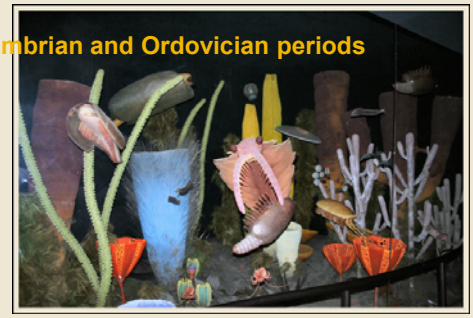
Cambrian and Ordivician



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Geological time scale and building height

(1floor – 60Ma, 72 floors, 12 feet/floor)

- **Major Eons (Ma)**
  - **Phanerozoic**
    - (550 Ma to present time, top 9 floors')
  - **Proterozoic**
    - (2,500 – 550 Ma, 33rd -63rd)
  - **Archaean**
    - (3,800 – 2,500 Ma, 12th – 33rd)
  - **Hadean**
    - (4,500 – 3,800 Ma, 0-12th)

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Beginnings of multicellular life. Occurs in 3 major divisions

Cenozoic

Mesozoic

Paleozoic

Geological time scale and building height

(1floor – 60Ma, 72 floors, 12 feet/floor)

- **Major Era**
  - **Phanerozoic**
    - Cenozoic (65 Ma to present time, 72nd floor)
    - Mesozoic (245-65 Ma, 65th to 71st)
    - Paleozoic (550-245 Ma, 63th to 65th)
  - Proterozoic (2,500 – 550 Ma)
  - Archaean (3,800 – 2,500 Ma)
  - Hadean (4,500 – 3,800 Ma)

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Beginnings of multicellular life. Occurs in 3 major divisions:

Paleozoic: Multicellular life in oceans

Mesozoic: Lots of multicellular life on land

Cenozoic: End of dinosaurs, rise of mammals and birds

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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Beginnings of animal multicellular life in the oceans.
Continents are starting to form.
Erosions from the bare rock will change ocean chemistry
Beginnings of every single animal life form.
Starts with invertebrates, leading to vertebrates after.
Explosions of life in Cambrian and Ordovician ending in massive extinction, losing everything.

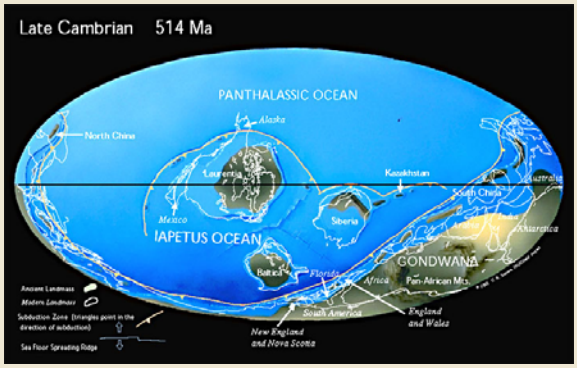

Figure 27-8

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Continental shelf is shallow water which means lots of solar energy. It's also on the equator. This continent is sitting in the ideal location with a large continental shelf and perfect placement at the equator. Land is just raw rock. As continents start to shift, they will bash together making mountains. What was in the ideal location will be pushed up and form what is now the rocky mountains. Lots of fossils are found here.

Burgess shales – Yoho National park

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500 million years old fossils from just off the coats of continental shelf of the Lorentia. Soft bodied animals.

The Cambrian explosion

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Many of these fossils are completely unrecognizable, nothing these days looks anything like them.

Burgess shales and its unusual invertebrates

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Burgess shales and its unusual invertebrates

Video 1, 2,

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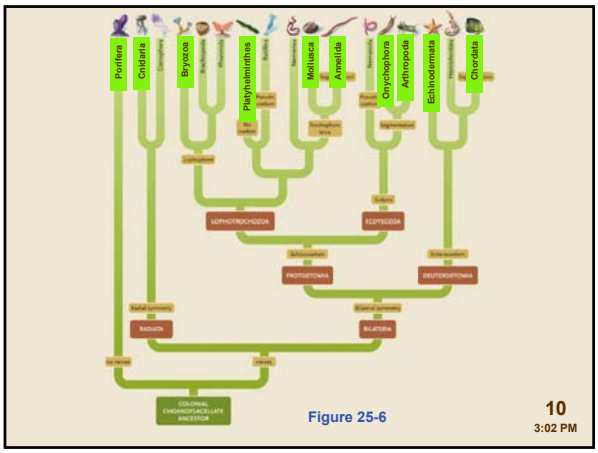
We have a one of a kind set of organisms. In them, we find the descendants of the animals of today.



First cladogram.

Animal architecture

- Tissues
- Symmetry and cephalization
- Embryology
- Body cavities

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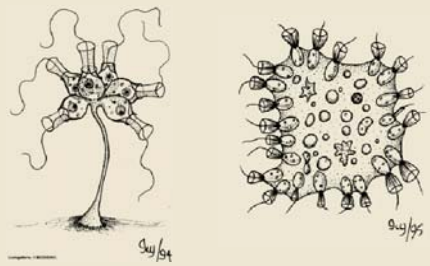
How we divide the animal world.
Tissues: will the organism have tissues with cell to cell communication or will the cells just have their own tasks and how many tissues.

Colonial choanocyte ancestor



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This cell extends cytoplasm like fingers and the flagellum passed the water into the fingers and the nutrients get caught in the fingers.
This is the ancestor because the microtubules that make the fingers are exactly the same as the microvili on any animal cell.
When they get together as a group they can pump more water and trap more food so they form aggregates (groups) but they havent formed tissues yet.

Animal architecture: Tissues

- No tissues
- Diploblastic germ layers
  - Ectoderm and endoderm
- Triploblastic germ layers
  - Ectoderm, mesoderm and endoderm

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Next step, forming these two tissues. Cells are sending each other chemical signals to work together. First tissue has two layers and then the mesoderm was added (muscles) and we can now use them for moving.
Tissues = first division in the animal world.
Second division : 2 layers or 3

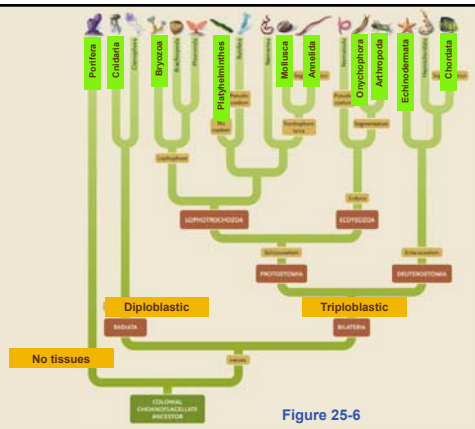

Figure 25-6

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Colonial choanoflagellates

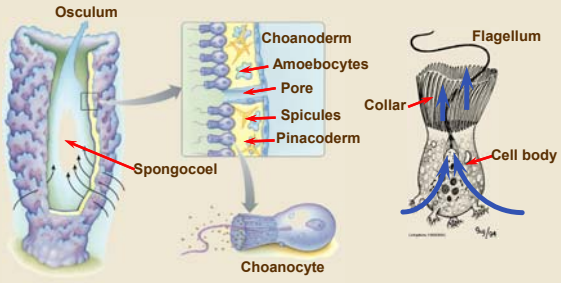

Figure 25.8

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Specialist on filtering large volumes of water. Sponge.
No cell to cell communication so these layers cannot be called tissues. The choanocytes form in a line and as they beat water is pumped into the tube and the choanocytes are able to get the nutrients.
Inner body surface (choanocyte cells) and outer body (choanoderm cells) surface with an inner jelly-like matrix.
A surplus of food will be passed to an amoebocyte which will pass it to the choanoderm.
Very early staged animal with no tissues.
First filter feeder. Prion like proteins are in these organism to glue the cells together, they just don't communicate.)

