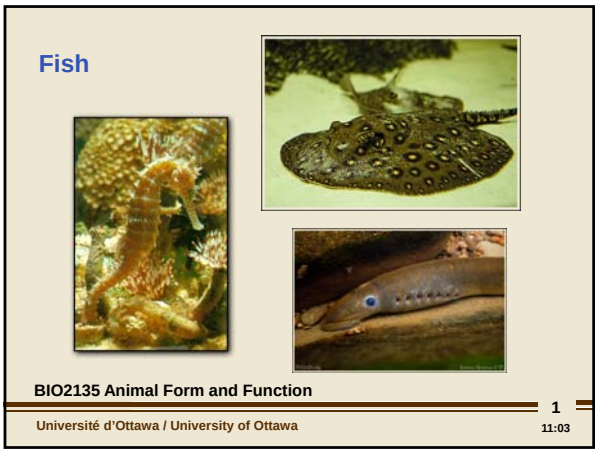
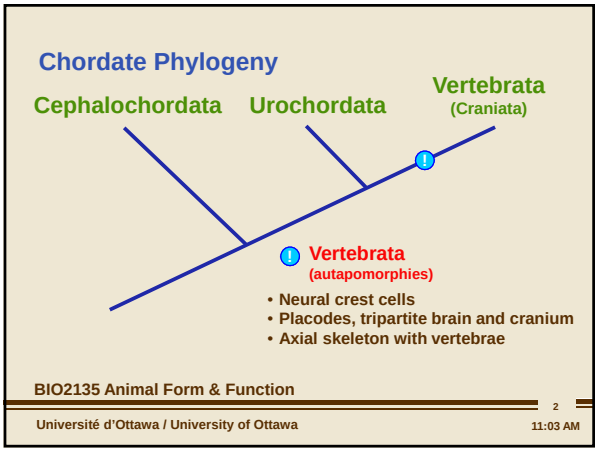
Fishes

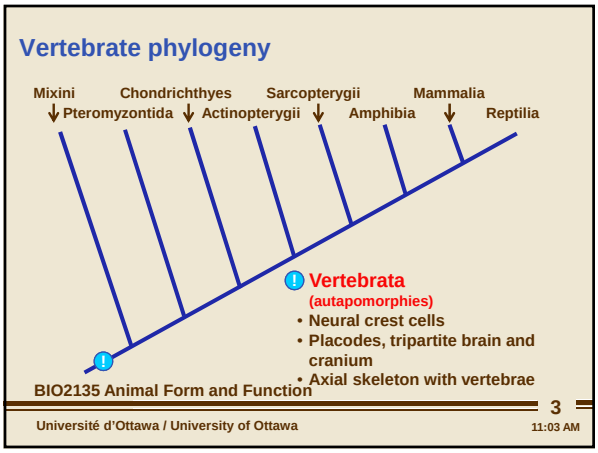


fish is a generic term that represent anything that swims that is a vertebrate



look at previous lecture!

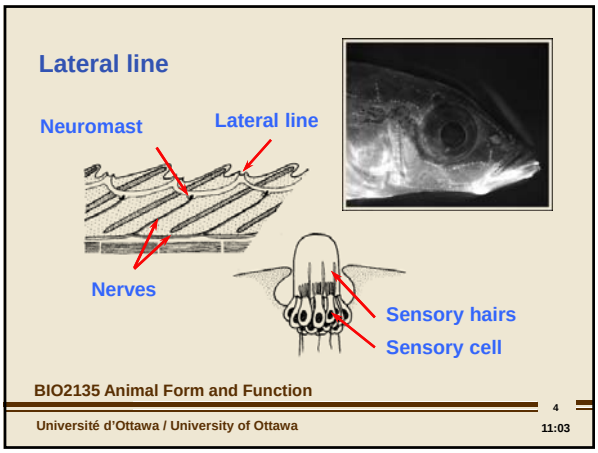
subphylum of chordata - have important role of induction



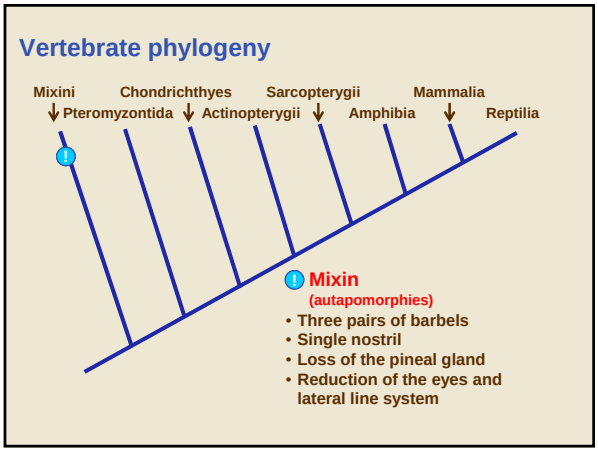
8 major classes/group that share the same ancestor with the notochord

introduced 2 agnathan - lamprey and hag fish
hag fish didnt have vetebrae
lamprey have vetebrae remnants in its tail
-looking at hox genes/genetic, they are present in the hag fish - end up with a animal that ha unique- has slime and knotting tail - got reduced
would have been divided into two groups - vertebrates and the hag fish and lamprey would join together
cyclostomata (no jaws) and gnathostomata (have jaws)

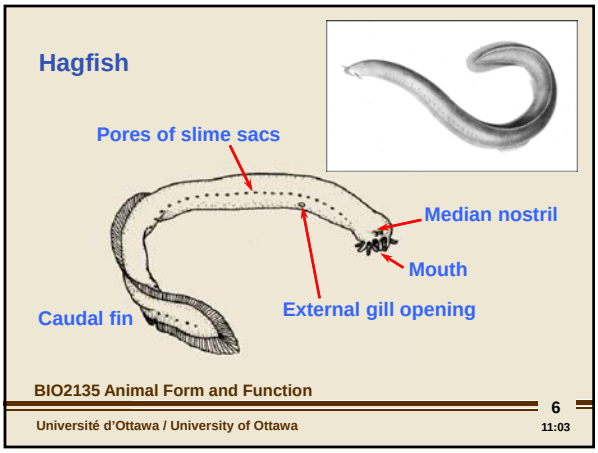
Fishes



organism has unique sensory structure - lateral line (line of dots down the side of the fish)
attached to the hind brain - vibration center
underneath the skin of the fish there is a hollow channel of water that contains water that opens to the outside by small pores
picks up changes in water pressure - vibration are transmitted through the water column and when they reach the lateral line - pressure causes the water inside the fish to jiggle - at the base there is a neuromast cell when neuromast cell jiggles it sends a signal
-a fish can tell when something is swimming towards it because the the lateral lines are concentrated at the head, motions compress the water around them

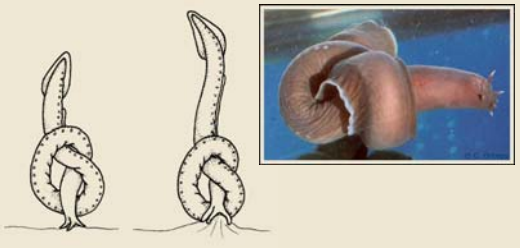


at the bottom of the tree -mixini
-hag fish and cousin lamprey (pteromyzontida) have no jaw, mouths are opened in circles
survivors of the first fish structures - heavily armored fish that had their mouths open for eating
they dont look anything like the first fish, they have adapted to the way they live
have three pairs of barbels - tentacle like structure that are extensions of the mouth that are sensory
-use this instead because they dont have a lateral line system or eyes, all sensory system is in the barbels
loss of pineal gland - gland that is on the back of the head light sensitive



