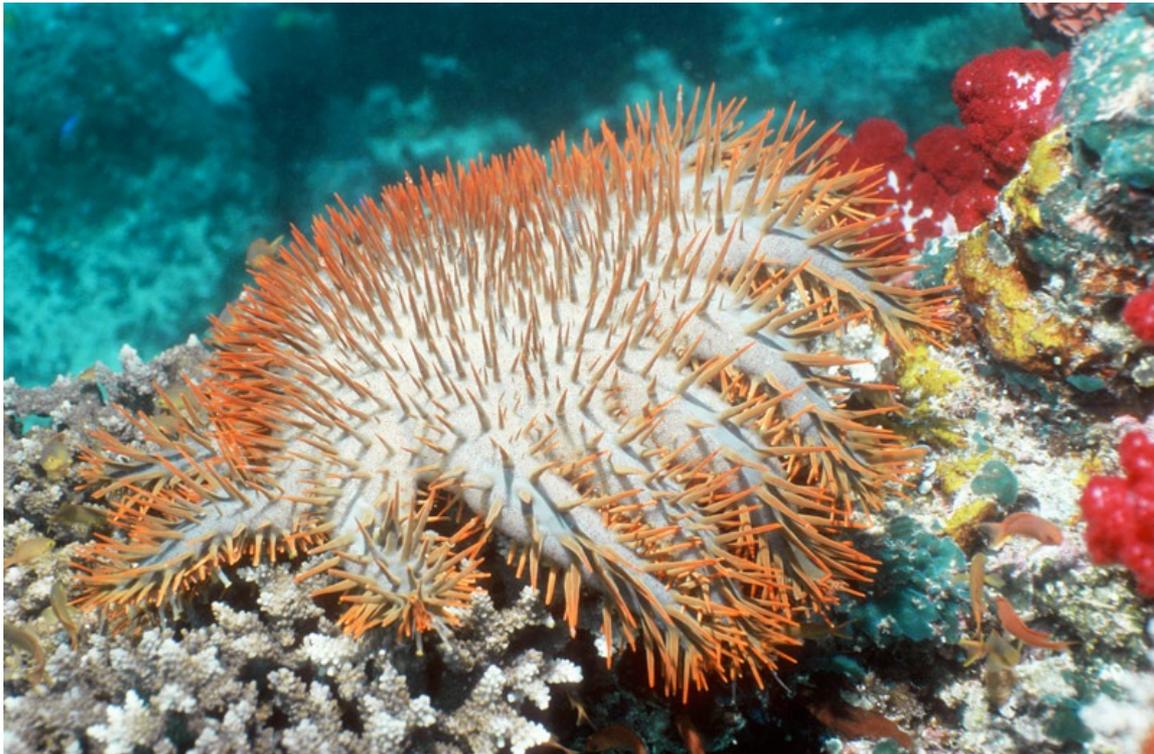
Asteroidea- Eversible stomach

- When feeding, sea stars can extend their stomach pushing it through very small openings
- The **water vascular system** is used to slowly pull muscles apart along with specialized '**catch collagen**'



Astroidea- Crown of Thorns

- Among the largest sea stars, spines have **neurotoxins**
- Voracious predator of coral (Great Barrier Reef)
- **Introduced species** that is difficult to control



Ophiuroidea- Brittle stars and basket stars

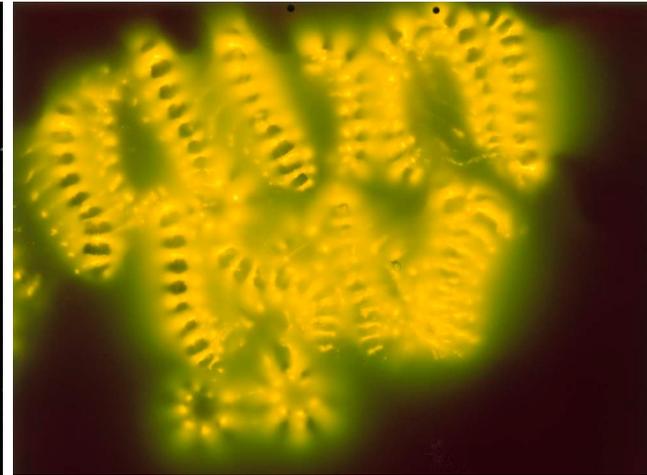
- 1,900 described species
- Long, slender arms often with spines; fast moving
- Secretive predators, some are **bioluminescent**



Brittle Star



Basket Star



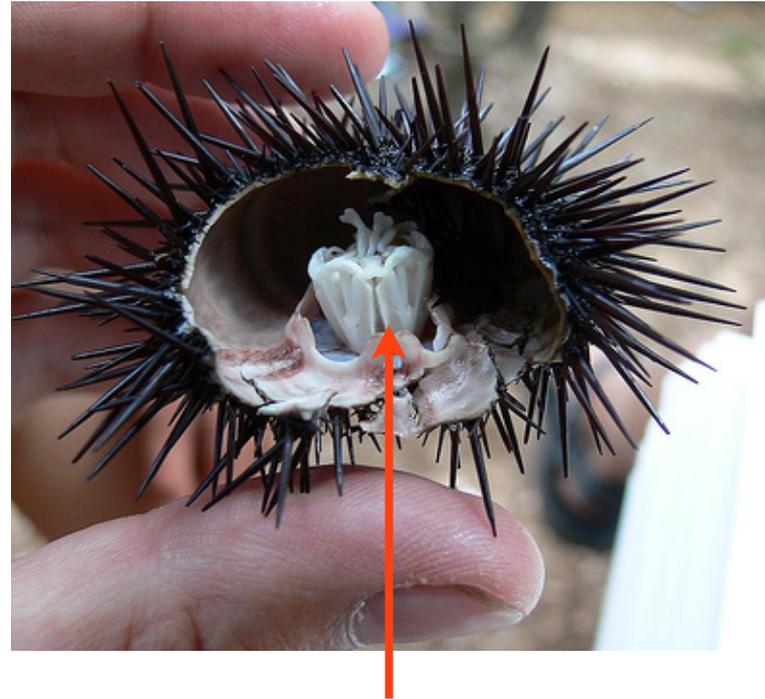
Basket Star

Echinoidea- Sea Urchins and Sand Dollars

- 950 described species
- Slow moving, **grazers** on algae (Aristotle's lantern)
- Protected by spines (urchins) and a **calcareous test**



Strongylocentrotus



Aristotle's lantern

Echinoidea- Sea Urchins and California Kelp

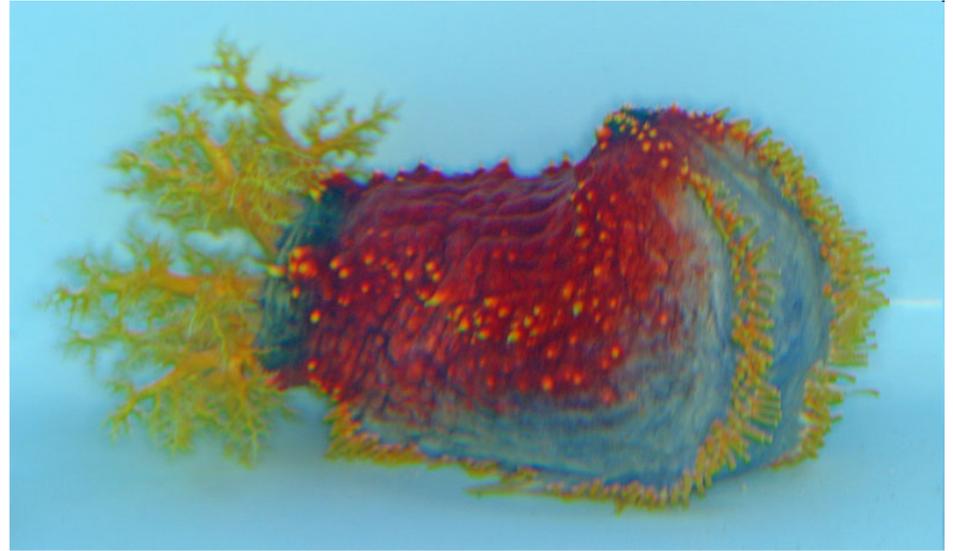
- Urchins feed on **kelp** (brown algae)
- Kelp forests in California harbor a great diversity of species
- If unchecked, urchins can create 'urchin barrens'
- Sea otters prey on urchins (using tools) keeping populations in check; they are a **keystone species**



