

Phanerozoic - Paleozoic

An explanation for the Cambrian explosion

- Snowball earth
- Burrowing
- Shelled arms race
- Developmental – *hox* genes

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The cambrian said that contrary to what everyone though the most diverse assemblage of animals appeared at the beginning of multicellular life and ever since the number of different body plans has been changing over time.

Late Proterozoic 650 Ma

- Snowball earth
- Slushball earth

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Before phanarozotic, a large block of land mass (bare rock) is straddling the equator. Because it is rock it doesn't readily absorb and hold onto heat. It actually tends to reflect most of the suns energy. That means that the planted was cooler. The rocks was also eroding, which was loading calcium and silica into the oceans. We can see this enormous sedimentation in samples and determine that once plants came up onto land it would be impossible to get erosion liket hat again. In this process carbon dioxide was also being taken out of the air, taking the planets warm blanket off. There are also indications that more methane was converted to carbon dioxide which was being taken out. This was an even better green house gas so planet got even colder creating ice masses. The levels of the oceans started to drop and the ice masses started to reflect solar energy. This was believed to hit a tipping point where the ice mass was like a series of dominos and the ice mass kept going until the whole thing was completely covered in ice. There could still be life in the oceans but other than that we dont have much of an idea. This is implicated as a rest point in the planet.


Early animal evolution

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There are 2 sets of fossils that pre date the cambrian

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Doushantuo fossils
590-565 Ma




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These look like little embryos in different states of division. There must have been something out there for which we don't have its fossils but we have its eggs.

Ediacaran fossils
580-542 Ma
(Mistaken point NFLD)



Protoanimals of Mistaken point
Australian footprints

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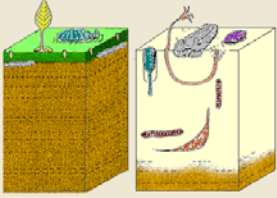
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Found in Newfoundland. Inside these fossils are impressions. You can see burrowing marks. They say that there were complex forms of life there. These are unusual because if you look at one branch it will have additional branchings. They are all exactly the same except a but bigger than each other.

Cambrian burrowers

- **Advantages**
 - Feeding
 - Anchorage
 - Protection



Ediacaran benthic zone Cambrian benthic zone

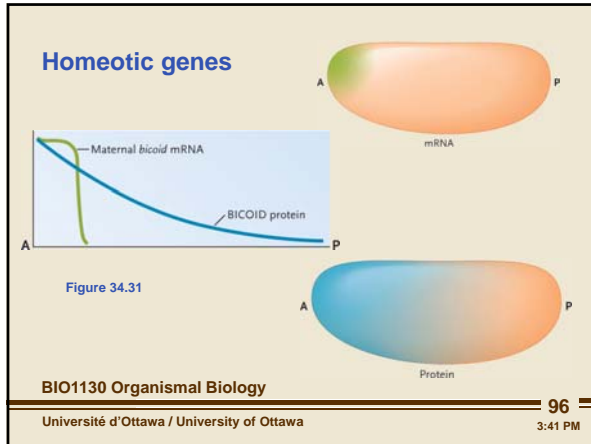
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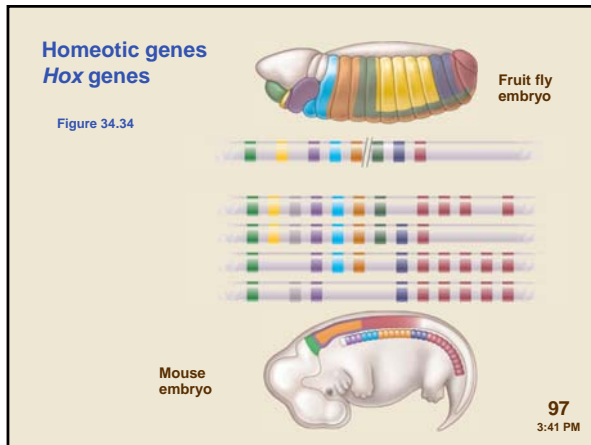
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Prior to the Cambrian the sediments on the ocean floor built up in a slim or biofilm of organic material over time. All of the sudden on the bottom of the cambrian ocean that stopped happening. They believe the first animals were able to break through this organic material. We end up thinking the mollusks found a way to start breaking through this material. Then you get the burrowers that were going in and eating as well. Burrowing was a great advantage for these animals for protection and tapping into a new food source.