Sponge sex

- Choanoctyes become sperm
- Archeocytes (sponge stem cells) form egg

http://www.waterexplorer.com/il_cool102.htm

Figure 25.7

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At certain times of the year, the choanocytes undergo mitotic division and become sperm cells and some or the archeocytes turn into an egg. The sponges release their sperm. As the sponge next to it is pumping water, it engulfs the sperm and instead of digesting it an amaebocyte carries it to the egg.

Animal architecture
Symmetry and cephalization

- Assymetric
- Radial symmetry
- Bilateral symmetry and cephalization

Figure 25.3

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There are two basic symmetries in the animal world, radial and bilateral. All animals with tissues are going to have a mouth, because there needs to be a way to get food in. The side with the mouth is the oral side and the side opposite is the aboral side. Symmetry, when you can draw a line from the oral to aboral and get the same thing on either sides.

Radial symmetry, you can rotate the plane and get multiple symmetries.

Bilateral symmetry, you can only have one plane.

Symmetry determines how you respond to the world around you.

Radial: Passive to the world around you.

Bilateral: Reactive to the world around you. Sense which way they are going. Concentration of sensory tissues at the front (look where they're going). Cephalization : they get a head. They can turn and orient themselves. towards whatever needs to be "seen".

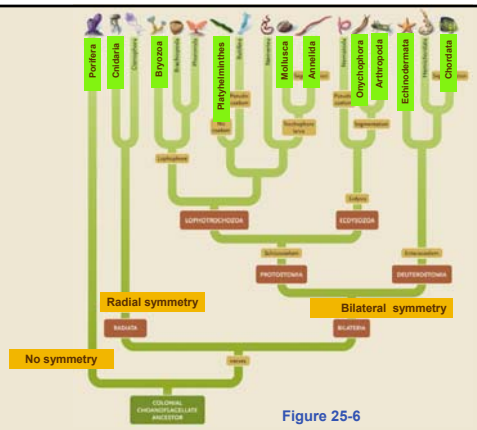

Figure 25-6

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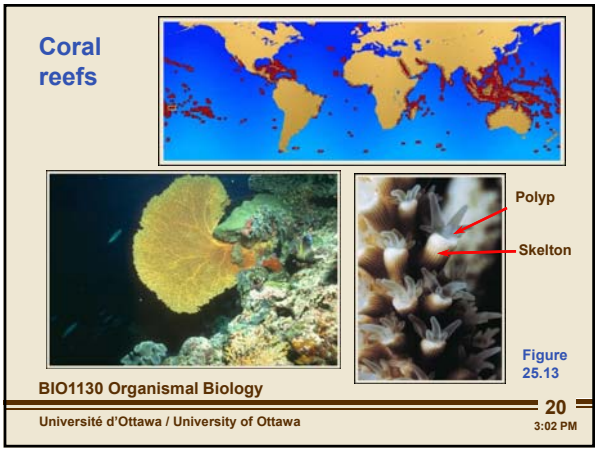
Another major division : radial vs bilateral symmetry.

Radial symmetry associated with diploblastic.

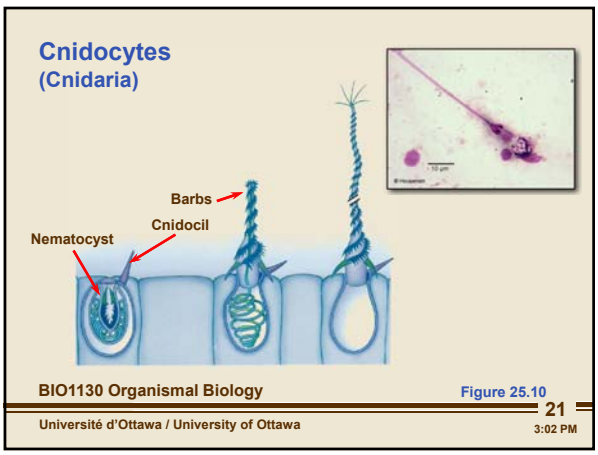
Bilateral symmetry associated with triploblastic.

Colonial nidarians.

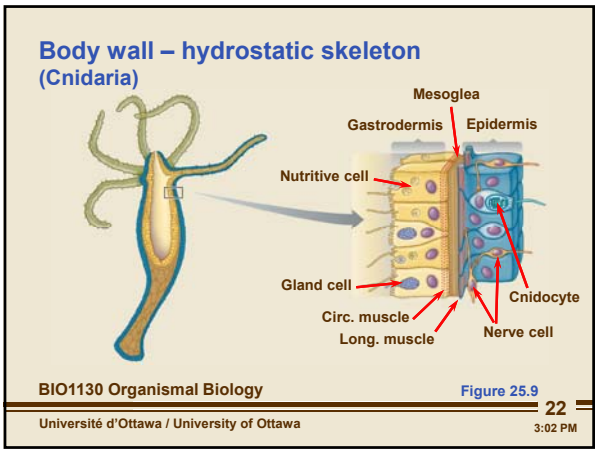


Most significant primary productivity zones in the oceans. Coral reefs are build by corals. Equivalent to tropical rain forests.

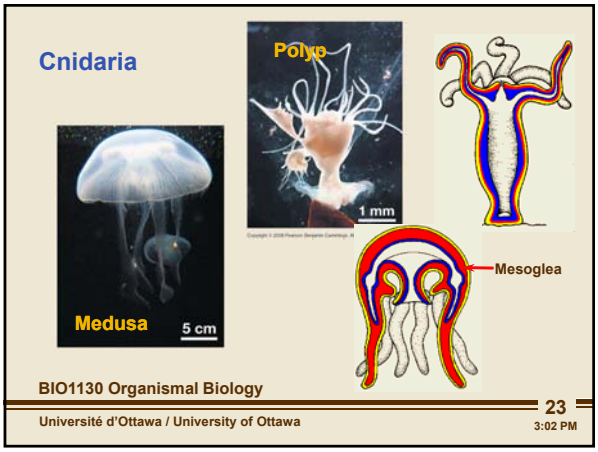
Coral consists of a Polyp that lives inside a secreted casing made of minerals. It stick its head out, feeds, and goes back inside.



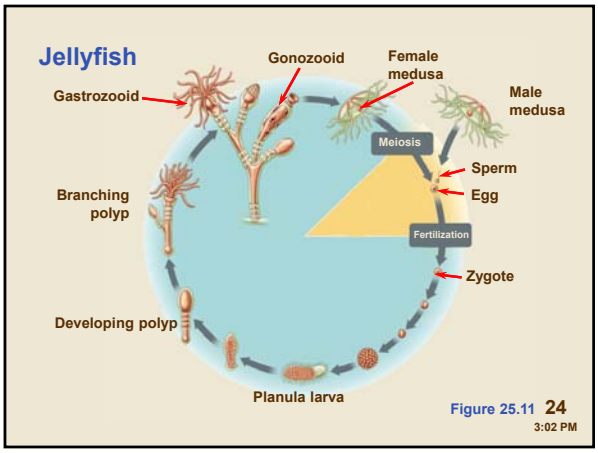
Cnidarians are one of the first exclusive predators in the oceans. Going after and feeding on large organisms. Uses a Cnidocyte, little stinger. Used to trap and capture prey. This cell contains a pressurized spring. If the right stimulus hits the trigger, the pressure fires this stinger out so fast it can penetrate the shell of an organism. Lots of neurotoxic poisons that subdue the prey. Sticks to the prey with adhesives.