Kelp forest, Monterey Bay

Holothuroidea- Sea Cucumbers

- 1,200 described species, scavengers and filter feeders
- Soft-bodied, secondary bilateral symmetry*
- Catch collagen allows them squeeze into tight places
- Unique defense (evisceration), some are toxic



Chordates

Focus on Chordates

Radial symmetry as adults,
calcified internal plates,
loss of

Ciliated
larvae

Echinoderms

Hemichordates

Ambulacrarians

Common ancestor
(bilaterally
symmetrical,
pharyngeal
slits
present)

Notochord,
dorsal hollow
nerve cord,
post-anal tail

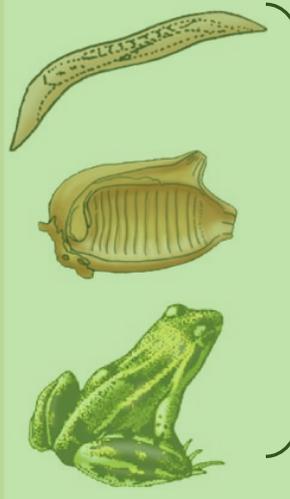
Vertebral column, anterior skull,
large brain, ventral heart

Lancelets

Tunicates

Vertebrates

Chordates



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Chordates

Focus on Chordates

Radial symmetry as adults,
calcified internal plates,
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Ciliated
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Echinoderms

Hemichordates

Ambulacrarians

Common ancestor
(bilaterally
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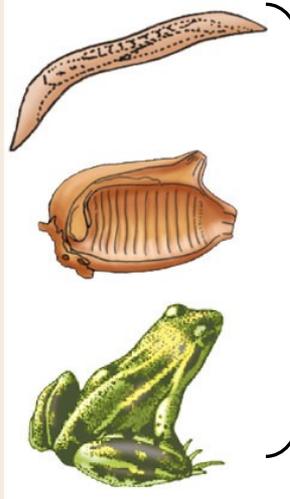
Notochord,
dorsal hollow
nerve cord,
post-anal tail

