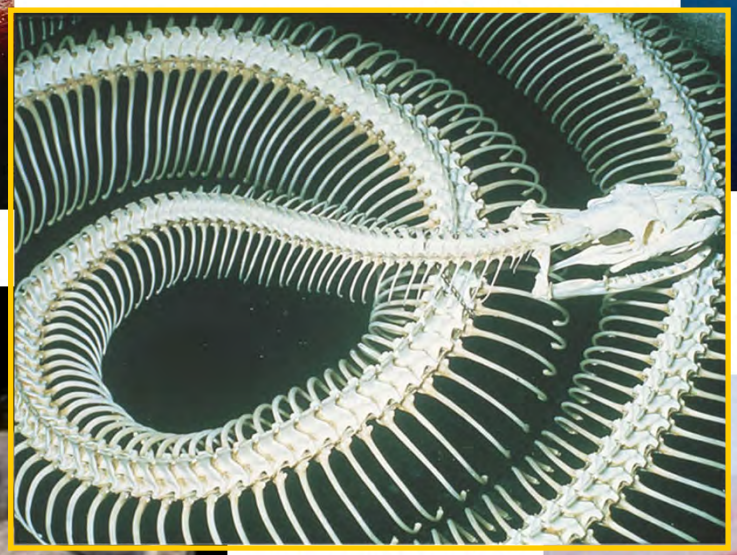
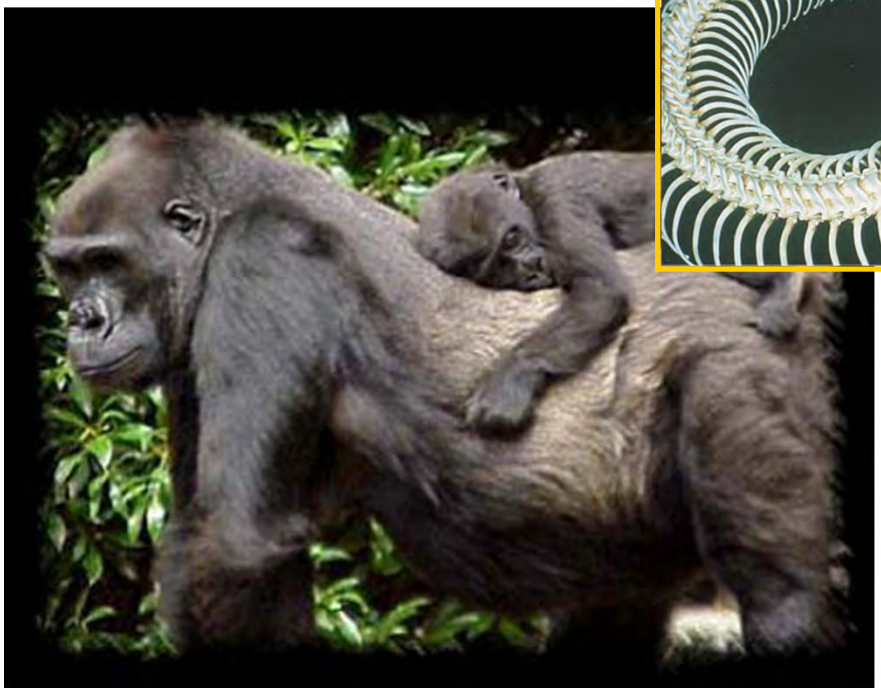
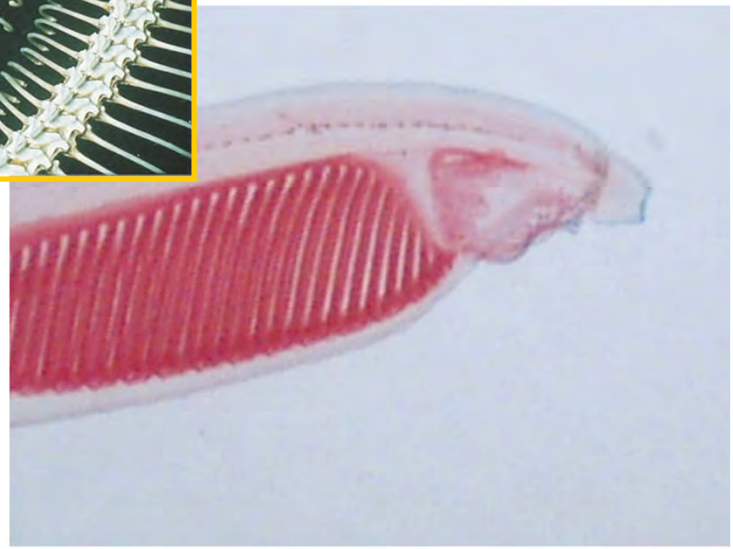
Vertebrates

Chapter 34



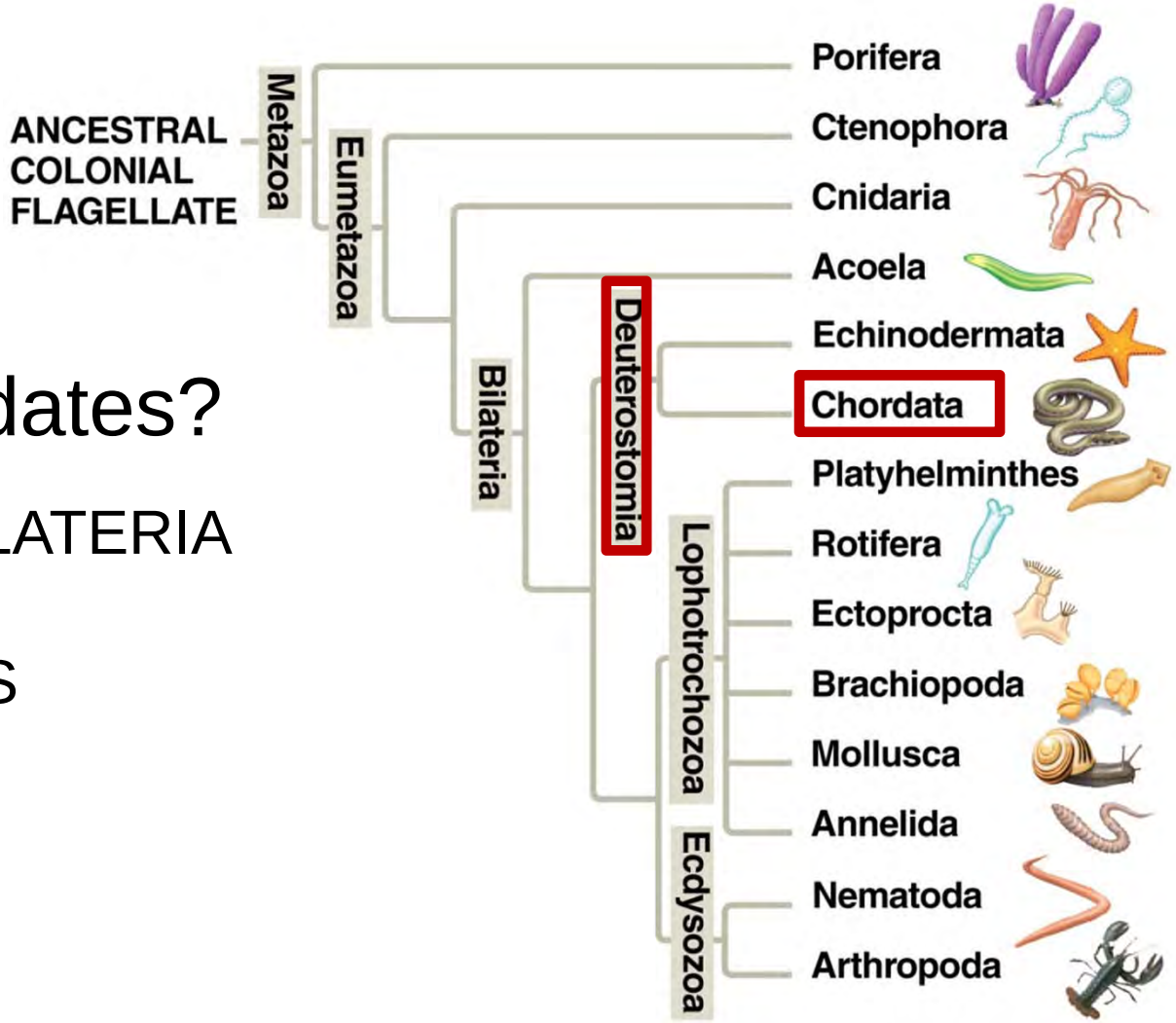




2

Phylum: Chordata

Lancelets, sea squirts, hagfish, and vertebrates



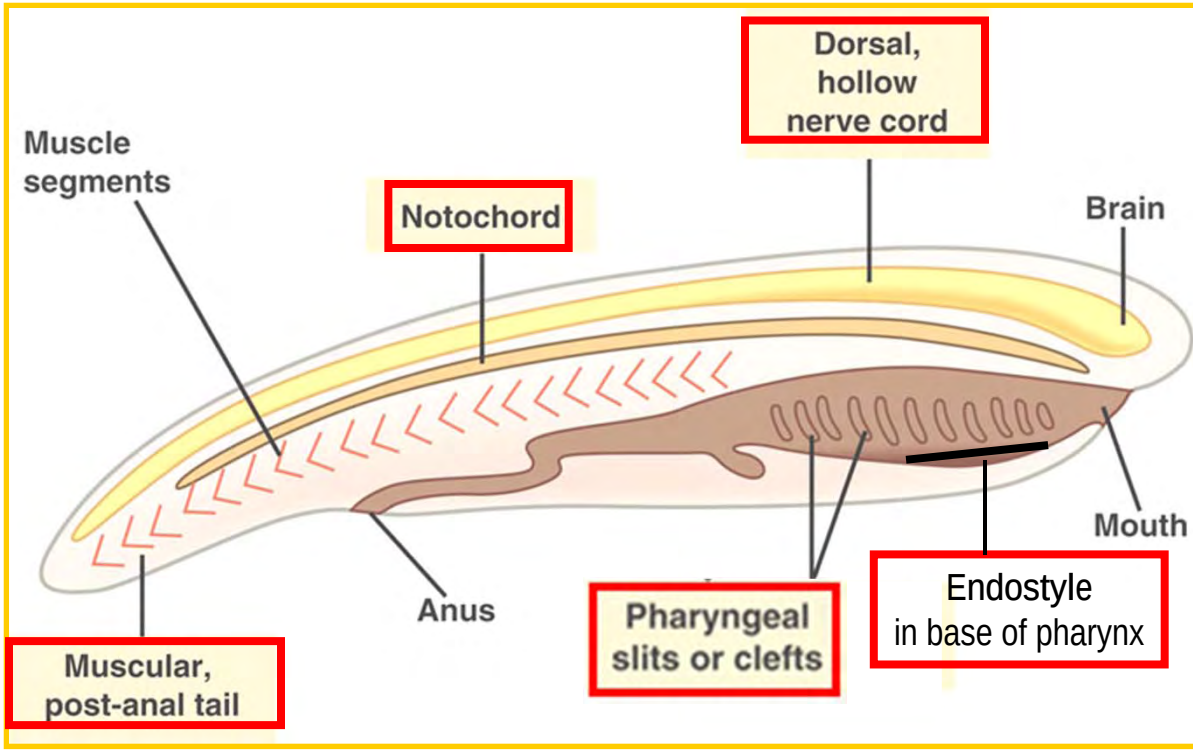
What are Chordates?

1. TRIBLOBASTIC BILATERIA
2. COELOMATES
3. DEUTEROSTOMES

Figures 32.10 and 32.11 (Campbell et al.)

3 Five characters common to all Chordates:

1. Notochord
2. Dorsal, hollow nerve chord
3. Muscular post-anal tail
4. Endostyle
5. Pharyngeal slits



- ALL 5 characters occur in ALL chordate <u>embryos</u>
- All larvae and adults retain a DHNC plus 0-4 of the other characters

**1-4 = shared derived characters

5 = ancestral Deuterostome character

Modified from Figure 34.3 (Campbell et al)

1. Notochord

- This is the “chord” in chordates
- Flexible rod made of fluid-filled cells encased in stiff fibrous tissue
- IF retained in larvae or adult = skeletal support & anchor for swimming muscle
  - In vertebrate adults is absent or only remnants remain
    (e.g. notochord cells remain within intervertebral discs
    in young humans but lost by age 4)

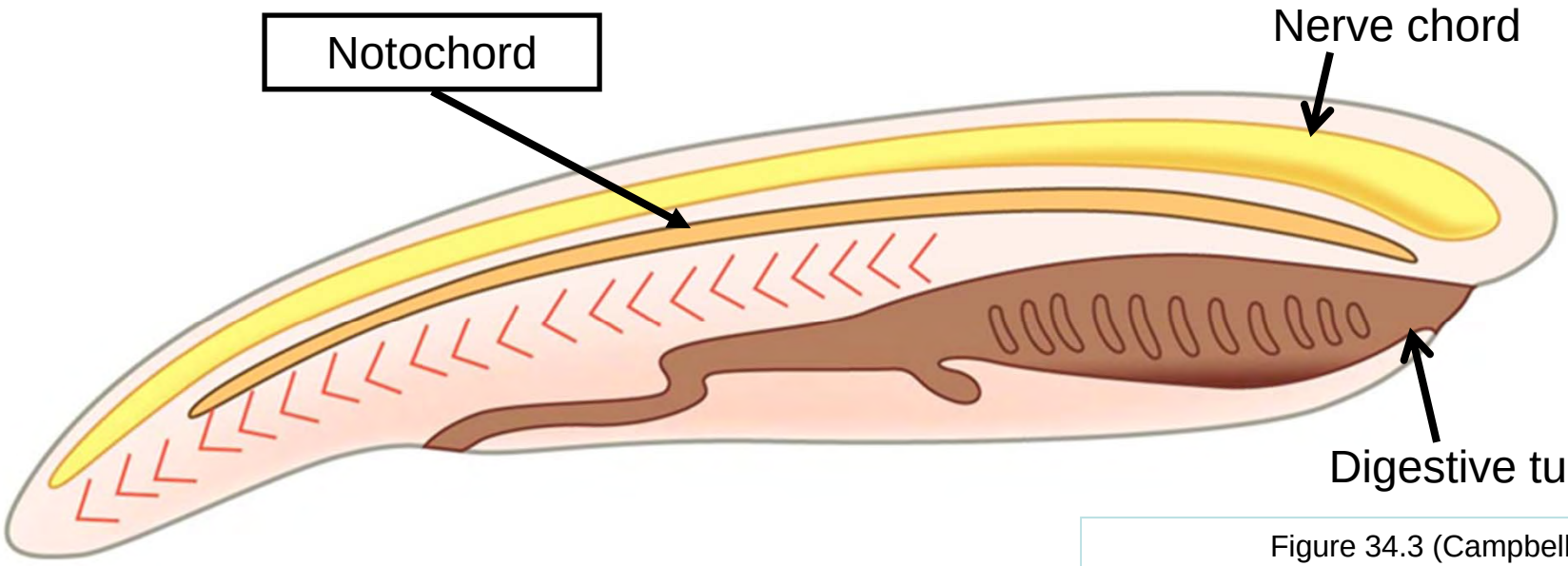
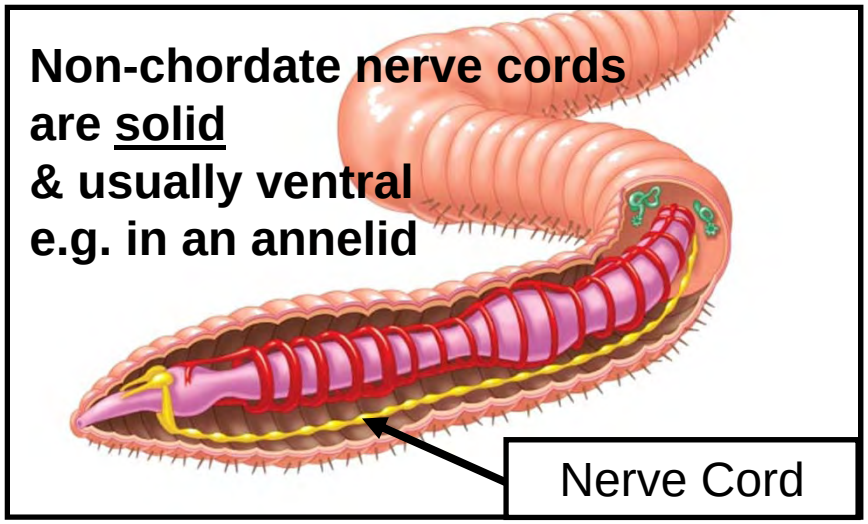


Figure 34.3 (Campbell et al)

2. Dorsal, hollow nerve cord

- Embryonic DHNC develops into central nervous system in adults (brain and spinal cord)



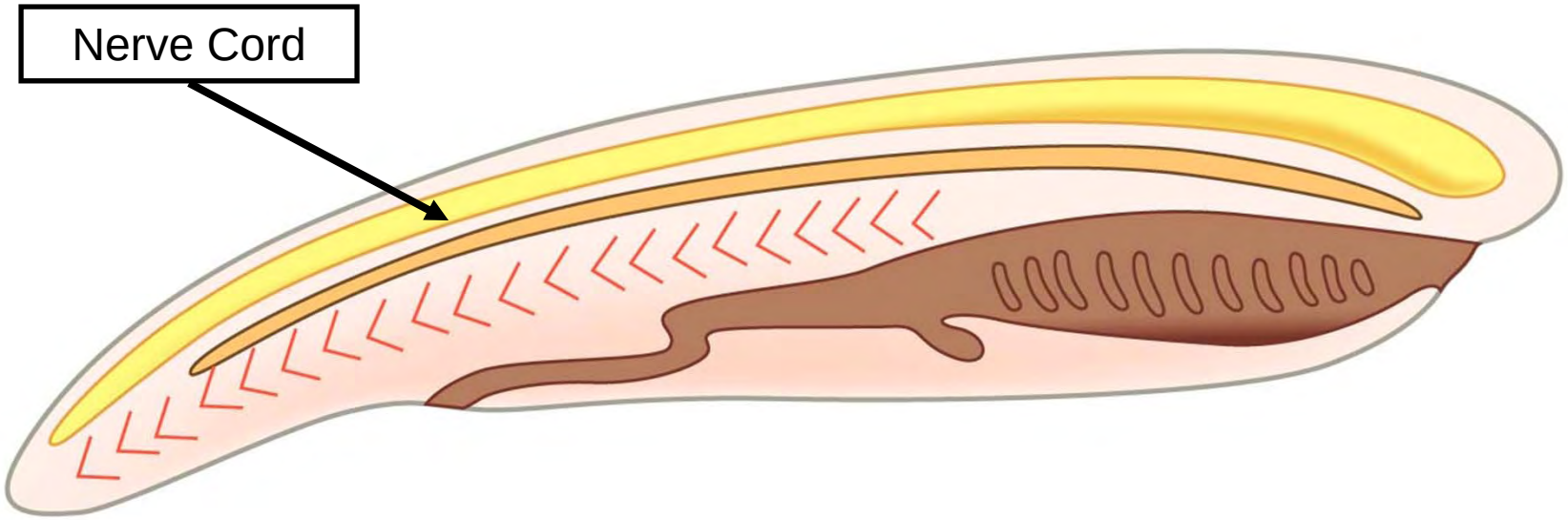
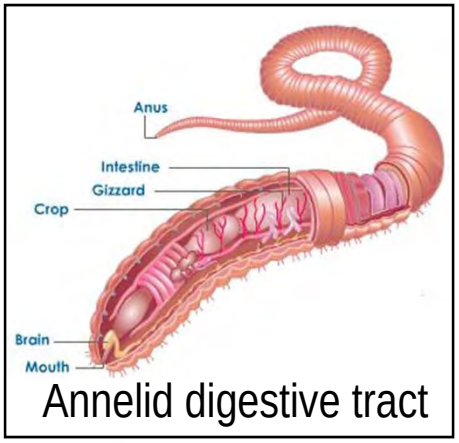


Figure 34.3 (Campbell et al)

3. Muscular, post-anal tail

- Tail extends beyond anus
  - vs digestive tract extends through entire body in nonchordates
- IF retained, used in propulsion



