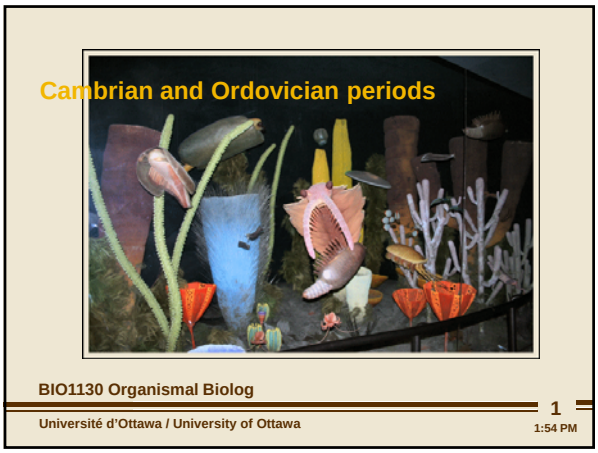
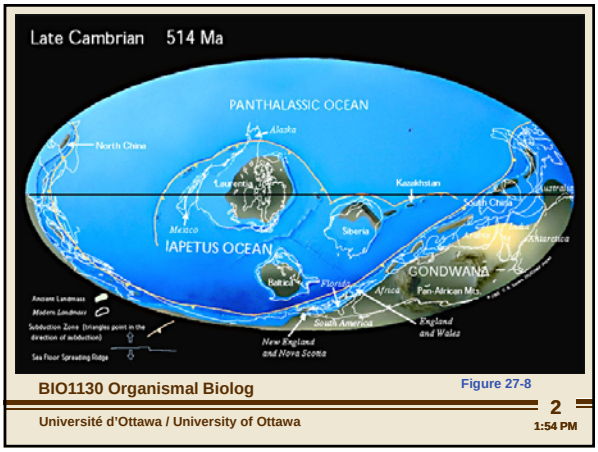
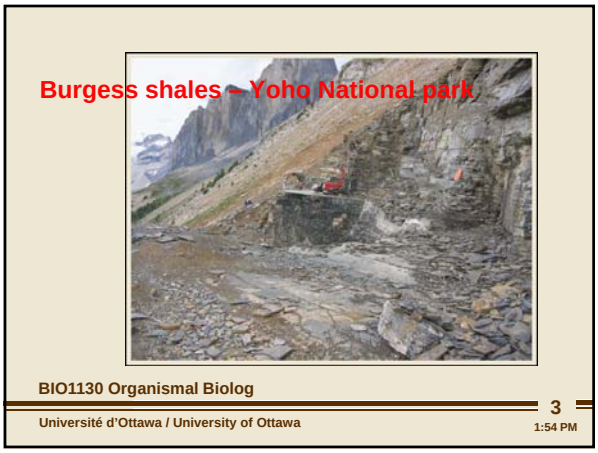
Cambrian and Ordivician



3 lineages of organisms that will figure out how to create multicellular organisms in Cambrian - fossils through Cambrian - 540 Ma explosion of organisms found in shell deposits
- ex. arthropods with outer shell
-all animals, not plants



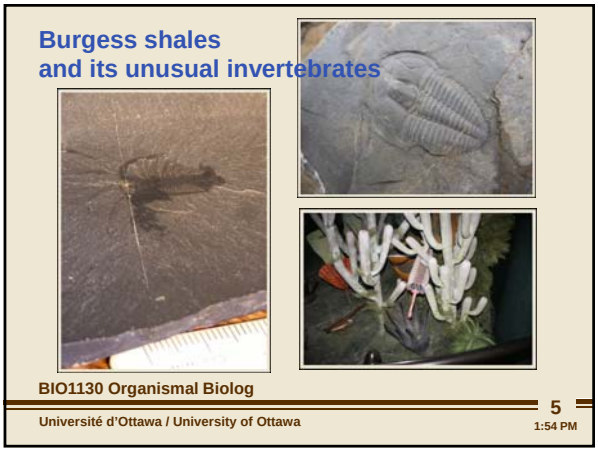
Laurentia - North America and Greenland - sits on equator - lots of productivity to feed animals - prime zone for warmth, sunlight, and productivity is equator.
-bare rock - rains falling on it-erosion as well
-hugely vast area of shallow seas-instead of single cellular organisms eating primary producers -multicellular organisms.
-so many types of fossils, explosion of animal life



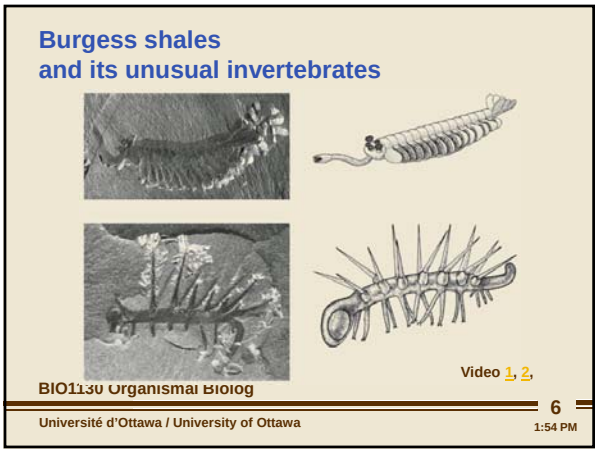
- Darwin had difficulty explaining gradual change at this point - used as a point against grad. change.
-Rocky mountains on edge of Laurentia plate - animal carcasses fossilized in oxygen depleted area - preserving invertebrates - Yoho National park - Burgess Shales

100s to 1000s of same organisms. Can even dissect animals and see what they were eating.

-organisms that have never been seen before
-Walcot - found fossils in Burgess shales - after death, family allowed people to look at the shales - two uni peeps from england came and found fossils



Have little or no resemblance to what we have today in terms of animal diversity

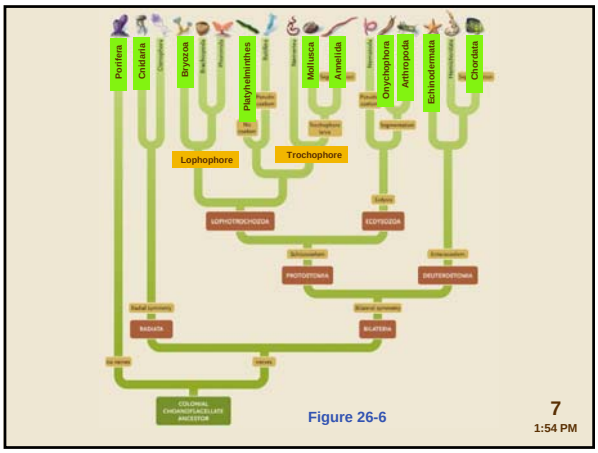


-Problem: these structures of these animals and major variations occurred but then went extinct
-Amount of diversity has been diminishing over time
-Contrasts what we think: diversity increasing
-whole sets that never made it through - completely contrary to Darwin's theory of gradual change and complexity increasing.
-same burgess shale fossils found in Rocky's, africa, greenland.... etc.

Cambrian - two new types of morphologies - animals that burrow, and animals that dive underwater.

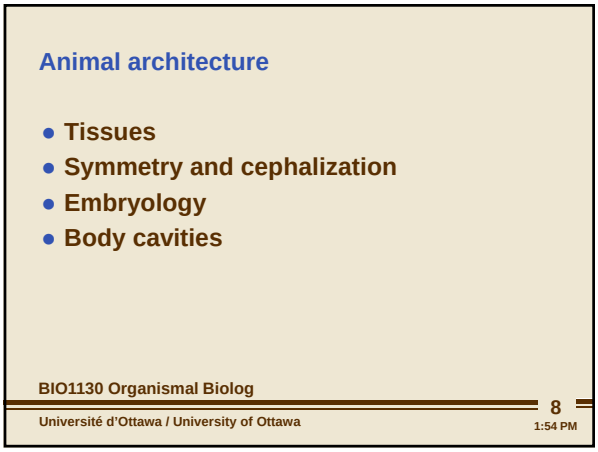
Cambrian and Ordivician

Going to take a look at phylogeny and diversity of animalls at this time - looking at terminal branch and major changes that occur on each.



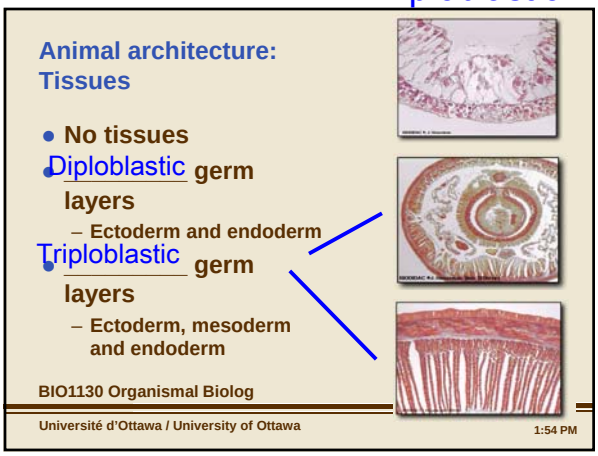
- Bottom of tree - colonial choanoflagellate ancestor (jump to slide 13) - ancestral cell to all organisms - cell will undergo transformations - either bilateral or radial symmetry or no symmetry at all
-Porifera or sponges are the first to form without any symmetry.

-Tremendous architecture diversity in animal fossils in Burgess Shales.

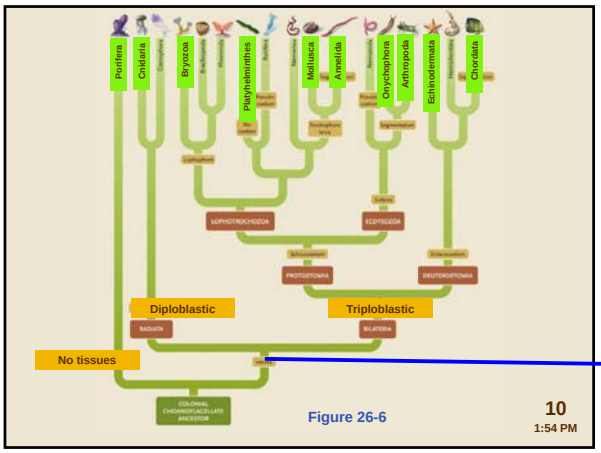


-first thing to deal with - tissues
-can start off telling story here : which organisms have tissues, how many layers ... etc.