Vertebral column, anterior skull,
large brain, ventral heart

Lancelets

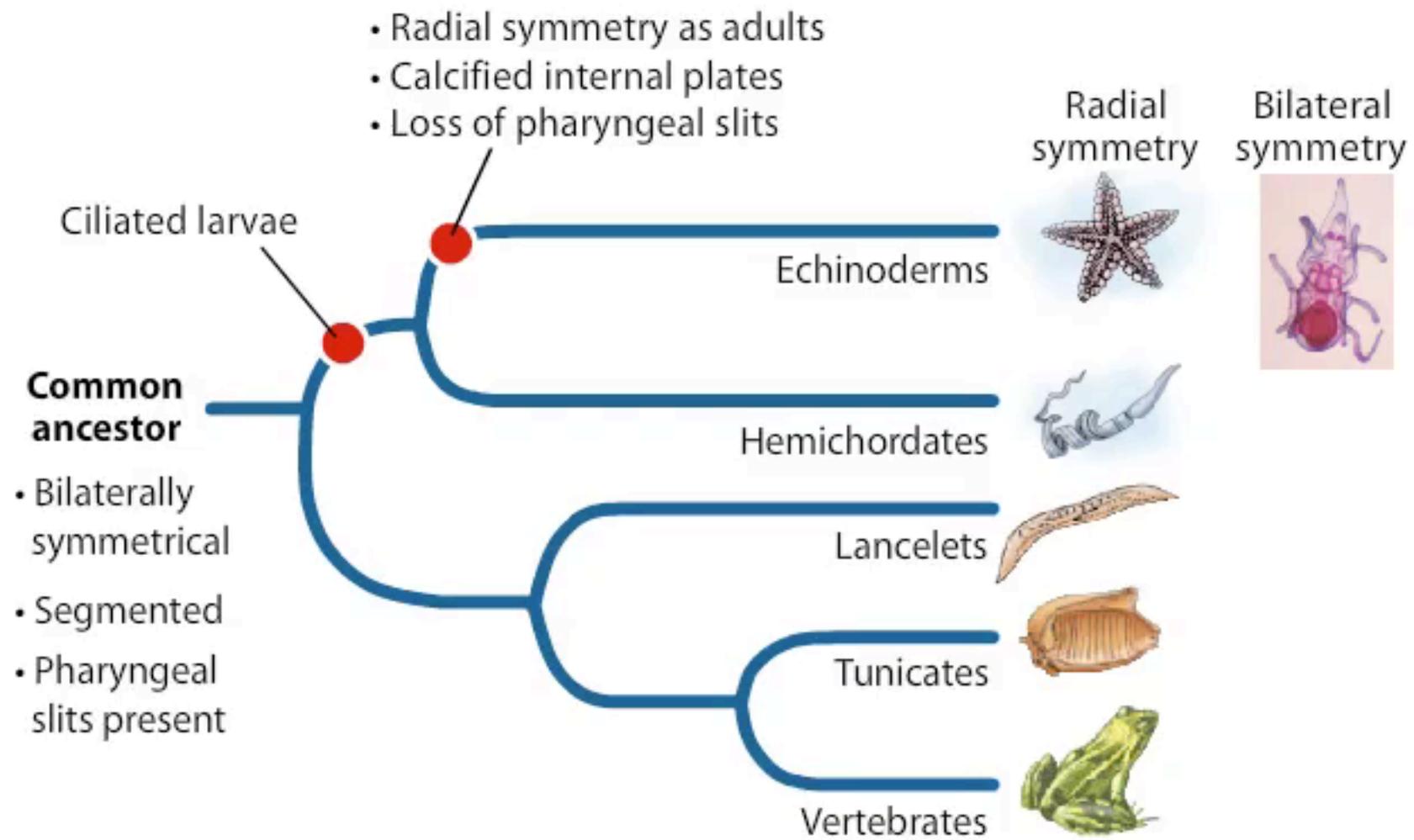
Tunicates

Vertebrates



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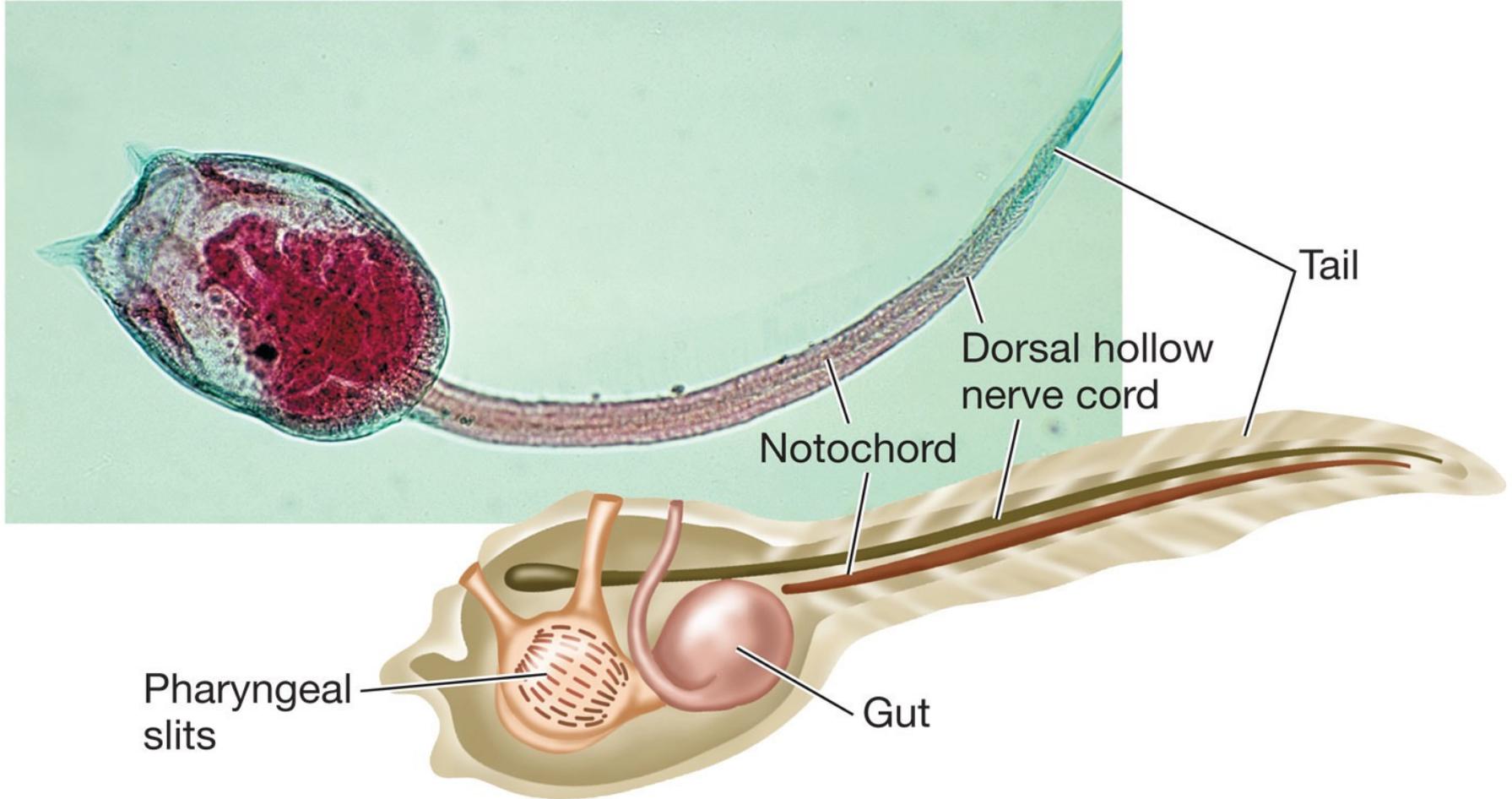
Deuterostomes



Chordate Derived Traits Most Apparent in Juveniles

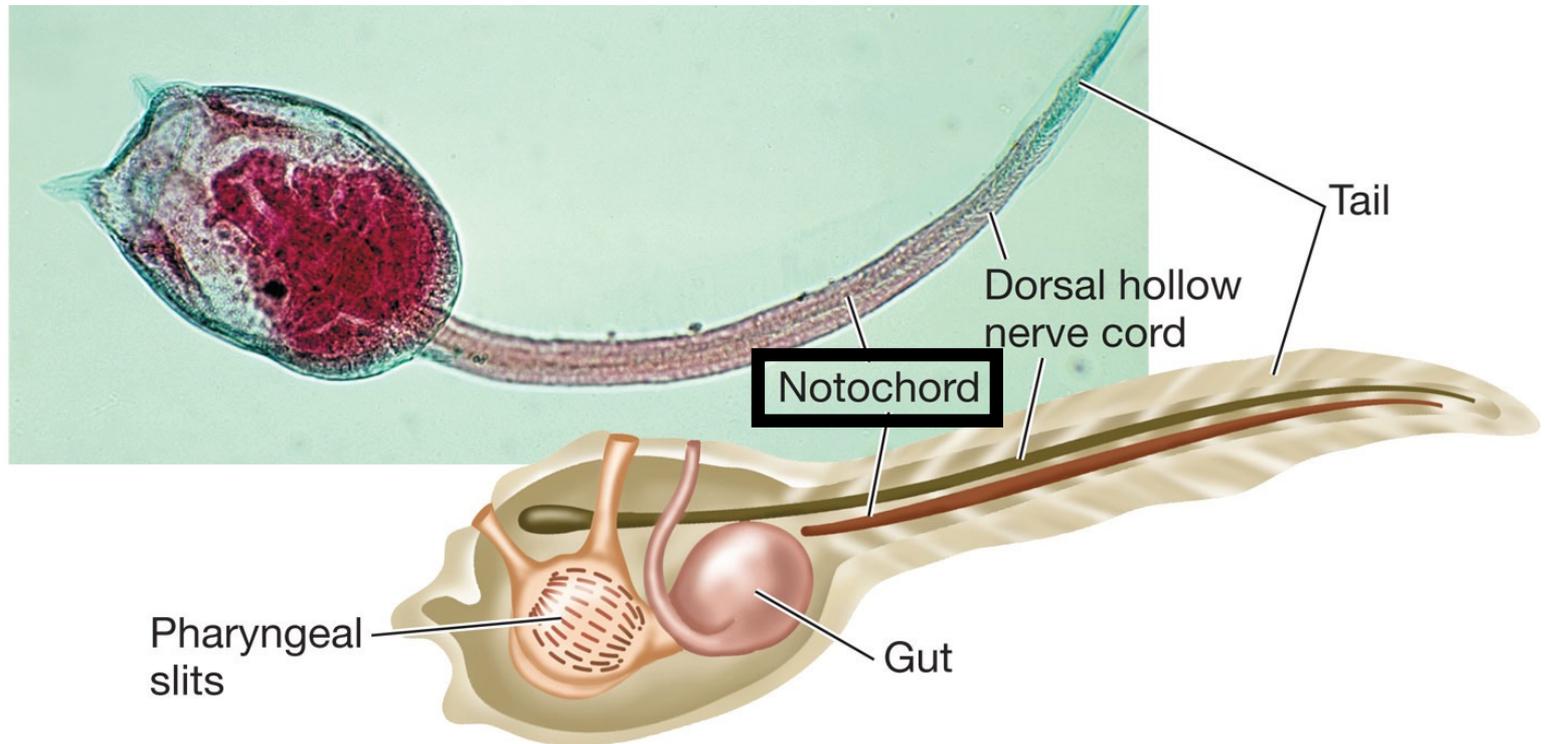
(A)

Ciona sp.



