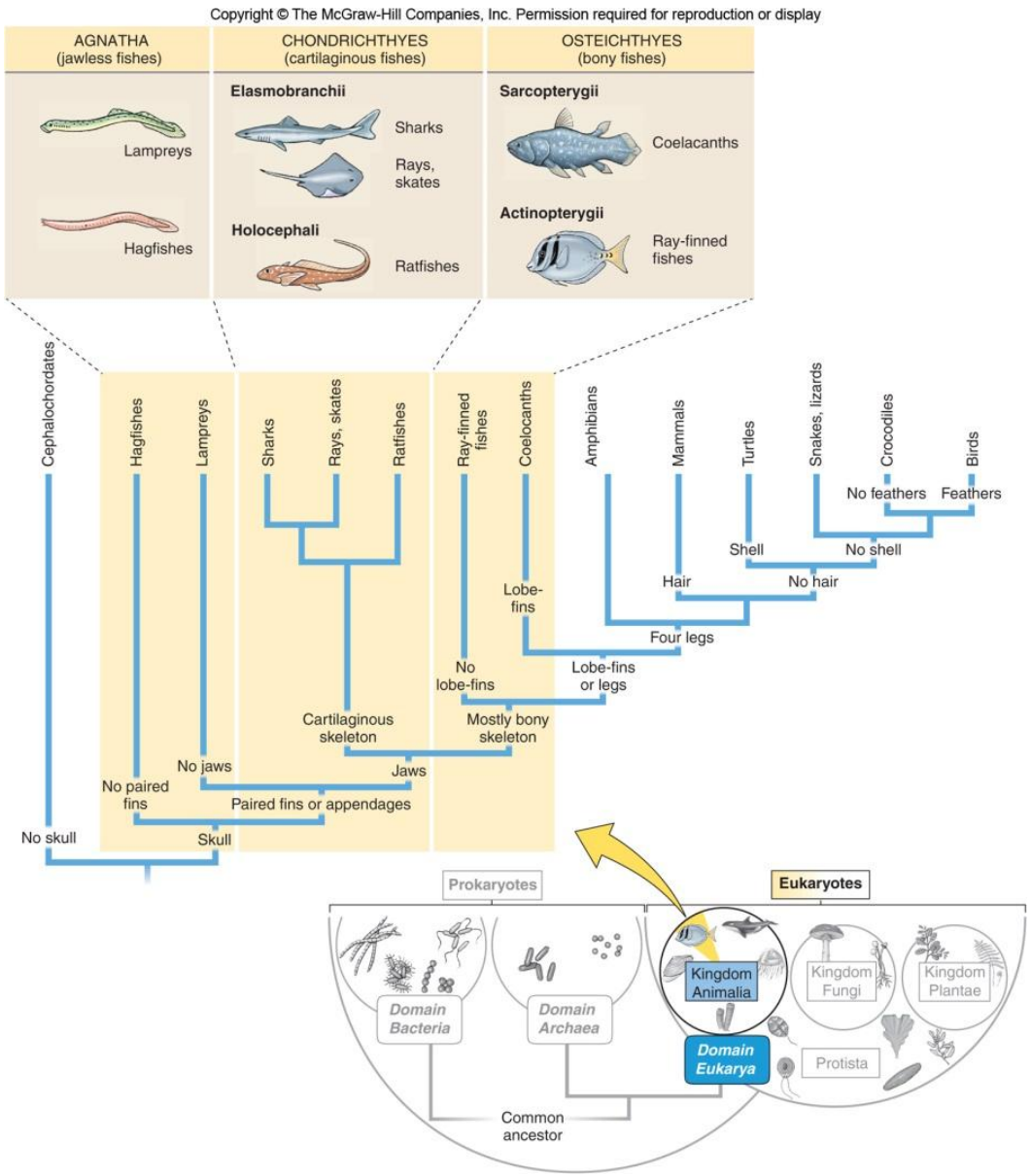
Chapter 8- Marine Fishes

Types of Fish

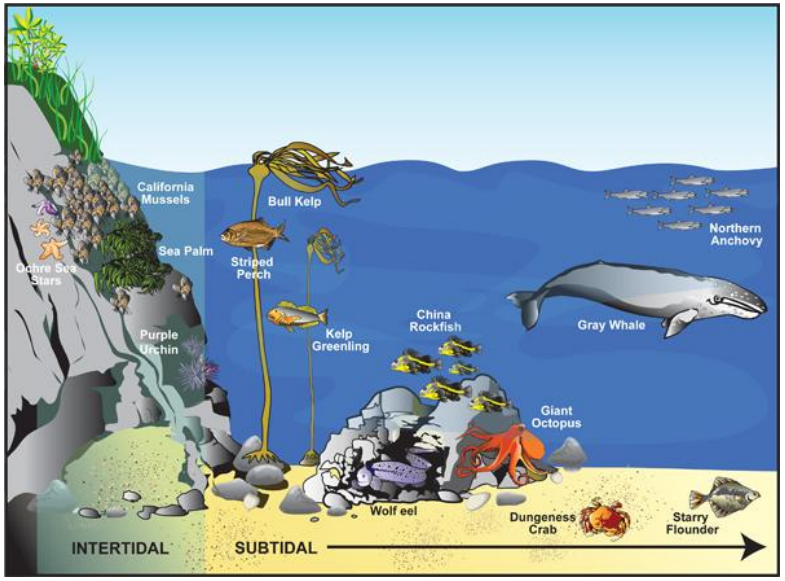
1. Agnatha (jawless fish)
   - Hagfish
   - Lampreys
2. Chondrichthyes (cartilaginous fish)
   - Sharks
   - Skates
   - Rays
   - Ratfish
3. Osteichthyes (bony fish)
   - Lobe-finned fishes
   - Ray-finned fishes



Fresh vs saltwater diversity

- Ocean takes up 70% of the Earth's surface- but only contains 15-25% of species.

- 28- 32,000 fish species
  - ~15,000 live in freshwater
  - ~14,000 live in saltwater



Jawless Fishes

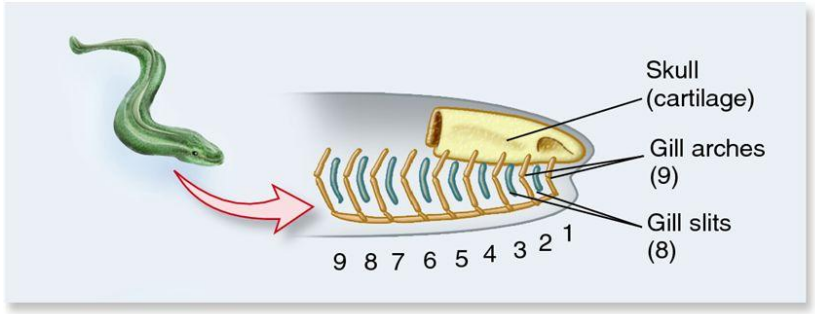
Kingdom: Animalia
Phylum: Chordata
Superclass: Agnatha

- Lack jaws, paired fins, and scales
- Have a notocods
- Hagfish
  - 20 species, exclusively marine
  - Slime eels
  - Feed on dead/dying fish
  - Live in burrows in muddy bottoms
- Lampreys
  - 30 species, primarily freshwater
  - Attach to other fish and suck their blood

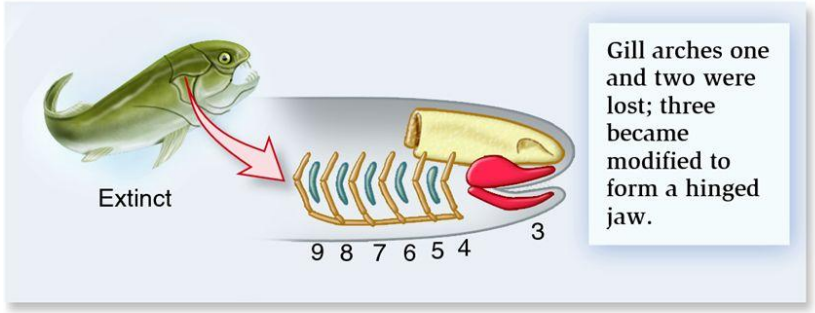
Evolution of the jaw

- Jaws are thought to have evolved from gill arches and to have evolved only once in biological history

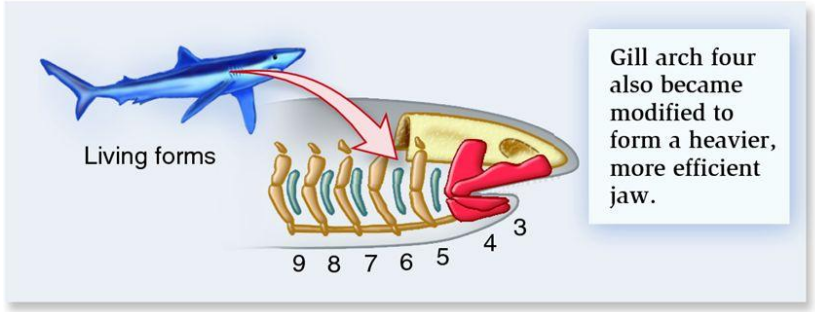
- The original selective advantage offered by the jaw was not related to feeding, but to increased respiration efficiency.



(a) Ancestral jawless fishes

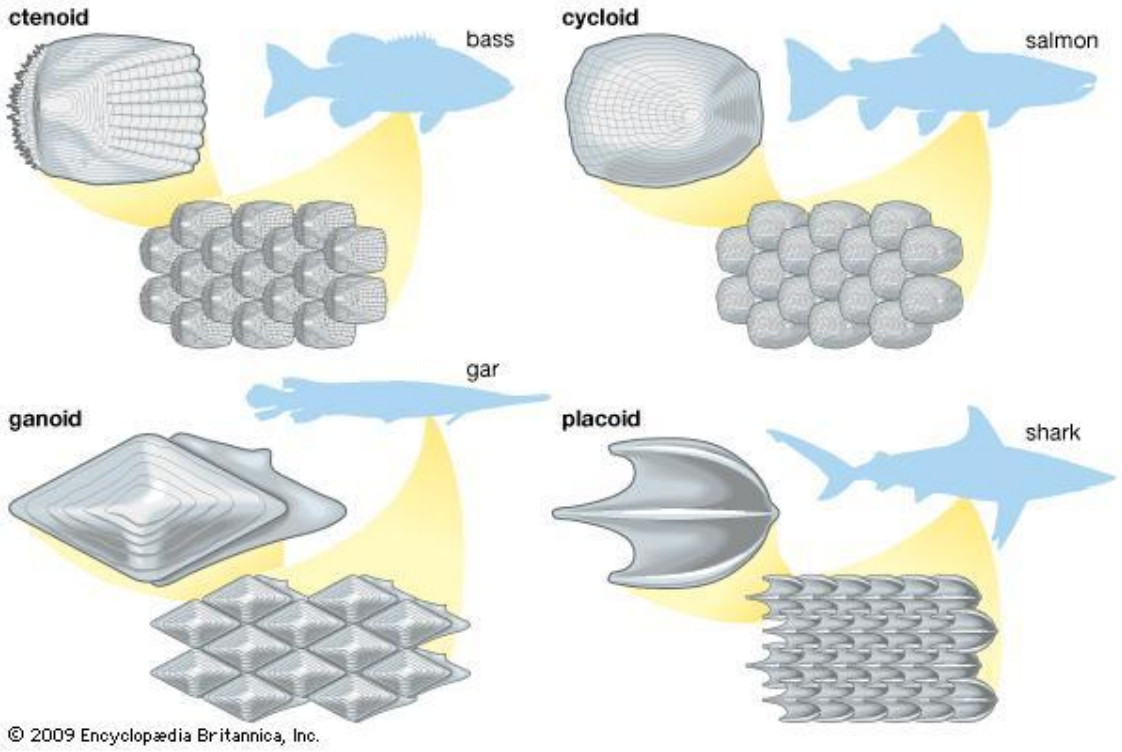


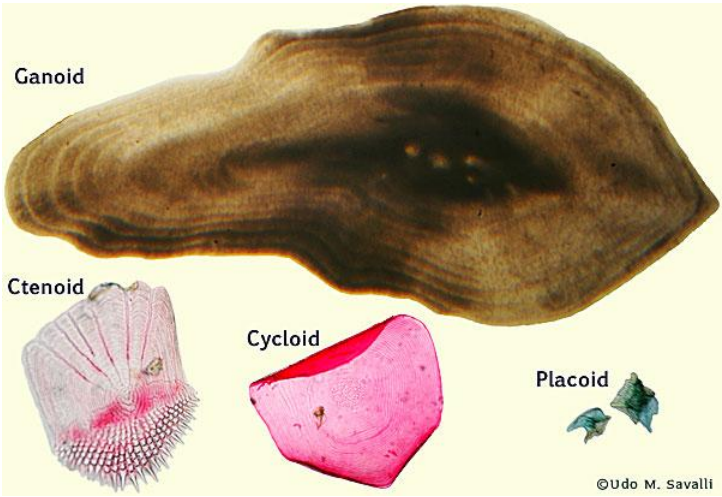
(b) Early jawed fishes (placoderms)



(c) Modern jawed fishes (cartilaginous and bony fishes)

