Ichthyology

The Study of Fish

FISH: the members of a single species

FISHES: more than one species of fish

What are fish?

- Aquatic Vertebrates that have fins (for movement), scales (for protection), and gills (for gas exchange).
- Any of a large group of cold-blooded, finned aquatic vertebrates.
- Extant fish are divided into "three classes."
  - I. AGNATHA, primitive jawless fish.
    - Lampreys
    - Hagfish
  - II. CHONDRICHTHYES, the jawed fish with cartilaginous skeletons.
  - III. OSTEICHTHYES, fish with bony skeletons.
- There are exceptions to every rule with fish…
  - ie: Some no scales

Evolution

- Earliest fish appear in the fossil record ~540 mya.
  - Had bodies that were "armored" with bony plates.
  - They were jawless.
- Devonian period is often called the "Age of Fishes".
  - Fish ruled the seas during this period.
  - They were jawless, but many of them had less armor.

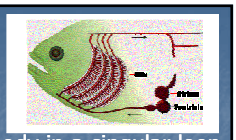
Evolution

- Jaws evolved late in the Devonian
  - Jaws were accompanied by the formation of paired pectoral fins and pelvic fins.
  - Fins gave more control over movement.
  - Jaws allowed a wider variety of foods to be eaten as well as greater protection/defense mechanisms through biting.
- Even later came the modern fish
  - Some with a skeleton made up of resilient, strong cartilage.
  - Some with skeletons made of true bone.

Respiration

- Most exchange gases by using gills
  - Feathery filaments with fine capilaries providing a large surface area.
  - Pull oxygen rich water in through their mouths and pumps it over their gills and then pumps the oxygen deficient water out over the gill slits in the sides of the pharynx.
    - Most have one gill slit on each side of the body hidden beneath the operculum (a protective bony covering.)
      - Sharks and lampreys have more than one.
  - Lungfish have specialized organs that serve as lungs.
    - These allow them to survive in oxygen poor water or areas where water dries up often.
    - (A tube brings air into the organ through the mouth.)

Circulation



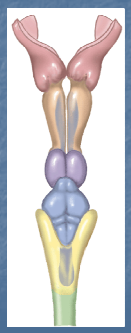
- Closed circulatory system
- Heart pumps blood around the body in a singular loop.
- Heart has 4 chambers
  - Sinus venosus
    - Thin walled sac that collects blood from the body
  - Atrium
    - Large muscular one-way cavity for blood that is about to enter the ventricle.
  - Ventricle
    - Thick walled muscular chamber that actually does the pumping.
    - Pumps blood into the Conus arteriosus
  - Conus arteriosus
    - Large muscular tube that connects to the aorta.
      - Aorta moves blood to the fish gills.

Excretion

- Most rid themselves of nitrogenous wastes in the formation of ammonia.
- Some wastes diffuse through the gills
- Other wastes are removed via kidneys.
  - Kidneys control the amount of water in the bodies.

Response

- Well developed nervous systems.
- Brain
  - Olfactory bulbs: most anterior, connected to the cerebrum
  - Cerebrum: Sense of smell
    - In most vertebrates this is not the function, instead it usually is responsible for voluntary activities.
  - Optic Lobe: process information from the eyes
  - Cerebellum: coordinates body movements
  - Medulla oblongata: controls internal organ functions and maintains balance.



Response

- Ears: Do not hear sounds; located within their bodies; lets them feel their surroundings. Sound vibrations transmit from the water through the fish's body to its internal ears.
  - The ears are divided into two sections, an upper section (pars superior) and a lower section (utriculus)
    - The pars superior is divided into three semicircular canals and give the fish its sense of balance. It is fluid-filled with sensory hairs. The sensory hairs detect the rotational acceleration of the fluid. The canals are arranged so that one gives yaw, another pitch, and the last- roll.
    - The utriculus gives the fish its ability to "hear". It has two large otoliths which vibrate with the sound and stimulate surrounding hair cells.