Notochord

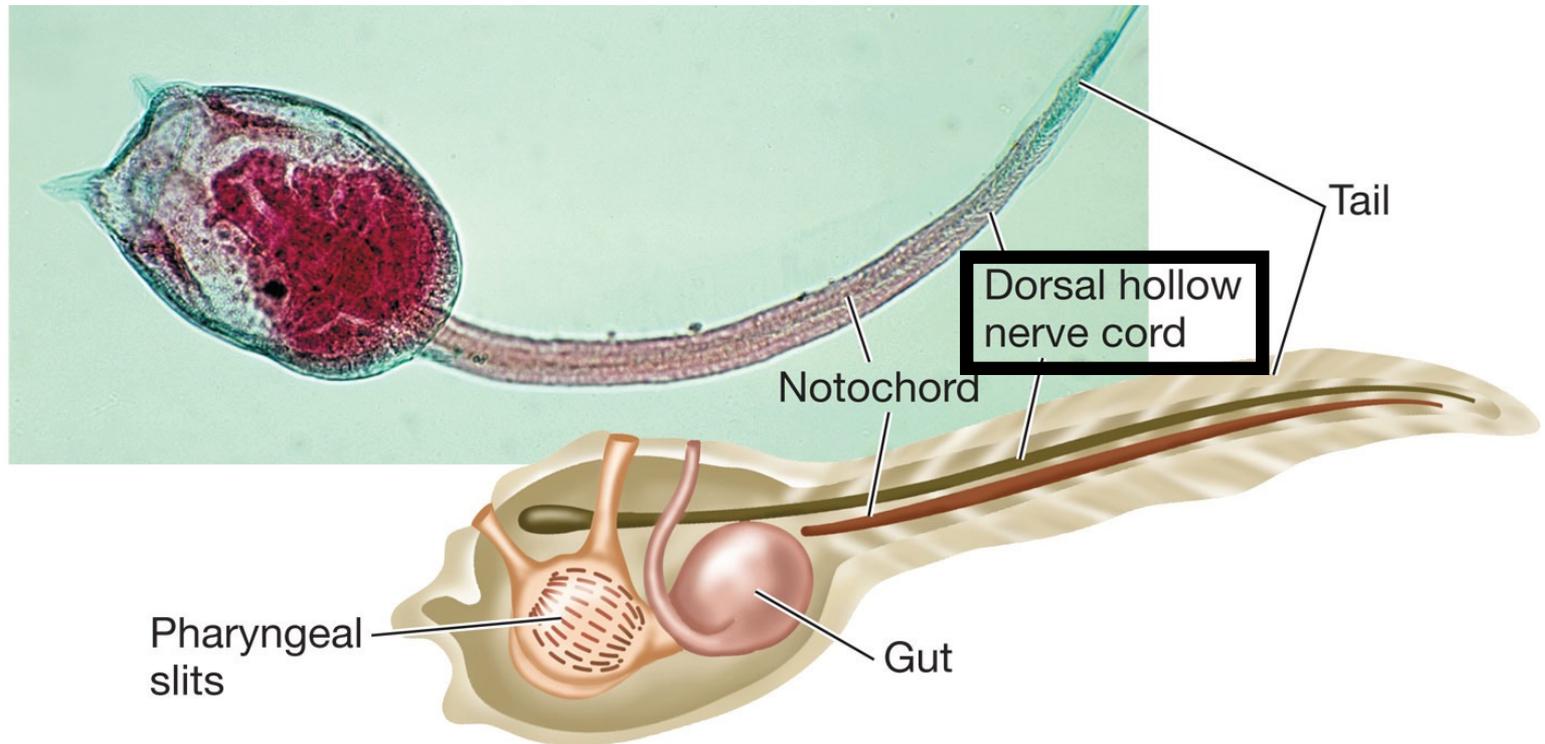
- Notochord is a dorsal supporting rod.
- Core of large cells with fluid-filled vacuoles, making it rigid but flexible.
- In tunicates it is lost during metamorphosis to the adult stage.
- In vertebrates it is replaced by skeletal structures.



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Dorsal hollow nerve cord

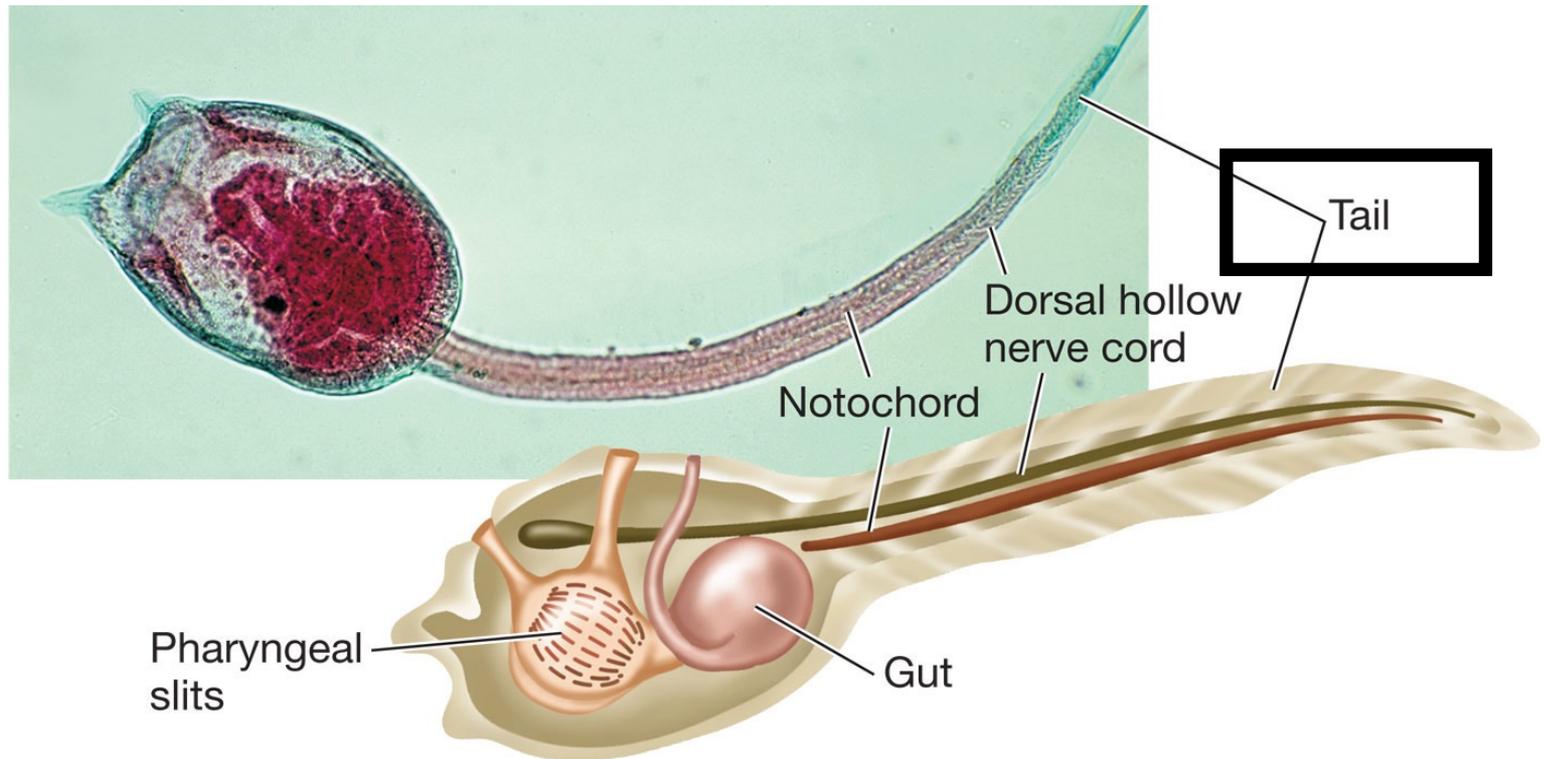
- Formed by an embryonic folding of the ectoderm
- Develops to form the central nervous system in vertebrates



