


"Protochordates"

Hemichordates and Invertebrate chordates



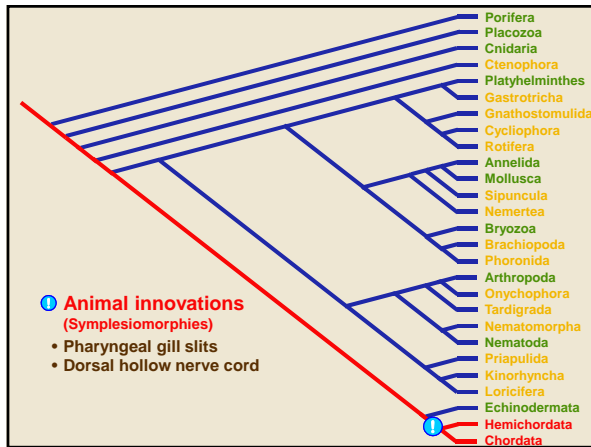
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invertebrate chordata

vertebrates are a subphylum in chordates

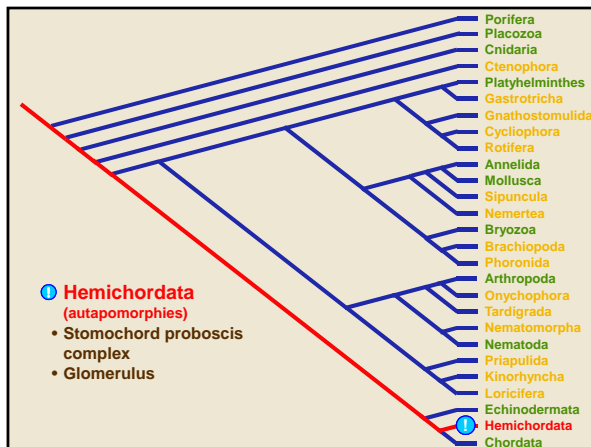


two major innovations in hemichordates

series of slits in the gills in the pharynx region - where water is going to move across those slits (originally part of the feeding mechanism - bring food into their mouths, concentrate the food to move it to the digestive tract. excess water move out of the slits) movement of water will also carry out gas exchange

dorsal hollow nerve cord - in embryology, see a hollow nerve cord on the dorsal side (opposite to protostomes where it is normally on the ventral side)

if looking at chordates, would also have notochord - creates a unique way of swimming and post-anal segmentation (a tail to swim with)



going to have unique structure - stomochord proboscis complex

-allow organism to support the oral opening for feeding

-collect food on a proboscis - part of the body that extends out in front

have an excretory structure - glomerulus

-create an ultra-filtrate of the blood by pressure, put pressure of blood and pass it through a thick membrane forces fluid out the thin wall and take anything small with it

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Hemichordate

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show an intermediate complexity between the starfish radial symmetry to a bilaterally worm like animal that has three body regions

- have the protocoel - proboscis
- the mesocoel - collar
- the metacoel - divided up into different functional zones

the proboscis complex - had the proboscis and the stomochord inside at the internal structure water is going to be pulled in which will go out the openings of the gills at the branchiotrunk - also where the gonads are located - branchiogenital trunk

hepatic is where final digestion is going to occur - have a gut instead of a gland to carry out the digestion and then the intestines are at the end- to remove the waste

Stomochord proboscis complex

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proboscis complex at the front - give functionality to the animal

have a diverticulum of the gut - part of the gut that folds back on itself

-when this happened, it created a rigid structure that is used as a skeletal element - derived from the gut in a small region- important because keeps the mouth open so that water can flow in

have a closed circulatory system and have an anterior dorsal blood vessel that goes forward

-blood vessel runs over the surface of the rigid stomochord- the muscle above it - heart vesicle - squeezes down on the vessel from one end to the other (rolling squeeze) - pumps and puts pressure on the blood on the other side of the heart vesicle - the wall of the blood vessel enlarges and become very thin - oozes and leaks liquid (filtrate of the blood) - oozes it into the cavity of the protocoel

- protocoel has a metanephridia that will filter the liquid before expelling it to the outside