Response

- Lateral line: receives signals stimulated in a sequence, and gives the fish much more information and short-range prey detection "the sense of distant touch".
- The organ responsible for this is the neuromast, a cluster of hair cells which have their hairs linked in a glob of jelly known as 'cupala'.
  - All fish posses free neuromasts, which come in contact directly with the water. These are arranged linearly and form the fishes lateral lines.
  - A free neuromast gives the fish directional input. Most fish have a series of neuromasts not in direct contact with the water.

Response

- Eye: Most have well developed eyes and color vision. Some can see in extremely dim light.
  - Their lenses are perfectly spherical
    - which enables them to see underwater because it has a higher refractive index to help them focus. They focus by moving the lens in and out instead of stretching it like we do.
  - They cannot dilate or contract their pupils because the lens bulges through the iris.
  - As the depth at which fish are found increases, the eye sizes increase in order to gather the dimmer light.
    - This process continues until the end of the photic zone, when eye size drops off as their is no light to see with.
  - Nocturnal fish tend to have larger eyes then diurnal fish.
  - Some fish have a special eye structure known as the Tapetum lucidum, which amplifies the incoming light.

Response

- Chemo receptors: Sense of taste and smell
  - They have taste buds on their lips, tongue, and all over their mouths.
  - Barbels: whiskers that have taste structures.
    - This allows them to taste prey before they even reach their mouths.
  - Fish have two nostrils on each side of their head
  - There is no connection between the nostrils and the throat.
  - The olfactory rosette: the organ that detects chemicals.
    - The size of the rosette is proportional to the fish's ability to smell.
    - Some fish (such as sharks, rays, eels, and salmon) can detect chemical levels as low as 1 part per billion.

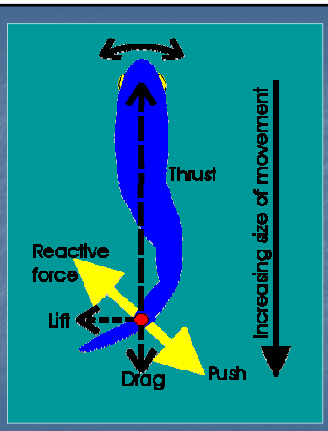
Response

- Sharks and rays posses special organs for detecting electrical potential.
- A set of pits comprise the electroreceptive system called the Ampullae of Lorenzini.
  - These are canals in the skin filled with a gelatin-like material that also contain sensory cells.
- Movements near the shark change the voltage drop, which allows the shark to sense other organisms nearby.
  - These sensors are so sensitive that if there were not any other distortions a shark could detect the heartbeat of a fish 500 miles away!
  - They can detect muscular contractions of struggling prey.
  - They can sense even the earth's magnetic field (which they use for navigation).

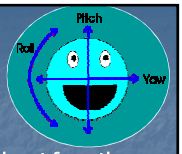
Movement

- The skull acts as a fulcrum,
- The vertebral column acts as levers that operate for the movement of the fish.
- The muscles provide the power for swimming and constitute up to 80% of the fish itself.
- The muscles are arranged in multiple directions (myomeres) that allow the fish to move in any direction.
- A sinusoidal wave (S-shaped wave) passes down from the head to the tail.
  - Made by alternately contracting paired muscle sets on either side of the backbone.
  - Creates backward force that propels the fish forward.

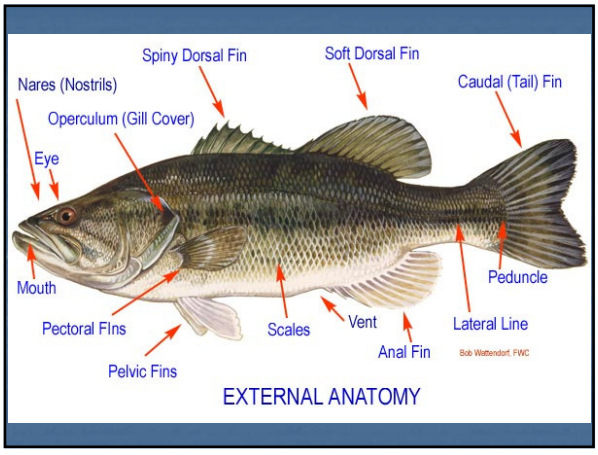
Movement



Fins and Motion



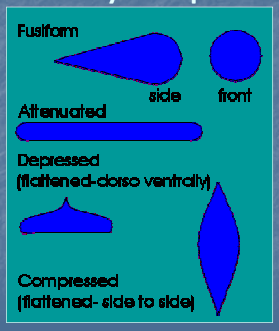
- The fins provide a platform to exert the thrust from the muscles onto the water.
- Fins also increase surface area of the tail that provides an extra boost of speed.
- Fins:
  - Caudal fin-- provides thrust, and control the fishes direction
  - Pectorals-- act mostly as rudders and hydroplanes to control yaw and pitch. Also act as very important brakes by causing drag.
  - Pelvic fins-- mostly controls pitch
  - Dorsal/anal-- control roll