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Post Anal Tail

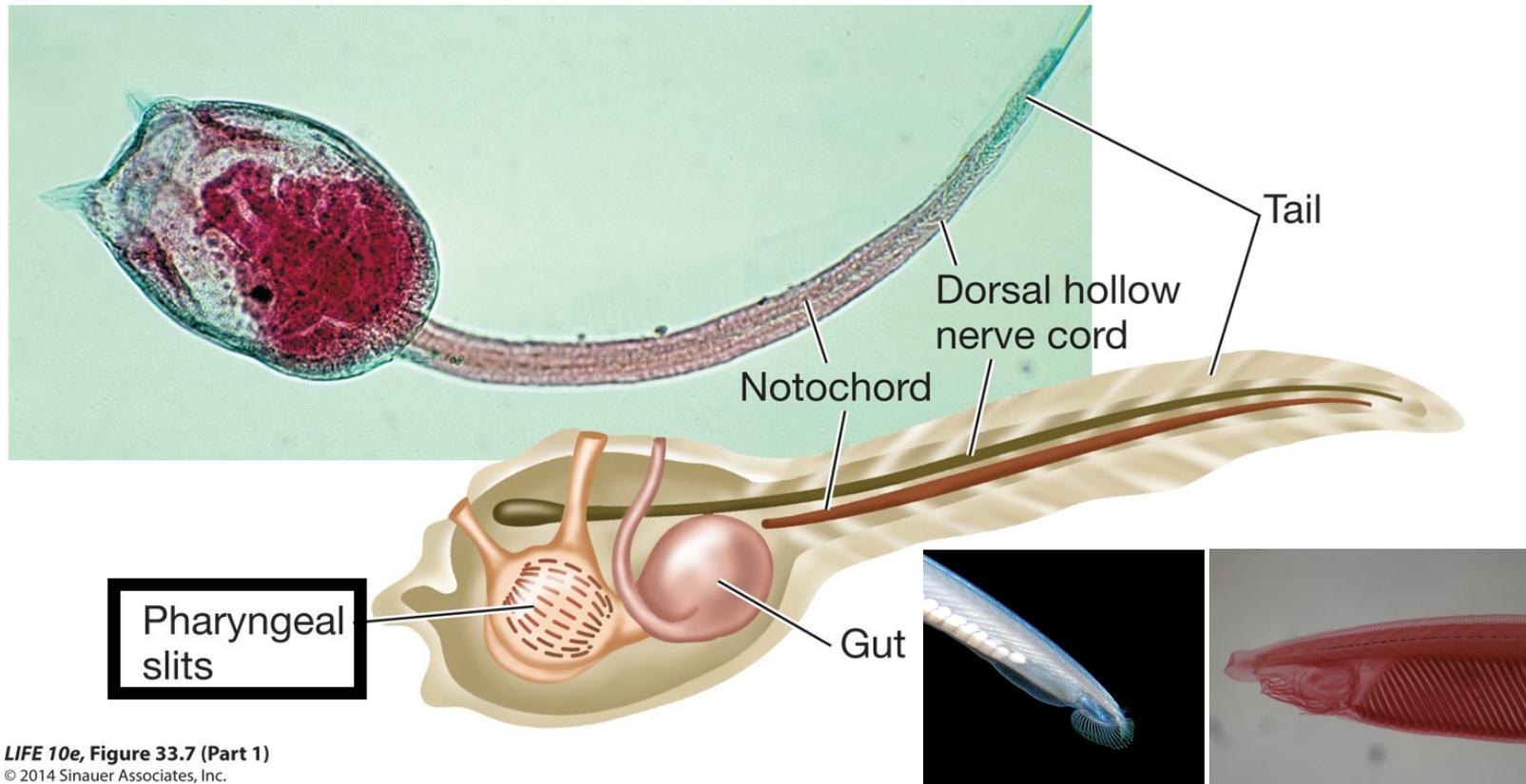
- Extension of the body past the anal opening
- In some species (e.g., humans) most visible in embryos
- The combination of postanal tail, notochord, and muscles provides propulsion



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Pharyngeal Slits

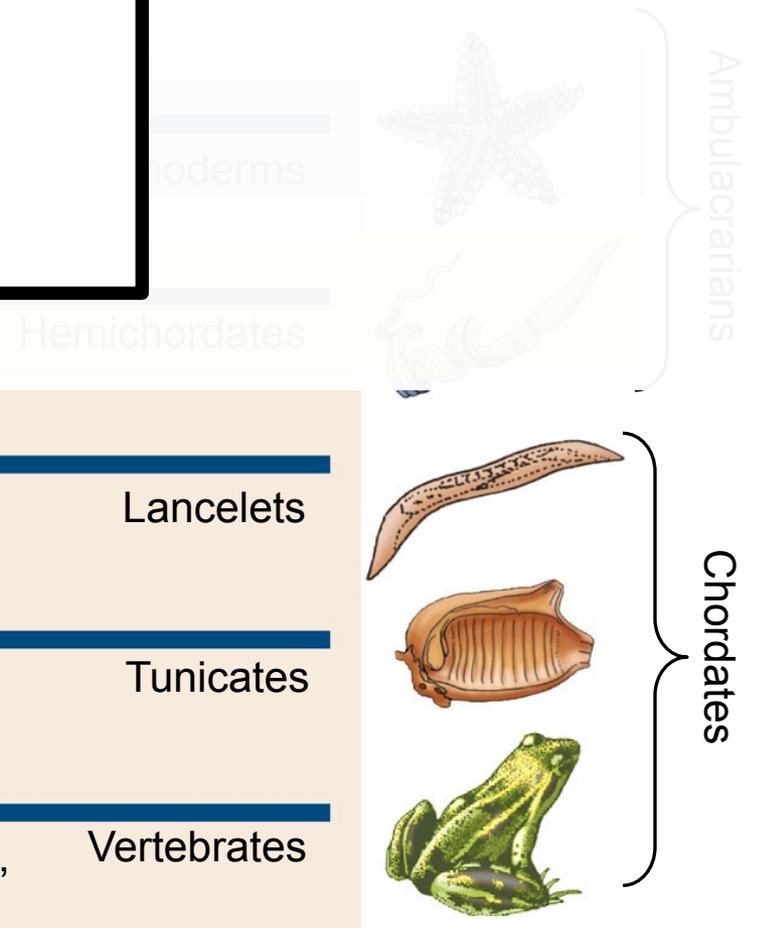
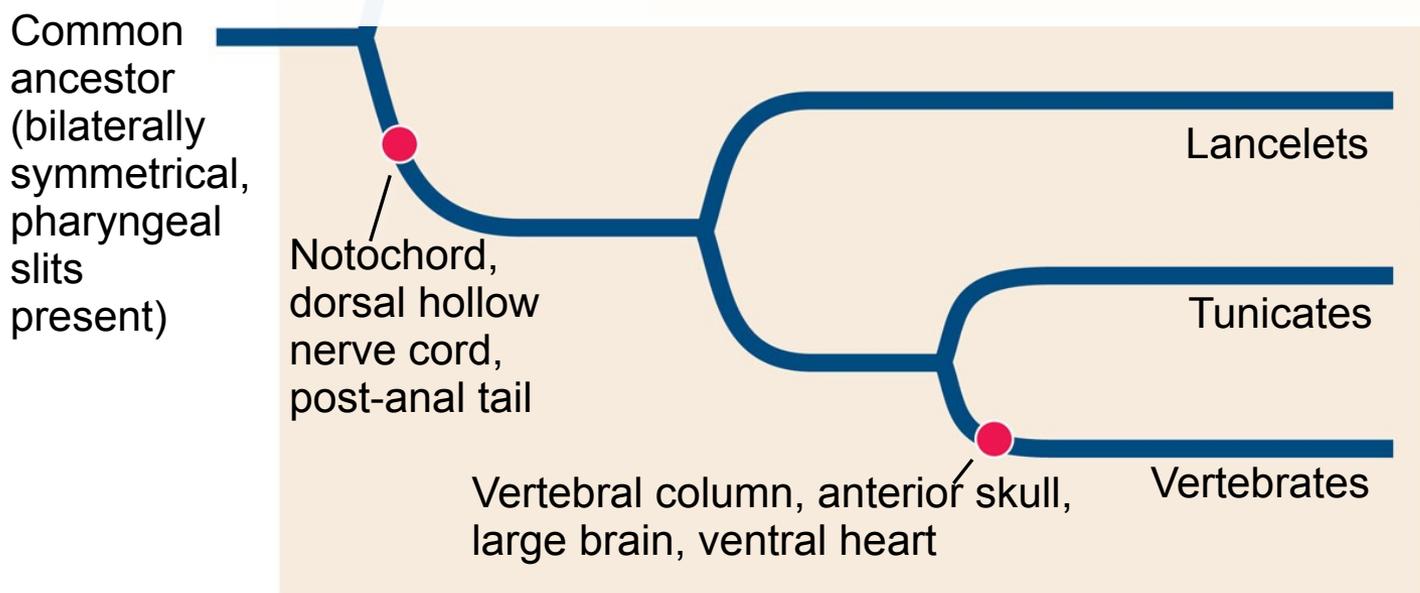
- The pharynx is a muscular organ that brings water in through the mouth (via cilia) which then passes through a series of openings to the outside (slits).
- Ancestral pharyngeal slits present at some developmental stage; often lost or modified in adults.
- Supported by pharyngeal arches.