Types of Scales



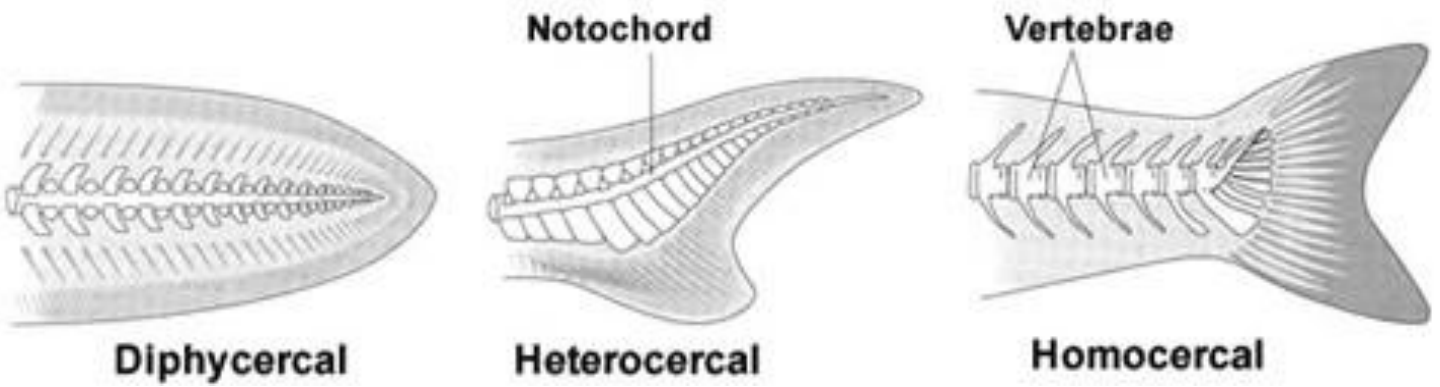


Basic Fins Shapes

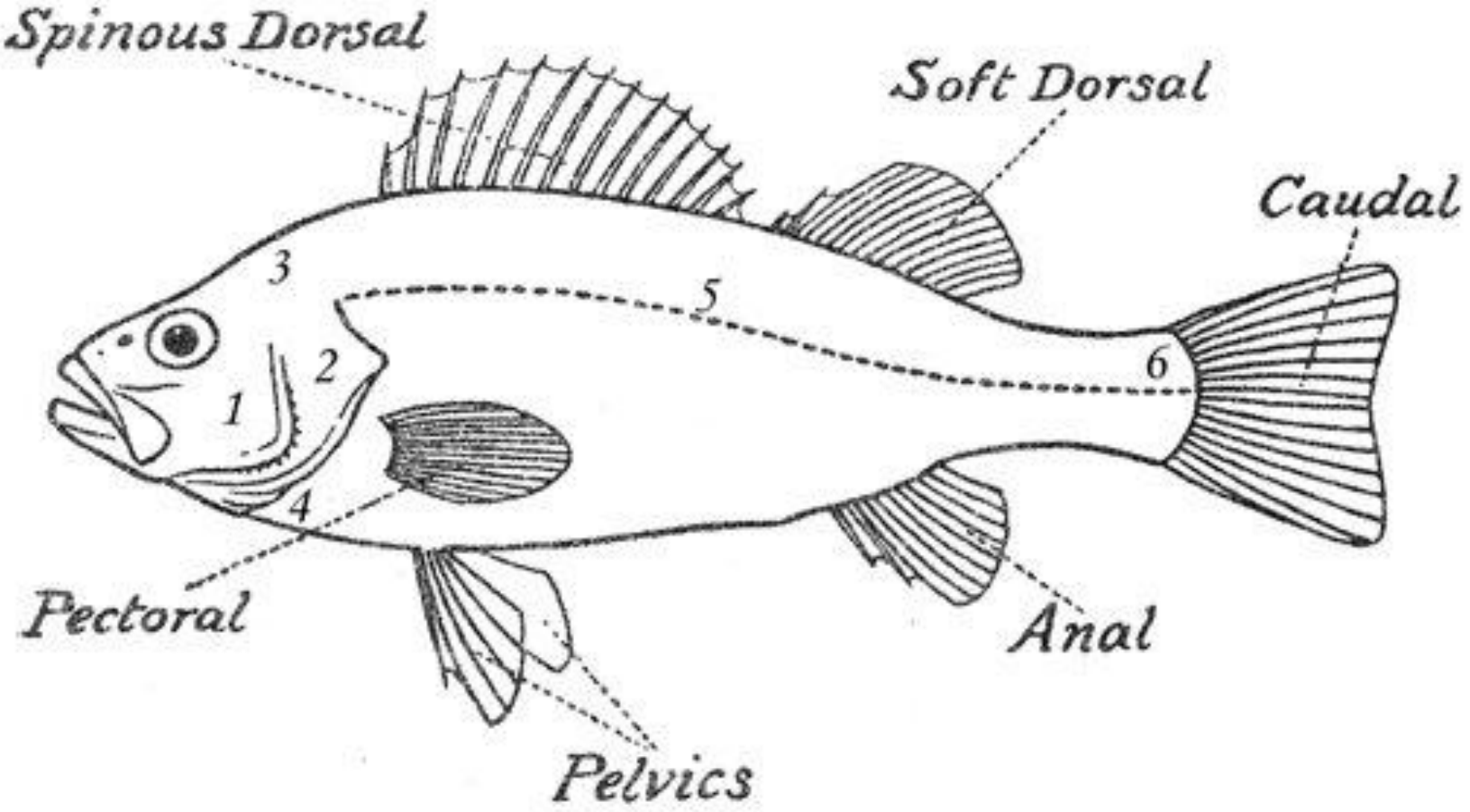
- Homocercal- symmetrical
  - includes truncate, square, slightly forked, deeply forked
  - most common shape

- Heterocercal- ancient form
  - Possessed by a few primitive fishes (sharks, sturgeon)
  - necessary when fish had no swim bladders and were heave in front; if tail was symmetrical it would plunge to the bottom

- Non-differntiated- eels/ lampreys



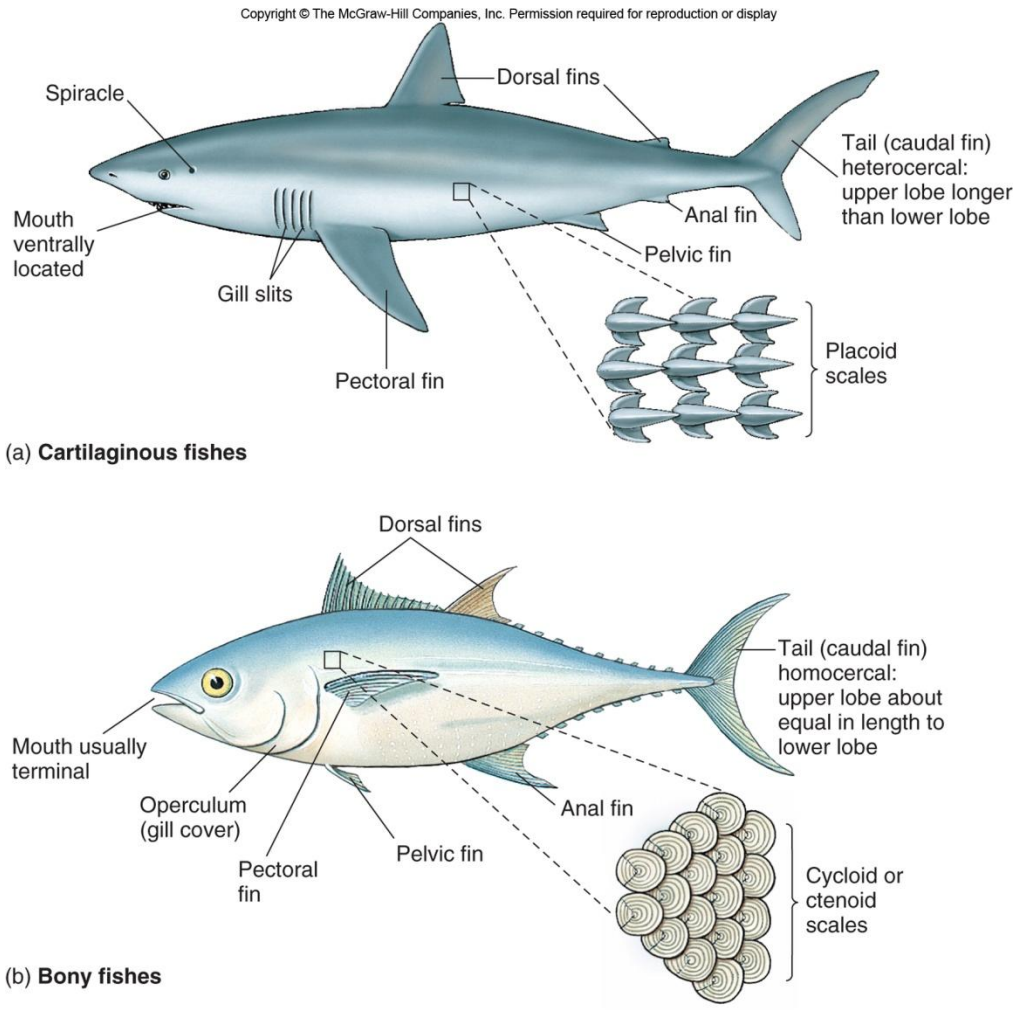
Fins


Spinous Dorsal
Soft Dorsal
Caudal
3
5
2
1
6
4
Pectoral
Anal
Pelvics

More Advanced Fishes

- Fishes in the Chondrichthyes and Osteichthyes are considered to be more advanced.

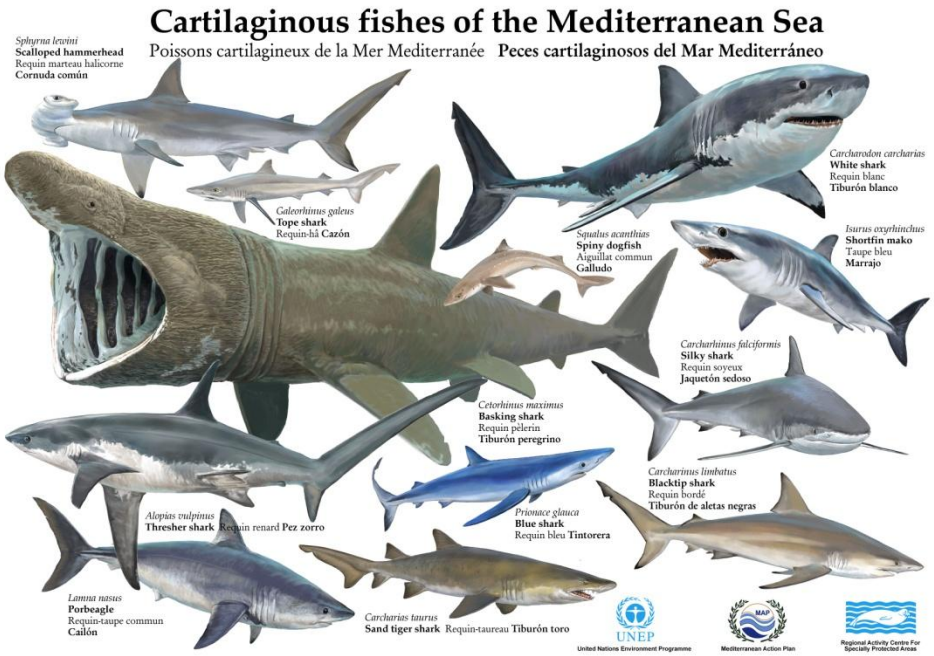
- General Characteristics seen in these groups:
  - Highly efficient gills
  - Scales cover the body, streamlined
  - Paired fins
  - A wide variety of jaw and feeding types
  - Lateral line and other sensory organs



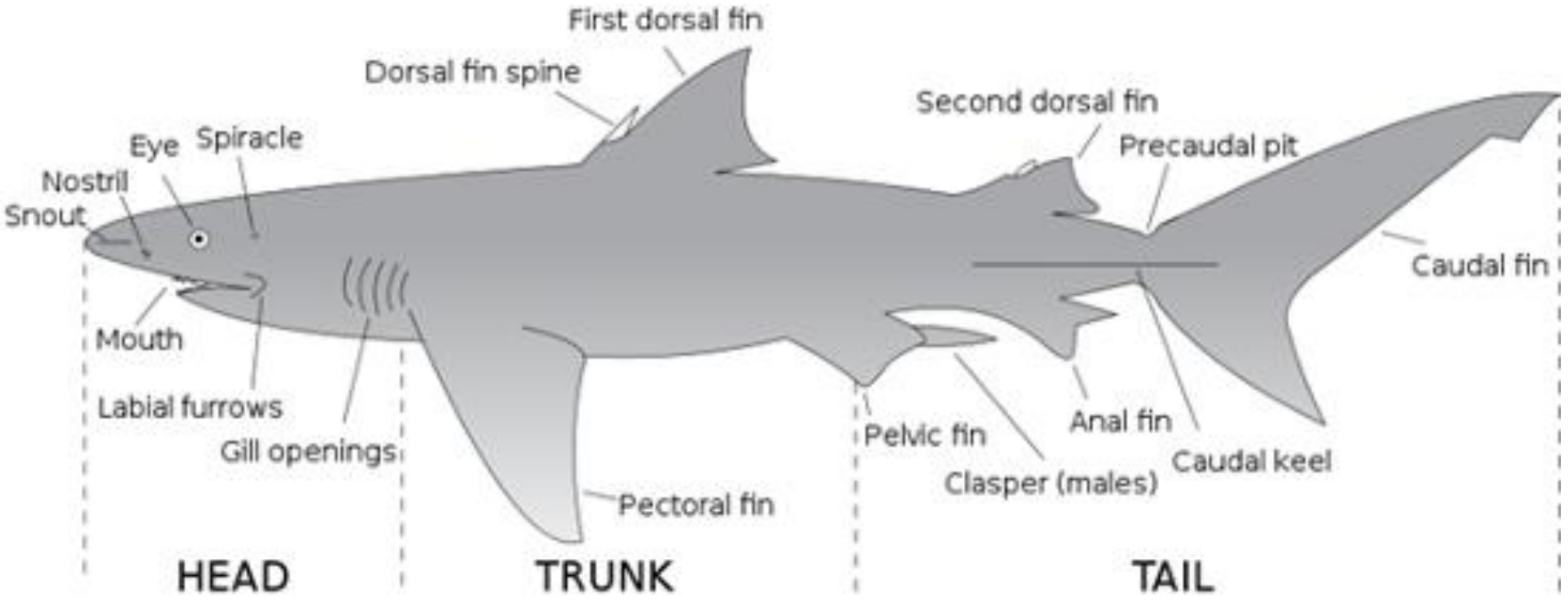
Cartilaginous Fishes

Kingdom: Animalia
Phylum: Chordata
Class: Chondrichthyes

- Sharks, rays, skates, and ratfish
  - ~ 1,000 species
- Skeleton made of cartilage
- Possess mobile jaws and paired lateral fins
- Placoid scales and paired fins
- No swim bladder
  - Some species have high lipid contents in the liver

