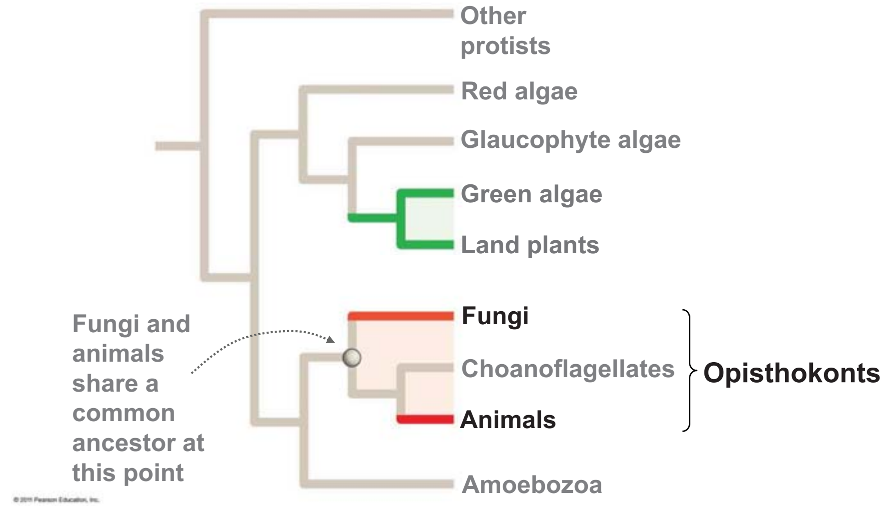
Part III. Conserving biodiversity

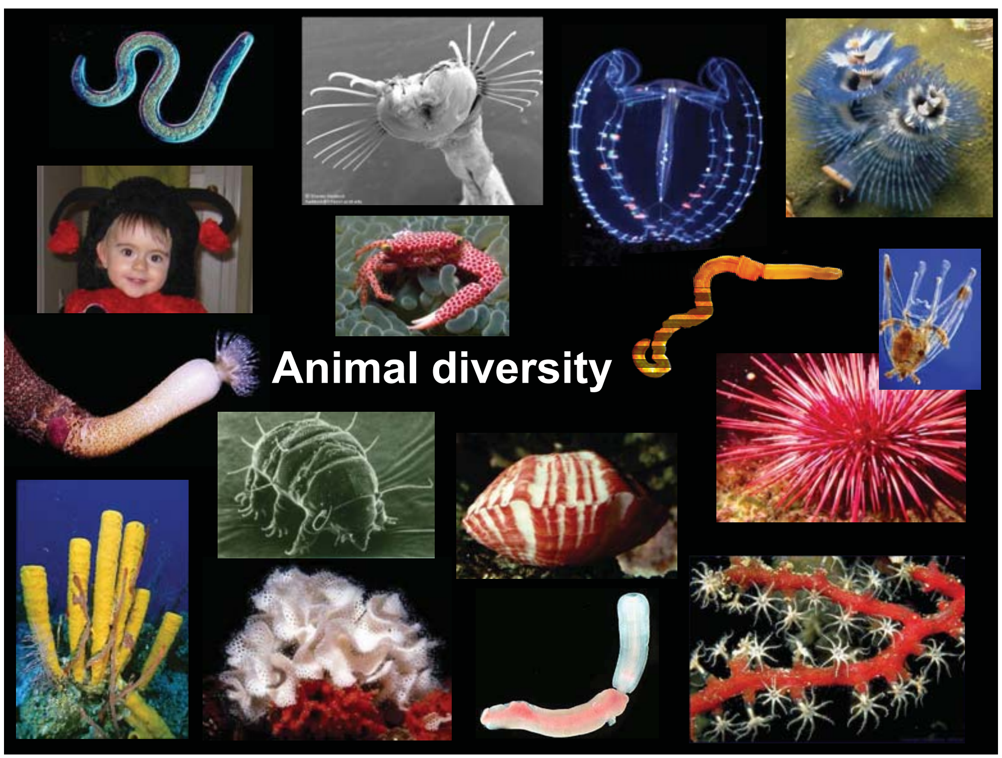
I. How populations work
II. How communities & ecosystems work
III. Origins of biodiversity

- How do species arise?
- How are phylogenies used to organize diversity?
- Surveys of biodiversity and evolutionary trends
  - Unit 8. Prokaryotes and protists (single-celled organisms)
  - Unit 9. Green plants and fungi
  - ➢ Unit 10. Animals

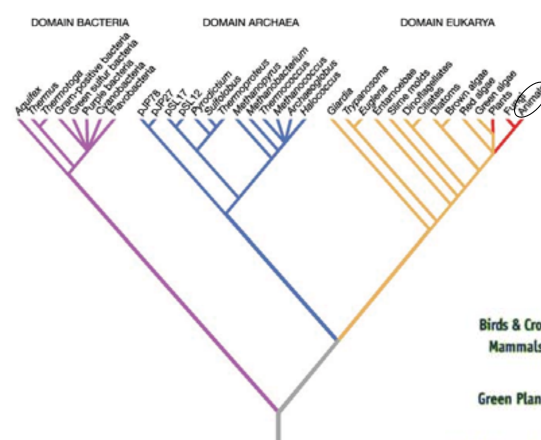
Opisthokonts

- **Fungi, Choanoflagellates, Animals**
- **flagella** (locomotion)
- **chitin** (structure)
- **glycogen** (energy storage)

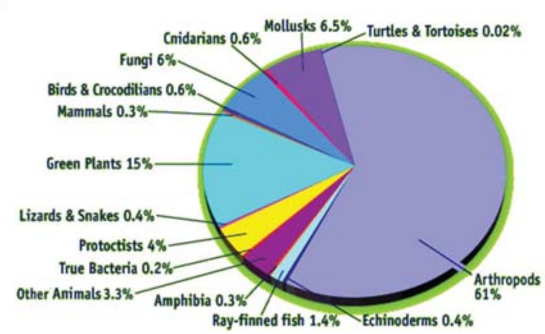




Animals: how diverse compared with other organisms?



- 75% of described species
- vast majority of diversity in body design

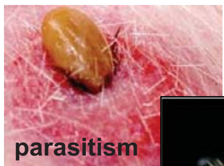


Animals – species rich, morphologically diverse

Multicellular eukaryotes with no cell walls

EVOLUTIONARY INNOVATION:
- **collagen**

Heterotrophy

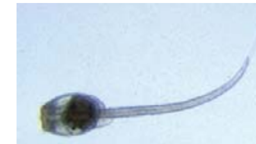


EVOLUTIONARY INNOVATION:
- **digestive system**

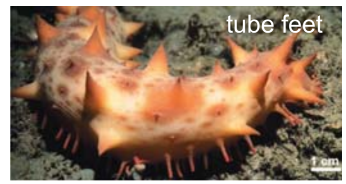
Animals – species rich, morphologically diverse

Multicellular eukaryotes with no cell walls
Heterotrophy
Motile (during some stage of life cycle)