Simplest body plan = polyp
Mouth at the one end and no anus = incomplete digestive system.
It has to barf out the food once it has been completely digested so that it can feed again. Later it will develop an anus to have a linear digestive track.
Food gets close to the tentacle, the cnidocil shoots out and captures the food. The tentacle brings it back into the mouth and the cnidaria can eat it.
It has no mesoderm, yet it can still move it's tentacles because of it's hydrostatic skeleton. Outer ectoderm and inner endoderm, on the inside there are gland cells that release digestive enzymes, there are absorptive cells and at the base there is a myonene (fiber) that runs in one direction and connects to all the cells. It is a contractile cell. Inside the gastrodermis, the myonenes are running around in circles. In the ectoderme, they run along the length on the animal. Skeleton is what makes it come back after an extension. Length myonenes contract making the diameter increase. Then, gastrodermis myonenes contract to reduce he diameter and the length ones stretch back out. Hydrostatic skeleton : water filled cylinder.



Cnidarians exist as a medusa as well. These can suspend themselves in water to capture nutrients and then they can swim around. "Muscles" contract and squeeze a jelly like matrix into the "head" and then when the muscles contract it relaxes and goes back to it's original position. It swims up and then as it falls back down it captures nutrients with it's tentacles.



Life cycle moves between two different morphologies. In the colony, there can be a division of labour with the polyp. Some will specialize at collecting food and pass it on (gastrozooid), others will become medusas and reproduce (ganozooid). Medusa doesn't actually swim, the water courant moves it around. Male and female medusi will drop out sperm and eggs in the water column, making a zygote. Divides until it becomes a larva covered will cilia that allows it to crawl around the substrate and develop into a polyp. That will keep making more polyps until it has enough feeding polyps then it will make for reproducing polyps.

Animal architecture

- Tissues
- Symmetry and cephalization
- Embryology
- Body cavities

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Embryology: everything starts as a zygote and it will divided and become an embryo.

Animal architecture

Embryology - cleavage

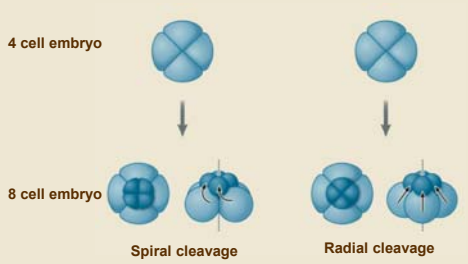

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Figure 25.5a
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At the 8 cell stage, either the top for cells will do a small twist and lie in the cleft of the two lower cells, or they will line up perfectly on top. The cleavage causes a spiral to occur. Every animal in the world can be divided into either of these two patterns.

Animal architecture

Embryology - gastrulation

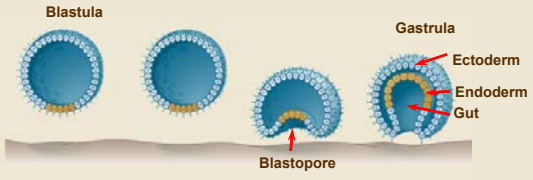

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Figure 25.2
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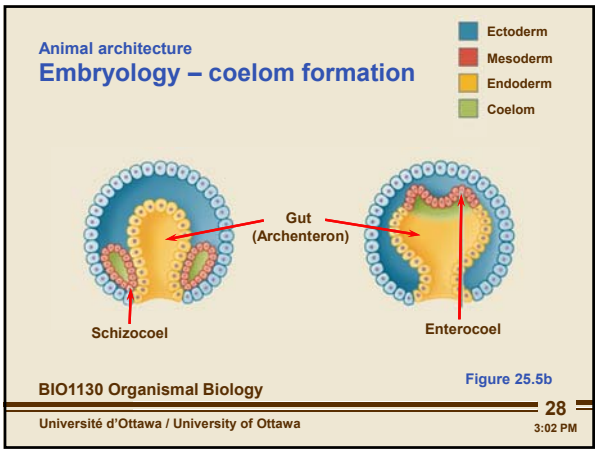
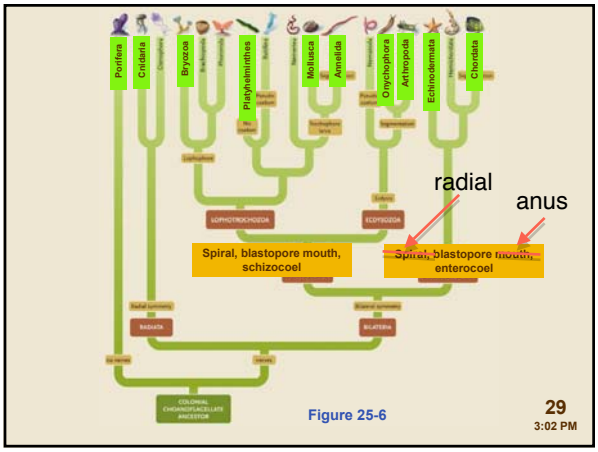
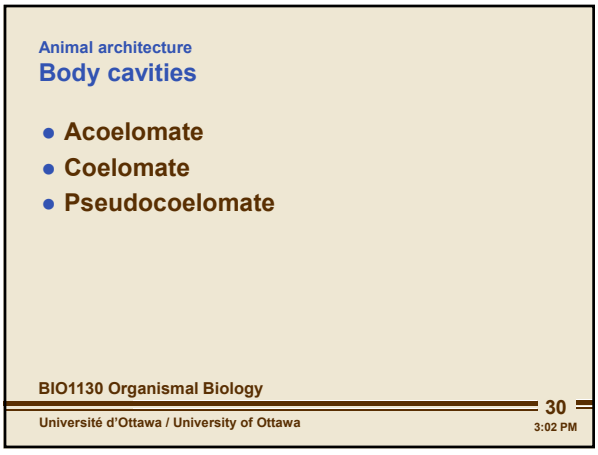
As the cells divide they form a holo ball - Blastula. At some point some of the cells will deferential into a new cell type, endoderm. They multiply very rapidly and an invagination forms (gut). It now has two layers. The ectoderm is an epithelium that will line the outside of the body and the endoderm in an epithelium that will line the inside of the body. Forms a primitive gut without anus. Basically we have the beginnings of a cnidarian.
To get the anus, the cells proliferate all the way to the end and push through to make another opening.



