


Phanerozoic - Paleozoic

Plantae (Verdiplantae)



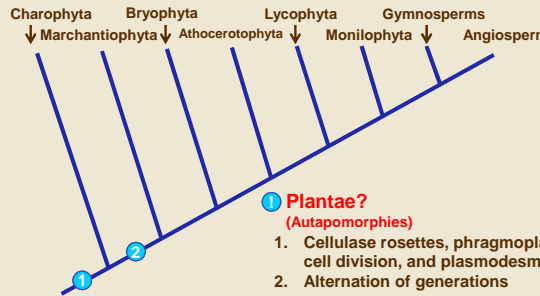
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On the moist shores, algae was starting to form colonies. These colonies of algae were the beginnings of plants on land.

Plant phylogeny Figure 24.9



Charophyta
↓ Marchantiophyta

Bryophyta
↓ Athocerotophyta

Lycophyta
↓ Monilophyta

Gymnosperms
↓ Angiosperms

1 Plantae? (Autapomorphies)

1. Cellulose rosettes, phragmoplast cell division, and plasmodesmata
2. Alternation of generations

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At the very bottom of the tree with plants. The first one is a colonial algal form that does not have the very last characteristic that we associate with plants.

There are 2 steps to get the qualities we know of are:
The way they synthesize cellulose for their cell walls
-How their cells decide and communicate.

There is no centriole involved and they communicated differently and have alternations of generations.

Plant autapomorphies

- Cellulose cell wall from hexameric cellulase synthase
- Phragmoplastic cell division
- Plasmodesmata

Alteration of generations

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By the time we get all 4 of these we have the very first plants. Cells with specialized functions forming organisms in moist environments next to both fresh and ocean water.

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Cellulose and cellulose synthase

The diagram illustrates the hierarchical structure of cellulose. It starts with a plant cell, showing a cross-section of the cell wall. A fibril is shown as a bundle of microfibrils. A microfibril is a single chain of cellulose molecules. The chemical structure of cellulose is shown at the bottom, consisting of a chain of glucose units linked by beta-1,4-glycosidic bonds.

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The genes for cellulose are bacterial. These bacterial genes are homologous across the living world. It is made out of glucose molecules stuck together in a chain. Cellulose molecules can come together when glucose molecules, which have hydroxyl groups, which form hydrogen bonds to make microfibrils and these are rapped around each other to form plants (a much larger cellulose fibre).

Cellulose and cellulose synthetase

The diagram shows the synthesis of cellulose. Cellulose molecules are synthesized by cellulose synthase. The cellulose molecules are then bundled into a cellulose fibril. The cellulose synthase is embedded in the plasma membrane. The cellulose synthase is organized into a rosette. The rosette is anchored to the plasma membrane by microtubules.

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Whats different about this cellulose is that the molecule that makes cellulose (cellulose synthase) stitches glucose together into a cellulose molecule. This cellulose molecule joins and are held together in a subunit of 6 by the cellulose fibril. You get 3 different types of cellulase which work together in a subunit of 6. This subunit of 6 organizes as 6 more and is called a rosette where hydrogen bonds hold together 36 cellulose strands of cellulose molecules in 6 groups of 6. When all of the subunits are there, a mixture of the 3 different cellulose molecules, you immediately get the little groups of 6 which immediately assemble into the rosette. The end of the fibre ultimately is on the outside of the cell wall. Cell walls can be stretchy or rigid, which is determined by the bonding of cellulose. This is all embedded in the plasma membrane of the cell wall. Underneath the plasma membrane are a series of microtubuals, base of the rosette interacts with the microtubuals. And as it produces cellulose it gets anchored into the cell wall making it stationary. The rosette then slides along the microtubual. The rosette slides along the microtubual by the molecular motors. As it moves it is laying down fibres on the outside of the cell they can move in may different directions. Every single plant does this. If you get different layers of cellulose you get a very rigid structure for a cell wall. If yo want the cell wall to be stretchy you would make them all parallel. This gives the cell wall its characteristics when adding proteins in other components.