EVOLUTIONARY INNOVATIONS:
- **muscle tissue**
- **nervous tissue**



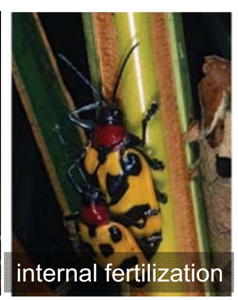
mobile larvae
sessile adults



Animals – species rich, morphologically diverse

Multicellular eukaryotes with no cell walls
Heterotrophy
Motile (during some stage of life cycle)
Sexual or asexual reproduction

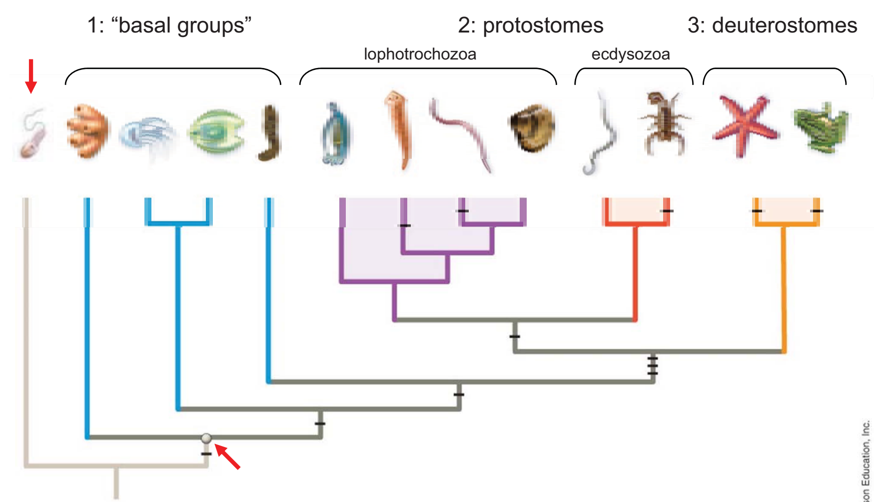
EVOLUTIONARY INNOVATION:
- **metamorphosis**



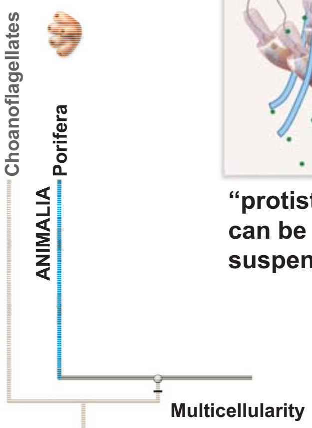
Why has metamorphosis evolved?

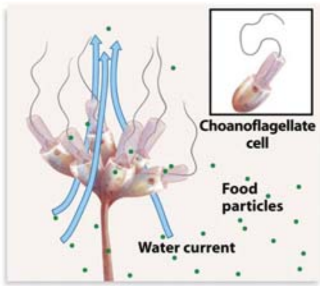
Phylogenetic diversity of animals

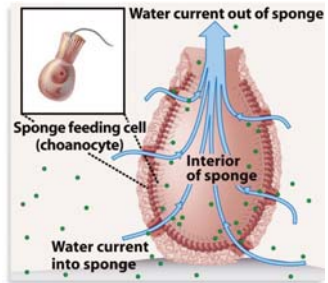
sister group to choanoflagellates
monophyletic group
~30 phyla with distinct body plans



Choanoflagellates – sister group to animals
Ph. Porifera – basal animals





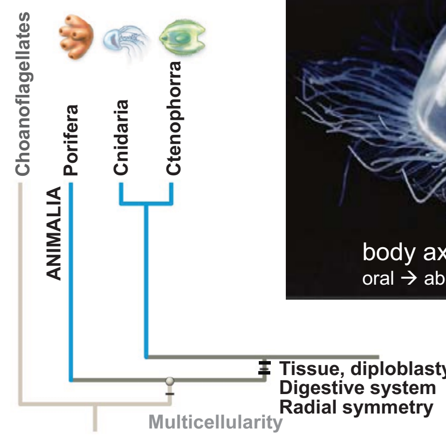


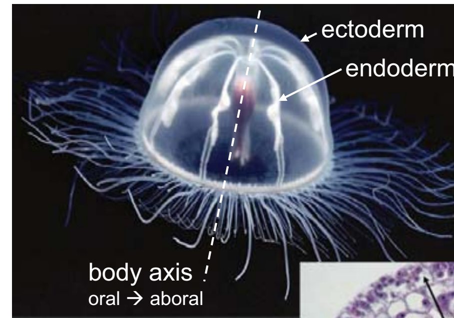
"protists"
can be colonial
suspension feed

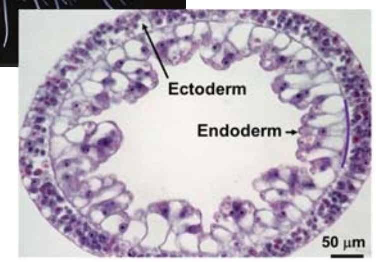
specialized cell types
no distinct tissues
no axis of symmetry

Diploblasts – evolution of tissues and symmetry

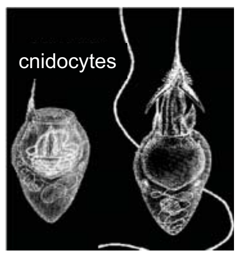
two tissue layers (derived from embryonic endoderm and ectoderm)
one body opening (mouth/anus)
single body axis (rise of regulatory genes)

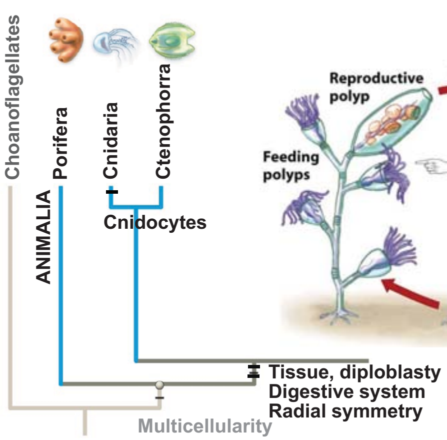


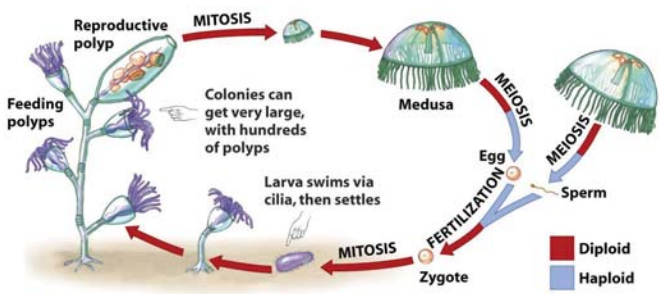




Diploblasts – **Ph. Cnidaria**



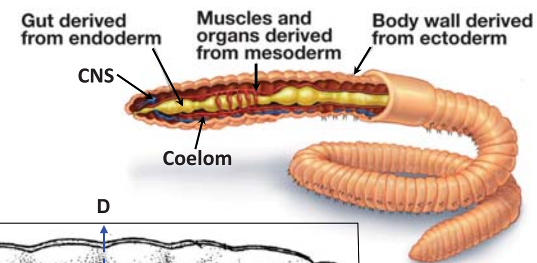


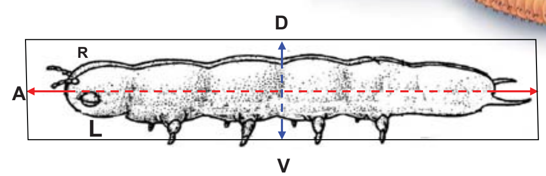


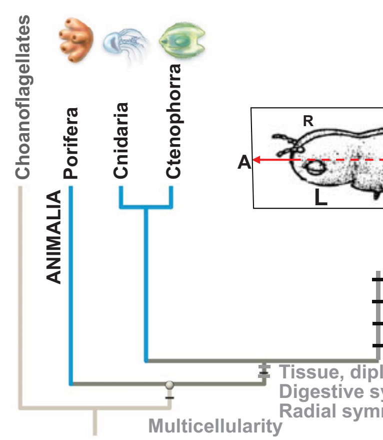
some have an alternation of
diploid multicellular forms