Diploblastic



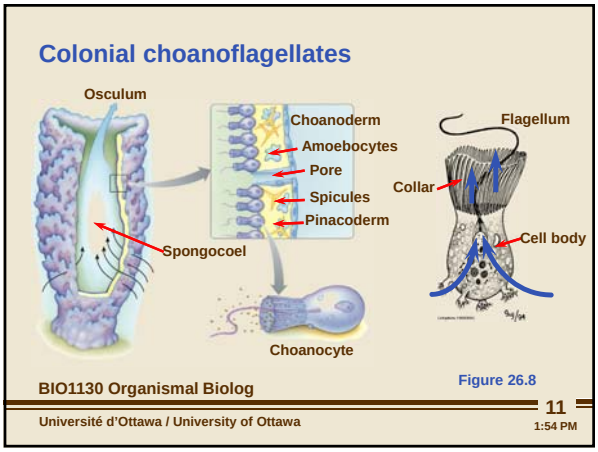
- multicellularity - communication system between cells and different functions - in a large group of organisms
- will have group of organisms develop ectoderm and endoderm - two layers of tissue - Diploblastic
-mesoderm - produces muscles - muscle system
-ecto - nervous system
-endo- gut



- very first step was no tissues - but differentiation in cells
-

communication instead of nerves

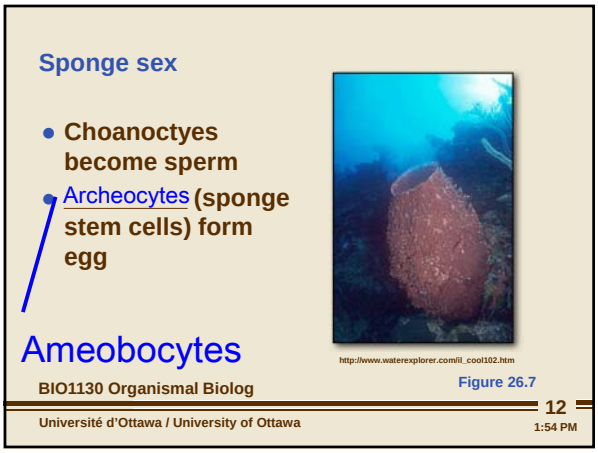
-most effective filter-ers of ocean
-no cell to cell communication, but division of labour



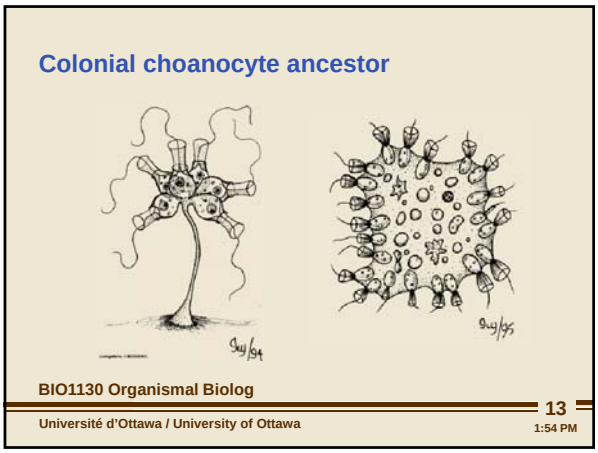
- sponge - similar to vase - hollow structure that has choanocytes lining inside and pinacoderm (layer of pinacocytes) outside
-all choanocytes pump water, while water is pushed out of the top of the sponge
-vase shaped structure specialized for pumping large quantities of water
-choanocytes take water past microvilli which trap particles for food.
-different cell types with different functions, but NO tissues

-four or five cell types working together that trap particles and use.
-sponges set stage for mineralization

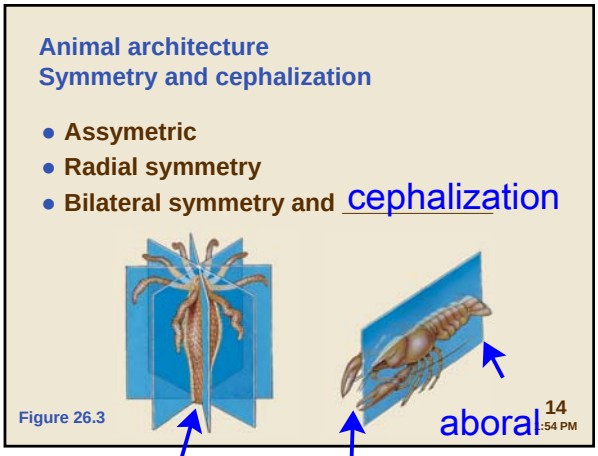
-in between pinacoderm and choanocytes, we have amoebocytes which move and provide food. - main feature of animals - collagen "glue" that holds cells together in animals - sponge distant ancestor of us.



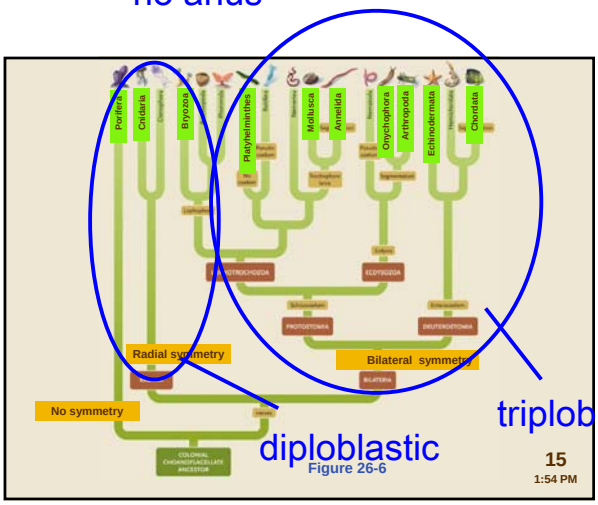
- some choanocytes turn into sperm - those that remain will cause water current
- released in a cloud, often called "smoking"
- somewhere closeby ameobocytes become eggs.
- baby sponge forms
-sponges have both sexes or can be separate.



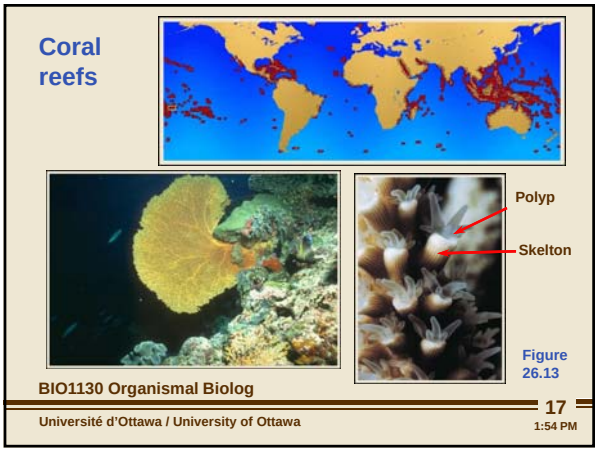
- cell that has cell body, one flagellum, and microvilli surounding it. - flagellum beating, water pulled into microvili cover - trapping particles - phagocytosis - filtering out algae in water, and trapping them. - single cell animal like protist.



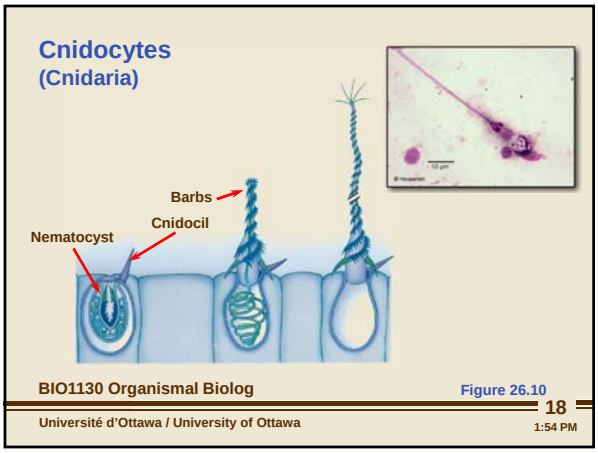
- important about symmetry - tells us about lifestyle or mode of living of organism
- radial symmetry - slicing from oral to aboral - and being able to do it on multiple surfaces - occurs mostly on sesile organisms - totally passive in environment - sitting on bottom of ocean
- bilateral - does not sit on bottom of ocean - uses locomotion - moves in one direction - when we have directory movement, we need sensory info - concentration of sensory info processed in anterior end. - only one plane dividing
- for the most part, animals are divided in radial or bilateral



- sponges don't have symmetry - don't have oral to aboral
- bilateral - movement, and therefore need muscle - leads to cephalization in bilateral organisms
-Cnidaria - ex. corals, and jellyfish - reef like structures - corals

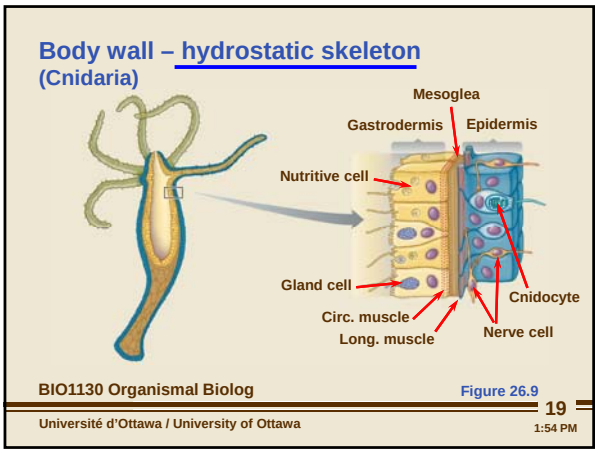


- coral reefs appear in shallow waters across equator
- promote diversity
- often called rainforest of ocean - allows diversity
- when coral reefs become poisoned, affects entire marine ecosystem



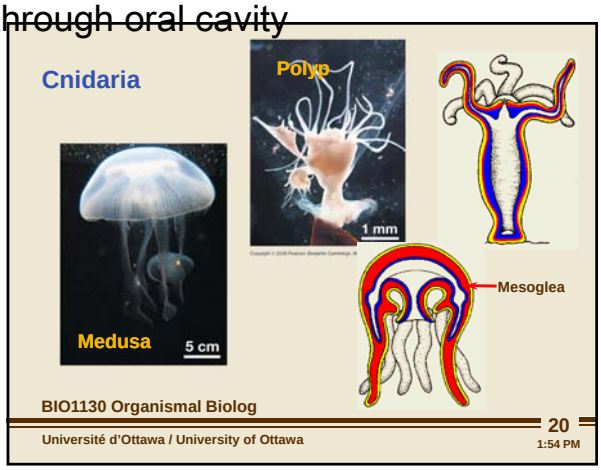
- cnidocytes - can shoot out barbs which shoot into skin of prey and then hold them in place.
- most jellyfish stings are not fatal to humans - some types, eg. ones in Australia, are.