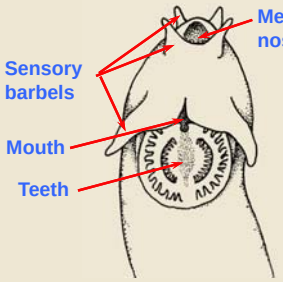
no lateral fins, worm and eel like, has dorsal fin that runs the length of the tail
swims by lateral undulations
it feeds at the bottom sediments of the ocean - feeds are carcasses of death fish that sink to the bottom of the ocean
have slime sacks/pores to secrete and cover entire body
epidermis is not tightly attached so it can be skinned really well
they burrow into the carcass and chew up decomposing debris
if you are feeding by attaching to an organism and you have no limbs there is an issue of how to hold on
-the structure of their mouth allow them to attach

Hagfish knotting behaviour



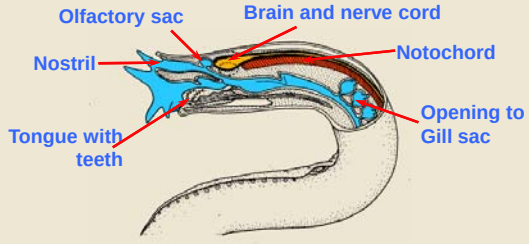
once they attach, they are able to tie themselves in a knot - extremely flexible
can slide the knot down their body
as they slide the knot down, it pulls the head up so they can tear of pieces to eat
have slime- defensive structure to escape predators
knotting behavior also helps with getting rid of slime

Hagfish head



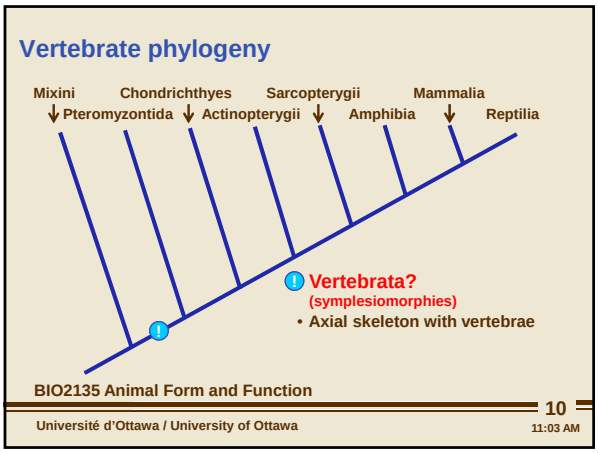
have a dental plate to attach to carcass
needs to be able to breathe, have single median nostril

Hagfish

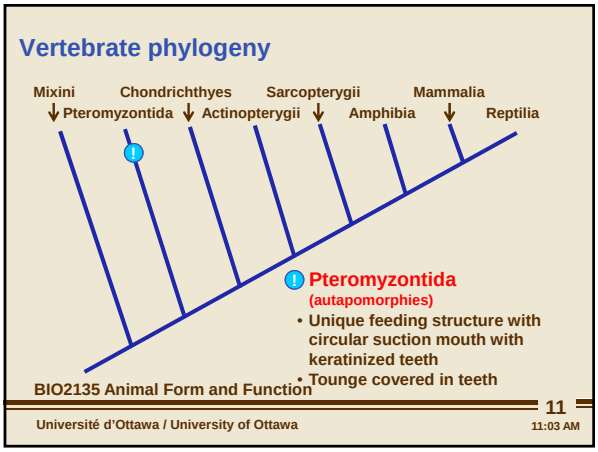


opening at the top of the head which give an alternate path for air in to respiratory system
ancestrally there were multiple pharyngeal slits down the side, but this organism internalized the opening
have pouches inside for breathing but one opening to the outside - never end up getting slime
covering the gas exchange system

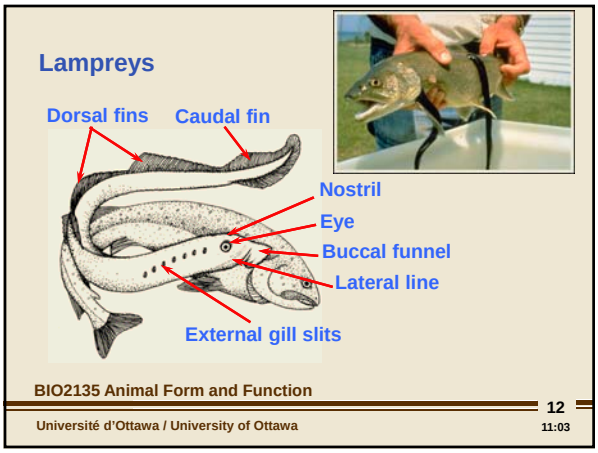
Fishes



vertebrata - axial skeleton with vertebrae
hag fish is not included
-their brains are protected by a cartilaginous cranium
craniata include all of these groups



lamprey - defined by their feeing structure
-unique structure that is designed for suction to drink their preys blood
all lampreys are fluid feeders
larval state lives in freshwater creek/stream- hatched from eggs that the adults made after swimming up river system



lamprey attaches itself onto the side of the host also has median nostril for breathing
mouth has been enlarged with buccal funnel - contains the feeding structure

Lamprey mouth

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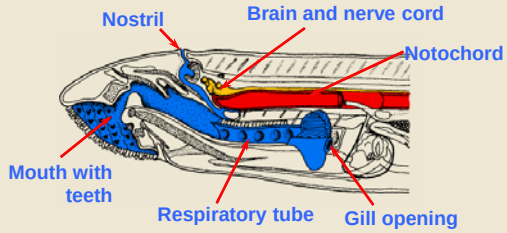
have crazy teeth
oral rim is held up with cartilage so it can stay open - have papillae all around (are sensory but) use them to grip onto the host for suction
in buccal funnel - has a lot of teeth, and the tongue also has teeth -keratinized (skin) teeth - on land there will be keratinized horns etc.
cuts into the host and eats the blood that comes out

Lamprey



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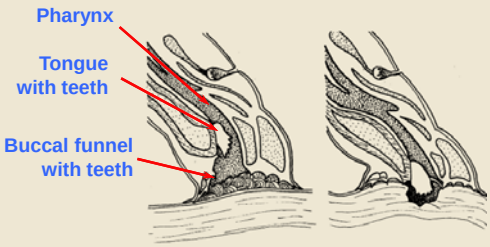
have attachement at the bottom and the nostril at the top that is going to give air to the respiratory surface inside the body
the skeleton is reduced, the notochord is there

Lampreys



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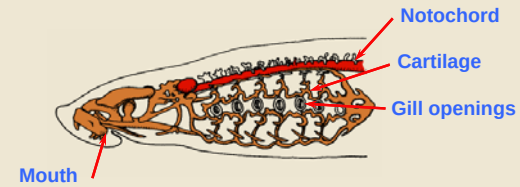
stays attached for long periods of time
there is suction so it can attach and then the tongue that will scratch at the skin
-tongue tears away the wound healing of the host - has anti-coagulants to make sure that blood stays liquid
see a circular scar on fishes and not a burrow because of the ways that the lamprey feeds

Fishes

Lamprey skeleton



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have a skeleton but mostly made of cartilage
end up with cartilaginous bars that hold up the opening between the gills