Triploblasts – three embryonic tissue layers

- 3rd layer derived from mesoderm
- bilateral symmetry
- cephalization



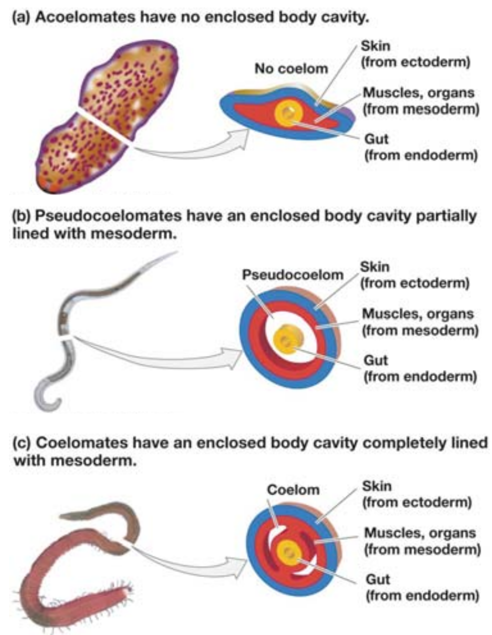




Morphological diversity of animals

<u>Traditional characters</u>

- **symmetry** (none,radial,bilateral)
- **tissue layers** (0,2,3)
- **body cavity** (a-, pseudo-, coelmate)
- **early development** (prot-, deut-)



Morphological diversity of animals

<u>Traditional characters</u>

- **symmetry** (none,radial,bilateral)
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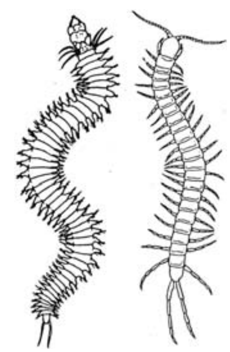
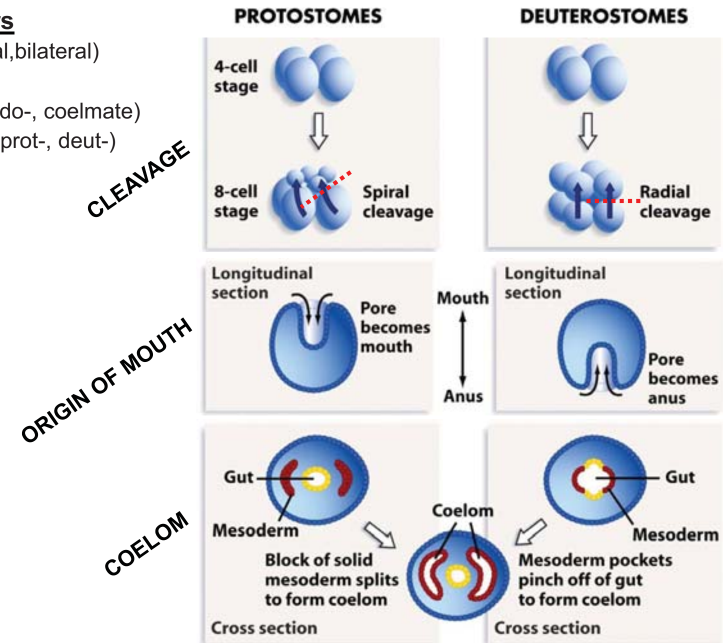
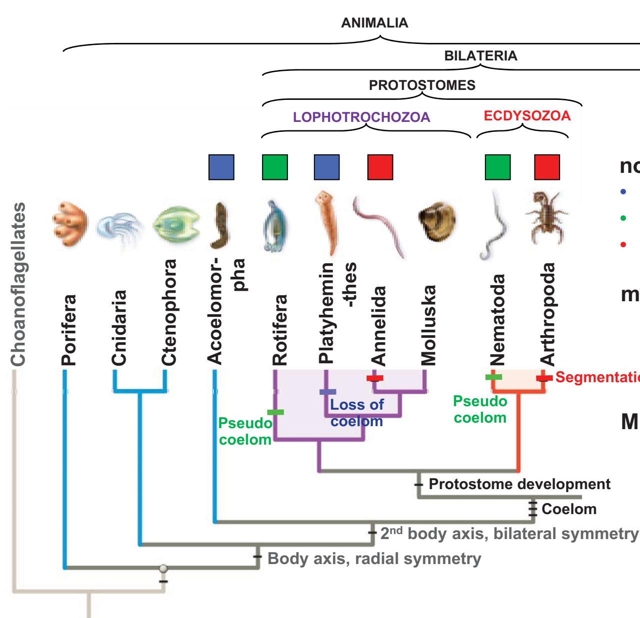
- **early development** (prot-, deut-)
- **segmentation**





Molecular phylogeny: convergent surprises



not monophyletic!

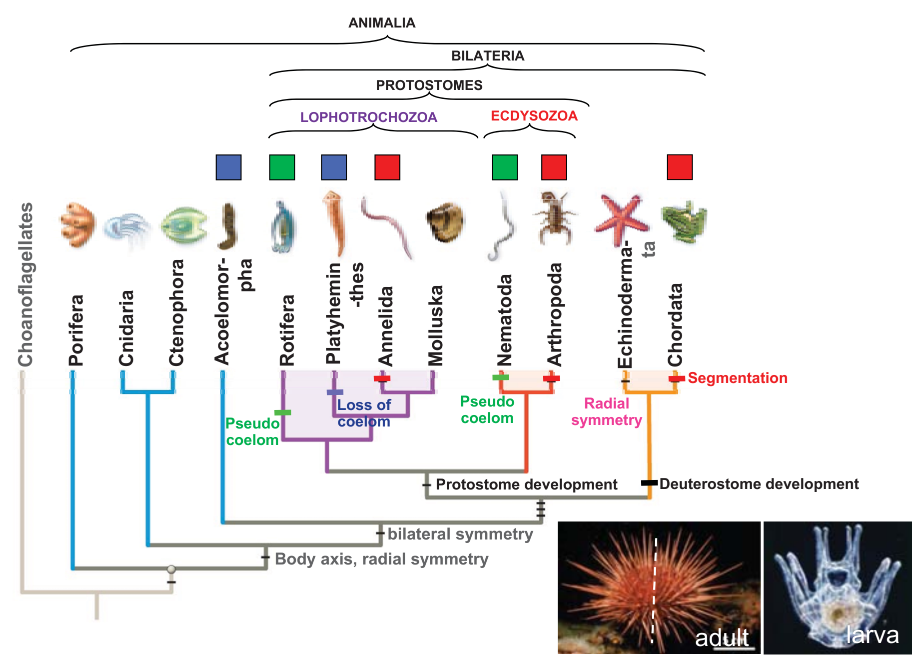
- **acoelomates**
- **pseudocoelomates**
- **segmented body plans**