Annelid digestive tract

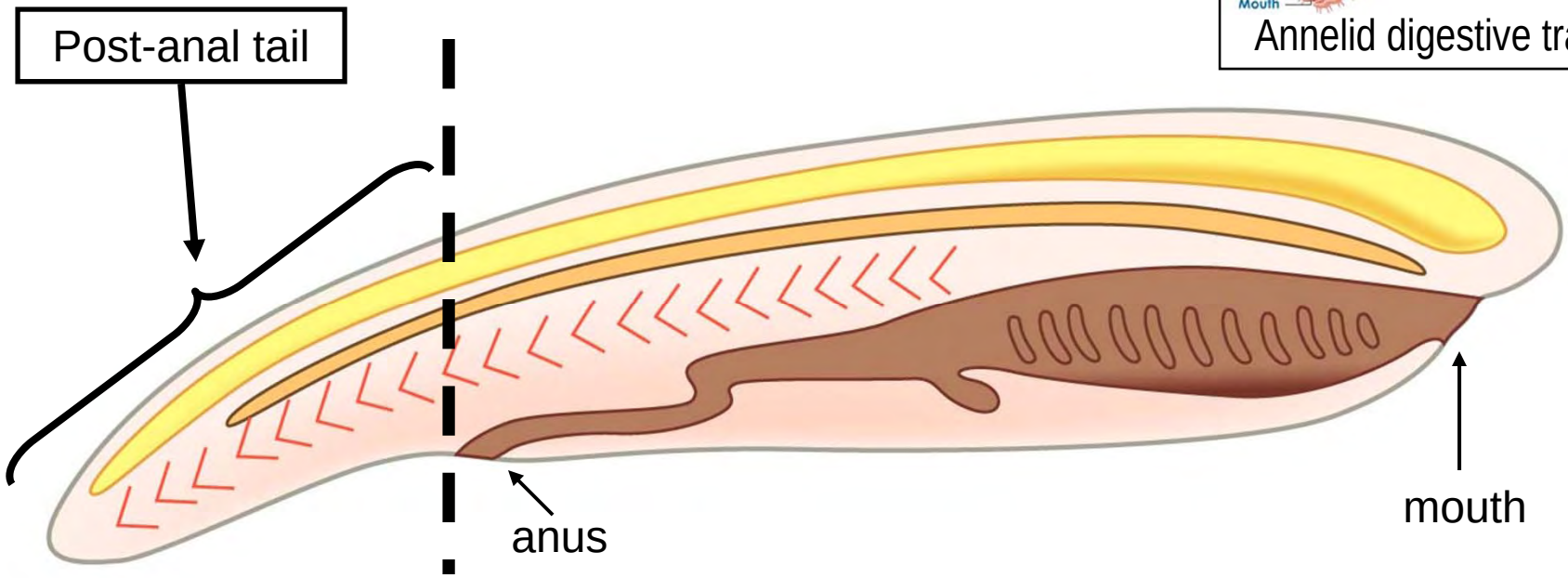
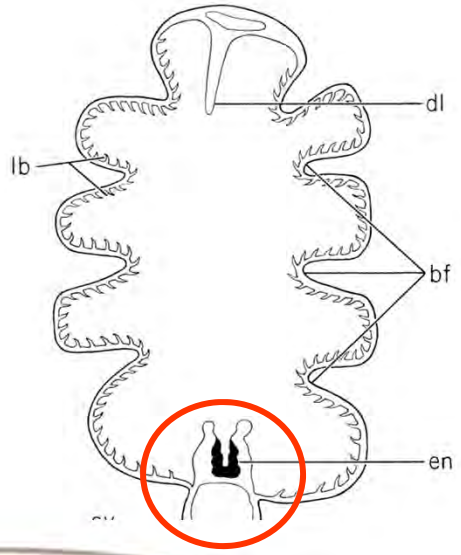
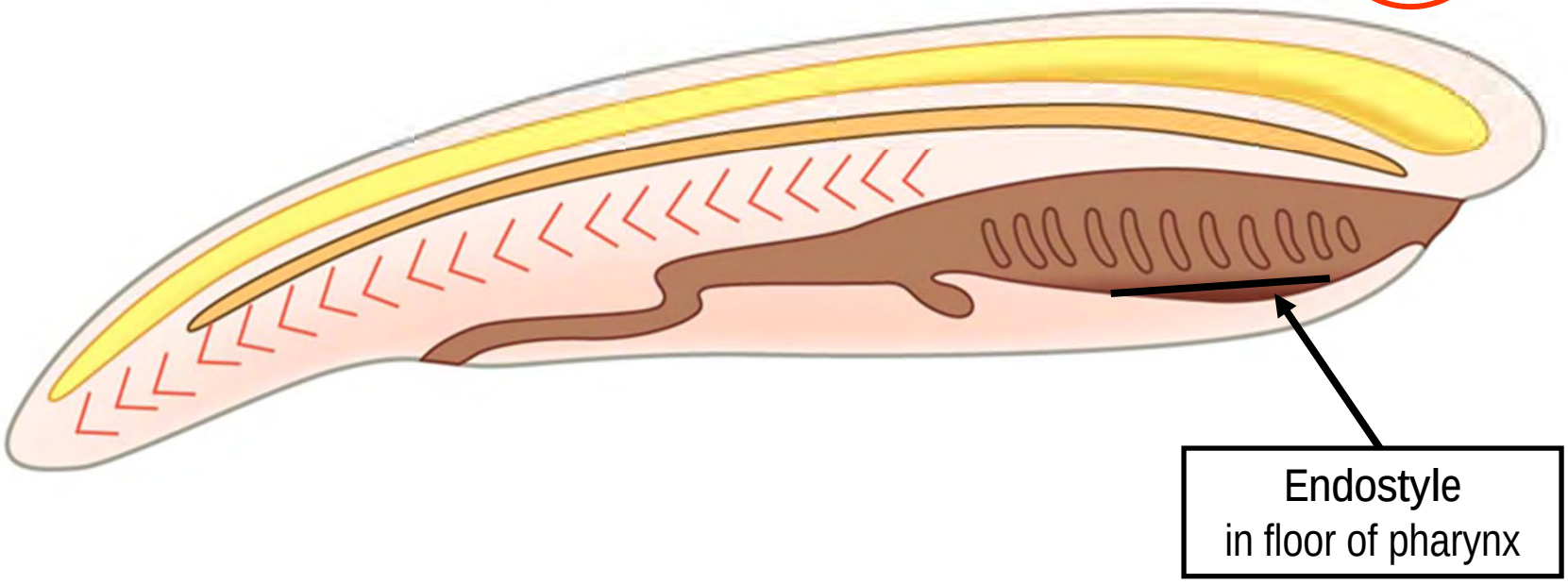


Figure 34.3 (Campbell et al)

4. Endostyle

- Ciliated glandular groove on floor of pharynx
- Secretes mucus for trapping food particles
- Occurs in all Chordate subphyla
  - But in vertebrates is only in larval lampreys.





5. Pharyngeal slits or grooves

- In embryo, grooves (aka clefts) develop on side of pharynx btwn cartilage arches
  - (Pharynx = portion of digestive tract just posterior to mouth)

- In most chordates grooves become slits that open to outside
  - Slits usually become structures for filter feeding or respiration (gills)
    - i.e. H_2O w/ food enters mouth & leaves via slits w/o food (filter) or O_2 (gills)

- In tetrapod adults, 1st groove becomes outer ear opening & others disappear

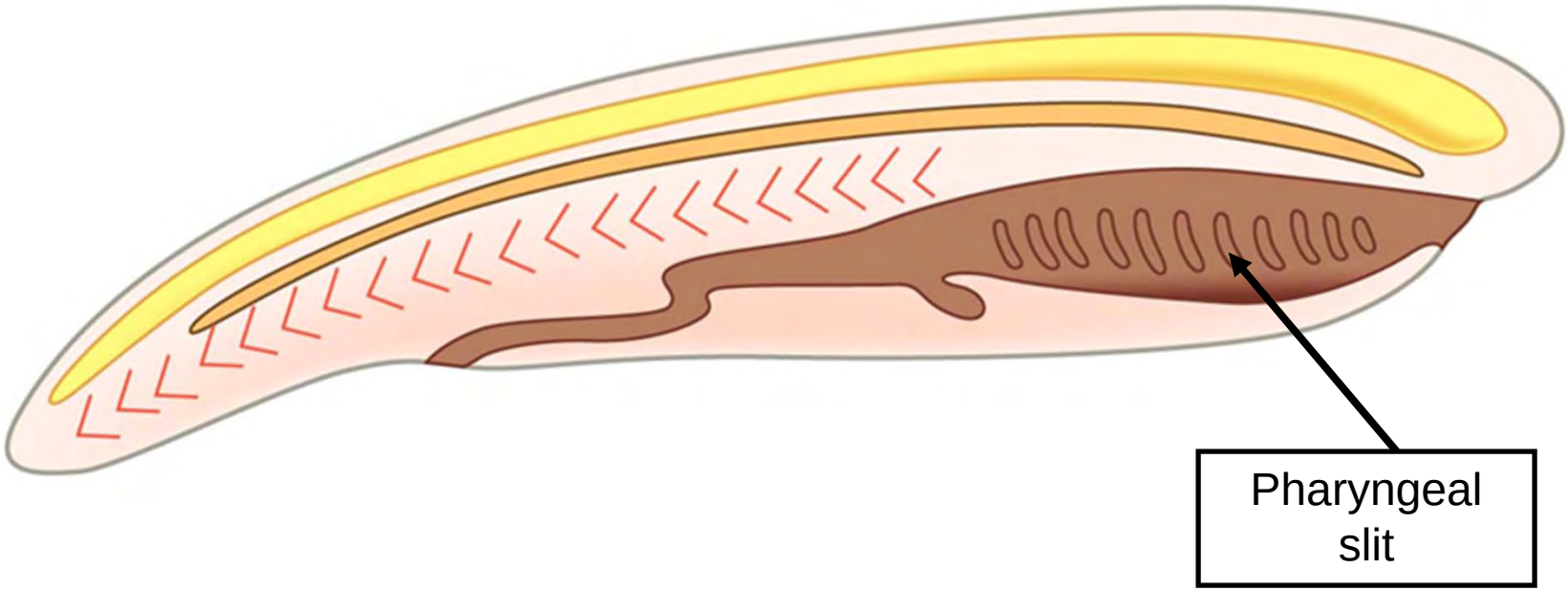
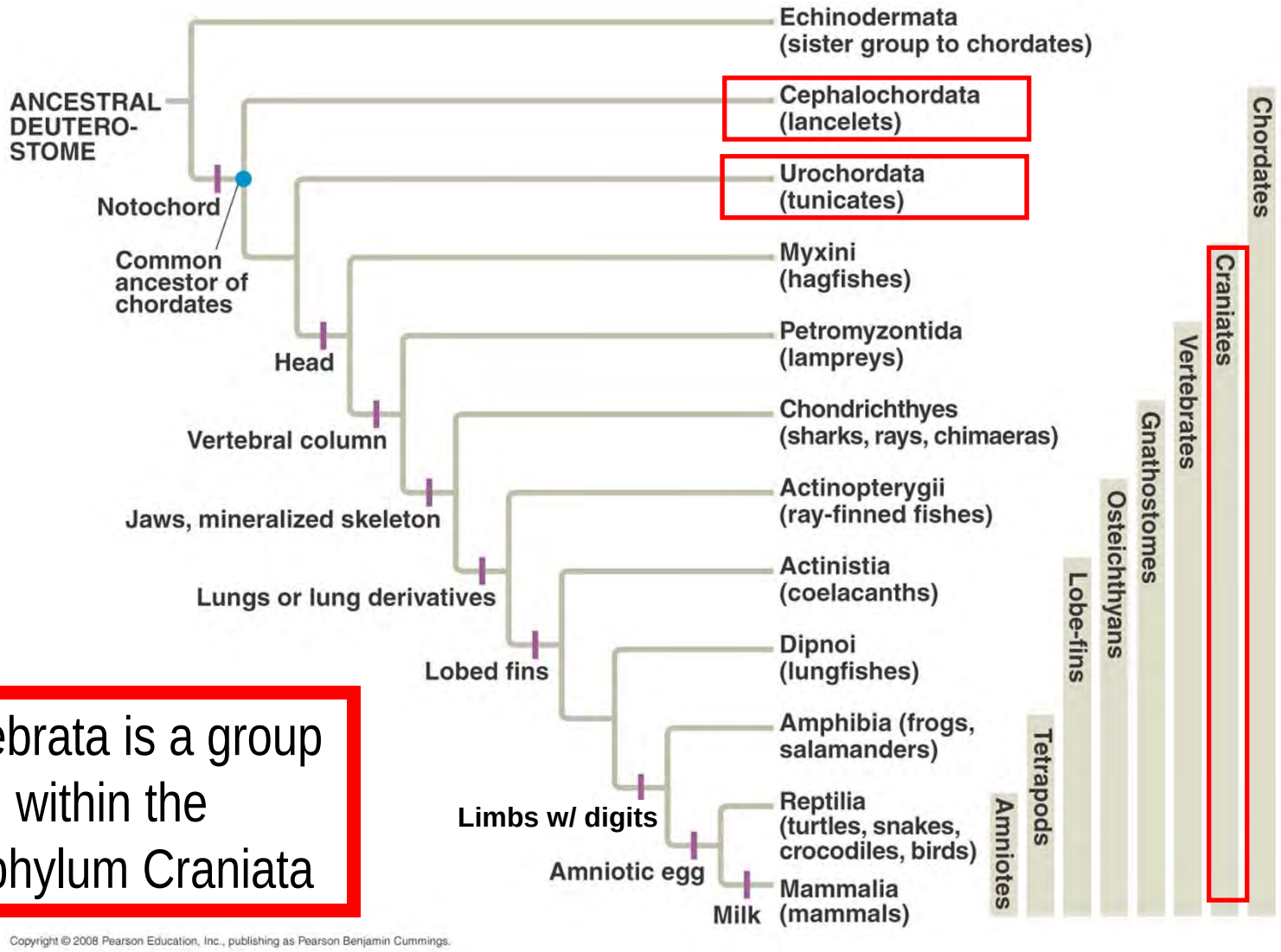


Figure 34.3 (Campbell et al)

Phylum Chordata

3 Subphyla:

(1) Lancelets (Cephalochordata) (2) Tunicates (Urochordata) (3)Craniates



Vertebrata is a group within the subphylum Craniata

Figure 34.2 (Campbell et al)

1. Lancelets (Cephalochordata)

- ~25 marine species (e.g. lancelet “amphioxus”)
- Small (<5cm), translucent, fish-like
- Larvae swim vs. most adults sedentary burrowers
- Adults have all 5 chordate characters
- Gill slits primarily for filter feeding (not respiration)
- Unlike vertebrates, notochord extends to tip of snout

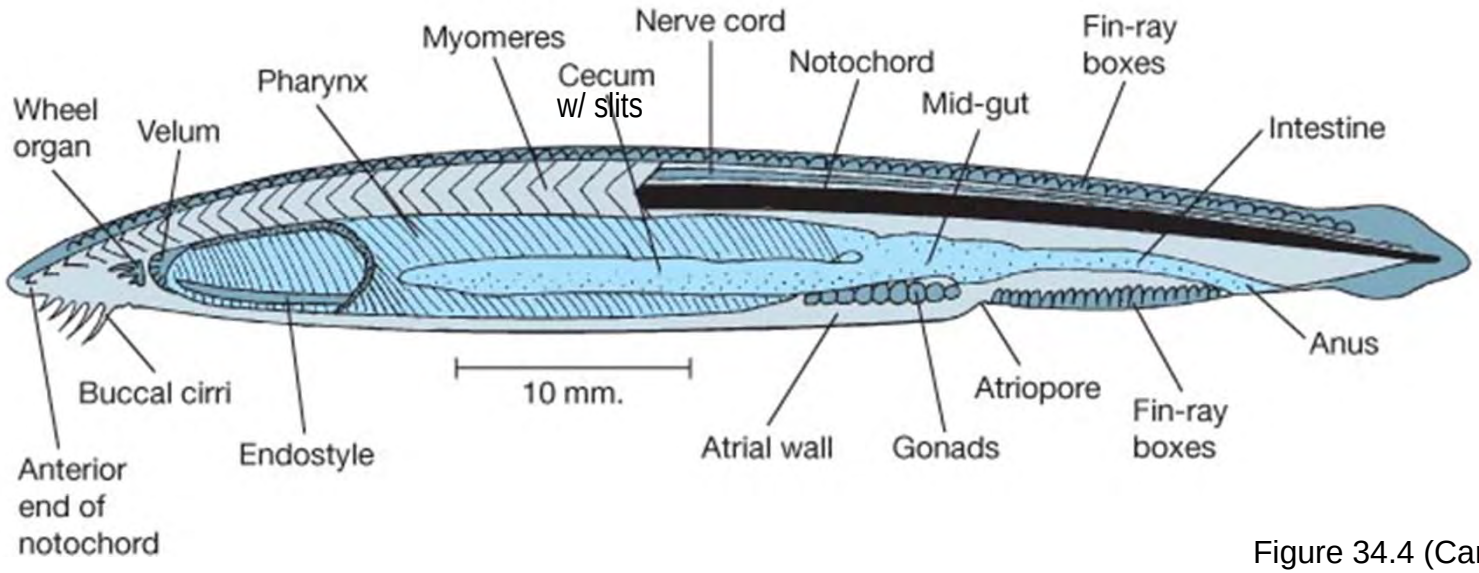
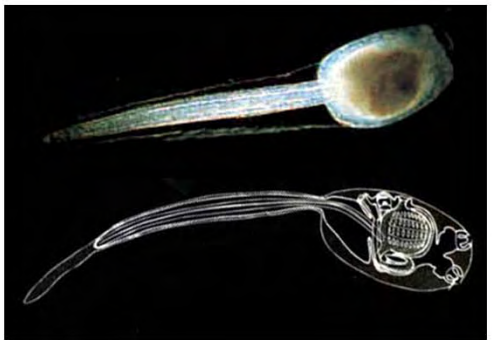


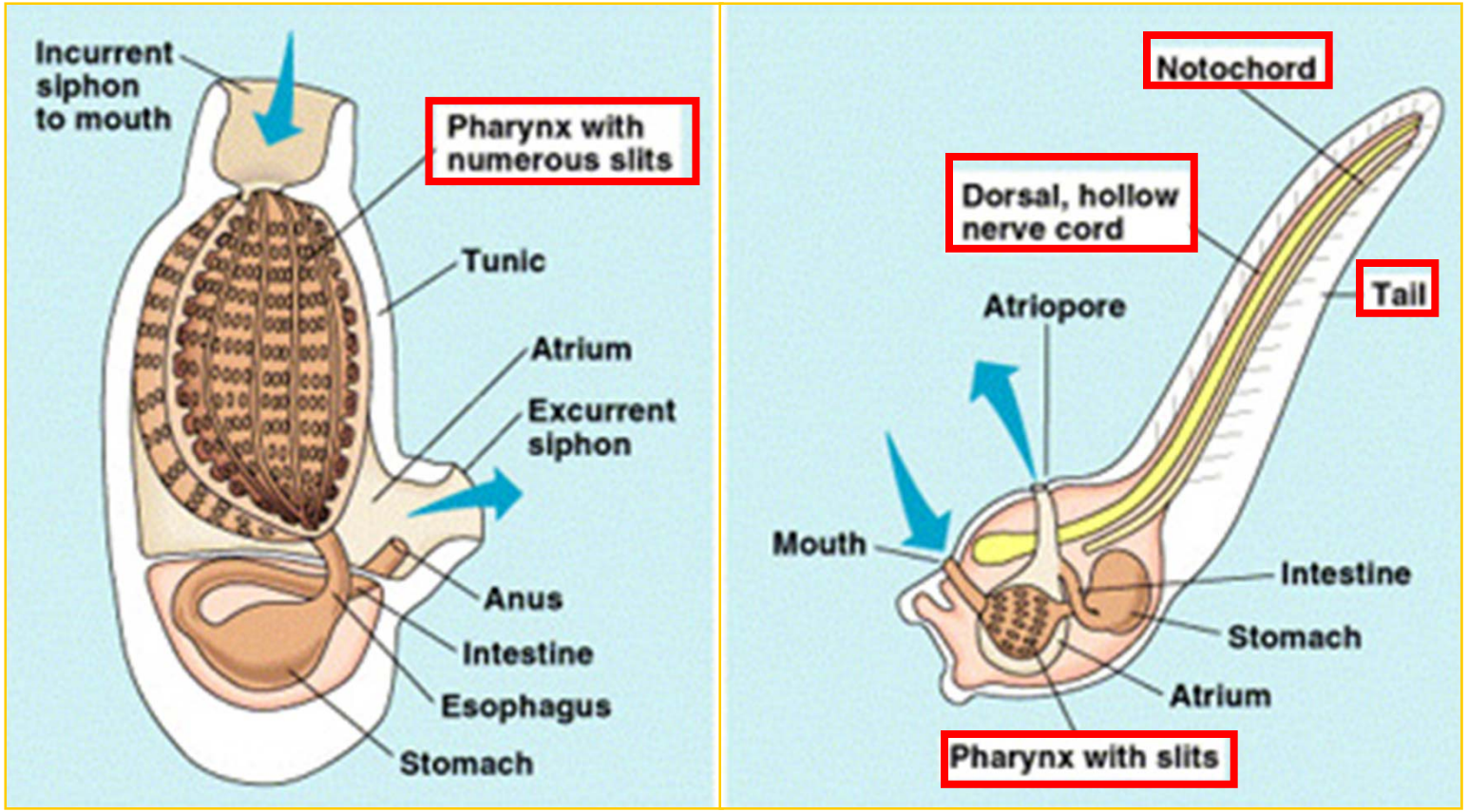
Figure 34.4 (Campbell et al)

2. Tunicates (Urochordata)

- Tunicates
- ~2000 species
- Filter-feeders
- Free swimming larvae
- Most sessile as adults



2. Tunicates (Urochordata)



ADULT

(1) DHNC (2) Endostyle

(3) Pharyngeal slits *No notochord or tail

LARVA

• All 5 chordate charachters

Adult Water flow: Incurrent siphon → Pharynx → Gill slits → Atrium → Excurrent siphon

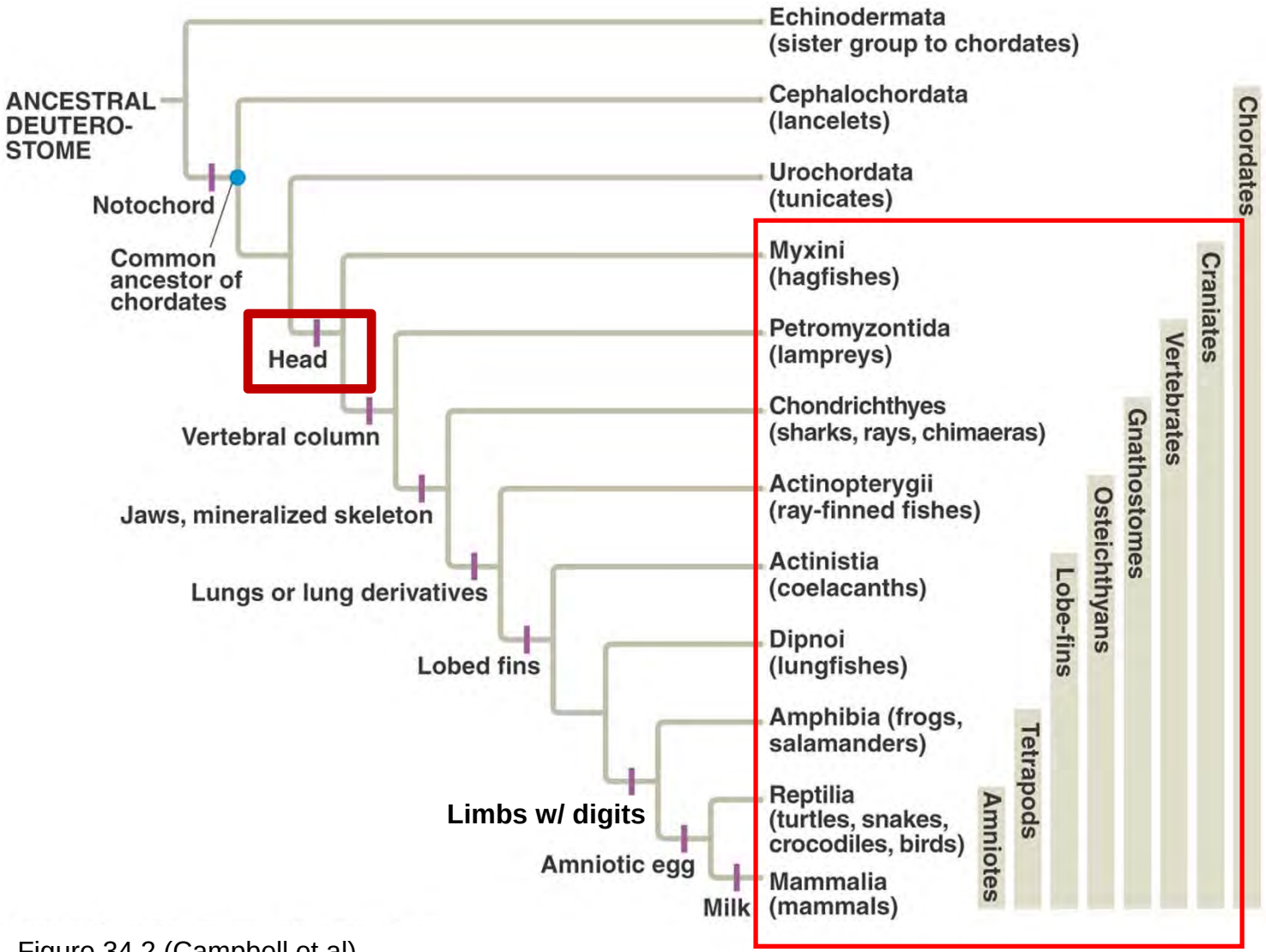
Spp w/ free-swimming adults resemble larval form more.

