# ORGANISMS:INVERTS (2) AND VERTS

Lecture 5 – Oct 5th, 2015

Intro to Marine Science

Instructor: Lauren Bell

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# *Your 'issues' this week

**Daniel: Arctic Amplification (as if the world got 'stuck' in the negative AO phase)**
**Autumn Records: Pollution (noise, debris, oil spills, eutrophication)**
**Autumn Redmond: Warming water temperatures**
**Sawyer: Ocean acidification**
**Bryan: Increased terrestrial run-off/inputs to the sea (terrestrial matter and sediments)**

<u>This week:</u>
Daniel: Sponges (Porifera)
Autumn Records: Round worms (Nematoda)
Autumn Redmond: Anemones (Actinaria)
Sawyer: Nudibranchs (Ophisthobranchia)
Bryan: Clams (Bivalvia)

# *Your 'issues'

"Some studies suggest **greater boring rates** by porifera into shellfish due to ph changes brought on by arctic amplification and ocean acidification.

This bio erosion can cause dramtic effects on shellfish populations, which in alaska and the greater pacific northwest, is really bad news. Add this to reduced calcification by calfifying organisms and we can start to see a double whammy developing. Adding insult to injury. So that means the boring rates of porifera would be increasing at a time when calcifying rates of shellfish would be decreasing. All of this would add to the stress of the species.....and when fish get stressed they get sick. In that way fish are just like people.  could be catastrophic."

-Daniel

# *Your ‘issues’

“…terrestrial runoff has almost the same effect on bivalves a to does on coral reefs but not to the extent. It has been found that terrestrial runoff has to a part in the **collapse of the oyster fishery** in the Chesapeake Bay. At on time the numbers of oysters in the bay were enough to filter the entire volume of the Chesapeake Bay in just over 2 days, today it is estimated that it would take todays oyster populations over 350 days. It is believed that the terrestrial runoff also in some cases weakens the hardend shells of some bivalves”

-Bryan

# *Your 'issues'

"There are many different sea anemones, they have their own preferences. For example giant green sea anemones do very well in cool water, where as sunburst anemones like warm water. The warming temperatures are changing the places that you may find specific anemones. The species that live in the warm water are moving to places that are suitable to their likings. **The anemones' that prefer the cool water are being driven elsewhere.** If they weren't mobile I could see the warming temperatures decreasing numbers because it is happening so fast they have **no time to adapt to the change**. If the whole ocean warms up the species that prefer cold water will either have to adapt to warmer waters or go extinct."

-Autumn Redmond

# *Your 'issues'

"Nematodes are incredibly abundant and are found in just about every conceivable habitat. ….Because of their diversity and abundance nematodes are frequently used to measure the impacts of various disturbances or changes within an environment such as pollution. This is especially true when testing heavy metal pollution, where nematodes are often used as biological markers. Some study's have shown that nematodes are **relatively resilient to pollution**. A study conducted near Helgoland, Germany showed no change in nematode abundances or distribution after one whole year of titanium waste disposal in a concentrated area. Similarly, a study done off the coast of France found a high abundance of nematodes in an area where industrial wastes from aluminum production had been dumped for a number of years.
Considering these studies It seems possible **that nematodes could survive in conditions of substantial pollution**, but what is hard to measure is the effects that nematode abundance could have on all the other organisms in the area, since they are so widely distributed and could possibly effect a number of factors within an environment. "

- Autumn Records

# *Your 'issues'

"Nudibranchs are a soft bodied marine gastropod. Ocean acidification can directly impact marine organisms with calcified shells by weakening the shells and causing a variety of problems. **This impacts Nudibranchs because the environment they survive in, and many organisms that they consume fit into this category.** Nudibranchs commonly live around coral reefs, which have shown to be severely affected by ocean acidification. The Nudibranchs could be limited on food that it finds or the level of protection provided before could be reduced. Many of the **main components of their diet (algae, anemones, etc.)** are things that have been negatively impacted by ocean acidification. As the things that provide food and habitat are impacted, the nudibranchs could struggle."

- Sawyer

# Learning objectives

After this lesson, you will be able to:

- List the defining characteristics separating the major invertebrate and vertebrate taxa
- Explain the general ecological function of each taxon
- Draw a marine taxonomic tree and describe the morphological divisions separating major taxonomic 'branches' (e.g., prokaryotes vs. eukaryotes, protostomes vs. deuterostomes, symmetry, etc.)

# *Invert taxonomic tree

Cnidaria
(true jellyfish
& anemones)

Nemertea
(ribbon worms)

Mollusca
(snails, clams,
cephalopods)


Annelids
(worms w/
lots of legs)

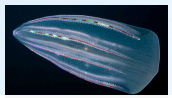
Lophophorates
(bryozoans)

Chordates
(have backbone)

segmentation

Urochordates
(tunicates)

chordate
attributes in
larval stage



Ctenophora
(comb jellies)

Nematoda
(round worms)

Arthropods
(crabs)

Echinoderms
(stars, cucumbers,
urchins)

segmentation

protostomes

deuterostomes

Porifera
(sponges)

pseudocoelomates

coelomates

acoelomate

radial symmetry

bilateral symmetry

no true tissues

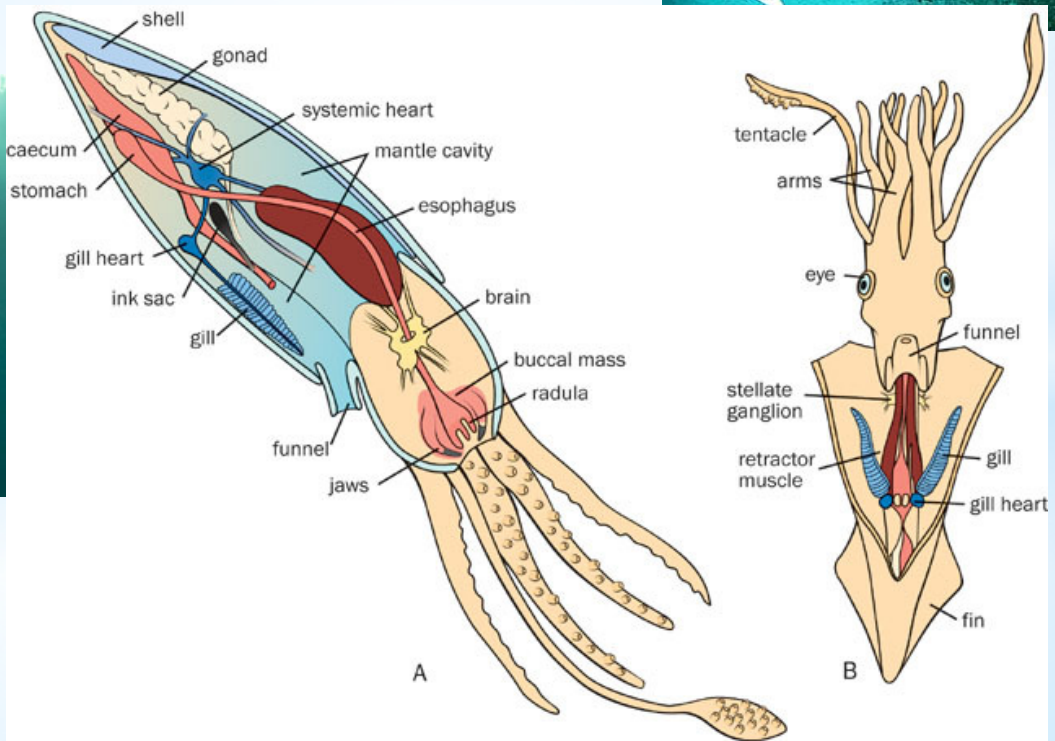
true tissues

multicellularity

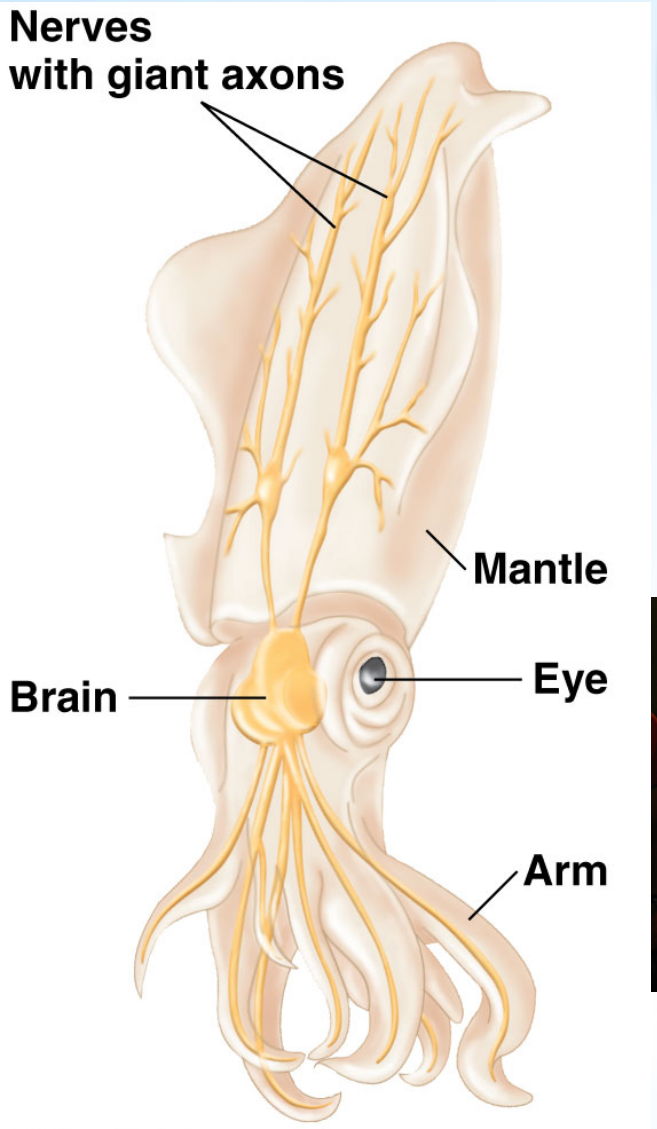
# *Class Cephalopoda (squid, cuttlefish, nautilus, octopus)

Cephalopoda = "head-foot"

- Reduction of shell (absent in octopus)
- Mostly pelagic lifestyles (exception octopus)
- Directed locomotion by jet propulsion
- The fastest of all invertebrates
- Radula + jaws (beak!)