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Chordates

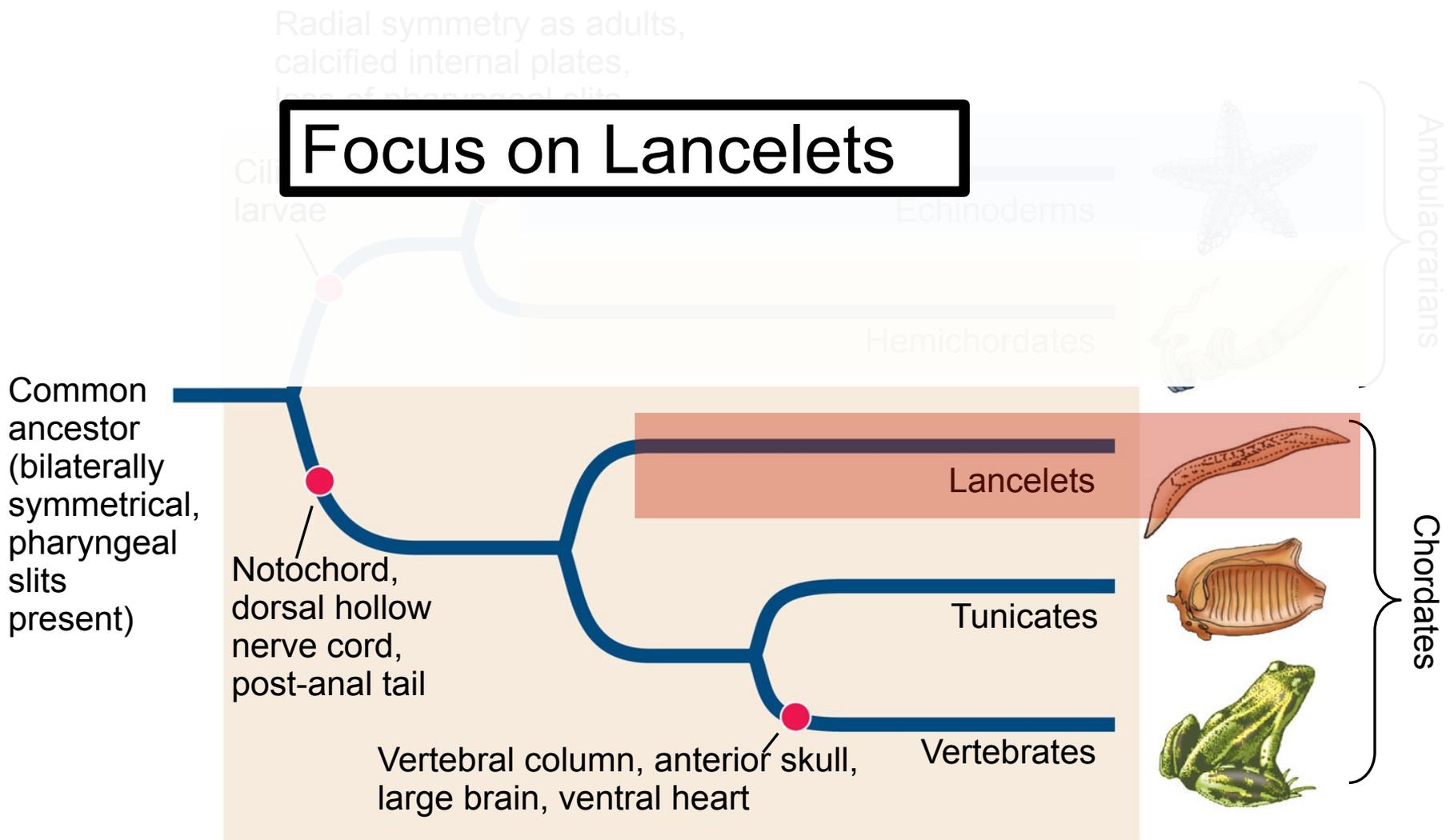
Three Major Groups
* Lancelets
* Tunicates
* Vertebrates



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Lancelets (aka Cephalochordates)