Figure 34.5 (Campbell et al)

A juvenile of tunicate *Oikopleura dioica*

3. Subphylum Craniata

- 1 invertebrate class (Hagfish (Myxini))
- All other classes are vertebrates



3 Subphyla:

1.Lancelets

2.Tunicates

3.Craniates

Figure 34.2 (Campbell et al)

CRANIATE FEATURES

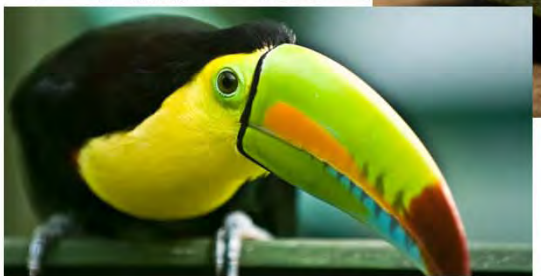
- Cranium to protect brain;
- Head extends beyond notochord;
- Complex brain and sense organs
- Closed circulatory system
- Complex multichambered heart
- Gills primarily for respiration not feeding;
- etc…











Hagfish (Class Myxini)

- Cartilaginous skull
- No jaws and no vertebrae
- Mouth w/ “toothed” tongue (keratin)
- Bottom-dwelling scavengers
  - rip off flesh
  - eviscerate dead or dying animals from inside

Hagfish (Class Myxini)

- Produce slime to aid in movement through animal and as a defense (several L in 1 min.)

A student with the Youth Forum in Bamfield, B.C.. Hagfish slime works quite well as a cooking ingredient, with a make-up similar to egg whites. *Source: Oceanlink.island.net*

The Vertebrates

- 1 jawless class (lampreys)
- The rest w/ jaws

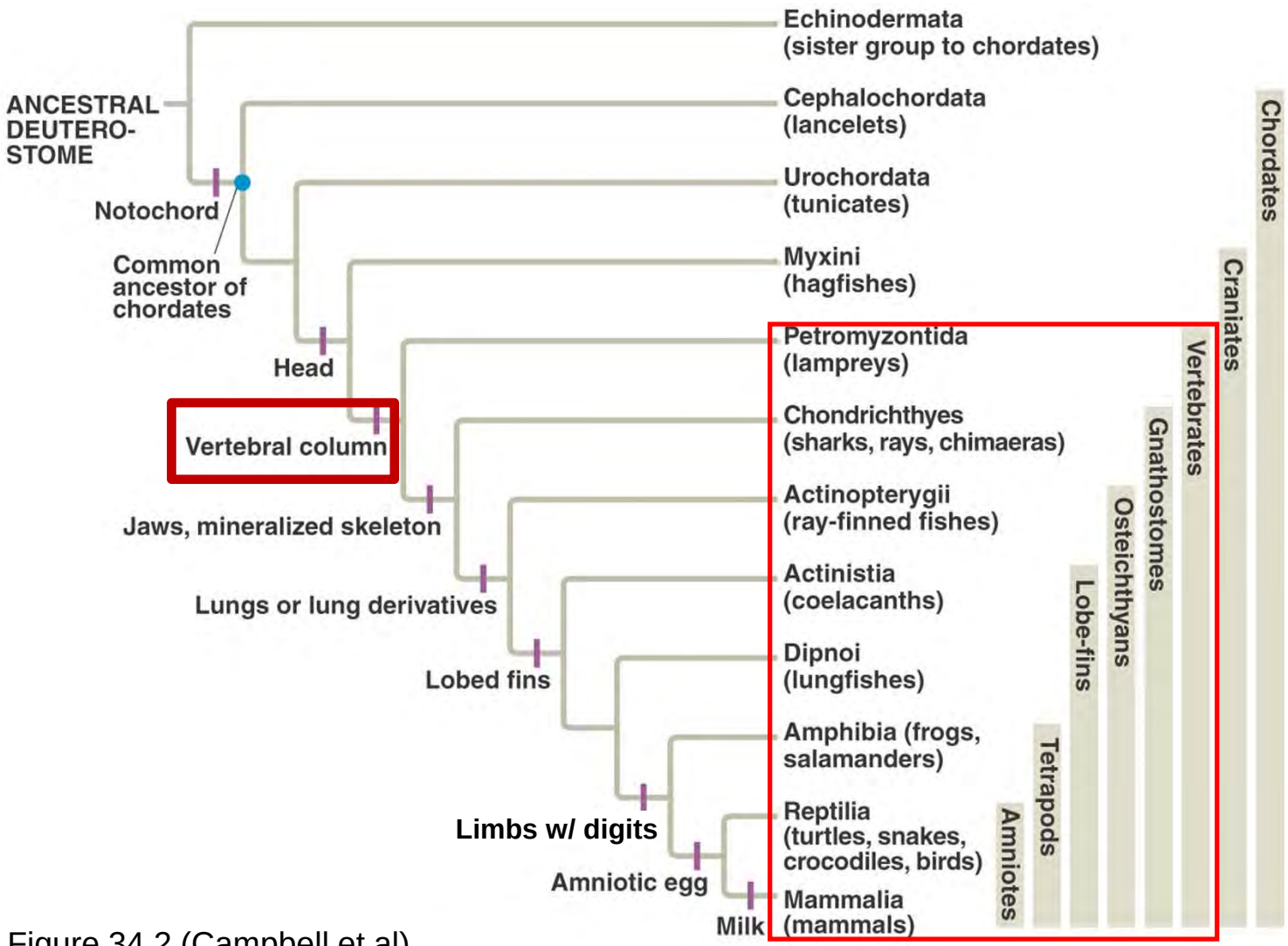
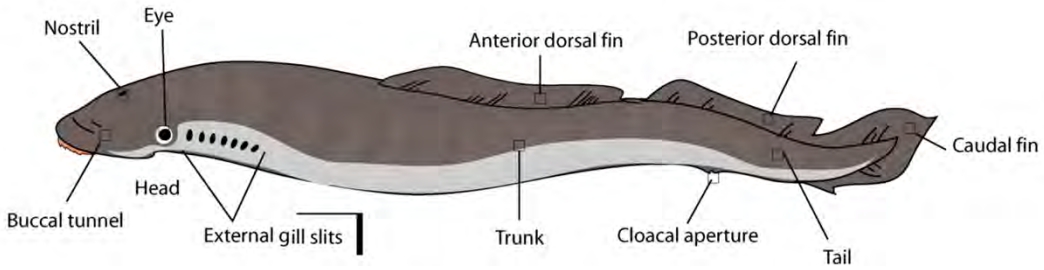


Figure 34.2 (Campbell et al)

Lampreys (Petromyzontida)

- ~40 species
- Have cranium & vertebral column made of cartilage
- But still NO jaws
- Adults w/ notochord and pharyngeal slits … gills



- Head w/ large eyes
- External gill slit
- 2 dorsal fins + caudal fin

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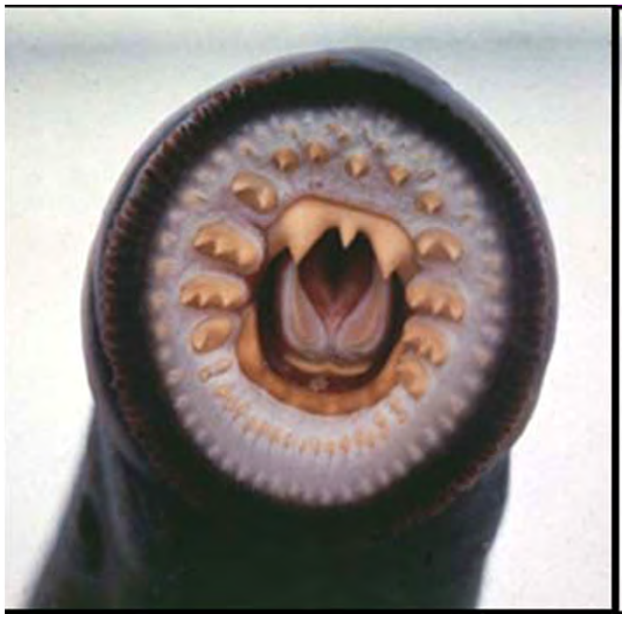
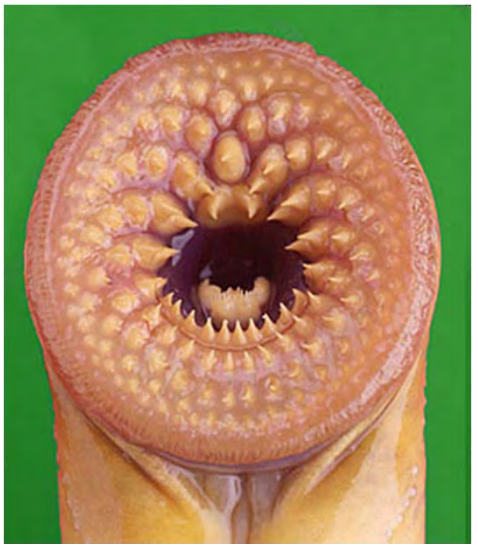
Figure 34.10 (Campbell et al)

Lampreys (Petromyzontida)

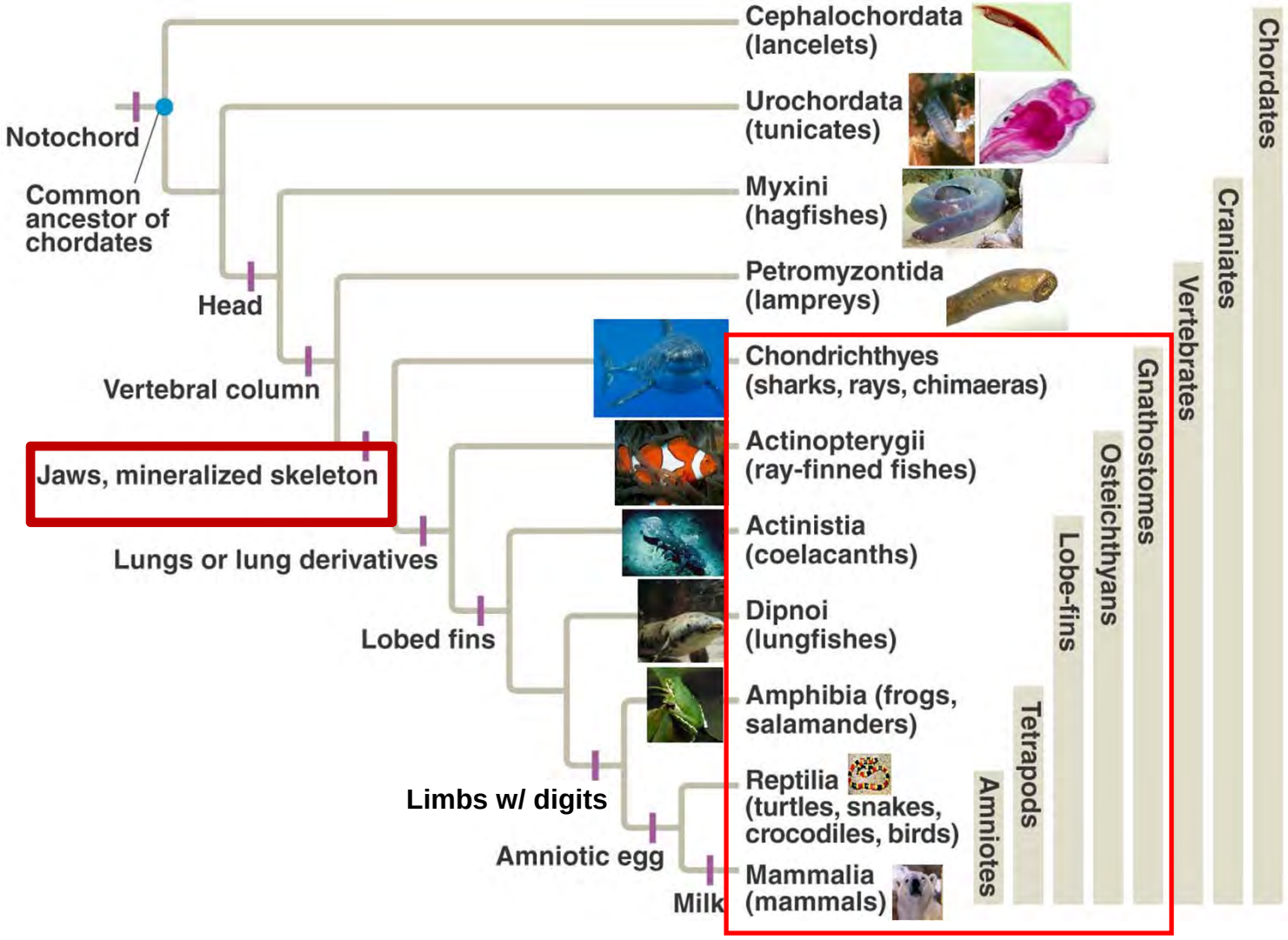


- Larvae are free-swimming filter feeders
- Adults are ectoparasites
- Rasping tongue
- Eat invertebrates or drink blood (sanguivores)



The Gnathostomes

Chondrichthyes (sharks, rays) + Osteichthyes (Bony fish + tetrapods)



All have craniums, vertebral column, skeleton, and jaws

Figure 34.2 (Campbell et al)

29 Class Chondrichthyes

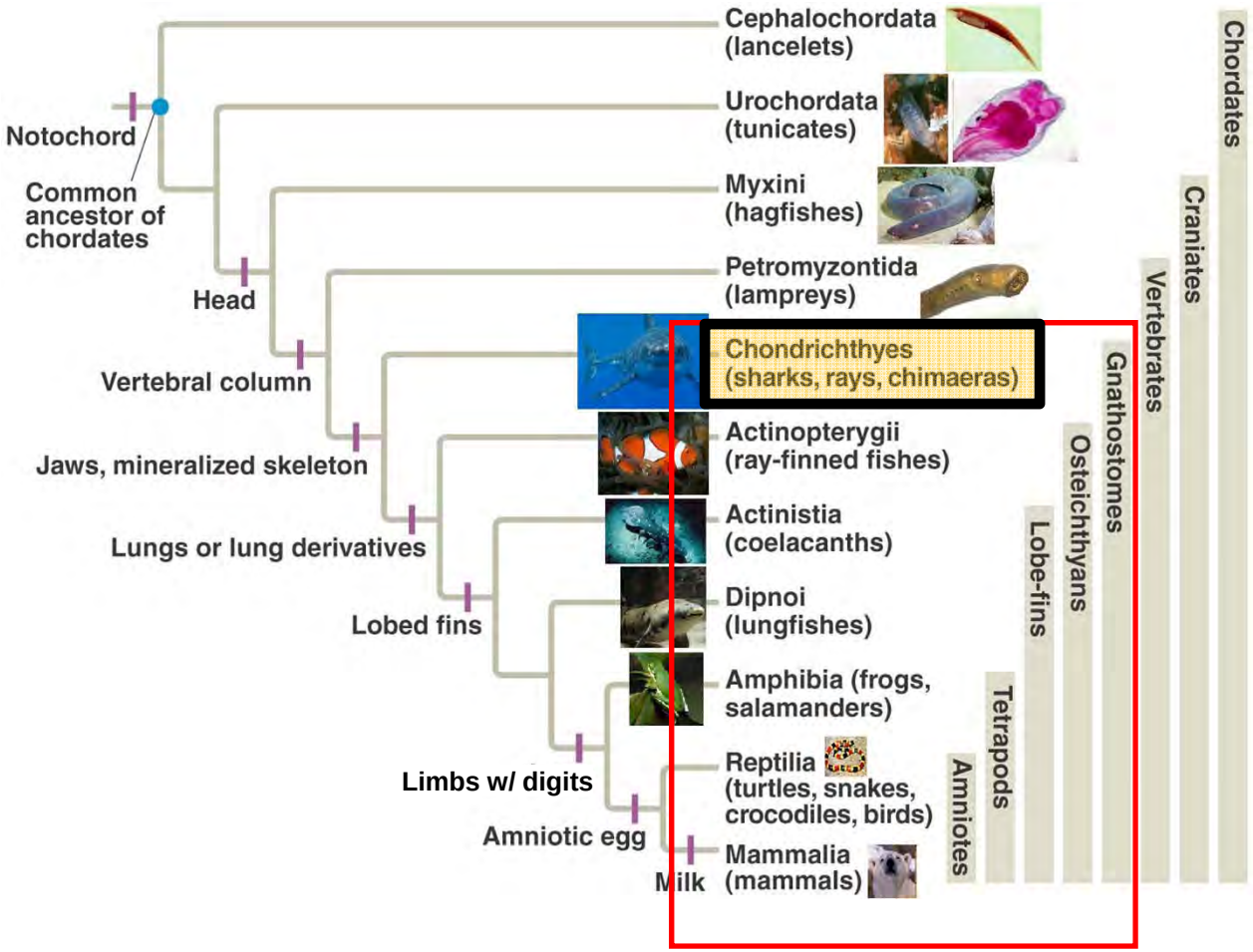
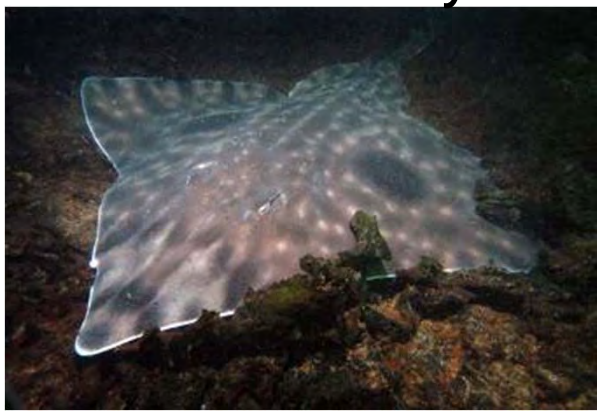


Figure 34.2 (Campbell et al)