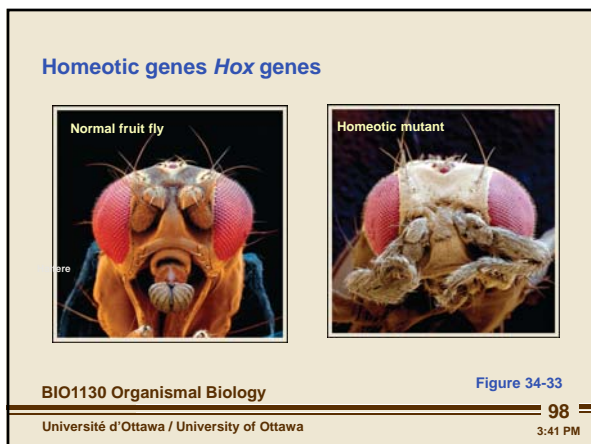
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Basically there is a set of transcription factors which determine what genes will be turned on and off. The site for the production of the mRNA that's associated with these is at the front. When it is released it diffuses down the length of the organism. The concentration is very high at the region where it is produced and declines as it goes down. There are other factors that are produced at the posterior end as well. The cells get different messages of what genes to turn on or off. Depending on where the cell is position in the embryo it will get a signal to turn on the appropriate genes for where it is located. When the cell gets the signal it is then committed to it. This is key because up until now if we don't have genetic control for pattern then we can't have it and simple structures are repeated over and over.

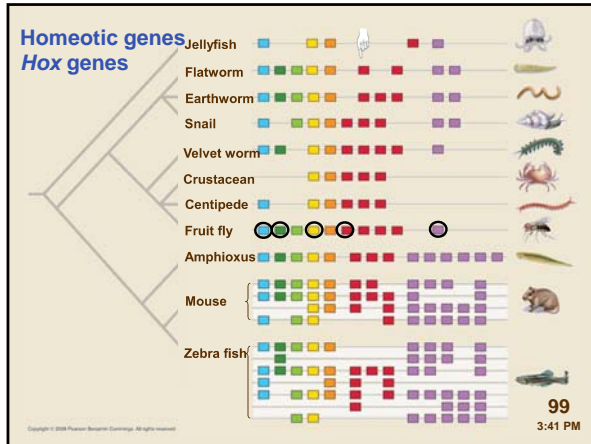


There is a set of universal genes that is found in all organisms which determines the pattern of the organism. The only thing that happens is that some disappear and some duplicate.

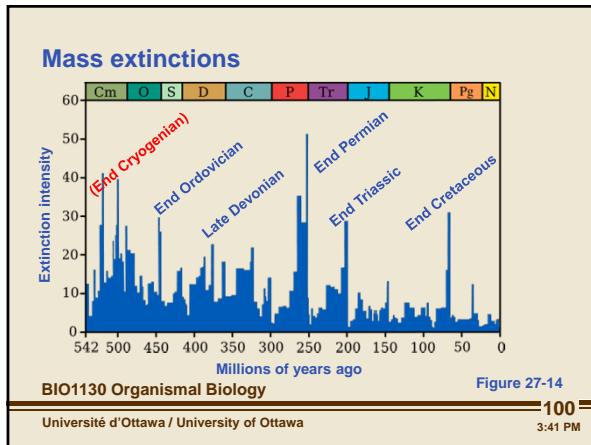


Since the cell was committed to being a leg, when they were placed in the spot for an antenna they still came out as legs.

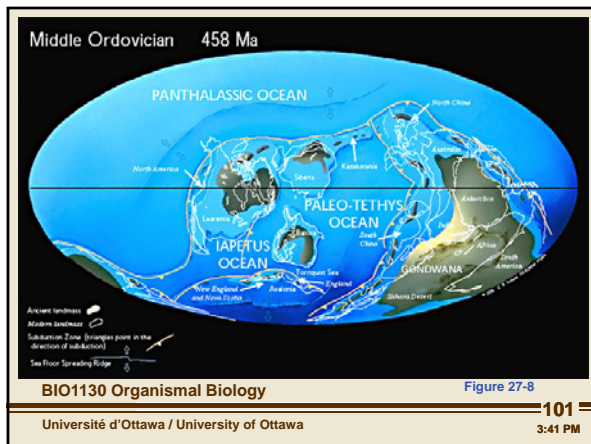
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There are commonalities and multiplications. There was an event that occurred because they all share common ancestry of the genetic pattern once it was under control you end up with a huge variation because you can control their appearance. The genetics require to create the patterns in these organisms came about in the Cambrian.