Primary cell wall

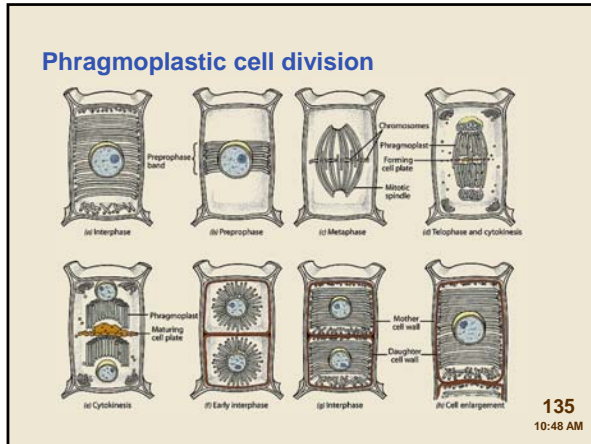
The diagram shows the primary cell wall structure. It consists of cellulose, protein, hemicellulose, and pectin. The cellulose is the main component, and the other three are embedded in it.

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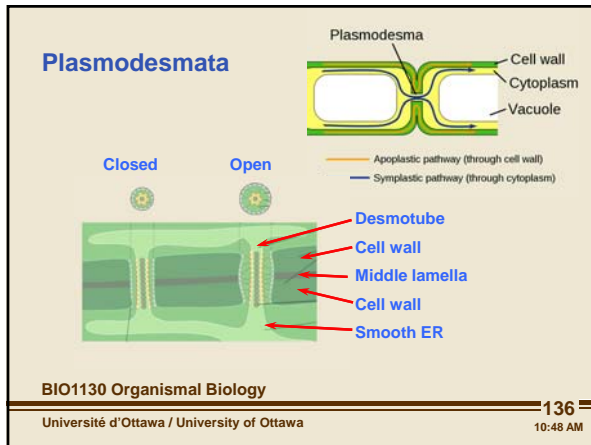
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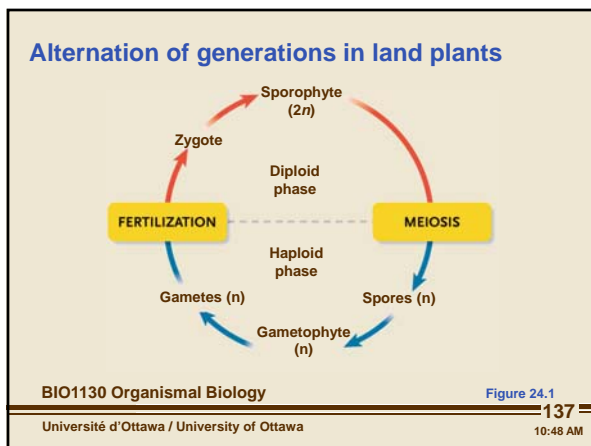
A major problem that things with cell walls have is that during division, you get a pinching in on each side. If this furrow develops the plasma membrane and cell wall will move in, ultimately creating 2 cell walls. If this occurs, you will never get cell to cell communication since they are separated by cell walls.

Normally when a cell is at rest, it has a huge array of microtubules that are constantly building the cell wall, and then just at the start of cell division the microtubules aggregate at the centre of the cell and pull the nucleus into this position. Duplication is about to occur so the microtubules change their positioning to the poles of the cell and create the spindle fibres. They are doing all of this without the centriole. They pull the chromosomes into different directions and the nucleus has been divided into 2 sides of the cell without actually dividing the cell. The little molecular motors then start transporting the vesicles towards the middle, releasing their content (cellulose) and fusing with each other to create a new cell wall to divide the cells (cell plate). When the cell is finally large enough it will attach to the new cell wall which was previously there. This cell wall was placed after the cell divided, but the ER gets trapped in this cell wall (cell plate) as well as cytoplasm. This then allows for cell to cell communication.



The plasmodesmata is the communication mechanisms between cells. This gave us a pathway that involves the cytoplasm.