Agnatha



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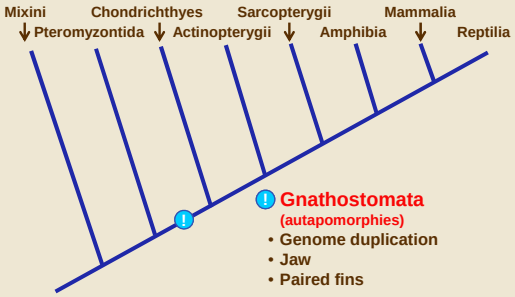
two groups called the agnatha because they have no jaws
hag fish are not vertebrates
but they are - when it developed knotting behavior - rudiment
lamprey has pieces of vertebrae
actually called the cyclostomata because of circular jaw - these are two variations on one animal
-blood feeder and bottom feeder

Vertebrate phylogeny



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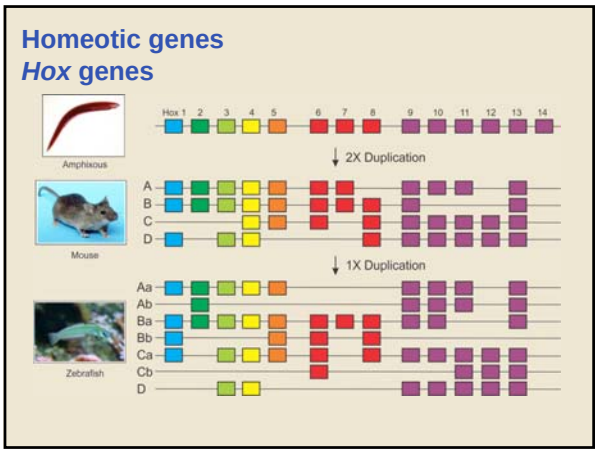
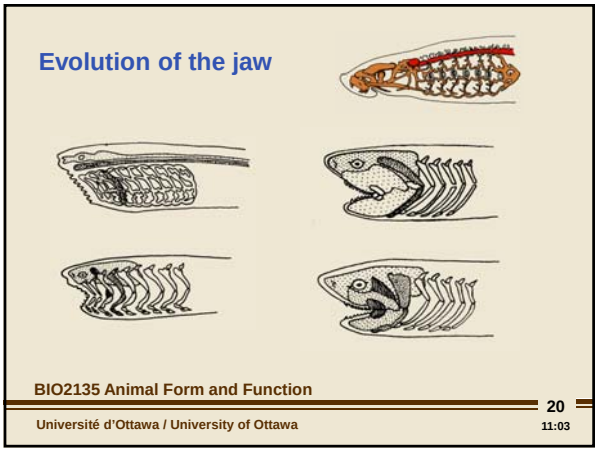
get presence of jaws
presence of paired fins at anterior and posterior of the organism important for swimming
pectral for the front and pelvic for the back - stabilizes the fish in all three directions
used to have medial fins
yah - going side ways
pitch - tipping up or down
roll - tipping side to side
-have a big tail in the back that causes undulation of the water, need to control the movement of the head
-hard to find prey or a mate and get away from predator is head is swinging around
-so get fins to stabilize like an airplane

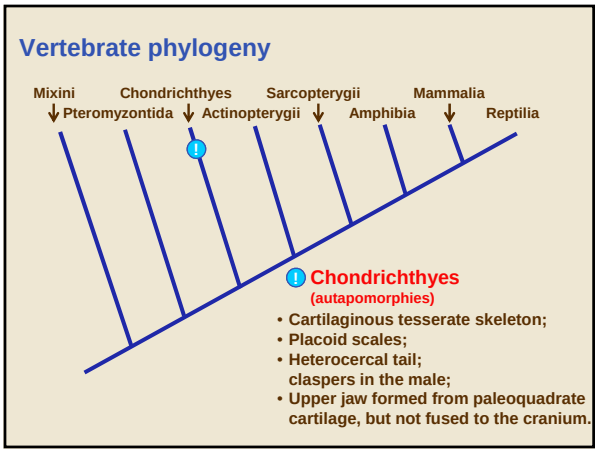
Fishes



genome duplication - look a hox genes that identify what parts of the body are made
-amiphioxis at the base of evolutionary tree- has one set of hox genes that are present
-urochordate- have the huge damage - a lot of genes are missing, things gets simplified
-always had something that is missing - looks like the hox genes that are found in sponges and cnidarians
-lack of genes werent terminal, survivors didnt have the patterning formulas that are found in later chordates
-reason for why they took on sessile existence
sharks had 2 rounds of duplications in the hox genes - instead of having one pair, there are two sets
-gnathostomes had 4 and up
-duplication of genomes is typically associated with plants (polyploidy)- but happens in this lineage
-happens before cyclostomata - because lamprey has 2X duplication as well
-have a back up copy- if there is a mutation in vital process in animal and you only have one set of genes - could be deadly
if you have mutation and have back up copy and only one gets mutated, still have the other that can do the function that is damaged - could have variation in the second function that could be passed to later generations
have one set that makes the body work and another set that can be tinkered with to try different things
the two rounds of genome duplication - created a whole amount of genetic variability - that give complexity of vertebrates
-humans have 4x duplication in hox genes - gave explosion of variations
there is a group of bony fish that go another round of duplication and have 8 copies of hox genes in their genome
-dominant vertebrate fish species on the planet, most abundant

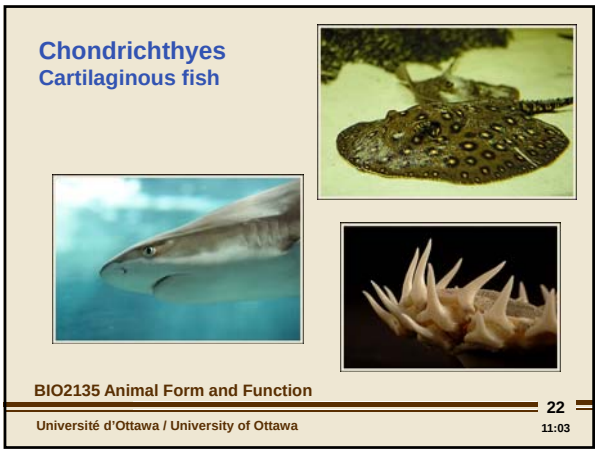


jaw was known as feeding structure
look at lamprey- 7 pharyngeal openings, and have cartilage in between to hold it open that allow water to move through
have gills arches that hold open the mouth that alternate down the organism
early chordates had cilia that move water across the pharyngeal cavity
when you get to the vertebrates - now have muscles that can move water across
originally swam with their mouth open to feed though the water to catch food (gets caught on the pharyngeal basket)
over time they would dig into get to the substrate to feed - to get food into the mouth, they would change the size of their buccal cavity - flex in the gill arches with a hinge in between
-dig their face into the substrate and change the shape to suck up food
now know innovation was not for feeding - made for a more efficient way to breathe
changing the size of the buccal cavity was to take in more water to push it towards the gills
-as gill arches flex and bend - it was pumping water
the first two gill arches bend and folded on themselves to make a closing structure to become a jaw
first two gill arches fold on themselves - first opening of the pharynx on the side gets lost
molecular biologist - identify the placoid cells - induce the ectoderm to make gill arches (makes a piece of cartilage and a muscle attached to it so arch can bend)
find the expression of the hinge element expressed in all gill arches - placoids all used for respiration
same gene in lamprey, but dont turn it on -not expressed- never bends and mouth stays opens
-lamprey got rid of the hinge to be able to suck on the prey (reduction!!)