Cambrian and Ordivician



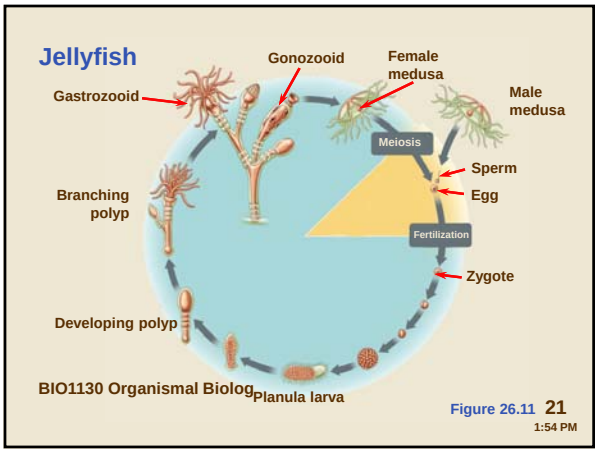
- hydra are one of the first animals to move
- have tissues lining digestive tract, endoderm, and also have ectoderm on outside.
- also has nerve cells, ectoderm builds those.
- gastrodermis - contains cells that secrete digestive substances - fibres encircling inside of hydra
- mesoglea - contains some muscle, and digestive cells.
- major role of skeleton - antagonist pairs interact with skeleton. - work in combo with skeleton
- hydra has incomplete gut, has a fluid filled digestive cavity - if all of the longitudinal muscles contracted, gets wider - circular muscles are stretched - we have a skeleton - used to produce movement

-technically does not have "muscles" - Hydra can generate some very fine types of movement - has an incomplete digestive system because it has no anus - all goes in and out through oral cavity



- all predators - feeds on herbivores - carnivores
- medusa is basically polyp flipped upside down.
- bell closes when muscles contract (jelly is elastic), and opens when muscles relax - jelly allows the bell to pop back out again.
- contracting - squirts water out faster than it fills.
- has fluid filled sacs inside bell
- moves up and down - passively stings prey
- cnidaria can exist in many enviros

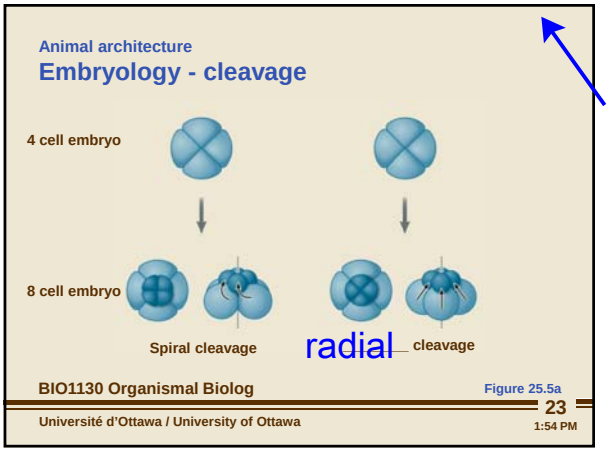
- watching for feeding, locomotion...



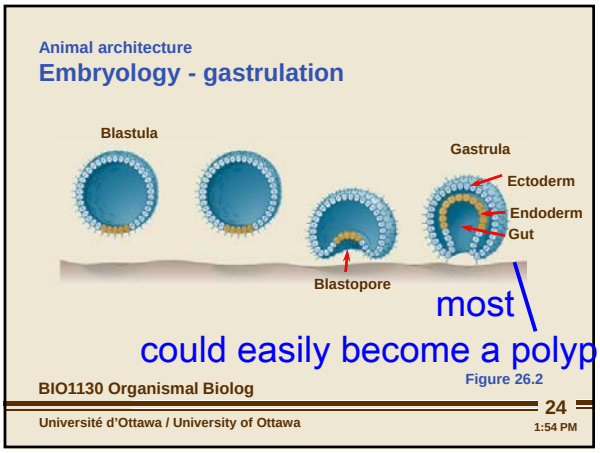
- life cycle that switches from being sesile to locomot
- alternate between polyp and medusa stages
- medusa swimming around (sexes are separate) - will release eggs and sperm in water column - based on chance that eggs and sperm mee
- zygote replicates cells, becomes planula larva, becomes polyp, sitting on ground and feeds
- gastrozooid - specialized - gonozooid produces gonads.

- next events - bilateral symmetry development

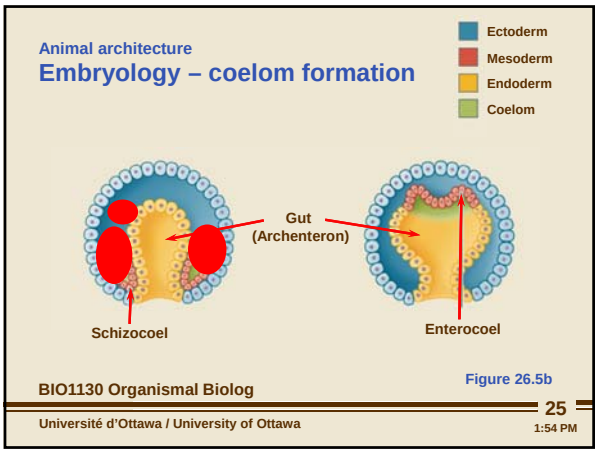
- triploblasts and diploblasts both appeared at the same time
- major events have occurred in embryology
- can divide up up animals based on these
-



- cell divisions will be instrumental in growth
- 8 cell stage division occurs across the center, horizontally.
- some do a twisting - produces spiral
- some organisms just hold them on top - radial cleavage
- can divide all animals of the world with spiral or radial cleavage.

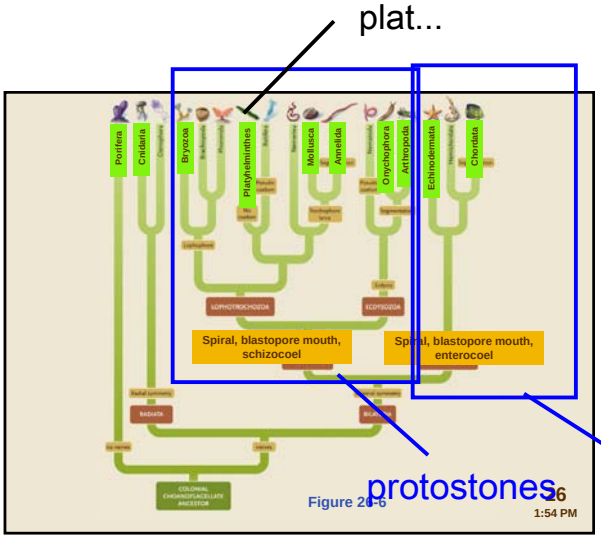


- no matter whether radial or spiral cleavage is there, the next stage will be a hollow ball of cells (ectodermal in origin). A certain set of cells will start to invaginate inwards, creating a blastopore. The inner layer of cells become endoderm - the gut.
- next stage - inserting mesoderm
-



- when the endoderm reaches the other side (folded part) - the topmost layer of cells form enterocoel which split from endoderm - fill area between gut and endoderm with mesoderm - called shizocoel

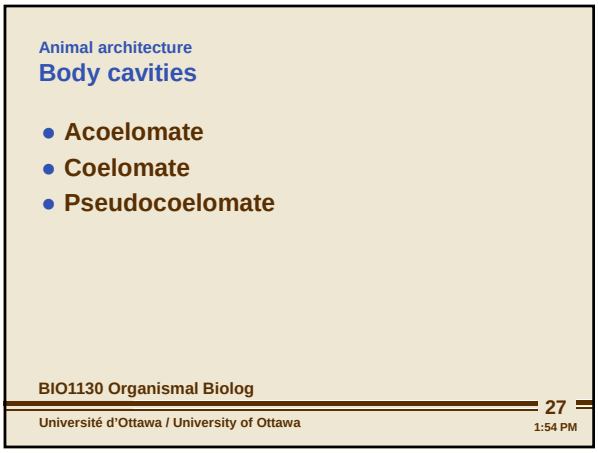
- mesoderm allows for muscles
- have mesoderm - now have a cavity



- spiral cleavage always related to blastopore and splitting of mesoderm stays together with one lineage of animals
- radial cleavage - first opening will be mouth - mesoderm will proliferate from gut and fills space.
- bilateral share origin of mouth, digestive cavity...
- digestive system can process food independently in hydrastatic structure - tube within a tube

- protostones - blastopore becomes the mouth

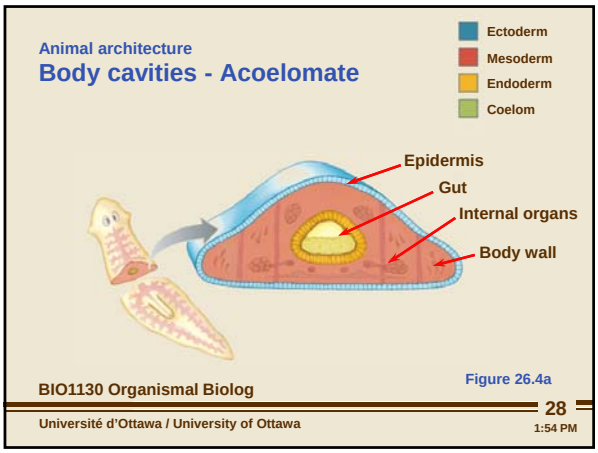
- cavity will be used in different ways for every phylum.