Acorn worm burrow

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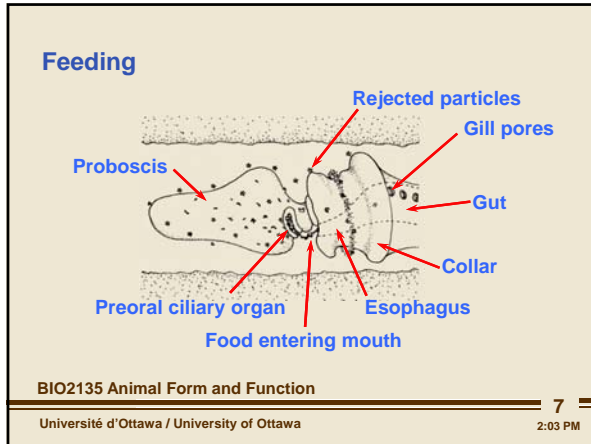
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worms tend to live in burrows - create water current that brings food for them to feed

sometimes come up and go back and put their posterior end at another location

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in their burrows, proboscis does its other role of feeding

- proboscis is covered in cilia - constantly beating and pulling in water and particulate food over the surface, as food is being propelled across the surface, certain size particles are taken to the ciliary organ (sorting)

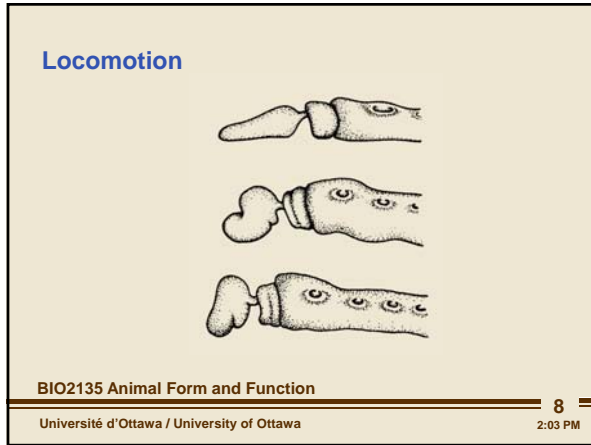
if particle in current is too big, cilia will reject it and will go down the burrow

if it is of the right size, they will move to the preoral ciliary organ - food particles will then be propelled to the digestive tract for feeding (make it into a string)

water that propels the string of food into the animal, will exit the pharyngeal openings of the gill pores

food will go into the digestive tract without the water! - now will be at a higher concentration for nutrients to be digested

mucus string - similar in mollusc

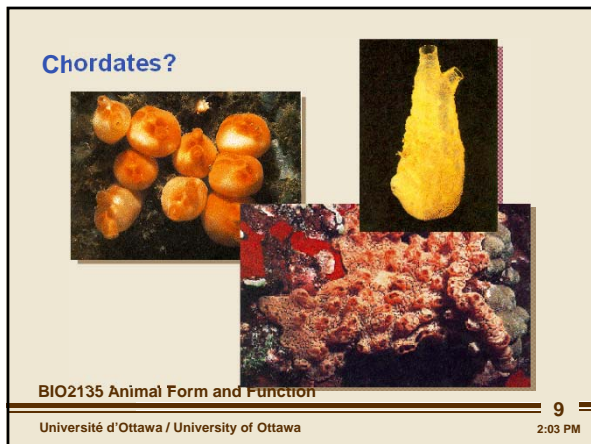


capable of movement, will always try to find a burrow

collar held open the opening is to get the food to the slits

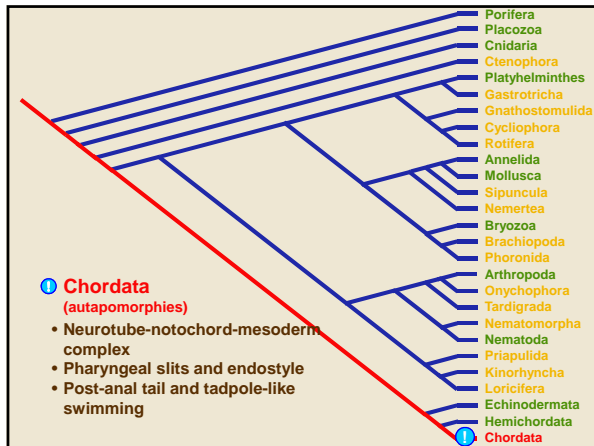
-metacoel has little to no musculature

when it is out of the burrow, the only way to make a new burrow is by the proboscis - drags entire body with the proboscis



we are all chordates - we are relative

"Protochordates"



in chordates - have pharyngeal gill slits, have a hollow nerve chord (add a notochord and post-anal segmentation)
 major difference in protostomes and deuterostomes

- deuterostomes in development use cell to cell proximity and signals to create developmental sequences

-ex primitive gut touches the dorsal surface of the epithelium, turns on a developmental sequence that builds notochord, mesoderm etc