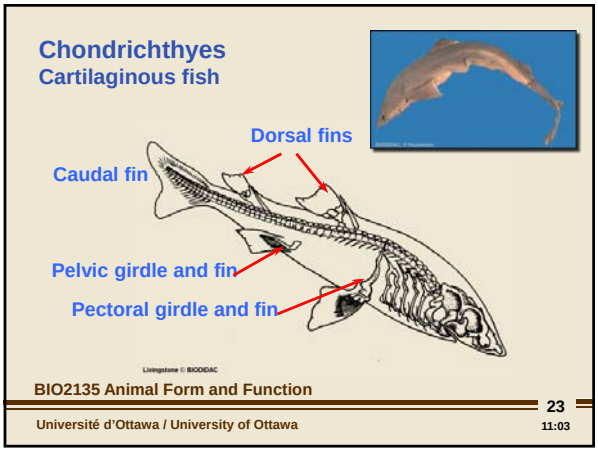


shark! - have cartilaginous tesserate skeleton
unique set of scales on the skin
heterocercal tail
males have special claspers to hold onto female to mate
upper piece of the jaw is not attached to the head
after sharks, top jaw will always be attached to the head
bottom jaw will be mobile

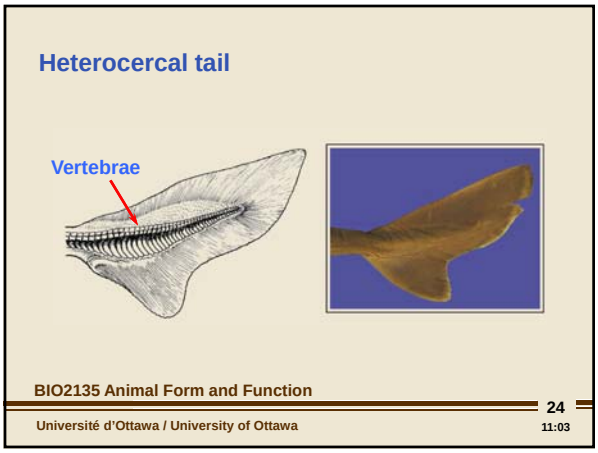
Fishes



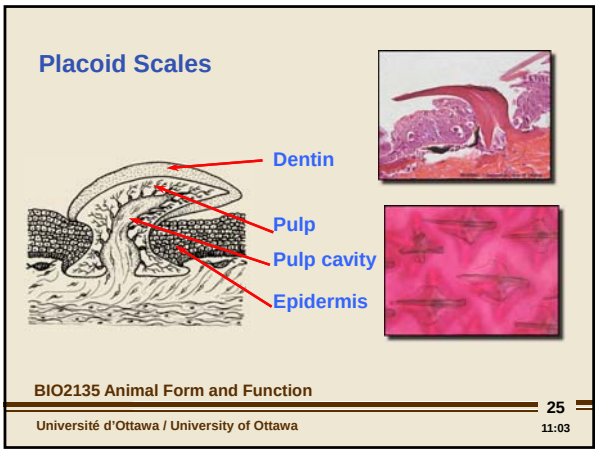
sharks, rays, fresh water survivors that move back to the marine environment after permean and celurean extinction where most fishes disappear
-bony and cartilaginous fish
cartilaginous bone is not a primitive condition
-less dense than calcified bones so buoyancy is much better
-calciferous will sink much faster
one of the most threatened species - make shark fin soup
reproduction of species, female only produces 20 to 30 young, dont produce lots of eggs



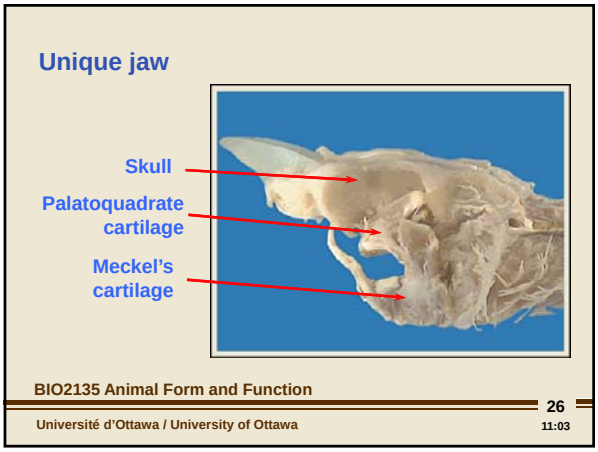
cartilaginous skeleton combines with pelvic and pectoral girdles
inside girdles are bones
bones are support structure that do not attach to the main axil skeleton
fins are attached to the muscular body wall, no connection



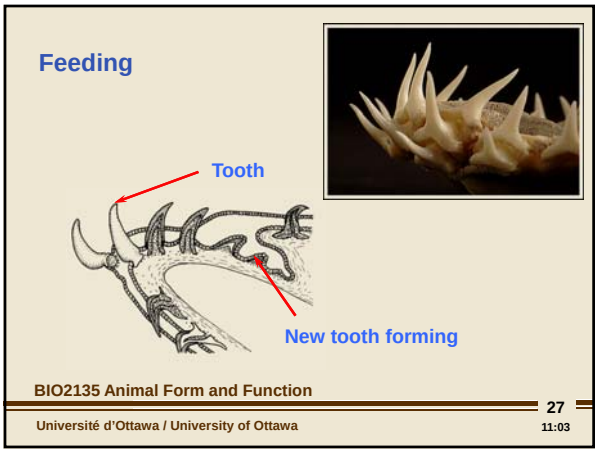
major structure - heterocercal tail
have vertebrae that extends up into the tail - upper lobe is bigger than bottom
top edge is always leading and bottom edges is following
top pushes down on the water column -always downward propulsive force on the back fin - makes the front move up, so it counters gravity and moves up in the water column



have adaptation on the surface - scales
-secreted by the epidermal layer
bone occurs in two ways:
body mass bone
dermal bone
scales contains components of bone that is referred to dentin and a pulpy core - composition of calcium commonly found in teeth
-embedded just in the epidermis, not deeply rooted, have a spine on them that point backwards
another adaptation to swimming
smooth surface in smooth water -laminar flow between the surface
-creates an important friction that allows lifts - like plane
sharkes dont want that because it causes them to slow down - scales used to make micro-turbulence - prevents makes non-laminar water so that there wont be resistance in swimming
more propulsive force for swimming



upper and lower jaw still articulation with the head,
not attached to the skull so able to extend and move the jaw to capture prey



teeth are larger version of scales
-since it is embedded in the epidermal layer and not in bone - when it eat, teeth can just fall out
teeth that clamp down are not meant to cut pieces - just meant to hold on to prey
have epidermal pocket at the back on the jaw that will make new teeth and move it to the front of the teeth

Vertebrate digestive system

- Pharynx
  - Salivary glands
- Esophagous
- Stomach
- Small intestine
  - Pancreas
- Liver
  - Gall Bladder
- Large intestine
- Rectum

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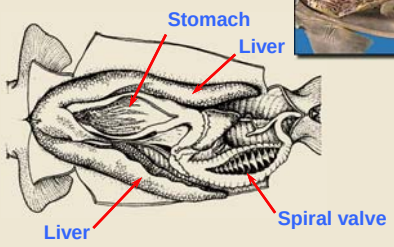
takes food and brings it to the digestive tract - digestive tract has different components that will process food in different ways
-pharynx are the muscles in the mouth to move it to the digestive system -
-used to have food get stuck in mucus before swallowing
-now have pharynx that can make a swallowing motion and salivary glands that could be used in pre-digestion
sometimes pharynx is next to the stomach or it will have esophagous - tube that connects pharynx to stomach
-stomach next major site for digestion - have acidity-
-move to small intestine for alkaline digestion - gets its enzymes from the pancreas
(hepatic cecum in chordates) - liver is now going to appear from now on
involved in intermediary metabolism - deaminate amino acids to make carbon back bone chains, excess carbon chains get stored into glycogen in liver - important metabolic power house
blood from digestive tract goes to the liver before going to the rest of the body - carries all of the nutrients and toxins where liver will detoxify them
liver also produce bile and sent it to gall bladder
-emulsifier for fats that are in meal
large intestine- last chance of absorption, concentrate the food
and rectum for pooping out the indigestible food