monophyletic: protostomes

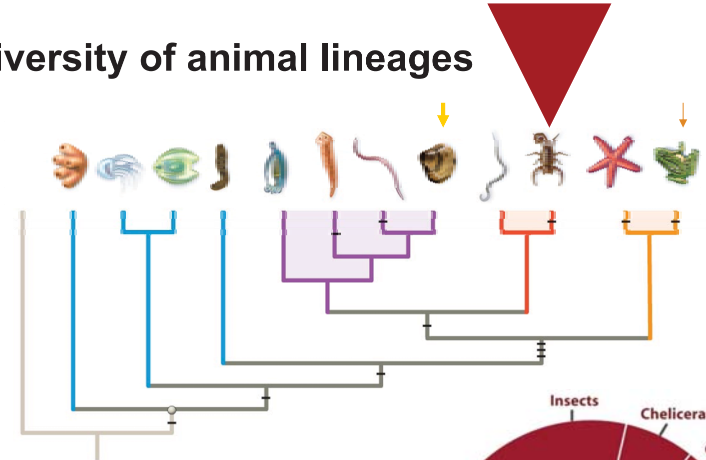
Multiple evolutionary origins?

A) animals
B) segments
C) coeloms
D) bilateral symmetry
E) spiral cleavage

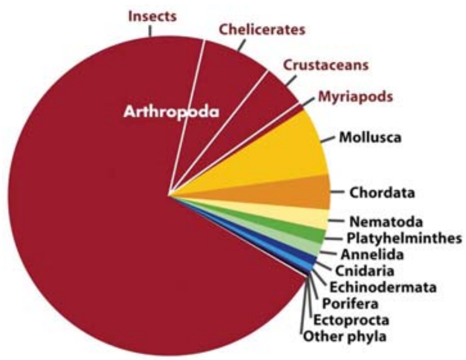
Molecular phylogeny: convergent surprises



Diversity of animal lineages



Why are arthropods, mollusks, and chordates so diverse?



LOPHOTROCHOZOA

Phylum Mollusca

highly reduced coelom
100,000 species

ecological roles:
- suspension feeders
- herbivores
- deposit feeders
- predators

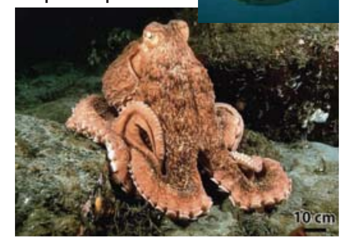
gastropods

bivalves

Q: Why are molluscs so diverse?

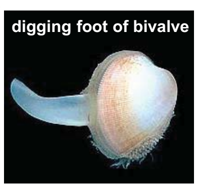
chitins

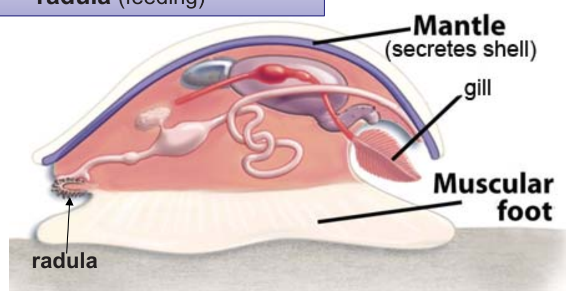
cephalopods

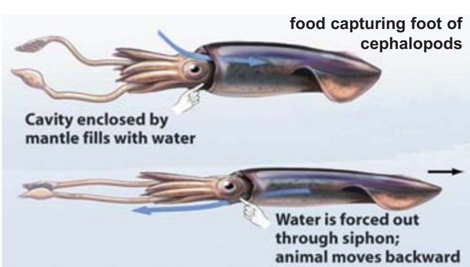


Why are molluscs so diverse?

MORPHOLOGICAL INNOVATIONS: **foot** (locomotion)
mantle/shell (protection)
radula (feeding)



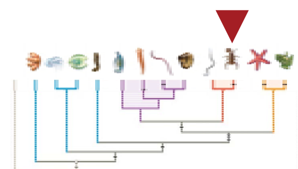




radula in mouth opening

ECDYSOZOA

Ph. Arthropoda



segmentation
highly reduced coelom
eyes and antennae
> 1 million species (and counting)
ecological roles: you name it!

insects

tracheates

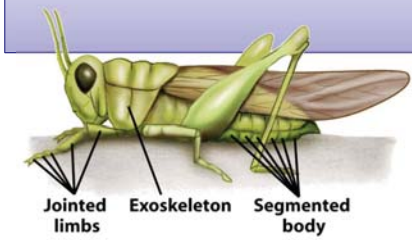
myriapods

crustaceans

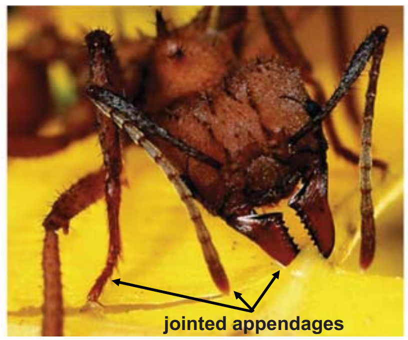
chelicerates

Why are arthropods so diverse?

MORPHOLOGICAL INNOVATIONS: segmentation
exoskeleton
jointed appendages (incl. mouthparts)
wings



ECOLOGICAL OPPORTUNITY:
invasion of terrestrial habitats



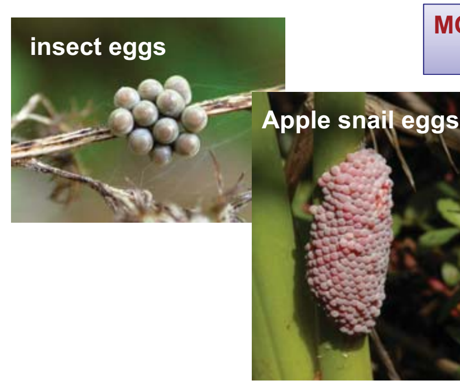
Why are arthropods (and molluscs) so diverse?

What challenges are associated with life on land?