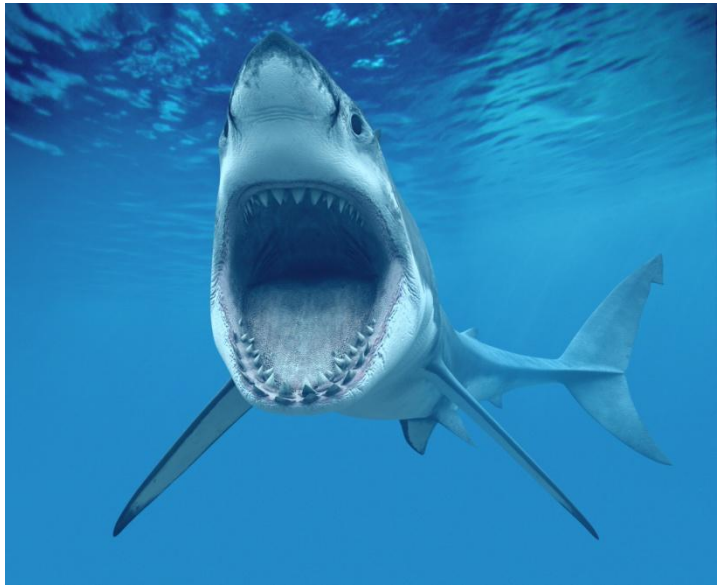


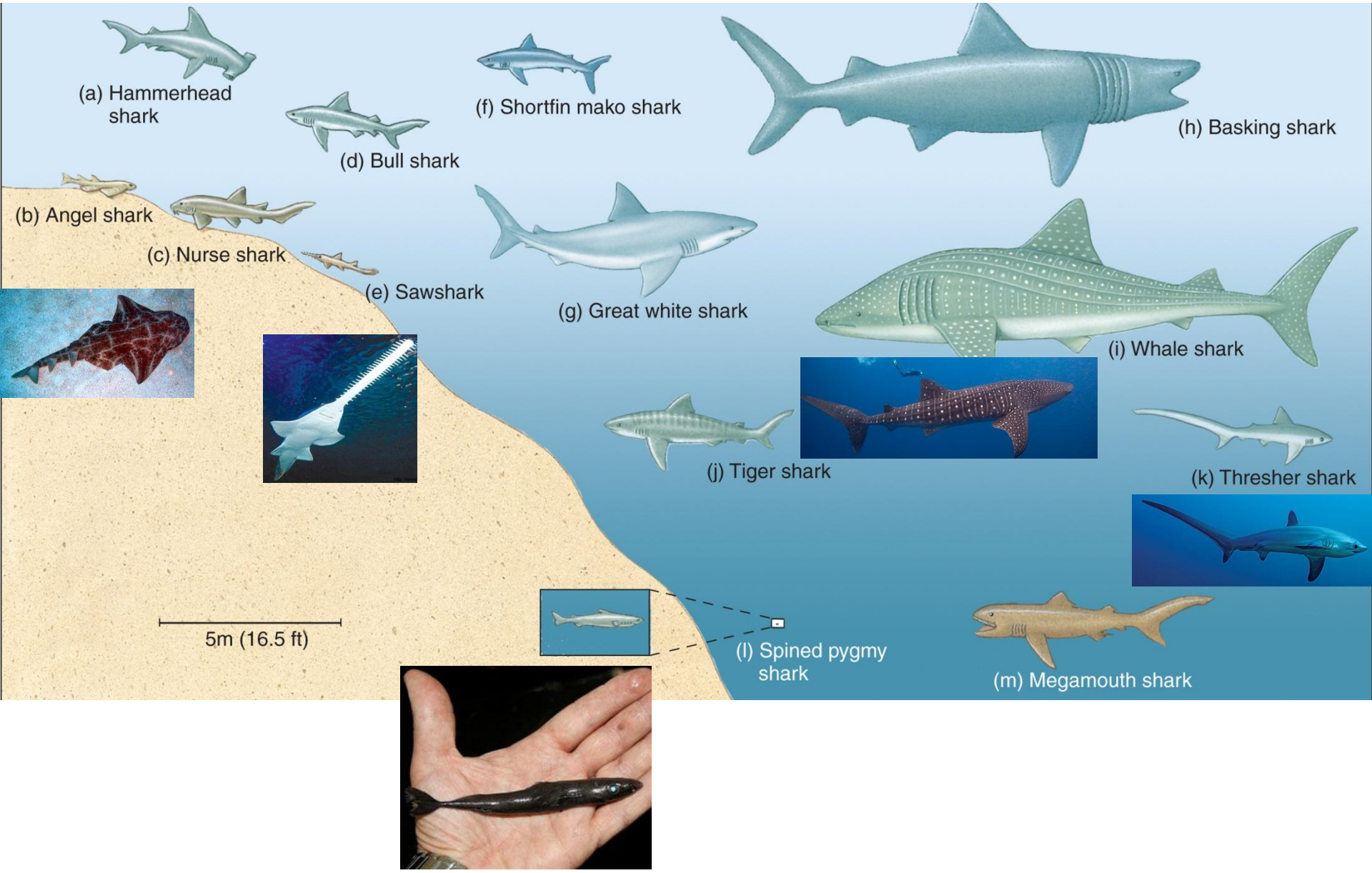
Anatomy


First dorsal fin
Dorsal fin spine
Second dorsal fin
Precaudal pit
Eye
Spiracle
Nostril
Snout
Caudal fin
Mouth
Labial furrows
Gill openings
Pectoral fin
Pelvic fin
Anal fin
Caudal keel
Clasper (males)
HEAD
TRUNK
TAIL

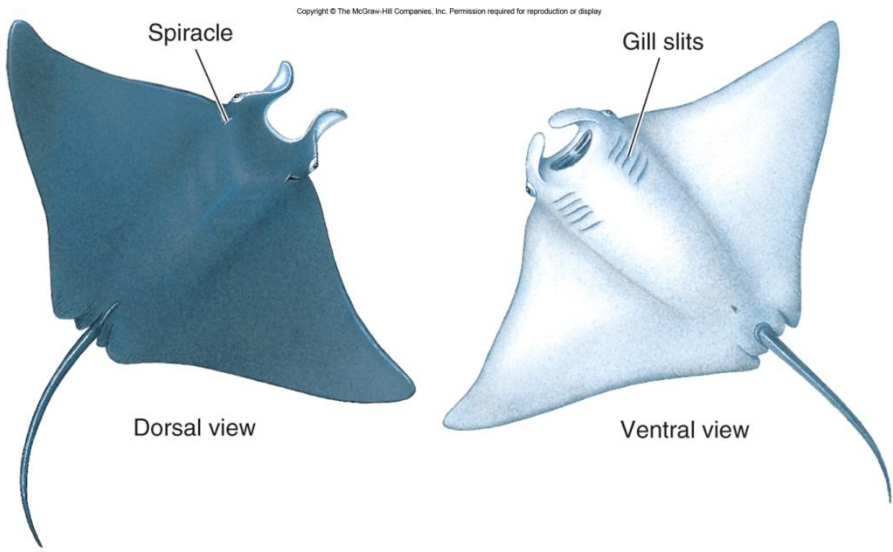
Sharks

- ~350 species currently exist
- Many are carnivorous, some planktonic
- Most species possess 2 dorsal fins
- Reproduction varies between live birth, laying egg cases, and having eggs hatch inside the mother




(a) Hammerhead shark
(f) Shortfin mako shark
(h) Basking shark
(d) Bull shark
(b) Angel shark
(c) Nurse shark
(e) Sawshark
(g) Great white shark
(i) Whale shark
(j) Tiger shark
(k) Thresher shark
5m (16.5 ft)
(l) Spined pygmy shark
(m) Megamouth shark

Rays



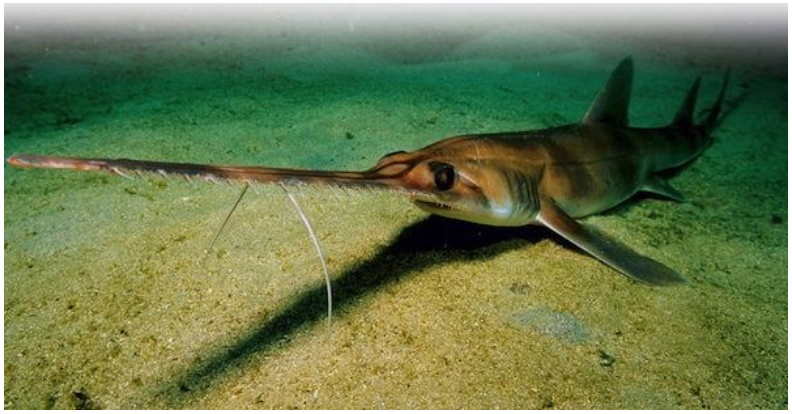
•450 – 500 species

•Rays always have live birth

•Pectoral fins are expanded into "wings"
•Body is dorsoventrally flattened

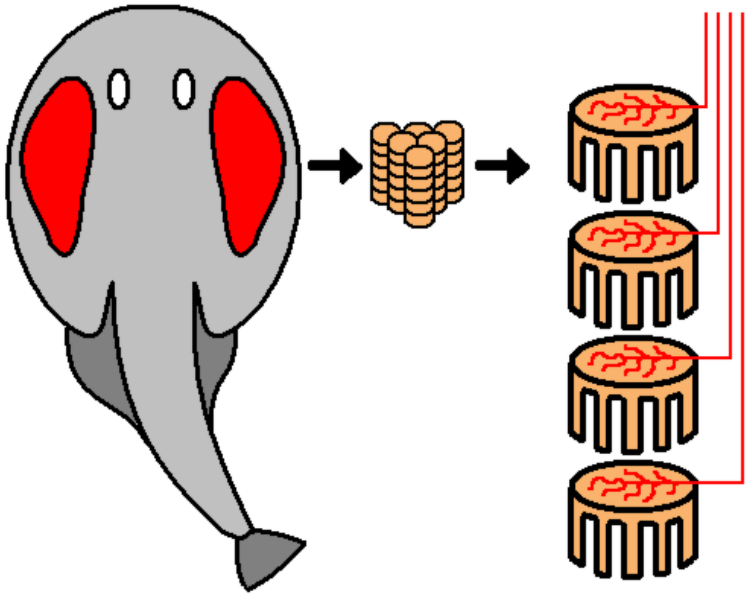
•Gill slits (5 pairs) mouth are on the underside of the body
•Spiracles are located on the top of the body

•Rays spend much of their time on the bottom (demersal) partially covered in sand
•Large flattened teeth for feeding on molluscs and arthropods



Rays

- Most have long whip-like tails; in sting rays, there is a spine at the base of the tail with an associated poison gland
- Venom from this gland is delivered to other organisms if they make contact with this spine by stepping on a ray or making contact with the ray in some fashion
- Electric rays have organs that produce electricity on either side of head
  - Electrocytes- flat, disk-like cells that produce 0.15 V



Skates

•Dorsoventrally flattened with pectoral fins modified into wings

•Unlike rays, skates have a fleshy tail and no spine on the tail

•Also unlike rays, skates always lay egg cases

•After fertilization, the female lays egg cases with an embryo inside

•The embryo develops within the protection of the egg case for weeks to months

•They are also demersal and feed on molluscs and arthropods primarily

Ratfish

- Only about 30 species
- Mostly are deep water inhabitant
- One pair of gill slits is covered by a flap of skin (very unusually in the chondrichthyes)
- They feed on the bottom on crustaceans and molluscs primarily
- Heterocercal tail like in sharks
- Unlike others in this group, they also have fin rays (tiny support rods) in the fins