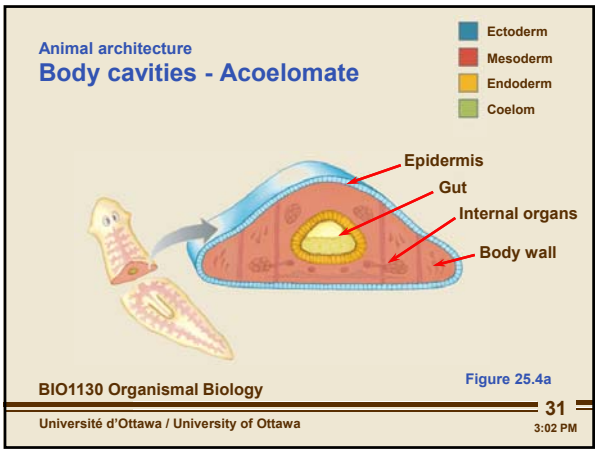
Next, mesoderm is placed between the endoderm and the ectoderm. It fills in two ways.
1) At the opening to the gut, the cells associated with the transition between outer and inner generate a new cell type and fold in filling the space. Fills it all the way and then it splits and forms a cavity inside the mesoderm. Body cavities can be used for many things like hydrostatic skeleton or cell-cell transport.
2) The primitive gut's cells will become new cells. They start to proliferate as a pocket and starts to fill the space. In the end it gives the same result, the space is filled with a cavity in it. Once it's done they look the same.
Only two ways that this happens in all animals.



Two possibilities at this stage in the evolutionary tree,
1)Spiral cells, first opening forms the mouth, mesoderm formed by schizocoel.
2)Radial cells, first opening forms the anus, mesoderm formed by enterocoel.

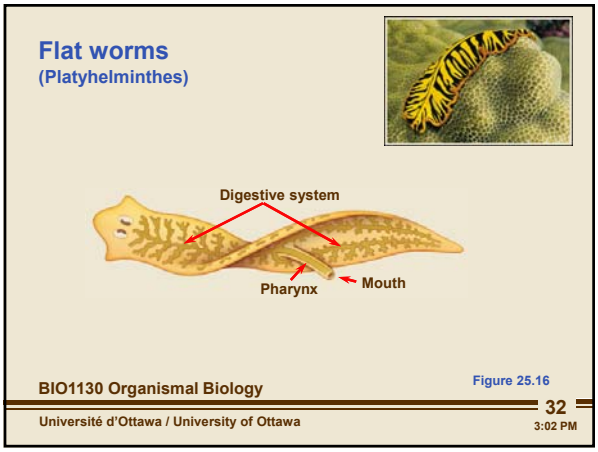


Acoelomate: no body cavity.
Coelomate: has a body cavity.
Pseudocoelomate: Cavity partially line with mesoderm.

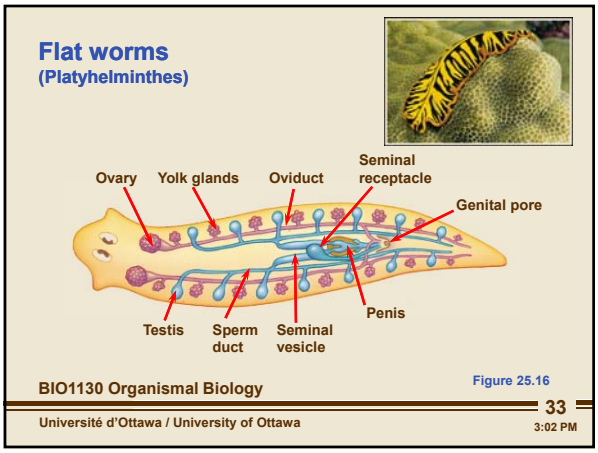


ASSHOLE MUTED THIS!!!! FUCK HOUSEMAN DICK!!

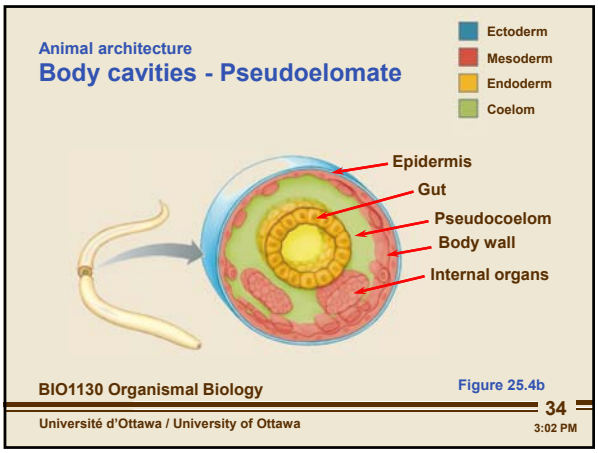
Flatworm has a very good surface to volume ratio because it is so flat. Everything is close enough to surface to get nutrients from the gut as well as close enough to the surface for gas exchange. Very successful as an internal parasite (ie. tape worms, etc.) Hide in host cavities without obstructing them.



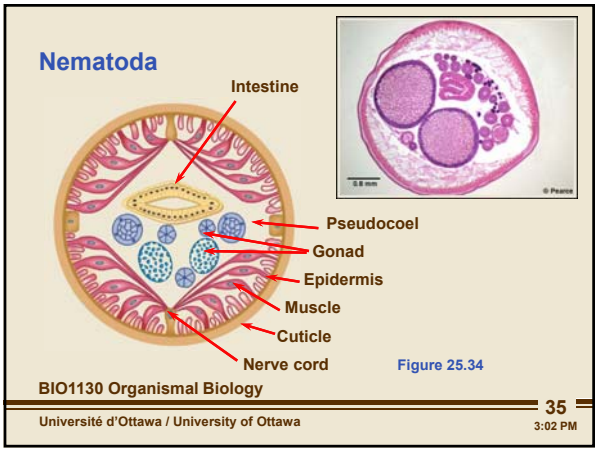
It has an incomplete digestive track, got rid of the anus, but it has such a long track that it forms a current that can circulate the nutrients. Problem: no hydrostatic skeleton so how will it move?
Whole body is covered in cilia that beat to make a nice sliding motion without the body needing to move. Also contracts muscles along int outer edges to move.
Pushes it's head forward, glues it to the ground, then contracts in the but end and it makes an accordion like movement. (Differential contractions to move)



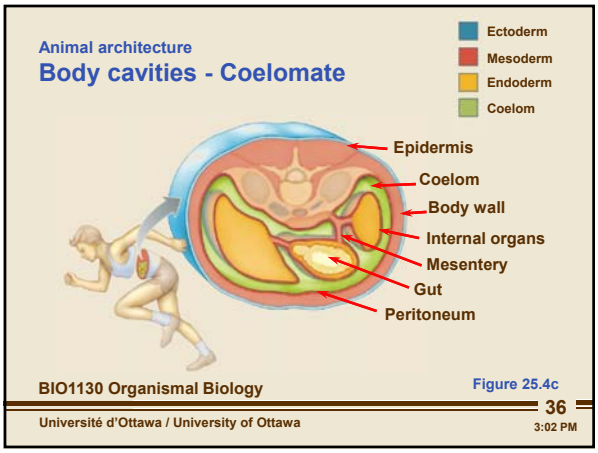
Their reproductive circle is that of a hermaphrodite (both sets of sexual organs).
Advantage: every mating event produces a pregnant individual because they fertilize each other. Never self fertilizes.
Testis transfer sperm down sperm duct to seminal vesicle then penis that puts it in seminal receptacle. Egg moves out of the ovary through the yolk glands and as it passed the seminal receptacle, sperm s release to fertilize it.