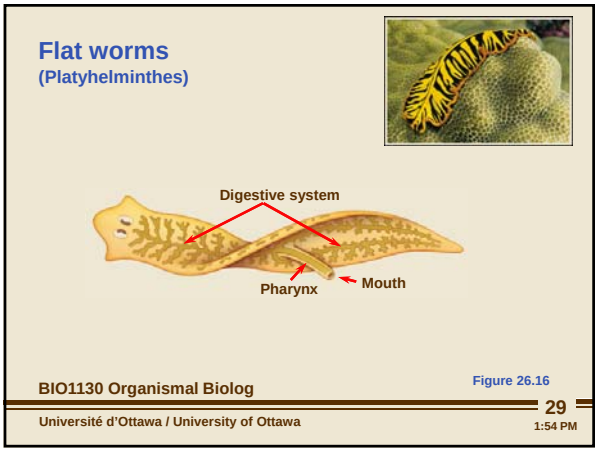
- animals with body cavity - coelomate - can use for hydrostatic skeleton... etc.
- modifies the body cavity - acoelomate - animals that LOSE the body cavity - get rid of all of the advantages of the coelom - flatworms

- pseudo - has mesoderm - instead of having a body cavity totally surrounded of mesoderm - there is only mesoderm associated with outer body wall, the ectoderm
- a digestive tract that has no muscles associated with it at all.

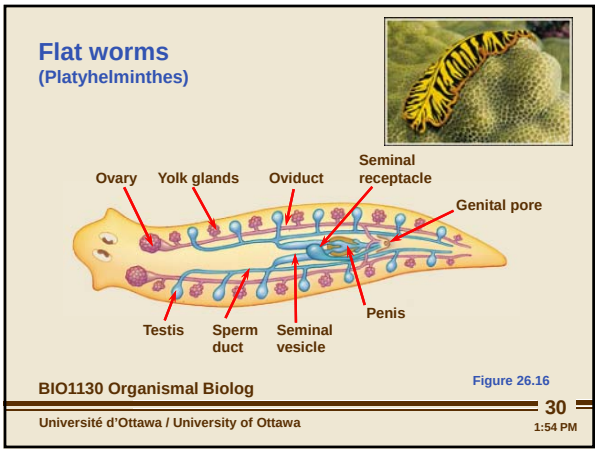
- FLATWORMS
- as an animal gets bigger, the surface to volume ratio gets bigger
- cell exchanges across the surface - there is a powerhouse that occurs inside a 3D space, while there is an exchange with the outside world across a 2D space. - surface area is a limiting factor for the volume
- these organisms have become smaller to have an optimal surface to volume ration.
- incomplete digestive system - no anus - but extended digestive tract.



- mouth on bottom to stuck into substrate from underneath
- most that are alive now are not free-living, they are parasitic.
- invaded the body cavities of other animals, and then live in the fluid filled places.
- successful, they are capable of entering any animal with a fluid filled space
- still have circular, longitudinal muscles...
- covered with ciliated cells - waving in metachronal wave. - soft-bodied, so can be easily food for other animals
- defensive - when it fed on a cnidaria, can absorb and coat itself in cnidaria stuff- doesn't trigger it
- hydrostatic skeleton - also allows it to stick into place - cephalization (does not require placing mouth at front of body) - has eyes, smell detectors, can orient

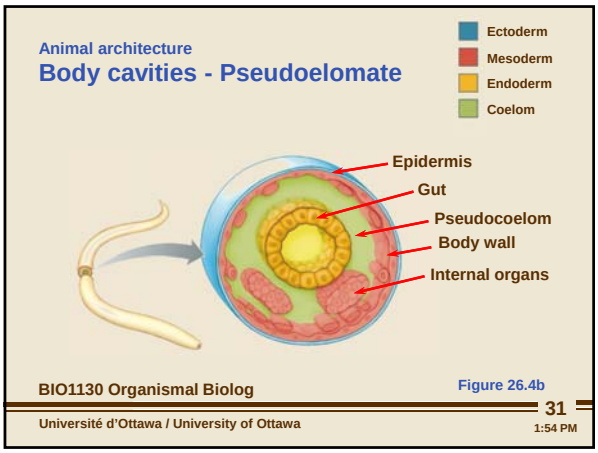


- can have behaviour...

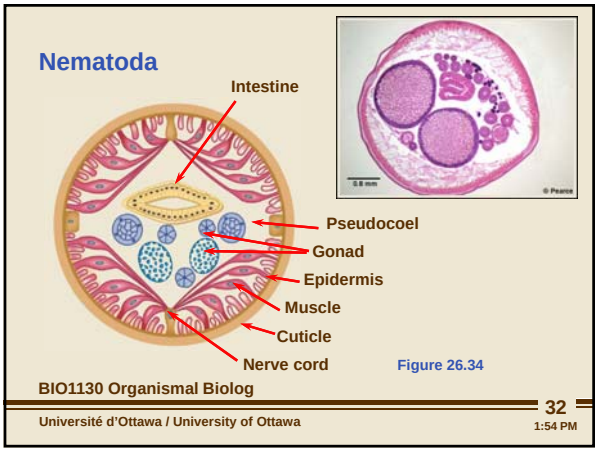


- hermaphrodites, has male and female reprod. systems inside
- some advantages: when two planeria meet, then in a mating event, both will produce young; variability that comes from recombination of genes;
- sperm produced in sperm duct, and then stored in seminal vesicle. - B's sperm passed on to seminal receptacle of A and sperm passed onto seminal receptacle of B from A
- eggs will come from ovaries, move past seminal receptacle - put outside after fertilized through genital pore

- length of a fingernail
- tapeworms can be up to 3-4 metres long

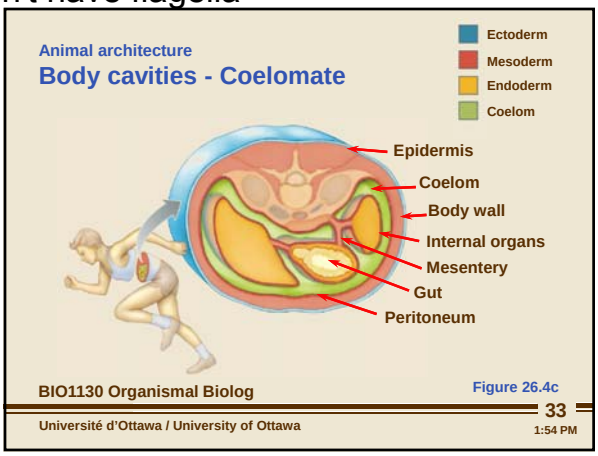


- no muscles to propel -
- tend to be animals with a strategy towards micromizati
- multicellular, but smaller than paramecium



- round worms - very small in size, microscopic
- don't know how many exactly exist, except for the ones that are important in med
- round worms fit into decomposer
- doesn't have mesoderm - so have pseudo-(or fake) coel - there is no connection with the mesoderm with the outside and the mesoderm in the gut. - not anchored anywhere in place
- they have all the surface to volume advantages
- muscles that they have are all longitudinal - if it contracts its muscles - one side contracts, and then the other - whiplike motion
- always found in substrate - use whiplike movement to move between elements of substrate that they live in. ex. in soil - don't swim
- relationship between nervous system and muscles - instead of axon, a cytoplasmic arm of the muscle cell that goes to the nerve core - muscle connected directly to nervous system