Bony Fish

•As the name implies, these fish have a skeleton composed of bone

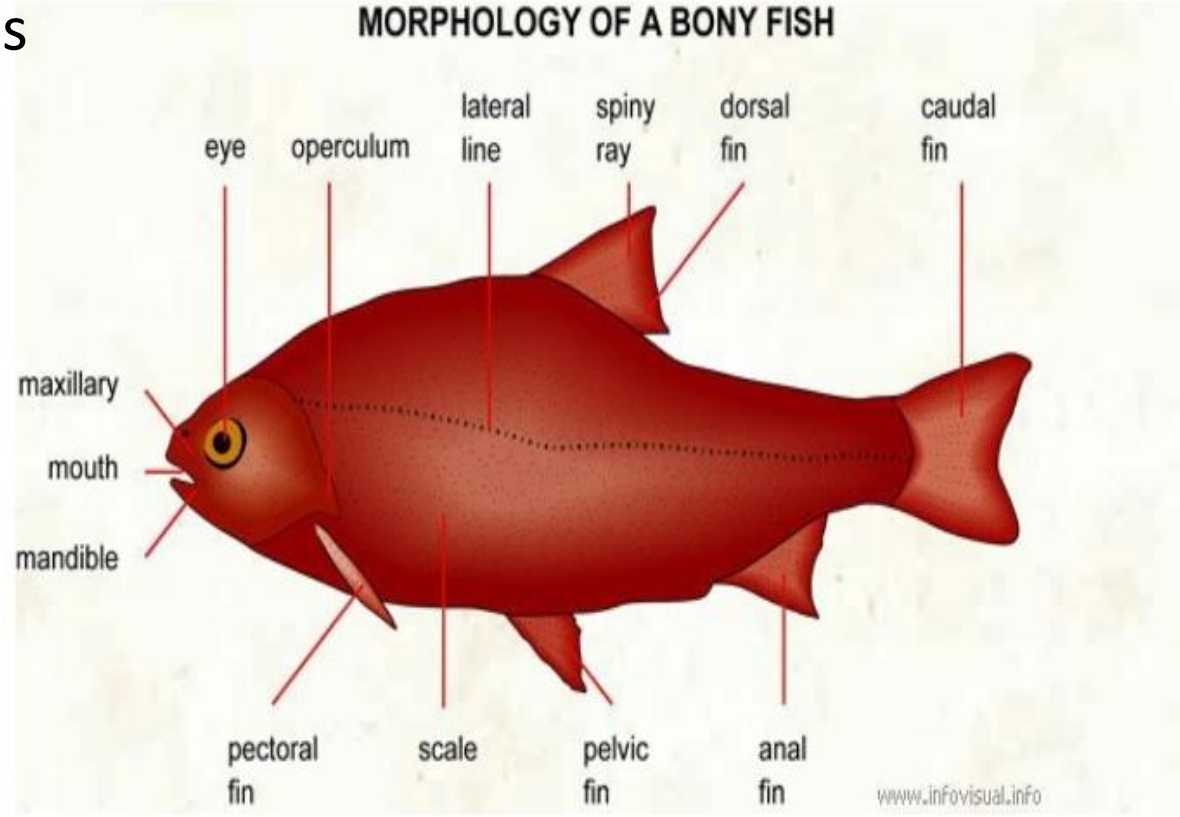
•More species that all other vertebrates combined- over 23,000 species worldwide

•Have adapted to nearly every habitat

•Hinged jaws allow for a variety of different ways of feeding

•Homocercal tail (two lobes of equal size) provides forward thrust

- Ctenoid or cycloid scales
- Operculum covers gills
- Lateral line used for sensory and communication
- Swim bladder
- Variable body plans



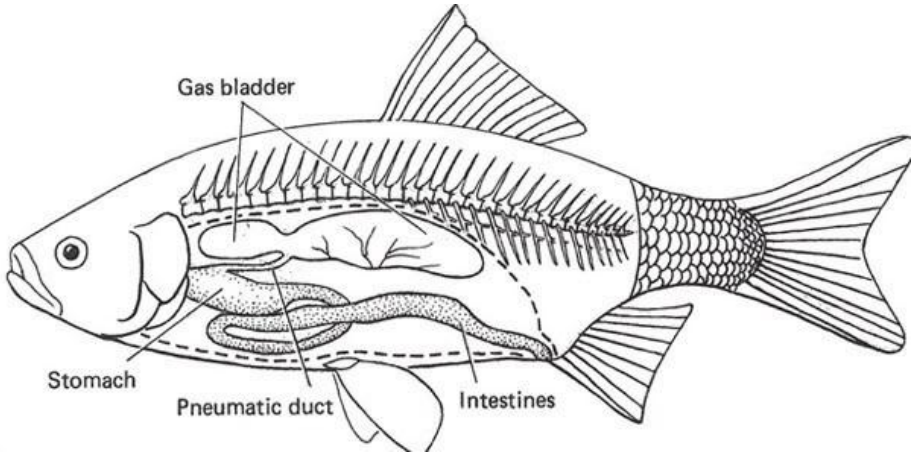
Swim Bladder

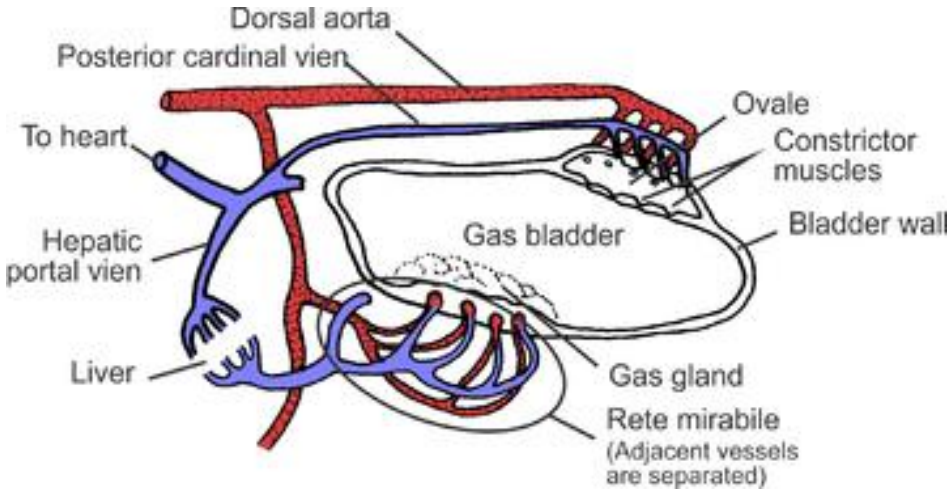
- Internal gas-filled organ that contributes to the ability of a fish to control its buoyancy

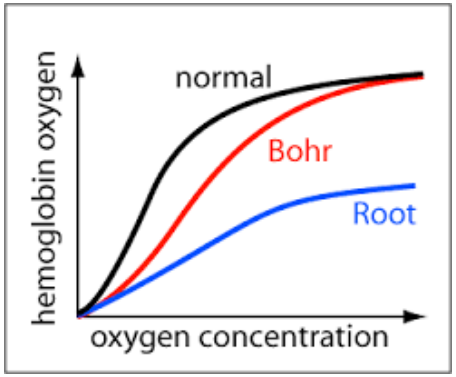
- Two Types:

1. Physostomous
   - Connection is retained between swim bladder and the gut
   - Can fill up bladder by gulping air

2. Physoclisti
   - Connection to the guy it lost
   - Use gas gland to introduce gas (usually oxygen)





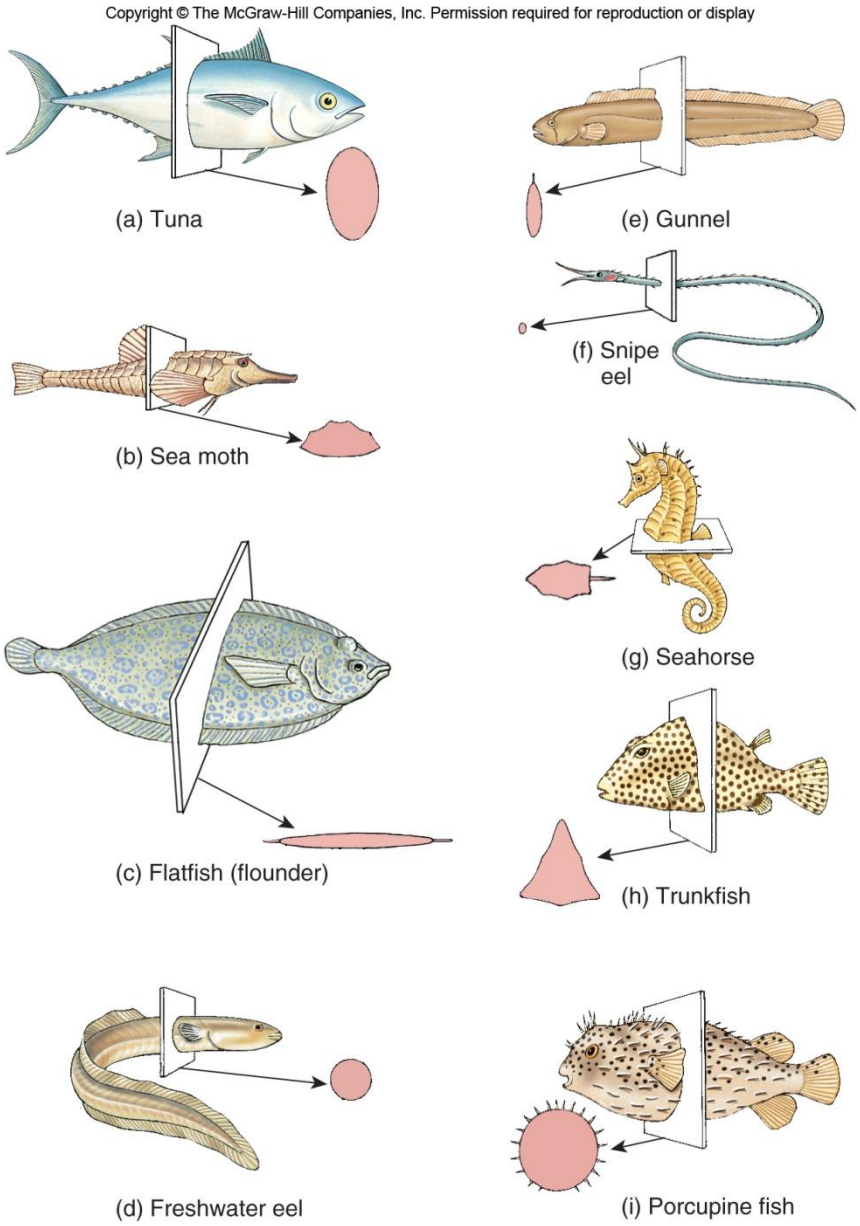


Coloration Patterns

- Cryptic Shading
- Countershading: dorsally darkened, ventrally whitened
- Disruptive coloration
- Eye spot (false eye)
- Warning colors

Body Shape

- Body shapes vary greatly among fish dependent on the environment that fish calls home
- Flounders/sole live on the bottom= dorsally flattened
- Tuna/billfish are fast moving predators= long, streamlined
  - fusiform
- Reef fish inhabit coral reefs= not streamlined, laterally compressed
  - fins are feather-like for flexibility
  - Deep-bodied
- Eels hide in crevices= skinny, elongated bodies



Caudal Fin Shapes

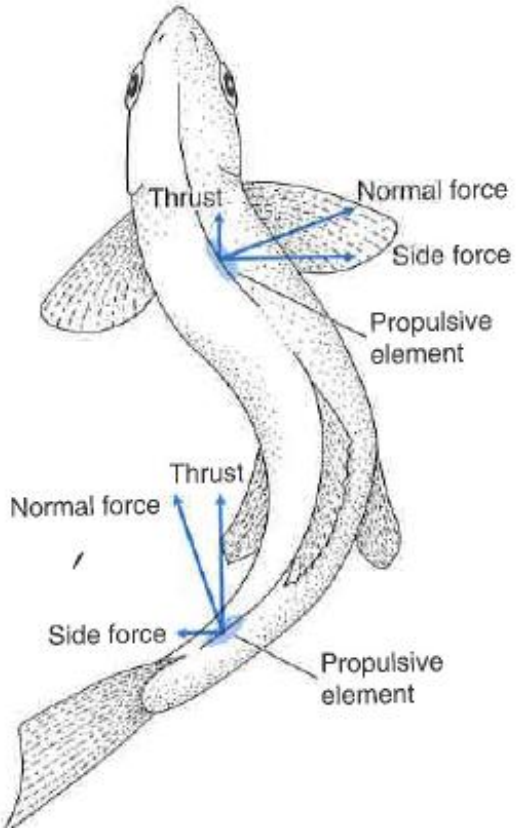
CAUDAL FIN SHAPE

Shape	Function
Rounded 	Large amount of surface area allows for effective acceleration and maneuvering, but creates drag causing fish to tire easily.
Truncate 	Effective acceleration and maneuvering. Not as much drag as a rounded shape.
Emarginate 	Effective acceleration and maneuvering. Not as much drag as a rounded shape or truncate shape.
Forked 	Good acceleration and maneuvering. Less surface area means less drag.
Lunate 	Rigid fin with less surface area means less drag and great acceleration, but decreased maneuvering.