Sharks

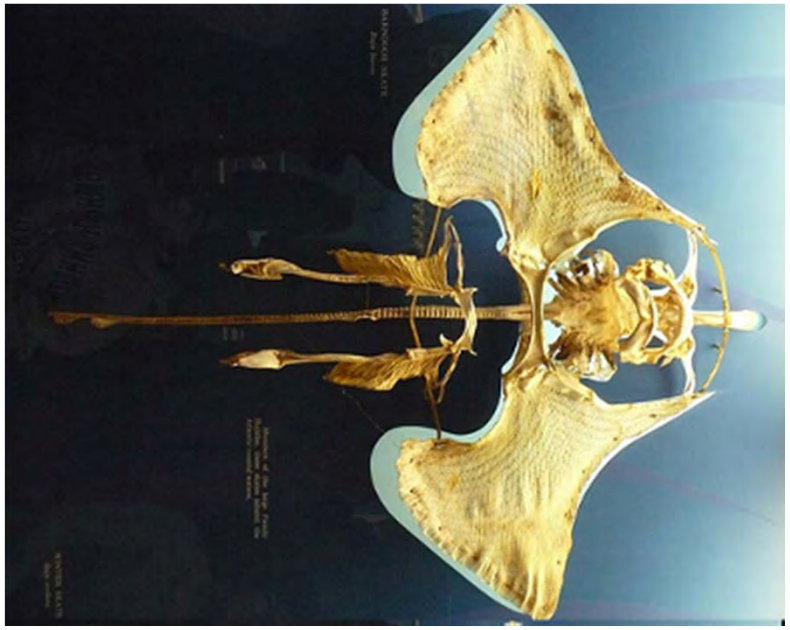
Skates and Rays



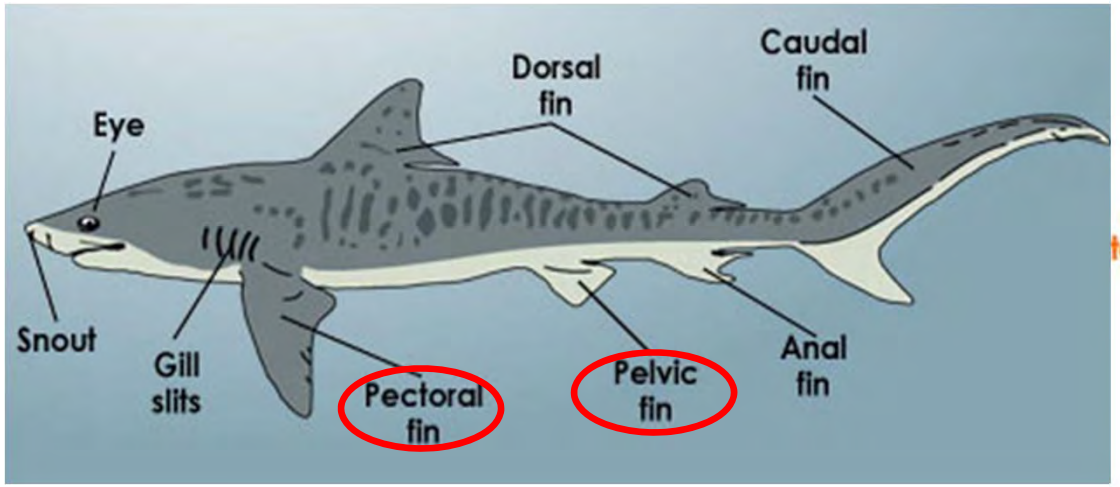
Chimeras (ratfish)

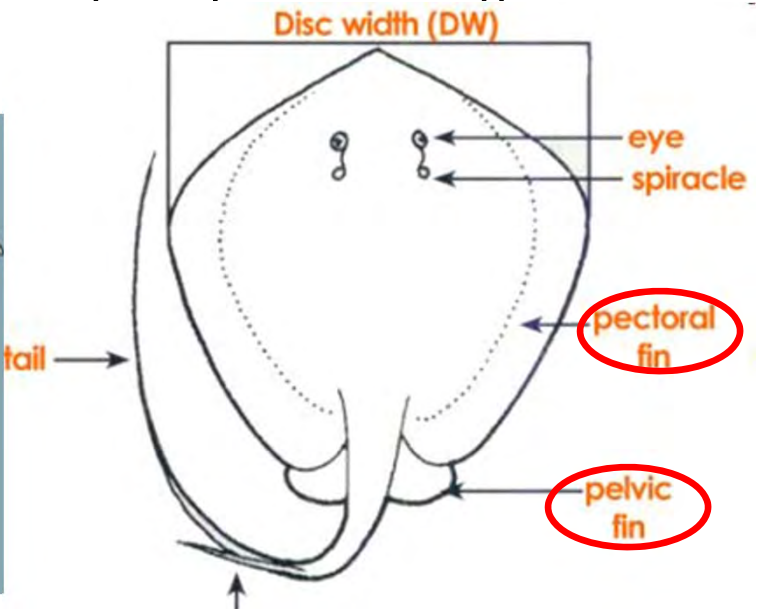
Class Chondrichthyes:

sharks, rays and chimaeras



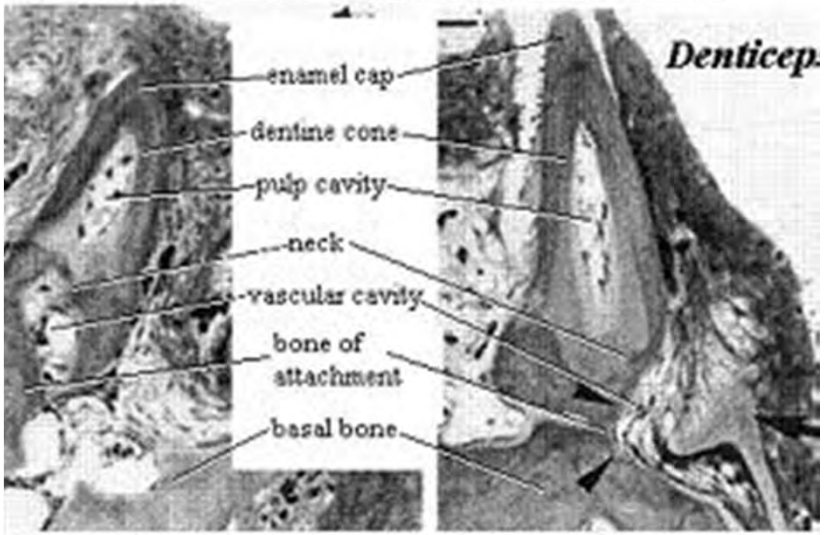
- ~750 spp
- Mineralized (Ca) cartilage skeleton
- Paired inflexible pelvic & pectoral fins
- No swim bladders (so sink or swim)
- No operculum (except chimeras)
- Cloaca: 1 urogenital 1 opening (except chimeras))





Class Chondrichthyes:

sharks, rays and chimaeras



Denticles from dentary (left) and dermal bone (right). Adapted from Sire et al. (1998).

- Teeth continually replaced in most
- Dermal denticles (scales):
  - "tooth" like scales in skin in most
  - Much different from bony fish scales

Class Chondrichthyes

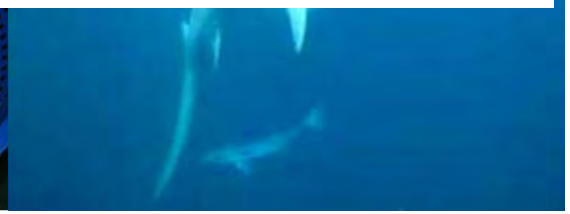
Reproduction

- Mature in 5 -15 years
- Internal fertilization
- Males w/ clasper organs on pelvic fins
  - Chimeras also have clasper on head
- May use teeth to hold female
- Lay eggs or live young

Class Chondrichthyes

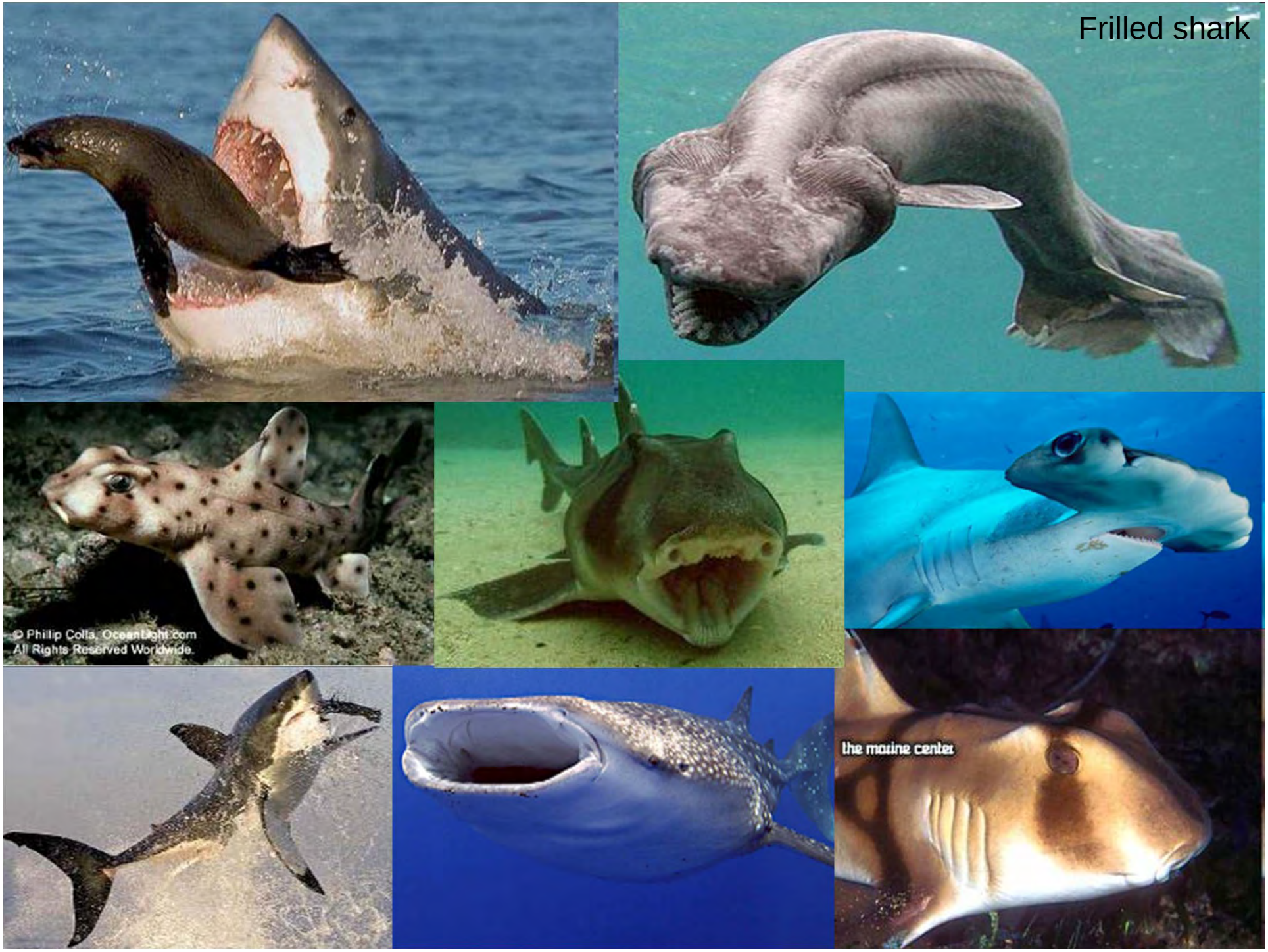
Ecological Concerns

Shark hunting for meat, fins and sport and entanglement



Of 17 large spp studied in North Atlantic:

- all populations ↓ 50% in 20 yrs
- hammerheads ↓ by 89%


Frilled shark
© Philip Colla, OceanLight.com
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the marine center

Osteichthyes

Ray-finned fish & Lobe-fins

- Animals w/ a bony endoskeleton hardened w/ calcium phosphate

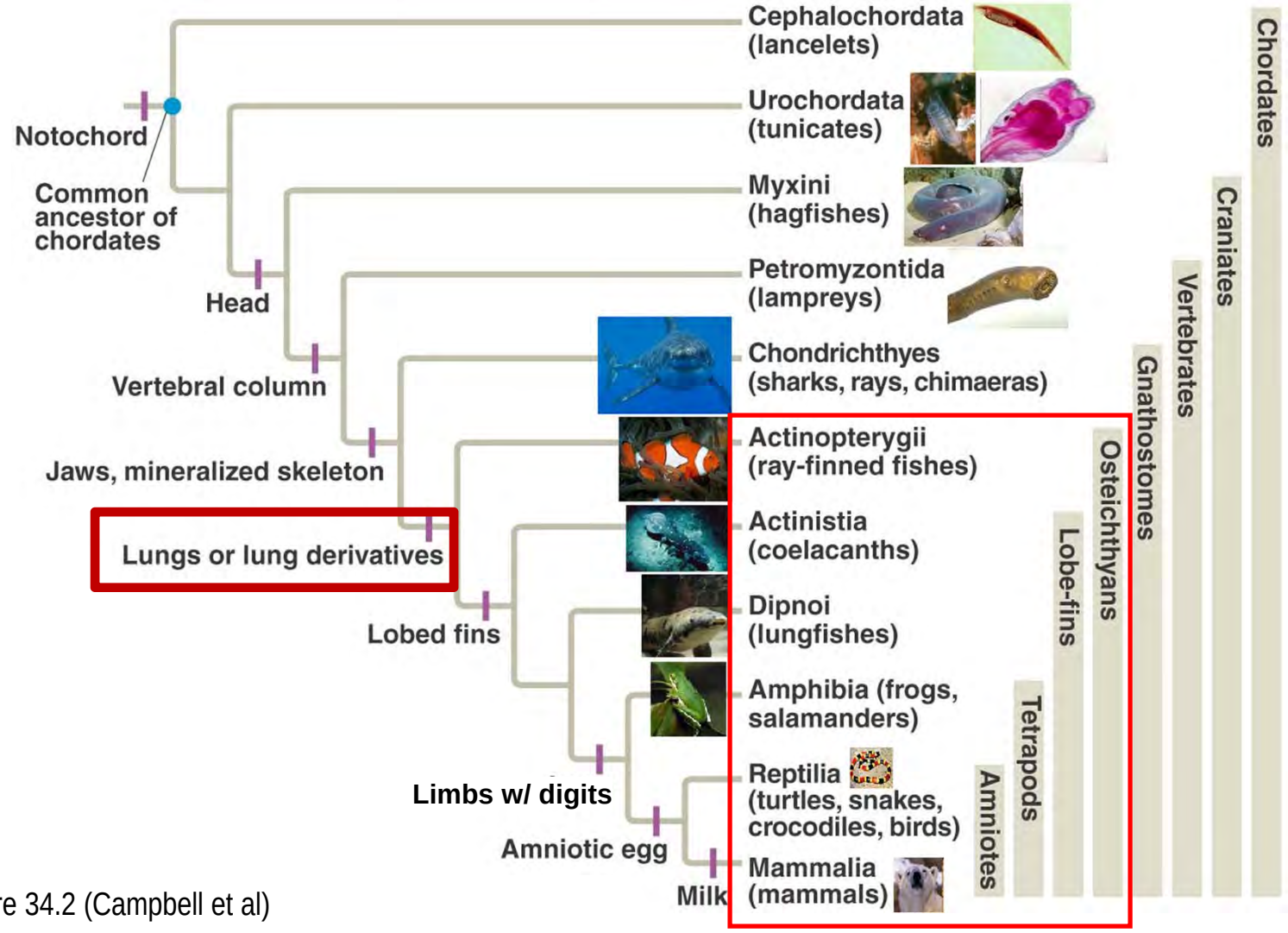
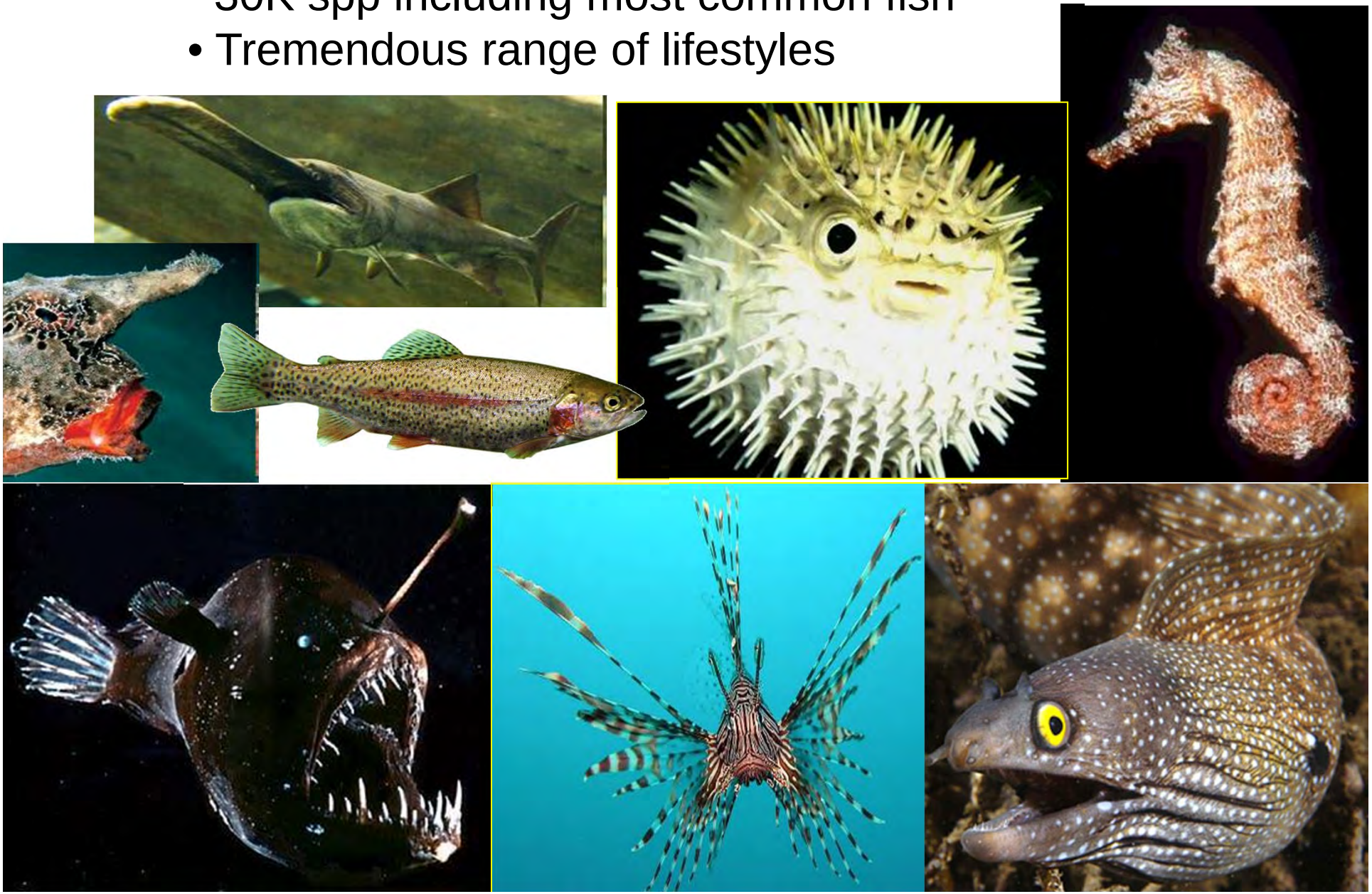


Figure 34.2 (Campbell et al)

Ray-finned fishes (Actinopterygii)

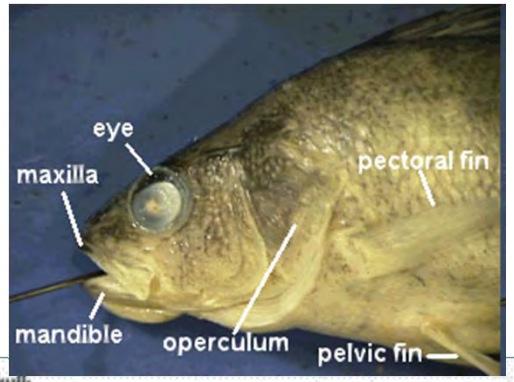
~30K spp including most common fish

- Tremendous range of lifestyles

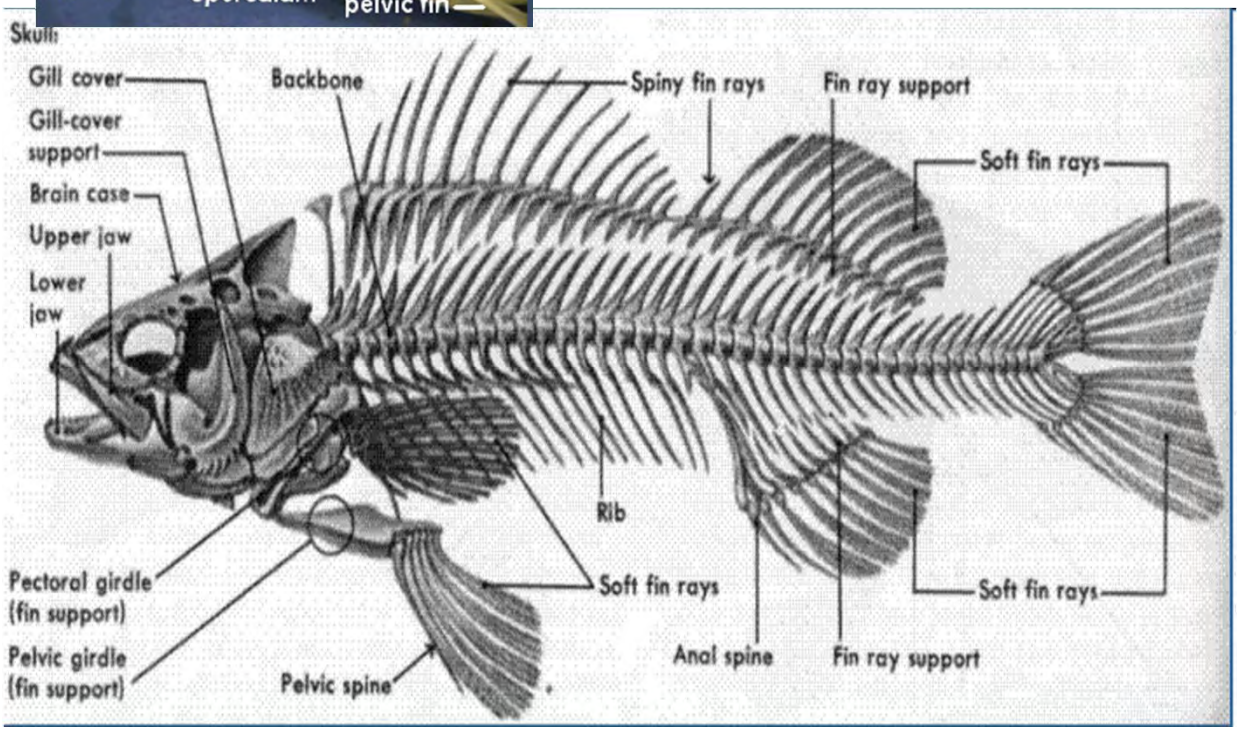


Actinopterygii (Ray-finned fishes)