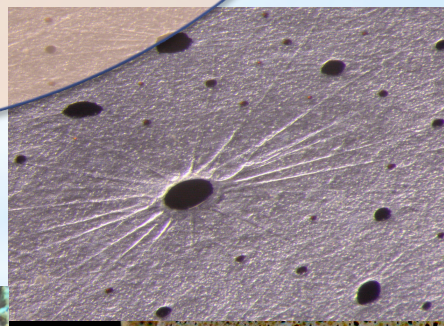
# *Cephalopoda nervous system

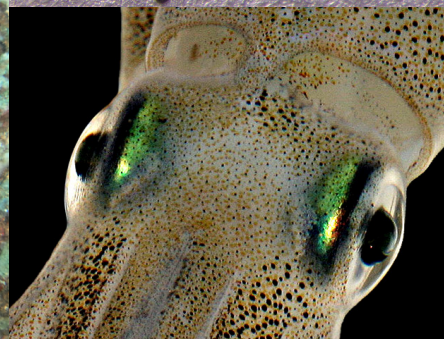




← Squid giant axon: 800 µm diameter →
Mammalian axon: 2 µm diameter

- Large nerve fibers enable FAST reactions
- Coordination of physical, chromatophore (pigment), and iridiphore (light) structures
- Direct control by brain may not be necessary for all reflexes/reactions
  - Highest developed nervous system in inverts





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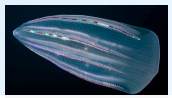

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deuterostomes

Porifera
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coelomates

acoelomate

radial symmetry

bilateral symmetry

no true tissues

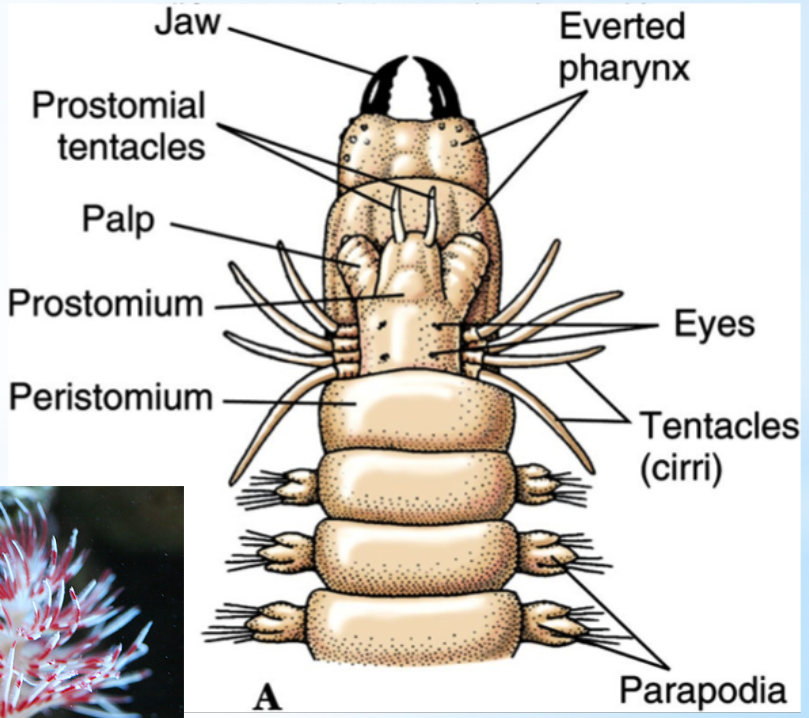
true tissues

multicellularity

# *Annelida - the segmented worms

Polychaeta = "many bristles"

- Wholly marine group
- Majority of body is segmented into repeating sections
- Legs on each segment with bristles
- Species adapted to live in tubes have modified tentacles for suspension feeding



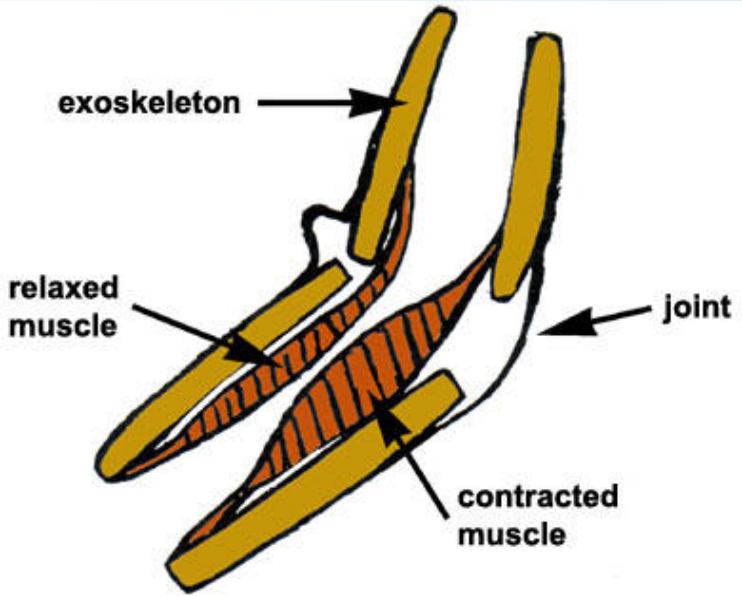

Important predators and prey!

Holoplankters!

# *Arthropoda - (*in marine world:* crabs, copepods, krill, amphipods, barnacles & sea spiders)

- Enormous group – on land and sea
- Segmented body (like annelids)
- Paired appendages per segment
- **Exoskeleton** of chitin, calcium carbonate, calcium phosphate
- Molting to allow for growth
- Compound eyes, mechano- and chemo-receptors

Simple lever system
(staggered movement to prevent tripping!)

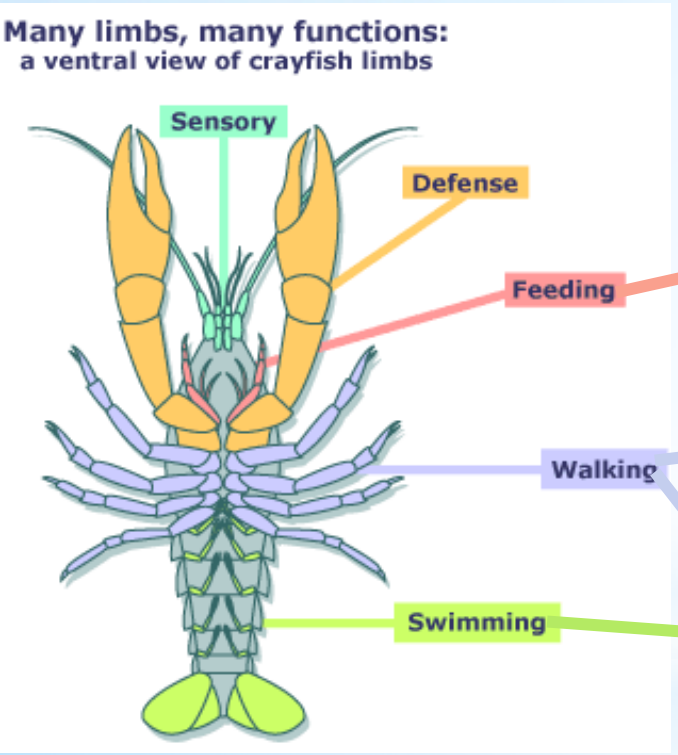


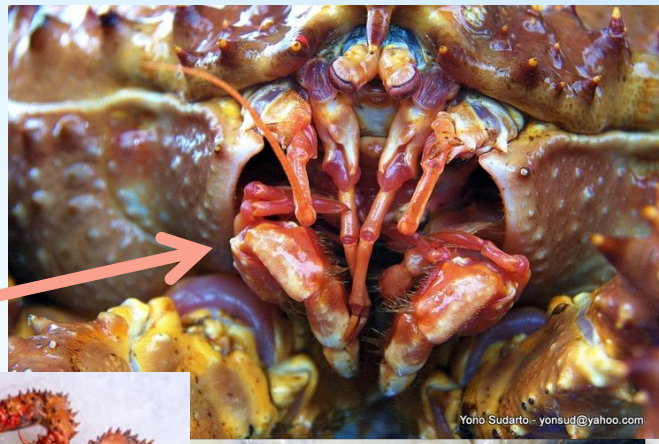

A flexed arthropod joint

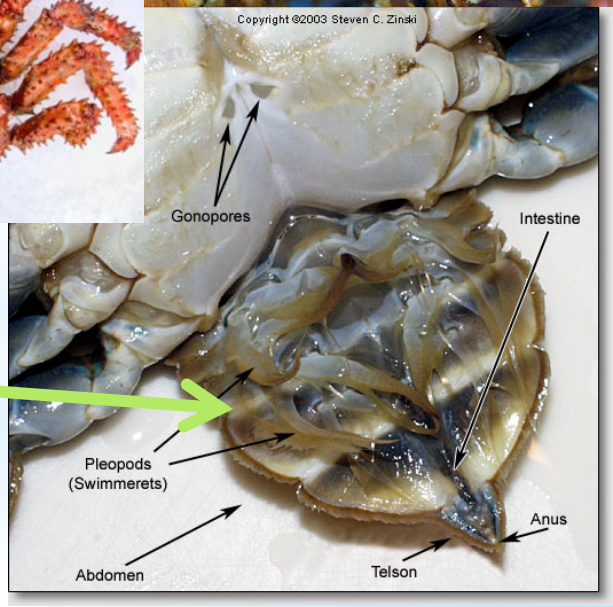
# *Diversity of legs!

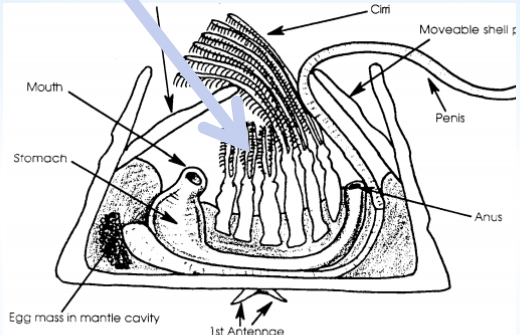
Subphylum Crustacea: the stereotypical marine arthropods

Modification of appendage size and function to fit with lifestyle



# *Ecological role

- **Adaptive radiation into all marine realms**
- **Key roles as:**
  - ✧ Grazers (herbivores)
  - ✧ Predators
  - ✧ Space competitors (barnacles)
  - ✧ Links up the food web
- **Compose very important fisheries**
- **Fishing impact can significantly affect ecosystem**

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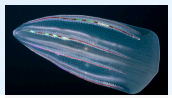

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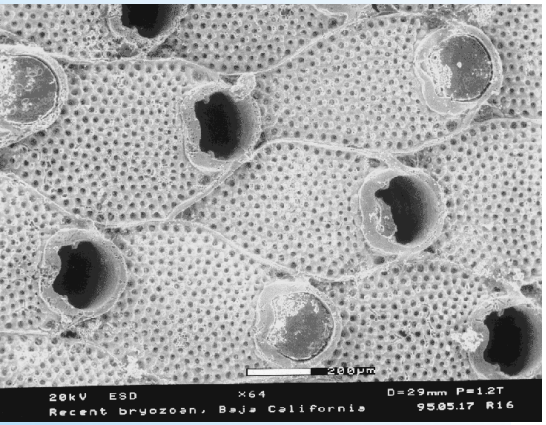
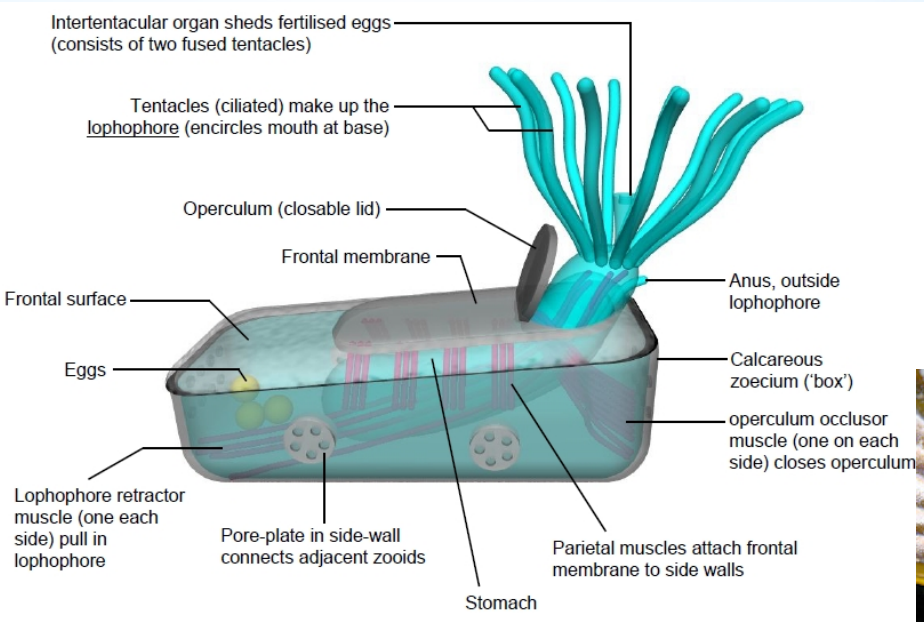
# *Lophophorates

- Sessile w/ special feeding apparatus: **lophophore**
- Place on taxonomic tree not well defined – most recent analyses places them as protostomes

BRYOZOANS – most common taxa in this group

- encrusting (easily confused with sponges)
- upright (easily confused with hydroids)
- colonies of individual animals in little “boxes”