- may be one of the most abundant phyla on the planet
- doesn't have flagella

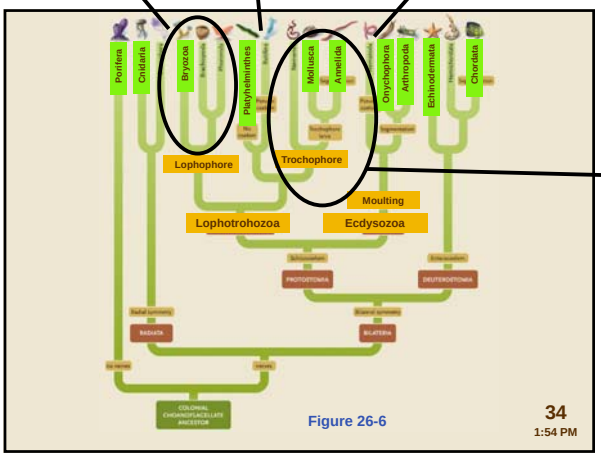


Cambrian and Ordivician

nematoda

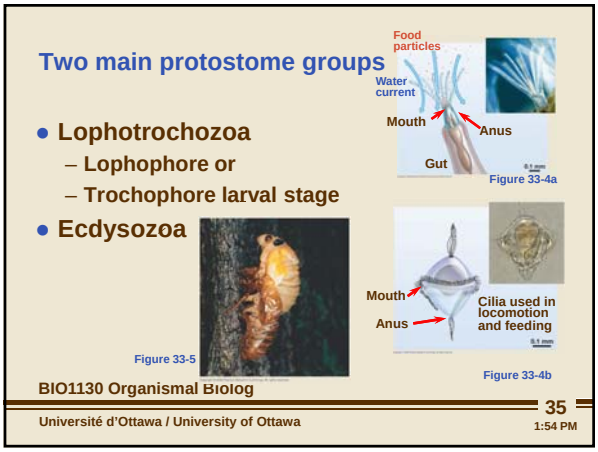
rotifera also have pseudocoelem

Lophophores



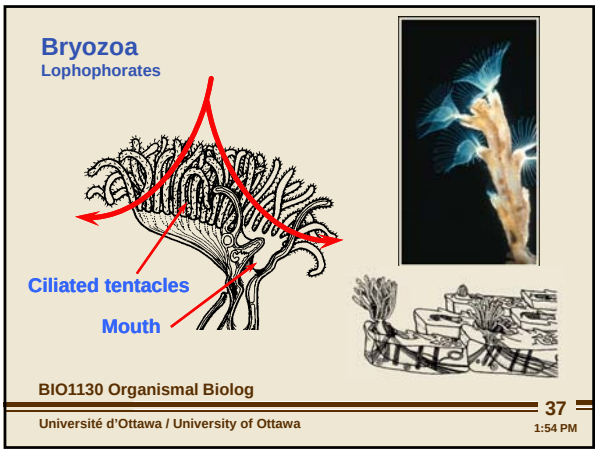
-

Trochophore



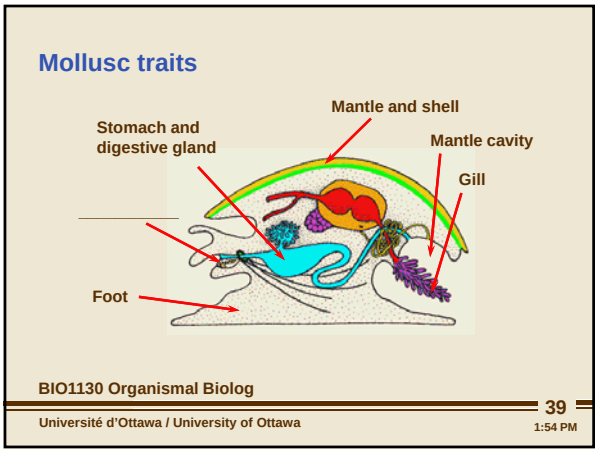
- Lophotrochozoa - there is no single morphological characteristic that unifies them other than RNA/DNa
- morphological larval stage is similar
- either have lophophore or trophophore larval stage
- lophophore is a feeding structure, trochophore larval stage is a developmental stage
- also include reef buiders - Bryozoans - small minute organisms that have a different feeding mechanism

- Trochophore - turn into annelids and molluscs from larval stage - ciliated top and ... - all go through the same stage.

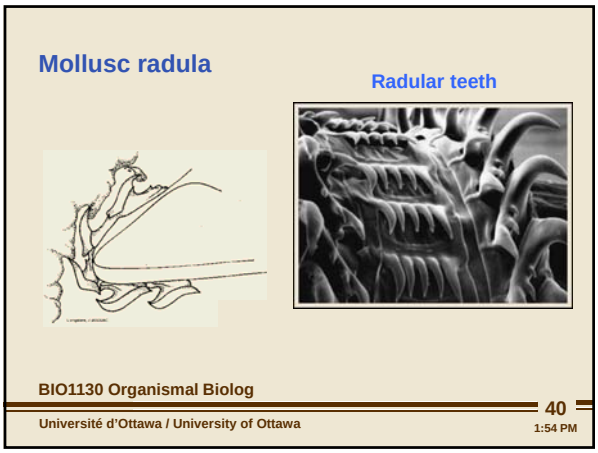


- can extend, direct, ... because of tentacles
- covered with cilia, water current being pulled in across teh tentacles and create water current, and also trap particulate matter for food out of water column - food rolled down cilia and and into mouth - filter feeding
- sponges were doing this
- much more control than sponges - usage of current
- usually sessile if filter feeding. All of the bryozoans are stacked, sits inside "case", can retract when avoiding predators.
- create reefs in the same way that corals create reefs - coral polyp was a carnivore, this is a filter feeder
- have not trapped all of particulate matter, has not take all of it up. Sessile sucks in large amounts of water... and stores inside cavity

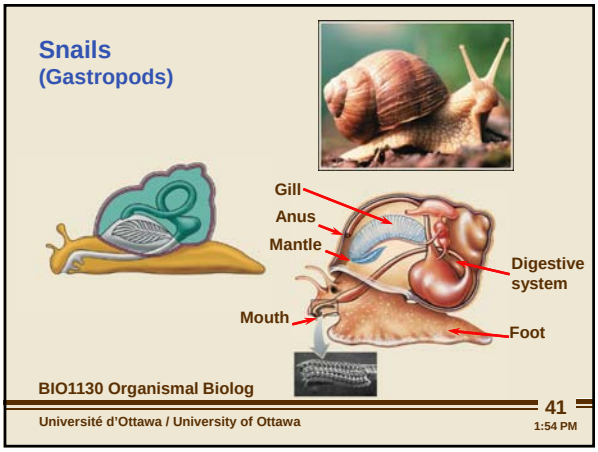
- second to arthropods in numbers
- tremendously diverse and very long evolutionary history
- Lyell - used mollusc shells for stratigraphy
- range from simple snails to clams, mussels, oysters, squids and octopus.



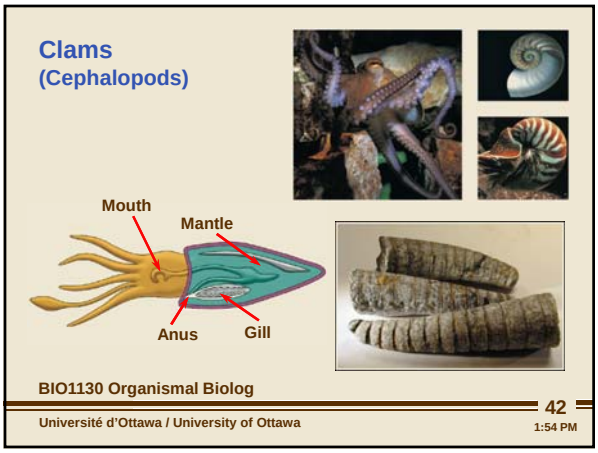
- take the ability to pull out of water the minerals to create a shell
- shell - then epithelial layer that secretes what creates the mantle
- takes shell, protects, and becomes mobile
- simplest of molluscs, have shell and then mantle underneath - have muscular foot for locomotion
- almost functionally divided into two pieces
- dorsoventral muscles - used to protect itself and escape predators - pulls down on shell
- when shell clamps down, still small amount of gas exchange through gill



- instead of sticking tongue out, rows of teeth can be rolled inwards and outwards, can grate against substrate, scraping off organic material off of substrate
- piles of particulate material that can be sweeped into digestive system that can be used for food
- reason for the success of molluscs

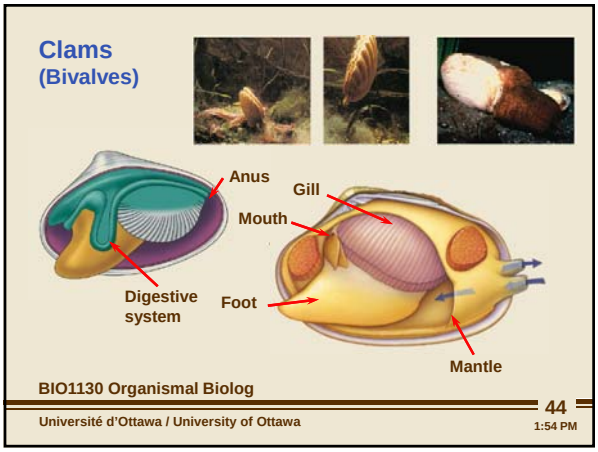


- animal gets bigger - visceral mass elongates, but footprint does not change
- if water current comes along, tips it over
- large visceral mass that is wound inside cell
- hermaphrodites - reproductive organs inside shell
- some have a little piece of shell on foot - allows it to withdraw into shell completely
- snails will be first to come up on land - start chomping on plants - become successful on terrestrial land
- snails can wait out dry periods in shell before coming out during wet season - can live in desert.

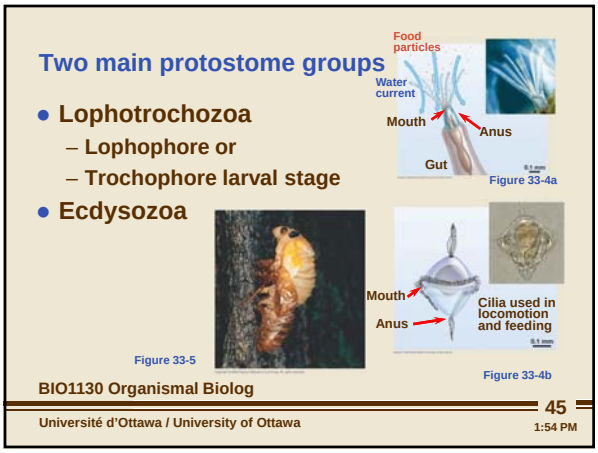


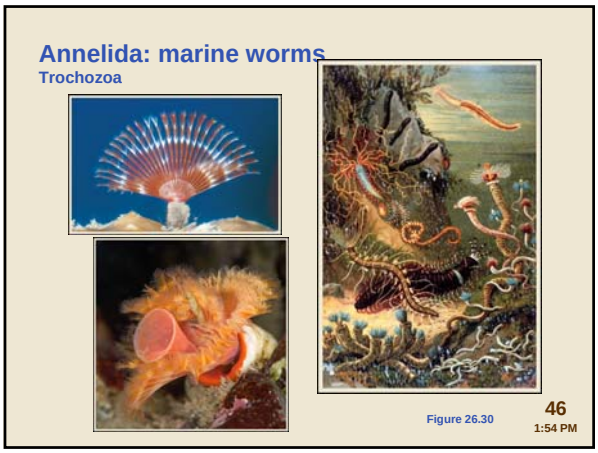
- another strategy for enlarging and becoming big - elongating body - wrapping shell around the body in a cone
- conical shells - foot becomes modified into tentacles - ability to pump water out - fill mantle cavity and squeeze water out of one cavity - jet propuls
- extremely effective predator
- squids and octopi have little to no shells now. - main predator in oceans
- eye in squid is very similar to ours

- major predator in oceans
- propelling themselves around in these shells and attacking for food - top predator in ancient seas
- shell is made up of layers, and innermost layer creates mother of pearl - sand grain gets inside shell - epithelial layer begins coating grain with layers of mantle
- only place to find these fossils is in canada
- main question - why did they lose their shells
- fish at the end of permian explodes in pop. - gradually decreases weight of shell - become even more effective at predation - faster