Locomotion

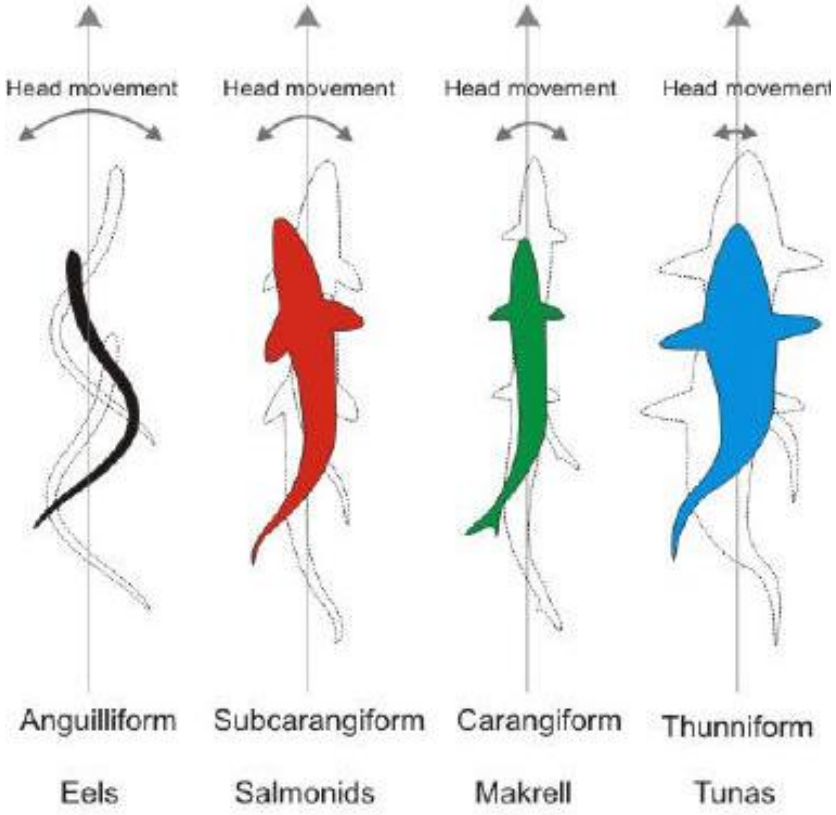
- Fish exhibit an “s-shaped” swimming pattern

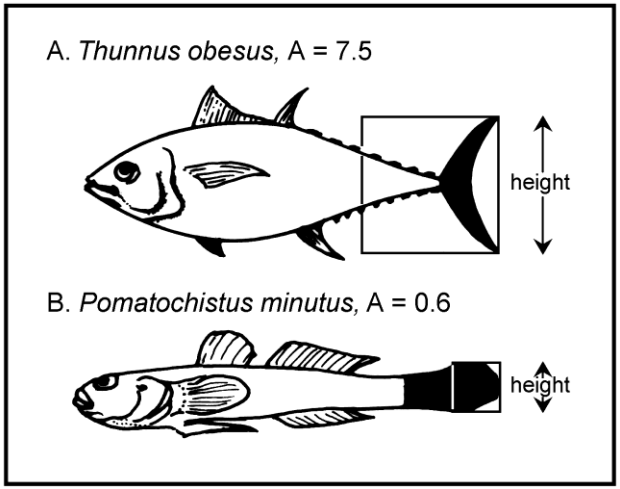
- Primary forces involved in fish swimming:
  - Thrust - force that propels forward
  - Drag - friction produced from passing an object through a medium
  - Gravity – force from earth’s magnetic pull (partially counterbalanced by density of water)
  - Lift - upward force that counteracts gravity



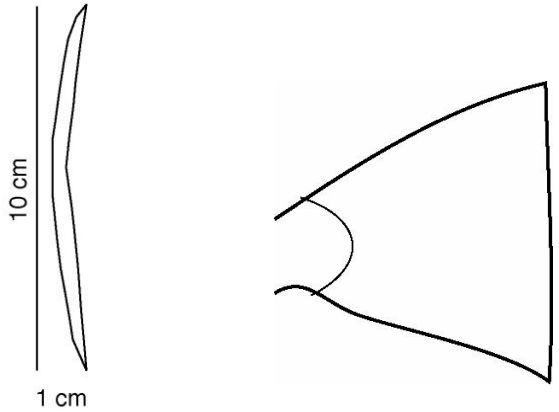
Swimming Styles

- Anguilliform
  - body waves
  - eels
- Carangiform/ thunniform
  - partial body waves
  - tuna
- Ostraciform
  - caudal peduncle/fin beats
  - Pufferfish
- Amiiform
  - medial fin waves
  - triggerfish
- Labriform
  - pectoral fin beats
  - Deep bodied fish



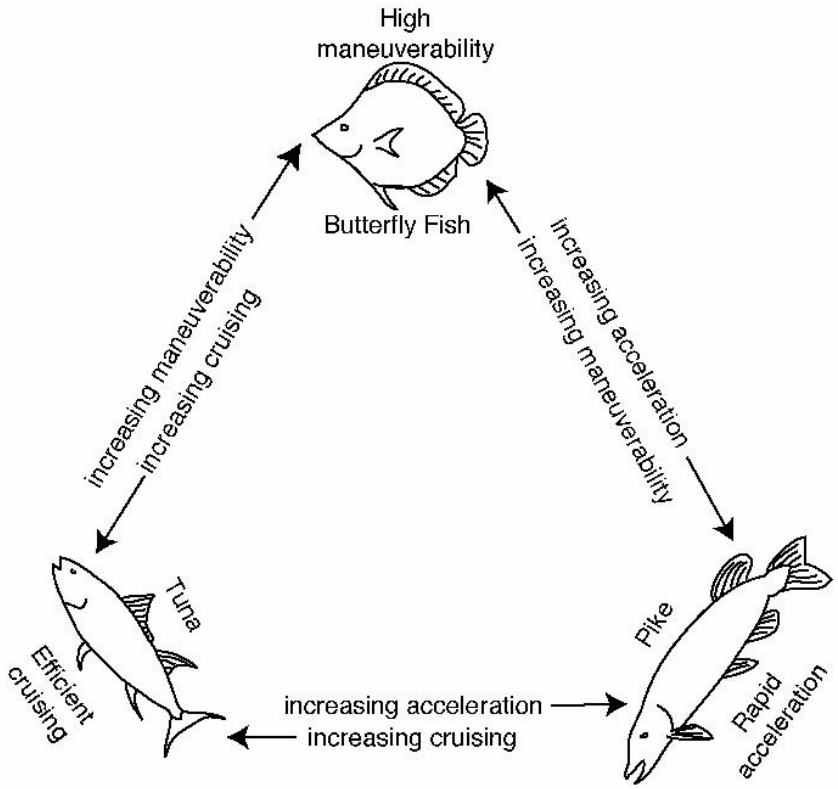


Functional Swimming



•Aspect ratio of the caudal fin can be used to asses the functionality of swimming
- •Height:width of caudal fin
- •High aspect ratio (>7)- lunate
- •Low aspect ratio (<7)- truncate

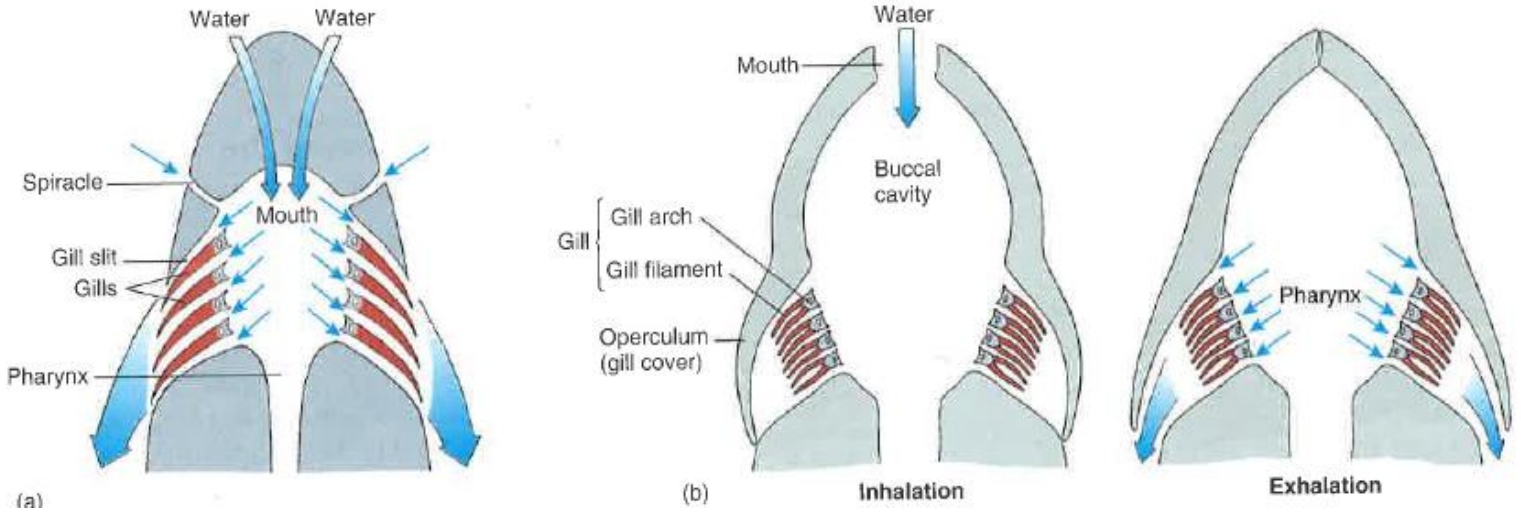
•Three main functional components to swimming:
- • Acceleration
  - •In-between aspect ratio
- • Cruising
  - •High aspect ratio
- • Maneuvering
  - •Low aspect ratio



Irrigation of Gills

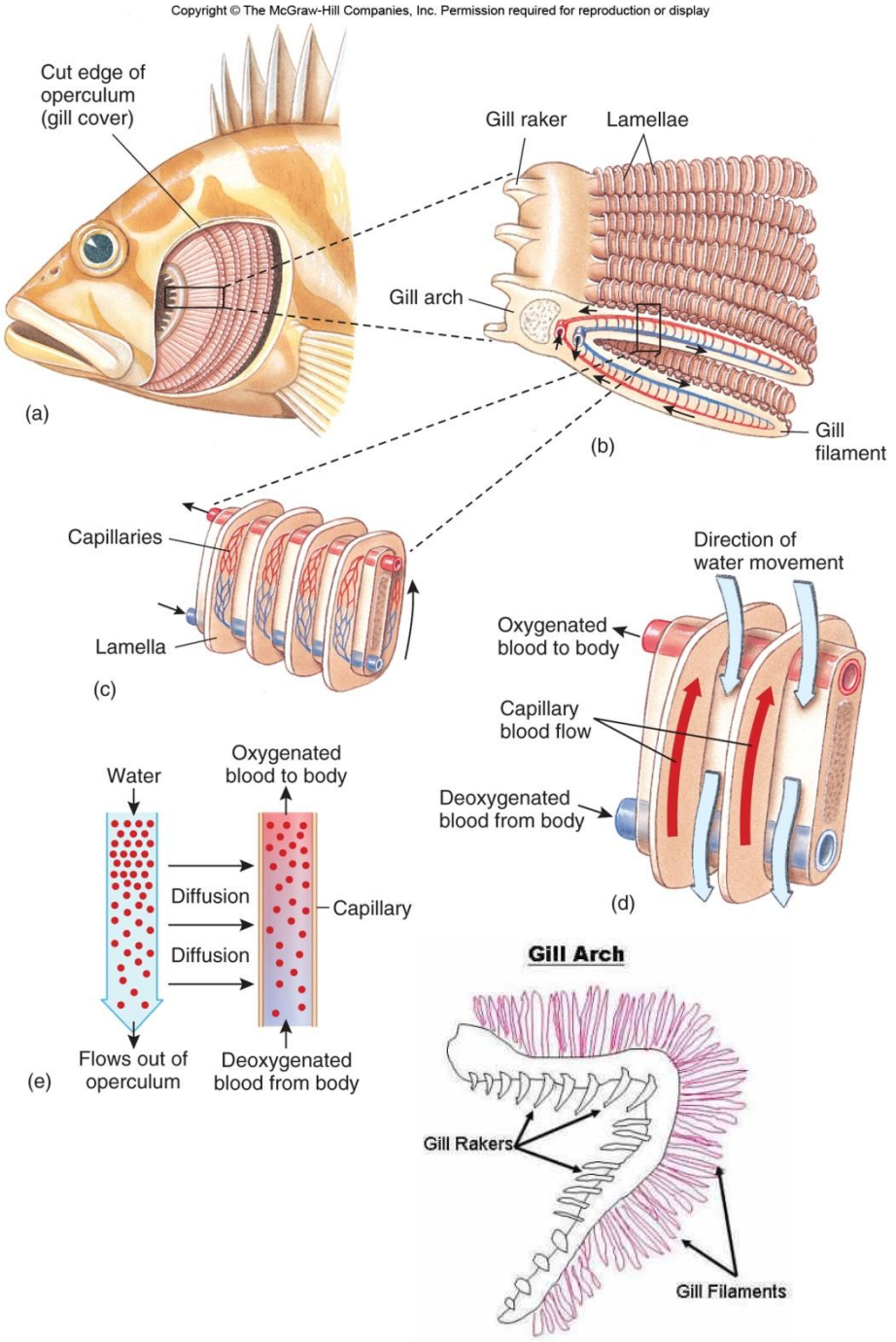
- Cartilaginous fish:
  - Each gill lies in its own chamber
  - Must force water through the gills

- Bony fishes:
  - Gills lie in one chamber
  - Use pharynx and operculum to pump water



Gills

- The construction of the gill is the same in all fish :
  - gill arch supports the entire structure
  - gill rakers are on the forward surface of the gill arch
    - involved with suspension feeding tiny prey
  - gill filaments trail behind the gill arch
- Lamellae: thin layer of skin used to increase surface area contact with oxygen
- Oxygen exchange through counter-current exchange