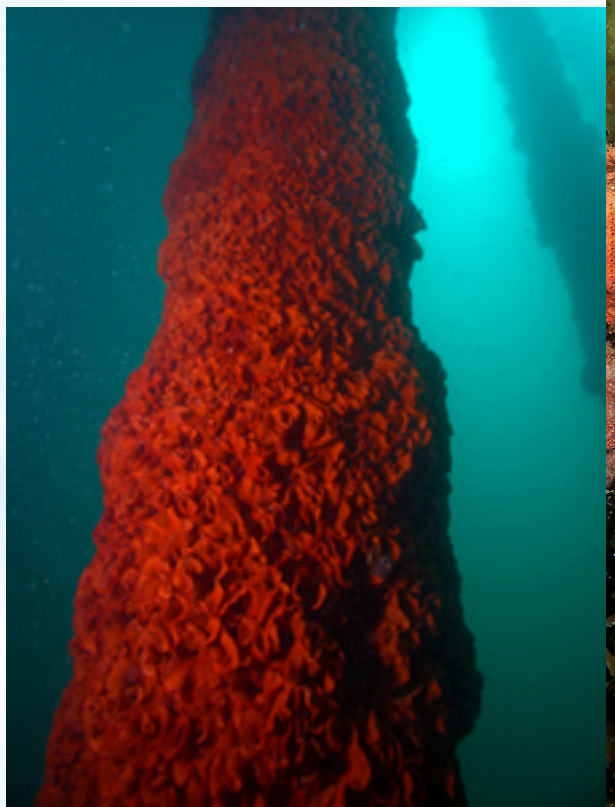



# *Ecological role

- important space competitors in hard substrate systems (rocky intertidal/coral reefs)
- fouling!
- facilitate Pelagic ↔ Benthic coupling (feed on phytos)
- food for grazers (molluscs)

**Invasive bryozoans can have a big ecosystem impact**



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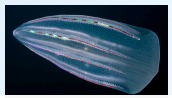

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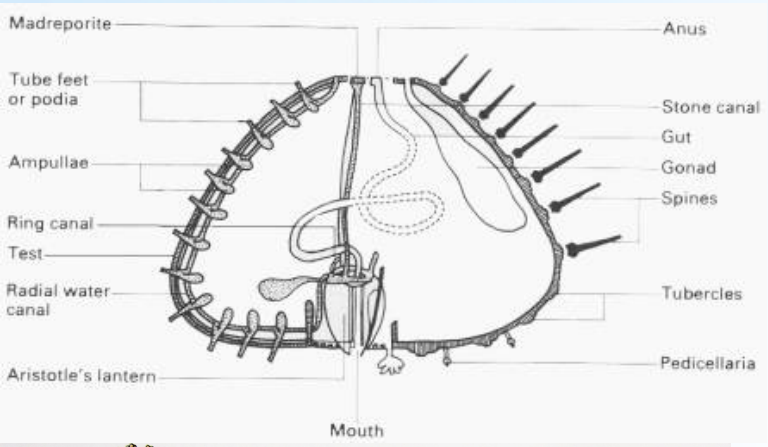
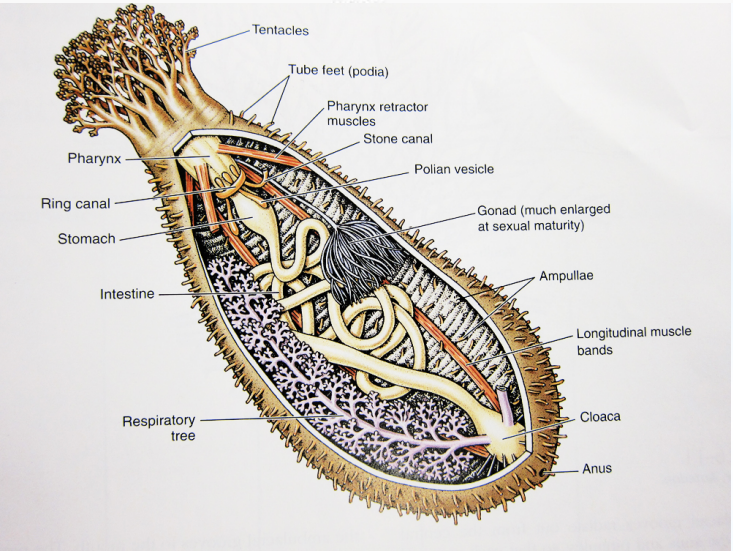
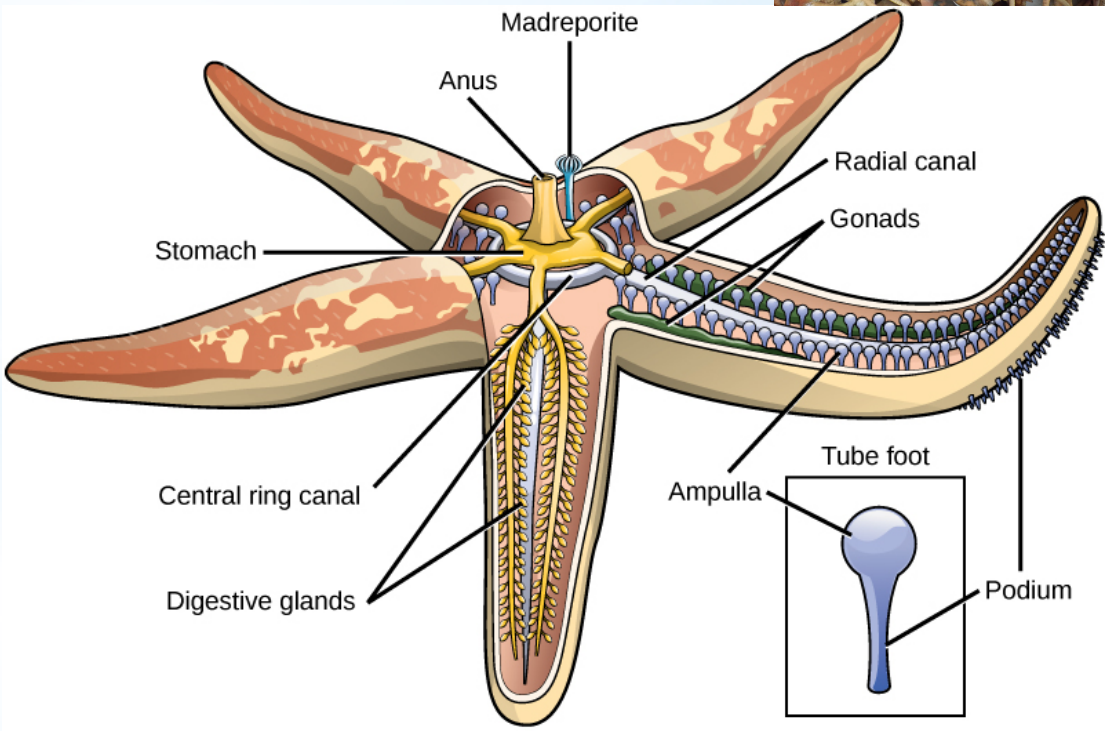
# *Echinodermata - (sea stars, brittle stars, sea urchins, sea cucumbers)

**"spiny-skin animals"**

- DEUTEROSTOMES!
- 5-way radial symmetry
- calcareous internal skeleton
- **water vascular system** (a.k.a. "hydrostatic skeleton")

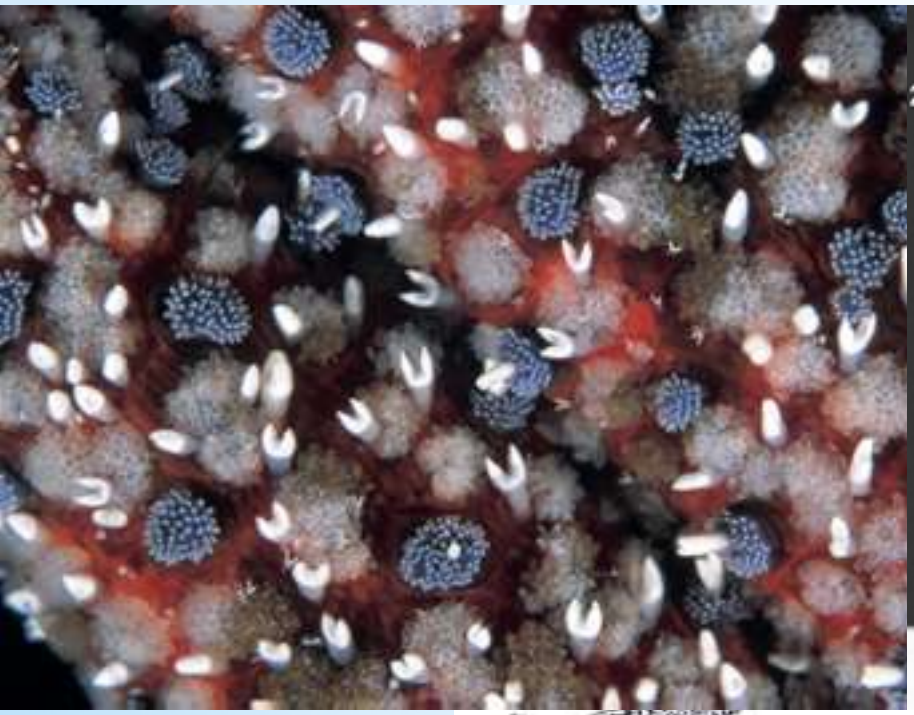


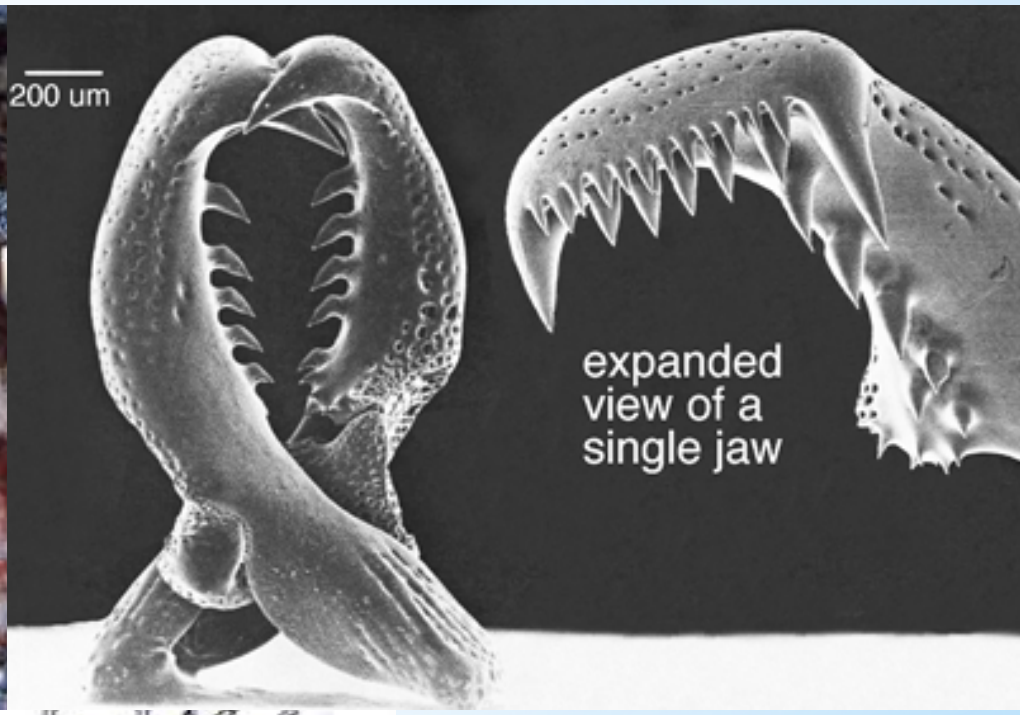



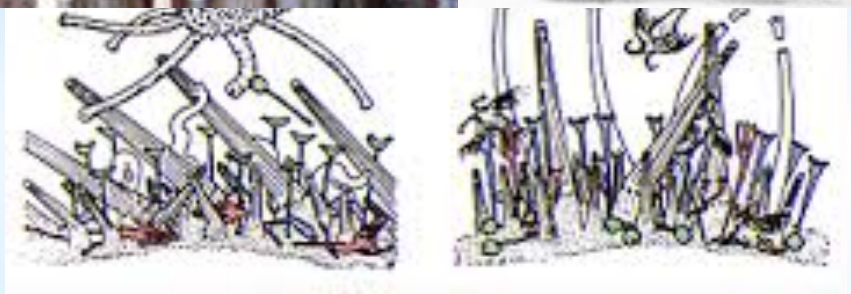



# *Pedicellaria

- Specialized ossicles for defense
- Not all echinoderm species have this, but most do
- Prevents other organisms from growing on or over