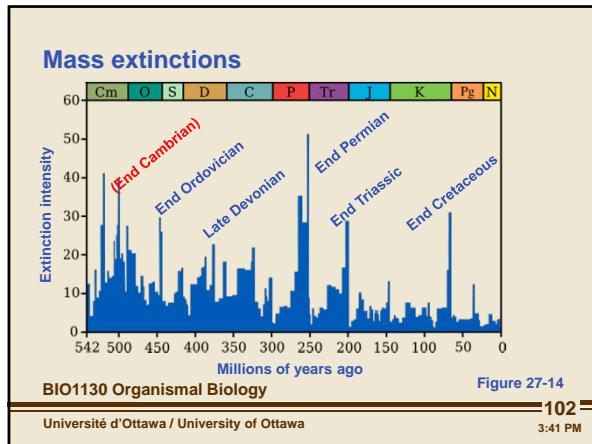


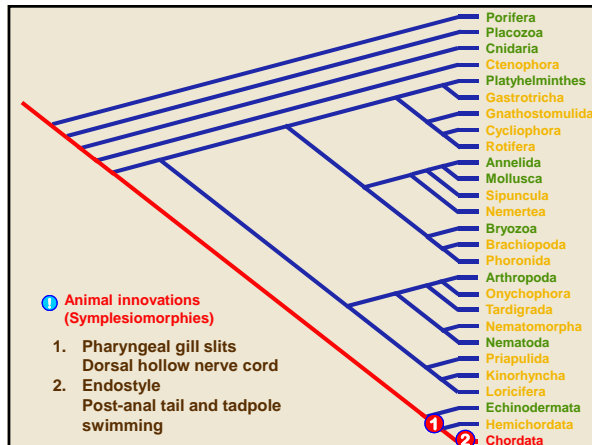
Mass extinction - Loss of more than 50% of the organisms.



The continental plates were starting the shift. The same kinds of cooling issues from before came back. There was a loss in the continental shelf causing a loss in diversity.

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There is a little invertebrate that has a unique way of feeding. As it swims through the water it holds its mouth open and allows water to flow out slits on their side. On the surface of these slits there is a mucus sheet which traps food. The food mucus goes into the digestive tract. This is also a new way of movement using an extension of the body past the anal cavity. The wagging of this tail propels that animal through the water so it could survive into the next thing.



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Paleozoic periods

- Paleozoic era
 - Cambrian 550-488 Ma
 - Ordovician 488-443 Ma
 - **Silurian 443-416 Ma**
 - **Devonian 416-359 Ma**
 - Carboniferous 359-299 Ma
 - Permian 299-245 Ma




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Ordovician survivors

- Cnidaria – corals
- Molluscs
 - Shelled cephalopods
 - Bivalves
 - Gastropods
- Worms
- Echinoderms
- Bryozoa
- Arthropods
 - Trilobites (some)
 - Marine forms (Crustacea)




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Middle Silurian 425 Ma



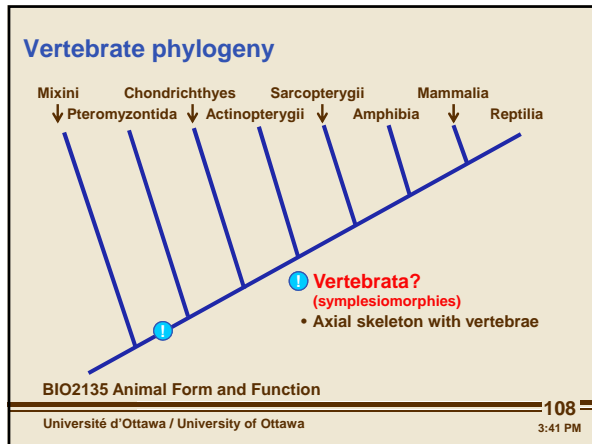
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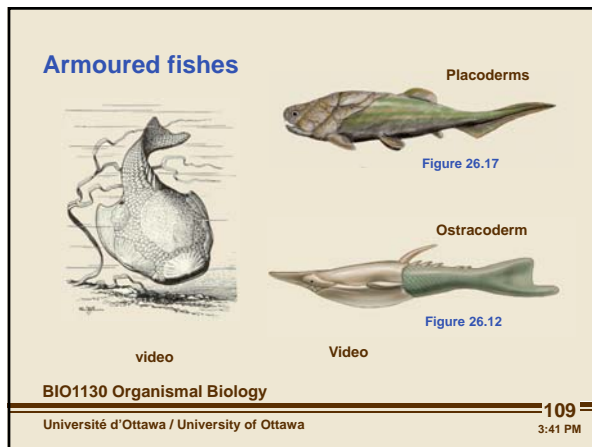
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There is now a scattering of continental land mass over the equator but the diversification is not as rich and abundant.