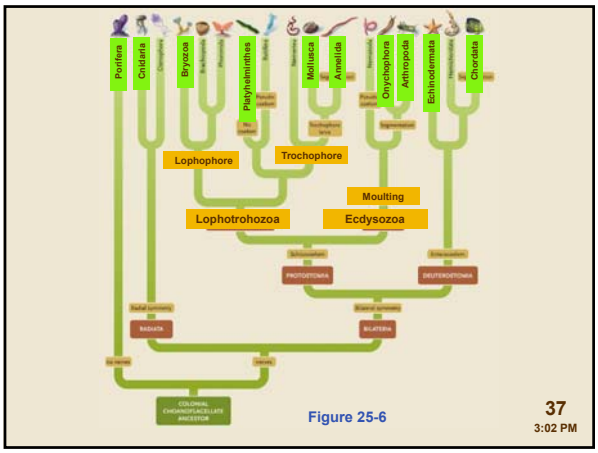
Round worm. Mesoderm is only associated with the outer ectoderm. The gut has no muscles.



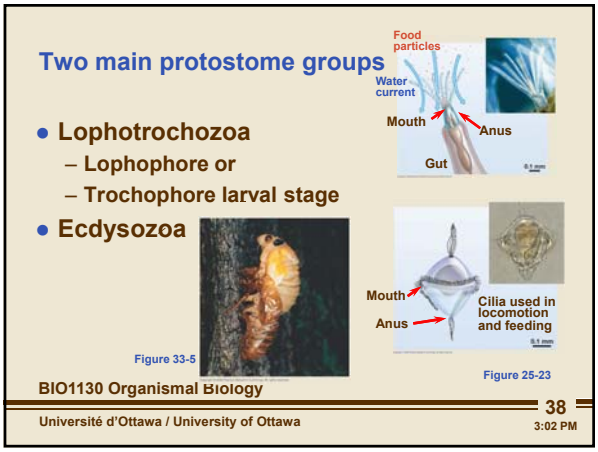
Unlike all other animals, the nematodes have no circulatory muscles. only longitudinal muscles. makes very unusual type of locomotive. Sinusoidal locomotion made by opposite contractions of longitudinal muscles. Doesn't swim well, lives mostly in dirt so it can pull itself with grains.
No peripheral nervous system to control muscles. Gut is only lined by a single layer of cells.
Males have amoeba sperm, no flagellum. only animal to have this.



Ectoderm and endoderm have mesoderm and they are connected by mesoderm (mesentery).



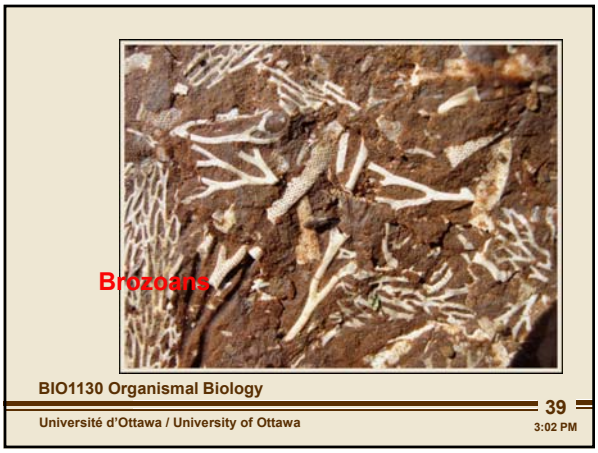
Ecdysozoa: outer ecsoskeleton that must be shed to grow. they moult.



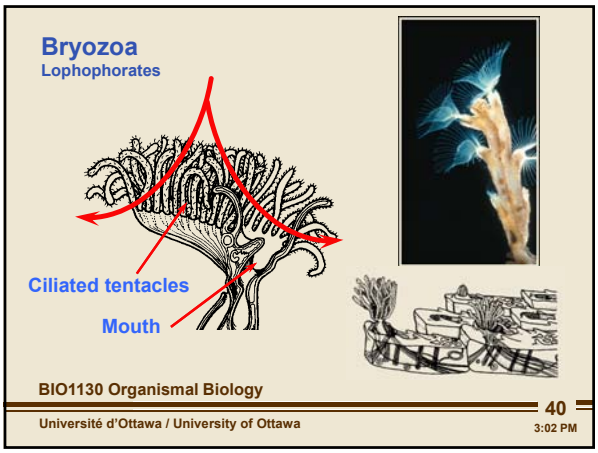
Lophotrochozoa: Feeds with a lophophore, a tentacular structure covered in cilia, or has a trochophore larval stage.

No single characteristic that unifies them morphologically, but they will have one of the two criteria.

Very very different, but unified by these traits. ie. clam, snail, squid, ...

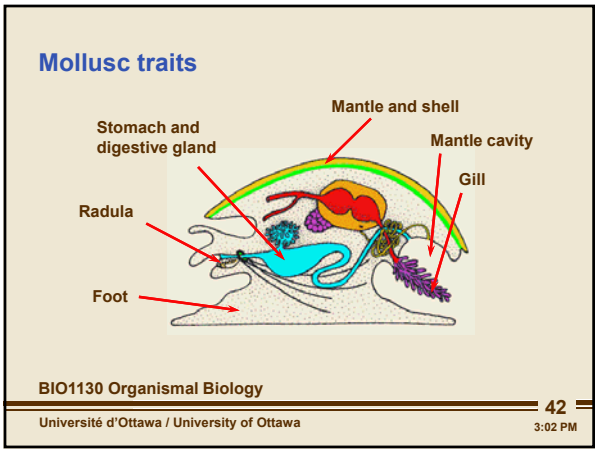


Lophopore. Live inside shells that they secrete. Like coral, they also make a specialized environment.

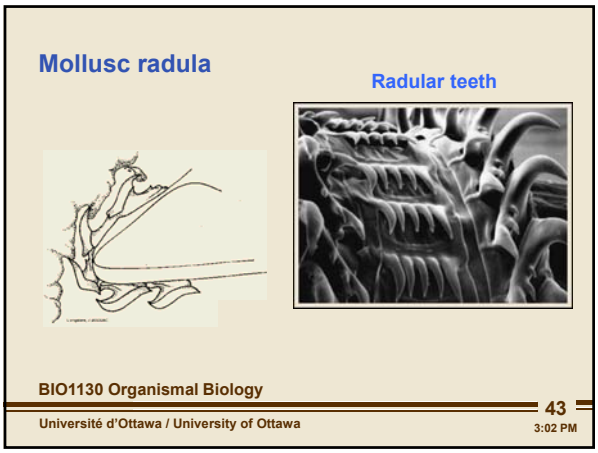


Lophore consists of a series of hollow tentacles coming out of the mouth covered in cilia. The cilia beat water into the tentacles and food that is in the water enters.
Very controlling filter feeder. Builds bryozoan reefs.
Immobile.

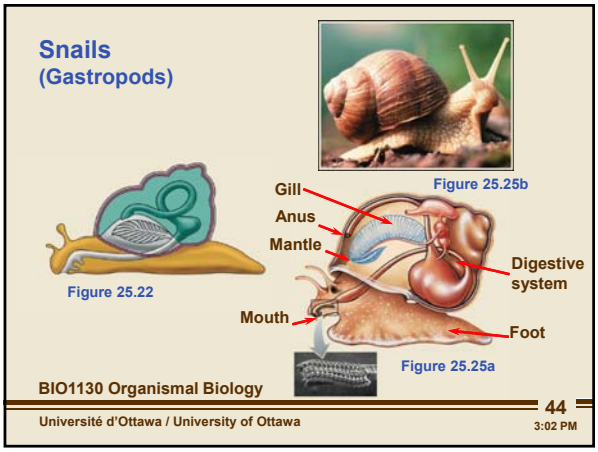
Adaptive radiation. Body plan is slightly changed to make a completely different structure and ability to do things.