# *Ecological role

**Very successful group**

**basic body plan = easy to adapt**
**well armored but flexible**
**high regeneration ability**

- Can exist in many different habitats (hard and soft bottoms, deep and shallow, exposed or not)
- CANNOT exist at low salinities (can't osmoregulate!)
- All feeding types
- Poles to tropics

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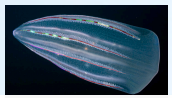

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# Chordates

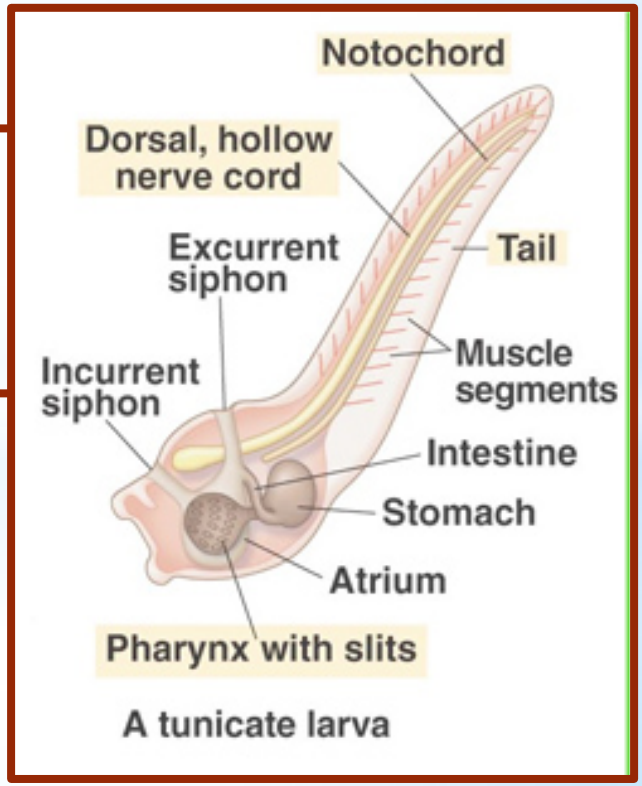
**CLASSIFIED BY THE FOLLOWING CHARACTERISTICS**

- Dorsal tubular **nerve cord** (brain and spinal cord)
- **Notochord** (flexible rod for support)
- **Gill slits** (for filter feeding, gas exchange, and other functions)
- Post-anal **tail** (extension of the notochord and nerve cord)

## *Urochordata "tunicates"

(sea squirts, salps, & larvaceans)

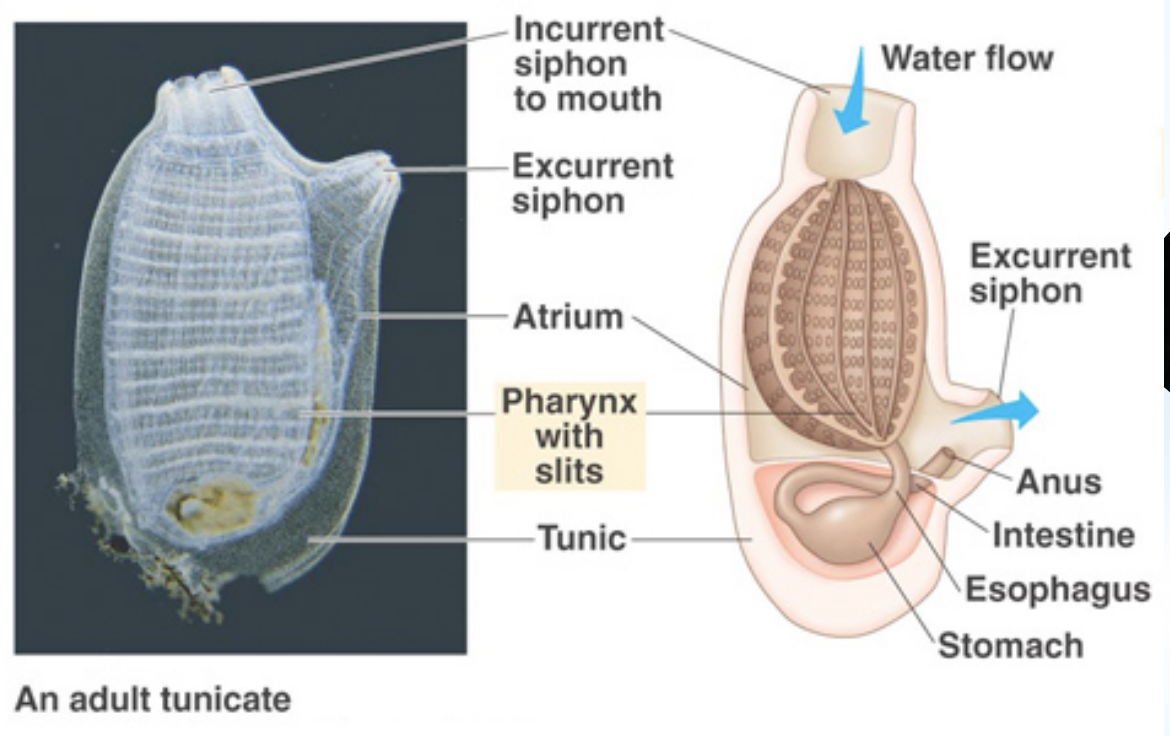
**CHORDATE CHARACTERISTICS**
**ONLY**
**DURING LARVAL STAGE**



# *Adult body form

- Suspension feeders with rotating endostyle (pulls mucus along)
- Body form can facilitate water movement
- Heart can beat in two directions
- No release of waste products until death
- Can be solitary, social, or colonial

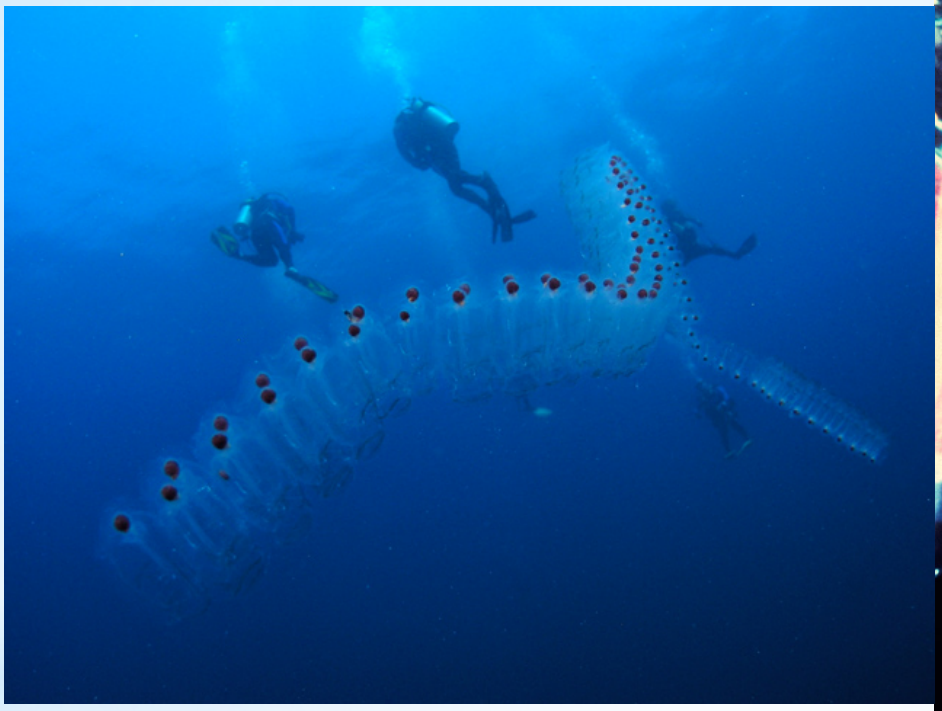
*individual tunicate/ sessile, solitary form*