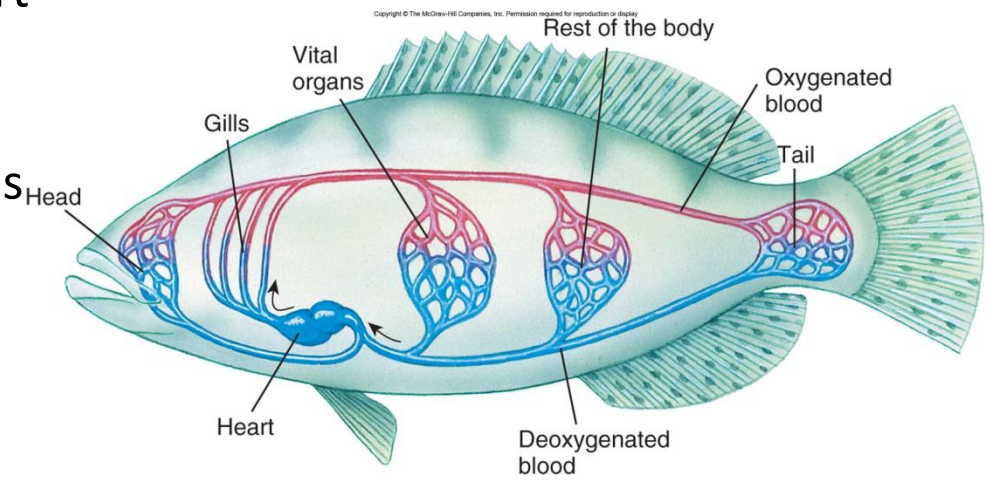


The Circulatory System

- Two chambered heart that serves to pump blood throughout the body
  - in contrast to the 4 chambered heart seen in mammals

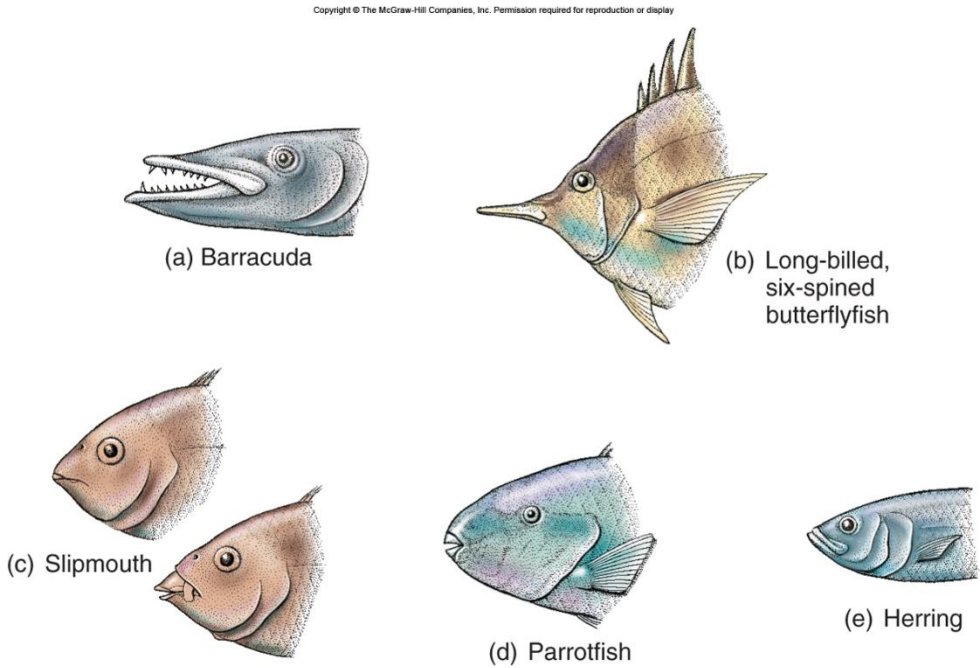
- A system of arteries, veins and capillaries takes blood to the body tissues and returns it for re-oxygenation by the gill filaments

- Oxygen and carbon dioxide will diffuse across the thin membranes of the capillaries either in the gills or at the tissues of the body



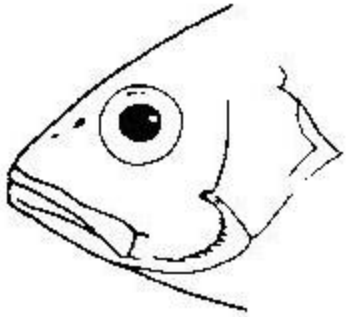
Mouth Shapes

- Mouth structure also reveals the dietary preferences of fish
- Beak in parrotfish is fused teeth used to scrape algae
- Long snout of butterflyfish used to feed on coral polyps
- Barracuda has a wide mouth and sharp teeth to capture and swallow whole fish

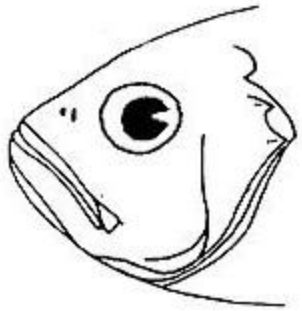


Mouth Position

- Types of mouths depending on what their diet is and how they feed

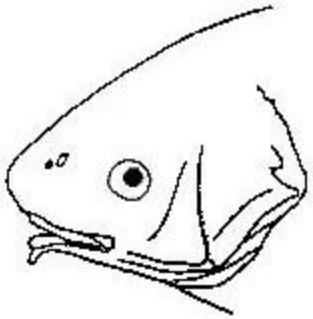


terminal

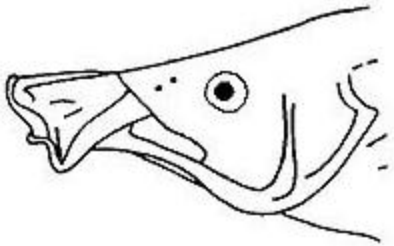


superior

- Terminal or protrusible = feed on other fish
- Superior= ambush predators
- Inferior= bottom feeder



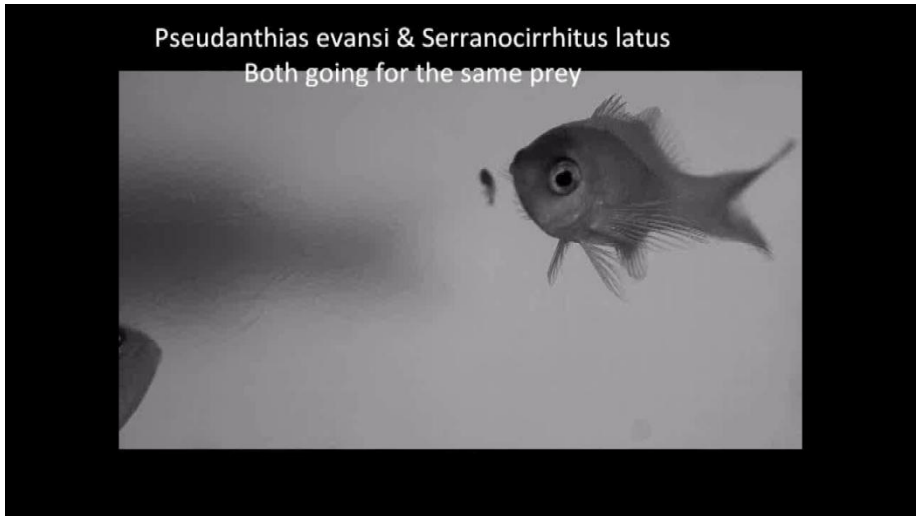
inferior



protrusible

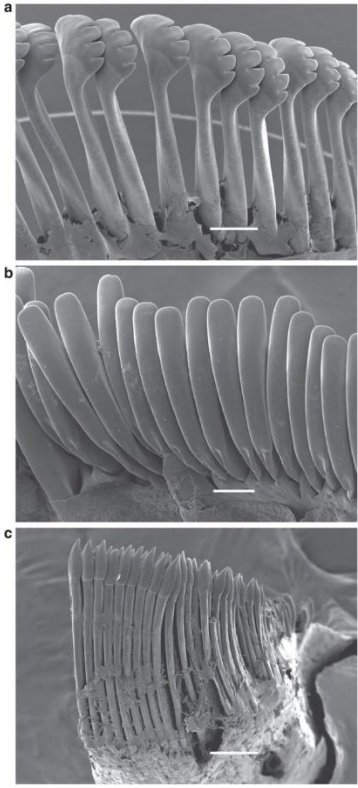
Feeding

- Suction
  - Most common
  - Rapid opening of mouth sucks in both water and prey



- Ram feeding
  - Larger, carnivorous fish
  - Predator moves forward with its mouth open, engulfing the prey along with the water surrounding it

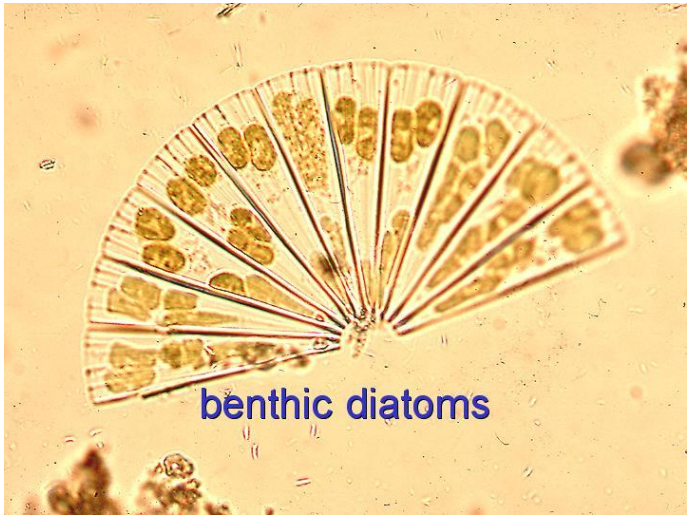
- Herbivore/Deposit feeding
  - Some use specialized teeth to brush up detritus

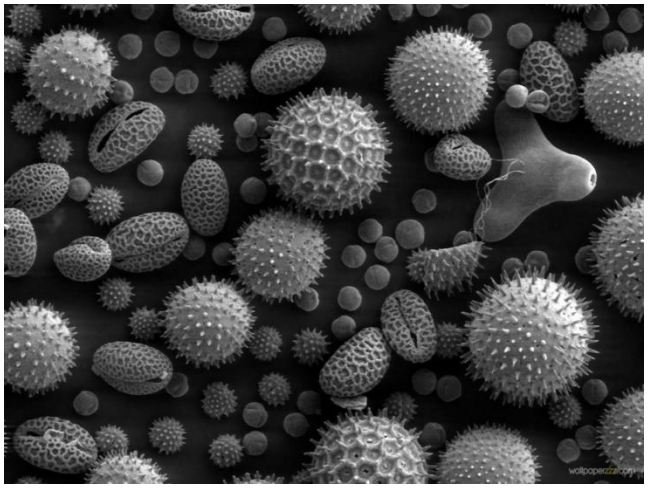


Microbial Stripping Hypothesis

- Deposit feeders are most efficient at digesting and assimilating benthic microbes (diatoms, bacteria, fungi)

- POM (particulate organic material) relatively indigestible and thus have the most nutrition from microbes on particles



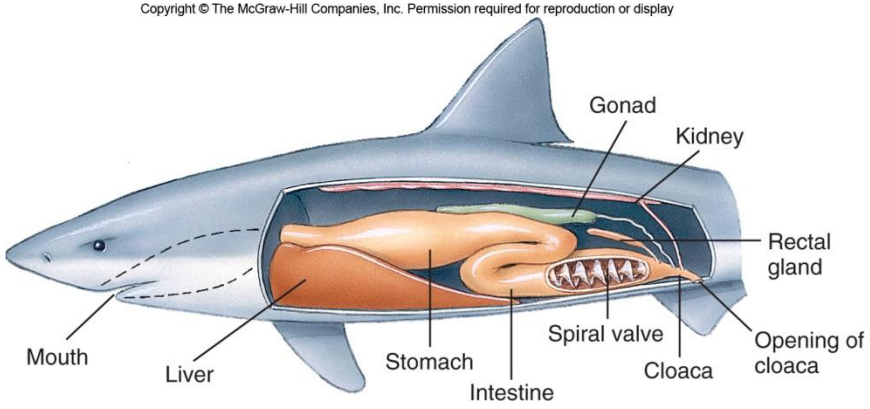


Processing Food

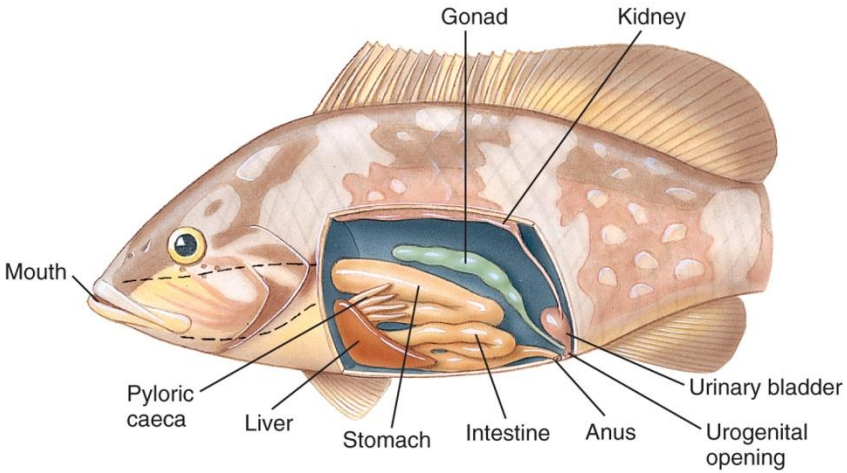
- Digestion of food in fish is completed with the aid of a stomach, intestine (with anus), liver, pyloric caeca and pancreas

- The intestines of carnivorous fish tend to be short and straight

- The intestines of herbivorous fish are longer and more coiled
  - plant and algae material is more difficult to process, so it needs to stay in the intestines longer