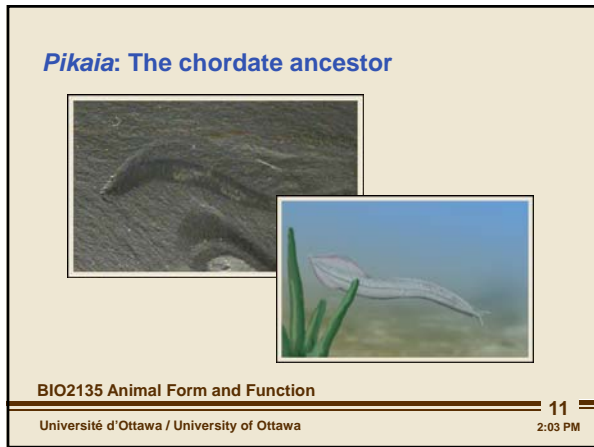
- protostomes, when you remove a cell, the developmental sequence would be destroyed

have a 4D cell that makes all mesoderm in organism - embryo will die if this cell is damaged

-in chordates -- development of the holodorsal nerve chord, the notochord and all of the mesoderm (high developmental sequence that puts organism together)

-pharyngeal slits will change slightly- water will still pass through them but will get an endostyle that will make mucus that will cover then inside of the slits - so the food will be suspended in water, water will be sent through the mucus net where food will be stuck and the entire net will be consumed

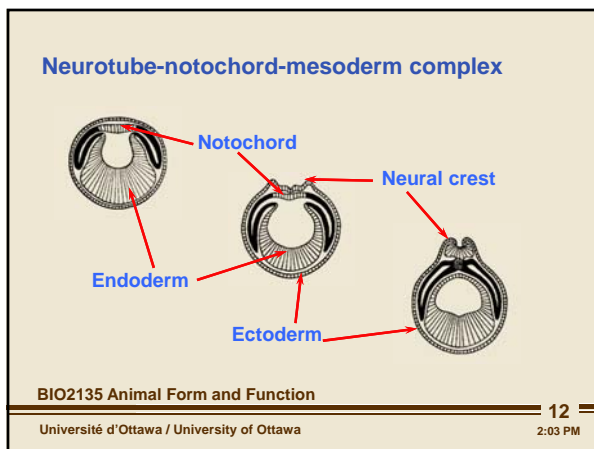
-get a new way of locomotion -post-anal tail (body segments behind the anus that will be able to wag (lateral undulation)) **always saw that anus was in the last segment but now they are after



one of the first chordates - pikaia

found in shales - fossil

when they die, sink to the bottom of the ocean where there is no oxygen so it is preserved



inside show the neurotube-notochord-mesoderm complex

in enterocoely - when there is the primitive gut (two bubbles that makes the mesoderm)

the gut wall region that is in between the two bubbles - this is picture they are the black flaps

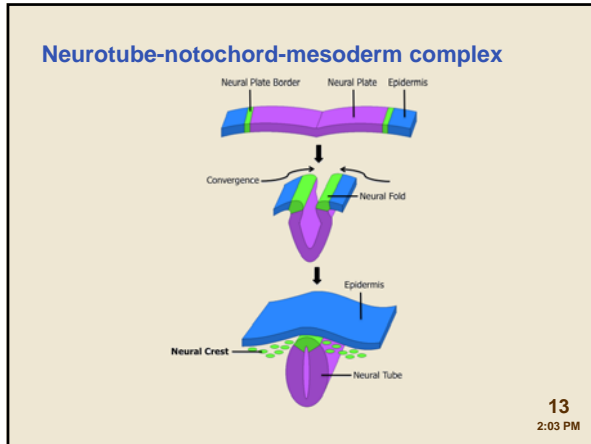
the tissue in between the flaps is going to turn into fold on itself and turn into the notochord

-when the two pieces came off, the gut bit between the two pieces became the notochord

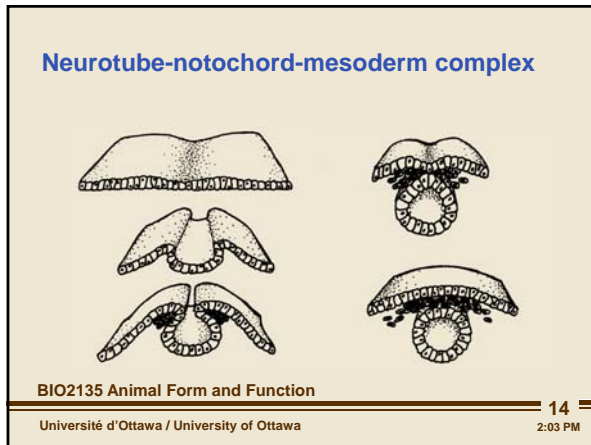
-notochord then comes in contact with the outer epithelium, which forces it to

change - making a crest on either end that will ultimately close on each other to make a holodorsal nerve chord