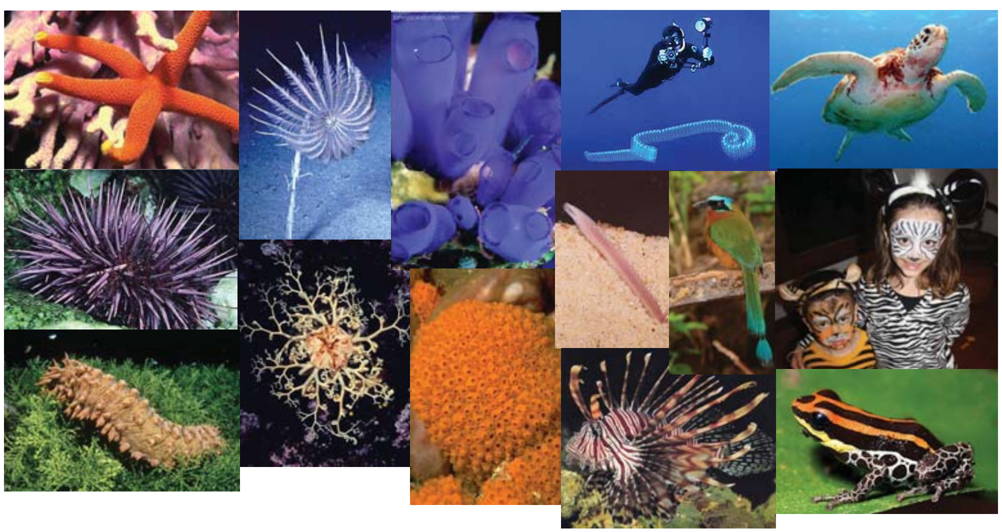
- Support
- Hydration
- Reproduction

ECOLOGICAL OPPORTUNITY:
invasion of terrestrial habitats

MORPHOLOGICAL INNOVATION:
water-tight eggs

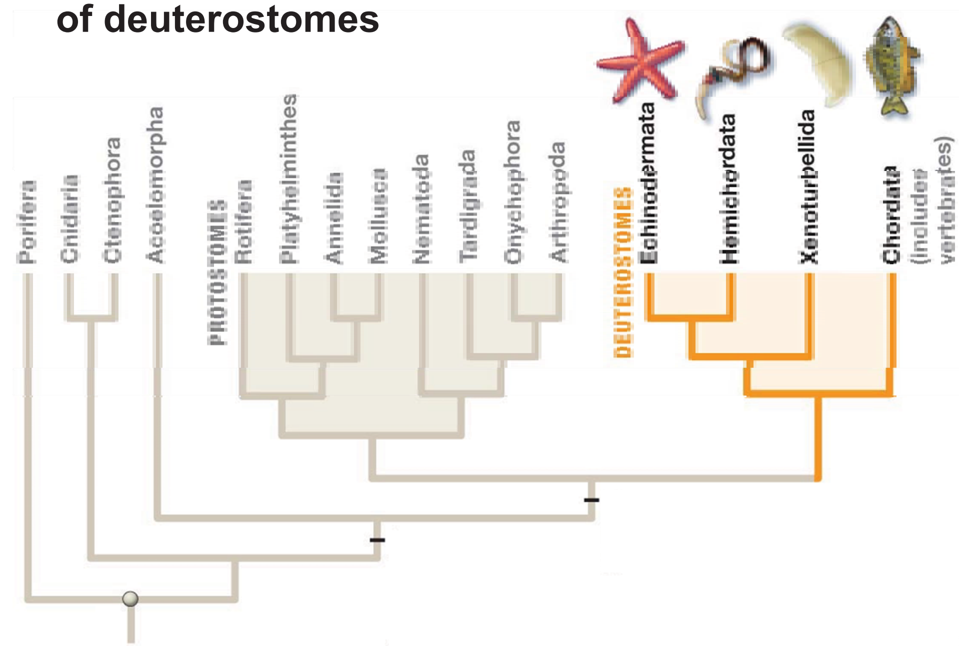


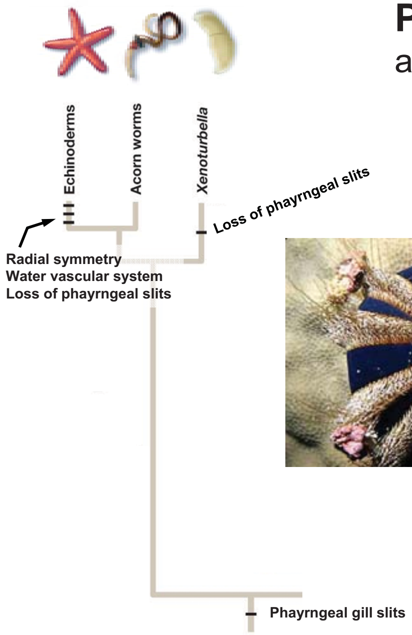
Morphological diversity of deuterostomes



→ large and morphologically complex
→ pentaradial symmetry in adult echinoderms
→ pharyngeal gill slits, notochord, and dorsal hollow nerve cord in chordates

Phylogenetic diversity of deuterostomes



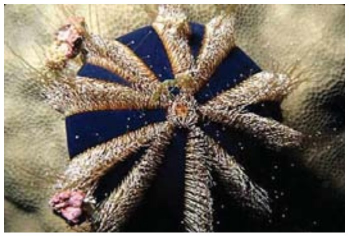
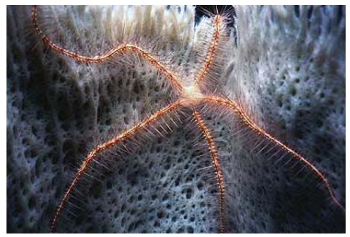


Phylum Echinodermata

a fundamentally different body plan

- "spiny skin" reflects endoskeleton
- five-part radial symmetry

adults: pentaradial symmetry – no head

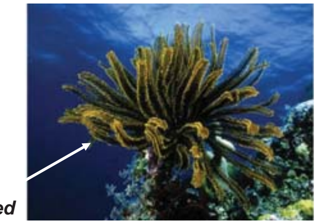



larvae: retain bilateral symmetry

Phylum Echinodermata

~6000 species in 5 living classes (20 extinct)

crinoids

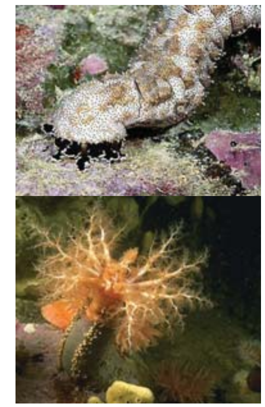


jointed arms

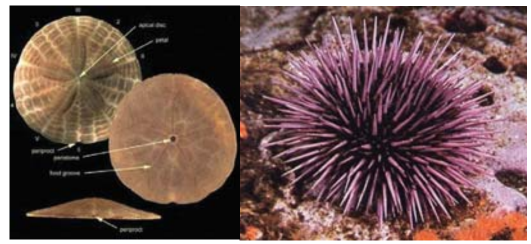
sea stars

brittlestars

sea cucumbers

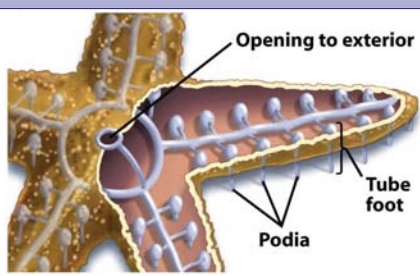


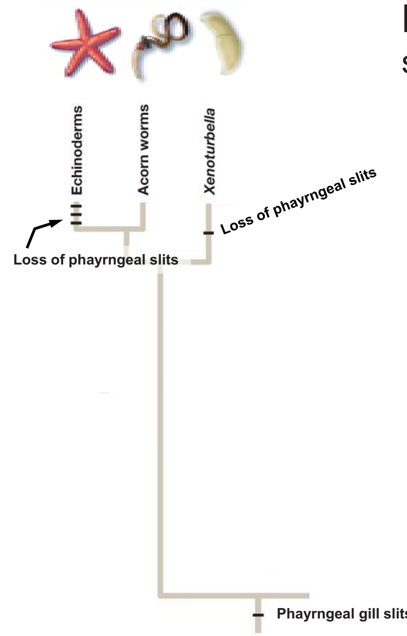
sea urchins & sand dollars



Why are echinoderms so diverse?

