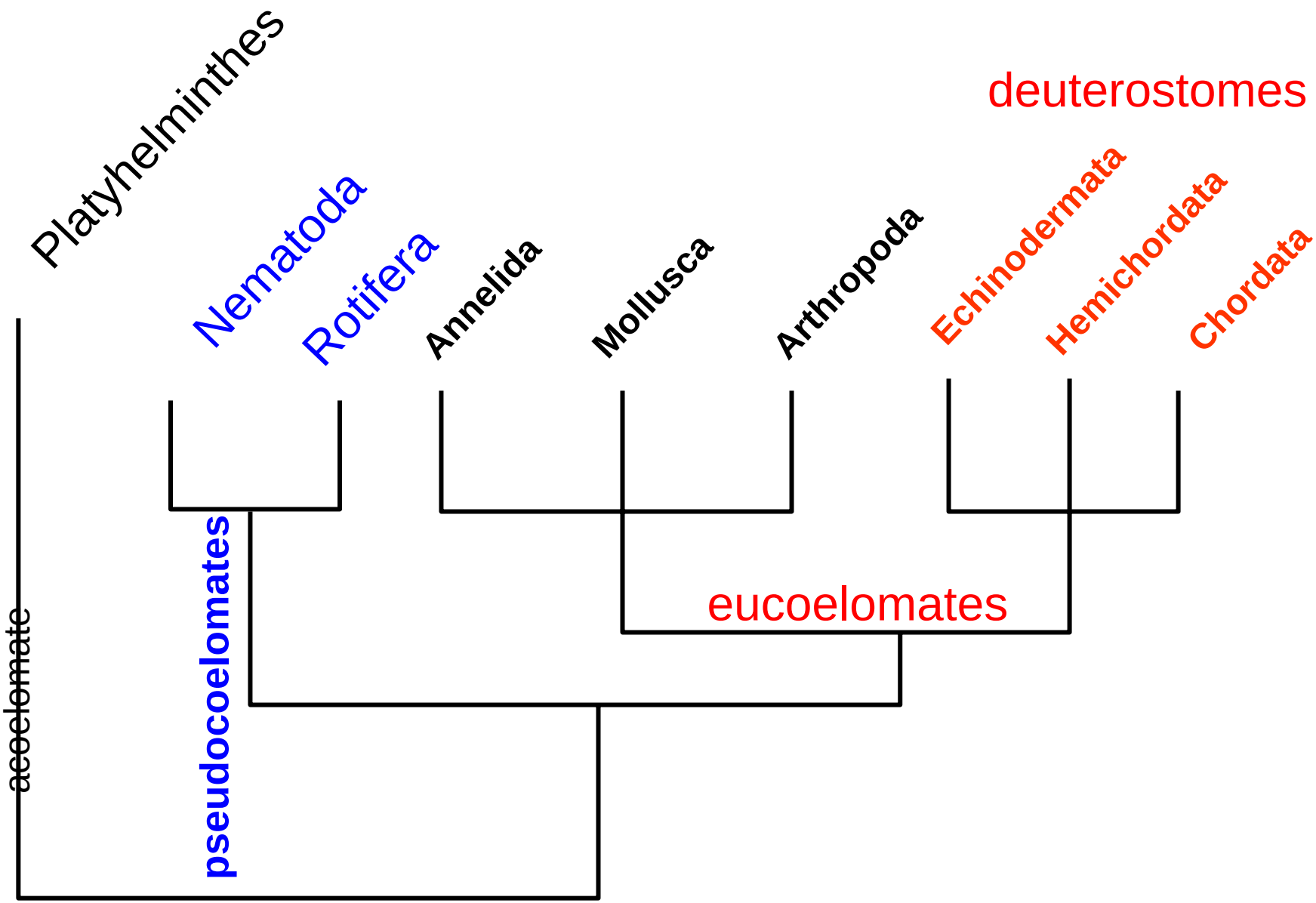
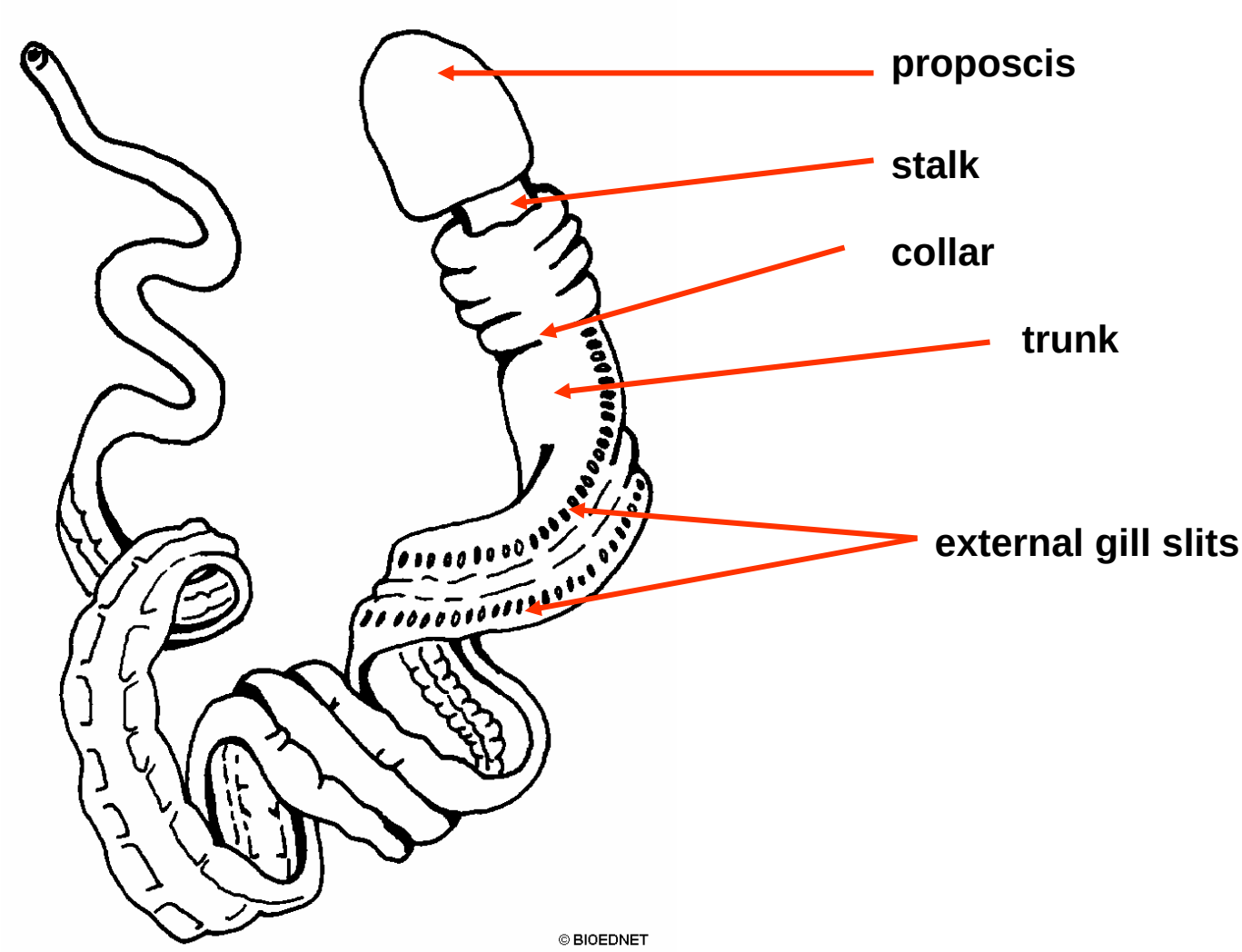

Platyhelminthes
Nematoda
Rotifera
Annelida
Mollusca
Arthropoda
Echinodermata
Hemichordata
Chordata
deuterostomes
eucoelomates
pseudocoelomates
acoelomate

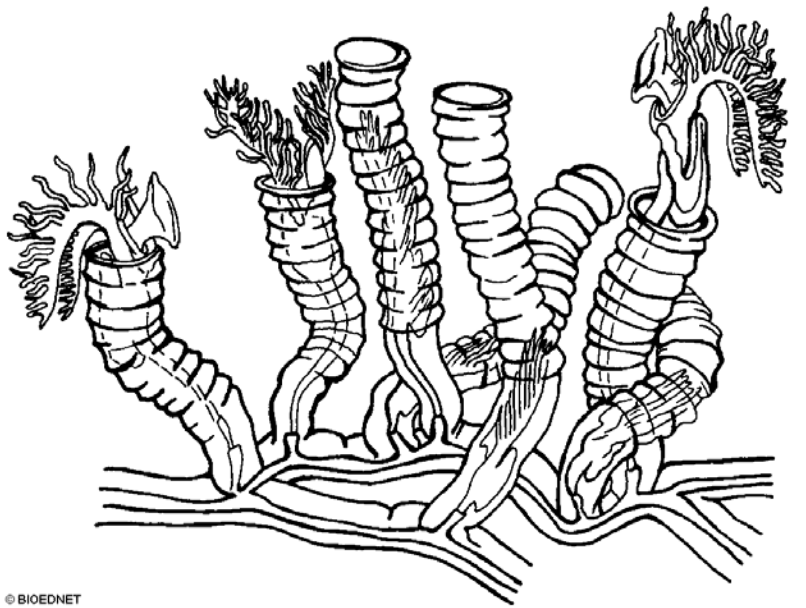
Phylum Hemichordata

- Share characteristics with both Echinoderms and Chordates
- Like chordates they have gill slits and a dorsal nerve cord.
- They have a larval form called a tornaria that is similar to the Echinoderm bipinnaria

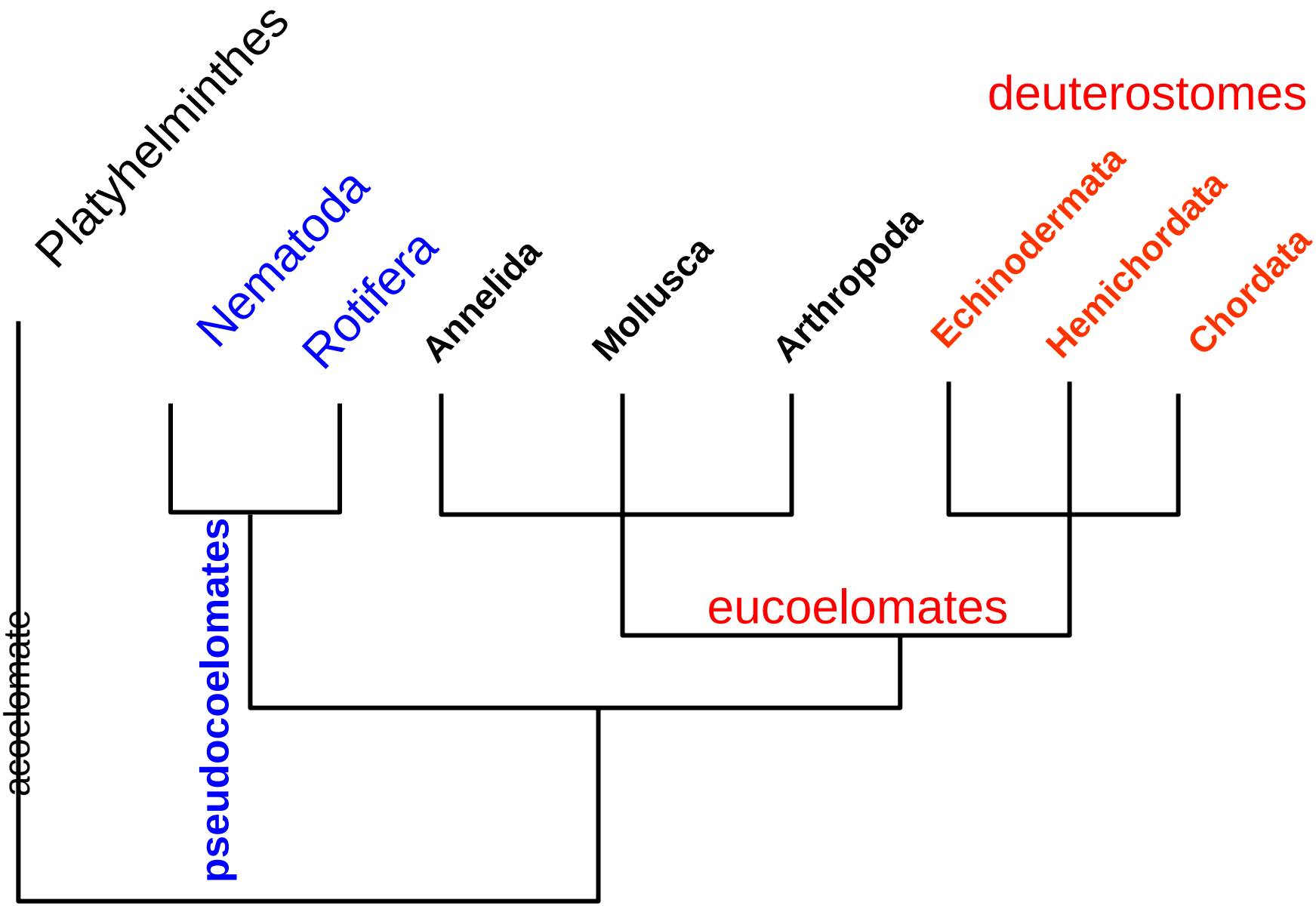
Phylum Hemichordata



Phylum Hemichordata



•Some species are colonial and live in secreted tubes (superficially resemble polychaetes)