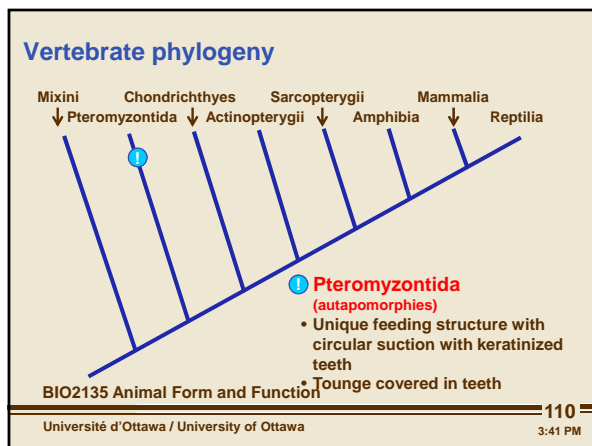
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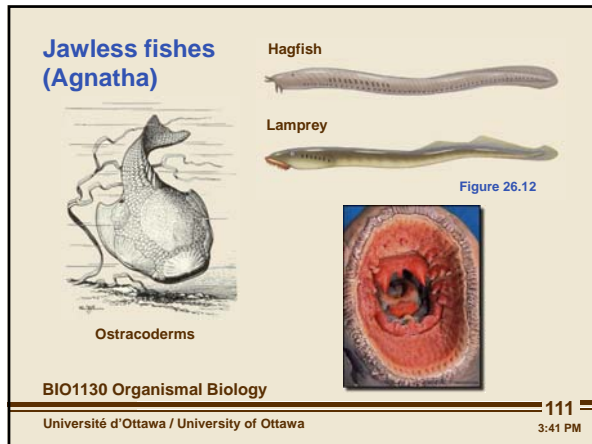
Those little fish like things sit at the very beginning of the vertebrate lineage. These were the jawless fish



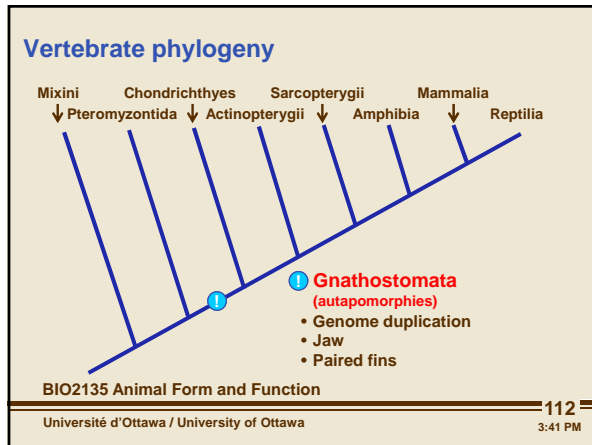
Originally covered in plates of armour and only the size of a finger. Most of these are gone and there are only 2 descendants in the line that are still jawless including the lampreys



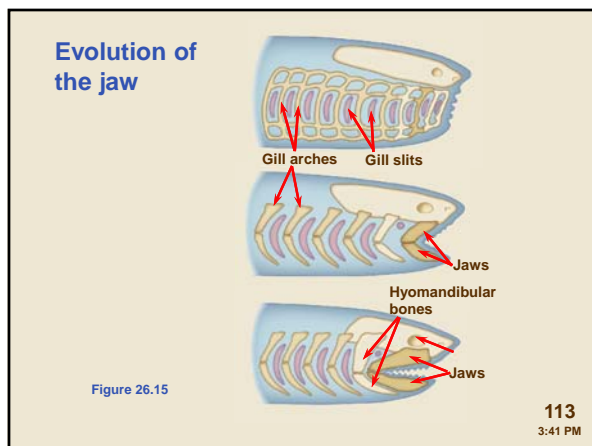
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The lamprey survive today by moving between the oceans and freshwater. When it comes back to the freshwater to spawn it goes back to where it was conceived. When the St. Lawrence locks came in lampreys made it into the great lakes and as a parasite it killed the fishing industry in the 1920s.