MORPHOLOGICAL INNOVATIONS: **penta-radial symmetry**
mutable collagen
water vascular system

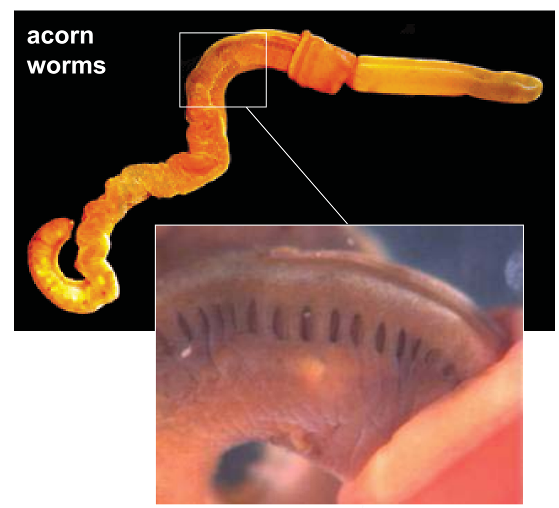




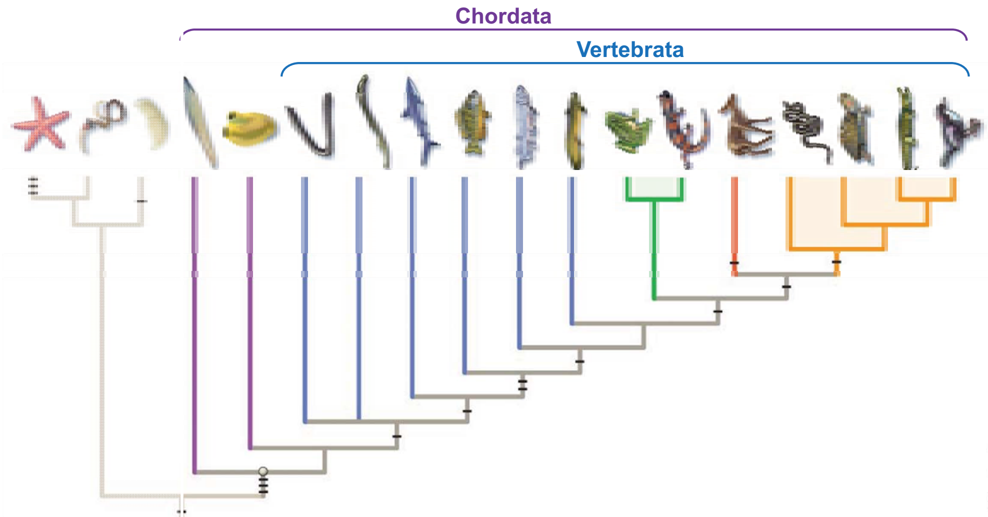
Phylum Hemichordata

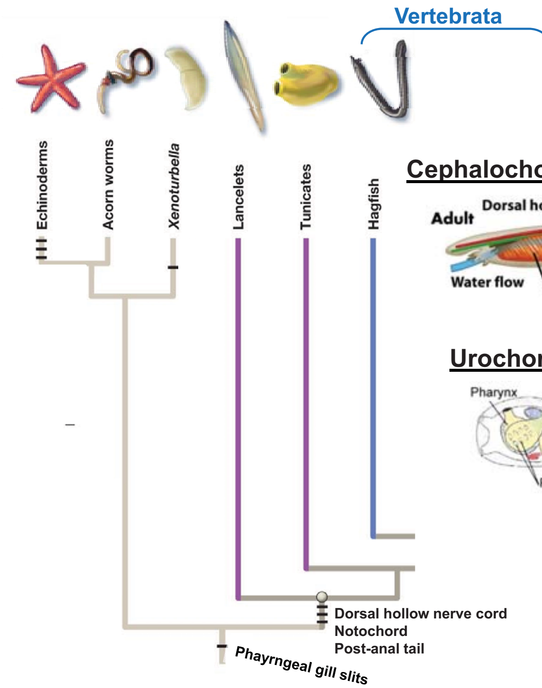
sister group to echinoderms

- retention of pharyngeal gill slits



Phylum Chordata

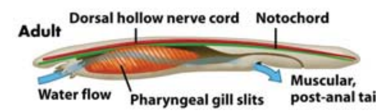




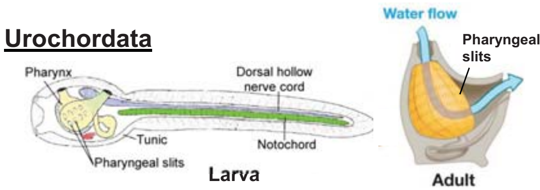
Phylum Chordata

- pharyngeal gill slits (ancest.)
- notochord (derived)
- dorsal hollow nerve cord (der.)

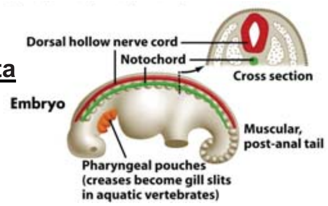
Cephalochordata (lancelets)



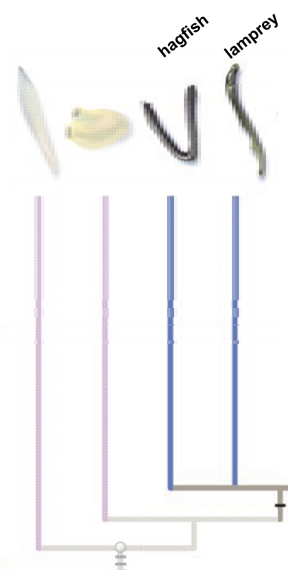
Urochordata



Vertebrata



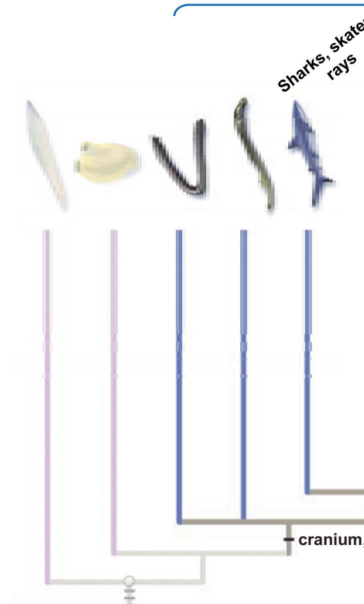
Basal vertebrates – “jawless fishes” (Cyclostomata)