- Fins are weblike and supported mainly by long flexible rays
- <u>Flexible</u> pelvic & pectoral fins

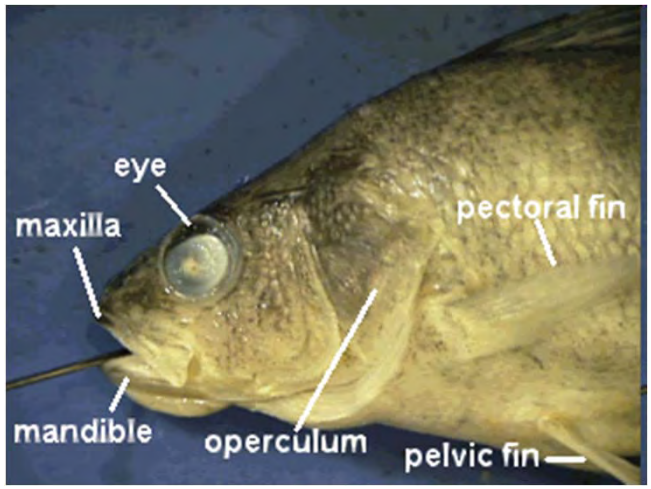


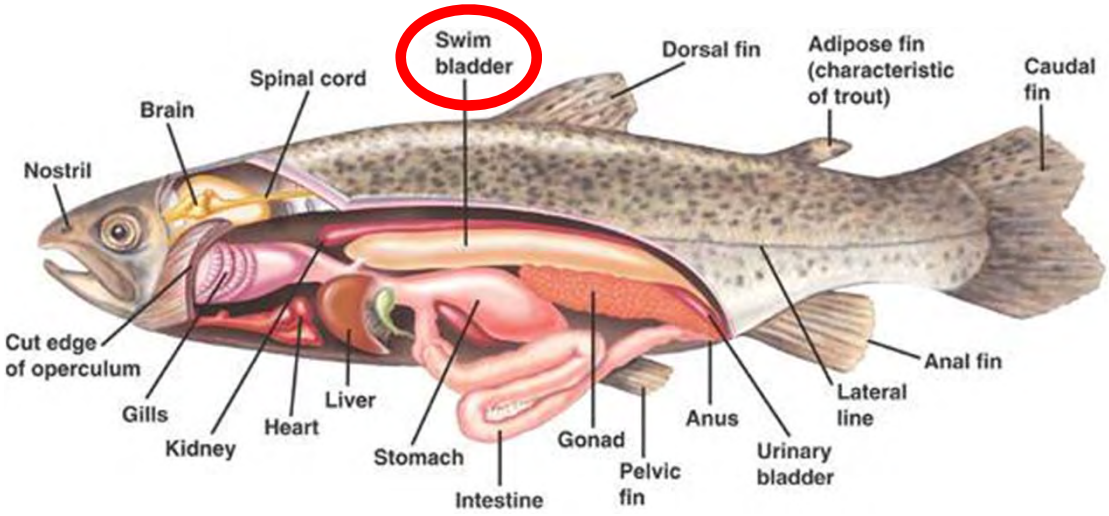
- Dermal scales that grow
  - Many types
  - Often made of bone



Actinopterygii (Ray-finned fishes)

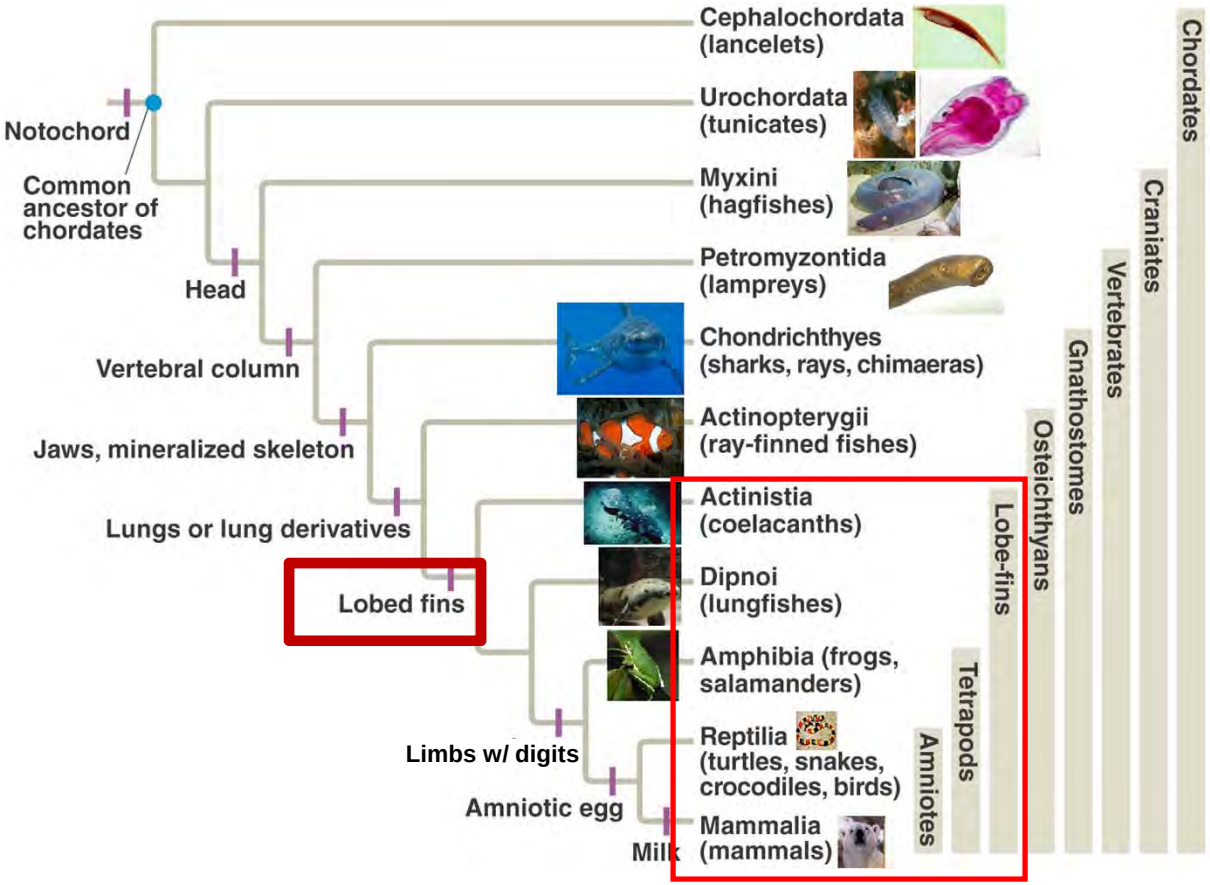
- Operculum pumps to move water in mouth and out across gills
  - analogous to diaphragm of mammals





- Swim bladder allows buoyancy
  - evolved from primitive lungs

Lobe-fins (Sarcopterygii) coelacanths + lungfishes + tetrapods

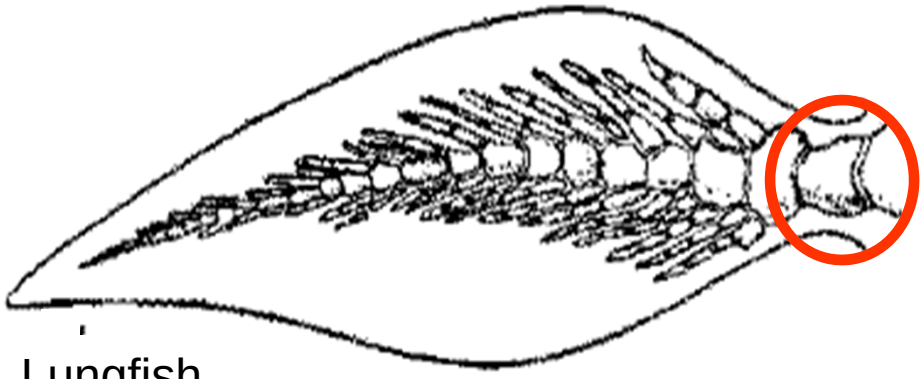


- Rod shaped bones surrounded by a thick layer of muscle

Figure 34.2 (Campbell et al)

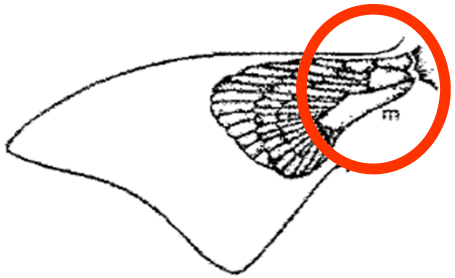
Lobe-fins (Sarcopterygii)

Pectoral and pelvic fins (or limbs) joined to body by a single bone

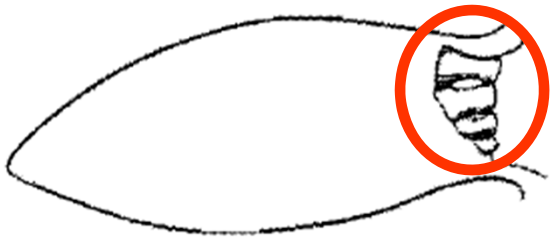


Lungfish

vs. multiple bones in Chondrichthyes and Osteichthyes



Shark



Ray-finned fish

Lobe-finned fishes

Actinistia: Coelacanths

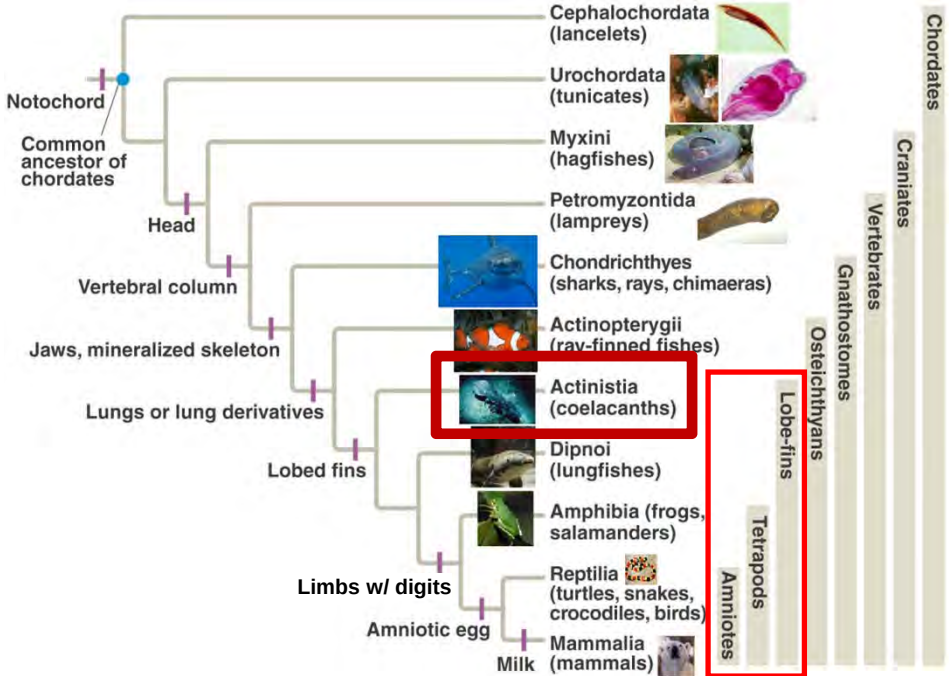
Marine

Thought extinct for 60my

Discovered in 1938

in South Africa

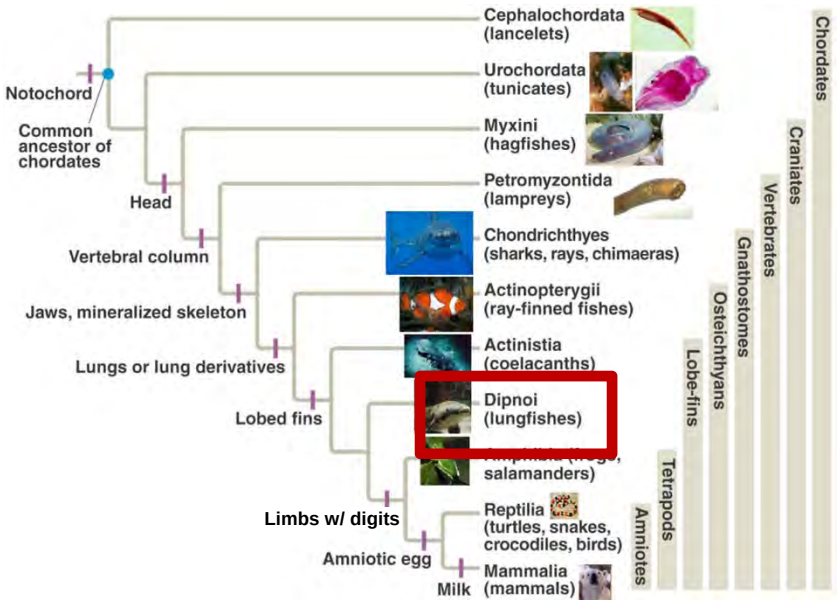
by Marjorie Courtney Latimer



Dipnoi: Lungfish

- Have true lungs!
  (which develop into a swim bladder in ray-finned fish)
- Also have gills

- Survive seasonal desiccation by aestivating in mud



Tetrapods

Amphibians + Amniotes

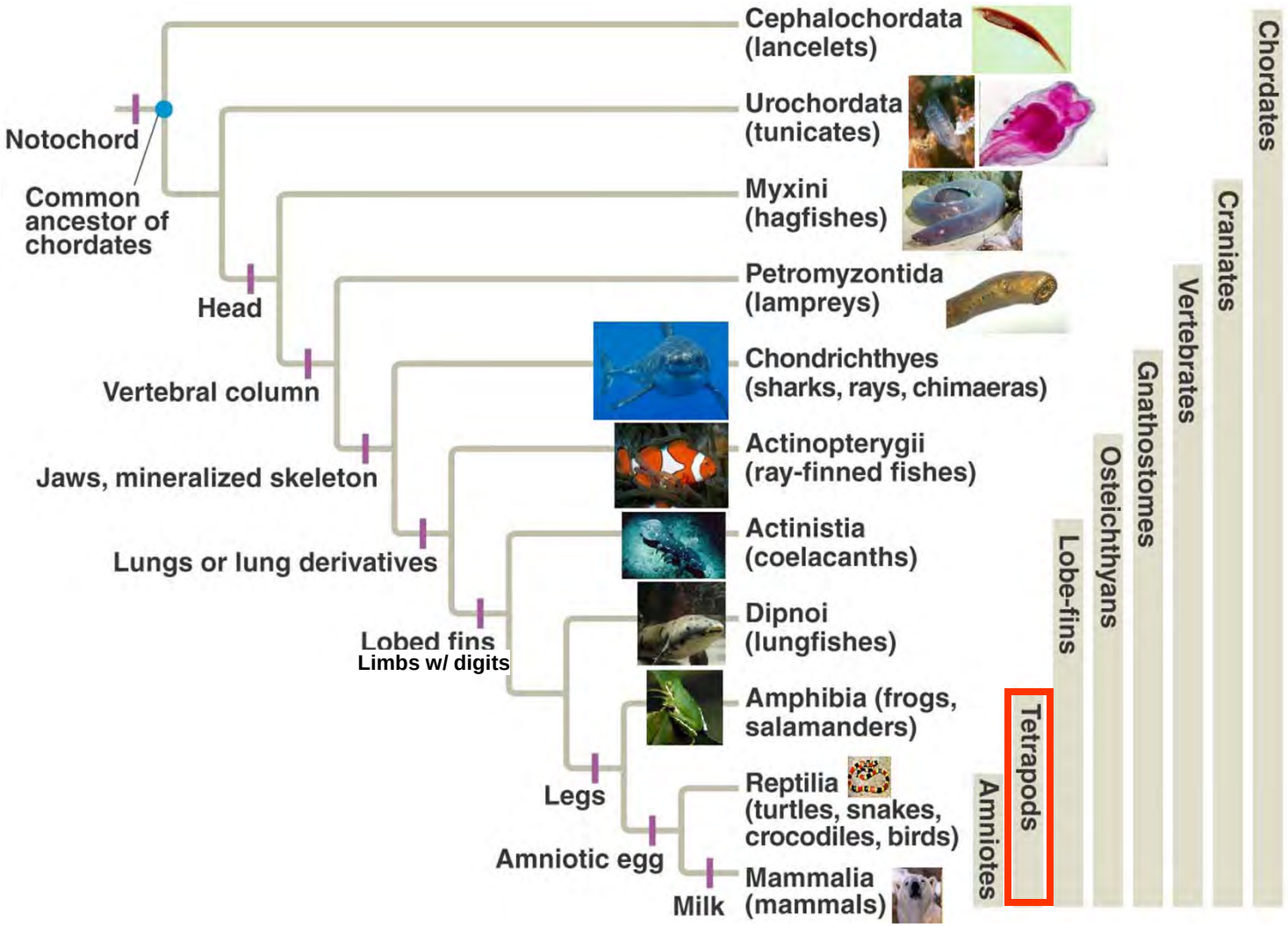


Figure 34.2 (Campbell et al)

Lungfishes to Tetrapods

- Clear fossil transition series
  - Series of lineages (all extinct) showing intermediate stages between lungfish (aquatic) and tetrapods (terrestrial) and amniotes.
- Only amphibians & amniote lineages survived.

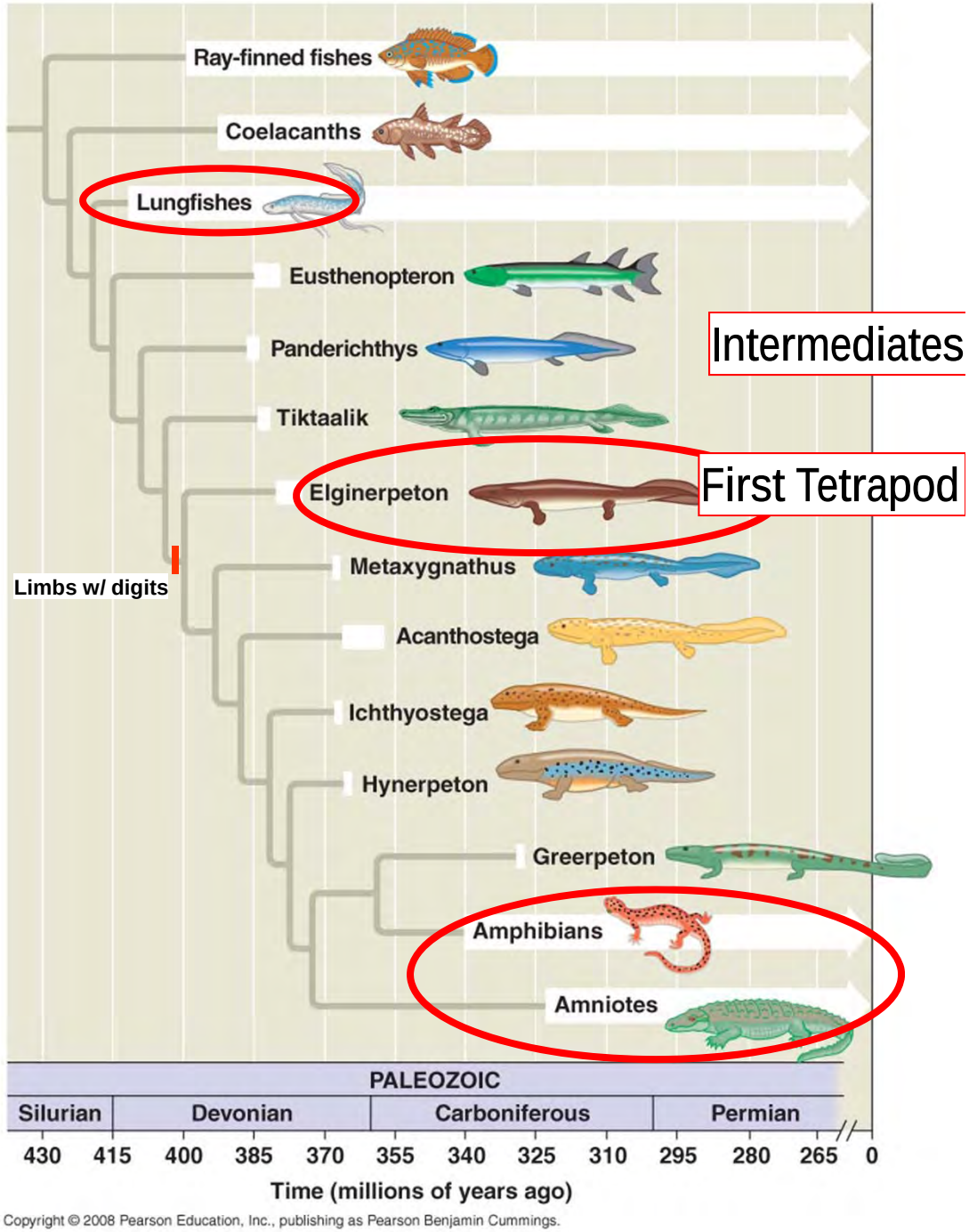


Figure 34.21 (Campbell et al)

Tiktaalik – a "fishapod"

Discovered in 2006

Fish Characters	Tetrapod Characters
Scales Fins Gills and lungs	Neck Ribs Fin skeleton Flat skull Eyes on top of skull