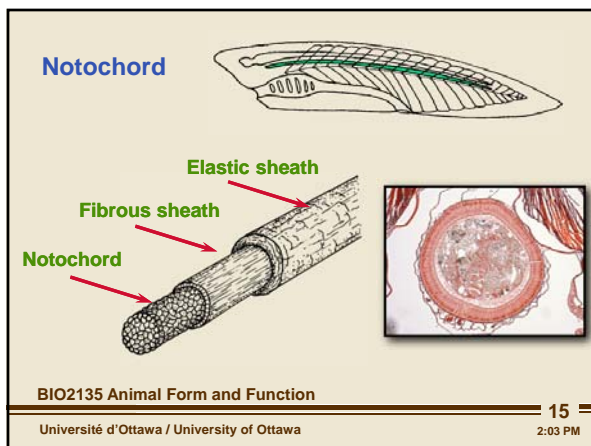
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notochord that is not shown induces the epidermal cells in the embryo above it to form the neural plate
 neural plate will proliferate and invaginate, seal itself off
 on the edges of the fold (green) gets incorporated into the neural tube
 the neural crest cells will rest or send out packs of cells (placoids) throughout the body
 -where placoids end up will determine what that place will become (limbs, eyes etc)



same principles with the notochord and the crest cells/placoid cells coming off



end result - a notochord
 has a rigid structure (cartilaginous structure) wrapped inside a fibrous sheath and an elastic sheath on the outside
 has unique mechanical characteristics - cannot be compressed, length stays the same, can only bend it
 muscle blocks on one side that can contract and bend it, causing the muscles on the other side to stretch and vice versa
 end up with lateral muscles on each side - as they contract forces the notochord to wag back and forth (undulating lateral motion/tadpole like swimming)

"Protochordates"

Neurotube-notochord-mesoderm complex

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on top of it is the holodorsal nerve chord
 the muscle that form down the side also formed in block that occur sequentially
 have two components

- muscles with upper component - solid block of mesoderm
- lower component - that has the cavity in it
- (a third one slightly in between)

Neurotube-notochord-mesoderm complex

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have a solid block of mesoderm adjacent to the neural tube-somatic blocks used for muscle movement
 have a block of mesoderm with a coelomic space inside-other somatic smooth muscle block used to line the organs

mesoderm differentiating into two types depending on its relationship with the notochord

Evolution of the nephros

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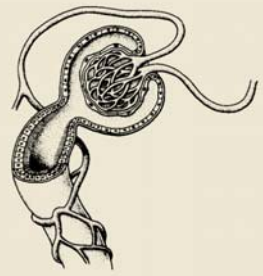
have a coelomic space with a metanephridia that filters the coelomic fluid
 in organization of the sequence- have a glomerulus that was using blood pressure to put filtrate into the coelomic space (like in hemichordates)

end up with a duct that runs down the length to get rid of waste
 over time proximity of glomerulus and metanephridia becomes closer and closer - and filtrate gets put right into the mouth of the metanephridia

have small blood vessels that are leaking blood fluids by pressure into a metanephridia - NEPHRON

"Protochordates"

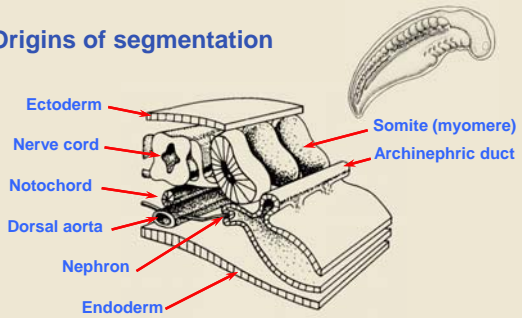
Nephron



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end up with a ball of capillaries that are leaking blood because of blood pressure directly into a metanephridia

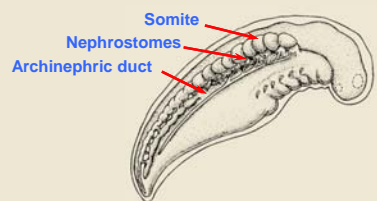
Origins of segmentation



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creates an embryo that is segmented down its length