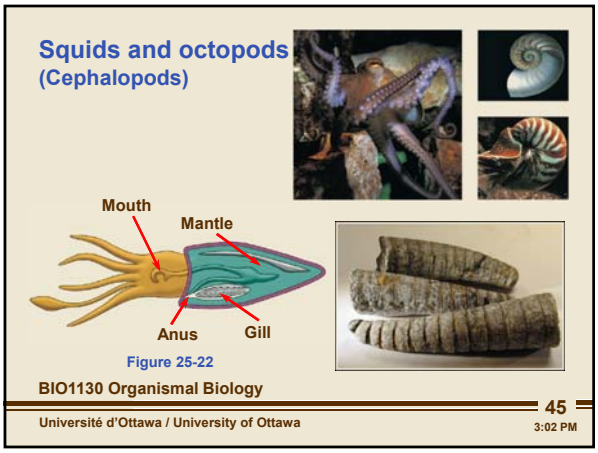
2 Major innovations.
1) Protective shell, secreted by a mantle. A skin tissue has learned how to pull salt out of the water to build a shell.
2) Body split in two. Organ systems sitting on a contractor muscle (foot). All under a shell.
Can contract it's shell and hide inside it to protect itself.
Radula for feeding.



Tongue covered with teeth that can grind material. They are very loosely connected so they can slide on the tongue and as they are lost they are replaced. Works like a sander/file. This structure allows them to grind nutrients that are stuck to rocks, etc. They are able to access nutrients that no one else can.

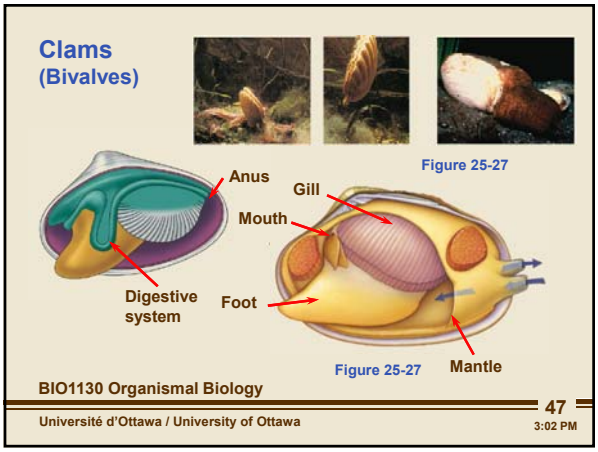


A snail has this body plan and has perfected it's shell. As it was growing bigger, it rolled it's visceral mass compacting it into a much titter shell (spiral). They have a piece of shell on the back of the foot so that when they go inside they can "close the door". This makes them able to move onto terrestrial land and survive as it waits for water (rain).

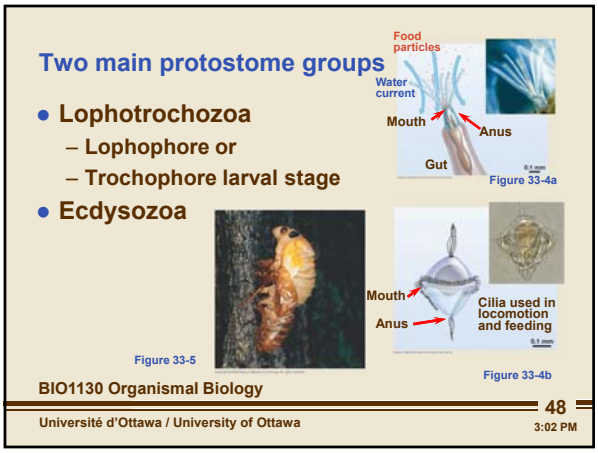


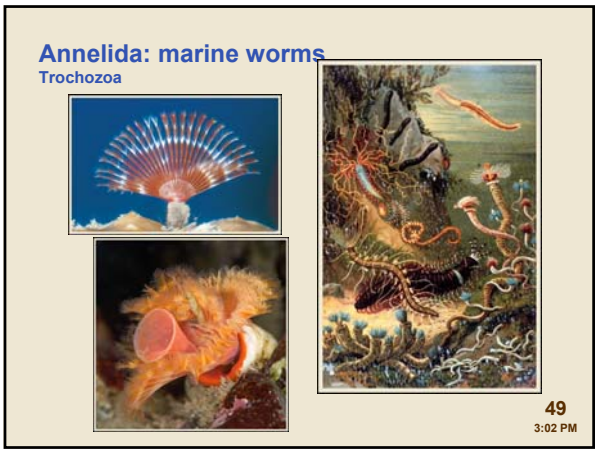
As it grew bigger, it tipped over. Tentacles around the mouth are used to pump water into the shell and when it came out it propells them forward.

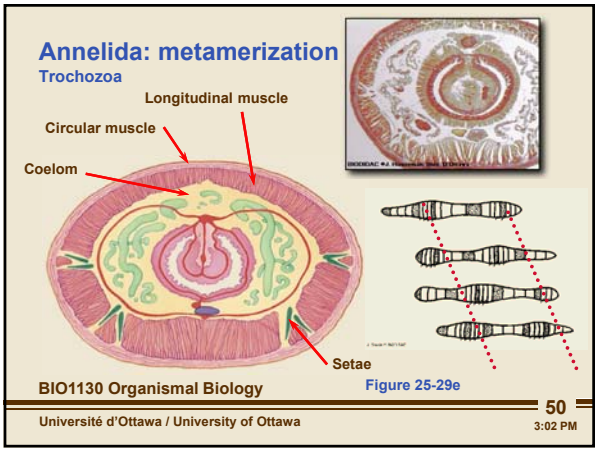
Rolled their shell in a different way than the snail. Challenged when fish come into the ocean, to adapt they drop their shells.



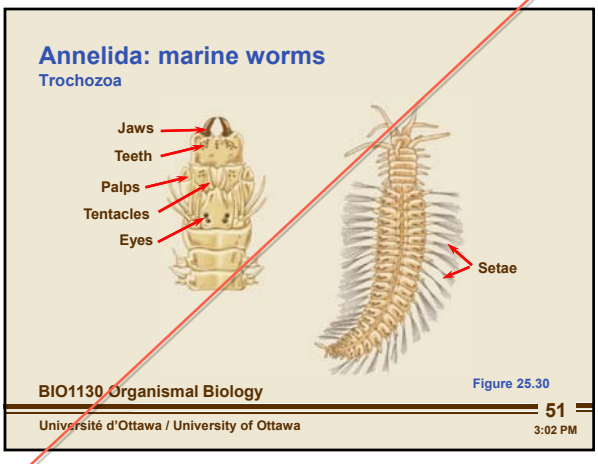
Immobile. Bury themselves into the sand. Perfect at particulate food feeding. Gills pump in water which brings in food.