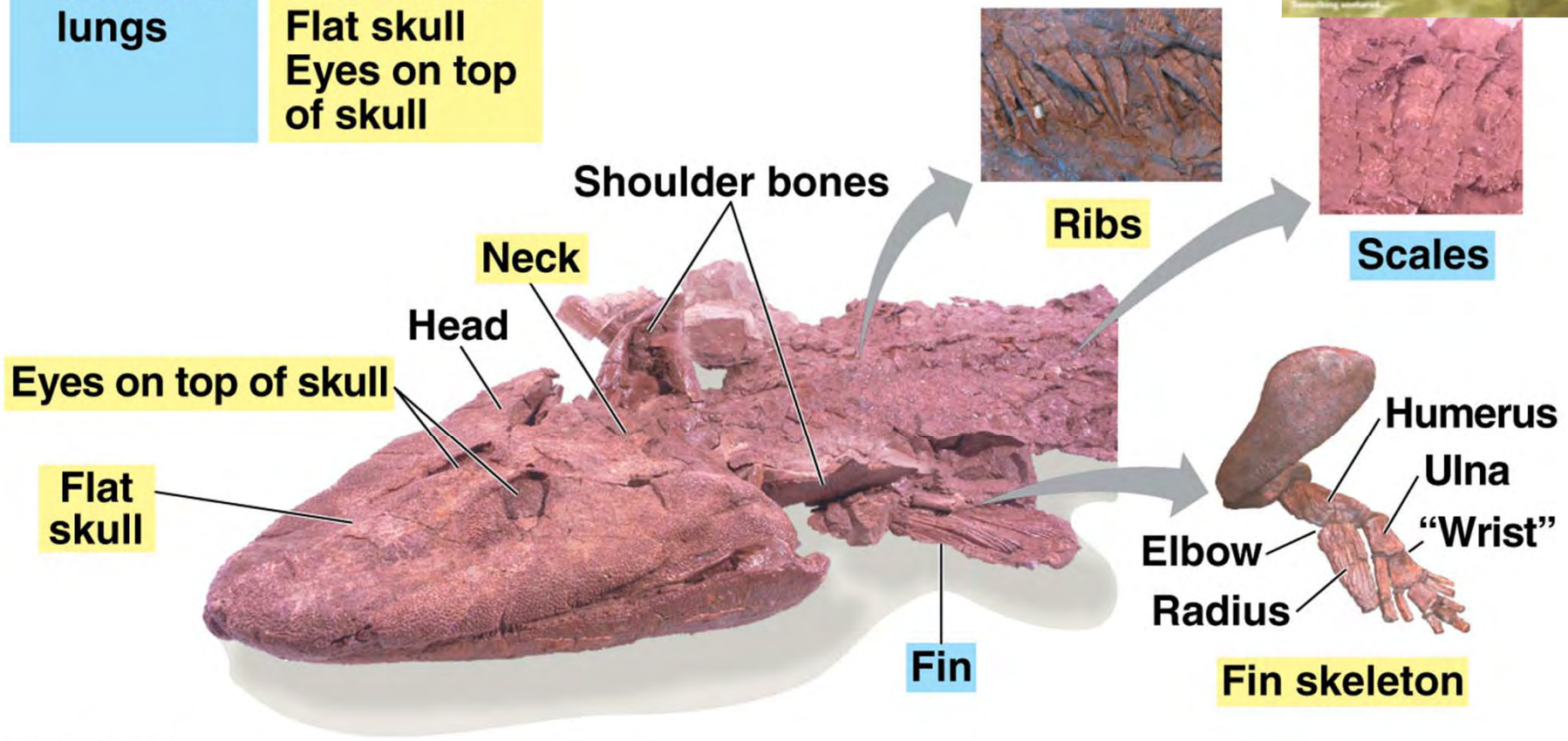
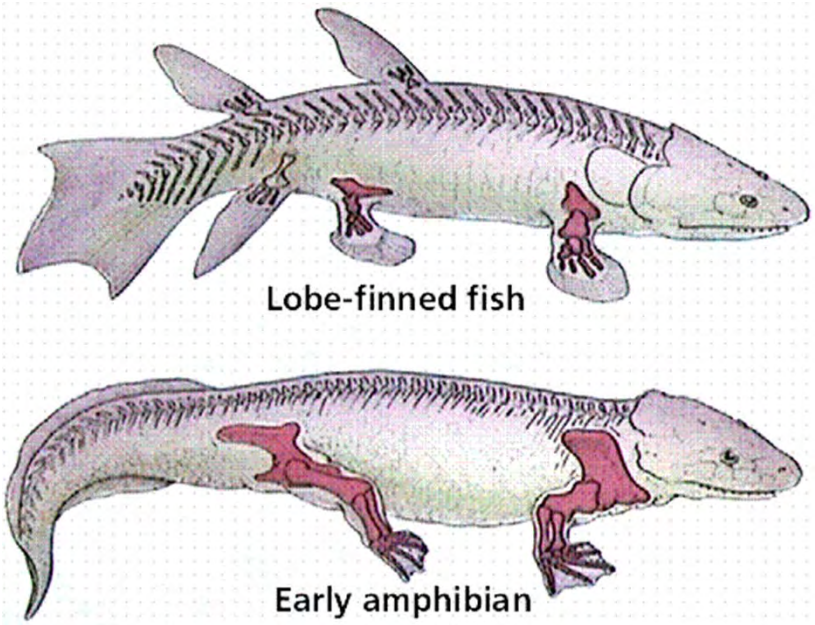
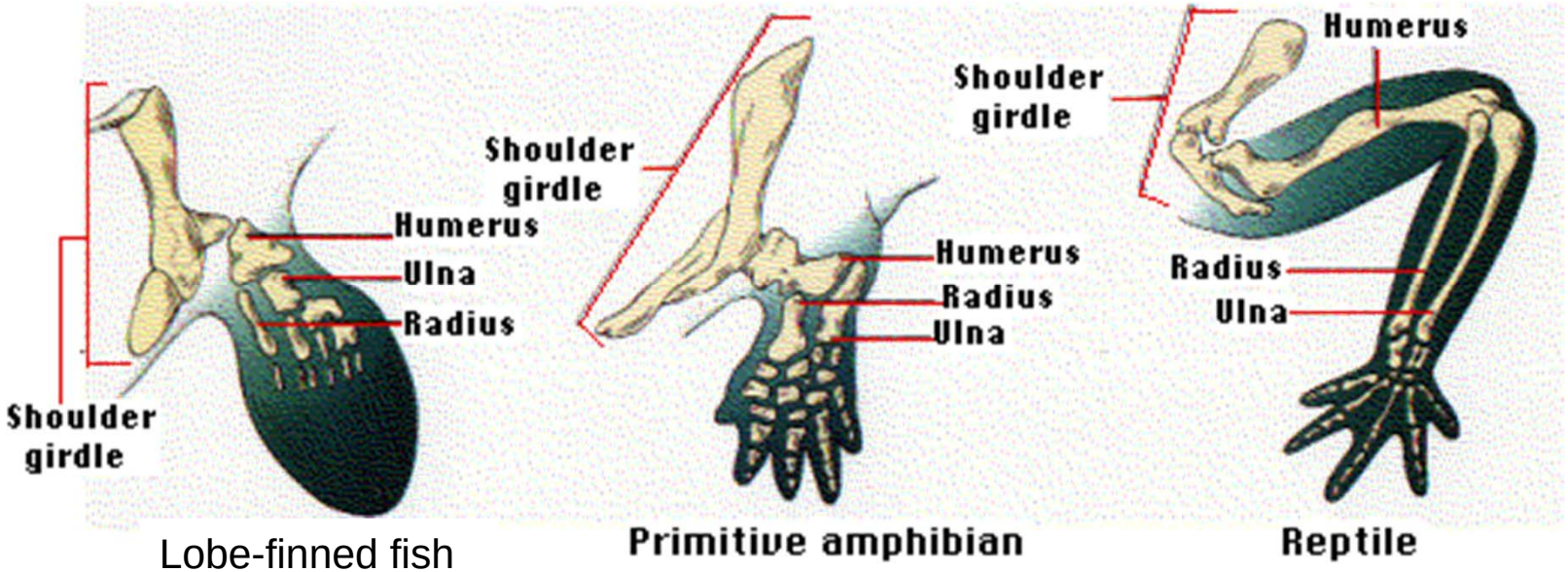


Figure 34.20 (Campbell et al)

Lobe-finned fish to Tetrapods





The transition to land:

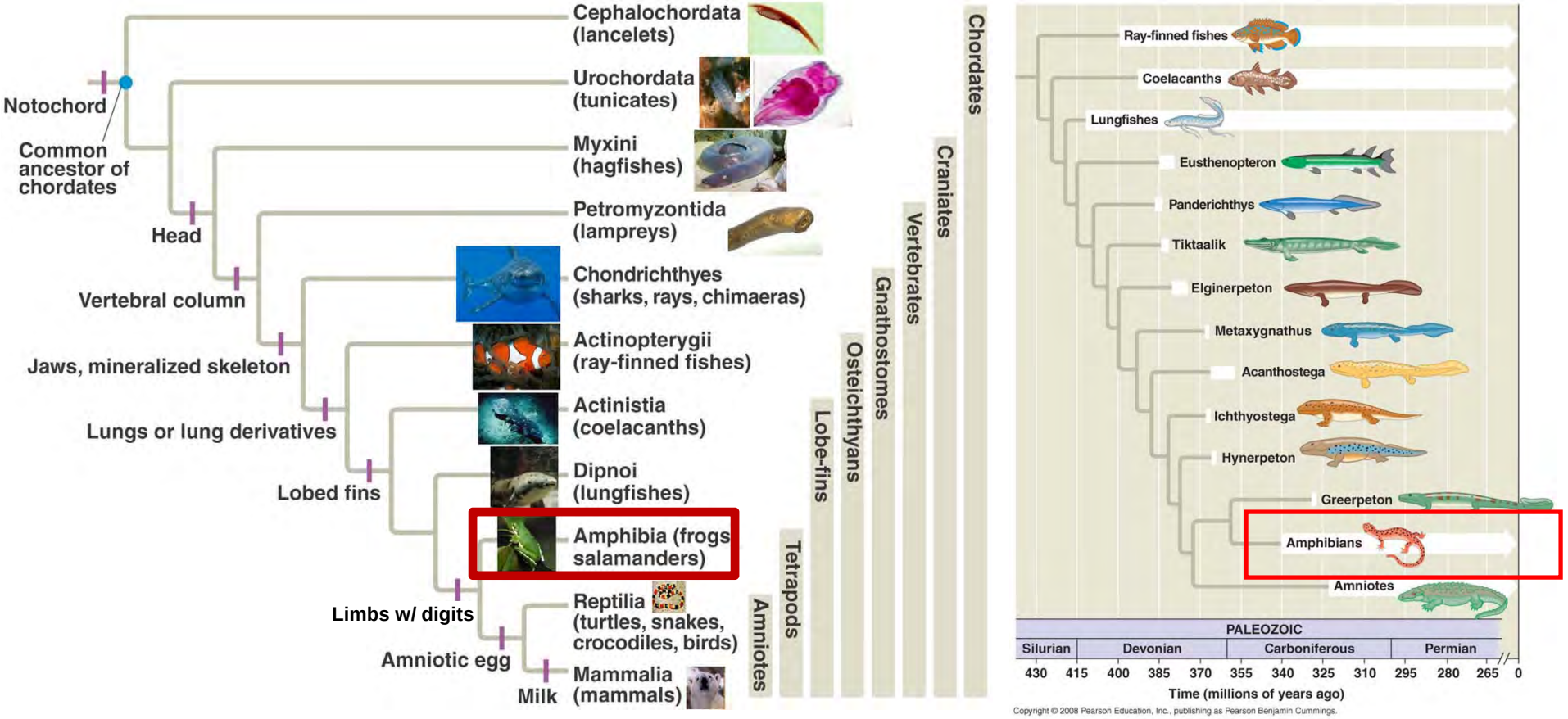
How?

- Limbs evolve for moving in shallow water, and onto land for short periods. First tetrapods were amphibious. Still required water for laying eggs.

Why?

- Lungs evolved first and maintained for life in anoxic swamps
- Legs evolve to exploit food on land (insects)

The modern amphibia



Figures 34.2 and 34.21 (Campbell et al)

Class Amphibia

Frogs


- Terrestrial, aquatic and arboreal
- Adults w/o tail
- External fertilization
- All toads are frogs
  but not all frogs are toads.

Salamanders



- Terrestrial & aquatic
- Most breathe through skin
  - – others w/ gills or lungs
- External & internal fertilization
- All newts are salamanders
  but not all salys are newts.

Caecilians



- Tropical
- Legless
- Burrowing & aquatic
- Internal fertilization

Class Amphibia

Reproduction still tied to water!

- Limits range and habitat types

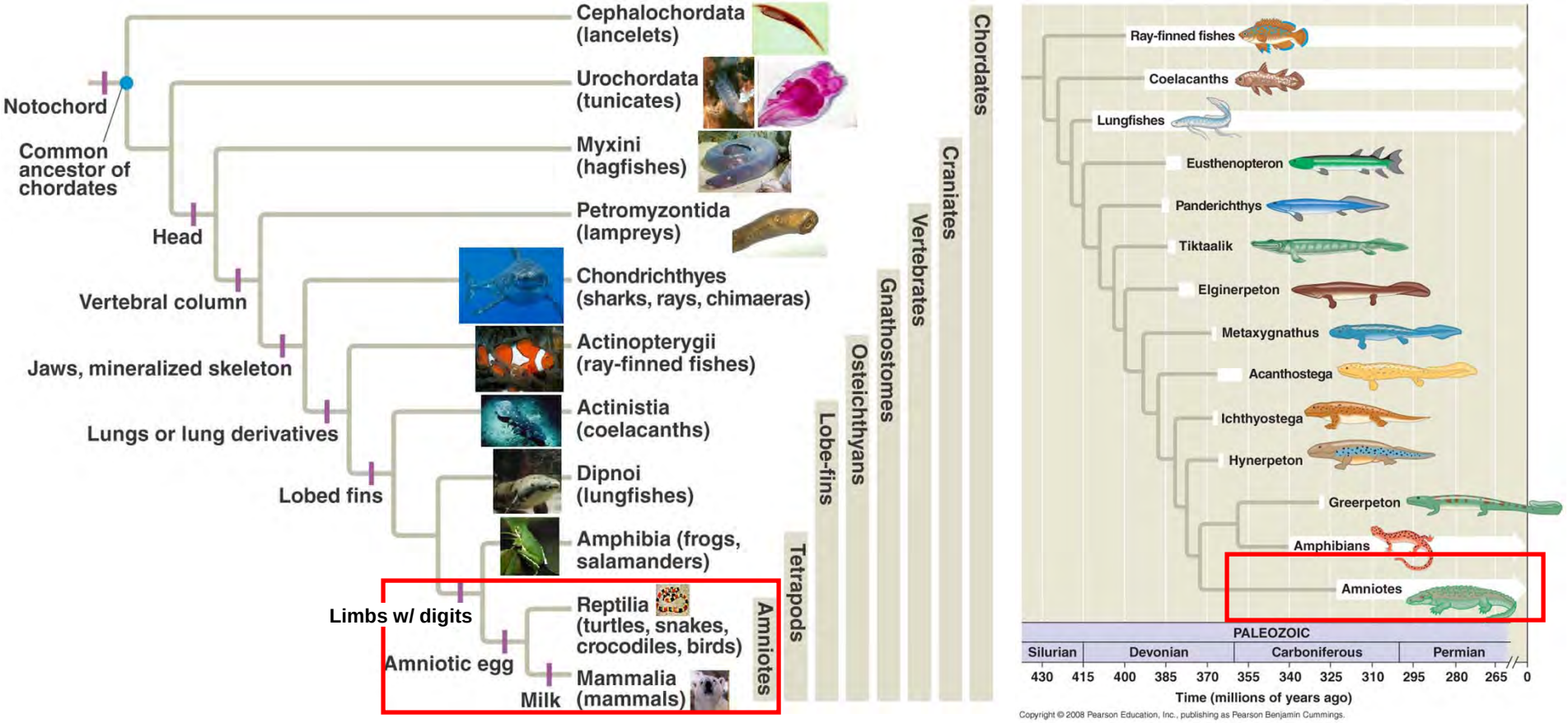
(a) The male grasps the female, stimulating her to release eggs. The eggs are laid and fertilized in water. They have a jelly coat but lack a shell and would desiccate in air.

(b) The tadpole is an aquatic herbivore with a fishlike tail and internal gills.

(c) During metamorphosis, the gills and tail are resorbed, and walking legs develop.

Amniotes

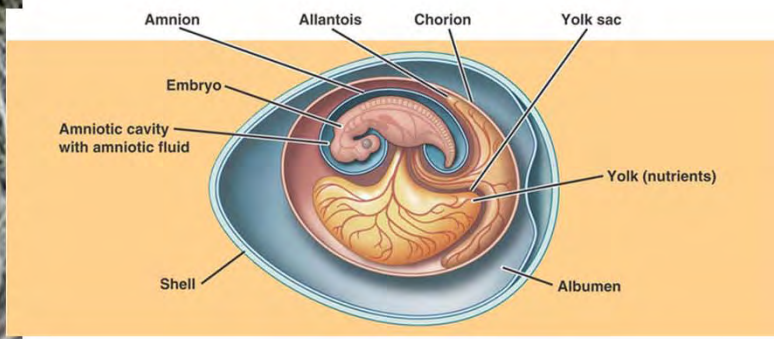
Reptiles (including birds) + Mammals



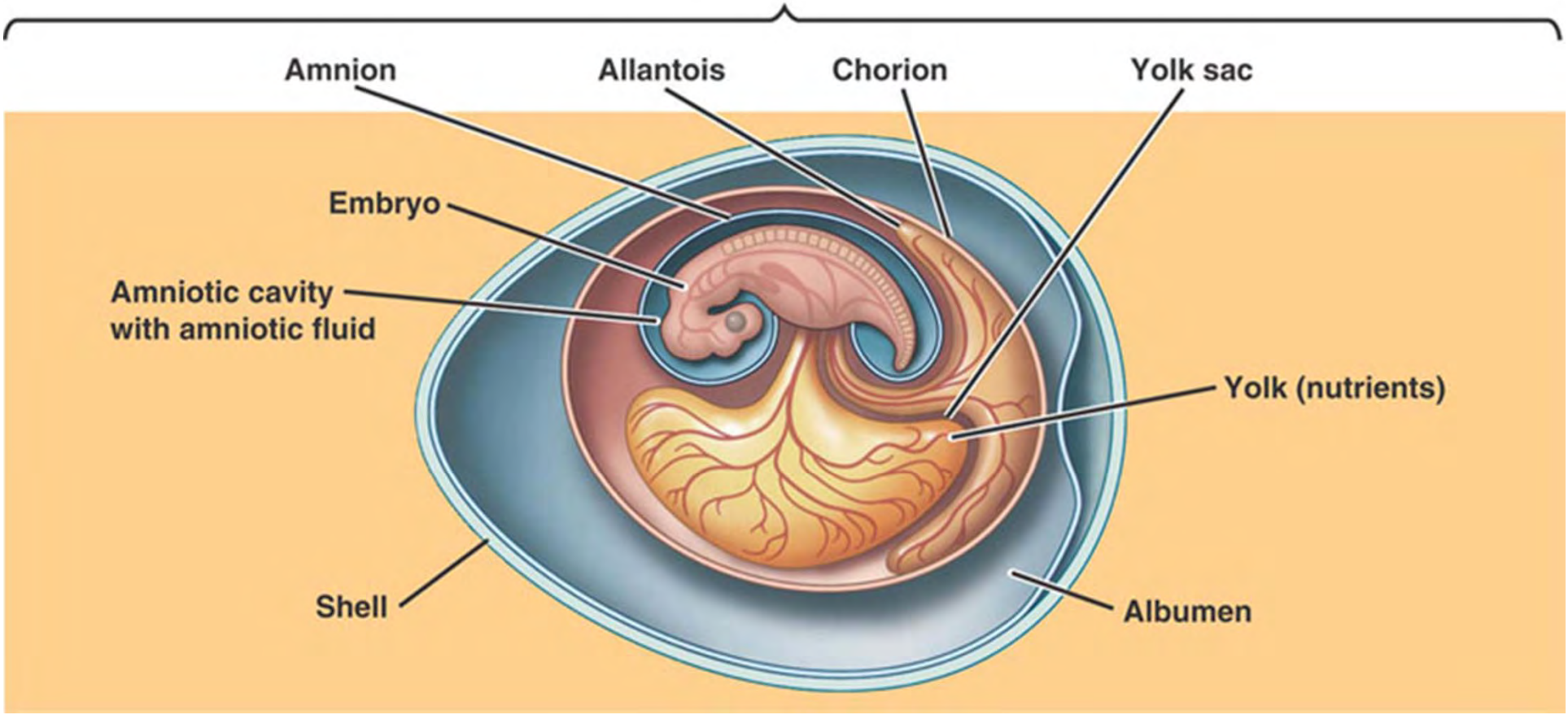
Figures 34.2 and 34.21 (Campbell et al)

Amniotes

- Adaptations to allow independence from H_2O and to avoid desiccation
  - Internal fertilization
  - Eggs have shells or develop internally
  - Extraembryonic membranes
  - Thicker skin (integument)
  - Scales – folds in the epidermis hardened by keratin
    (vs. from dermis in fish and sharks)