Motion

- Streamlined body shapes reduce the amount of drag or friction as they move through the water.
- Body tissues are more dense than the surrounding water so…many bony fish have a gas filled swim bladder to adjust buoyancy and keep from sinking.
  - Swim bladder lies just ventrally to the backbone.

Body shapes



Feeding

- Carnivores, Herbivores, and Detritovores
- Parasites
- Filter feeders
- Digestion of food:
  - Food enters the mouth
  - Food passes into the esophagus
    - short tube
  - Food passes to the stomach
    - food is partially broken down
  - Some have pyloric cecae
    - fingerlike pouches that secrete digestive enzymes and absorb nutrients from digested food
  - Food passes to the intestine
    - completion of digestion and absorption
  - Undigested materials are removed through the anus

Reproduction

- Fish have three modes of reproduction depending on the method they care for their eggs.
  - Oviparous
  - Ovoviviparous
  - Viviparous

Reproduction

- Oviparous–
  - Lay undeveloped eggs
  - External fertilization (90% of bony fish)
  - Internal fertilization (some sharks and rays)
  - When born, the fish must first go through a larval stage for growth before they transform into the adult stage. In this larval stage, they must fend for themselves in obtaining food and avoiding predation.
  - Millions of eggs must be produced in order for the parent to successfully produce offspring.

Reproduction

- Ovoviviparous-
  - Internal development- without direct maternal nourishment
    - The eggs develop inside the mother's body, and are nourished by food stored in a yolk sac to which it is attached.
    - Young are born after the yolk sac has been used and they can swim on their own.
  - Advanced at birth (most sharks + rays)
  - Larval birth (some scorpeaniforms- rockfish)

Reproduction

- Viviparous-
  - Internal development
  - Direct nourishment from mother
  - Fully advanced at birth (some sharks):
    - Truly "Live Bearing"

Hermaphroditic Fish

- Some fish individuals are both males and females, either simultaneously or sequentially.
- About 21 families of fish are hermaphrodites.
- Simultaneous hermaphrodite:
  - They can spawn with any individual encountered
  - Members of the fish family Salmoniformes (eg salmon) and Serranidae (hamlets) are simultaneous hermaphrodites.
- Sequential hermaphrodite:
  - Species whose individuals may change sex at some time in their life.
  - They may change from being males to females (protandry) or females to males (protogyny).

Hermaphroditic Fish

- An example of protandry is found in anemone fish. The fishes live with anemones in a symbiotic relationship. Groups of fishes will live with one anemone, and will not switch anemones. Only the two largest will mate; the largest female and the second largest, the male. With the female being the largest, she can produce the most eggs. When the female dies, the largest male will change sexes and become the female. The rest of the fish are immature males.
- A classic example of protogyny is found in the wrasses and parrot fishes. The males in these species form harems, with one large male sequestering and defending a group of smaller females. The male enjoys spectacular reproductive success, as it has many females to mate with. The females also enjoy a limited reproductive success, producing as many eggs as they can, all fertilized by the one male.

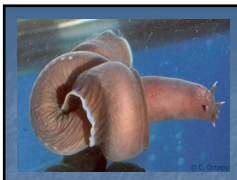
Characteristics- agnatha

- Primitive
- No jaws
- No true teeth
- Cartilaginous skeleton
- Scale-less skin
- Oral sucker in place of jaws
- Predators and filter feeders
- Anticoagulating saliva
- Live in fresh and salt water
- Some anadromous- spend lives in marine water, but migrate to fresh water to breed.
  - Catadromous: live in fresh water and migrate to marine water for breeding.
- They lack vertebrae
- Keep their notochords as adults.