Platyhelminthes
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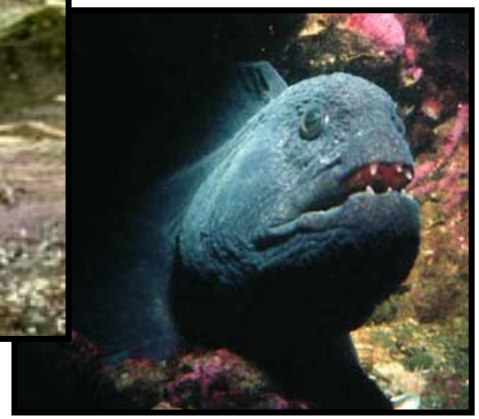


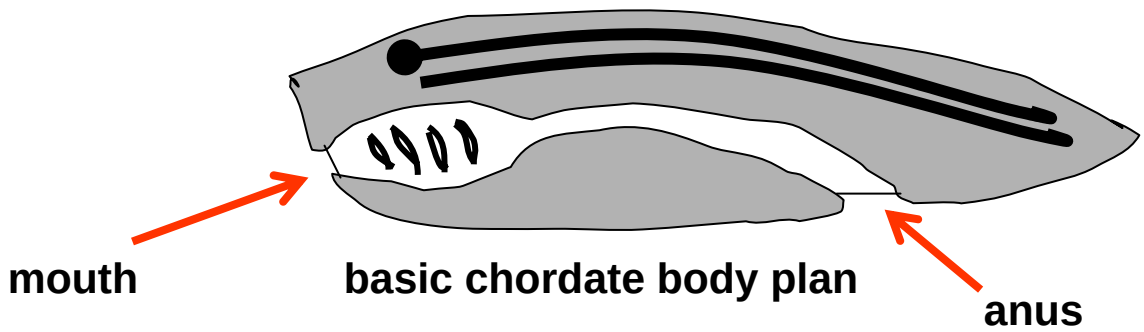
Phylum Chordata

the “chordates”

Chordata Characteristics

All chordates possess these 4 unique characters at some point in their life:

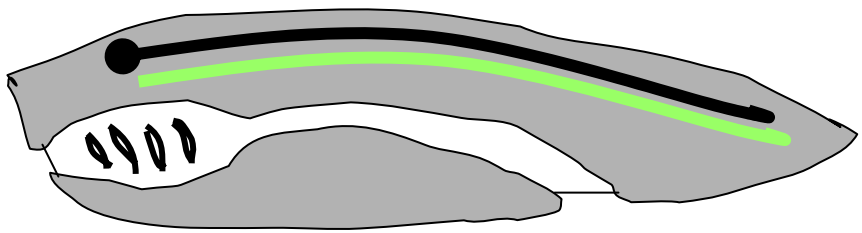
- notochord
- dorsal hollow nerve cord
- pharyngeal slits
- postanal tail



Chordata Characteristics

Notochord

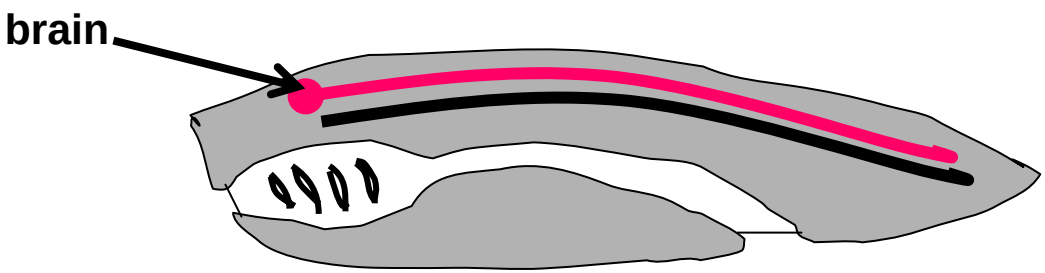
- a flexible rod-like structure
- extends the length of the body
- an axis for muscle attachment
- in all jawed vertebrates, it is replaced by a series of cartilaginous or bony vertebrae



Chordata Characteristics

Dorsal hollow nerve cord

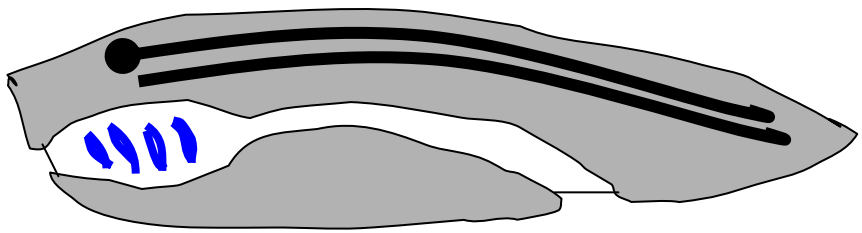
- a single hollow tube-like nerve cord
- dorsal to the alimentary canal and the notochord
- in vertebrates, the anterior end becomes enlarged to form the brain



Chordata Characteristics

Pharyngeal slits

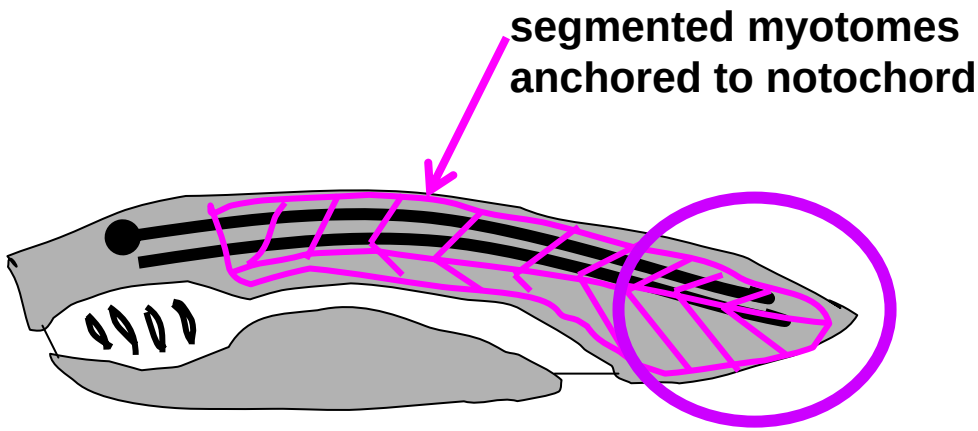
- perforated slit-like openings that connect the pharyngeal opening and the outside
- formed by alternating pharyngeal grooves and pouches
- in aquatic chordates, they become the gills
- in tetrapod (4 limbed) vertebrates, they become parts of the throat and ear cavity



Chordata Characteristics

Postanal tail

- located posterior to the anus
- associated with somatic musculature
- provides motility in the aquatic environment

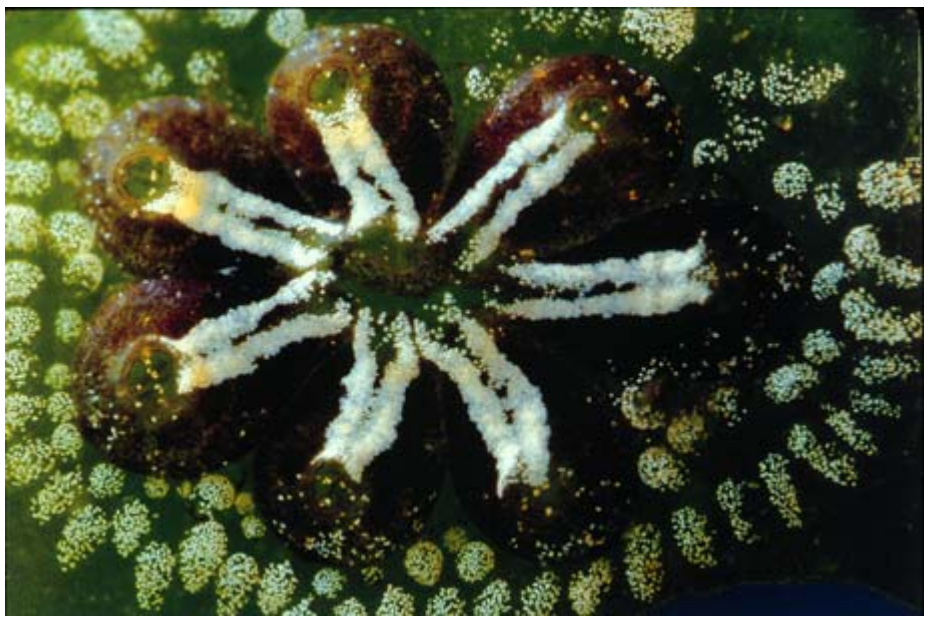


Phylum Chordata

Subphylum Urochordata
Subphylum Cephalochordata
Subphylum Vertebrata

Subphylum Urochordata

tunicates, ascidians, sea squirts, etc.

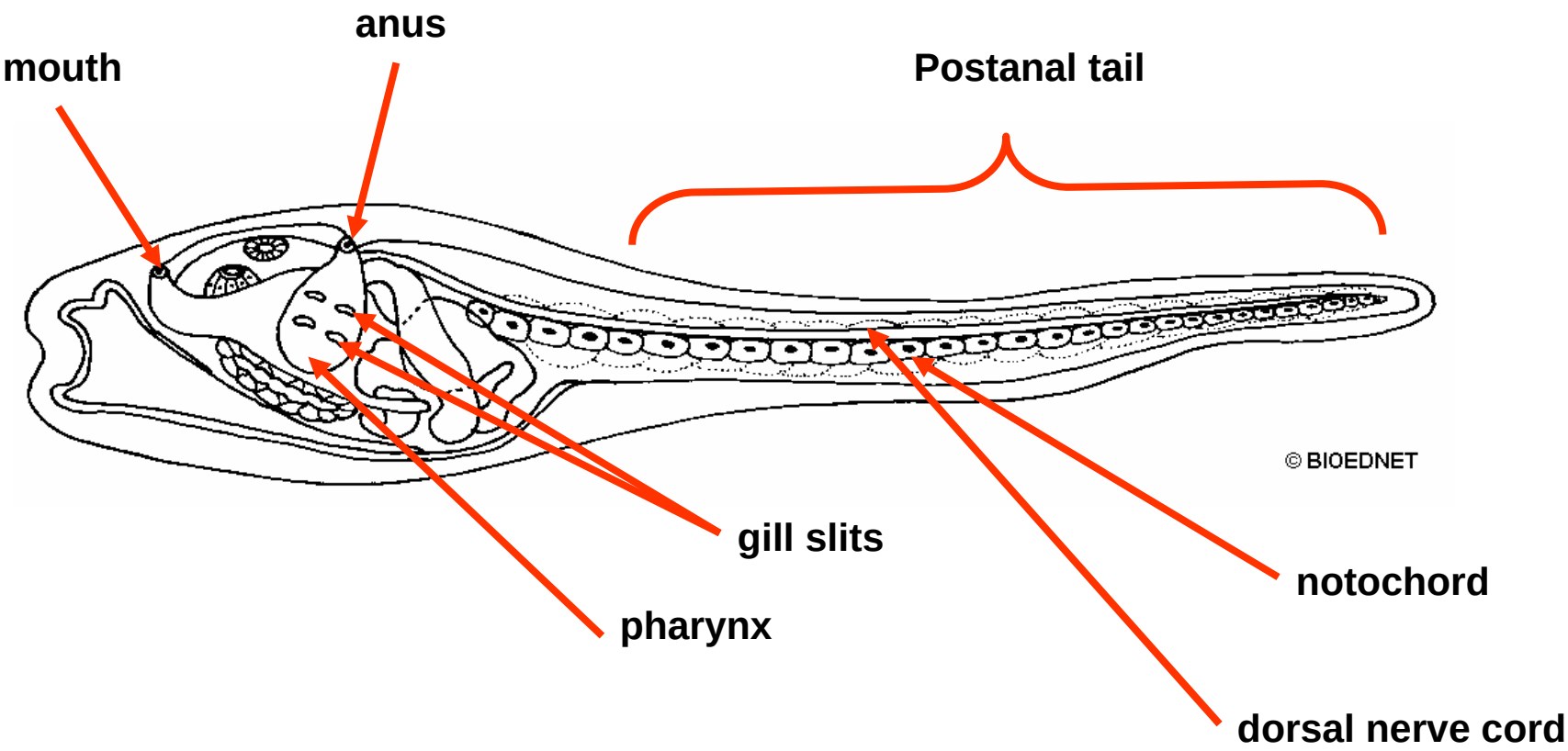


Subphylum Urochordata

- 3000 species
- marine
- swimming “tadpole larva”possesses all 4 chordate characteristics
- sessile adults (mostly) have lost all chordate characteristics except pharyngeal gill slits