Neurotube-notochord-mesoderm complex



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eventually see release of gametes

enterocoelic pouch going to start making mesoderm - that will make solid somatic block, then makes a coelomic block behind it

inbetween the blocks is where there will be the glomerulus and a metanephridia that will become the nephron while that is happening, the piece of gut becomes the notochord, comes in contact with the epithelium which induces the neural crest that rises up to form the holo nerve chord with neural crest cells/placoids that migrate to the rest of the body to make other complex structures

"Protochordates"

Pharyngeal gill slits

Endostyle

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in hemichordates - had a consolidated mucus string flushed into the digestive tract
 in chordates - endostyle at the bottom that creates mucus that lines the mouth cavity and the water is going to flow over the mouth, through the mucus net where food particles will get trapped
 mucus nest is constantly being regenerated from the bottom and at the top, the net is being rolled up into a tight string to be sent to the digestive system

Segmentation

Post anal segments (Tail)

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post-anal segmentation - segments that are beyond the length of the tail - gives propelling motion to the chordates

Chordate Phylogeny

Cephalochordata (autapomorphies)

- Assymmetric planktonic larval stage
- Extension of muscular notochord beyond neural tube
- Staggered myomeres and mouth a modified gill slit

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cephalochordata - amphioxus/lancelet/branchiostoma
 had all notochord characteristics
 -have asymmetric planktonic larval stage- things aren't paired on the left and right side
 -myomere block are not perfectly aligned beside the notochord, they are shifted out of position by a half - there is a septum in between the blocks
 -asymmetry is expressed in the staggered myomeres
 larva has an unusual developmental sequence - the mouth changes its position and becomes a gill arch (first chordates had pharyngeal gill slits had the mouth in between)
 starts pulling water in through the gill arch into the system (animal breathes through one side of the mouth, when it settles into the ground and starts to burrow, now the mouth is pointing down
 -reason for seeing one ocellus at the top of the head instead of being laterally arranged and one of the muscle blocks shift because one of the slits are no longer in use (became a mouth) [no longer paired structure]

"Protochordates"

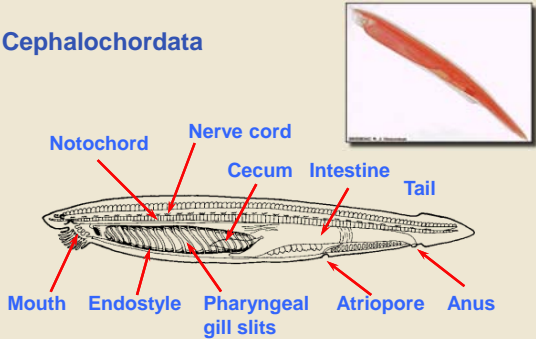
Cephalochordata



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end up with organism that has its tail in the sand - sedentary filter feeder
 anterior end will pull in water, pump in water across the pharynx, consolidate the food inside (using the endostyle)

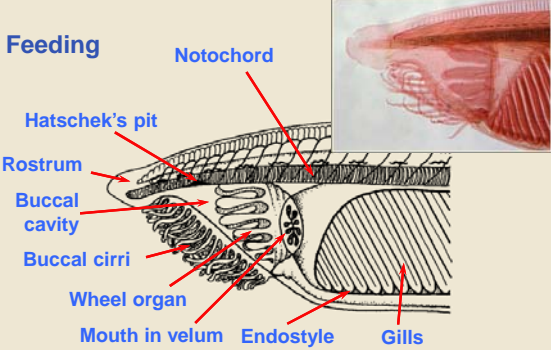
Cephalochordata



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have 3 main body regions
 head - mouth and feeding structure
 trunk - branchial genital system and intestinal system
 post-anal segmentation - tail
 doesn't swim, spends most of its time burrowing - tail is not the major locomotory structure, so it is really small
 burrows head first, moves the sediment before settling