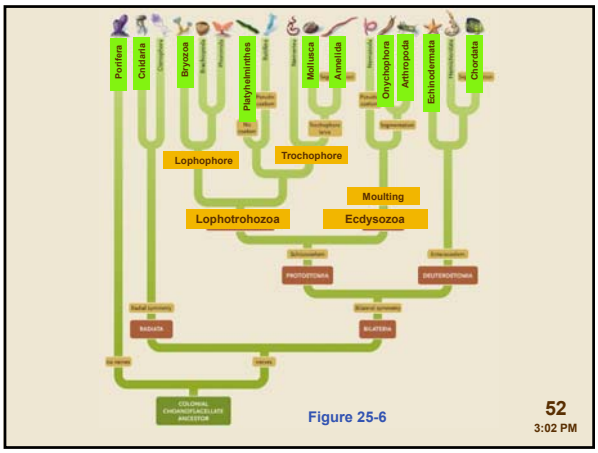




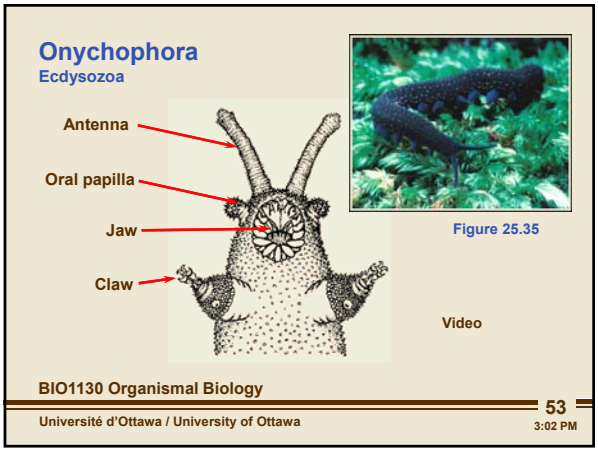


Many fluid filled segments aranged linearly down the animal : metamere. Each segment had it's own miniature body plan. Each cavity can contract and change it's shape independently. Also has a pair of setae that can go out and come in. As it swells to it's max size and the setae stick into the ground, anchoring it. As it lengthens the setae retract and the worm is pushed forward. Instead of just moving across the substrate, it burrowed into the sediments by either moving it's head back and forth to make a hole or by opening it's mouth. The result was a new source of nutrients that no other animal uses. Consumes the substrate and tunnels through it. Gets the organic materials in the soils and digests out the rest.

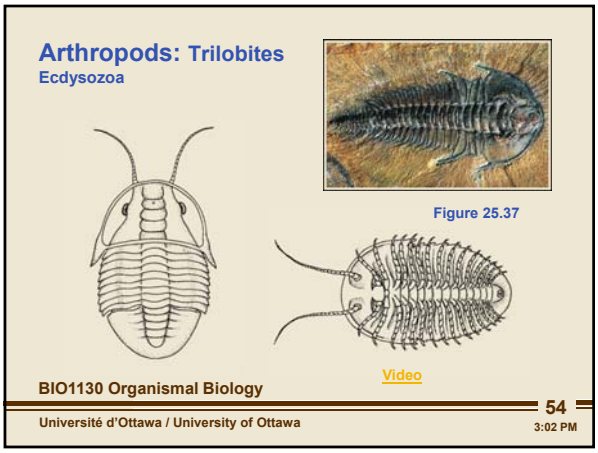




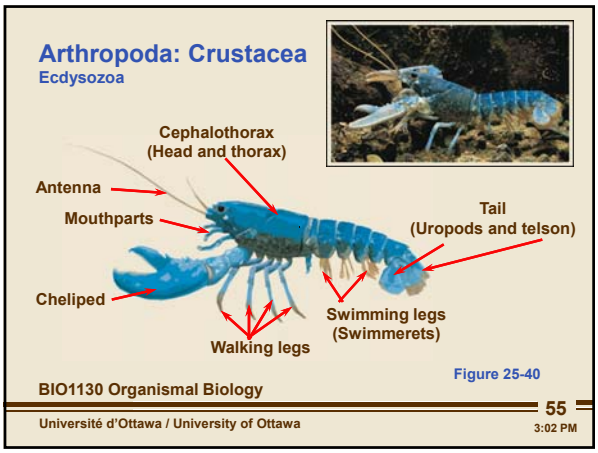
This segmentation occurs around the world, ie. humans, fish, mammals, etc.



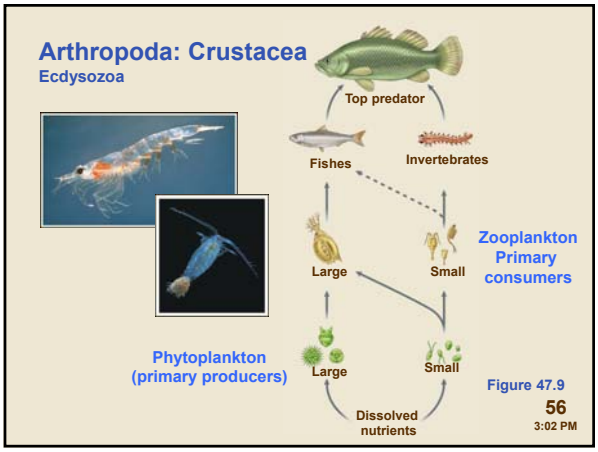
Worm-like, living fossil. They still live now. Terrestrial blind predator. Ejects a glue-like substance to freeze it's pray in place. Beginnings of an exoskeleton.

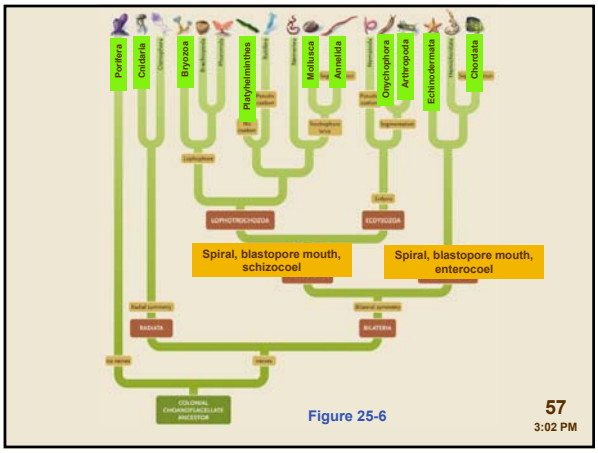


Instead of having legs on every segment, segments will fuse together to specialize.



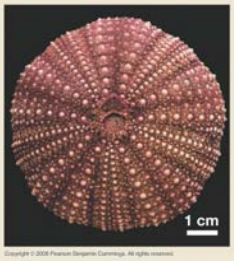
Toughens it's outer shell. Legs are restricted to certain segments. Segments are fused together to be specialized: tagma.
Example : Spiders.





Starfish and relatives

Adult radial symmetry



Larva bilateral symmetry

Figure 34-2

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Starfish and relatives

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Water vascular system

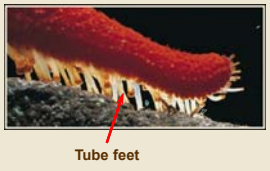

Figure 26.3

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An explanation for the Cambrian explosion

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

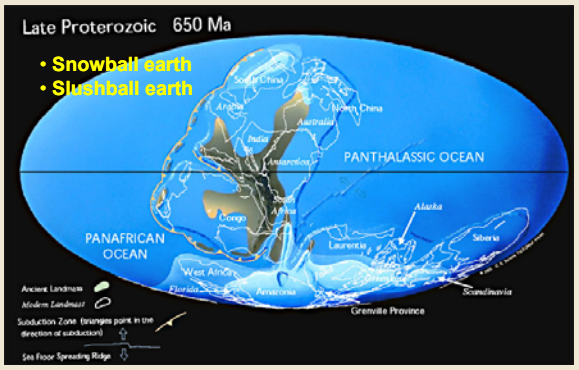
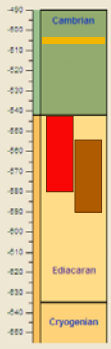