Digestive system



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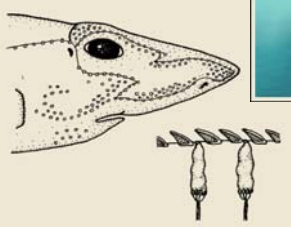
liver is massive in the shark
so big because it produces shark oil - squalene
-body of a shark is oily - have extremely oily tissue
another solution for buoyancy - to swim without sinking
oil is lighter then water- less likely to sink if there is lots of oil compared to the rest of the body
in intestine - have spiral valve *** - eats on high energy stuff as a predator but has a short digestive tract needs to slow down digestion
-have wall of tissue that projects into the center of the intestine that winds around -food would spend more time in intestine to maximize amount of energy

Ampullae of Lorenzini



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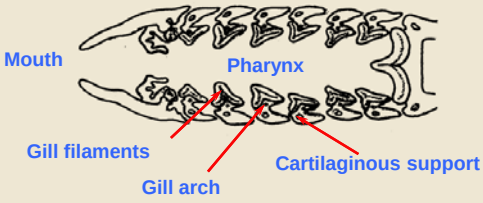
lateral line goes all the way through
also have new sensory structure -series of pores all over the skin
ampullae of Lorenzini - electricity detectors
-able to pick up electrical current of any organism in water - combines with vibration of motion to tell what is coming at them
ancestral sharks have no way of pumping water through the gills

Pharyngeal gills



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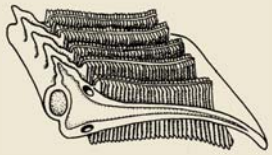
have to continue swimming with their mouth open
-ram ventilation - water moves into the mouth cavity, into the pharynx and across the gill silts and out
ancestral sharks were constantly swimming

Gill surface



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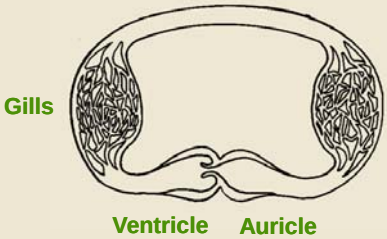
end up with gill filaments with bony projection so food doesnt fall through and an animal that constantly has to swim
fights neutral buoyancy with cartilage and urea, still need to move in order to swim
blood levels are really high in urea- not the most toxic, shark in salinity is hypertonic then water environment always gets the chance for water to diffuse in, surface of the gill will not allow urea to diffuse out
shark is constantly being inundated with water in the marine environment
kidney is present to get rid of urea
-high urea content would protect it in fresh water environment, urea would keep shark salty and gill surface would prevent it from leaving

Circulatory system



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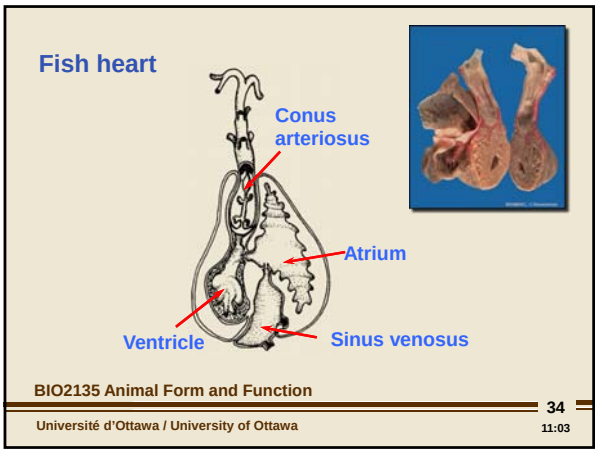
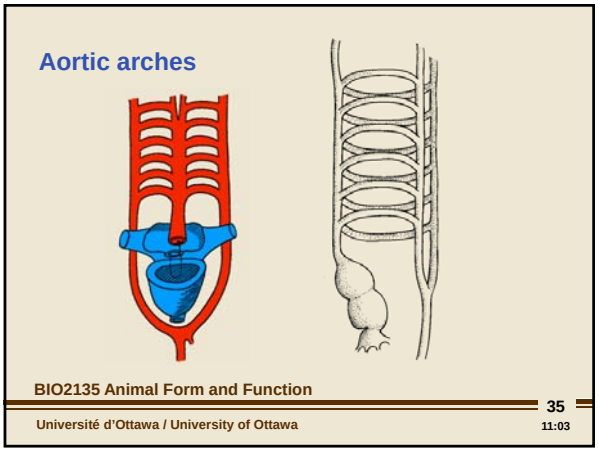
circulatory system- simple single loop, with heart
as it beats, sends blood to the gills where it gets aerated, gets distributed out the body where it provides nutrients to the various tissues before returning to the heart where then gets pumped back around again

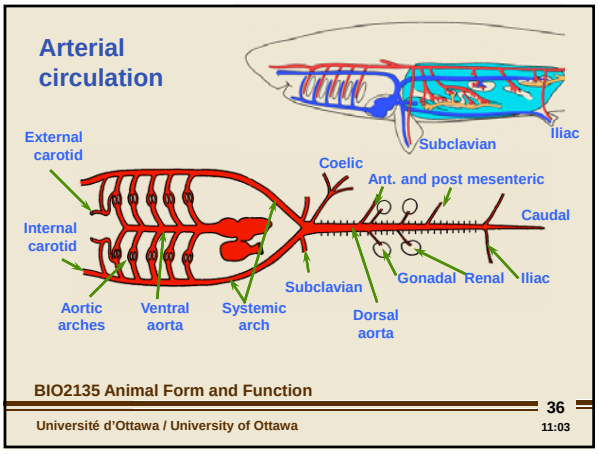
Fishes



large atrium gets the blood from the sinus venosa, sent into the ventrical and goes back out the conus arteriousus
conus - base of the arota - have series of opening that can pump blood to various parts of the body

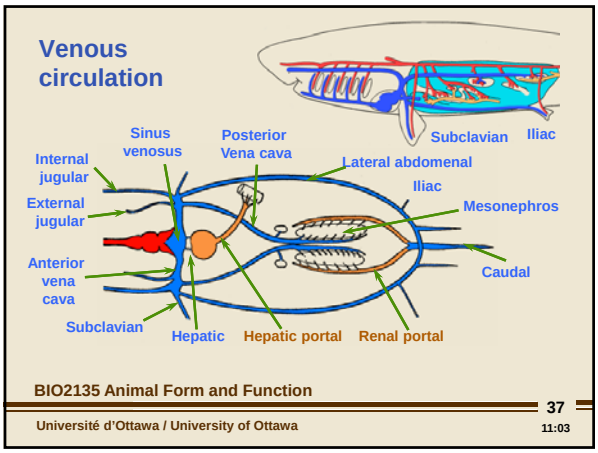


end up with 6 aortic arches that take blood to the top from the heart
-have systemic blood artery that move to the front and dorsal aorta to take blood to the back
vessels to bring blood back to the heart so system can continue