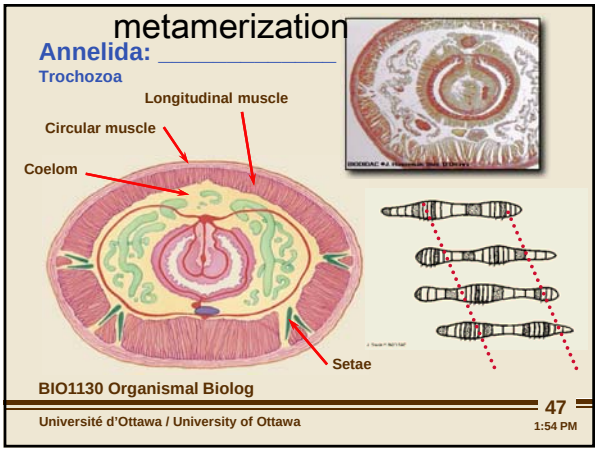


- ammonite close relative to clams
- example of adaptivity of group - giant filtering animal with a gill - cilia to trap food from water
- got rid of radula - don't need it anymore because what they are feeding on is already particulate
- whole point of radula is creating the particulate material
- therefore, complete loss of cephalization in this group - pretty much a sedentary animal
- only three most common body structures in molluscs

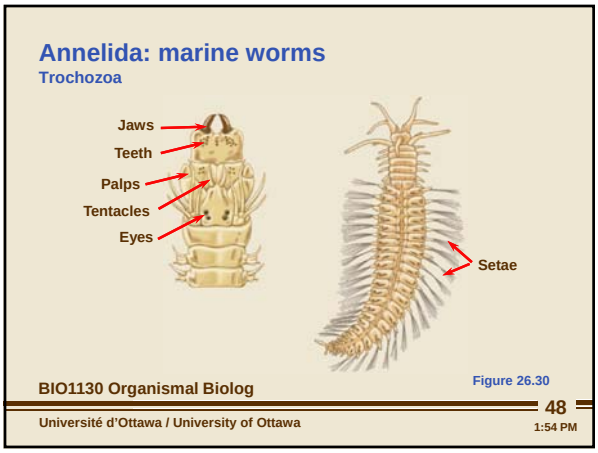




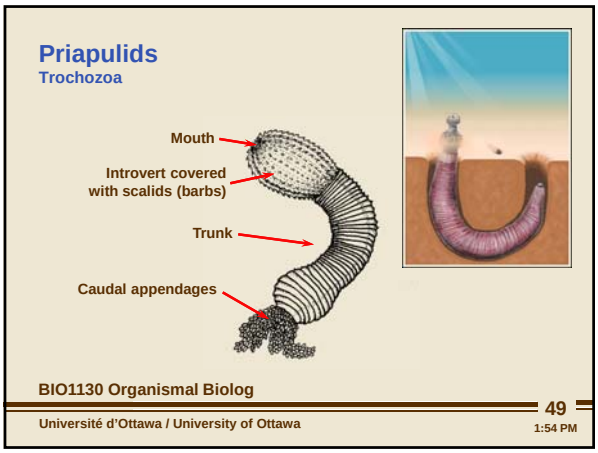
- also trophophores
- earthworm one of major success stories for land animals
- annelids - to become bigger - repeated coelems all the way down the animal - segmentation
- has whole set of independent hydrostatic skeletons down length of body - will be able to contract longitudinal and cirular muscles independently down
- when longitudinal muscles are contracted, bristles stick out - provide a grip on the substrate



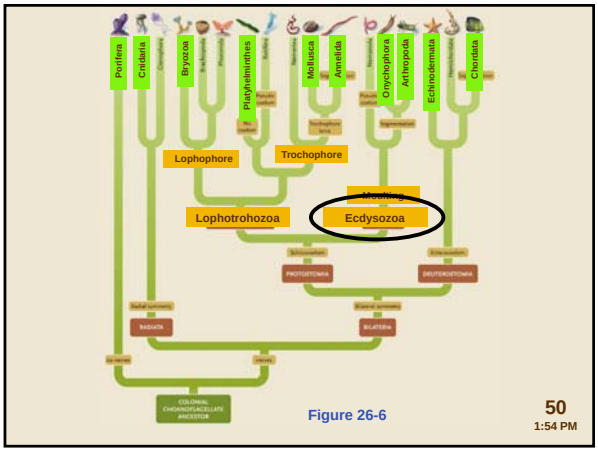
- the earthworm is essentially anchored to the substrate through bristles
- accordion like movement - because of independent hydrostatic skeleton
- flatworms also did the same movement - glue themselves in place using circular and longitudinal muscles
- can use bristles to burrow into soil
- open mouth and digest soil - feeding on organic material in soil.
- first animal that was able to burrow into substrate, and feeding.
- protected from predators



- swimmers, can also set up filtering systems

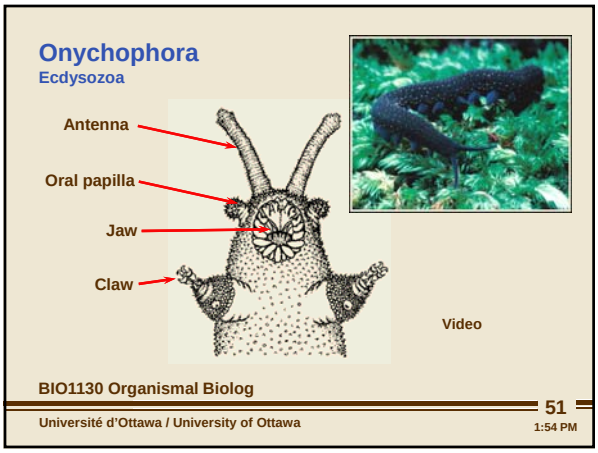


- lives in a burrow and also is predatory
- Trochophore - tremendously diverse

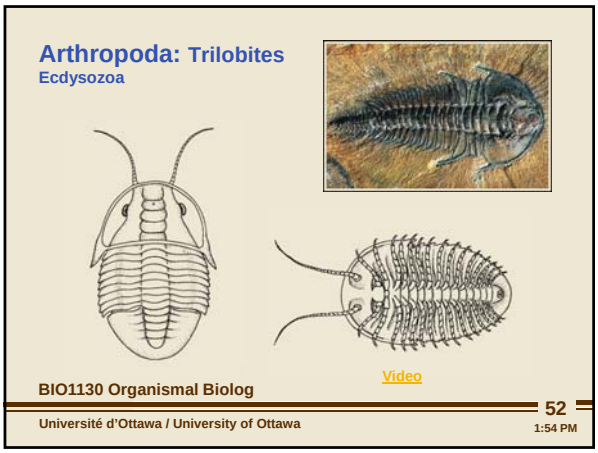


- ecdysis - the animals that mole
- important group - take segmentation and combines with exoskeleton

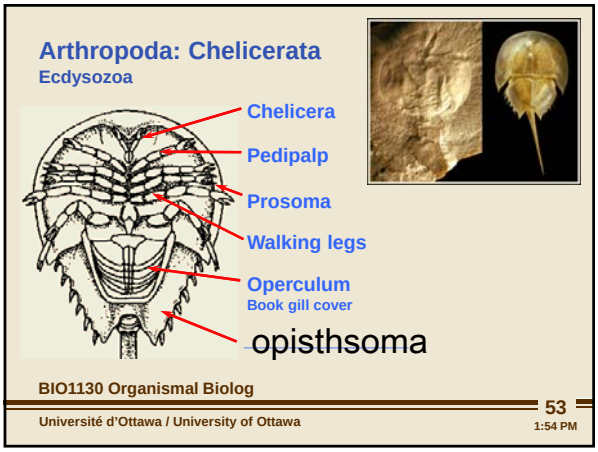
Velvet worm



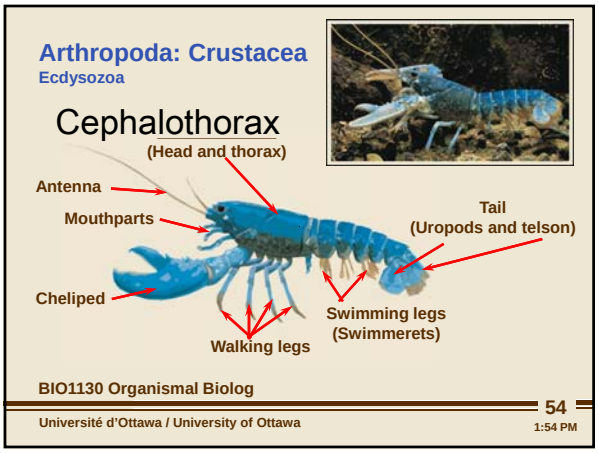
- midway between worm-like
- has a exoskeleton - elastic, has hydrostatic skeleton
- fleshy legs that it is able to walk on - these are hydros
- preyed on land on other arthropods
- a living fossil - functions the same way as it used to do in the oceans
- vicious mouth - holds in place with glue and jaws tear away
- shows segmentation
- so ancient, used as an example of continental drift to support this theory



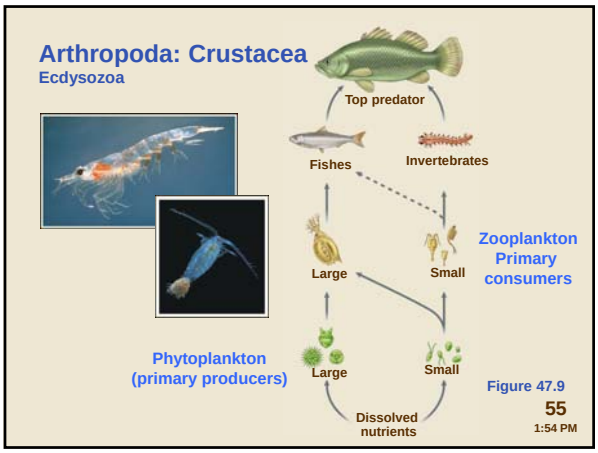
- Tagma - effusion of segments for locomotion
- modifies segment for carrying out specific functions
- one of four architectures in arthropods- trilobites
- Trilobites are extinct - replaced by more efficient predators
-