4 Extraembryonic membranes surround embryo



Amnion:protects and provides shock absorption

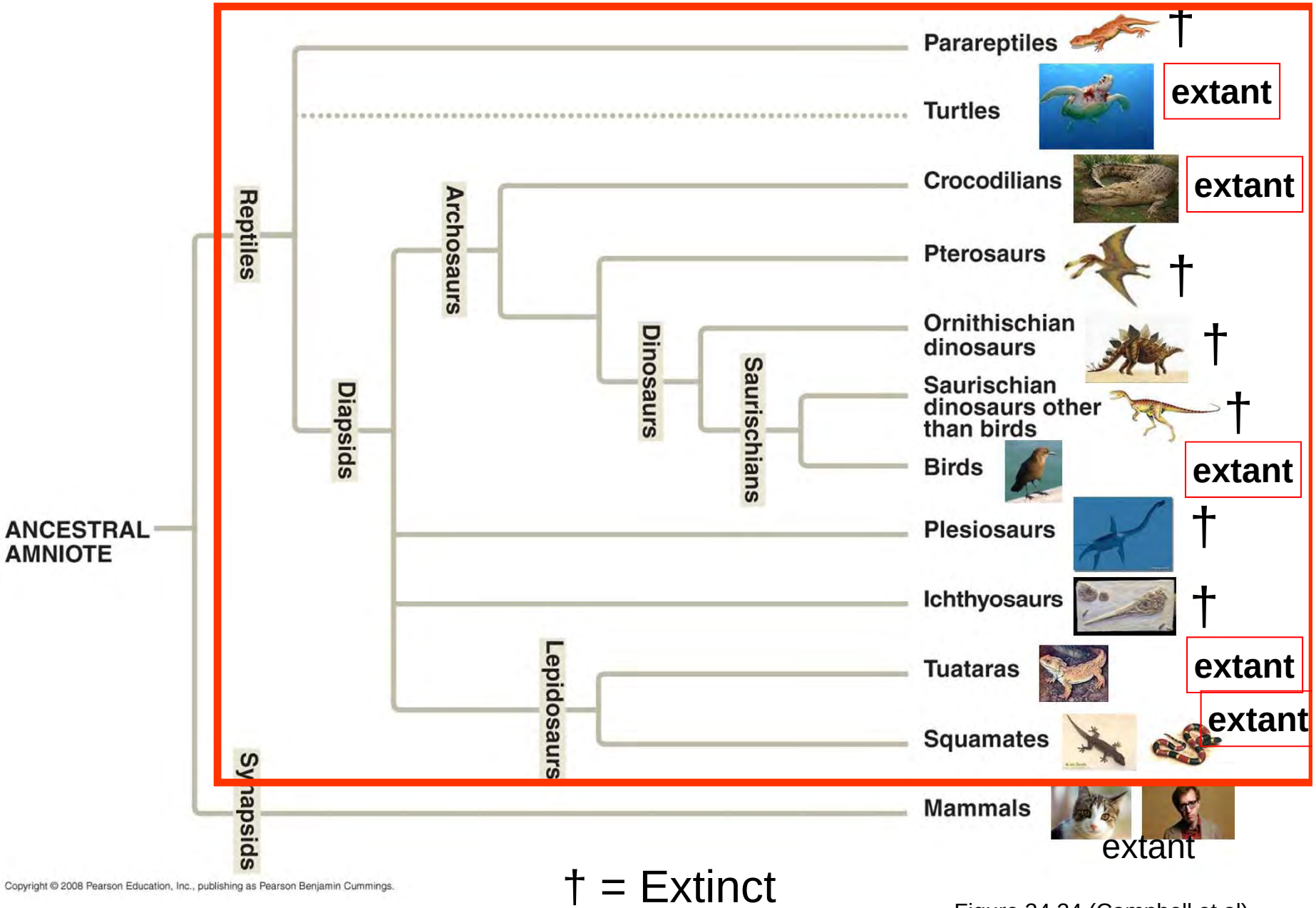
Allantois: disposal sac for wastes; also functions as a respiratory organ

Chorion: functions as a respiratory organ (gases diffuse freely across shell)

Yolk sac: stockpile of nutrients for the embryo

Figure 34.26 (Campbell et al)

5 extant lineages of REPTILES



† = Extinct

Figure 34.24 (Campbell et al)

Turtles

~ 300 living species,

- Aquatic and terrestrial
- Many highly endangered.

Some are giant:

All tortoises are turtles but not all turtles are tortoises

Crocodilia

Crocodiles, alligators, caimans, gharials

Only 23 species

American Alligator
Alligator mississippiensis

Indian Gharial
Gavialis gangeticus

Saltwater Crocodile
Crocodylus porosus

Grows to
8 m long

All alligators are crocodilians
but not all crocodilians
are alligators

Lepidosaurs

Tuataras, snakes and lizards

- Approximately 8,000 species
- All w/ internal fertilization
- Eggs and live birth

Tuataras

2 species: New Zealand

Snakes

~3400 spp

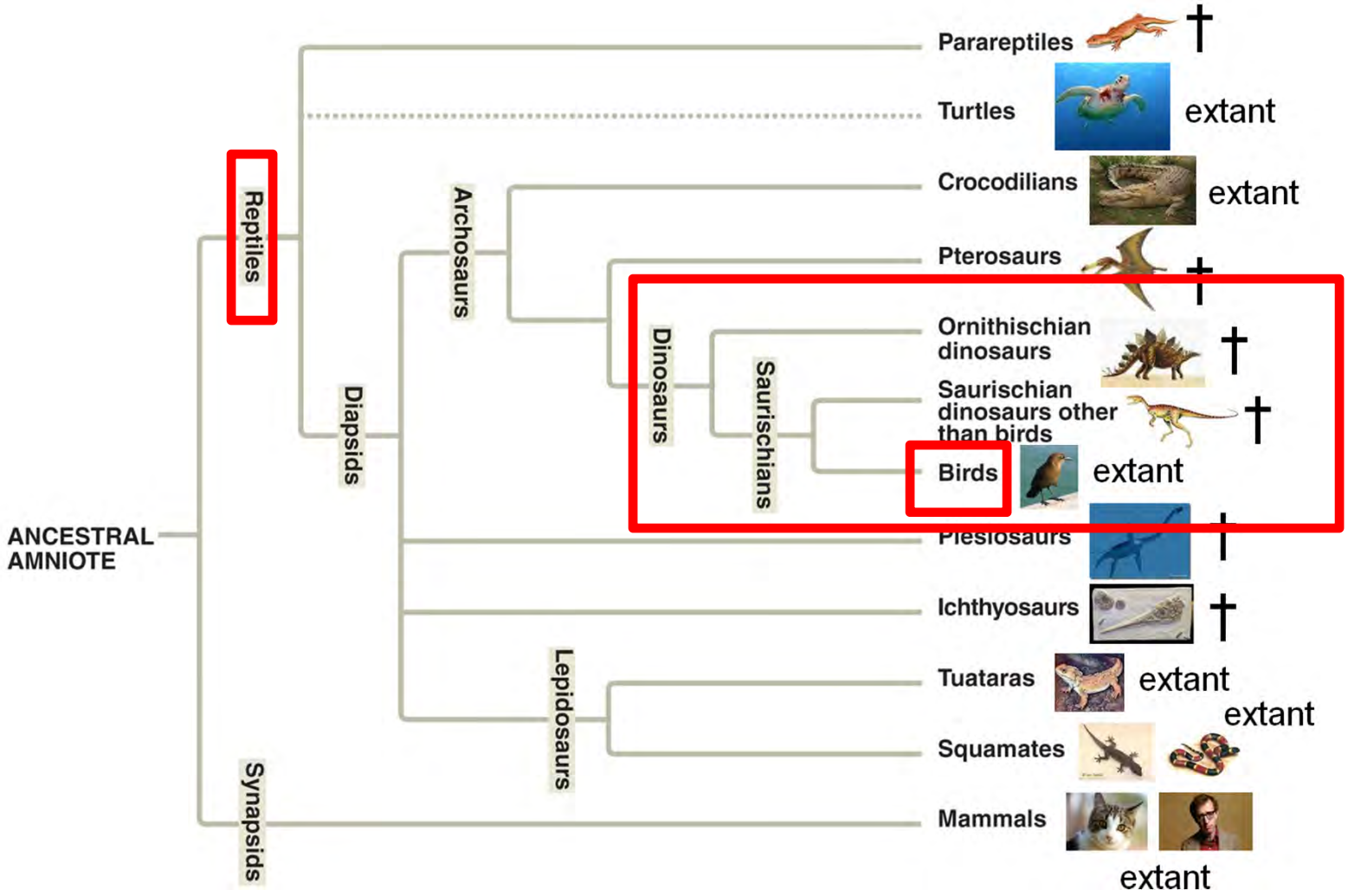
- Terrestrial, aquatic, arboreal, fossorial

Lizards

~5800 spp

- Terrestrial, arboreal, fossorial (1 aquatic)

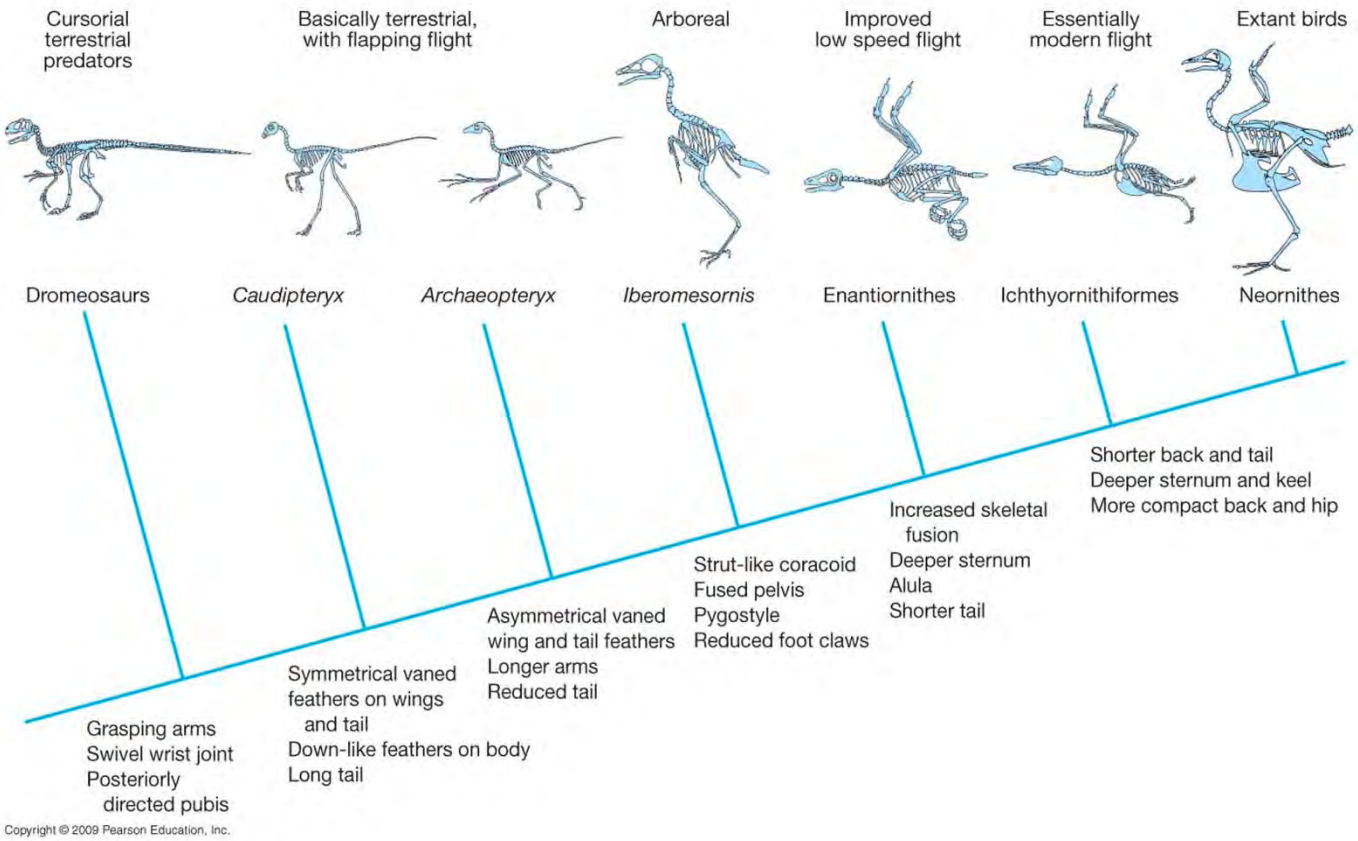
REPTILES INCLUDE THE BIRDS



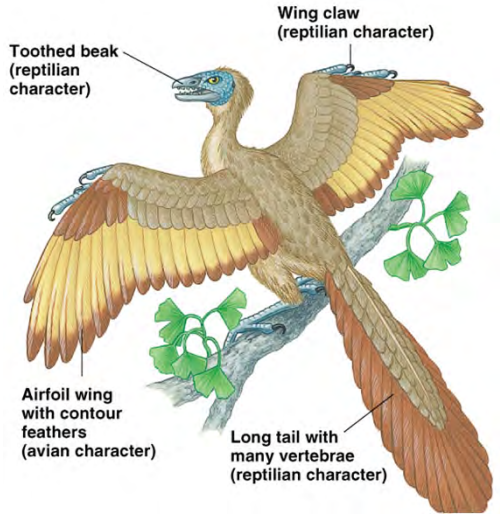
- Birds are the last living dinosaurs
- Derived from lineage that included *Tyrannosaurus rex*)

Clear fossil transition series

Series of lineages (all extinct) showing intermediate stages between non-feathered dinosaurs and birds



- Feathers probably for camouflage and insulation
- Hollow bones probably for speed and agility
- Mounting evidence that many avian and nonavian dinosaurs were endothermic (like modern birds)



Archaeopteryx lithographica

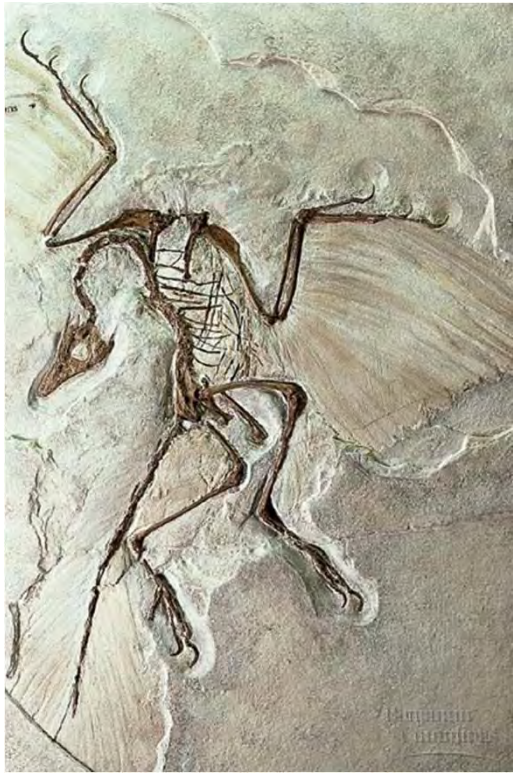
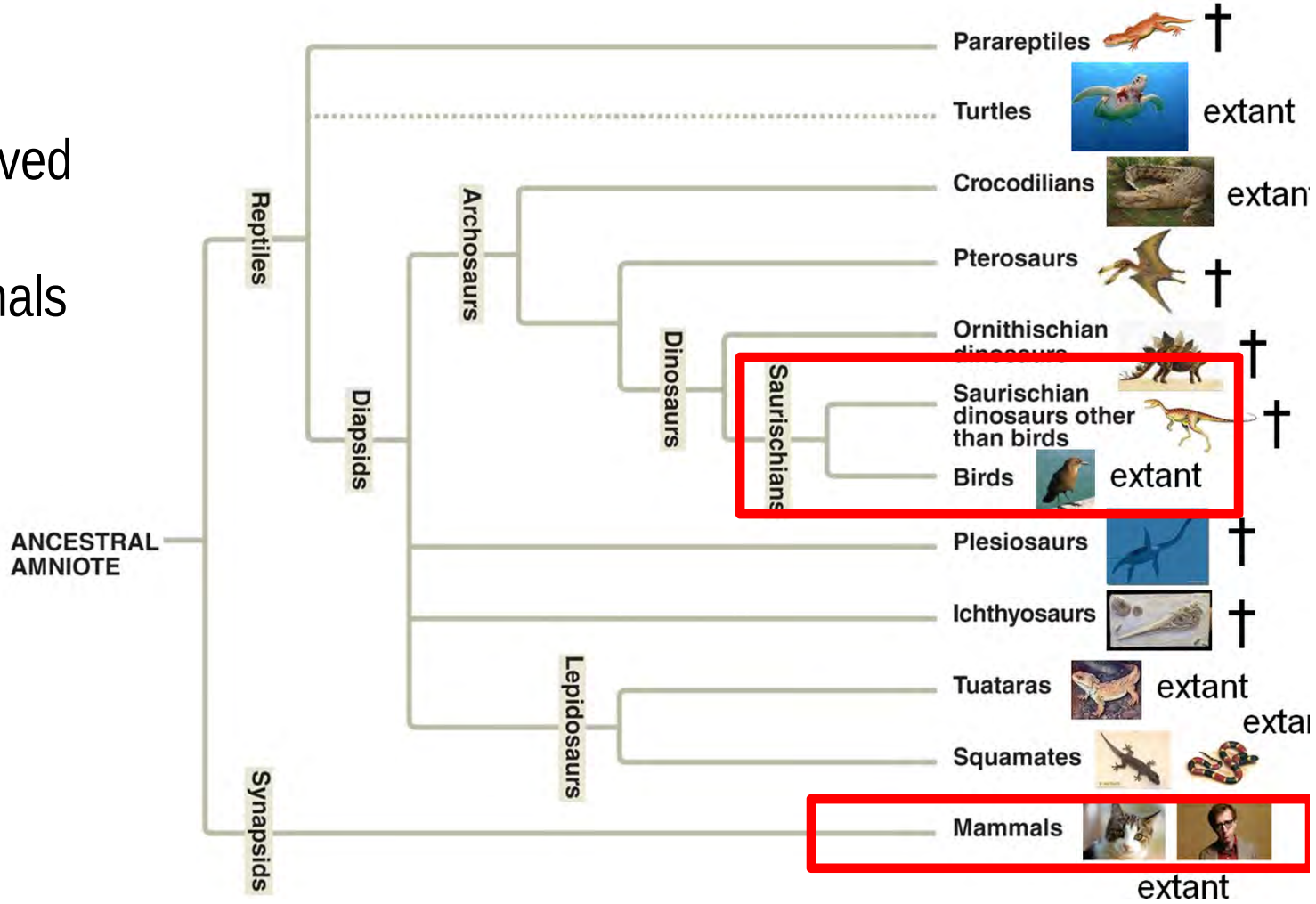


Figure 34.31 (Campbell et al)

ECTOTHERMS: Animals that derive body heat from the environment
e.g. fish, amphibians, reptiles

ENDOTHERMS: Animals that generate body heat by metabolism
e.g. birds & other related dinosaurs, mammals

Endothermy evolved convergently in birds and mammals

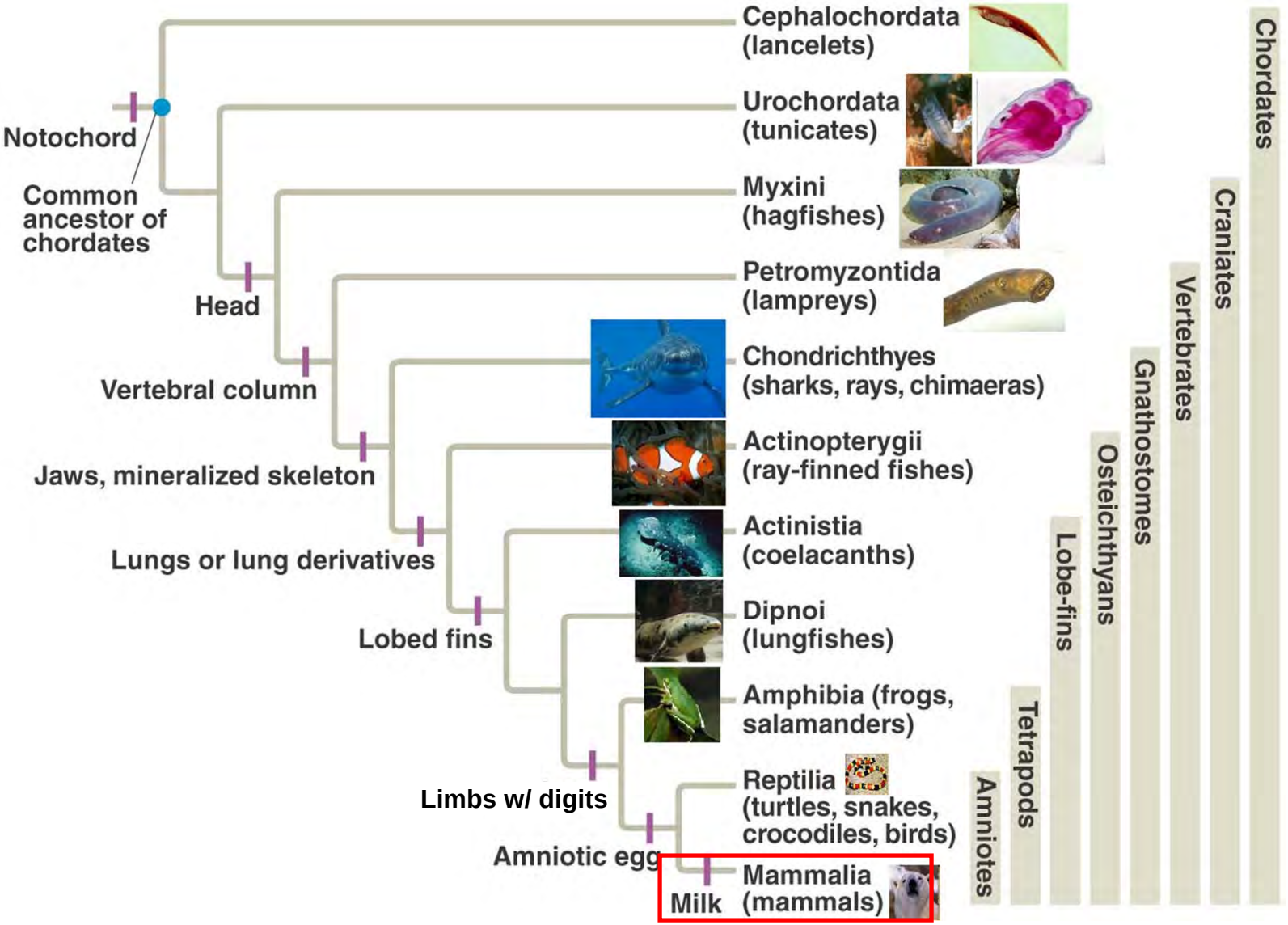


The Birds

Approximately 10,000 species (the most diverse tetrapods)