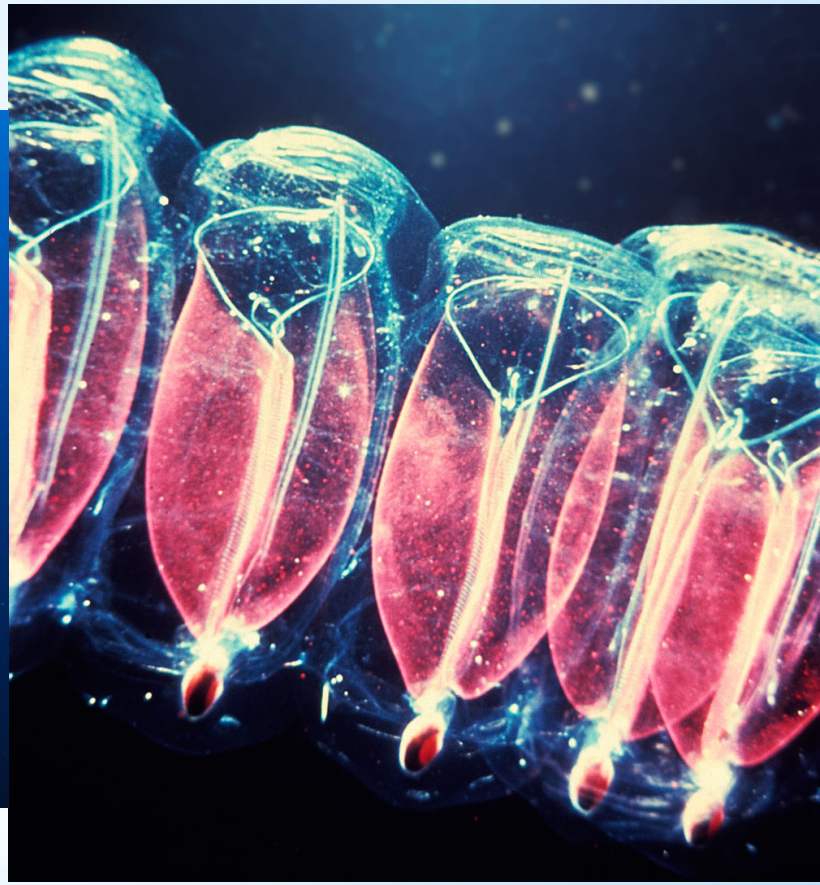



An adult tunicate

# *Adult body form

*pelagic form can be colonial or solitary*

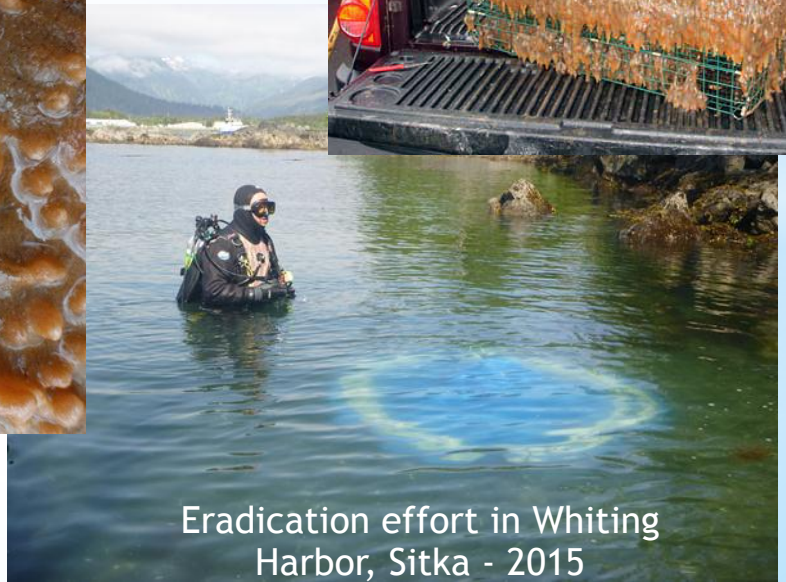




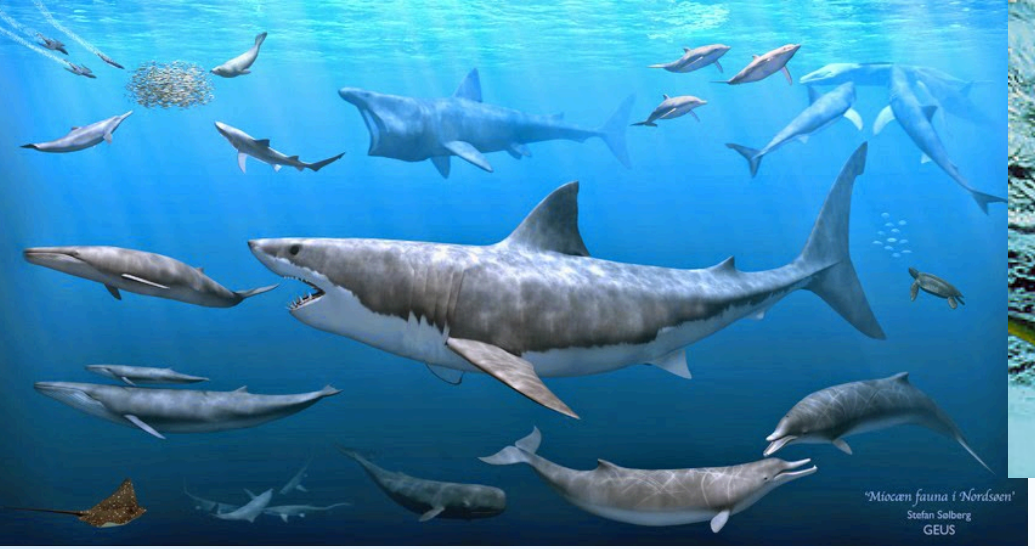
- Colonial chains 10's of meters long!
- Super efficient filter-feeders on phytoplankton – can clone during blooms
- Filter-feeding apparti can get clogged – SINK!
- Major component in "marine snow" – transport of organic matter to depth

# *Ecological role

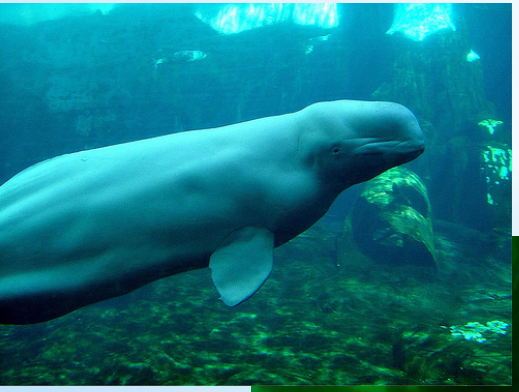
- Super-filter feeders
- Nasty as invasives! Very significant in fouling community
- Tend to accumulate heavy metals
- Very hearty; tolerant to pollution and salinity fluctuations
- Pelagic forms are FAST responders to phytoplankton blooms

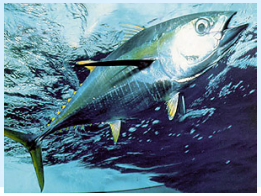



Eradication effort in Whiting Harbor, Sitka - 2015




# *THE VERTEBRATES



Actinopterygii
(tuna, salmon)

Reptilia
(reptiles)

Aves
(birds)

Mammalia
(mammals)

scales, cold-blooded

feathers, warm-blooded

hair/fur, warm-blooded

Elasmobranchii
(sharks, rays)

Sarcopterygii
(lungfish)

no true marine spp.
Amphibians

ray-finned

"Four-legs"

cartilaginous

lobe-finned

bony

Agnatha
(lamprey, hagfish)

No Jaws

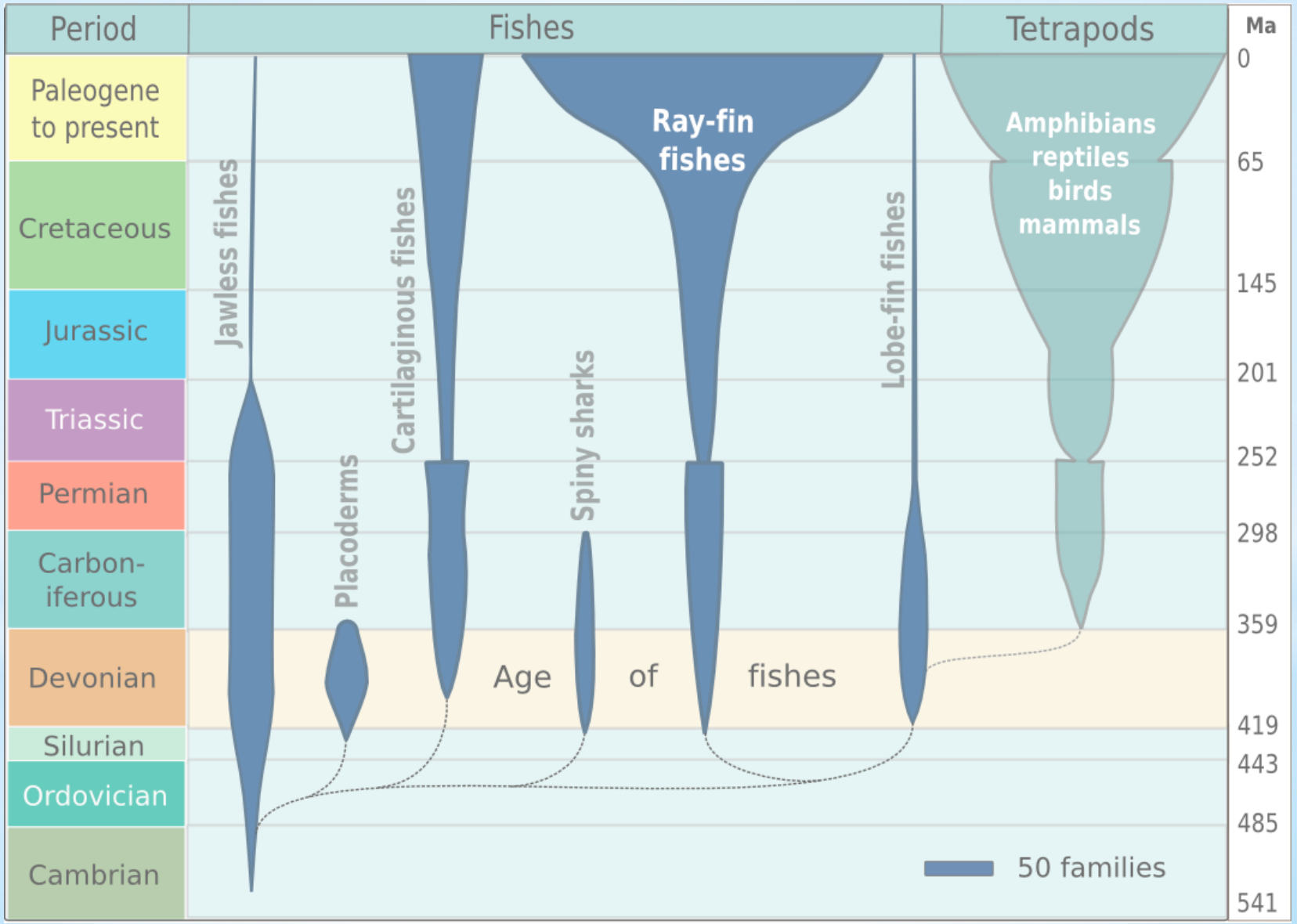
Jaws present

Vertebrates

Chordates
(have backbone)

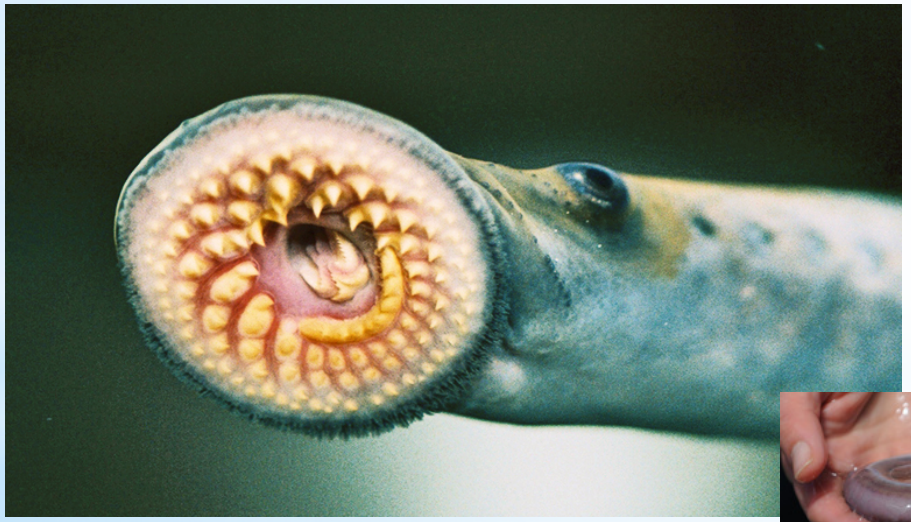
# *Marine vertebrate taxonomic tree

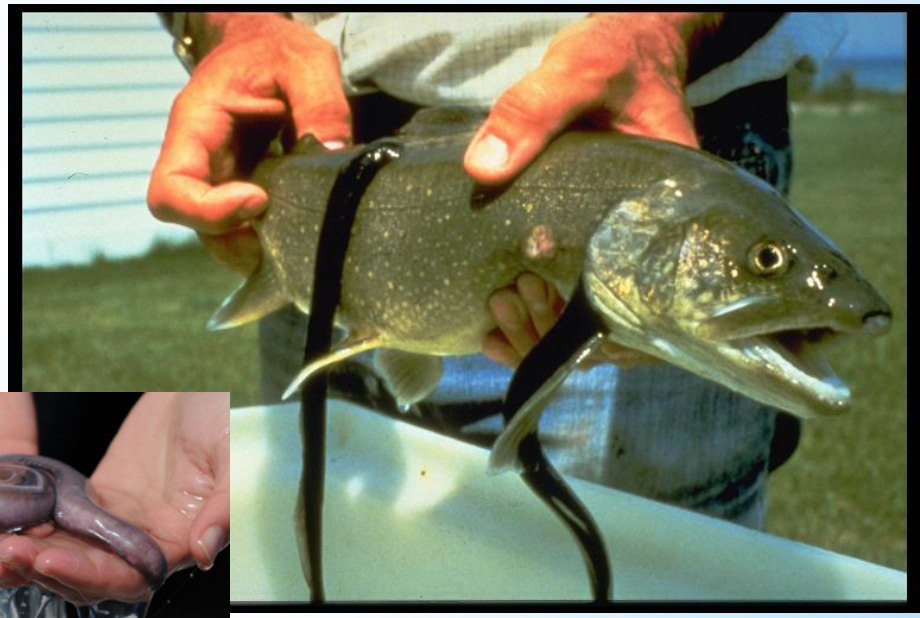
# *Evolution of fish

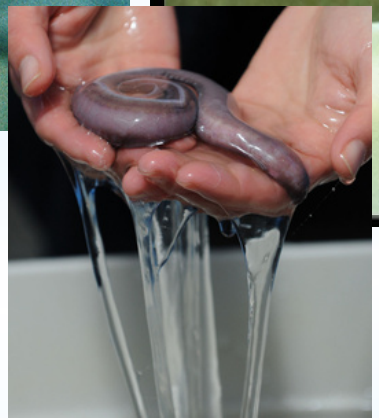


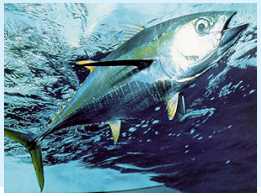
# The jawless fish (Agnatha)