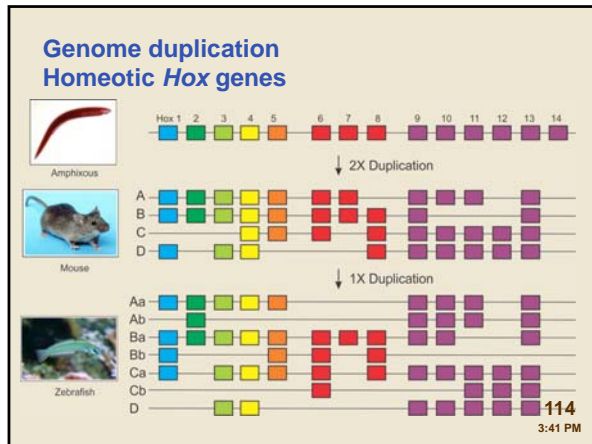


The jaw. It is combined with a very different type of architecture with paired fins on the side of an organism. This is important because the front part of the body will be stabilized from the tail movement. The dorsal fins also helps for stabilization.



Over time these fish are eventually able to take the muscles of the face and compress them. This gives them the ability to change the size of the mouth cavity and pump water into the cavity and out the gills. The very front 2 arches in all of the vertebrates have bent to the point where they create a jaw. This allows them to close the jaw to capture food. They can pump water. They don't need to continuously swim to feed. When they get teeth they can clamp down on food. This was an innovation in order to improve respiration but became a very advantageous trait for feeding because they could now feed without moving and clamp down of food.

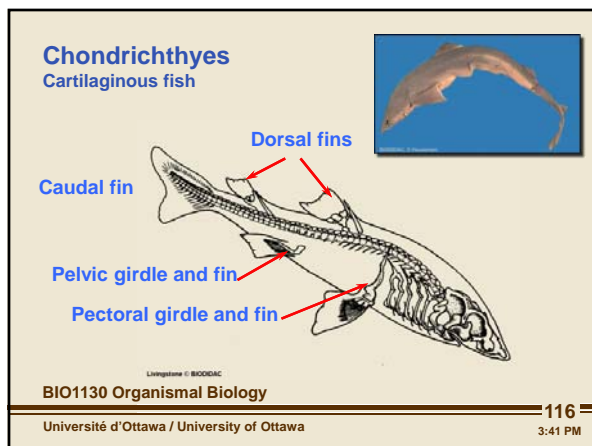
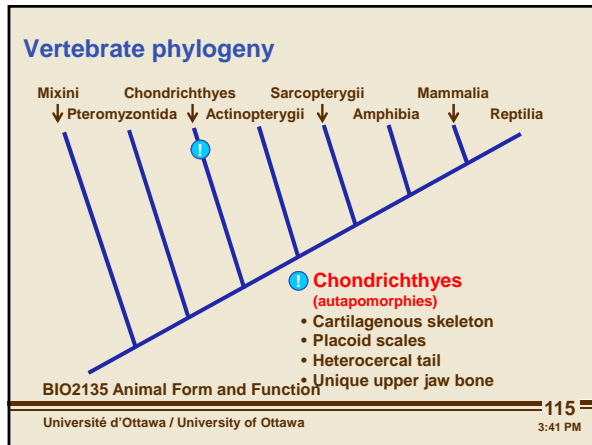
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there is one set of HOX genes at the base of the evolutionary tree. The vertebrate genome has undergone 2 polyploidic events. There are 4 copies of the entire genome.