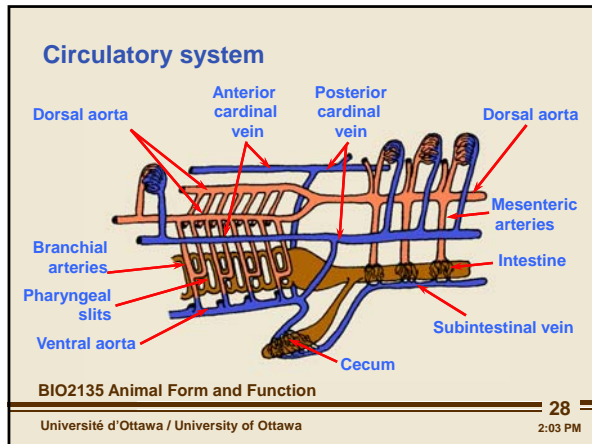
Feeding



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autapomorphy - notochord extends from the rostrum (hood of the head) past the head
 -notochord gives animal rigidity, prevents mouth from collapsing, give protection when it burrows
 the change in mouth position is important as to how it feeds
 there is a ciliary current - use fleshy extensions that surround the mouth (buccal cirri)
 -have the wheel organ inside
 -both create current to bring small particulate food into buccal cavity
 then have endostyle at the bottom that creates a sheet of mucus on top of the inner surface of the gills, food gets stuck and mucus sheet gets rolled up to be consumed

"Protochordates"



circulatory system is very similar to that of vertebrates

-contains ventral aorta that passes blood up and over the gills into a paired dorsal aorta that goes to the anterior attached to a single aorta that goes to the back - happens in all vertebrates

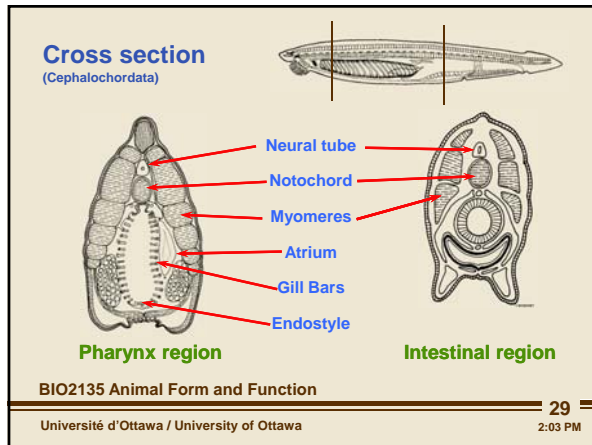
-also have a shunt (small opening) where blood passes from the digestive tract through a cecum before moving up into the gills

-digestive tract full of food that have blood vessels that move into a cecum (out-pocket of digestive tract) before moving to main circulatory system

-have an organ processing blood before it moves to oxygenation surface - what liver does in chordates hepatic portal system where blood is taken from digestive tract and filter/clean it up before it gets sent to the rest of the body

- important because when eating food there are toxins and elements that need to be removed (liver will put things into storage or detoxify the blood containing anything that could be absorbed from the food before sending it out to the body)

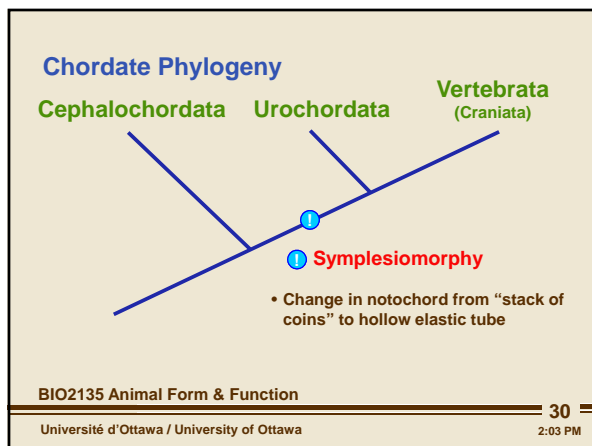
the heart is missing! -ventral aorta is the driving propulsive force, also not gills pharyngeal slits were there just to help with water removal



muscle blocks are arranged down the sides in chevron/v-shapes with myosepta in between

-improvement for swimming, if muscles slight overlap with each other, the one of top can be fully contracted, middle partially contracted, one inside not contracted at all - end up with a smooth surface as animal is undulating in the water - tadpole swimming