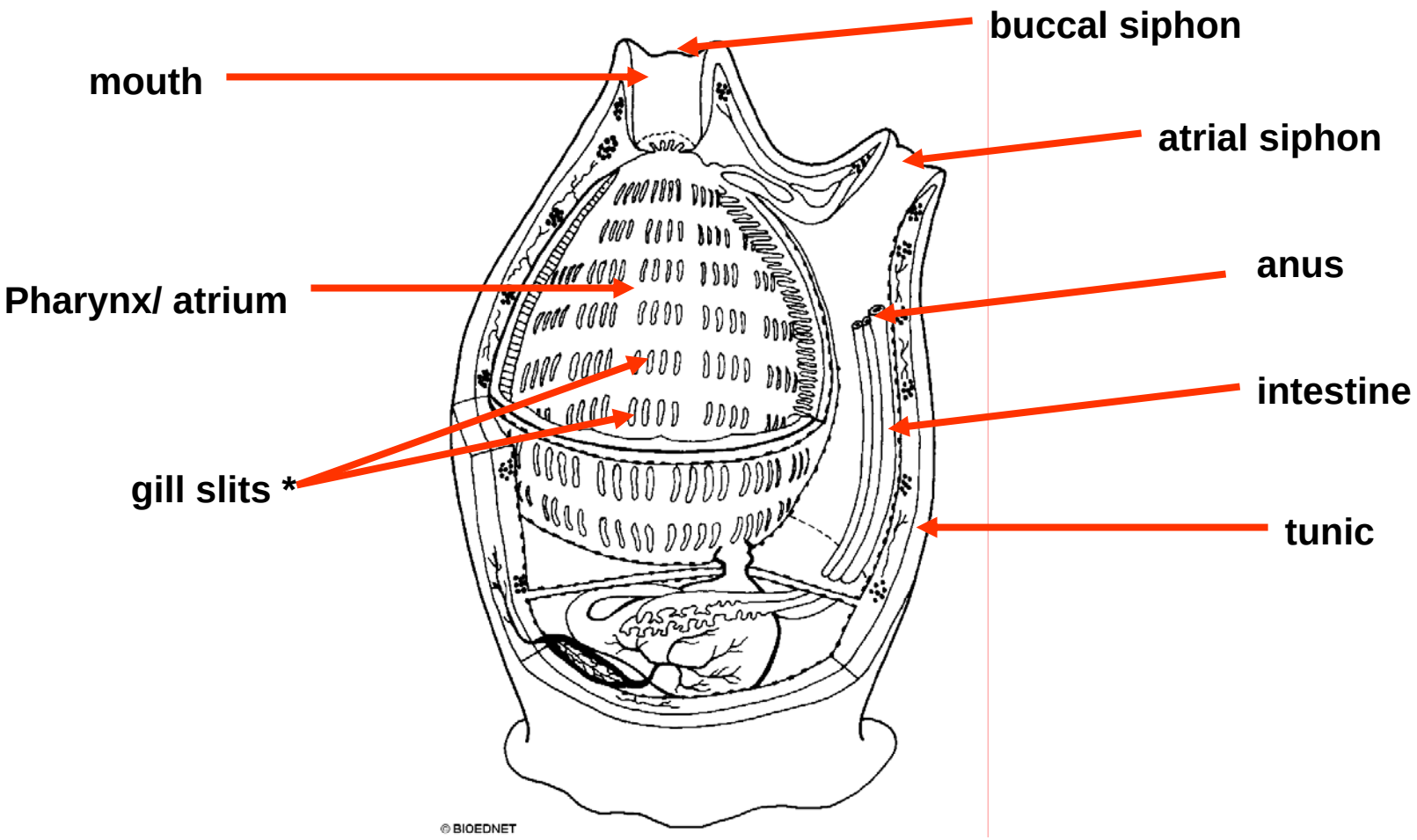
Subphylum Urochordata

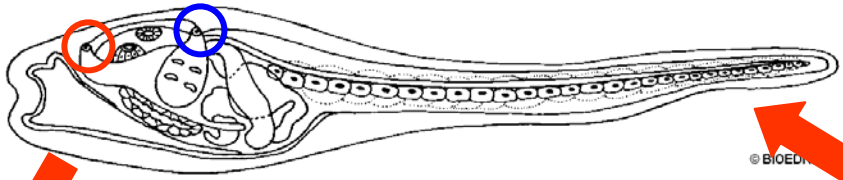
Larval Anatomy



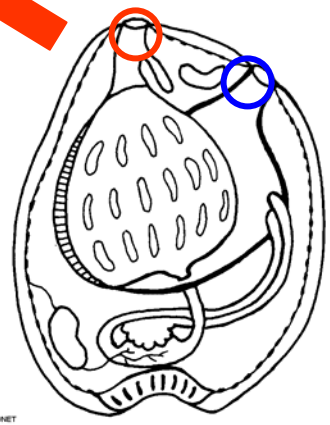
Subphylum Urochordata

Adult Anatomy

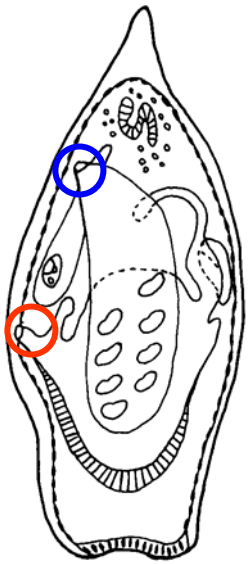




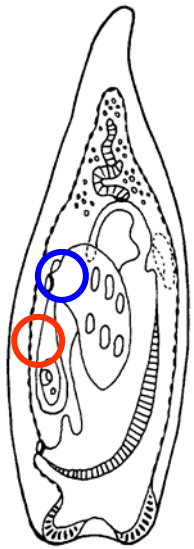
larvae



adult



settled larvae

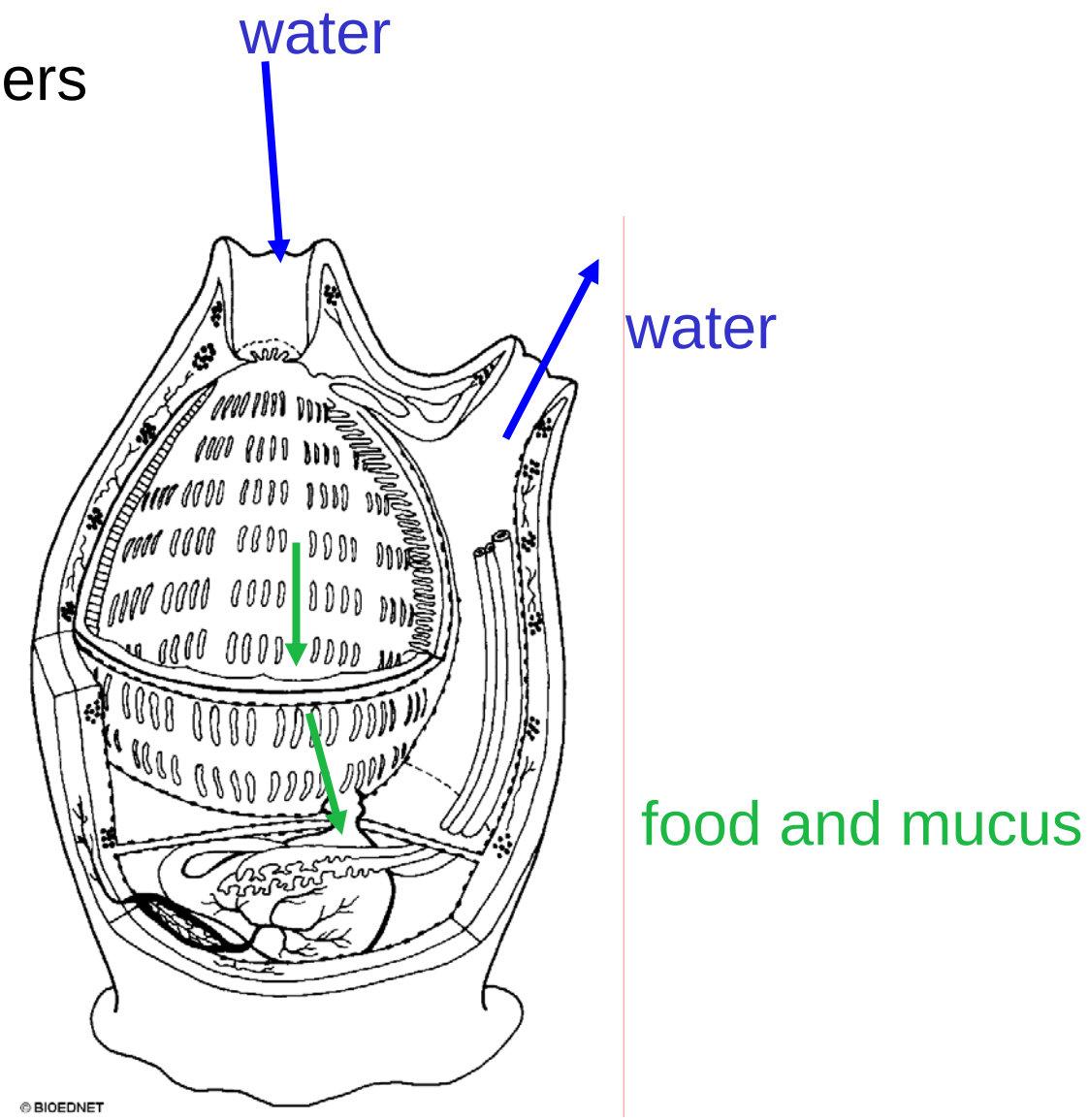


Metamorphosing

- Notochord and nerve cord absorbed
- Entire body rotates 180^{o}
- The number of pharyngeal slits increases

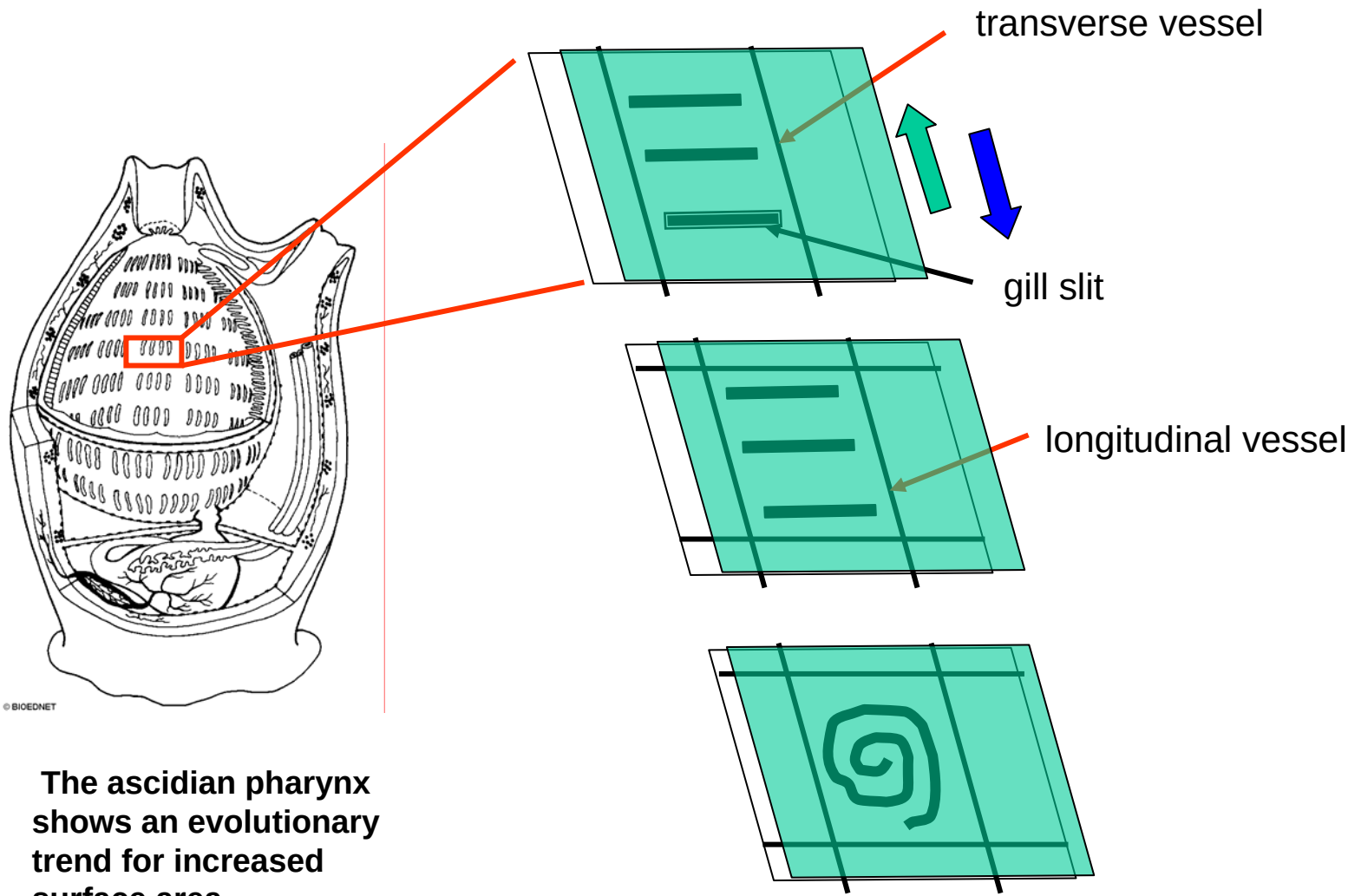
Feeding and Digestion

Filter feeders



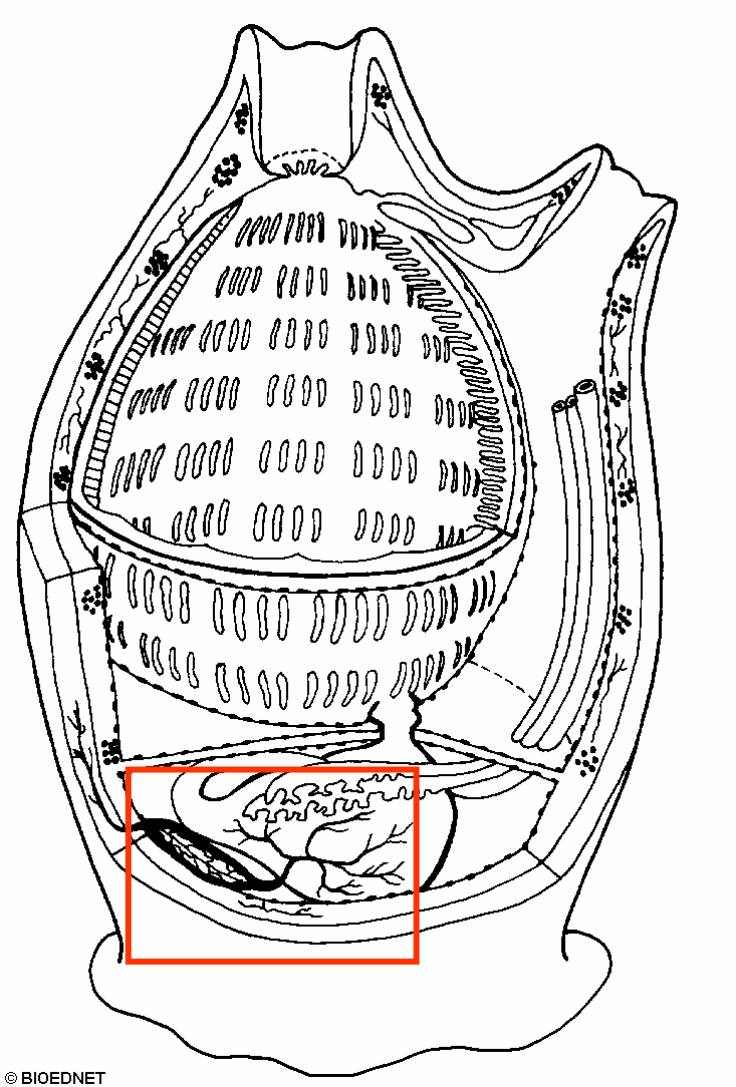
An individual a few centimeters long can filter more than 1000 liters of water in 24 hours