- No jaws (serious disadvantage)
- Produce anti-coagulant fluid to inject into prey
- No paired appendages – movement limited
- Scavengers / parasites
- Cold-blooded
- SLIMEY! Used as defense mechanism









Actinopterygii
(tuna, salmon)

Reptilia
(reptiles)

Aves
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scales, cold-blooded

feathers, warm-blooded

hair/fur, warm-blooded

Elasmobranchii
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Sarcopterygii
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no true marine spp.
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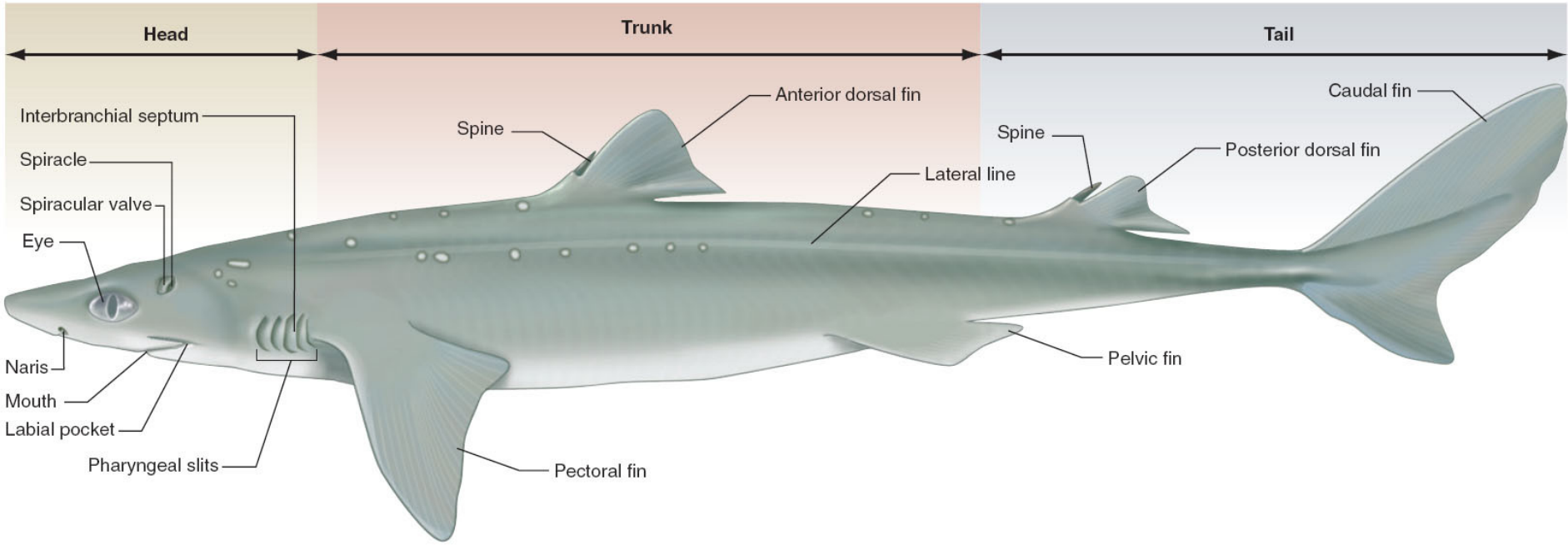
# *Marine vertebrate taxonomic tree

# *Cartilaginous fish (Elasmobranchii)

"ee-laz-mo-bran-kee-i"

- Skeletal structures primarily made of cartilage (advantage?)
- Lack swim bladders – store oil in liver for buoyancy (can compose up to 20% of body weight!)
- Teeth in series, jaws
- 5-7 gill pairs, either keep moving to move water over gills or pump water through **spiracles**
- High energy demands to maintain oxygenation – few found in polar environments



# *Ray-finned fish (Actinopterygii)

"ack-tin-op-ter-idg-ee-i"

## Represent 99% of all modern fish species

- Possess **"fin-rays"** : bony or horny spines protruding from skeletal elements
- Some are slightly **endothermic** – can regulate their body temps!

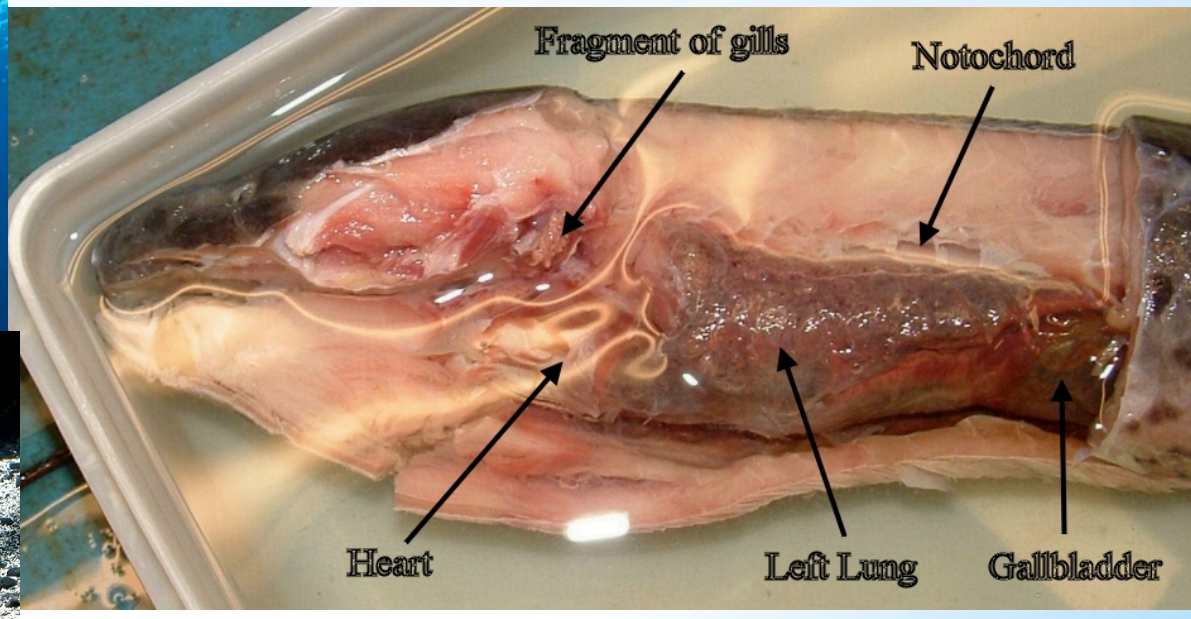
  Energy-demand goes up, but:
  - Better muscle control
  - Better nerve signals
  - Better digestion

**Wide-variety of adaptations to different environments**


# *Lobe-finned fish (Sarcopterygii)

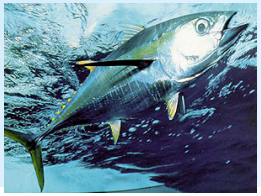
"sar-cop-ter-idg-ee-i"

- Most species now extinct
- Fins on "fleshy lobes"
- Pectoral and pelvic fins developed articulations (precursor to legs)
- Two separate dorsal fins, unlike single dorsal of ray-finned fish




**Lungfish: possess proto-lungs**

ancestor to the "tetrapods" (four-leggers)



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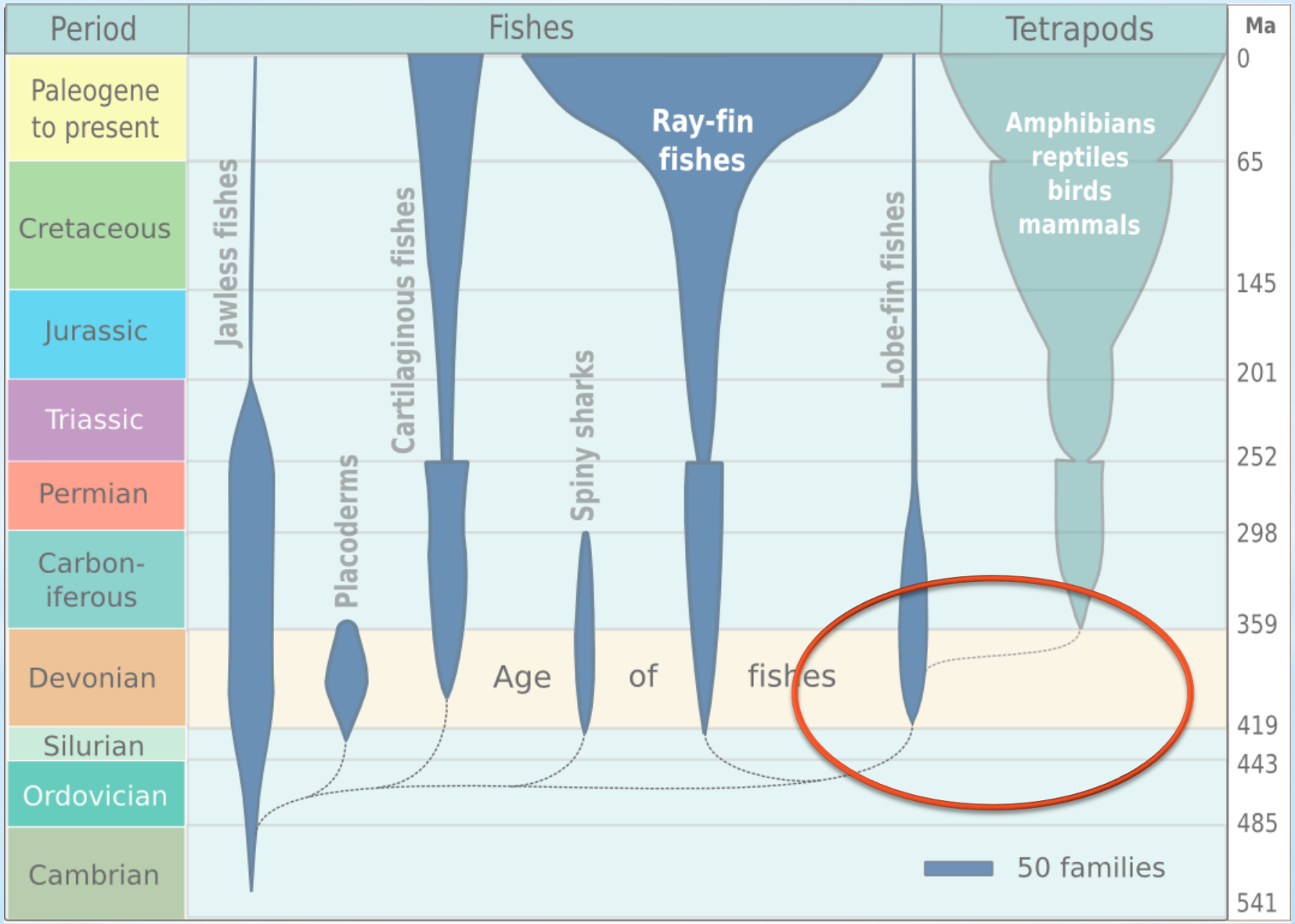