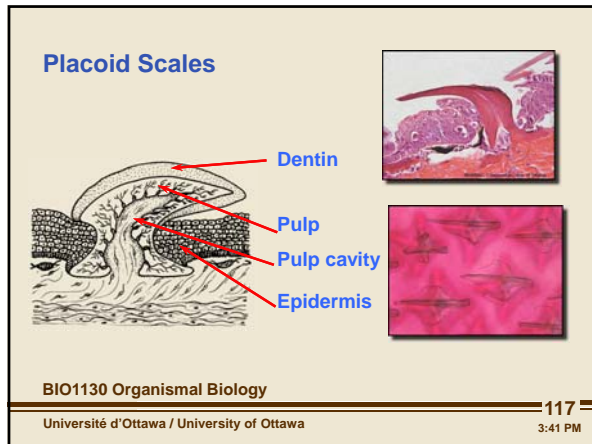
We don't have one copy of pattern genes, once we destroy this copy we have to live with the damage. But due to this duplication we have many different copies of the genome to allow for experimentation and variability.

Bony fish are the group that are diversifying the fastest of all vertebrates because they underwent another round of duplication and therefore have 8 genome copies.

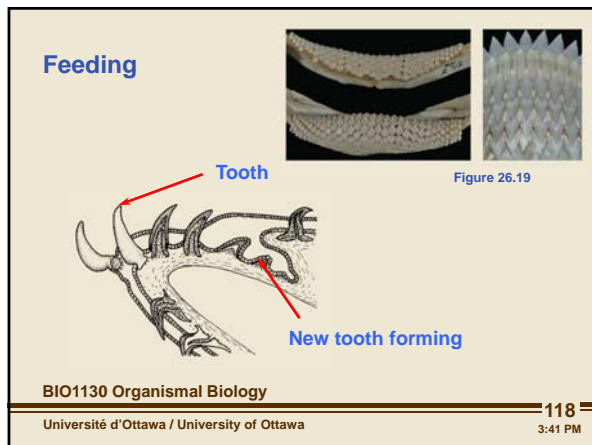


This tail wags back and forth and the fins stabilize it but the paired fins are not attached to the vertebrate. It is the tissue and muscle that keep the fins attached. This means that these fins do not have any movement other than slight tilts. Sharks have to constantly swim in order to breathe. The very first fish had to swim to force water over their gills so that they could breathe.

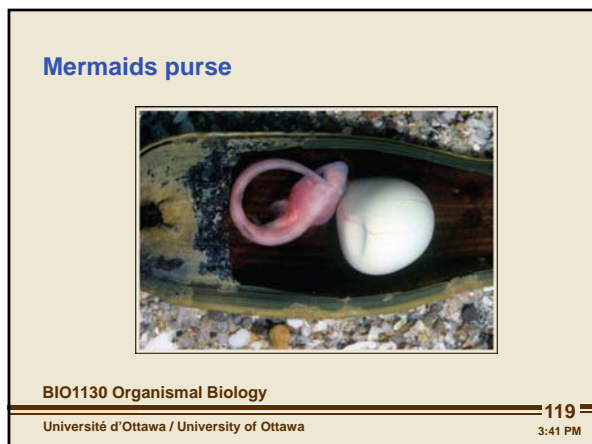
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A smooth surface moving through water creates suction and friction. If you have a smooth surface and you move through water there is an adhesive force that pulls the 2 things together and therefore there is a resistance to movement. Sharks have acquired very unique scales (placoid scales) that is inn the surface which create turbulence. This causes an area of disturbed water and decreases resistance allowing them to swim better because their body then does not create any laminar flow. It uses calcium to for dentin and a pulp core

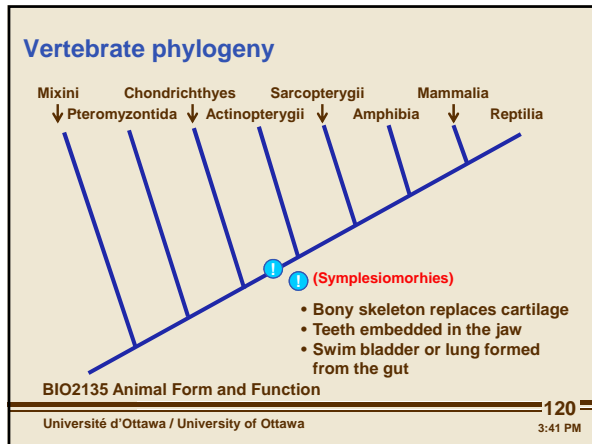


A sharks teeth are basically its scales but simply enlarged since they are made out of the same materials. They use this to clamp down on their prey and then sharks are unable to chew therefore they do a "death roll" and violent movements to try and rip apart the food. This causes the teeth to be ripped out. There is a little pocket under the teeth that are constantly creating new teeth that migrate to the front of the jaw for when a space becomes available.