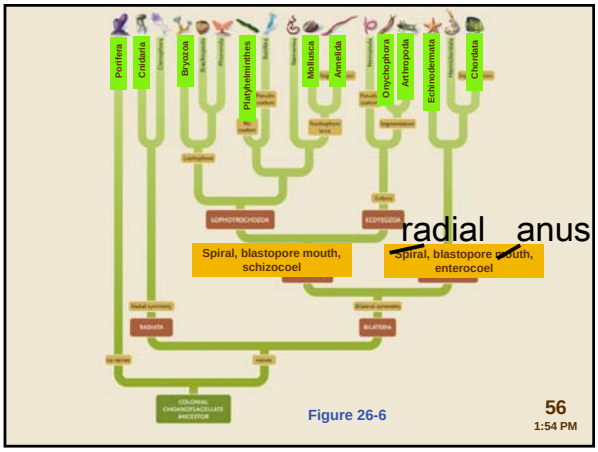


- predators in ancient oceans
- feeds with chelicera, most in this group are terrestrial - ex. spiders, ticks... etc.
- still one ancestor of this and trilobites still living in ocean is horseshoe crab

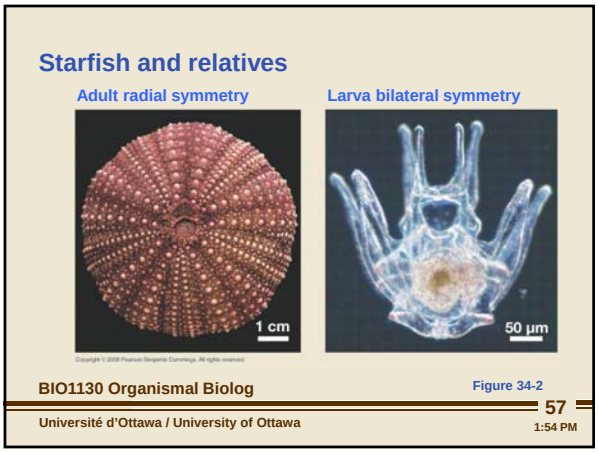


- can come on land
- blood from this animal are harvested - contains fine, high-resolution antigen to bacterial contaminants
- coagulates when comes into contact with bacterial contaminant - used to date to identify medical issues
- tremendously large forms - Zooplankton - primary consumers
- harvesters of primary products of ocean
- one group that does make appearance but does not have much success - arthropods including centipedes... etc.
- all feeding different ways... creates different architectures.

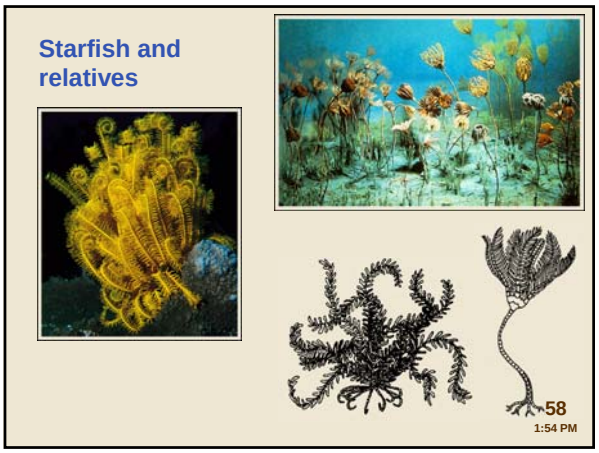




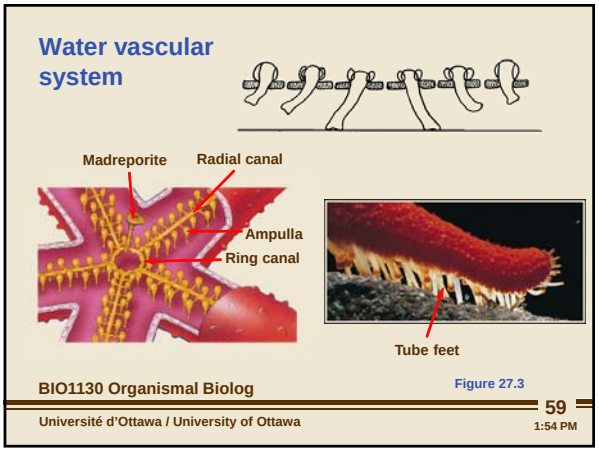
- one of our closest ancestors are sea urchins and starfi
-



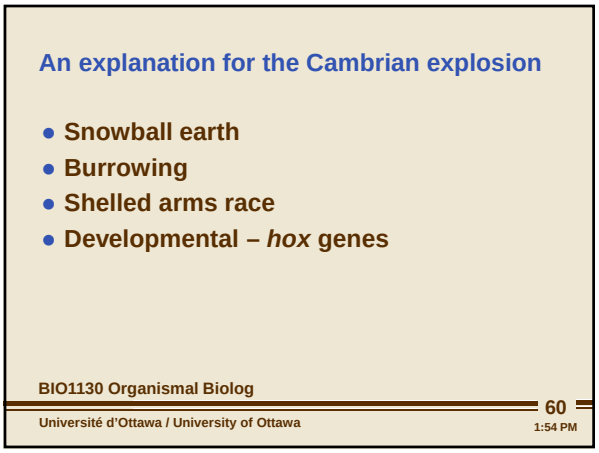
- bilaterally symmetrical larval stage- knew that this group had sacrificed bilateral symmetry for the advantages of radial



- sesile organims attached to substrate by a stalk - advantage - extended arms - inverted umbrella with arms that are fanlike in water column - getting above substrate and grabbing everything that is falling in water column before it reaches the bottom of the ocean
- all down the length of arms are tube feet



- tube feet- if a substrate fell on arm - tube feet would pass on to the next to move it to the move - primary role is to move the food
- then, starfish become mobile- disconnected stalk - tube feet pushing against substrate for locomotion - muscles can stretch it forward, suck it down on surface and move using that method
- will prey on clams - sessile creatures - will wrap around clam and then pull - snaps shell - turns itself inside out and puts itself into clam - puts enzymes into clam - liquified clam innards - sucks it up
- also feeds on coral - puts stomach on coral - liquifies it and sucks up sections



- why did all this diversity occur at this point in time in C
- sudden appearance in fossils - very diverse architectu
- Part of the point- to set the earth for Cambrian explosion - called snowball earth

- snowball earth may have stopped or slowed this down - snowball earth may represent the first extinction on Earth - but we didn't know it.

Cambrian and Ordivician

$CO_2 + H_2O \quad H_2CO_3$

$H^+ + HCO_3^-$

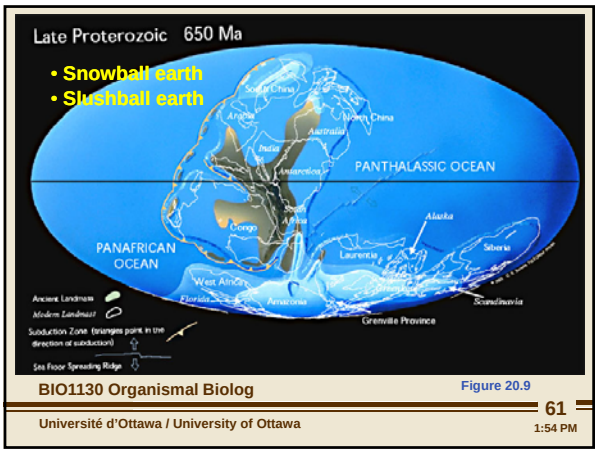
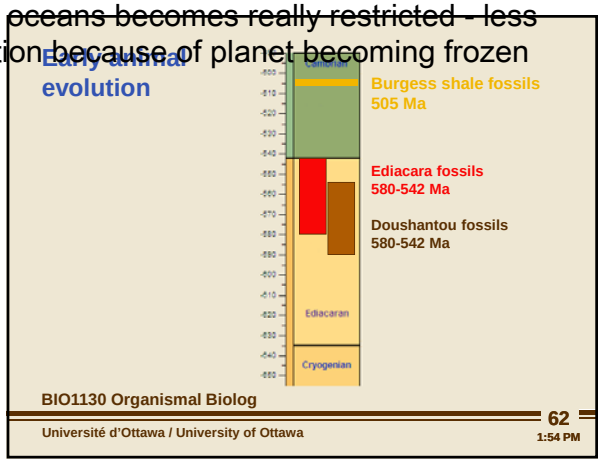
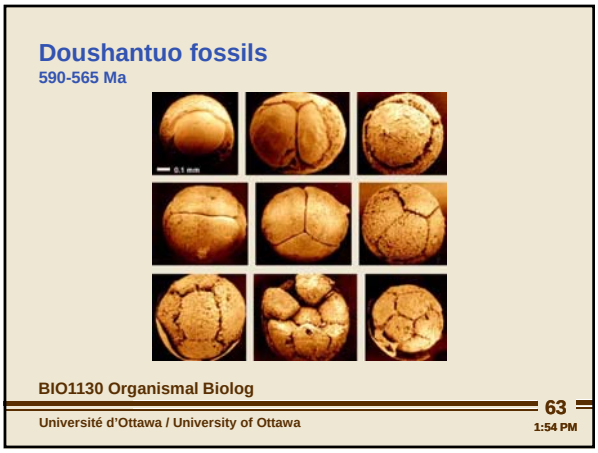


Figure 20.9

- insulative blanket keeps being scrubbed away
- reflecting away more solar energy than we can keep to keep the oceans warm
- life in the ~~oceans becomes really restricted - less~~ diversification because of planet becoming frozen