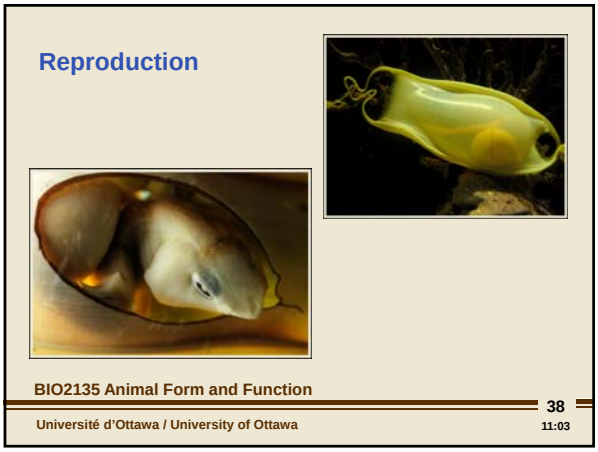


paired systemic arches move up to the anterior end of the shark
2 branches that go to the head (carotids- internal and external)
systemic arches are going to fuse to make the dorsal aorta to move to the back
branches that come off to supply all the pectoral girdles, pelvic, tail, the mesentaries, gonads, kidney and general body wall (subclavian, iliac, caudal, mesenteric, gonadal, renal and coelic)
as blood goes the dorsal aorta, also passes it to the fins and etc
main pattern that is seen
shark only have 5 major openings - remnant before the first arch called a spiracle that doesnt have air that goes through it
aortic arches decrease through time

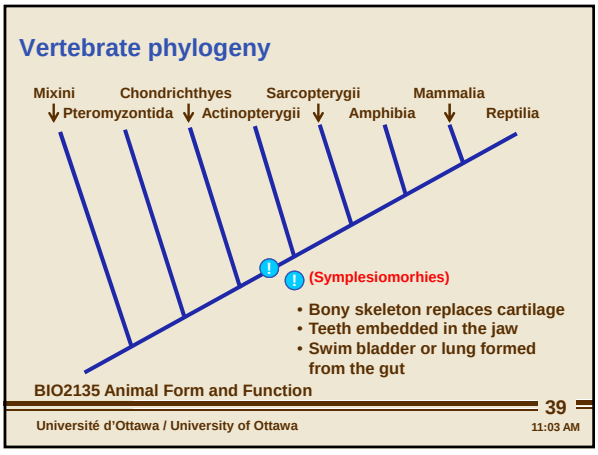
Fishes



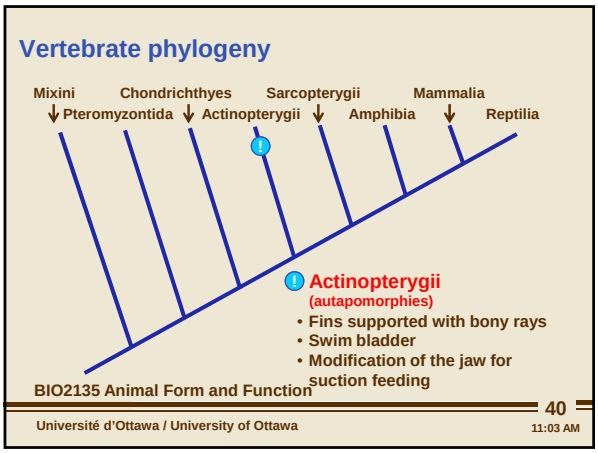
venous system- blood coming back is easy to understand from the front - jugular veins
blood is going to pool coming from the posterior in the sinus venosus before going back in the heart
have blood vessels that bring back the flood from the anterior appendages
-everything matches up, things that go to the fins have things that go back to the heart
-with liver causes some issue
-there is a blood vessel that goes from the intestine to the liver, have capillaries that are found in the intestine and the liver
every other blood vessel, a vein and an artery either has the capillaries that go to the tissue and have the heart as the destination or the origin
-these blood vessels have capillaries at both ends - portal veins because there are in between
liver detoxifies everything from the intestine - need capillaries on the gut to absorb from the intestine and need the capillaries in the liver to diffuse out the component to work on the nutrient rich blood
from the liver, the hepatic vein goes back into the sinus venosus
another shunt that occurs with the kidney - takes blood from the tail to the kidney, purifies it before putting it in a vein to go back to the heart
-two places to clean the blood
kidney deals with the high metabolism that is associated with the tail used for swimming
after swimming, tail has large amounts for nitrogenous waste that needs to be filtered - done by the kidney (blood is already high in urea, only kicks in when urea goes out of wack)



reproduction! sharks makes a mermaid's purse- takes an egg that is rich in yolk
places fertilized egg inside a leathery case and dig it underneath substrate
-organism turns the yolk into body mass (can take up to a year),
there are openings in the purse, when shark starts to grow and move, it will bring in water to get fresh oxygen and remove metabolic waste -emerges is a fully matured mature miniature shark
- have an organism that produces one offspring in one season - spend a lot of energy to mate and to make the purse
some sharks that are placental - the uterine wall makes yolk and nutrient to feed the embryo internally until baby is able to leave and feed for itself
other have eggs that hatches inside, instead of having a yolk, she keeps making eggs for mini shark to eat

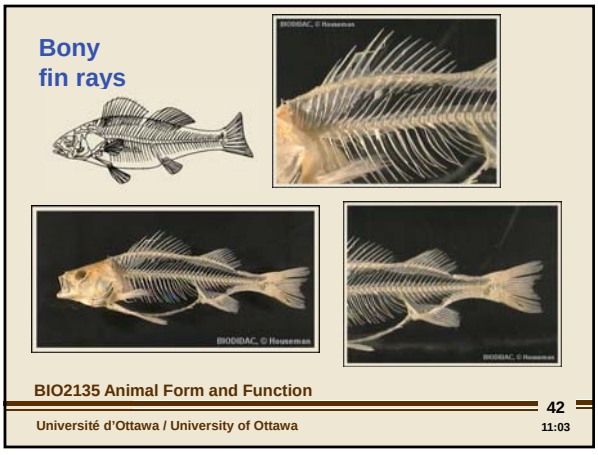


bony fish
3 major innovation
-replace cartilage with bone
-swim bladder/lung fold/out pocket of the digestive tract - new way to deal with neutral buoyancy
-teeth are now embedded in the jaw



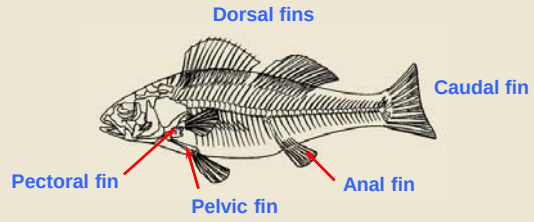
-also going to modify the fins
-shark fin was muscular, attached to the body wall, have very little maneuverability
-organism is now going to support their fins with needle like bones (actinpterygii)
- in sarcopterygii, going to have actual bone in fins (lobed fins)
-going to have a jaw associated with unique feeding

group that undergoes 3rd round of duplication, group that is diversifying the fastest



instead of having paddle like fins, now have needle like bones that fish uses to swim with
tail become homocercal
same size on top and bottom
group has perfected neutral buoyancy - can easily change their density to move up and down or stationary in water column
-tail becomes main propulsive element for fish

Osteichthyes skeleton



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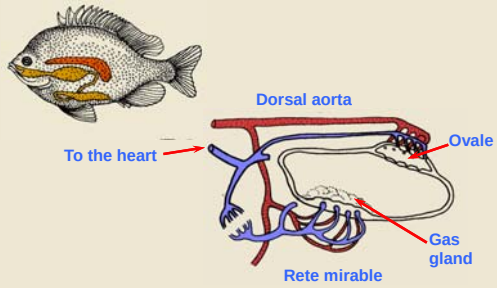
pectoral and pelvic fin have moved forward in the body and are attached to all the bones associated with the head region
smaller fins are for maneuvering