(a) **Cartilaginous fishes**



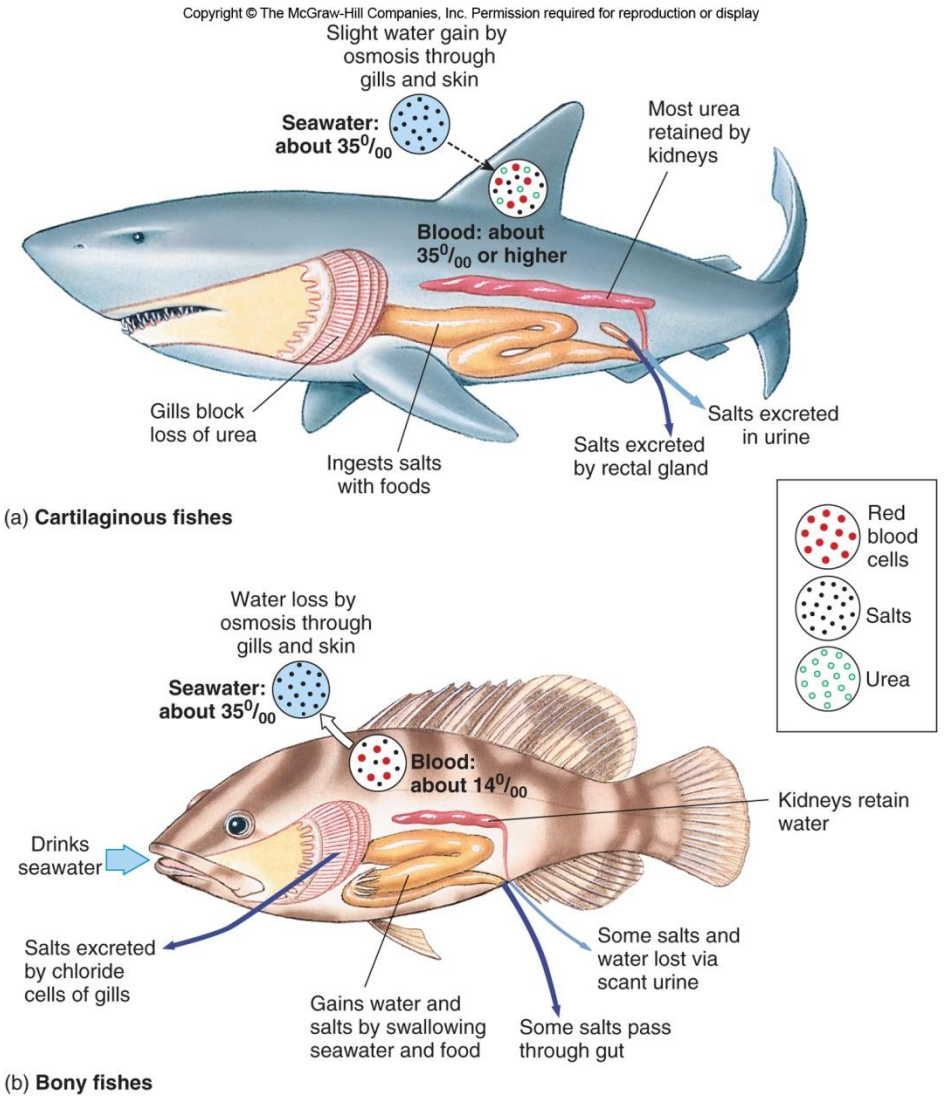
(b) **Bony fishes**

Fluid Regulation

- Osmoregulation
  - Water is very solute-rich, have a tendency to gain solutes and lose water

- Fish have evolved a variety of ways to osmoregulate including:
  - Many fish swallow seawater and expel the solutes in the digestive process
  - Most marine fish pass very little urine
  - This urine is highly concentrated with solutes with very little water content

- Cartilaginous fish the blood is kept the same concentration as seawater
  - accomplished by keeping urea in the bloodstream (this toxin is filtered out of the blood by other organisms)
  - no solutes are gained (or water lost) because the concentration internally and externally match

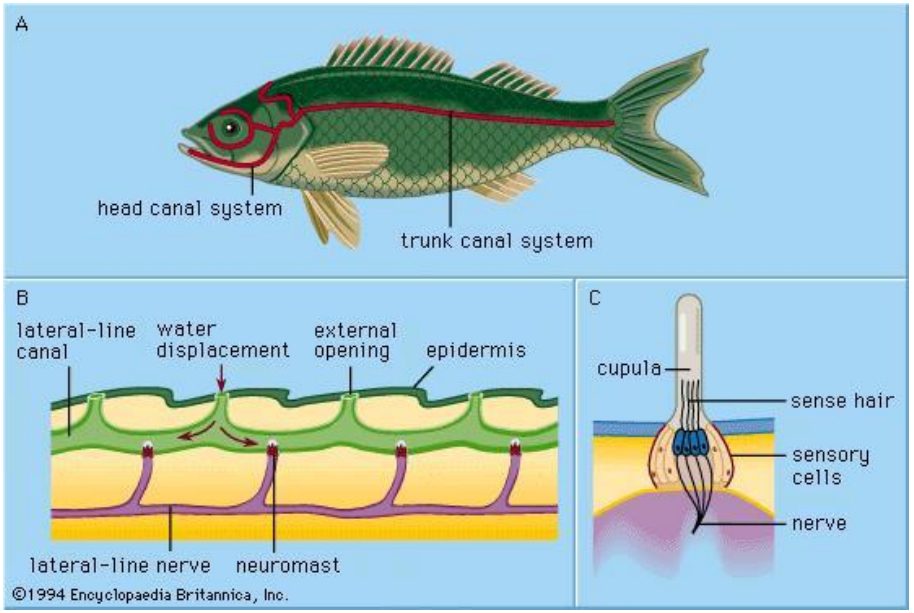


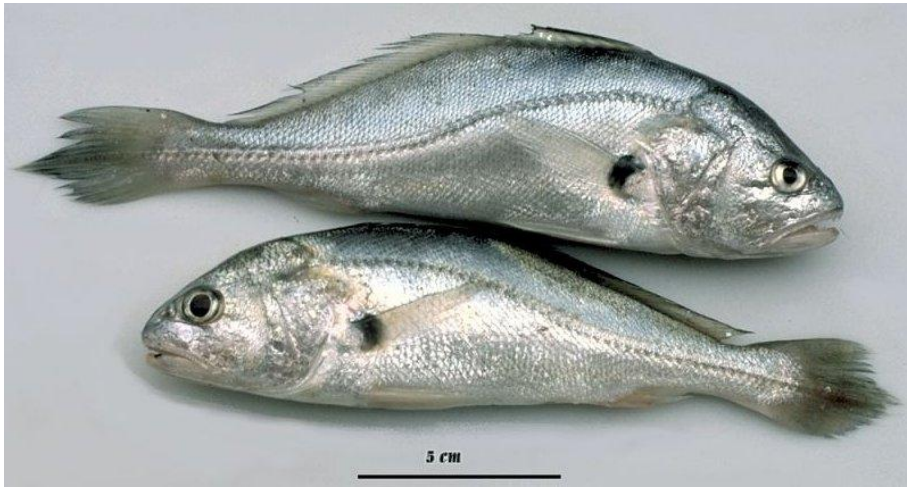
Nervous System

- The fish have a brain, spinal cord and numerous nerves like other vertebrates
- Fish also possess olfactory sacs (with nostrils) for smelling
- Taste buds are located in the mouth, lips, barbels and skin
- The eyes are structured slightly differently
  - In humans, the lens changes *shape* for focusing on items
  - In fish, the *position* of the lens changes like in a camera
- In some sharks, the eye is covered by a nictitating membrane that covers the eye

Lateral line

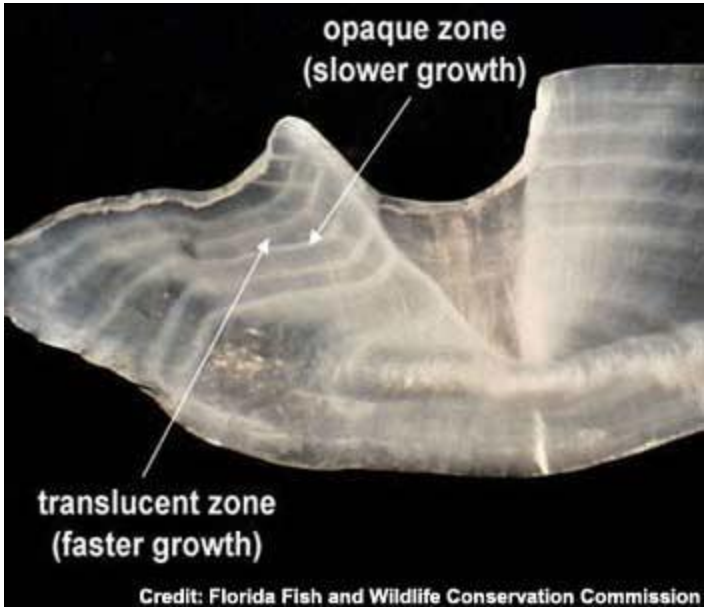
- All fish rely heavily on the lateral line system
- The lateral line is a series of pores and canals lined with cells called neuromasts that are specialized to detect vibrations
- These vibrations can indicate a predator or prey or the position of other fish in a school

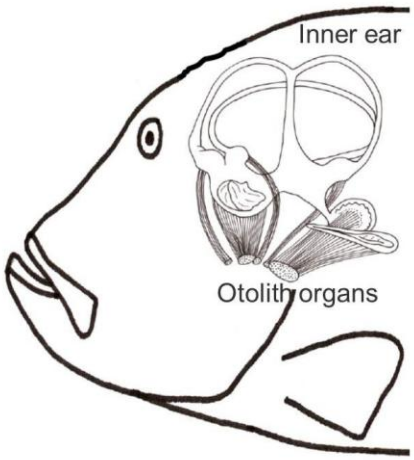


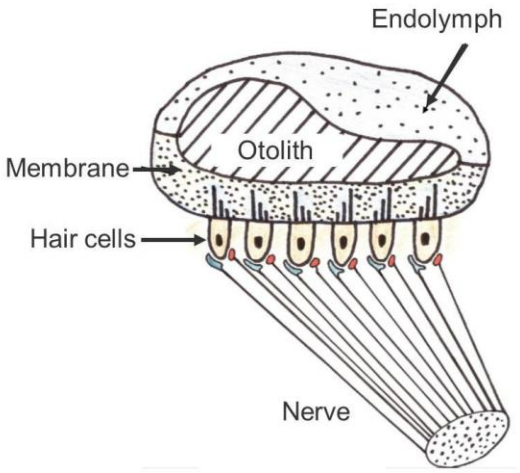


Otoliths

- Calcium carbonate deposit used in hearing and balance
- Suspended and in contact with hair-like fibers
  - Works like a statocyst
  - Pressure of the otolith against the fibers provides fish with information about its orientation
- Can be used to determine what water bodies the fish has occupied, and to age a fish

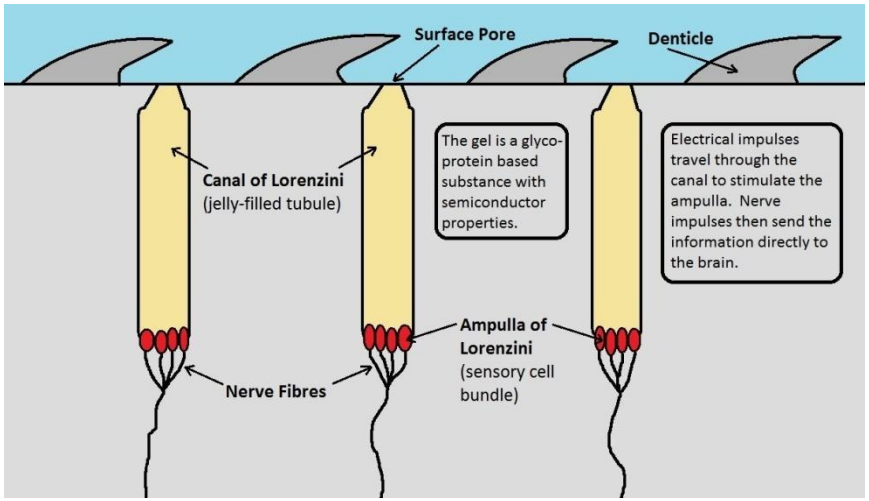






Ampullae of Lorenzini

- Cartilaginous fish also possess the Organ of Lorenzini
- This organ detects electrical charges
- All muscular system of organisms relies on small electrical charges
- Therefore, this organ can help cartilaginous fish detect prey, even if they are not visible (buried in sand, etc)