Focus on Lancelets

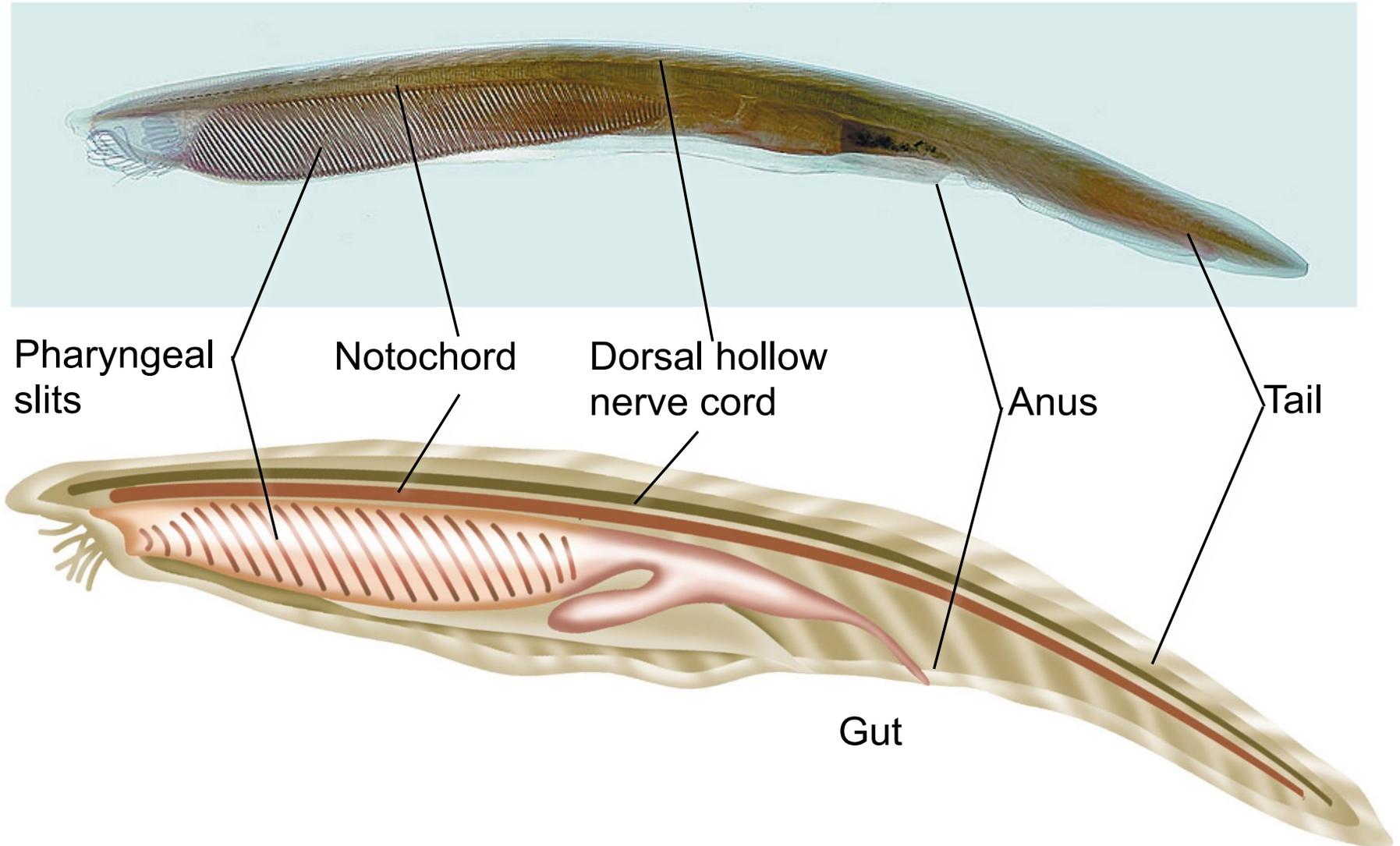


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Lancelet Has Key Chordate Features

(B)

Branchiostoma lanceolatum



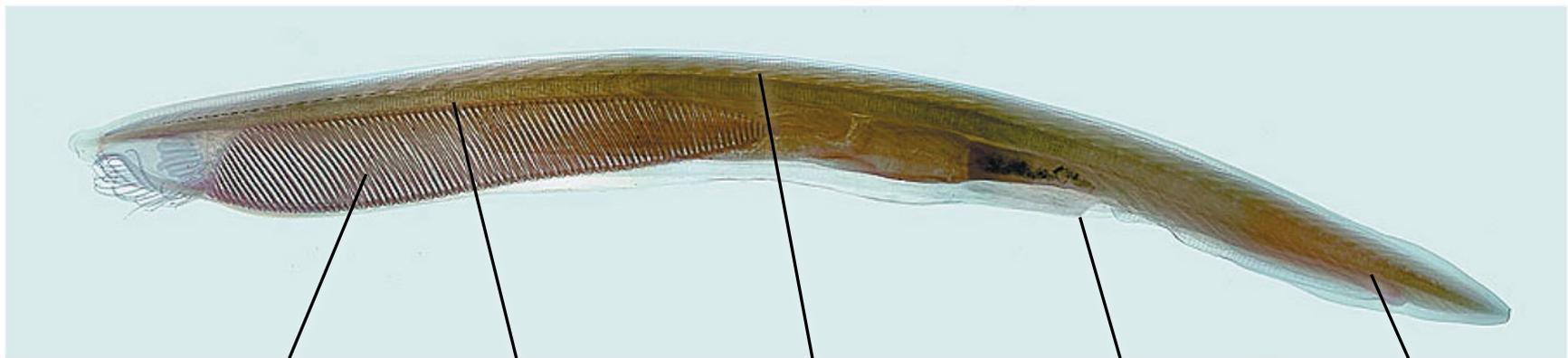
LIFE 10e, Figure 33.7 (Part 2)
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Lancelet Features

- Lancelets (aka amphioxus) are very small, less than 5 cm.
- Notochord is retained throughout life.
- Burrow in sand with head protruding; also swim.
- Pharynx is enlarged to form a pharyngeal basket for filtering prey from the water.
- Fertilization takes place in the water.
- Segmented body muscles

(B)

Branchiostoma lanceolatum



Pharyngeal
slits

Notochord

Dorsal hollow
nerve cord

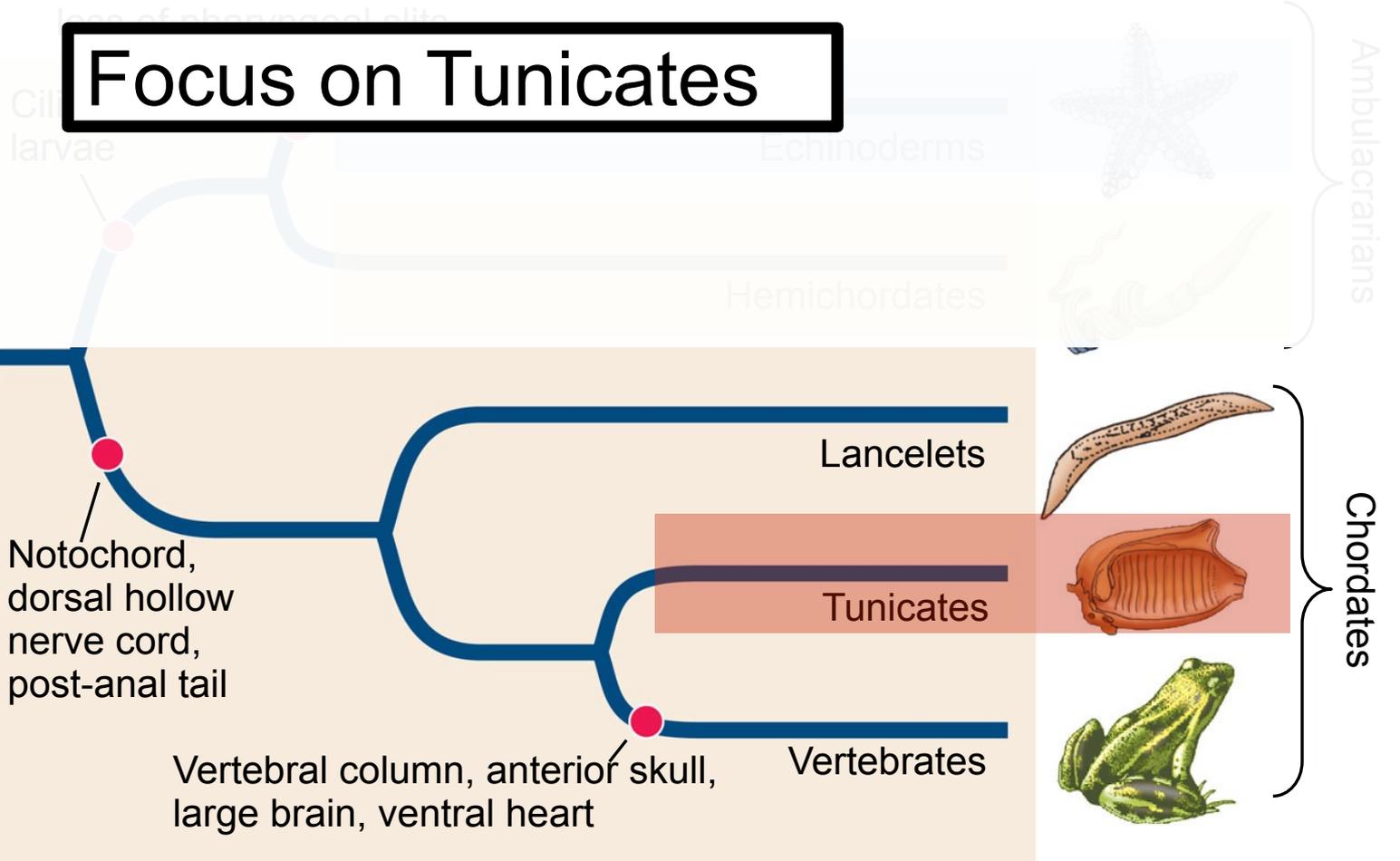
Anus

Tail

Tunicates

Focus on Tunicates

Radial symmetry as adults,
calcified internal plates,
loss of pharyngeal slits



Common ancestor
(bilaterally symmetrical,
pharyngeal slits present)