Swim bladder



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swim bladder is a bag of gas that is completely isolated from the air system
first sacs off the side of the gut are the ones known as lung, this bony fish have isolated them to make the swim bladder
-lungs turn into swim bladders and not the other way around
fish is going to use air to maintain its flotation in water
-deeper in water, means more pressure, so less air in the bag, meaning it would sink more
-bag has two capillary beds, as it sinks in the water column and it needs more air
rete mirable - transfers oxygen from blood to bladder - can sense water pressure and it is able to put the appropriate amount of air in to stabilize it
-as you move up in the water column need to remove air to re-stabilize, want to put excess oxygen back into the circulatory system
ovale - extract oxygen from bladder as you rise in water column, oxygen gets released off the surface of the gills
have instantaneous neutral buoyancy at any lever of the water
-
rete mirable has counter current exchange to fill up the swim bladder
blood vessels are moving into the rete mirable and out
-vessels dump oxygen into other vessel as it is leaving the rete mirable
-by the time it goes back to the body it will go back to 20%

Suction feeding

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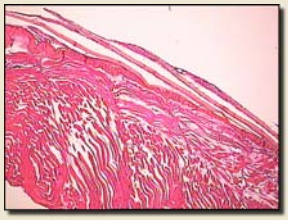
jaw highly modified for feeding- type of suction feeding - bones on the head are modified so when it opens it pulls water in - squeezes water into mouth and across gills
elaborated suction feeding, valve wave
if you are swimming forward you are creating a wave that compresses water - prey have lateral lines that are are going to detect motion and avoid predator
explosive way of eating - suction feeding
added in expanded bones and a membrane in between - lets them open their mouth wide for feeding
as it moves forward, it is sending and ultrasonic sound/vibration that warns its prey that it is coming, (pick it up by the lateral line system)
-suction allows prey to be capture before they escape
inside the mouth - one of the gill arches become a secondary jaw that has teeth that can hold onto prey

Fish integument



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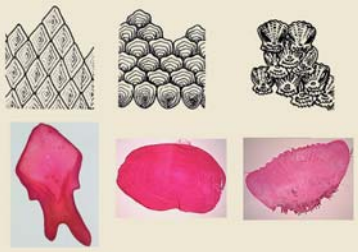
dermal bone turns into scales

-same function as in shark, create micro-turbulence on the surface on the fish to eliminate laminar flow, eliminate friction for better movement

Fish scales



Ganoid Cycloid Ctenoid

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3 different types of scales

-most primitive - ganoid scales - found only on ancient fish

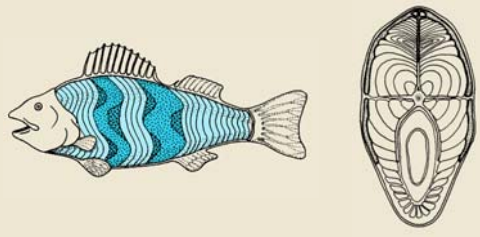
-very dense, over lapping and interlocking (similar to suit of armor) creates a lot of weight - get replaced by two types

-circular scales -cycloid

-ctenoid scales - has little teeth that are associated with the margin

all do the same thing - cancel out laminar flow

Trunk musculature



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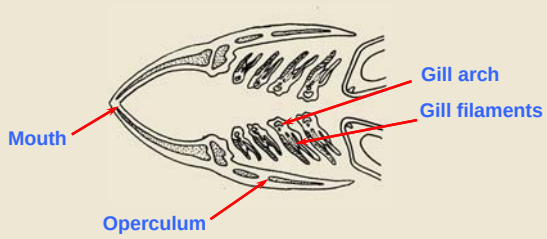
have a complex overlay of the myomere/muscles blocks that run the length of the body

overlap of the w-shaped myomeres that are in front of each other

-create 7 layers, so when it contracts, not the entire side contracts (gradual contractions that creates smooth swimming motion)

have small fins for hovering (pectoral fins) and tail in the back for main propulsive force

Opercular gills



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also able to breath when they are in one spot

-fish can hover in one place thanks to the swim bladder and maneuver in one place by using the pectoral fins

how do we get water over the gills? - with modification of the jaw, there is a operculum covering that covers the gills

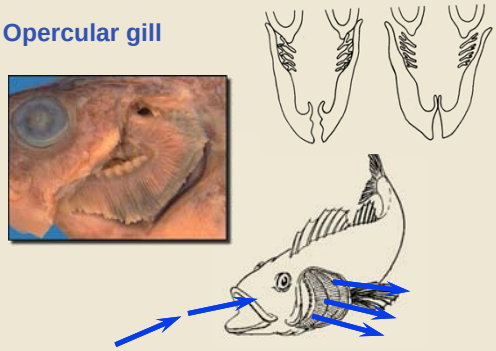
-can swing out and in to pull water across the gills

-mouth opens at the same time as operculum is out, creating a current based on the changes in the buccal cavity

-make an pumping mechanism - end up with a fish that hovers

-ex seahorse moves its tail to act like seaweed

Opercular gill



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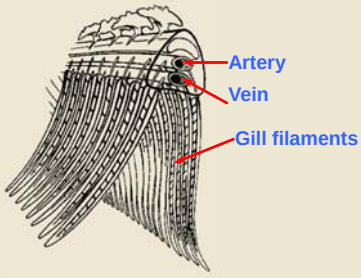
pumping water in at all times

Gill arch



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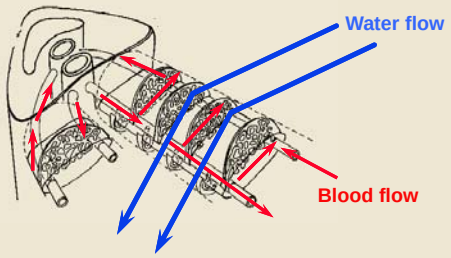
pumping water over the gill surface

-inside gill there is a artery and a vein that extends blood vessels into the gill lamellae (gill filaments)

Counter current exchange



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the gill filaments are set up with disk like structures, where blood is following a path that is unidirectional
-comes in from the blood vessel, across and into the next blood vessel
-vein is going to take it to the heart
water is flowing over the disks in the opposite direction
-counter current exchange - when you have two fluids in close proximity to each other and they are moving in opposite direction, the exchange is enhanced
-the fluid that is going across the gills are saturated in oxygen, blood moving in the opposite direction is low in oxygen because it just went through the body and dumping out its oxygen to the tissues

Concurrent exchange

- Fluids flow in the same direction
- equilibrium between the two fluids occurs

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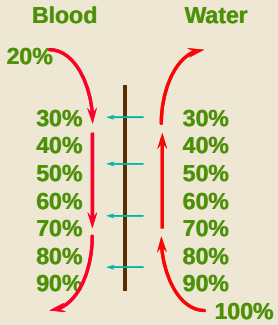
can happen in two ways (opposite direction or same direction)
concurrent flow
-blood at 20% and water at 100%
-at early point in the gills when the solutions are next to each other the water will be highly saturated and blood will be low and get oxygen diffusing between the two fluids
-water slowly loses oxygen, and its saturation levels got down and saturation of the bloods goes up
-still have exchange - when concentration is the same in both water and blood, it will stop because there is no more concentration gradient to get the oxygen
-end up with inefficient system because there is still oxygen in the water that could be used

Counter Current Exchange

- Fluids flow in the opposite directions
- Equilibrium between the two fluids never occurs