-this organism is highly adaptive to sedentary life

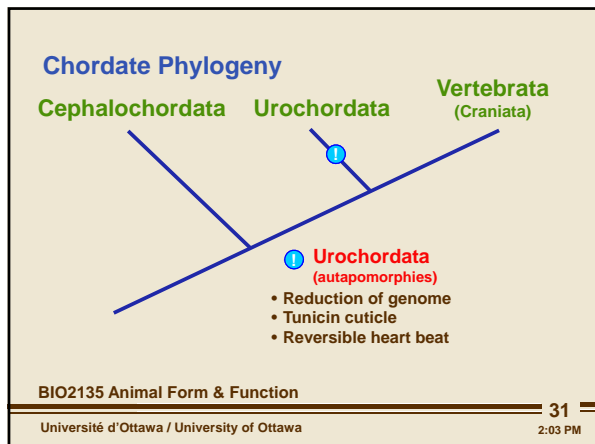


move up evolutionary tree - notochord changes its appearance

in urochordates - notochord become solid cartilaginous rod

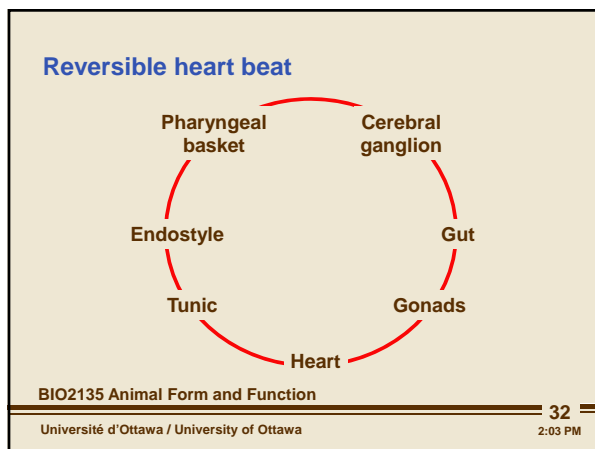
in cephalochordates - the same segmentation that made the somites and the metanephros due to the fact that the notochord is a series of disk like structures (primitive)

"Protochordates"



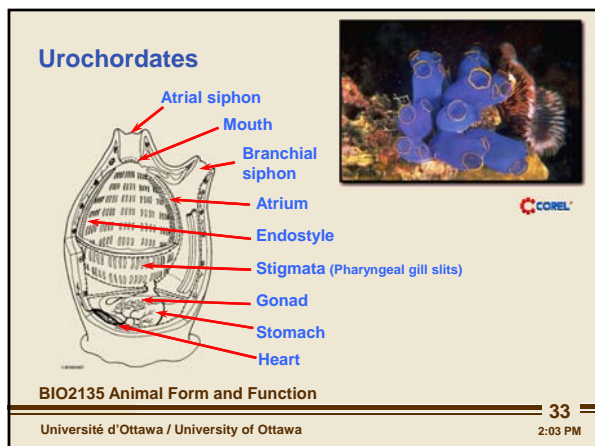
urochordates are weird

when molecular and genomic work was done - descendant with massive genomic failure in chordate lineage
 looking at hox genes, huge chunks are missing - genes got so simplified (end up looking like sessile cnidarians)
 survivor of reduction in genes- manage to survive in simplest form
 group represents genomic reduction in chordate lineage
 -sessile organism lives inside a tunic (outer casing - like in bryozoans)
 -called tunicin cuticle (not really a cuticle because the blood vessels permeate into the tunic that surrounds the organism) - tunicin is made up of a form of cellulose - an animal that makes cellulose!
 -uses cellulose in a protein matrix to make a body casing (like arthropods that use chitin and glucosamine chains to make an outer casing) - genes that make cellulose are homologous to those that make cellulose in plants
 because of damage, there is no flow sequence where you go from a pumping structure to a oxygenation structure
 out to the entire body fill it with nutrients and bring it back to circulate
 - now have a disrupted lineage sequence - have reversible heart beat



the outer casing - tunic (living structure) filled with cellulose has blood supply

flowing the blood clockwise - supplies the gland that makes the mucus string that goes across the pharyngeal basket where oxygen will be added
 -the cerebral ganglion/the brain receives oxygen rich blood but doesnt get nutrient rich blood because it only reaches the gut after getting to the brain then passes to the gonads and back to the heart
 -gonads dont get oxygenated blood
 -but the gonads gets a lot of nutrients
 to fix this, heart beats a few times in one direction and then beats in the other
 -if it goes in the other way, counterclockwise, now brain gets nutrients, gonads get starved from nutrients but it get compensated by changing direction of the blood



sessile filter feeding pharyngeal basket is a chordate related to humans and cephalochordates

animal is sitting at the bottom, with a giant pharyngeal basket, surrounded by a tunic and water goes in through one opening (atrial siphon), comes out through the walls and out the branchial siphon
 -incurrent and excurrent flow
 cilia are pulling water in through the walls of the basket into a space behind and out of the animal as water is being pulled in, the endostyle, located on one side of the organism is constantly making a mucus basket over all of the openings
 on opposite side of the side of the basket, food is being consolidated and being pulled into the stomach that is underneath
 any thing that is not digested is voided with an anus that is in the excurrent flow
 gonads are right next to the stomach so there is a lot of nutrient transfer, shuttling of blood back and forth means there is enough oxygen 50% of the time
 organism is hermaphrodite, eggs and sperms are going to be released into the marine environment, will find each other and form a zygote that will form a larval stage