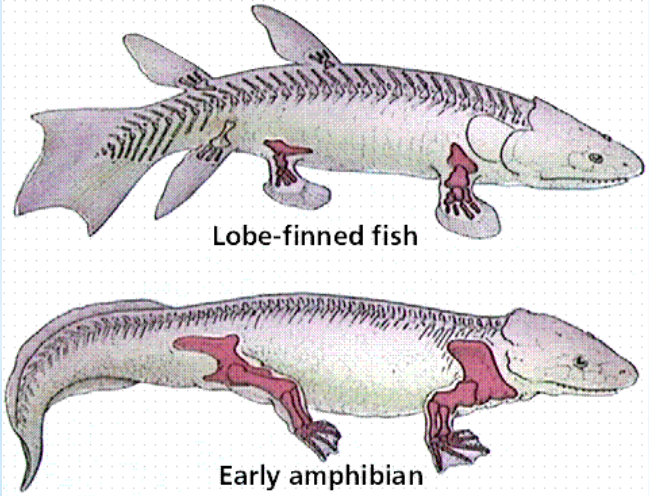
# *Movement to land

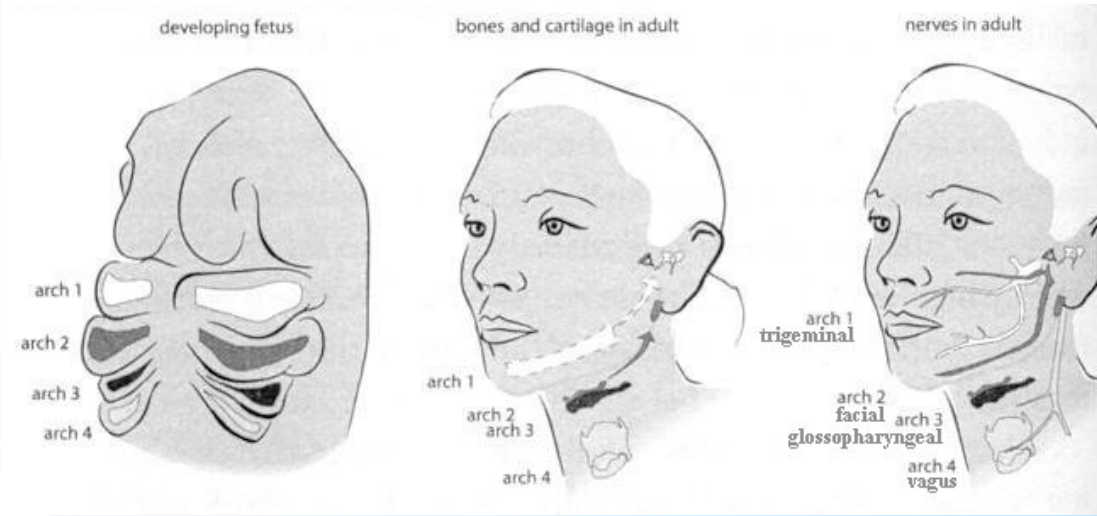
## Middle Devonian – 390 million years ago

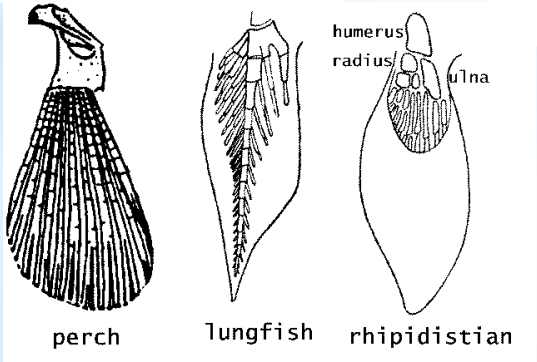
- Explosion of plant, fish life

  **falling $O_2$ in water, rising $O_2$ in air**

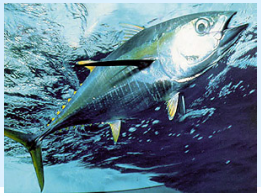
- Lungfish doing well, over time developed characteristics to allow to move to land and support selves




Chordate **gill slits** become jaws, inner ear, tonsils, or vocal organs in terrestrial chordates



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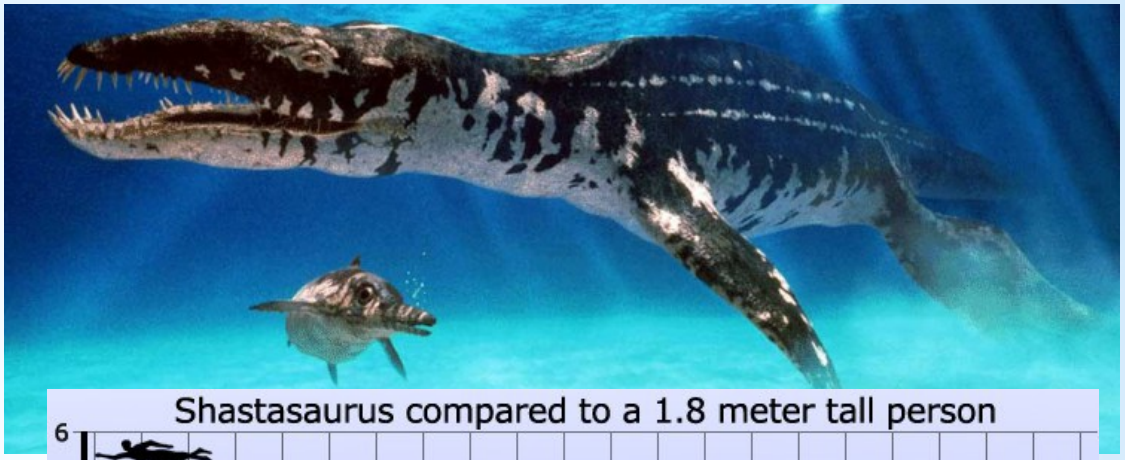
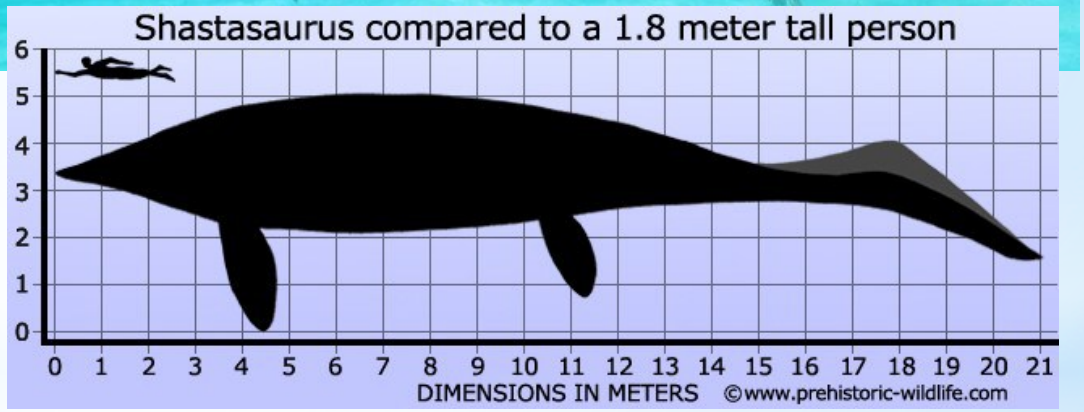
# *Marine vertebrate taxonomic tree

# *Marine reptiles - iguanas, sea snakes, sea turtles, saltwater crocodiles

**Ruled the earth**
**(as Dinosaurs!)**
**from 200 mya to 66mya**






- After dinosaurs wiped out, some smaller reptiles remained, mammals took to the sea to take over vacant ecological niches

<u>Reptiles of today</u>

- Cold-blooded
- Mainly live in shallow, warm waters near the equator (why?)
- Salt glands
- Snakes can have toxic venom
- Carnivores and herbivores
- Many species severely poached

# Marine birds

- Close relatives to the reptiles – but warm-blooded!
- Significant predators on larval stages of marine animals, small fish
- Many undergo significant annual migrations
- Known for their colonies – can include up to a million birds!
- Salt glands, webbed feet
- Best swimmers are often awkward on land (penguins)

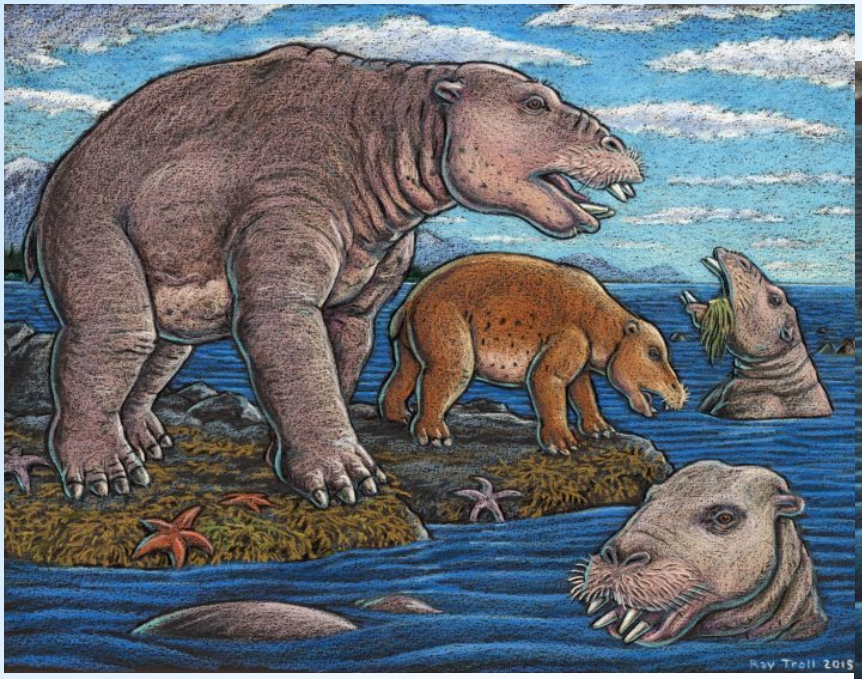
# *Marine mammals

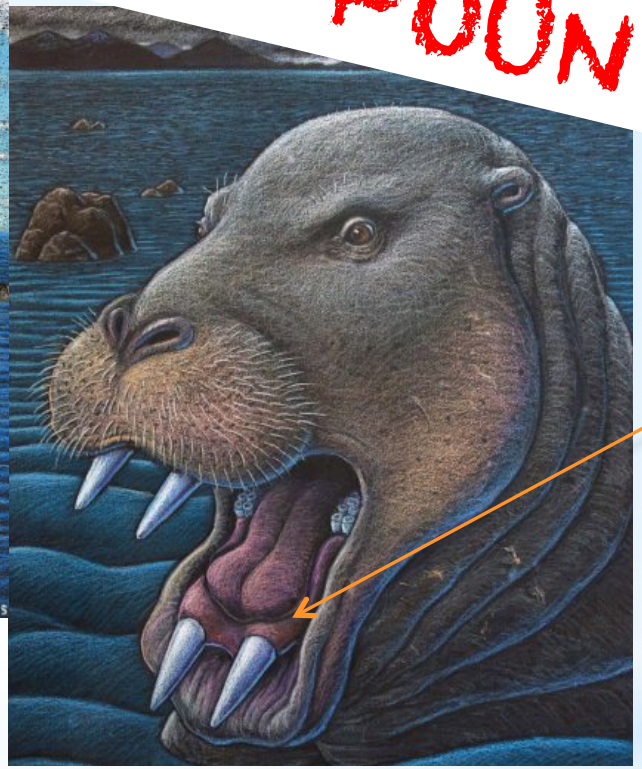
- Warm-blooded
- Have hair
- Females give birth to live young
- Produce milk

**"return to the sea"** requires major physiological adaptations

# *Current events

DESMOSYLIANS FOUND!




Only known order of marine mammals to go completely extinct

"It had the face of a walrus, swam like a polar bear, was as big as a hippopotamus and sucked its food off the rocks and mud around the Aleutian Islands 23 million years ago. *Ounalashkastylus tomidai* was described by a team of paleontologists from Texas, Canada and Japan in an article published in the scientific journal Historical Biology on Oct. 1."