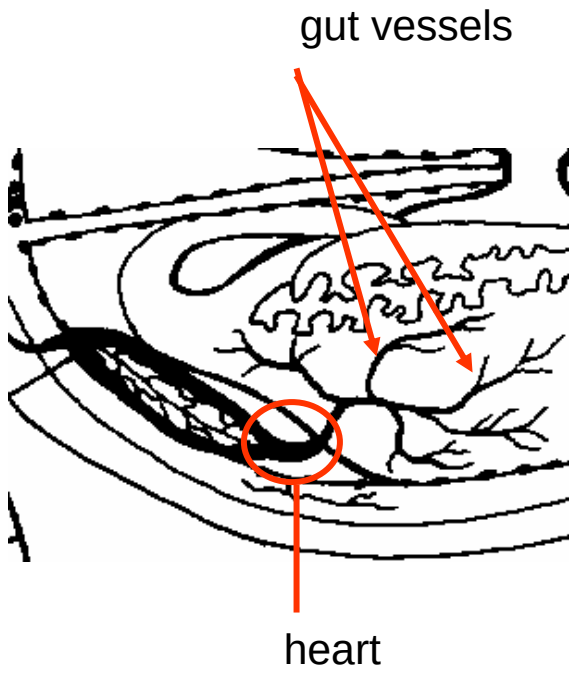
Feeding and Digestion



The ascidian pharynx shows an evolutionary trend for increased surface area

Circulation



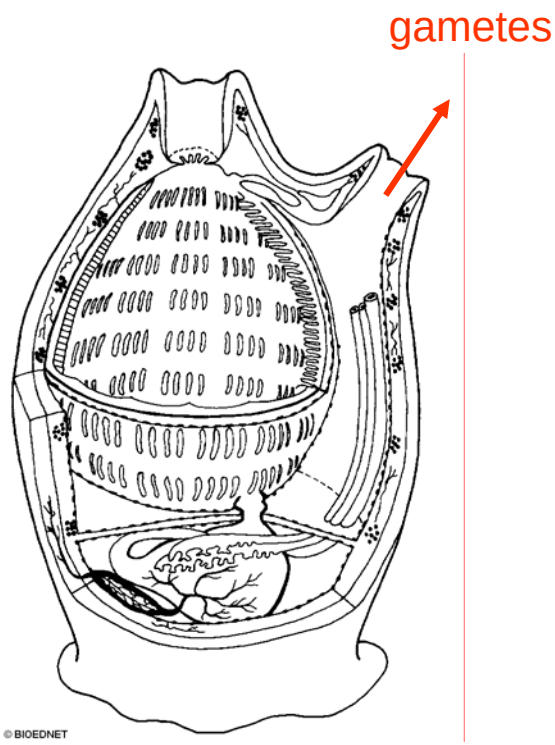


Urochordates have a complete circulatory system with a heart.

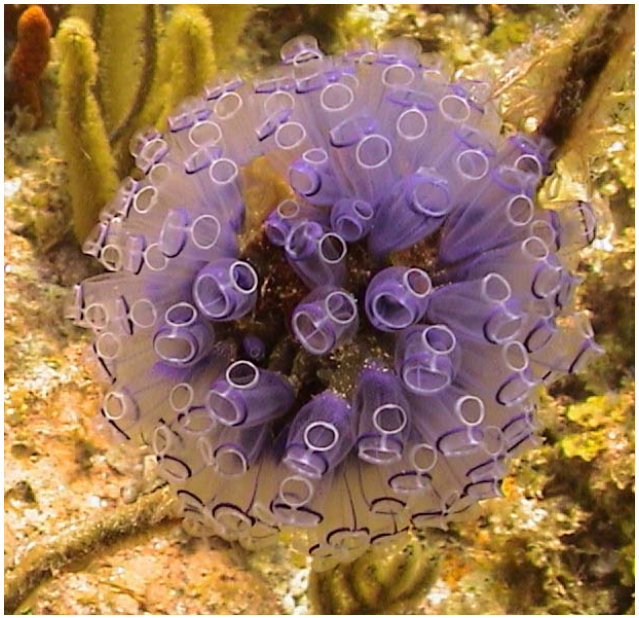
Reproduction

Asexual reproduction: occurs only in colonial forms.

Sexual reproduction: most species are monoecious

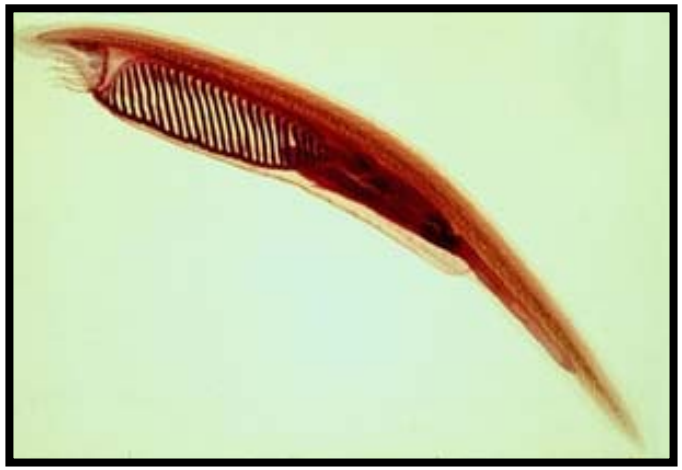


- Sperm and eggs are usually shed from the atrial siphon, and fertilization is external.
- Some species brood fertilized eggs in the atrium.



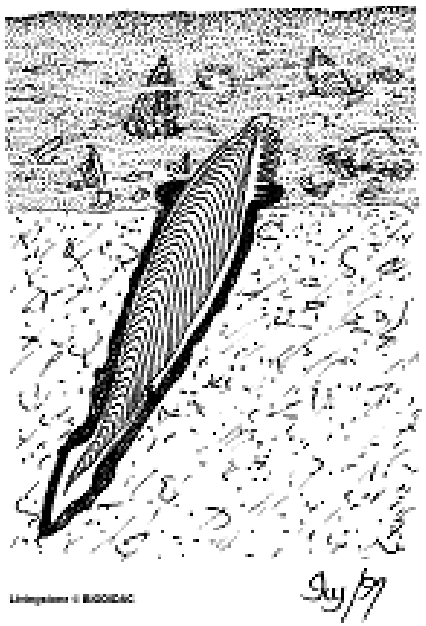
Salps

Most Urochordates are sessile as adults, however some are planktonic.



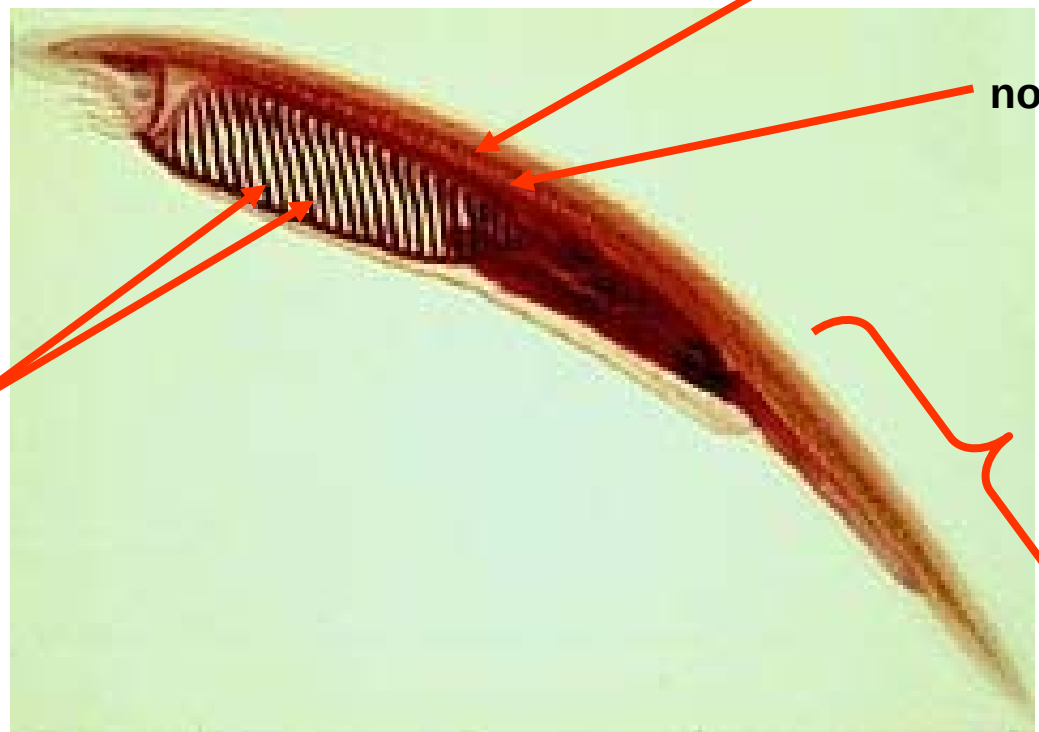
Subphylum Cephalochordata

the lancelets (amphioxus)