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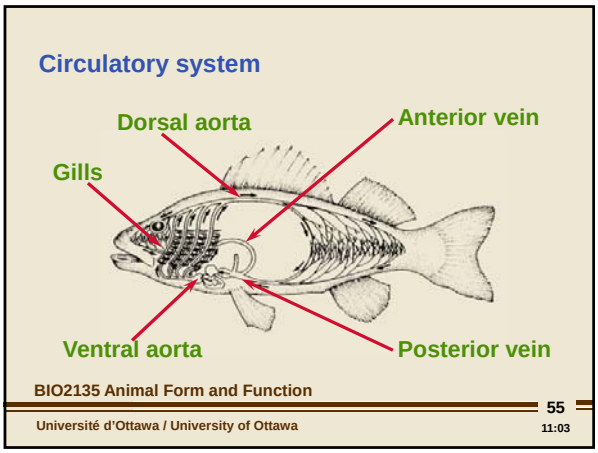
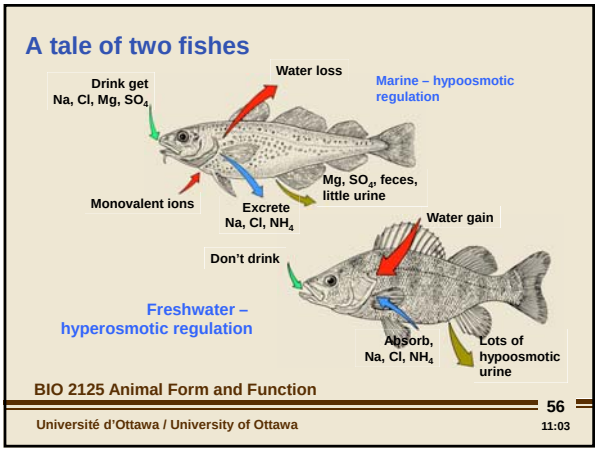
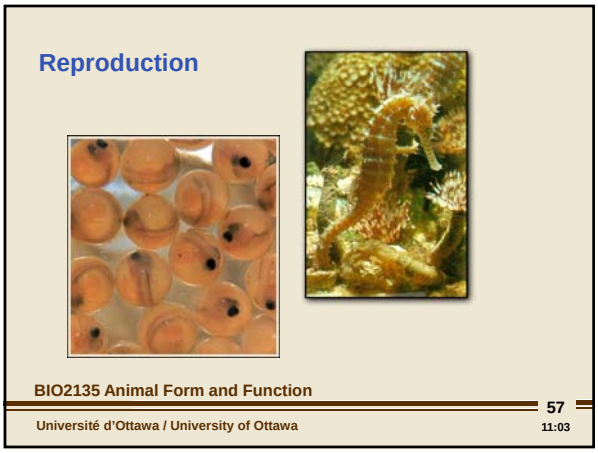
in counter current
-since it is going in opposite directions, water that comes in saturated will meet up with bloods thats at 100, but then meets up with blood that is at 90, and exchange will occur
-blood is always low in oxygen as it meets up with the water
-as water is low in saturation and it comes in contact with the bloods, exchange can still happen
-having counter current flow, able to extract the oxygen more effectively



all of this is hooked in a circulatory system that has a two chambered heart (very simple to the shark)
-now have 4 aortic arches
there is a gradual reduction in the aortic arches

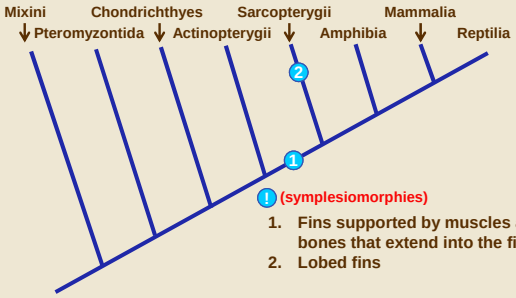


fishes have one issue, ancestry
in mass extinction that occur in the permean, fish were wiped out of the ocean
-fishes that came into the ocean came from fresh water
have an adaptation when they bring with them when fishes go back to the oceans.
when they move into fresh water- still get inundated with water
-fish scales give waterproofing, but gas exchange can still occur over the gills, meaning that water can diffuse into the system as well
-fish are hyperosmotic in fresh water, their blood is saltier
over time, they evolved in fresh water by lowering the salinity of their blood, so going back to the ocean, they are going to be less salty, no longer isotonic - have the danger of losing water and minerals across the gills
have two solution
-a fresh water fish, will not drink any freshwater except for feeding - kidney is going to clean the blood, produce a lot of diluted urine to get rid of excess water, and recover the salts
-kidney is unable to keep up and fish starts losing minerals, not 100% effective to keep all the mineral inside- cells on the surface of the gills can take minerals from the water that move across them
-in marine, drinks a lot of water and will flood their systems - to conserve their water, will produce little urine
-now has sea water that is loaded with ions - the gills will excrete all the extra ions that come in
-gill surface in both fish are major osmoregulatory structures that allow them to survive
-some fish that moves between marine to fresh are able to switch their ions pumps in their gills



reproduction- majority of eggs are laid and males release large amounts of sperm of the surface of the eggs they get fertilized and a large amount of fish are born- opposite of the shark
seahorse- males get "pregnant"

Vertebrate phylogeny



! (symplesiomorphies)

1. Fins supported by muscles and bones that extend into the fin
2. Lobed fins

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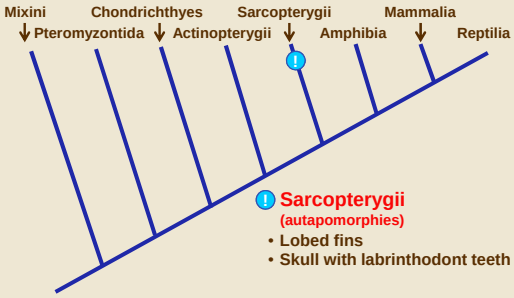
sarcopterygii - lobed fins

-fins are not supported by bony needle like structures, they are supported internally by harden bones

-reinforced paddles with bones inside

Vertebrate phylogeny



! Sarcopterygii
(autapomorphies)

- Lobed fins
- Skull with labrinthodont teeth

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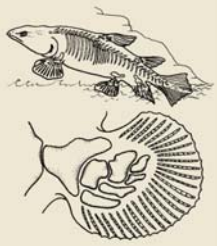
Transition to land (lobe fins)



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if we look inside those fins, can see the tetrapod limb that is coming

-there is a base bone that is attached to the body and a paired set of bones, and a smaller set of bones that are attached to it

-all fresh water that paddle along the bottom

-these fish all able to use their fins to push their heads out of the water and breath air into a bag (lung) when lakes were drying out and there was no oxygen and the earth was warming up

-dont have swim bladders

-fins also allow them to crawl up on land - if moist enough, they were able to move to a larger lake

-gradual shift in locomotion - come in contact with insects, fish were able to feed on flightless insects

Fishes

Lungfish

Australian lungfish

African lungfish

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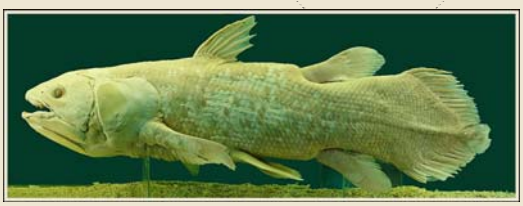
two main survivors- called lung fish - found in the southern hemisphere
-does less swimming and burrows in mud to sleep when conditions are not ideal
-African makes a mucilaginous cocoon to protect it from defecation when it is in dry mud
these fishes have three chambered hearts
-have two circulatory circuits, one to the lungs and the other for the rest of the body
amphibians that descend from them are going to be fresh water as well

Coelocanth



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coelocanth- had muscular lobed fins that were uses like a muscular gate - make a walking motion
almost blind and uses electrical currents to find food, points its nose down and has its tail up for eating
-spends most of its time in a cave