"Protochordates"

Urochordate larva

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chordate characteristics are found here

larva is a pharyngeal basket attached to a tail

in tail there is a notochord, a dorsal holonervechord

pharyngeal basket is not in use but the endostyle and pharyngeal openings are present

excurrent siphon when it functions is where the anus would be

-and the tail segmentation is behind it so there is post-anal segmentation

only thing that is short lived - eyespot and statocyst - because it swims

once fertilization occurs and larva undergoes transformation and has enough reserves to make a larva, it doesn't feed because the pharyngeal basket is closed

just disperses in the water current

Urochordate metamorphosis

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at anterior end - have set of oral papillae/sticky surfaces that sticks to the ground, undergoes metamorphosis, where pharyngeal basket enlarges and the organs find its place

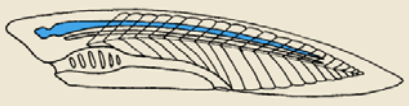
sea squirts - can contract tunic and squirt water out

Neurotube-notochord-mesoderm complex

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Dorsal hollow nerve chord



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Urochordate morphology

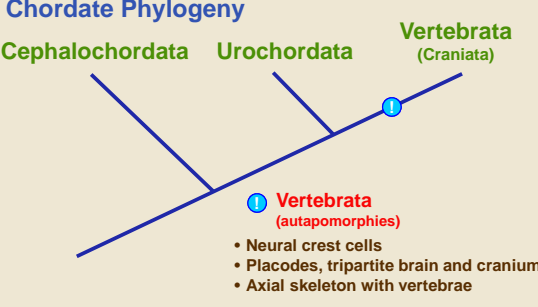
- **Benthic (Sessile)**
 - Solitary
 - Colonial
- **Pelagic (Swimming)**



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diversity
 solitary individuals- masters of camouflage, similar to cnidarians
 colonial - small tunicate organism that form a lumpy colony
 pelagic- swimming - set that share a single tunic - can contract different areas to rise in water column to feed

Chordate Phylogeny



Vertebrata (autapomorphies)


- Neural crest cells
- Placodes, tripartite brain and cranium
- Axial skeleton with vertebrae

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cephalochordate and urochordates can be reversed as to who should be at the base
 vertebrates [subset to craniata] (HUMANS)
 -in development where notochord induced epidermis above to make the dorsal holonervechord - there were special cells that met in the middle to make the neural crest cells
 neural crest cells are important in development of vertebrates
 -when they migrate through the body, they carry the induction signals to make different body structures
 -known as placoids - sets of cells that migrate through the body, when they find perfect cell to match up with - going to induce formation of specialized structures
body has 4 regions were placoids come from - whole set that are associated with the brain
 -at anterior region, neural crest cells fall and drift down - impact on solidifying nervous system, as they drift in to the system, some will become eyes, ears, nerve cell
 -some will become the jaw, the pharyngeal opening/silts, appendages
 embryo carries these cells that give complexity to the organism - have a receptor cell and a signal cell that will line up to make appropriate parts
 now have another tripartite brain - set of specific functions
 fore brain - smell
 middle - visions
 hind - vibrations and balance
 will have axial skeleton with vertebrae

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Cephalochordata



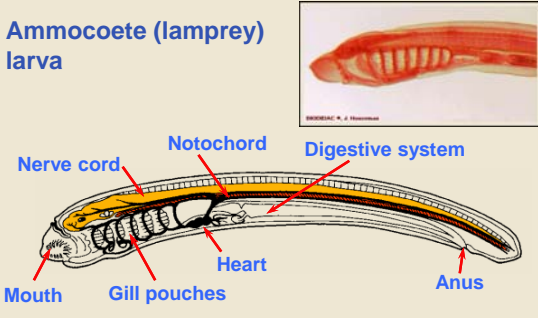
Ammocoete (lamprey) larva



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the link between the larval urochordate and lancelet is not obvious only one will show this link
most vertebrate give birth/lay eggs to small adult versions
frogs (amphibian) have unique larval stage- tadpole
nothing is close to cephalochordates or urochordates except for lamprey larva
-shows all of the characteristics

Ammocoete (lamprey) larva



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look at organism that is a sessile filter feeder
mouth cavity pumps water with food where there is endostyle that makes the mucus to trap the food
can still see the chords down the organism
also have anus at the end of the organism