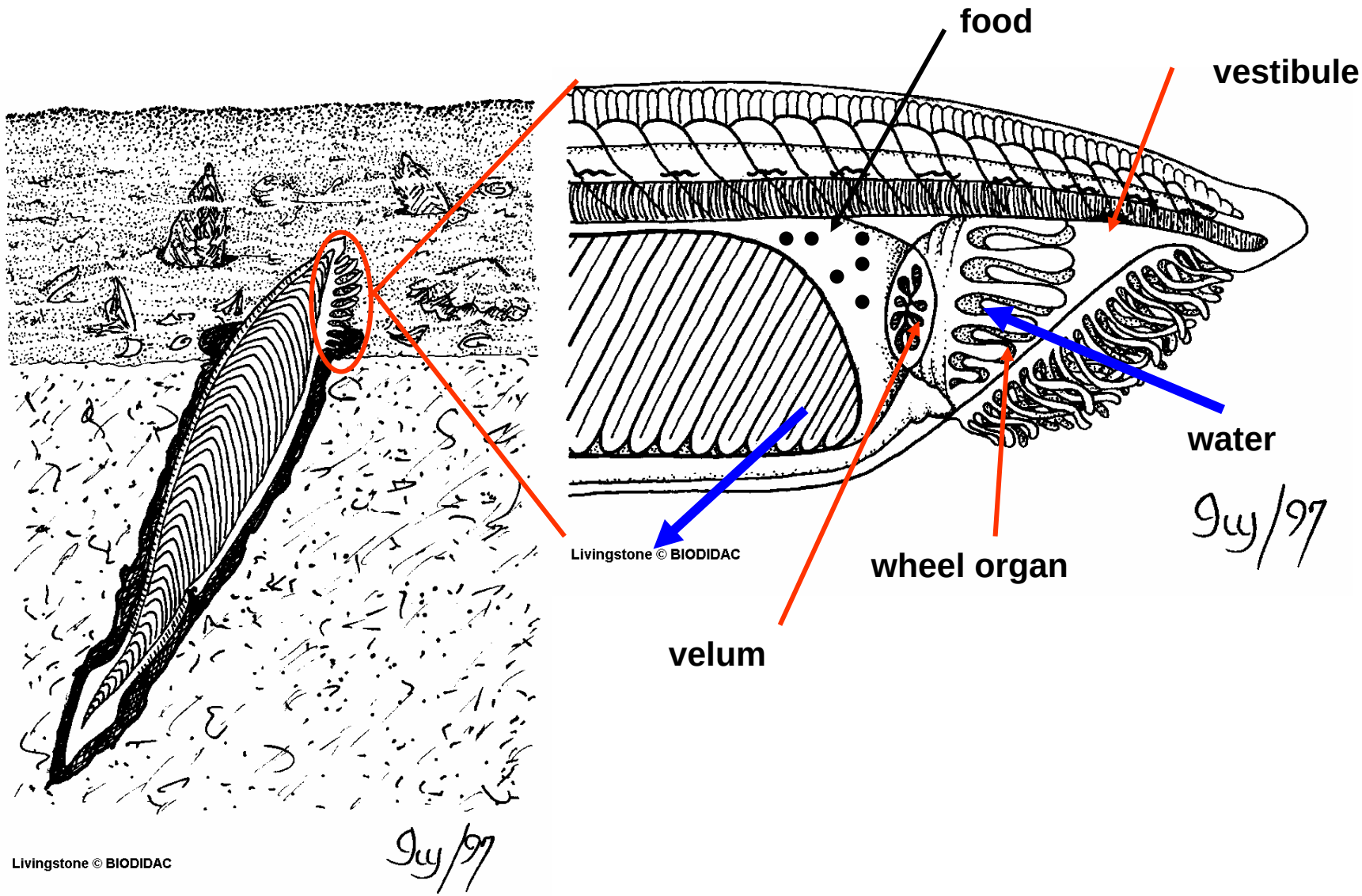


Subphylum Cephalochordata

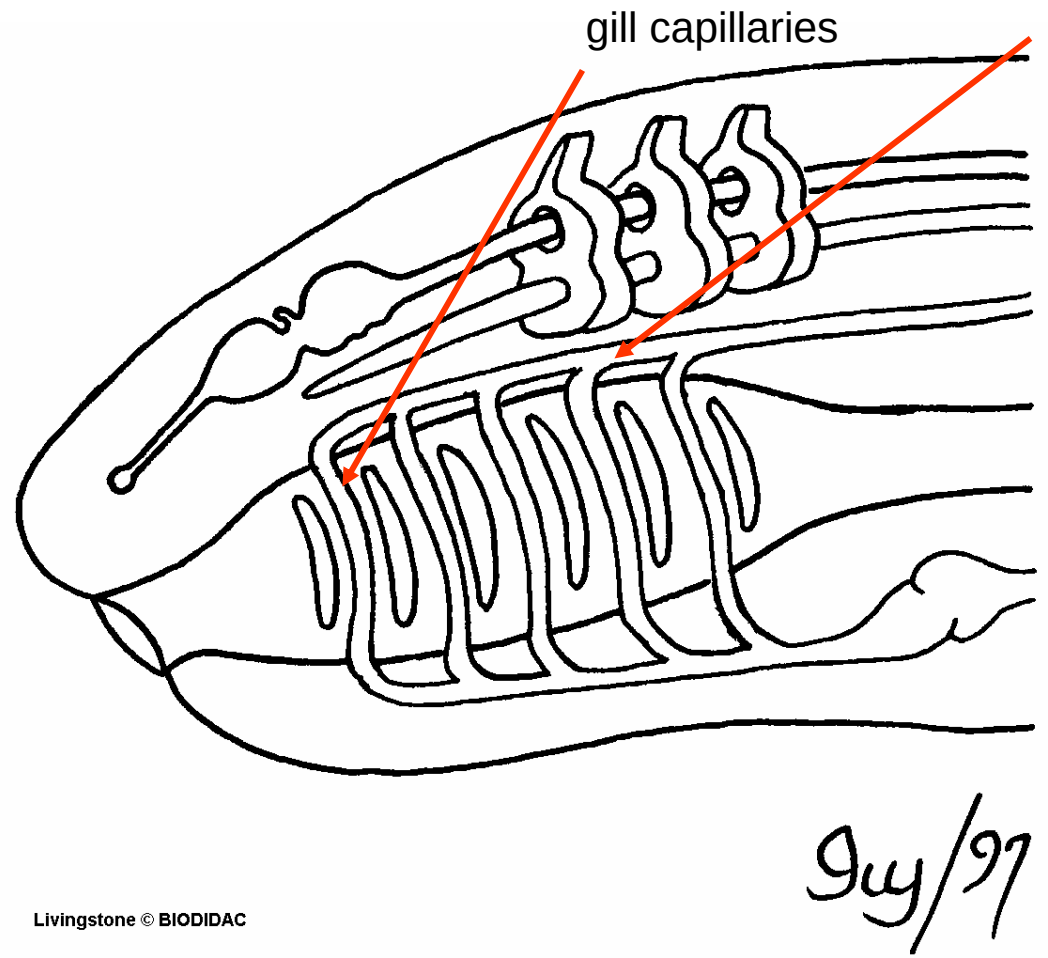
- 26 species
- have all 4 chordate characteristics throughout the lifecycle



Feeding and Digestion



Circulation

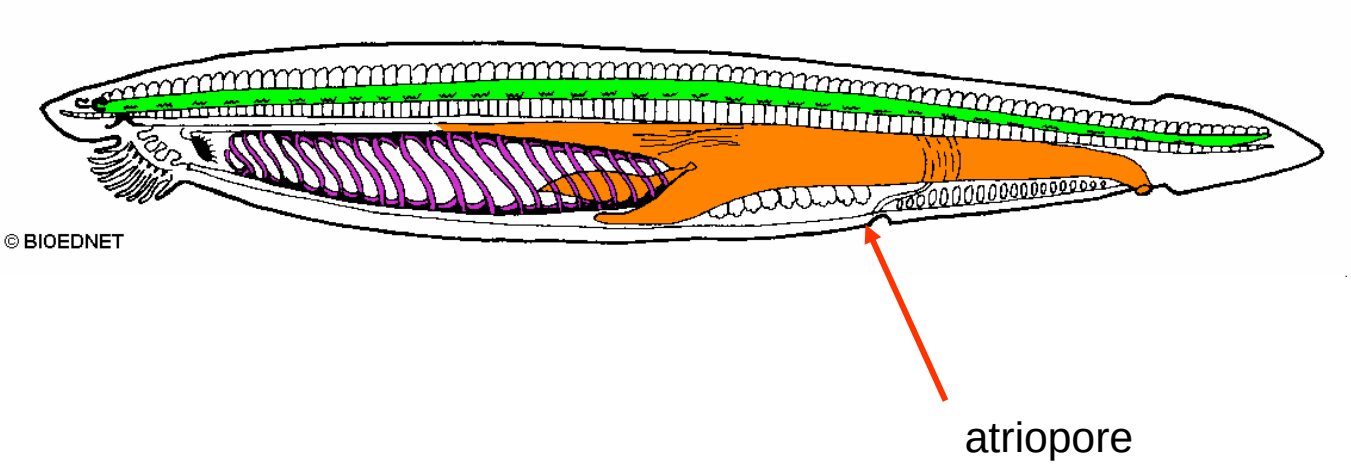


Cephalochordates have a complete circulatory system with no heart.

Reproduction

Sexual reproduction: most species are dioecious

Fertilization is external: gametes are shed through the atriopore.



Subphylum Vertebrata

the vertebrates

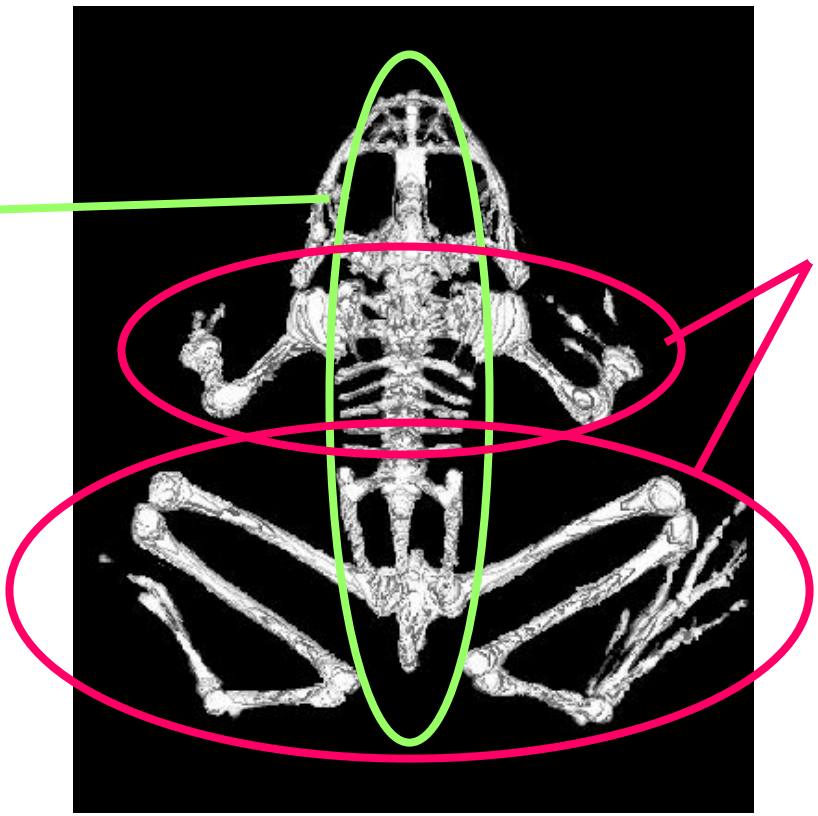
Subphylum Vertebrata

•Vertebrates have the 4 chordate characteristics plus a cranium (braincase)

Subphylum Vertebrata

• most vertebtrates have an endoskeleton consisting of a vertebral column, limb girdles, and paired appendages

axial skeleton
- consists of skull and vertebral column



appendicular skeleton
- consists of paired limbs

Subphylum Vertebrata

• outer epidermis (skin) that is modified into specialized structures (e.g. hair, scales, feathers…)

• ventral heart with 2- 4 chambers
• hemoglobin filled blood cells
• paired kidneys
• highly differentiated brain
• endocrine system with glands scattered throughout body

Subphylum Vertebrata

Adaptations that have been important in the adaptive radiation of Vertebrates:

1. Living endoskeleton

The endoskeleton allows for almost unlimited growth.

Excellent site for muscle attachment

Subphylum Vertebrata

Adaptations that have been important in the adaptive radiation of Vertebrates:

2. Pharynx / efficient respiration

Although originally used in filter feeding, the pharynx became modified into a powerful feeding apparatus.

Subphylum Vertebrata

Adaptations that have been important in the adaptive radiation of Vertebrates:

3. Head and nervous system:

Urochordates and Cephalochordates lack brains and highly developed sensory organs.

The switch from filter feeding to predation was accompanied by an increase in the sophistication of the nervous system.

Subphylum Vertebrata

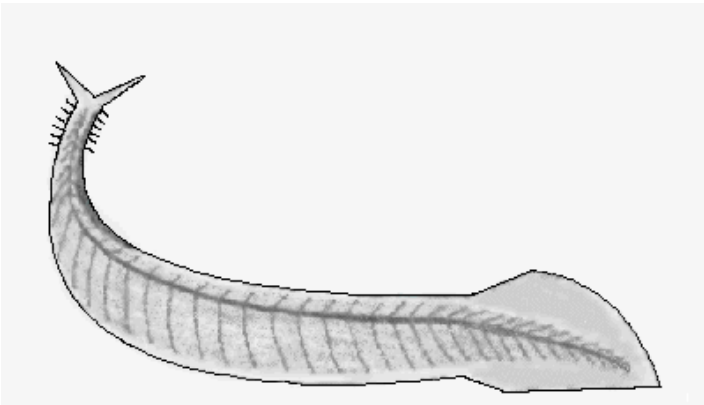
Adaptations that have been important in the adaptive radiation of Vertebrates:

3. Paired limbs:

Paired / jointed limbs enabled vertebrates to invade land.

Subphylum Vertebrata

The earliest chordate found to date is *Pikaia* (550 million years old)

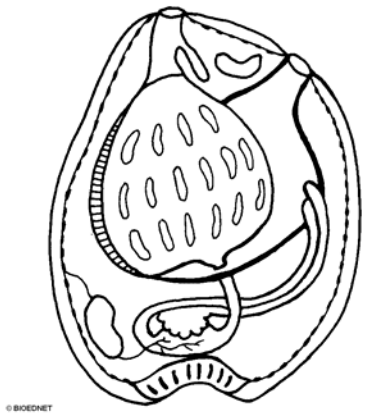


Pikaia had a notochord, and segmented muscles (myotomes)

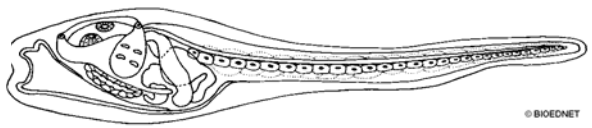
It was probably a Cephalochordate

Subphylum Vertebrata

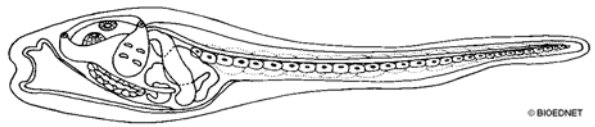
The evolution of vertebrates: Garstang's hypothesis.



adult



larvae

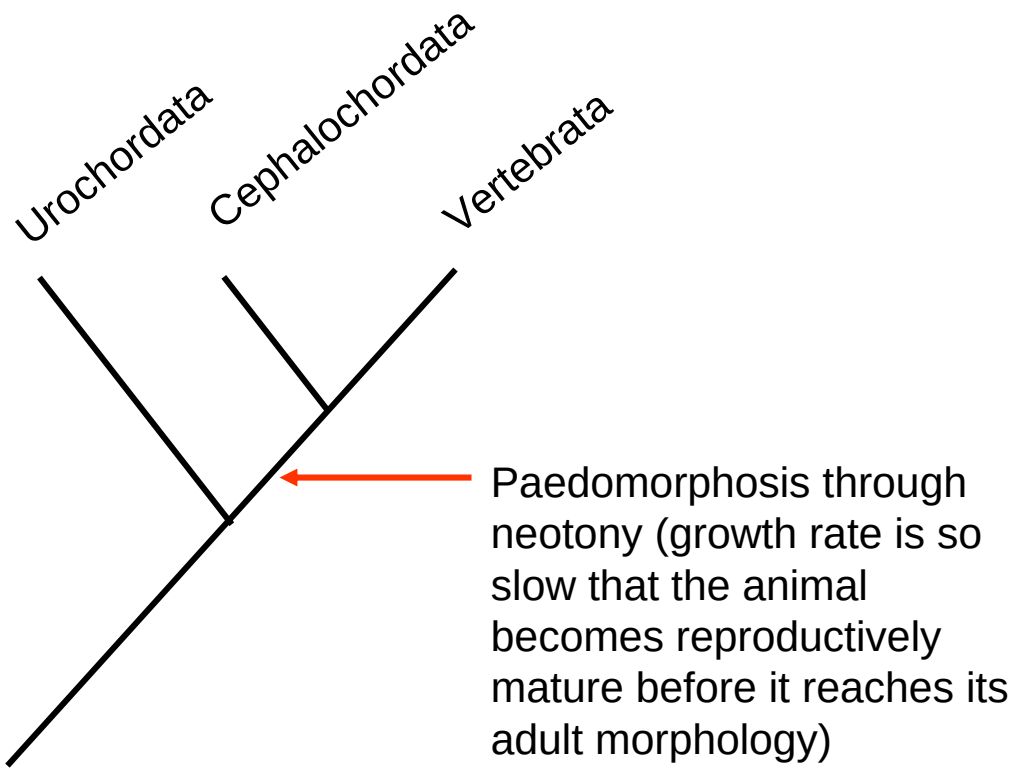


reproducing larvae

Garstang proposed that the ancestor of cephalochordates and vertebrates evolved through paedomorphosis (the evolutionary retention of juvenile traits in the adult)

Subphylum Vertebrata

The evolution of vertebrates: Garstang's hypothesis.