Cyclostomata

- cranium
- no jaw
- cartilaginous vertebral elements, but…
- no true vertebrae – *evolutionary loss?*

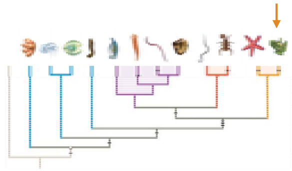
Cartilaginous fishes – Condrichthyes



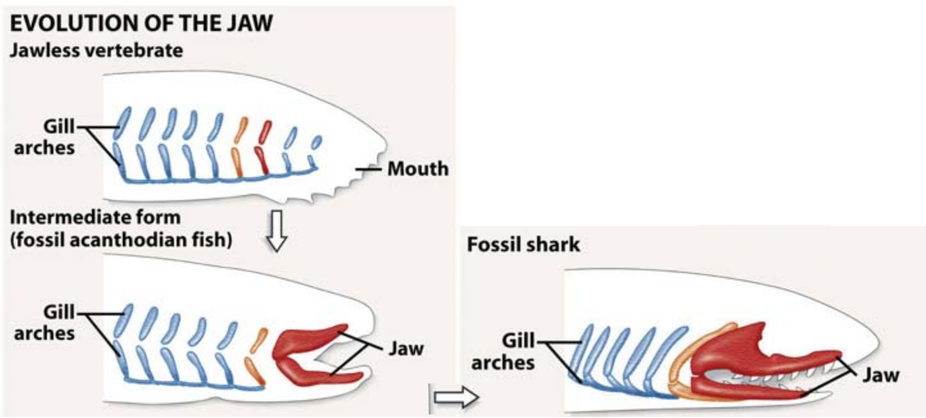
Condrichthyes

- jaws
- cartilaginous vertebral column
- no calcified bone

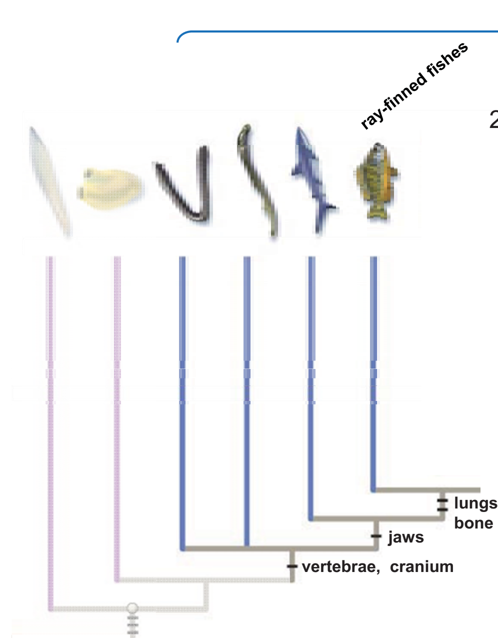
Why are chordates so diverse?



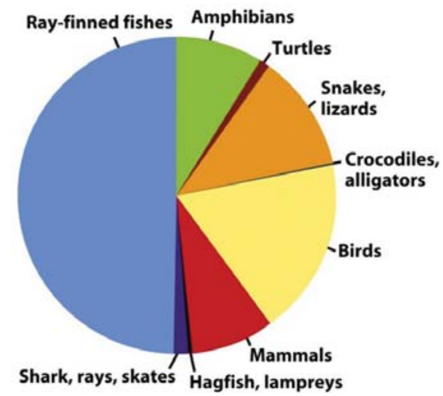
MORPHOLOGICAL INNOVATIONS: jaw
bony endoskeleton



Ray-finned fishes – Actinopterygii



20,000+ species

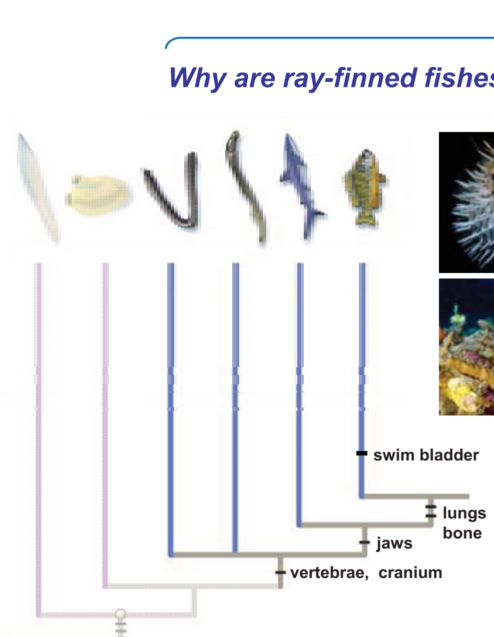


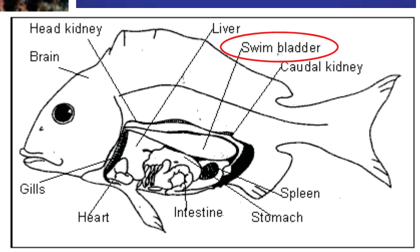
Ray-finned fishes – Actinopterygii

Vertebrata

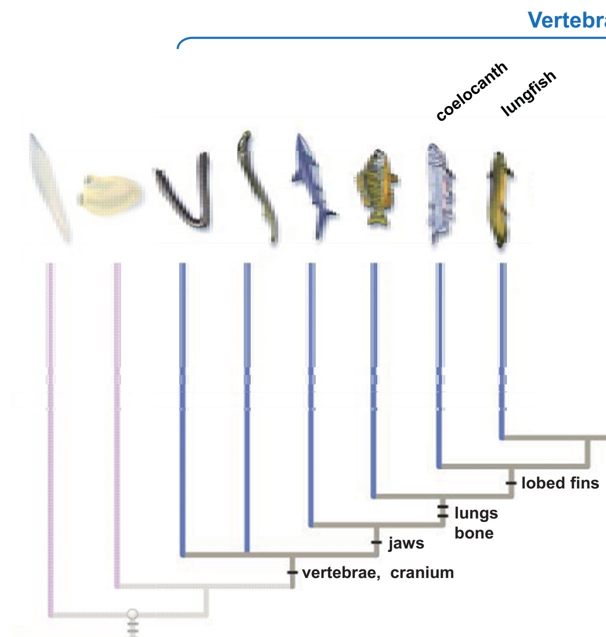
Why are ray-finned fishes so diverse?

- bony skeleton
- diversification of jaw
- diversification of shape
- swim bladder





Lobe-finned fishes – evolutionary link to tetrapods



Are fishes monophyletic?
A) Yes B) No

Why are chordates so diverse?