Figure 20.9

Early animal evolution

Be sure to look at Knoll VR00314 for most recent data on this period and the evidence



Burgess shale fossils
505 Ma

Ediacara fossils
580-542 Ma

Doushantou fossils
580-542 Ma

Doushantuo fossils

590-565 Ma

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Ediacaran fossils

580-542 Ma

(Mistaken point NFLD)

Protoanimals of Mistaken point

Australian footprints

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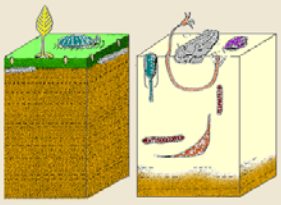
Cambrian burrowers

- Advantages
  - Feeding
  - Anchorage
  - Protection



Ediacaran benthic zone

Cambrian benthic zone

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Homeotic genes

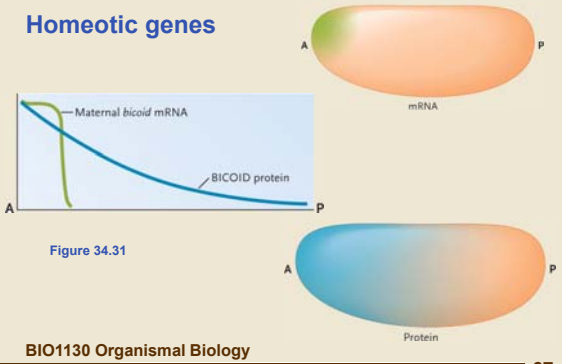

Figure 34.31

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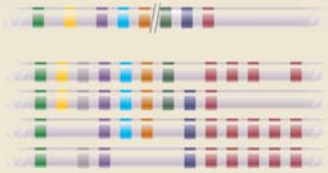
Homeotic genes *Hox* genes

Fruit fly embryo

Figure 34.34



Mouse embryo

68
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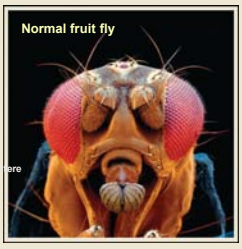
Homeotic genes *Hox* genes



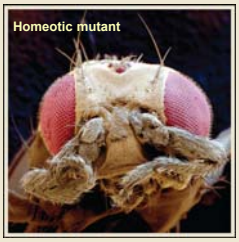


Figure 34-33

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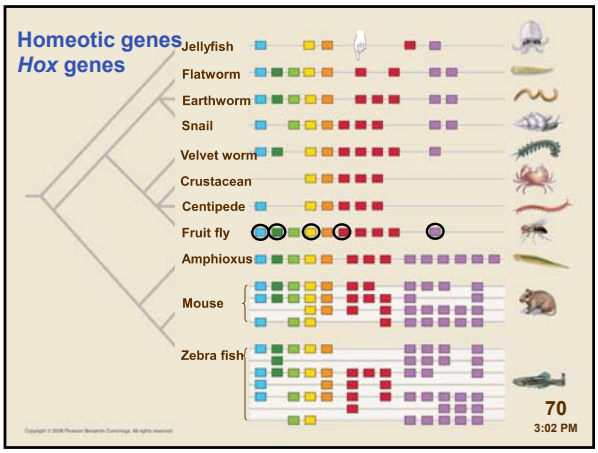
Homeotic genes
Hox genes
Jellyfish
Flatworm
Earthworm
Snail
Velvet worm
Crustacean
Centipede
Fruit fly
Amphioxus
Mouse
Zebra fish
70
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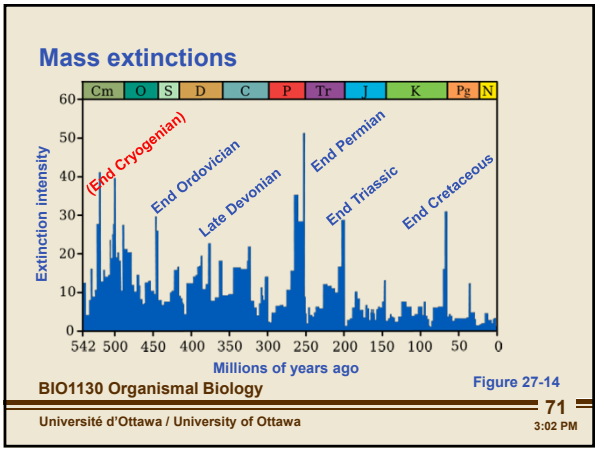
Mass extinctions
Cm
O
S
D
C
P
Tr
J
K
Pg
N
Extinction intensity
(End Cryogenian)
End Ordovician
Late Devonian
End Permian
End Triassic
End Cretaceous
542 500 450 400 350 300 250 200 150 100 50 0
Millions of years ago
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Figure 27-14
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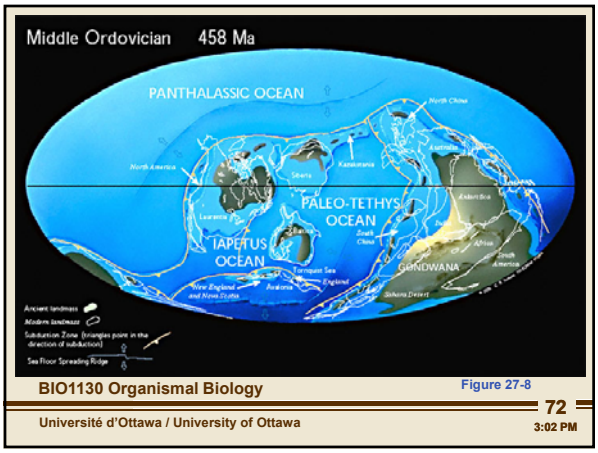
Middle Ordovician 458 Ma
PANTHALASSIC OCEAN
PALEO-TETHYS OCEAN
IAPETUS OCEAN
GONDWANA
BIO1130 Organismal Biology
Figure 27-8
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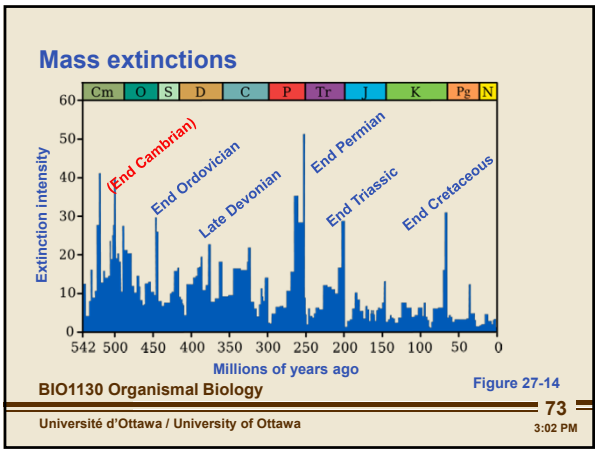
Mass extinctions
Cm
O
S
D
C
P
Tr
J
K
Pg
N
60
50
40
30
20
10
0
Extinction intensity
(End Cambrian)
End Ordovician
Late Devonian
End Permian
End Triassic
End Cretaceous
542 500 450 400 350 300 250 200 150 100 50 0
Millions of years ago
BIO1130 Organismal Biology
Figure 27-14
73
Université d'Ottawa / University of Ottawa
3:02 PM