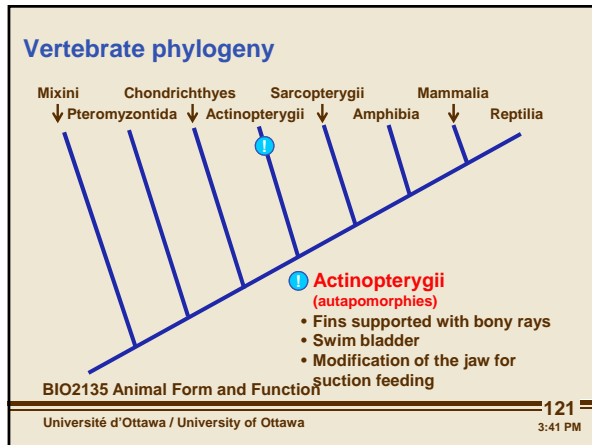
A female shark only produces a few offspring per year. She'll produce after mating with a male who passes the sperm directly to her. The female put the egg into a "mermaids purse" Inside this purse there is a lot of yoke and nutrients and placed in a safe place. The shark then develop after about a year protected from predators and when it hatches, it is a ready to feed predator. Sharks only lay about 2-3 eggs per year.

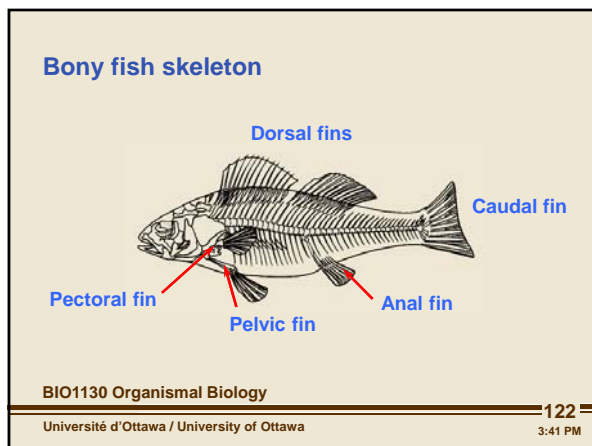
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Next is a series of bony fish which are much more rigid. They have embedded teeth in their jaw to be more effective at chewing. This group is also able to breathe without moving and even hover in the water without any work.

Neutral buoyancy is a large innovation to allow them to rest in any place in the water and hunt.

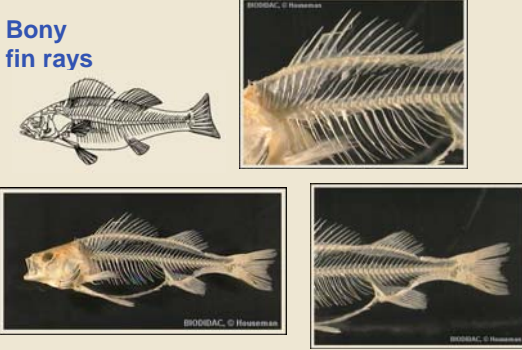




The thousands of little bones in bony fish protect the fins, and they project down into the body.

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Bony fin rays




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The paired fins in bony fish are now attached to the skeleton of the organism. Because of the muscles that are also attached, these animals are able to control these fins and use them for swimming as well. They now have 2 methods of swimming: the fish that use their tail to swim at high speeds. Using the paired fins allows these fish to have tremendous manoeuvrability. This group is now capable to use fine delicate movements unlike the shark that had to tilt their fins and wait for a wide turn. There is now a tremendous agility supported by bones

Suction feeding



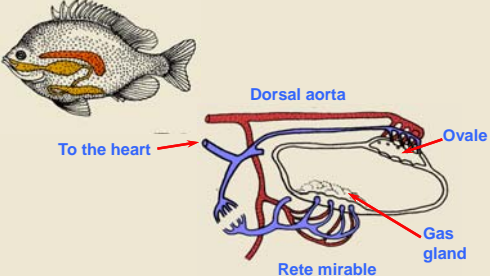
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There are extra muscles added to their jaw which allows them to extend their jaw forward in order to catch prey. These fish are capable of hovering and are very manoeuvrable but as well as having the ability to shoot their jaw further out to catch prey. This process does not warn the prey that they are feeding on and can sneak up on them and suck them in. They also have gill structures in the back that develop teeth and become like a secondary jaw.