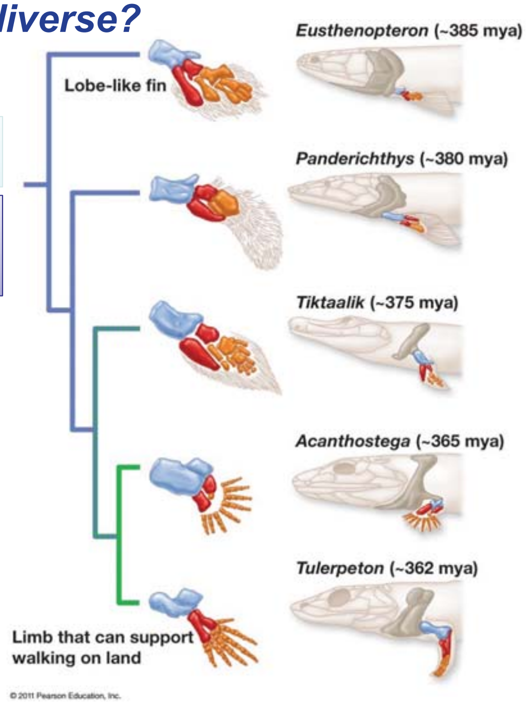
ECOLOGICAL OPPORTUNITY:
invasion of terrestrial habitats

MORPHOLOGICAL INNOVATIONS:
limbs
lungs (ancestral to swim bladder!?)

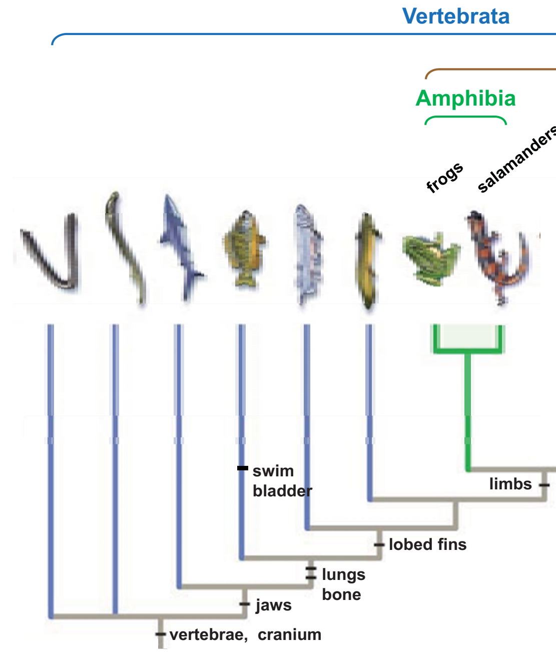
What are the challenges of life on land?

- support
- gas exchange
- hydration
- reproduction

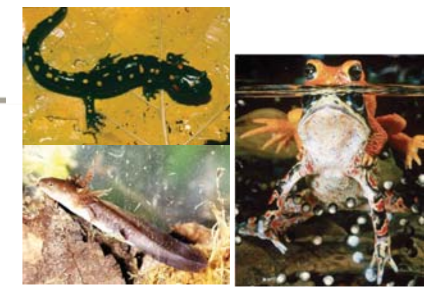
Compare and contrast the transition from water to land in plants and vertebrates.



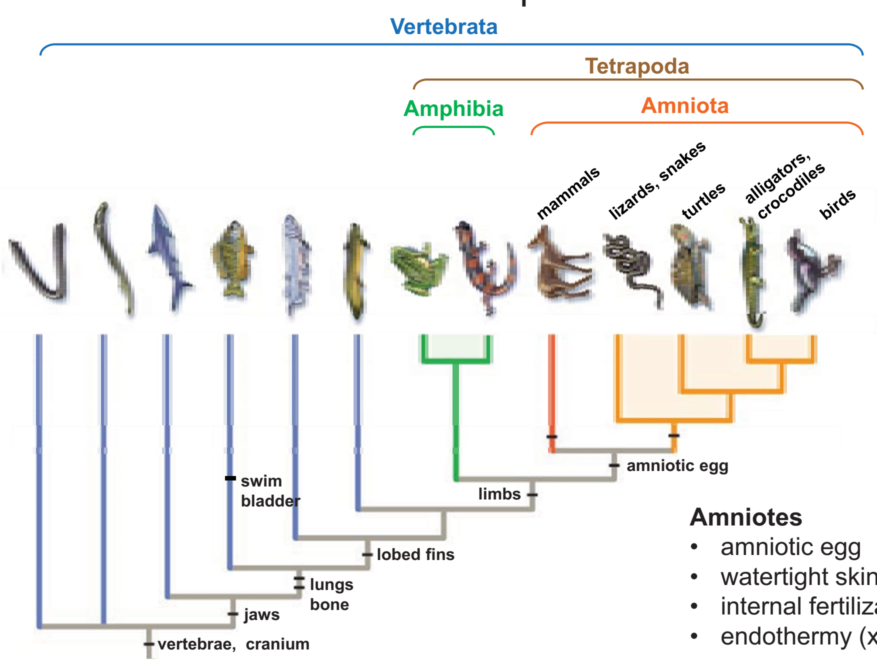
Amphibians – partial transition to life on land



Amphibia ~ 4800 species
- partial terrestriality
- gas exchange across skin
- typically with aquatic larvae
- some with internal fertilization



Amniotes – mammals and reptiles/birds

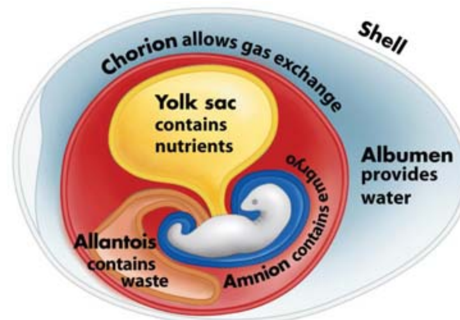


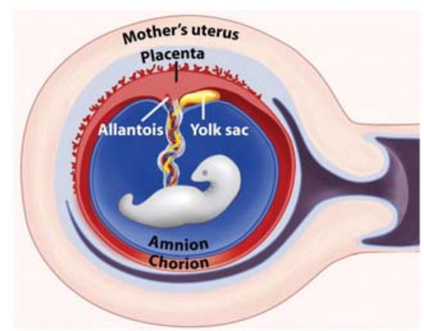
Amniotes
- amniotic egg
- watertight skin
- internal fertilization
- endothermy (x2)

Why are chordates so diverse?

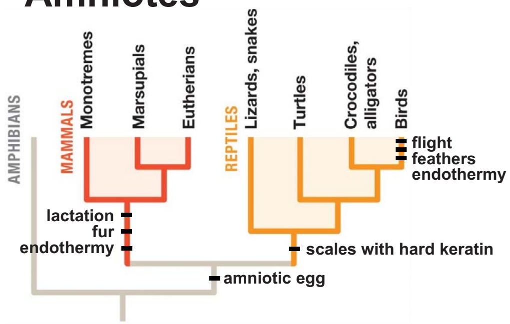
ECOLOGICAL OPPORTUNITY:
completing the transition to land

MORPHOLOGICAL INNOVATIONS:
amnion
waterproof skin

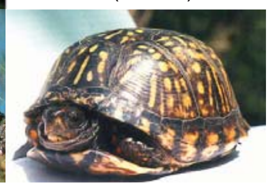




Amniotes



"Reptiles" ~7000 spp
- paraphyletic
- keratin (scales)



Mammals ~4500 spp
- early split w/reptiles
- mammary glands
- hair
- endothermy

Birds ~9700 spp
- feathers
- flight
- endothermy