- Forelimbs modified to wings
- Light bones, no teeth
- **4-chambered heart;**
- **Endothermic**
- Most widely spread group of amniotes

The Mammals


Cephalochordata (lancelets)
Urochordata (tunicates)
Myxini (hagfishes)
Petromyzontida (lampreys)
Chondrichthyes (sharks, rays, chimaeras)
Actinopterygii (ray-finned fishes)
Actinistia (coelacanths)
Dipnoi (lungfishes)
Amphibia (frogs, salamanders)
Reptilia (turtles, snakes, crocodiles, birds)
Mammalia (mammals)
Notochord
Common ancestor of chordates
Head
Vertebral column
Jaws, mineralized skeleton
Lungs or lung derivatives
Lobed fins
Limbs w/ digits
Amniotic egg
Milk
Chordates
Craniates
Vertebrates
Gnathostomes
Osteichthyans
Lobe-fins
Tetrapods
Amniotes

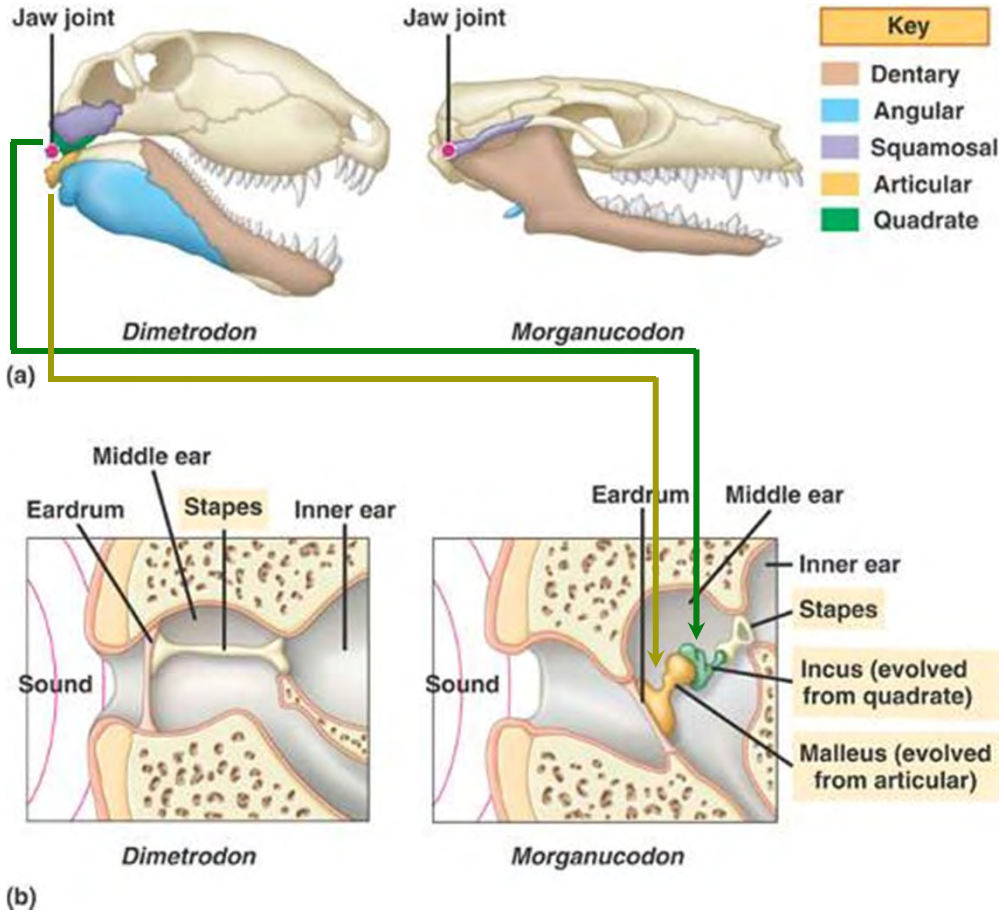
The Mammals

Approximately 5,400 species

- Arose during Jurassic period (150-200 Mya)
- Radiated after Cretaceous extinction

Defining traits:

- Mammary glands
- Hair
- 4-chambered heart;
- Endothermic
- Dentary-squamosal jaw joint
- 3 inner ear bones:
  - 2 evolved from jaw joint
- Divided into 3 groups primarily based on reproductive differences
  - Monotremes
  - Marsupials
  - Placentals



Mammals

Monotremes

- Only mammals to lay eggs
- Produce milk from pores
  - No nipples - suck milk from mother's fur
- Restricted to Australia & New Guinea

Mammals

Marsupials

- Live birth w/ very short gestation
  (embryo completes development in pouch)
- Milk from nipples
- Rudimentary placenta
  - Embryo and mother's circulatory system not joined

Kangaroos, wallabies, opossums, koalas etc.

Mostly: Australasia & South America
(1 N. American species *Didelphis virginianai*)

Mammals

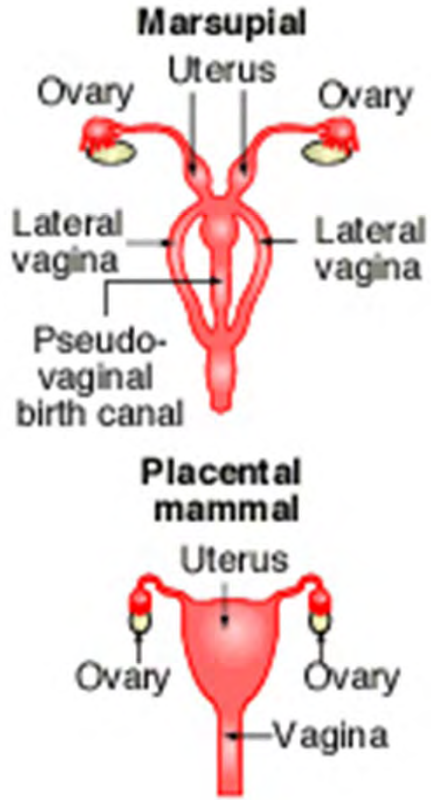
Eutherians

- Complex placenta
- Complete embryonic development in uterus

Mammals

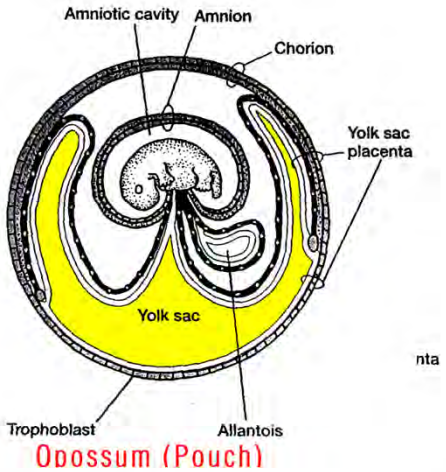
Eutherians

- Complete embryonic development in uterus

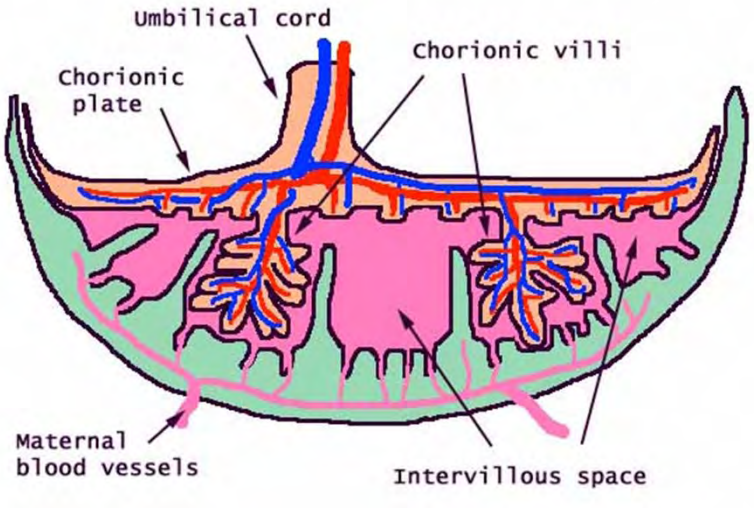


Vaginal segments of marsupial combine to form larger uterus for embryonic development in eutherians

- Complex placenta



In marsupials, nutrients from mother's blood go into yolk sac which nourishes embryo



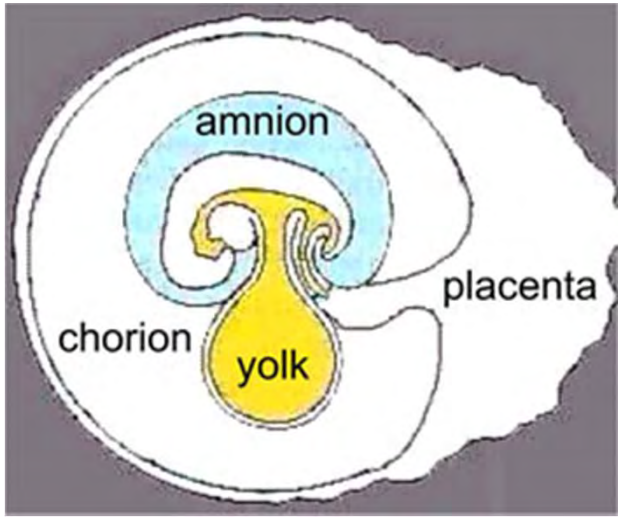
In eutherians, nutrients from mother's blood go directly into embryo's blood

http://palaeo.gly.bris.ac.uk/palaeofiles/marsupials/female%20repro.jpg

http://www.siumed.edu/~dking2/erg/images/placenta.jpg

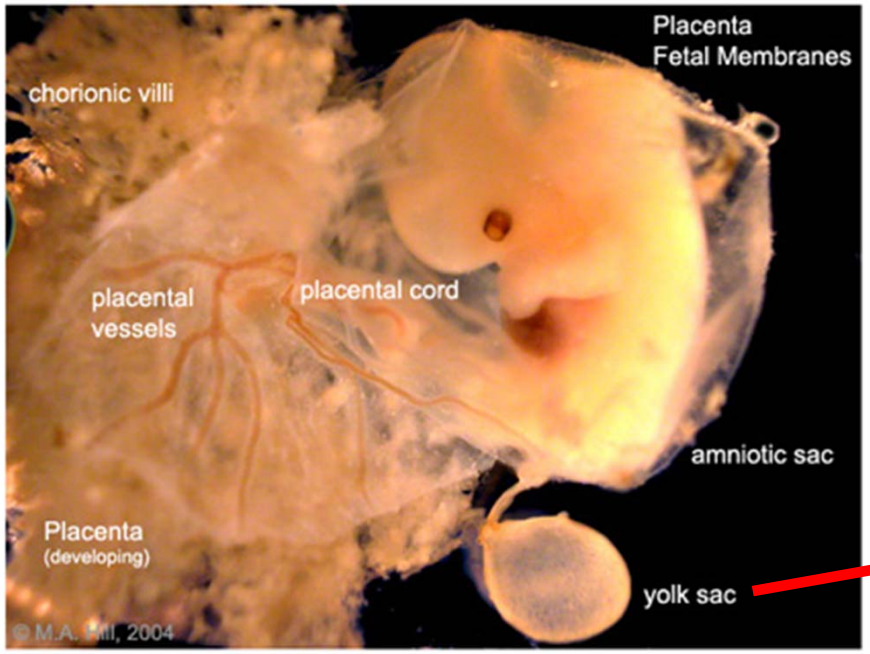
Mammals

Eutherians

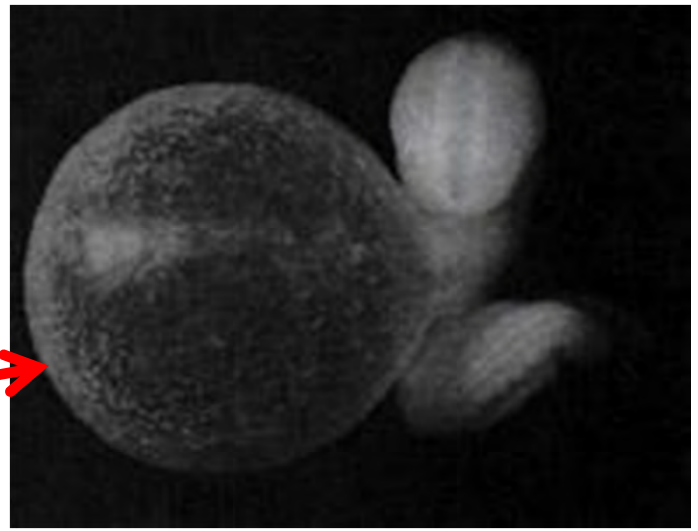


Though most mammals don't lay eggs, they still are amniotes!

All 4 extraembryonic membranes form though not all are used.
e.g. Yolk sac is an empty sac since have placenta for nutrients



Human embryo w/ empty yolk sac



http://embryology.med.unsw.edu.au/Medicine/BGDAfaq.htm

http://scienceblogs.com/pharyngula/2008/03/reproductive_history_writ_in_t.php

Primates

Opposable thumb

Fingerprints

Large Brain

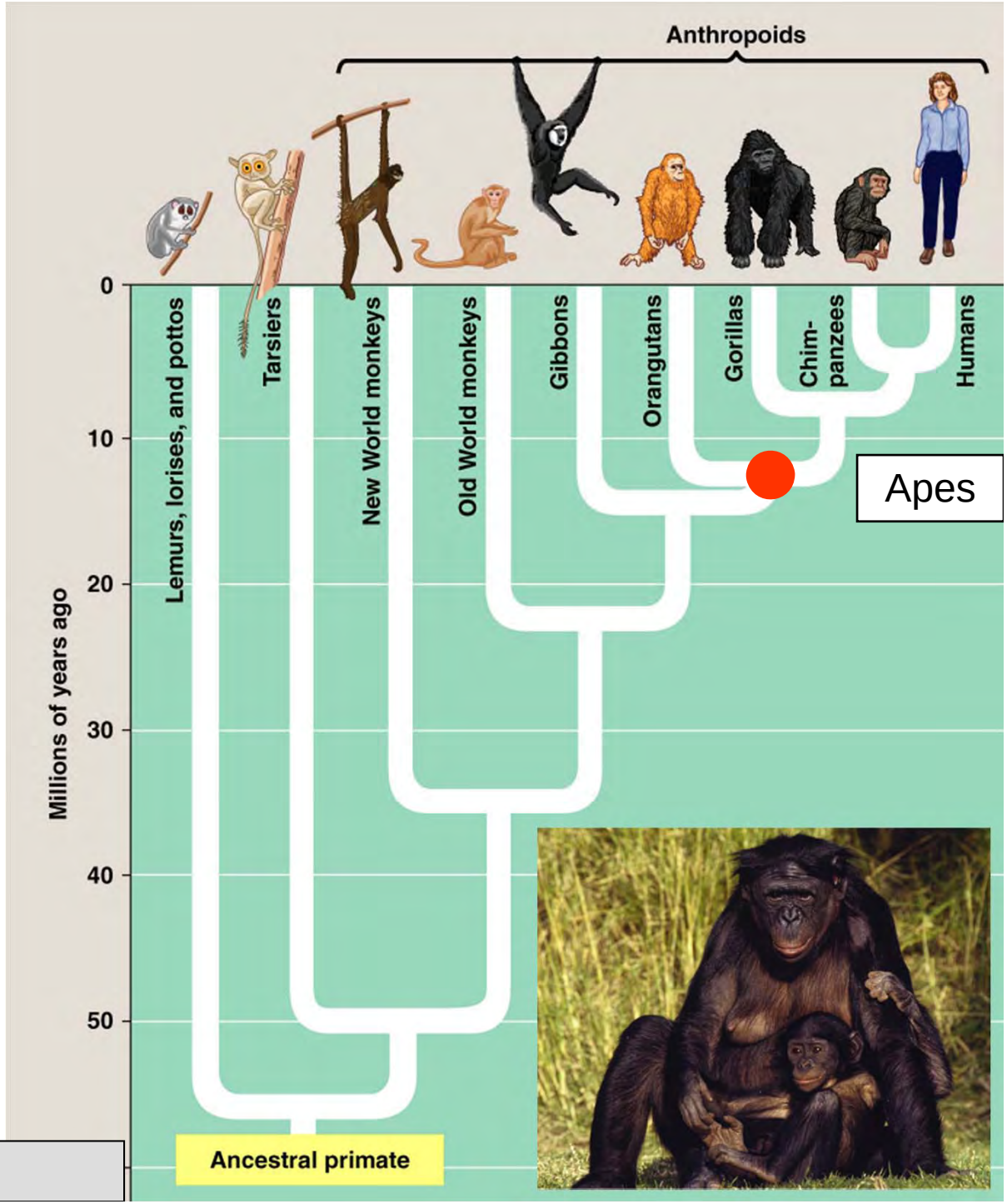
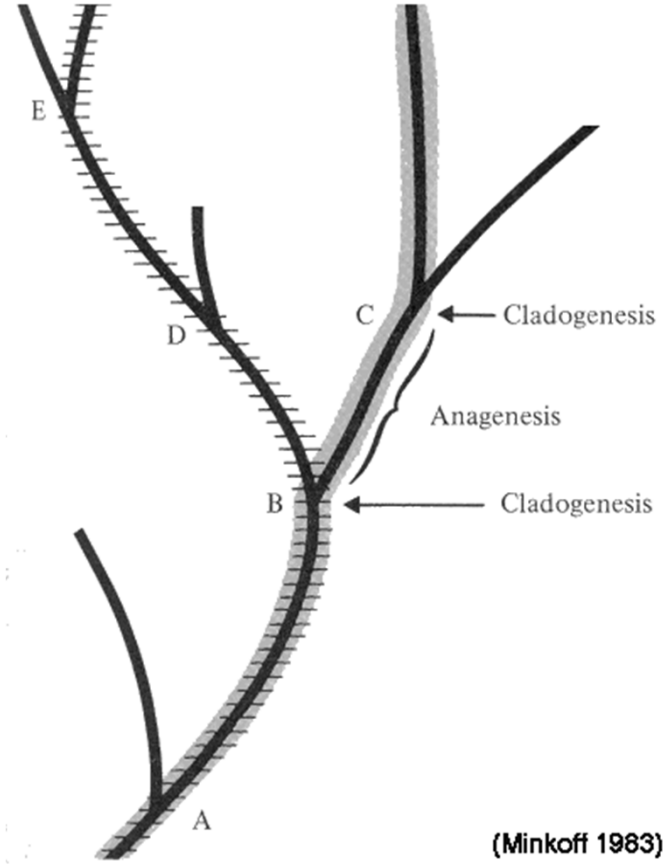
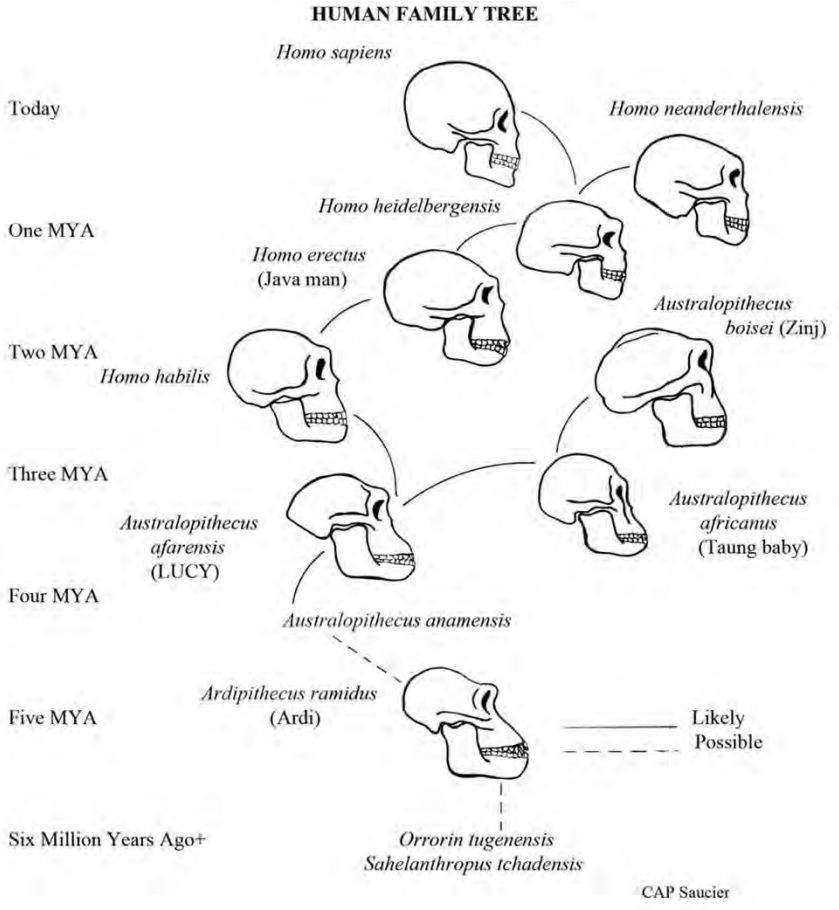


Figure 34.37



(Minkoff 1983)



Human Evolution