Agnatha- Lampreys

- Head has a circular sucking disk and a round mouth in the center.
- Filter feeders as larvae
- Parasites as adults.
  - Adult lampreys attach themselves to fishes, whales, and dolphins.
  - They scrape away at the skin with small toothlike structures.
  - It then sucks up the tissues and body fluids of its host.

Agnatha- Lampreys



Agnatha- Hagfish

- Hagfishes have pinkish gray, wormlike bodies and four or six short tentacles around their mouths.
- They lack eyes, but have light-detecting sensors scattered around their bodies.
- They feed on dead and dying fish by using a toothed tongue to scrape a hole into the fish's side.
- Secrete immense amounts of slime
- Have 6 hearts
- Tie themselves into knots
- Only fish with an open circulatory system

Characteristics- Chondrichthyes

- Sharks, skates, rays, sawfish, chimera
- From the Greek term "Chondros" meaning cartilage
- Cartilaginous skeleton
- Skin covered with denticles, not scales
- Five to seven gill slits per side
- No swim bladder
- Internal fertilization
- Spiral valve intestines
- Five to seven gill arches

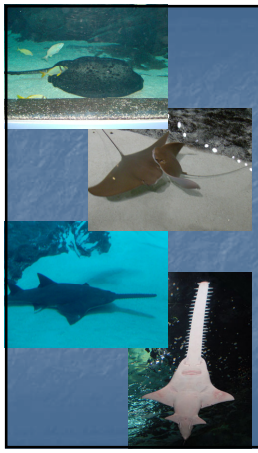
Sharks

- ~350 living species
- Large curved tails
- Torpedo shaped bodies
- Rounded snouts
- Mouth "underneath" or on the ventral side.
- Cartilaginous jaws, loosely attached lower jaws
- Many sharks have thousands of teeth arranged in 6-20 rows. (~3000 at a time; 20000 in a lifetime)

Sharks

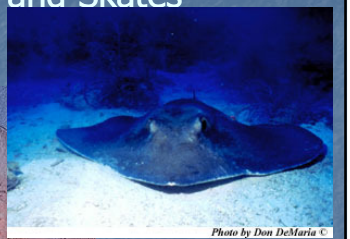
- Basking shark
- Nurse Shark

Skates and Rays



- There are about 100 species of skates and about 240 species of rays.
- Skates and rays glide through the sea with large, wing-like pectoral fins.
- Many skates and rays cover themselves with sand and rest on the ocean floor.
- Most skates and rays have bodies that are flattened from top to bottom.
- They have large pectoral fins, often called wings, are attached to the head.
- Skates and rays have five pairs of gill slits.
- The tails are often slender and whip-like.
- Skates and bottom-dwelling rays take in water through openings, called spiracles, at the top of the head.
- The sawfish, found in tropical waters, is a ray with an elongated snout that bears teeth on either side and resembles a double-edged saw.

Rays and Skates



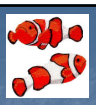
Skates or Rays?

- Skates live in cold seas; rays live in warm seas and in some tropical rivers.
- Skates are sluggish animals that either lie on the bottom or slowly cruise, looking for the clams, snails, shrimp, and other small animals that they eat. Rays are far more active, constantly moving about and often rolling and jumping along the ocean floor.
- Most rays have one or more sharp barbs (spines) on the ends of their tails; the barbs (spines) can inflict pain on humans. Sometimes these barbs (spines) contain poison. Skates do not have barbed (spined) tails, but some have organs along the sides of the tail that can produce an electric shock.
- Rays have no dorsal fins.

Dinner?

- Skates and rays are eaten throughout the world.
- They are used to make fertilizer and fish meal.
- The pectoral fins of some species are used to make imitation scallops in the United States.

Osteichthyes



- Their skeletons are made of hard calcified tissue called bone.
- Almost all living bony fishes are ray-finned fishes.
- "Ray-finned" refers to the slender bony spines, or rays, that are connected by a thin layer of skin to form the fins.
- The fleshy fins of lobe-finned fishes have support bones.
  - Some of these bones are jointed.
  - Includes lungfishes and the coelacanth.