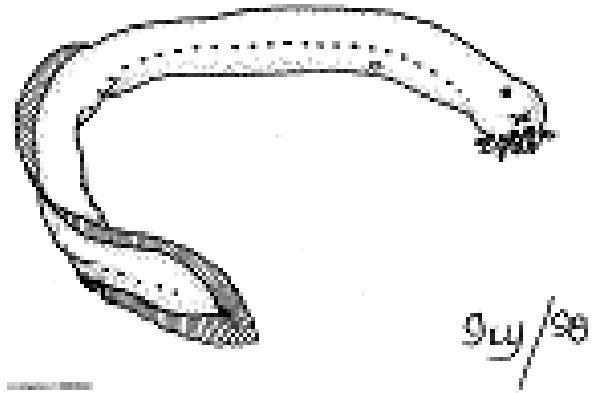
Subphylum Vertebrata

Superclass Agnatha (jawless vertebrates)

- **Class Myxini**
- **Class Cephalaspidomorphi**

Superclass Gnathostomata (jawed vertebrates)

- **Class Chondrichthyes**
- **Class Osteichthyes**
- **Class Amphibia**
- **Class Reptilia**
- **Class Aves**
- **Class Mammalia**



Superclass Agnatha

jawless fish

Superclass Agnatha

•84 species

• jawless with a sucker-like oral disk containing well developed teeth

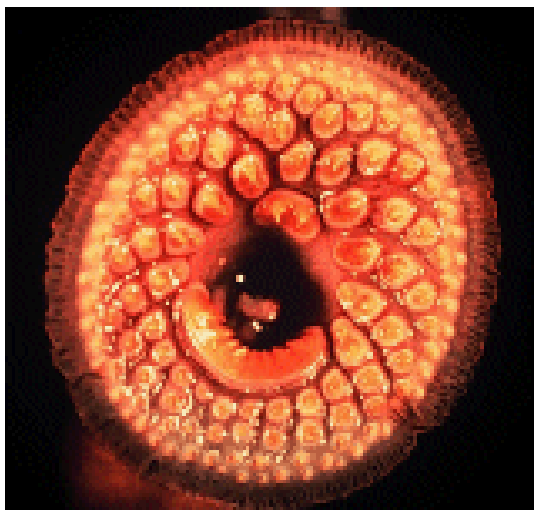
• fibrous and cartilaginous skeleton with no vertebrae

• no scales; no paired appendages

• pore-like gill openings

• two chambered heart

• no stomach → only intestine

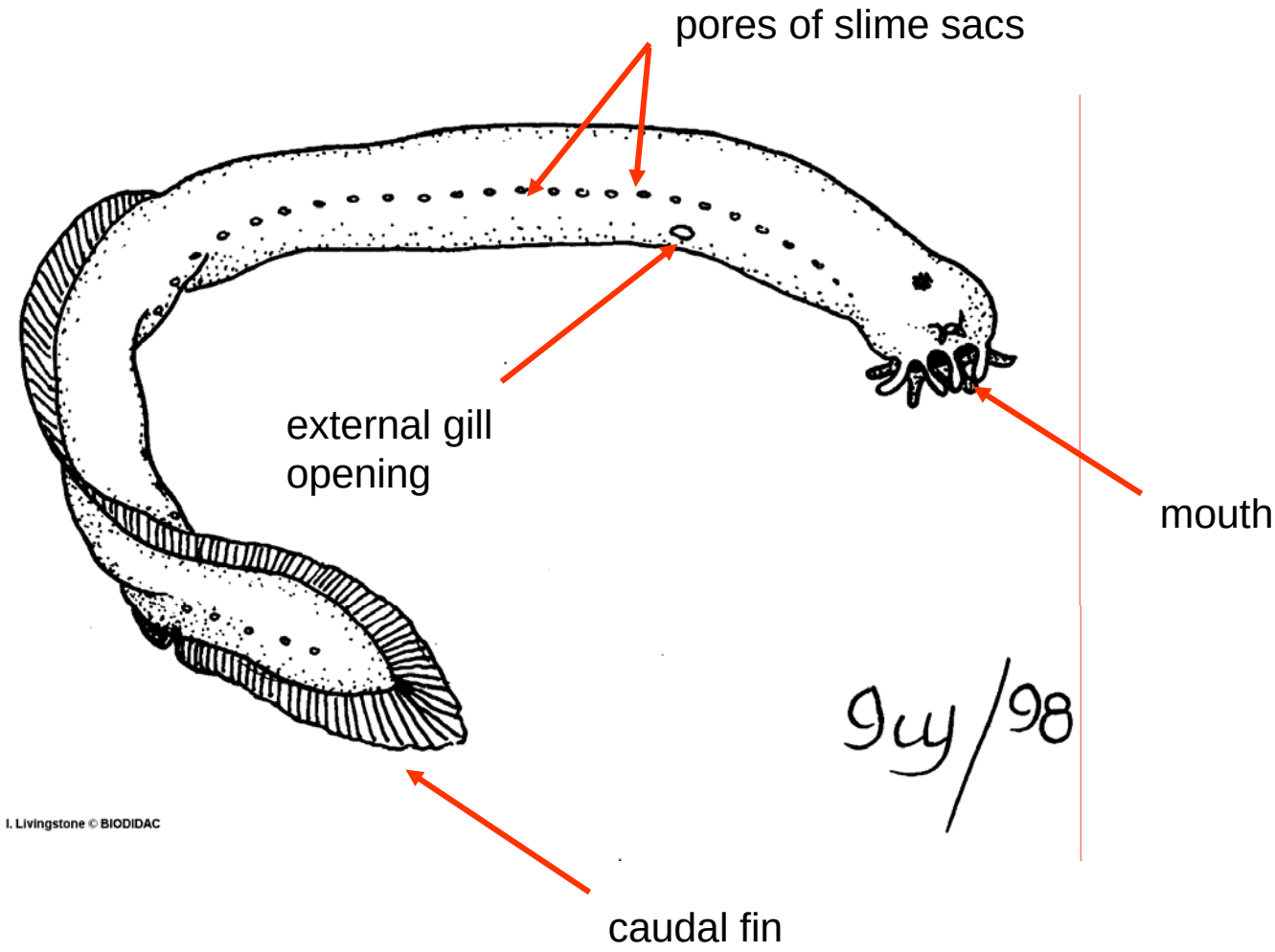


Class Myxini (hagfish)

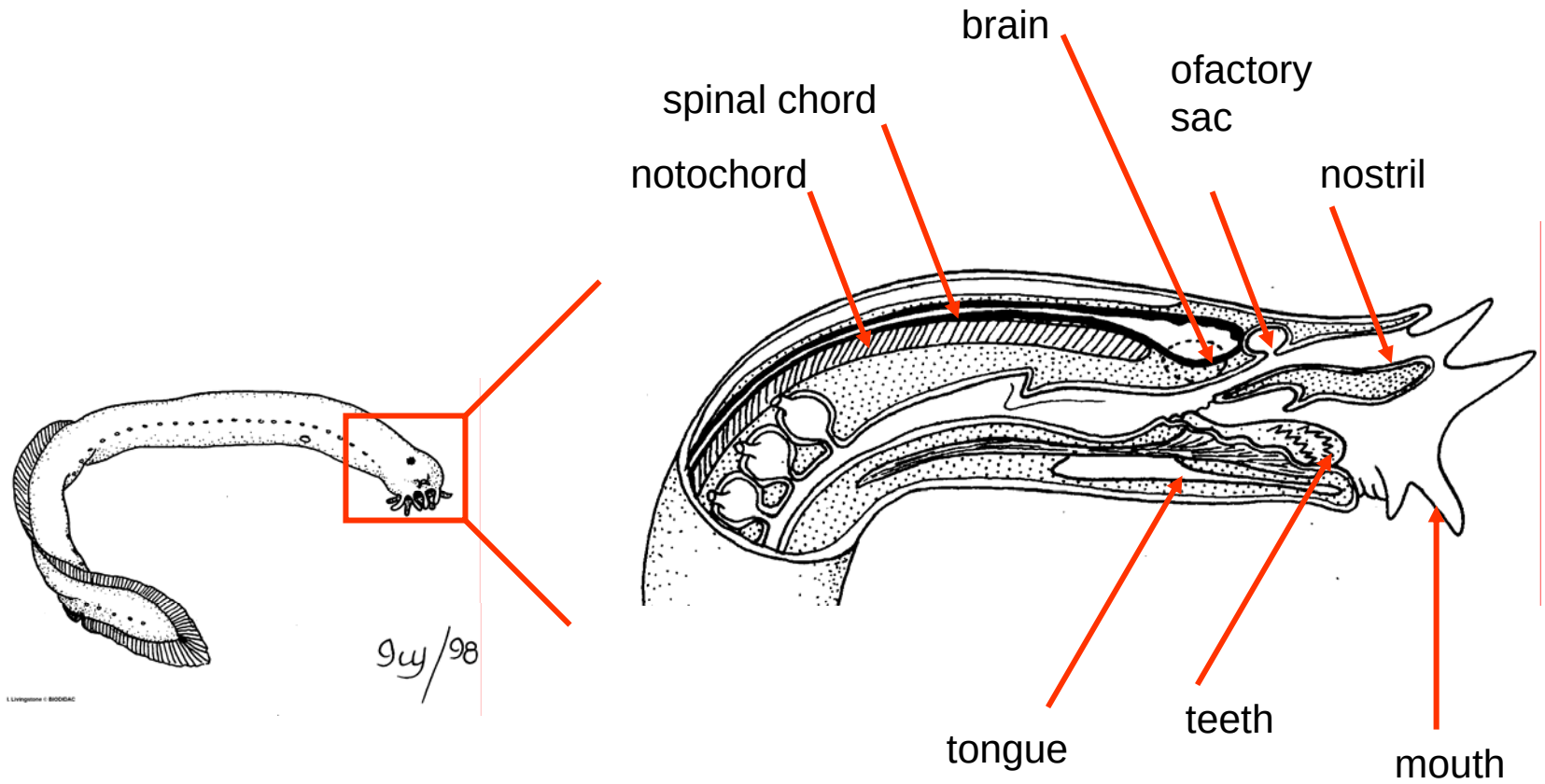
43 species, entirely marine

Feed on dead or dying fish and crustaceans

Class Myxini (hagfish)



Class Myxini (hagfish)



Class Myxini (hagfish)

- The only vertebrate whose body fluids are in osmotic equilibrium with sea water.
- Low pressure circulatory system: 1 major heart, 3 accessory hearts.
- Reproduction: male and female gonads are found in each individual, however only one type is functional (anatomically monoecious, functionally dioecious)

- Tie themselves in a knot to feed.