-Alaska Dispatch News, Oct 7 2015

# *Wide diversity of marine life

- Success of so many different taxa!!
- Unique ways of dealing with the "issues" of being marine
- Best 'strategy' in one environment may be less ideal in another

**Major physiological considerations:**

- Buoyancy (goal is to be neutral)
- Osmoregulation (salt balance)
- Thermoregulation
- Respiration (accessing/ maintaining oxygen levels)
- Hydrodynamics
- Pressure
- Energetics

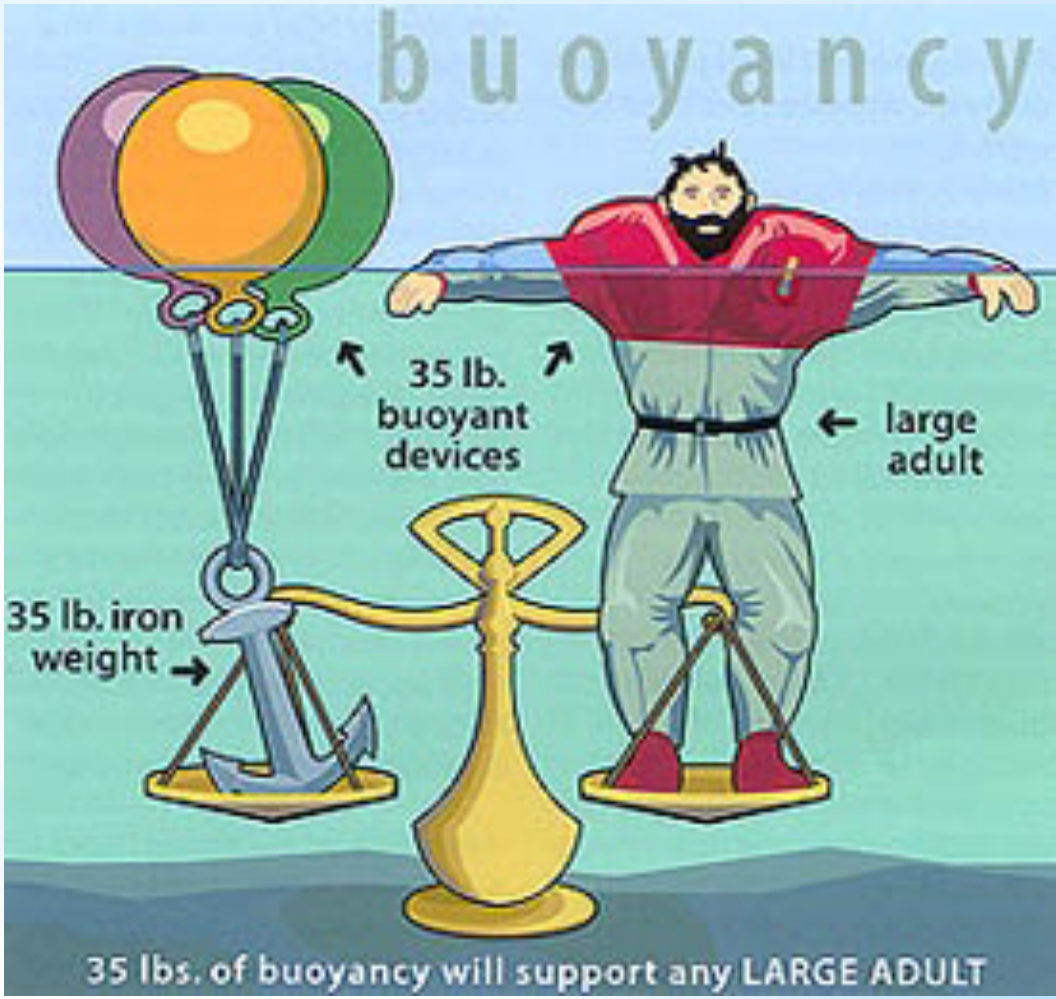
# *Buoyancy

## GOAL: Neutral buoyancy

- Less energy needed to maintain vertical position
- More energy available for horizontal movement

**How can only 35lbs of buoyancy support a 200lb adult???**

200lb adult:
- 75% water (150 lbs)
- 15% fat (30 lbs)
- 10% muscle (20 lbs)

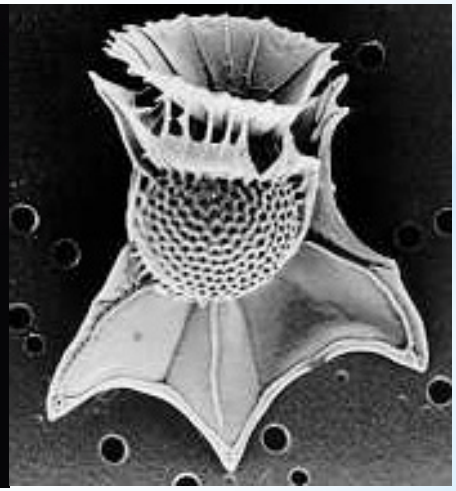


# Neutral Buoyancy

## Ways to achieve it:

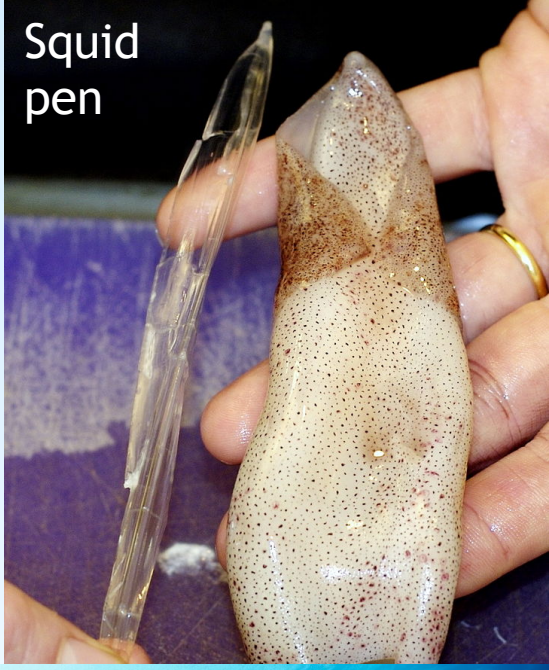
1. Don't even try - be heavy, live on the bottom

2. Be small, increase surface area (spines/drag)

# *Neutral Buoyancy

3. **Lighten up! (remove heavy substances)**
   - Some animals lose/reduce shells
   - Cartilage instead of bone

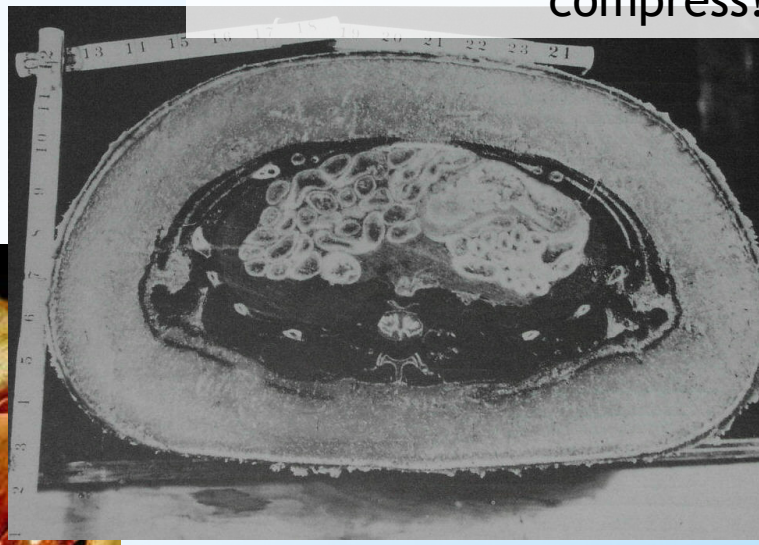




# *Neutral Buoyancy

4. Incorporate fats/oils
   - Blubber
   - Storage in liver
   - Spermaceti organ in Sperm Whales
   - Lipid sacs in plankton

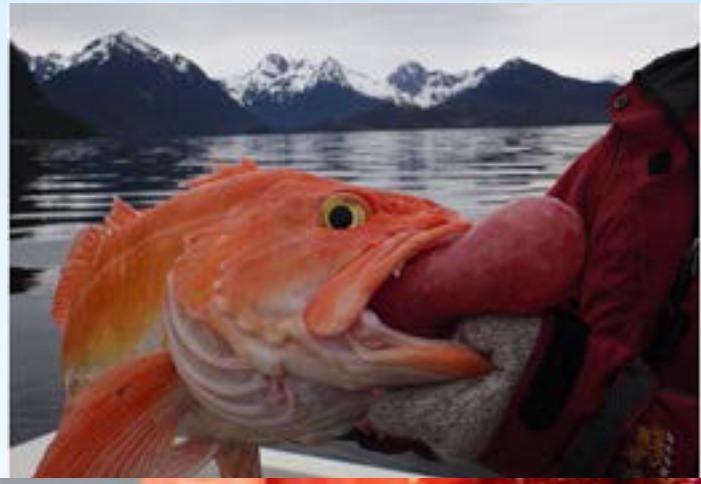
Pressure only impacts air spaces – lipids do not compress!

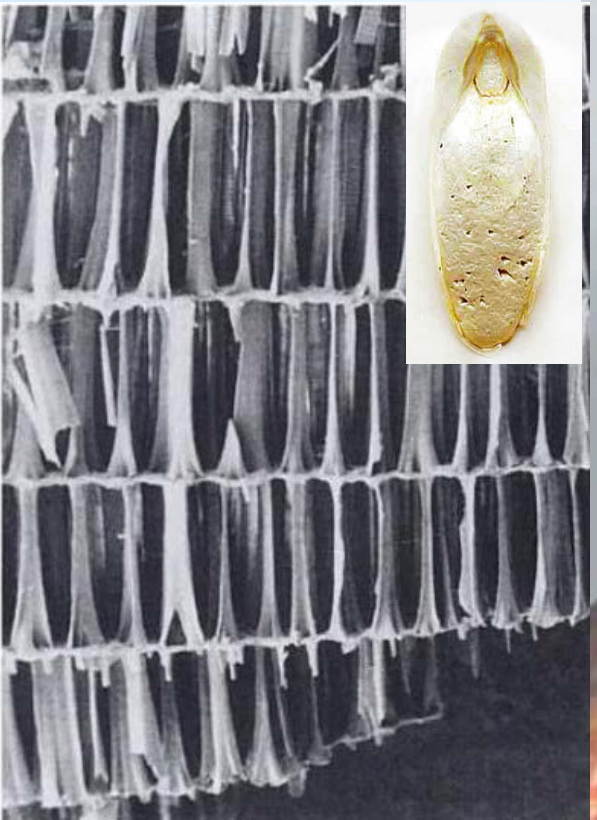


Shark liver: 15-25% of body weight
Humans: ~2% body weight

# *Neutral Buoyancy

5. Air sacs
   - ✧ Hard or soft-walled
   - ✧ Have to modify amount of gas within float
   - ✧ Stronger means heavier – need balance
   - ✧ Swim bladder lined with material making impermeable to gas diffusion!







# *MIDTERM

**Midterm will open at 8am, Monday Oct 19th**
**Midterm will close at 11:59pm, Friday Oct 23rd**
Your choice of when to take it. I am off-grid from Oct 22nd-25th.
You have 5 hours to complete once started. IT WILL NOT TAKE YOU THAT LONG.
No notes, no phone, no internet, no scratch paper – just your brain.

**~35 multiple choice questions**
**(+2 to +4 pts each)**

**~10 short & long answer questions**
**(+5 to +20 pts each)**

**Focus on big-picture concepts.**
**If I repeated something multiple times, I'm probably going to ask a question about it.**

# ORGANISMS:INVERTS (2) AND VERTS

Midterm Week is NEXT WEEK

Feel free to post any additional questions before Monday under “Questions” in discussion – I will try and answer

No major assignment this week – LIFE video

Wikimedia commons