Notochord,
dorsal hollow
nerve cord,
post-anal tail

Vertebral column, anterior skull,
large brain, ventral heart

Lancelets

Tunicates

Vertebrates

Ambulacrarians

Chordates

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Adult Tunicates

- Tunicates (sea squirts or ascidians, thaliaceans, and larvaceans):
- Sea squirts form colonies by budding from a single founder. Colonies may be meters across.
- Adult body is baglike and enclosed in a “tunic” of proteins and complex polysaccharides secreted by the epidermis.



(A) *Clavelina dellavallei*

1 cm



(B) *Pegea* sp.

1 cm

Adult Tunicates

- Solitary tunicates seem to lack all of the synapomorphies of chordates?
- No dorsal hollow nerve cord, no notochord, no postanal tail



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HOW ARE THESE CHORDATES?



(A) *Clavelina dellavallei*

1 cm

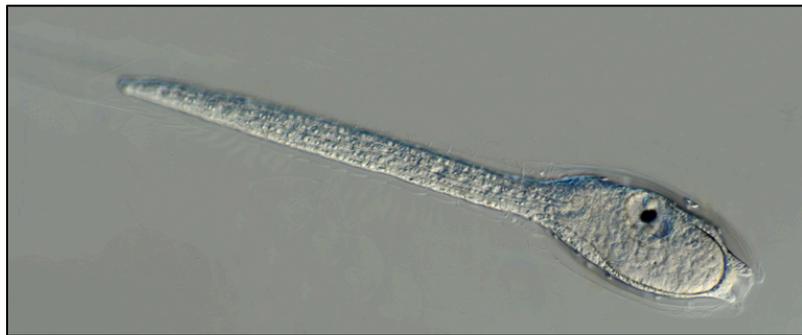


(B) *Pegea* sp.

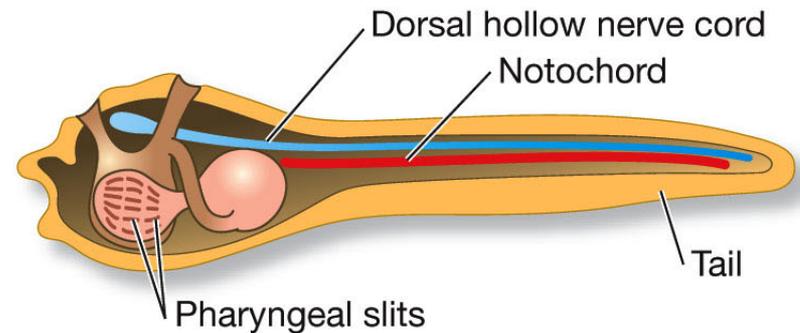
1 cm

Juvenile Tunicates

- Sea squirt larvae have pharyngeal slits, a hollow nerve cord, and notochord in the tail region.
- The swimming, tadpolelike larvae suggest a relationship between tunicates and vertebrates.
- Larvacean tunicates do not undergo the metamorphosis and retain all of the chordate features.

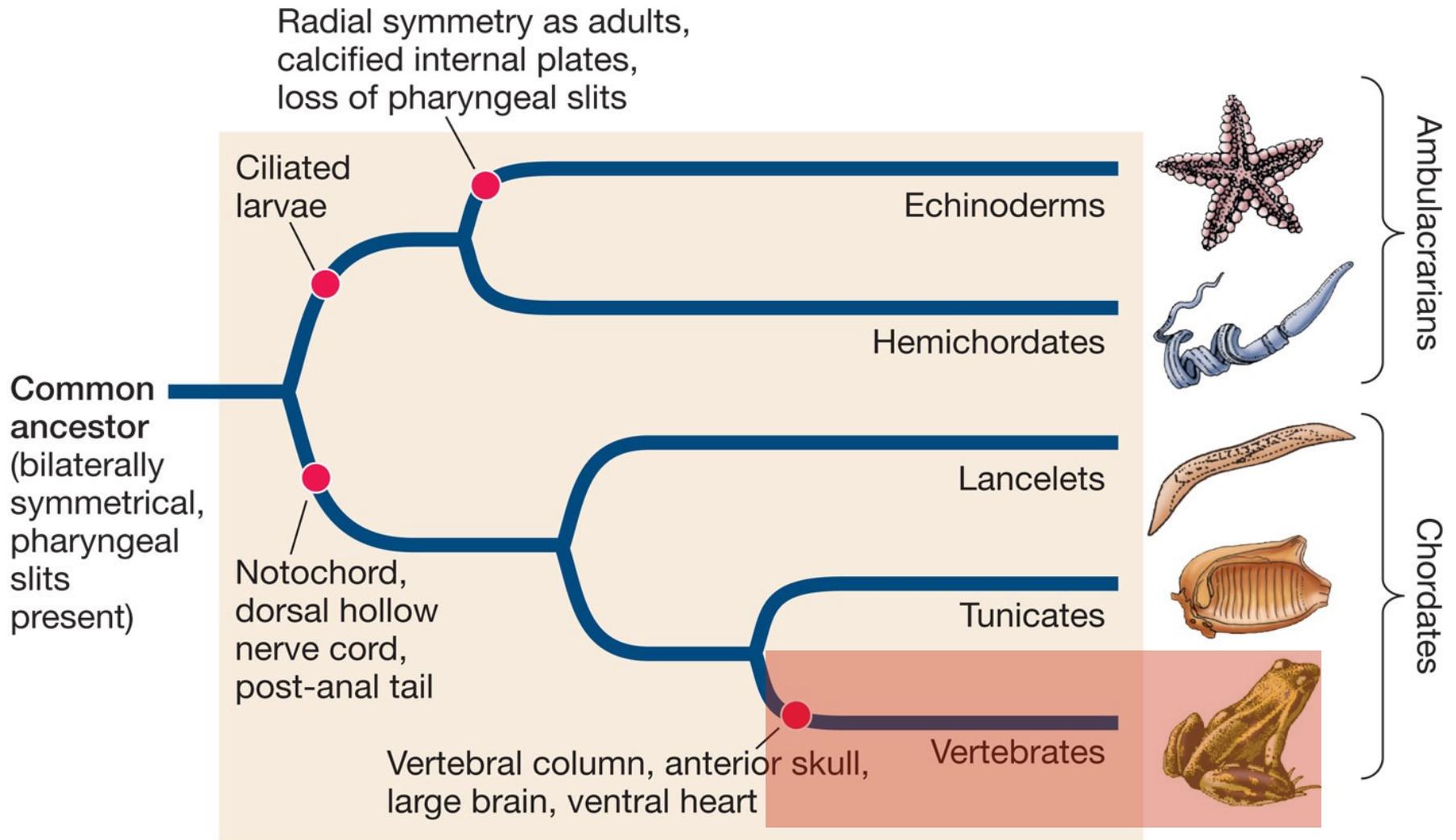


Ascidian tunicate larva



Larvacean tunicates

Tunicates (aka Urochordates)



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