Behaviors

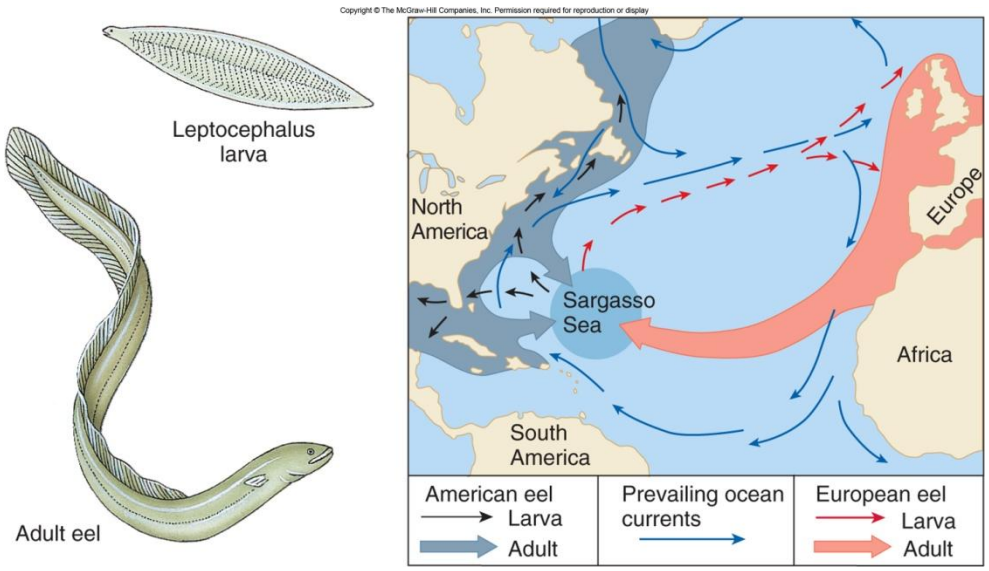
- **Schooling**
  - Schooling is used by a wide variety of fish
  - Schooling makes it possible for a group of smaller fish to appear much larger (as thus avoid detection by predators)
  - It also makes it harder for a predator to capture any one fish
  - Because of this, many fish school as juveniles
  - About 4000 species school as adults

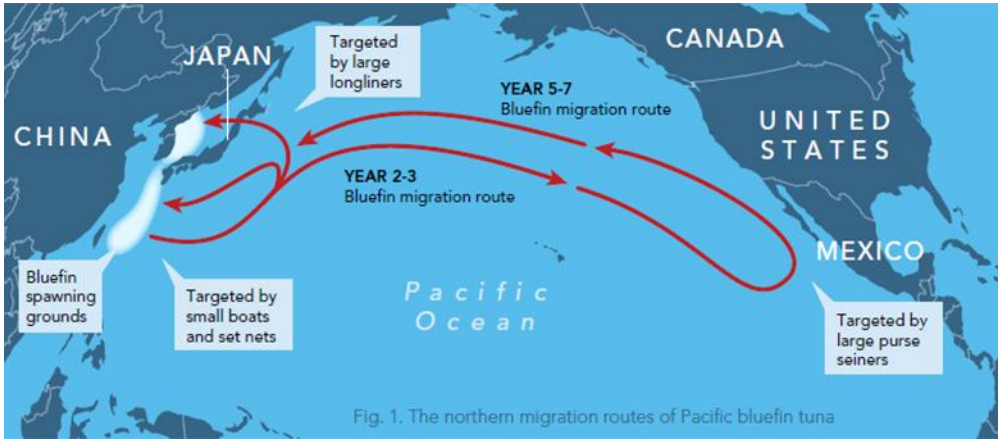
Behaviors

- **Territoriality**
  - Some fish are territorial by nature all the time, others are only territorial during reproduction
  - Fish maintain their territories normally by “posturing” to show their aggression
  - Posturing can include raised fins, open mouth, darting
  - Fights between individuals are actually rare

Behaviors

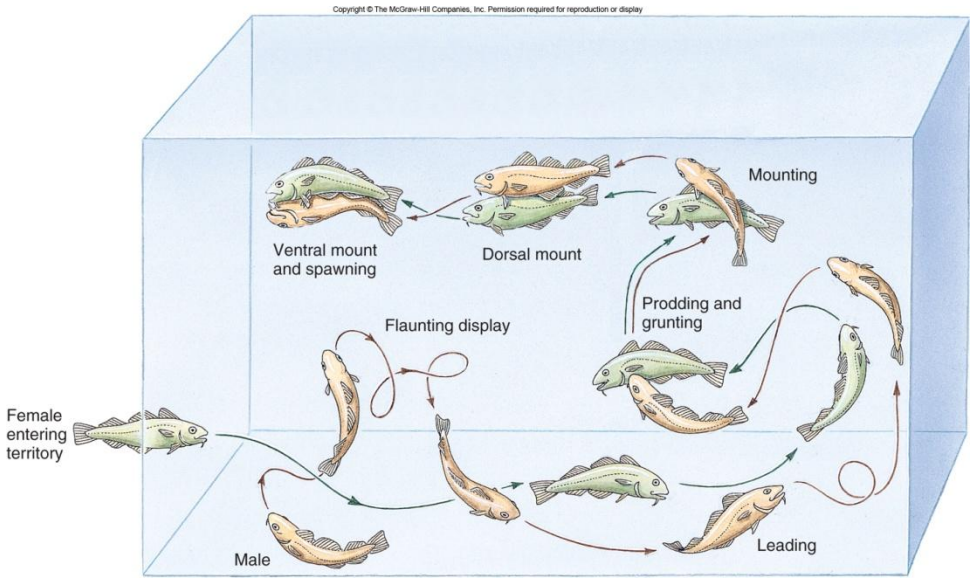
- Migration
- Anadromous
  - live in saltwater normally but go to freshwater for reproductive purposes
- Catadromous
  - live in freshwater but travel to saltwater for reproduction





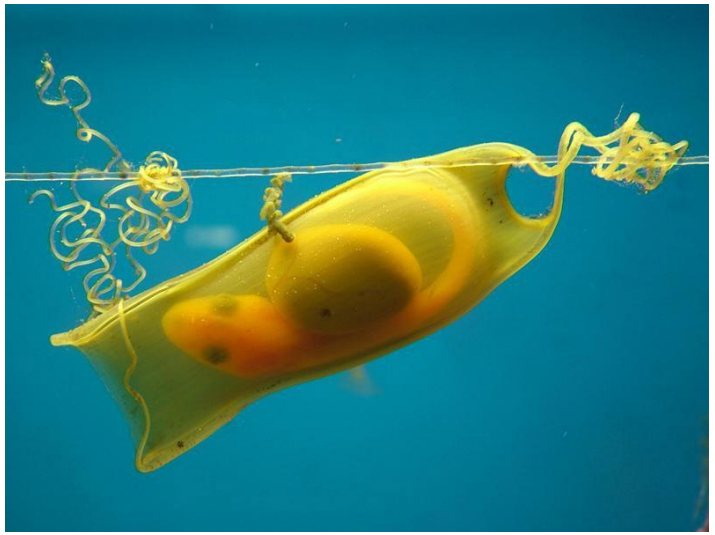
Reproduction

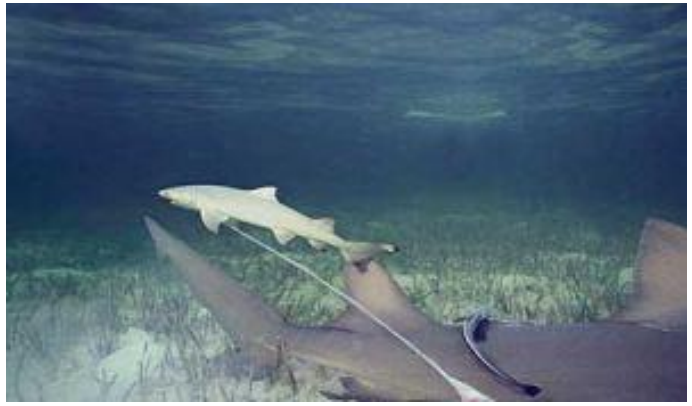
- Sex hormones control the development of sperm and eggs in fish
- The release of sex hormones can be cued by water temperature, day length, specific tide cycles, etc.
- Broadcast spawning is most common
  - Nesting can occur
- Some fish do have internal fertilization
- Complex mating behaviors are seen in some species



Egg development

- Oviparous: egg layers
- Ovoviviparous: eggs are kept inside and hatch inside the female reproductive tract
- Viviparous: young are born live
- Parthenogenesis: young develop directly from unfertilized eggs





Bony fishes Suborders to Know

- Clupeidae
  - Menhaden, herrings, shads, sardines
- Engraulidae
  - anchovies
- Scombridae
  - mackerels and tunas
- Paralichthyidae/Bothidae
  - flounders
- Sparidae
  - pinfish and porgies
- Serranidae
  - seabasses and groupers

Clupeidae

- Include menahden, herring, shad, and sardines
- Mostly marine
- body protected with shiny cycloid scales
- single dorsal fin, with a stream lined body
  - built for quick, evasive swimming and pursuit of prey composed of small planktonic animals.
- Commonly caught for food and fish oil
- Species to know: *Brevoortia patronus*

Engraulidae

- Anchovies
- 144 species, exclusively marine
- Shiny, slender body
  - Feed on plankton
- Commercially important species
- Important prey species

Sciaenidae

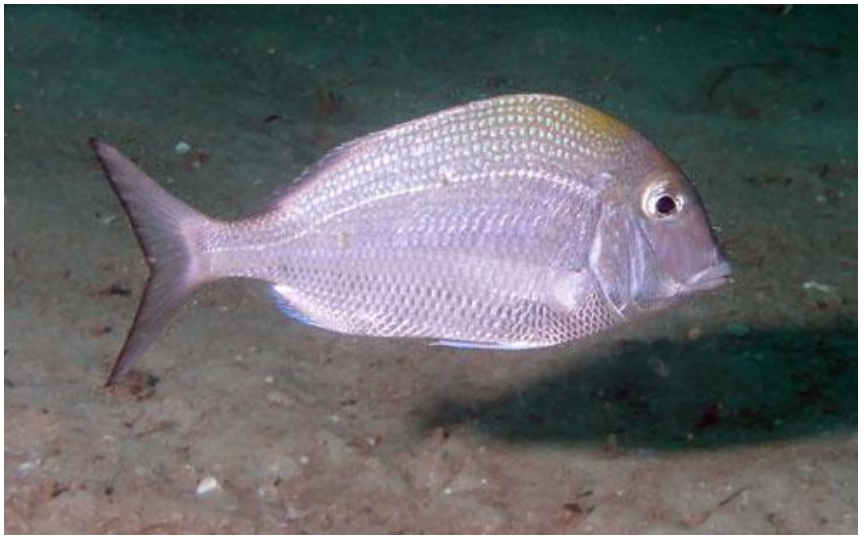
- Drums and croakers
  - 275 species
- Long dorsal fin reaching nearly to the tail
- Produce drumming or croaking sound by beating abdomen muscles against the swim bladder
- Typically benthic carnivores
- Species to know:
  - Red drum, *Sciaenops ocellatus*
  - Atlantic croaker, *Micropogonias undulatus*

Scombridae

- Mackerels and tuna
  - 51 species
- Streamlined for high speeds
- Two dorsal fins, and a series of finlets behind the rear dorsal fin and anal fin
- Some species partially endothermic
- One of the most important commercial fishery
- Generally predators in open ocean

Sparidae

- Porgies, pinfish
  - 147 species
- Laterally compressed, single dorsal fin
- Many species possess grinding molar-like teeth
- Species to know:
  - Pinfish- *Lagodon rhomboides*



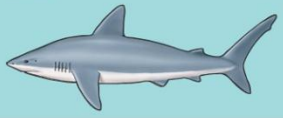
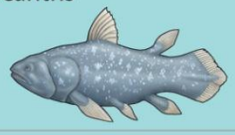
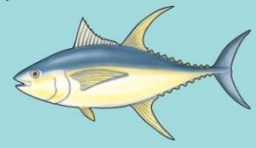
Serranidae

- Sea bass and groupers
  - 450 species
- Robust bodies, vary in size
- All carnivorous
  - Typically rows of small sharp teeth
- Long lived
  - Typically live up to 40 years
  - Estimated it could be up to 100 years
- Many species are protogynous hermaphrodites

Lutjanus

- Snappers
  - 70 species
- Some species can live up to 60 years
- Predatory fish
- Important recreational fishery
  - 10 day fishing season
- Species to know:
  - Red snapper- *Lutjanus campechanus*

Table 8.1 Most Important Characteristics of Marine Fishes

Group	Distinguishing Features	Skeleton	Feeding	Reproduction	Significance in the Marine Environment
Hagfishes 	No paired fins, no scales, exposed gill slits, marine	Cartilaginous skull, no vertebrae, no jaws	Suction by round, muscular mouth with teeth	Oviparous	Predators of dead or dying fishes and bottom invertebrates
Lampreys 	Two dorsal fins only, no scales, exposed gill slits, fresh water or anadromous	Cartilaginous skull, no vertebrae, no jaws	Suction by round, muscular mouth with teeth	Oviparous	Suckers of fish blood or predators of bottom invertebrates
Rays, skates 	Paired fins, placoid scales, pectoral fins greatly expanded, five ventral gill slits, mostly marine	Cartilaginous	Grinding plates to feed on bottom animals or gill rakers to filter plankton	Oviparous, viviparous	Predators of bottom animals or filter feeders
Sharks 	Paired fins, placoid scales, 5–7 exposed and lateral gill slits, mostly marine	Cartilaginous	Teeth in jaws to capture prey or gill rakers to filter plankton	Oviparous, ovoviviparous, viviparous	Predators or filter feeders
Ratfishes 	Paired fins, placoid scales, one pair of gill slits covered by flap of tissue, deep water	Cartilaginous	Grinding plates to feed on bottom invertebrates	Oviparous	Predators of bottom invertebrates
Coelocanths 	Paired lobe-fins, large scales, gills covered by operculum, deep water	Bony	Teeth in jaws to capture prey	Ovoviviparous	Predators
Bony fishes 	Paired fins, cycloid or ctenoid scales (absent in some), gills covered by operculum, marine and fresh water	Bony	Teeth in jaws to capture prey or graze or gill rakers to filter plankton	Oviparous, ovoviviparous, viviparous	Predators, grazers, or filter feeders