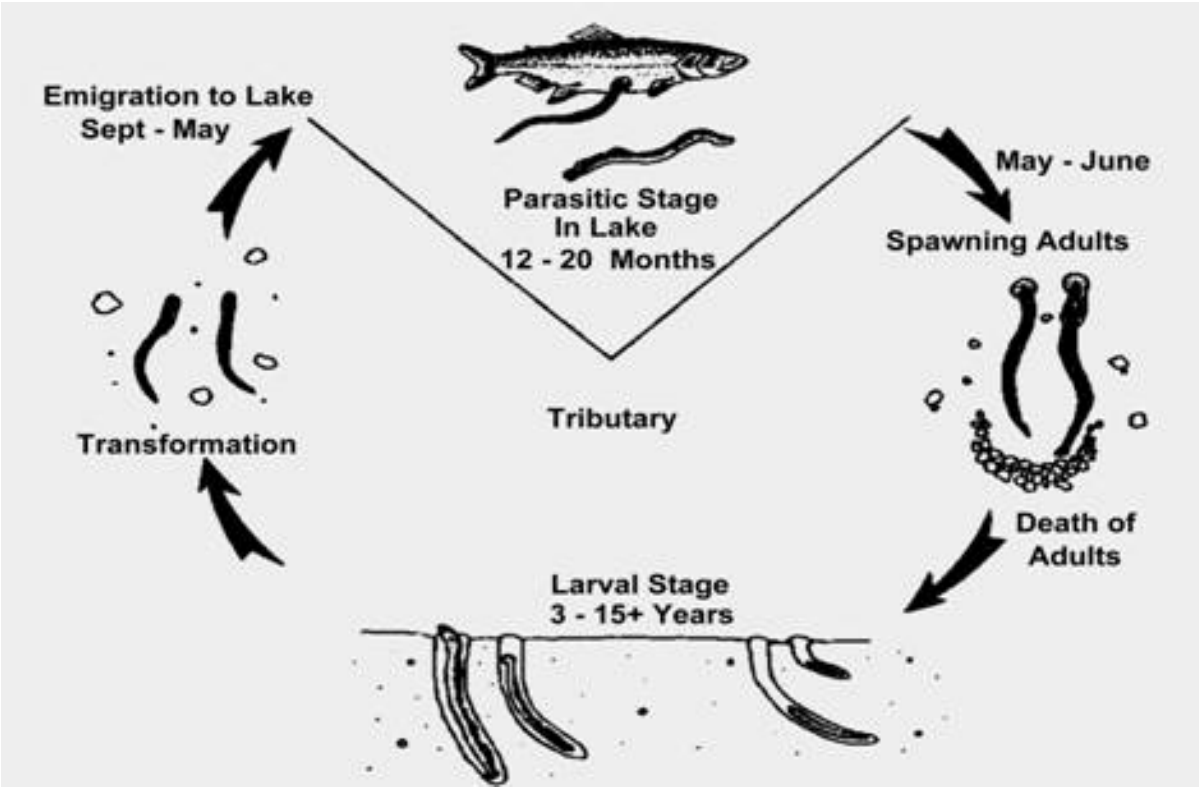
Class Cephalaspidomorphi (lampreys)

Found in salt and freshwater

1/2 are parasitic

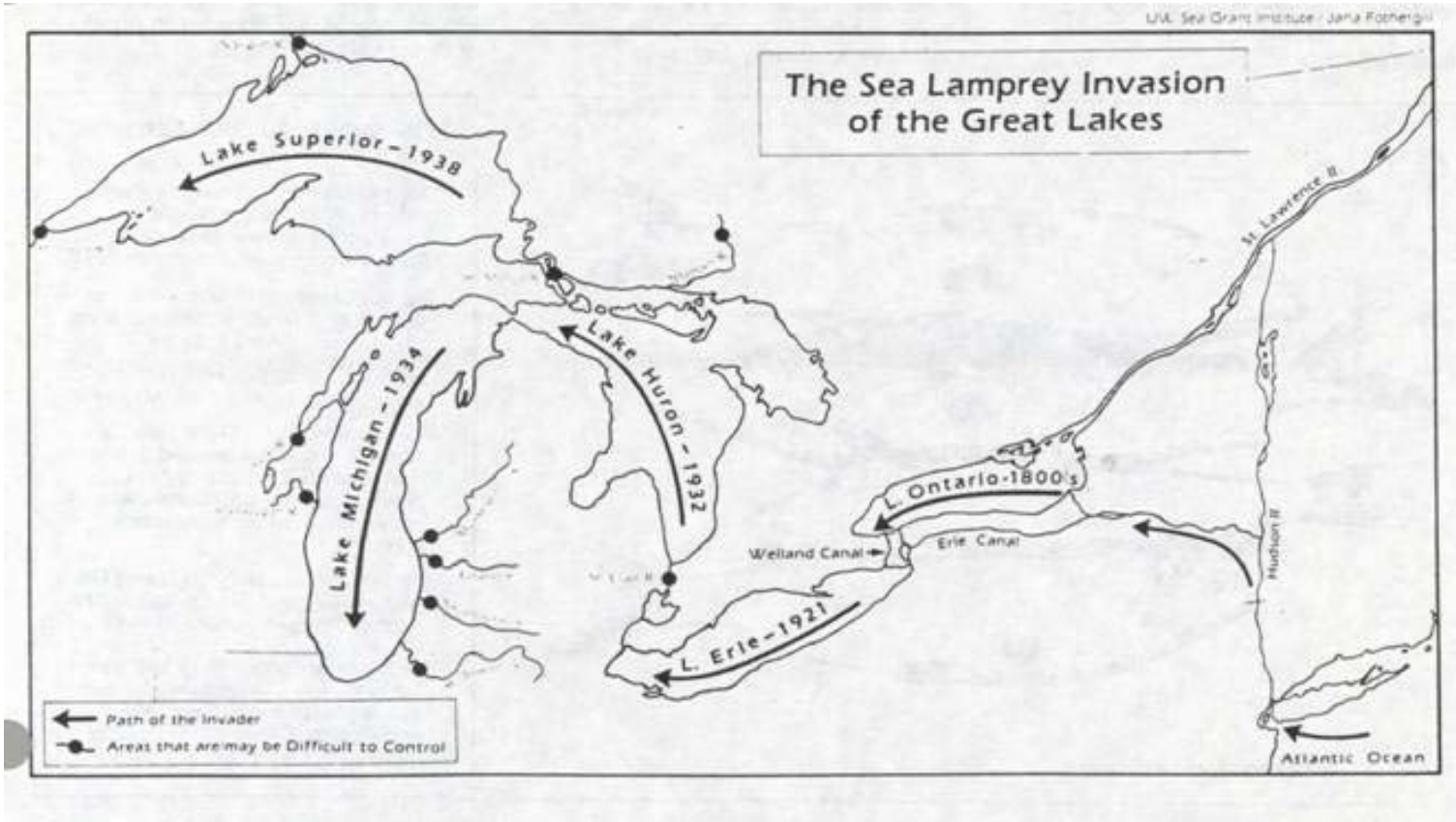
Those that are not parasitic do not feed as adults

Life cycle of parasitic lampreys

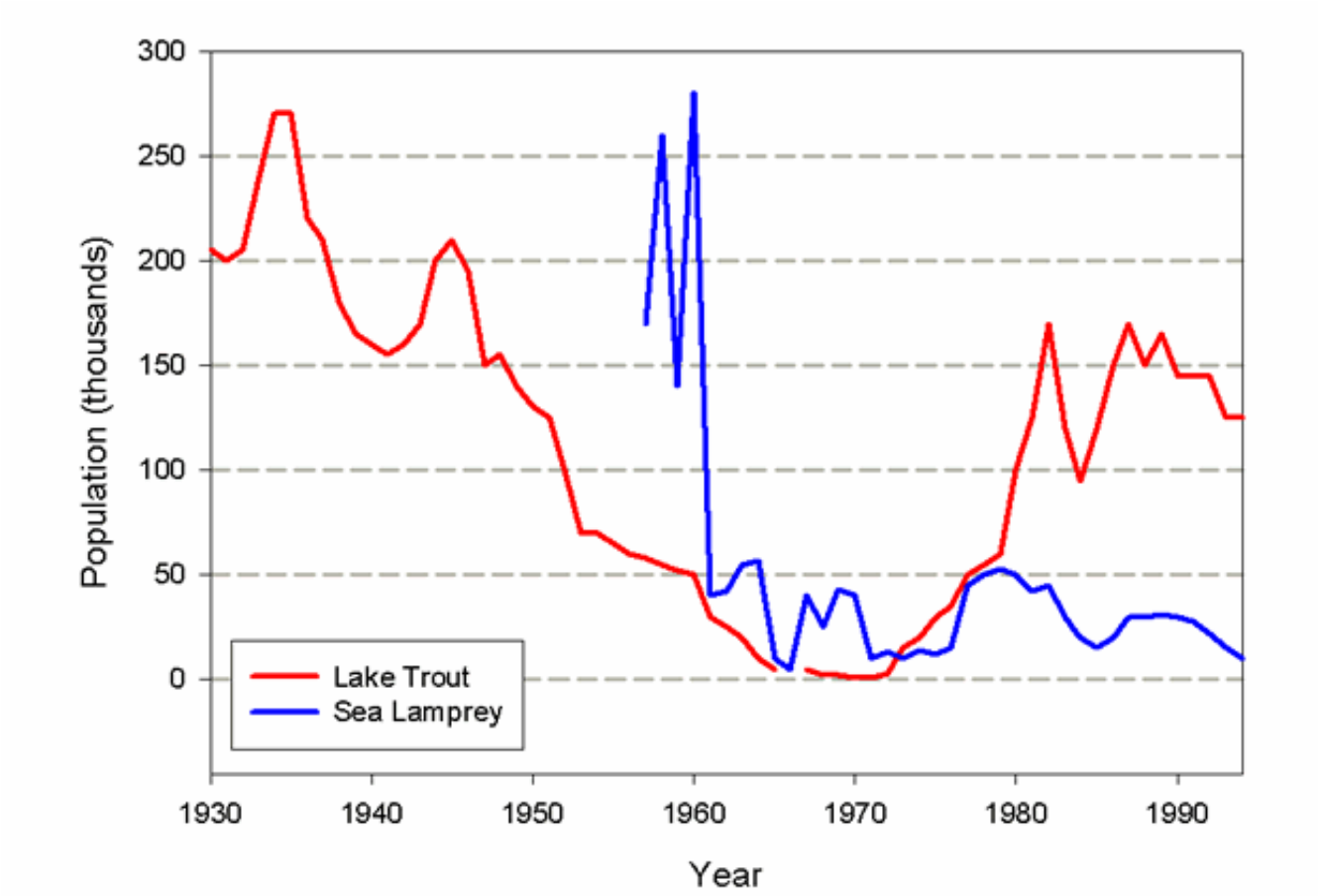


Lampreys are semelparous: they breed once and die

Sea lampreys were introduced to the Great Lakes in the late 1800s.



Overfishing and the spread of the sea lamprey caused the collapse of the commercial trout fishery in Lake Superior.

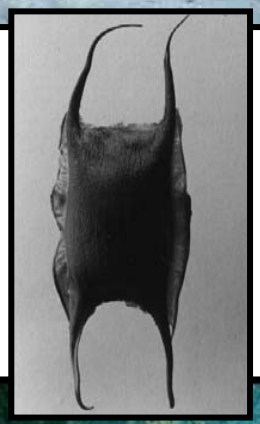


Subphylum Vertebrata

Superclass Agnatha (jawless vertebrates)

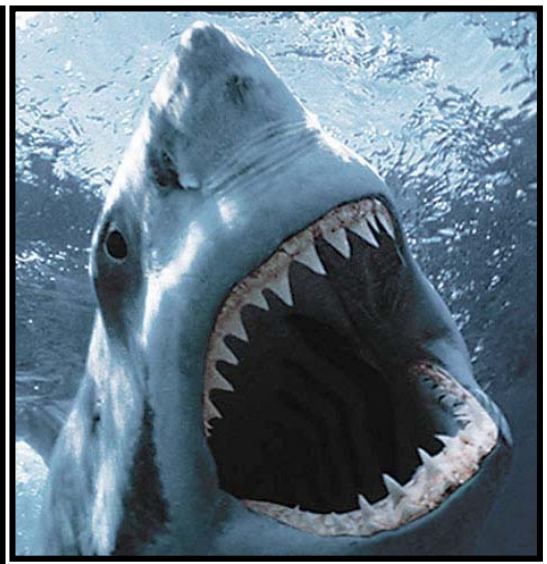
Superclass Gnathostomata (jawed vertebrates)

- **Class Chondrichthyes**
- **Class Osteichthyes**
- **Class Amphibia**
- **Class Reptilia**
- **Class Aves**
- **Class Mammalia**

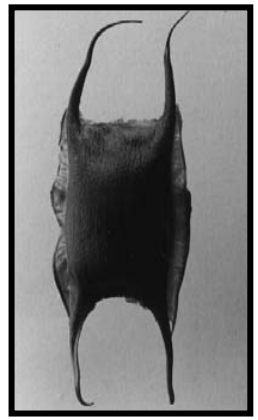


Class Chondrichthyes

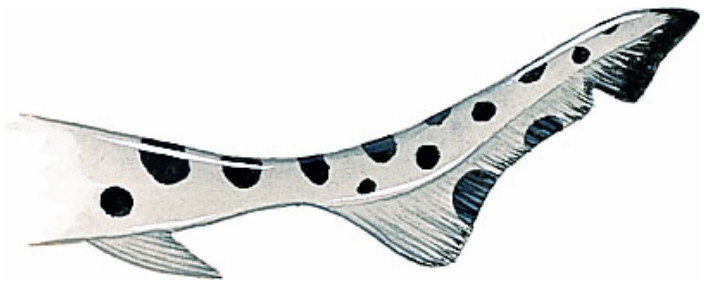
the sharks and rays

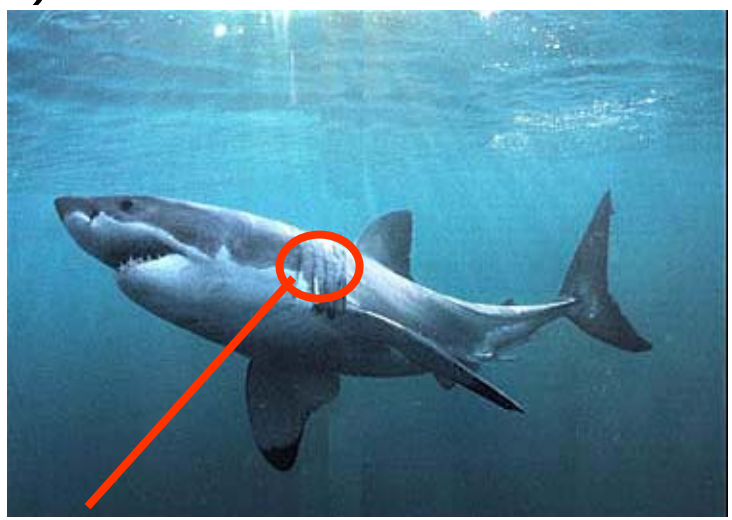


Class Chondrichthyes



- 850 species
- cartilaginous skeleton with bony jaws
- paired appendages
- two chambered heart
- heterocercal tail (asymmetrical)
- exposed gill slits (no operculum)
- no swim bladder