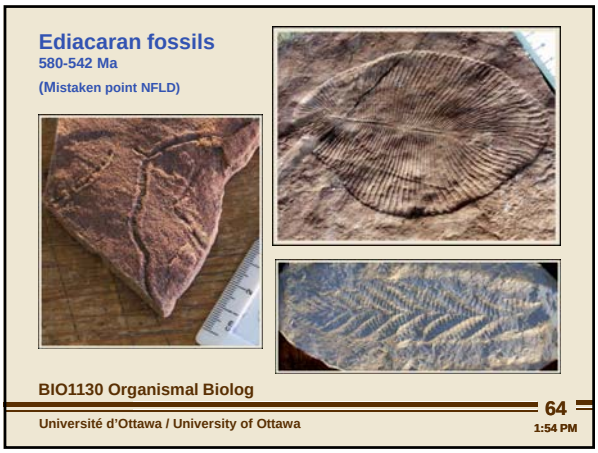
- ice from northern to southern poles -snowball earth
- cause of snowball earth - land masses emerging - where they are emerging are right on equator
- bare rock- land masses
- water in oceans is better absorber of solar heat than rock
- large amount of solar heat being reflected back by water - normally would have planet absorbing
- mineralization in the oceans - calcium, silica, iron all eroding from rain falling on land masses
- rain slowly dissolves out minerals from rock and to oceans
- carbon dioxide and water will create a reverse reaction that creates carbonate - reacts in water
- capable of being in equilibrium in its ionic form
- pulling CO_2 out of air, converting to carbonate in water - CO_2 levels start to drop

[- CO_2 - losing insulating blanket - losing heat
- erosion of minerals pulling CO_2 out of air
- temp drops
- glaciation starts from both of the poles
- absorbing even less heat from sun due to ice/snow reflecting heat
- thaw comes and then multicellularity arrives

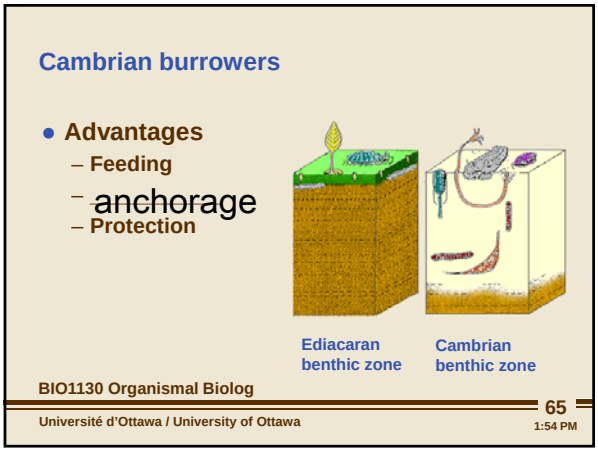
- Golden rule that multicellularity arised first in Cambrian is first being questioned

- in these fossils - trapped and captured the embryos
- what looks to be multicellular
- typically, embryonic cells are delicate - so does not explain why these were fossilized

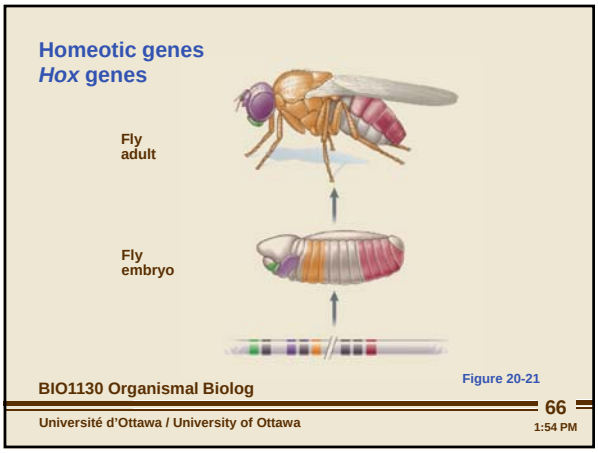
Cambrian and Ordivician



- older than Cambrian - looks like it is multicellular
- shows tracks in the fossils - looks like something has moved
-Ediacaran fossils tell us that there was perhaps something moving before Cambrian
- These fossils in Mistaken Point, NFLD
- protoanimals: very small modules that are attached to one another
- Mistaken point - an architectural unit that is made up of smaller modules- branching on another - does not have a lot of control - perpetual
- Multicellular life may have come around before Cambrian - but they were really simple, and no one recognized them as multicellular until 50 years ago
- Within the Pre-Cambrian time - there may have been the first sponges present and the first cnidaria - diploblasts may have been out there before...



- organisms that are able to penetrate through biofilm - very difficult (sort of like plastic wrap on bottom of ocean - no one really able to penetrate, but once you can burrow through it, lots of nutrients-home- ...
- high levels of predation - burrowers can hide, as well as those who have shells.
- shell - suit of armour - can hide inside from predators
- if predator got bigger - competition - increased diversity
- Whole slew of organisms never seen before - can explain them now : 1) Burrowers - only a few organisms that survive 2) Shelled animals - can hide in their shells - crustacea - coating themselves with mineral "shell"
- huge explosion - mineralization has been taken advantage of



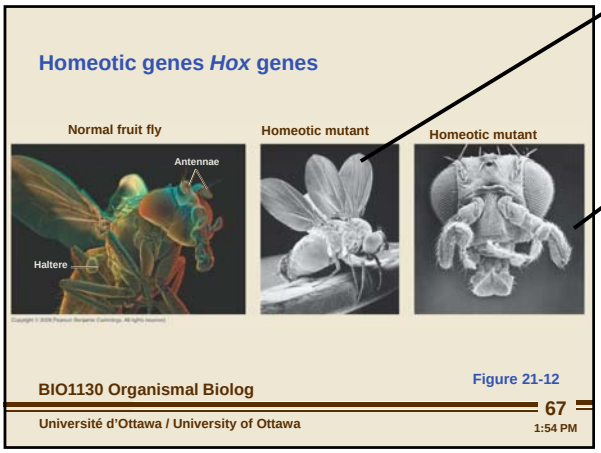
- ex. green is the most anterior end - creates eyes
- we can take the cells and mold them into head/appendages... etc.
- all transcription factors ; all RNA

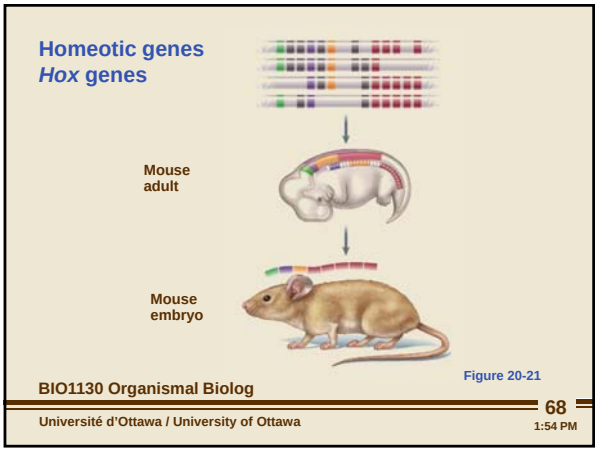
- Now have a multicellular organism with a series of cells - how do we get the pattern that the cells organize themselves in? - top/bottom or front/back
- even jellyfish have simple radial pattern
- how do you get from a ball to a set pattern of cells
- Hox genes - make transcription factors - responsible for folding the nucleotide information of the genetic code- bringing them together for transcription to occur
- part of the secret of how there is only 35 genes - depending on how you fold them gives you a different p
- they will control the genetics of the cell to determine it's fate .
- transcription factors are in gradients
- levels of transcription factors tell cells where they are meant to go.

second set of wings generated

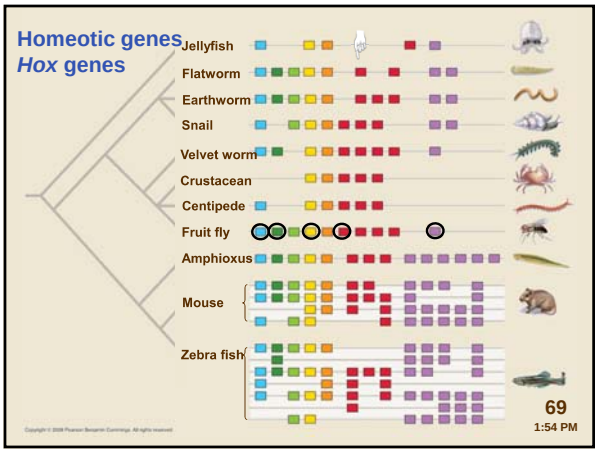
where antennae should be

- all this by just playing around with the transcription factors



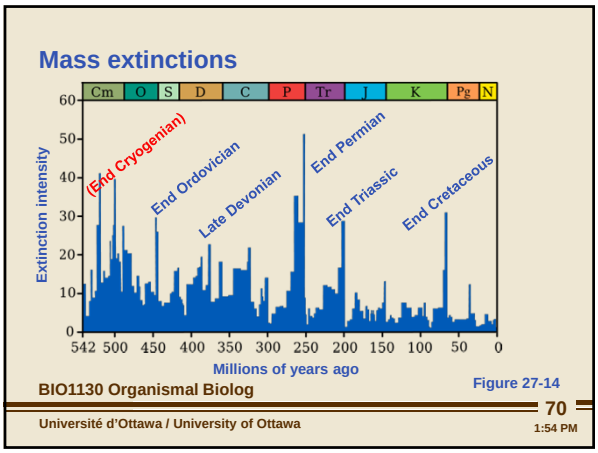


- a set of pattern control of genes - determine the fate of the multicellluar organism and producing a patt
- RNA sequences are involved in how pattern and complexity occurs
-



- green disappears sometimes - the one that codes for bilateral symmetry - radially symmetric ones don't have them
- fair amount of variation, but there are always these pat
- complex ones have a lot of the ones for the abdomen
- pattern regulated by exactly the same transcription factors across all of these animals
- pattern genetically coded- more complex over time - gene duplications that allow even more complexity
-

also found in plants - whirls of flowers ... etc.



Not going to talk to much about Ordivician - going to look at the survivors of the Ordivician - mass extinction at the end of the era - the End Cryogenian - extinction in snowball earth - paleontologists asking to make it official - mass extinction defined by extinction of 50% of biota that is there