Swim bladder



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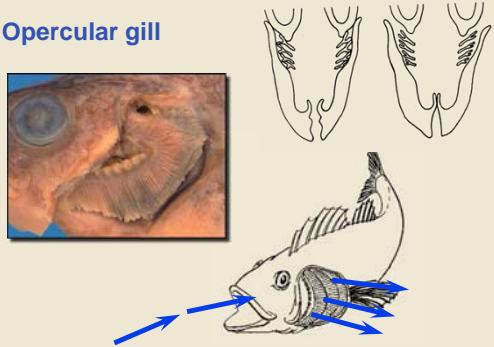
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Little air sac at the top of the body cavity. This air sac is hooked into the blood supply and circulatory system. As the fish goes deeper into the water, oxygen is taken from the blood and pumped into the swim bladder. As the fish comes back up to the surface there is another structure that removes the air so that it doesn't burst. Because this is all under nervous control, it is instantaneous. This is what allows the fish to maintain neutral buoyancy. (Body tissue is always slightly heavier than water and will always sink.)

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Opercular gill



The diagram shows a fish's head with arrows indicating the flow of water through the opercular gill. A photograph shows a close-up of a fish's gill cover. Two anatomical drawings show the operculum in open and closed positions. A fish illustration shows water entering the mouth and exiting through the gills.

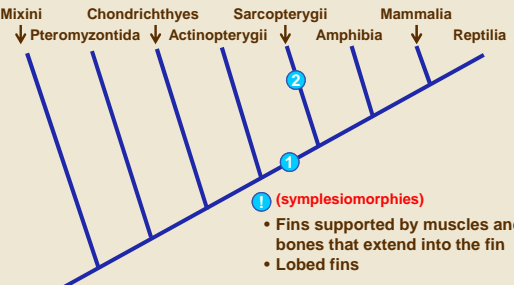
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The pumping structure that shoots the jaw out is also responsible for aerating the gills. On the side of the fish, as the operculum pulls the water out by closing the mouth, it pumps water to the gills. This means that the fish can pump water through their bodies without movement.

With all of these things together, you get an organism that is perfectly adapted to the aquatic environment.

Vertebrate phylogeny



A phylogenetic tree showing the relationships between various vertebrate groups. The tree branches from a common ancestor into Mixini, Chondrichthyes, Sarcopterygii, and Mammalia. Mixini includes Pteromyzontida. Chondrichthyes includes Actinopterygii. Sarcopterygii includes Amphibia. Mammalia includes Reptilia. Two nodes are marked with circled numbers 1 and 2. Node 1 is labeled '(symplesiomorphies)' and lists 'Fins supported by muscles and bones that extend into the fin' and 'Lobed fins'. Node 2 is located on the branch leading to Amphibia and Reptilia.

1 (symplesiomorphies)

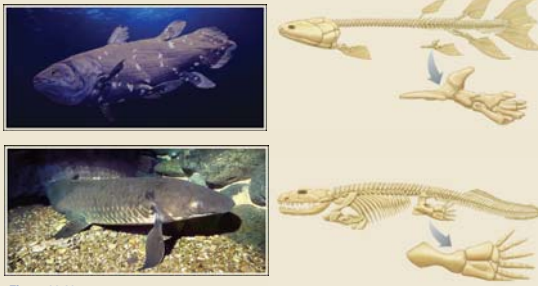
- Fins supported by muscles and bones that extend into the fin
- Lobed fins

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Sister group to the bony fish. Instead of the fins being supported by needle like rays there is actually a series of bones

Evolution of the tetrapod stance



Two figures illustrate the evolution of the tetrapod stance. Figure 26.23 shows a lungfish with paddle-like limbs. Figure 26.24 shows a tetrapod with digits. The diagrams show the transition from a fish-like body to a four-limbed vertebrate.

Figure 26.23

Figure 26.24

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Lung fish have paddle like limbs that resemble what is going to come of limbs with digits. When the water gets stagnant, the stick their nose into the air and breath into the lungs. The fins allow them to escape stagnant water they are able to crawl out of this water into better water to live. This is the beginnings of the movement on to land