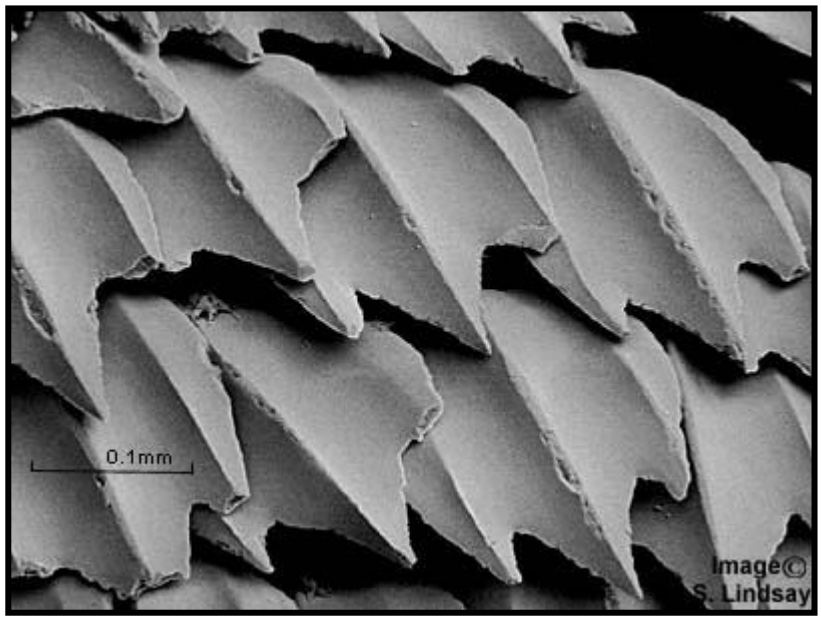


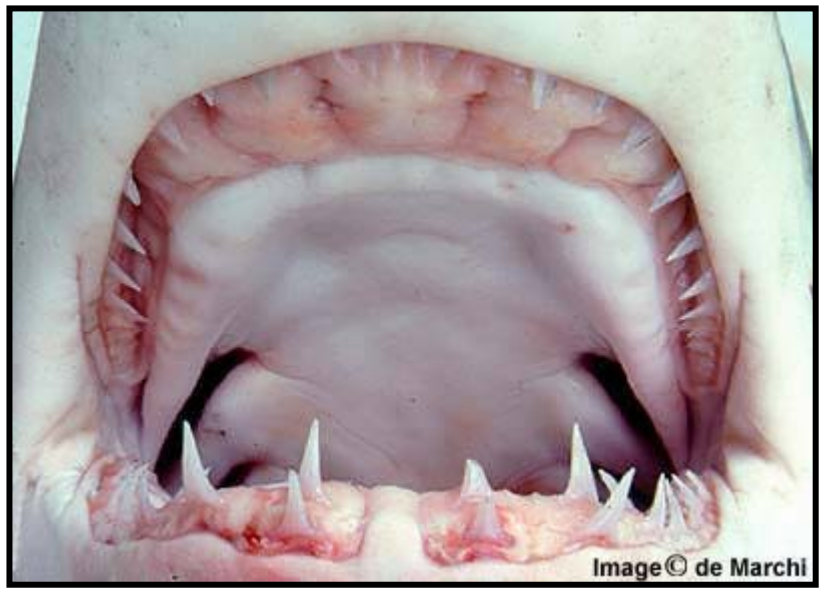


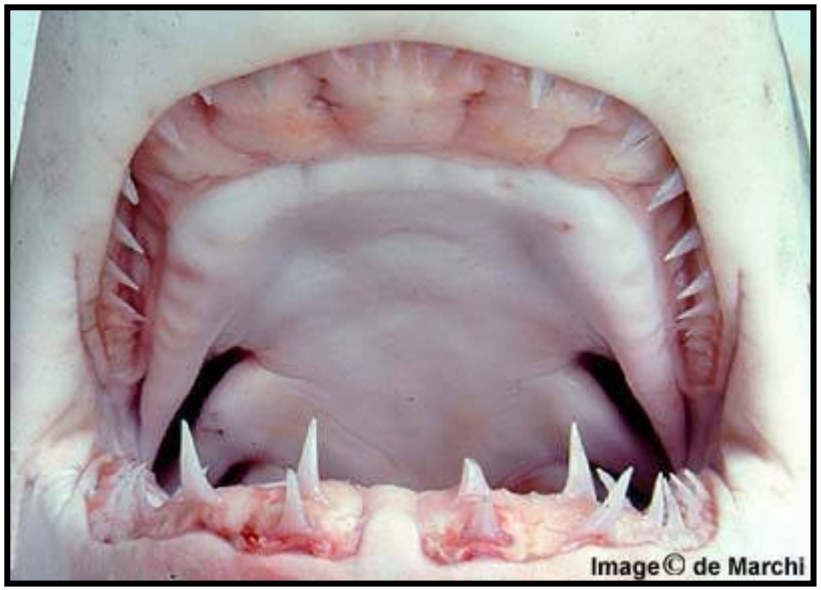
gill slits

Class Chondrichthyes

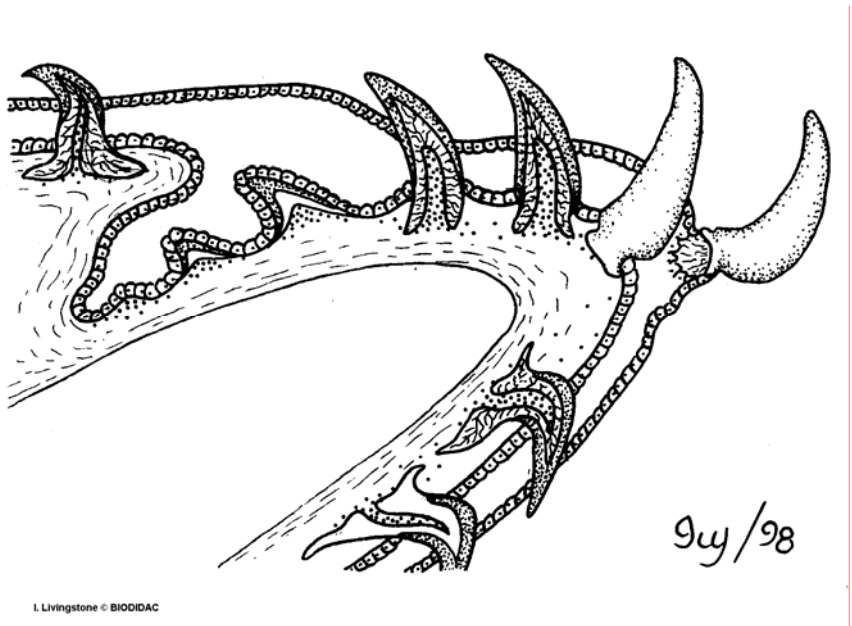
- skin is covered with dermal (placoid) scales which are also modified to form teeth



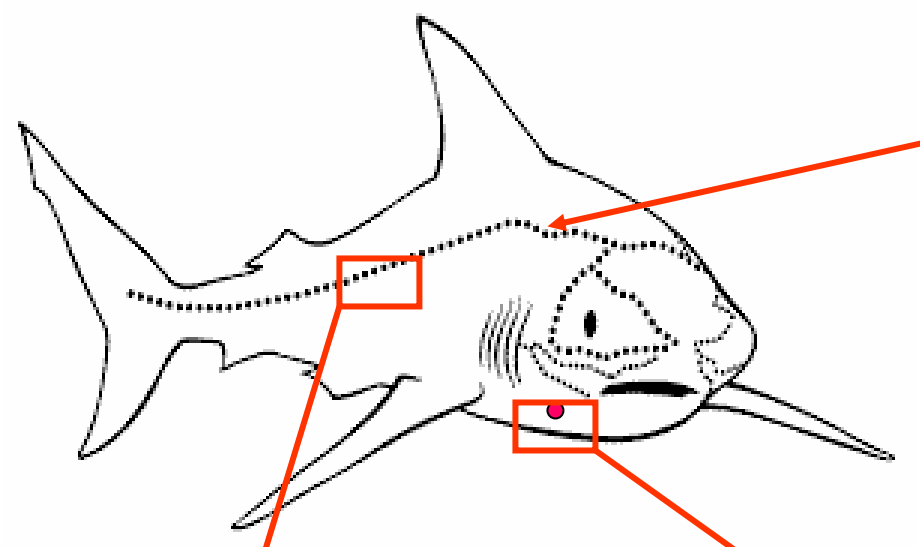




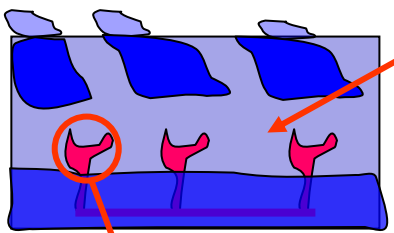
tooth replacement



Specialized sensory organs

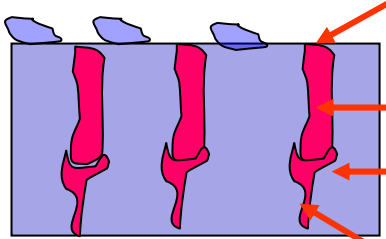


Lateral line system: a canal system containing specialized cells (neuromasts) that are sensitive to vibrations in the water.



lateral line canal

neuromast cells



pore

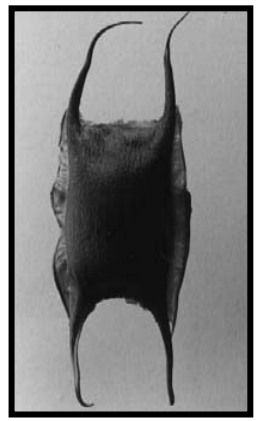
jelly filled canal

ampulla of Lorenzini

nerve

Ampulla of Lorenzini respond to weakly electric fields.

Class Chondrichthyes



- Reproduction
- Sexual, dioecious.
- Internal fertlilization

male **female**

Class Chondrichthyes

- Reproduction

- Viviparous: give birth to fully developed offspring.

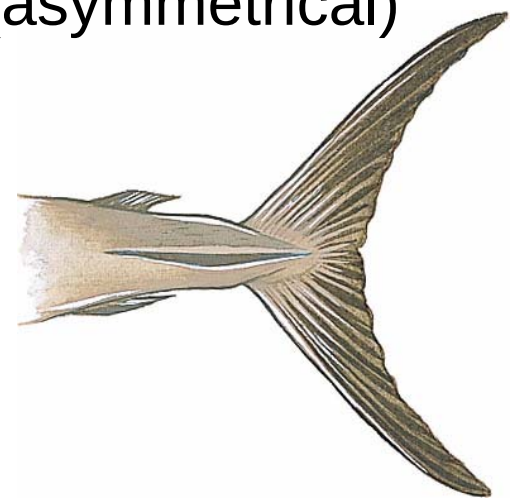
- Oviparous: lay eggs

Class Osteichthyes

the “bony” fish

Class Osteichthyes

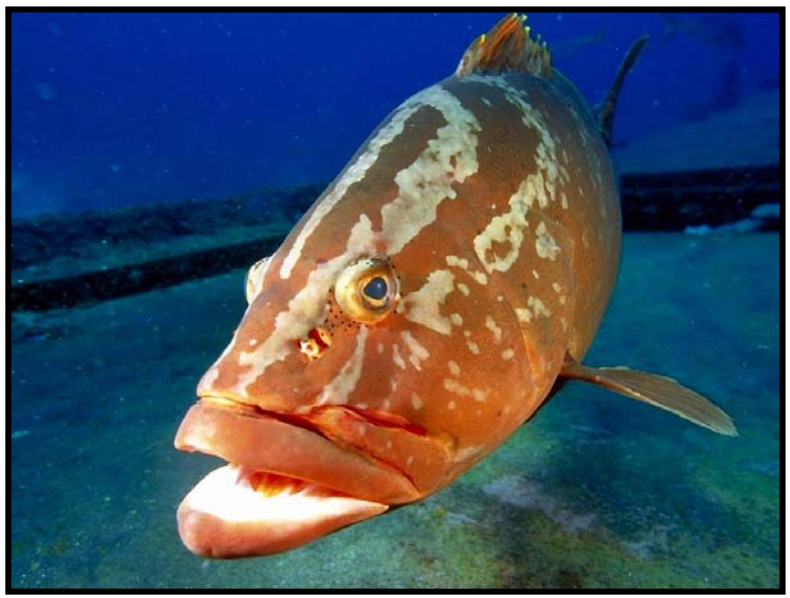
•more than 25, 000 species
•mostly bony skeleton
• skin covered in dermal scales
• paired appendages
• two chambered heart
• gills supported by bony gill arches and covered by an operculum
• most have a homocercal tail (asymmetrical)
• have a swim bladder



Class Osteichthyes

The bony fish display an amazing variety of reproductive and life history characteristics:

•Monoecious and dioecious species



Sequential hermaphrodites

Class Osteichthyes

The bony fish display an amazing variety of reproductive and life history characteristics:

•Unisexual species

Females produce diploid eggs, but require sperm from either the sailfin molly or the Atlantic molly to initiate development.

Amazon molly: all female species

Class Osteichthyes

The bony fish display an amazing variety of reproductive and life history characteristics:

•Livebearing species and egg laying species

Matrotrophic: provision young between fertilization and birth

Lecithotrophic species: young get nutrition from yolk deposited in eggs prior to fertilization

Class Osteichthyes

The bony fish display an amazing variety of reproductive and life history characteristics:

- Matrotrophic species and lecithotrophic species