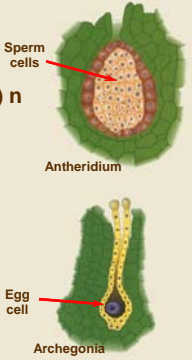
There are 2 ways to move things around inside a cell. The cell wall can act like a wick and absorb water. This is a transport system by wicking things through the cell wall. The plasmodesmata gave us a system to move things in the cytoplasm. The hole is the space of the endomembrane system. It also has a cytoplasmic sleeve for cytoplasmic movement. It can close and open to regulate the movement between the cells.



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Sorting out plant parts

- **Gametophyte (gamete plant) n**
 - Have gametangia producing gametes
 - Antheridia – sperm
 - Archegonia – egg
 - Formed from a zygote



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Gametophyte: is making gametes and will either produce sperm or eggs. This gametophyte tissue will produce the nourishment and materials for the egg or sperm in the plant.

Antheridia - sperm

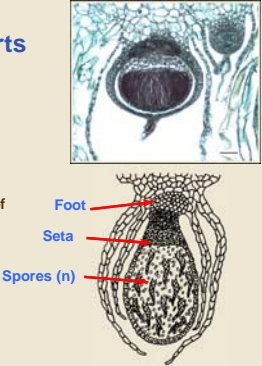
Archegonia - egg

Surrounding the gametophyte is the zygote.

The sporophite grows from the diploid egg. The structure that produces the spores is called the sporangium

Sorting out plant parts

- **Sporophyte (spore plant) 2n**
 - Have sporangia producing spores
 - From a zygote (fusion of sperm and egg)



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The egg is developed into this structure but is often still in the gametophyte plant. There is a very tight relationship in these stages.

Transitions to land (plants)

- **Water conservation**
 - Across exchange surfaces
 - Across body wall in general
- **Protect the gametes against drying out**
- **Support system (gravity)**

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Water conservation: Once they move to the terrestrial environment they must retain water so their bodies don't dry out.

They also need to protect the gametes without drying out from the environment.

They also need a support system to defend from gravity since they no longer have water to float.

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Liverworts,



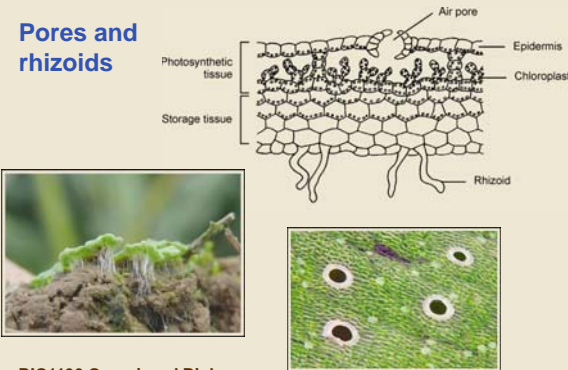
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Sit at the very bottom of the plant tree. They are still around today and still live in very restricted moist environment. They are a huge problem in greenhouses.

Pores and rhizoids



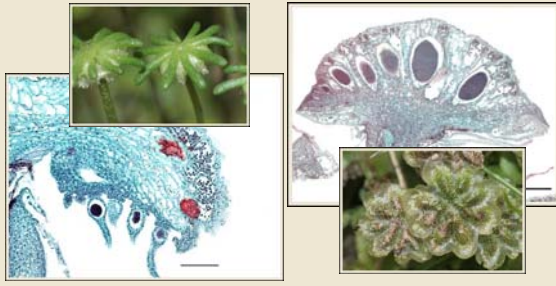
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They have the absence of any vascular tissue. This plant moves materials around with its cell wall. It has some protection because the epidermis has a waxy coat. But this coat means that water stays out as well as water. The plant needs the carbon dioxide to make water from air. This plant then has a series of pores on the upper side of its thallus, which allow air to penetrate into chambers below to bring about photosynthesis. They cannot close these pores and therefore they must stay in moist environments. On the under side some of the cells elongate into finger like structures called rhizoid which wicks up water from their soils.

Archegonia and antheridia



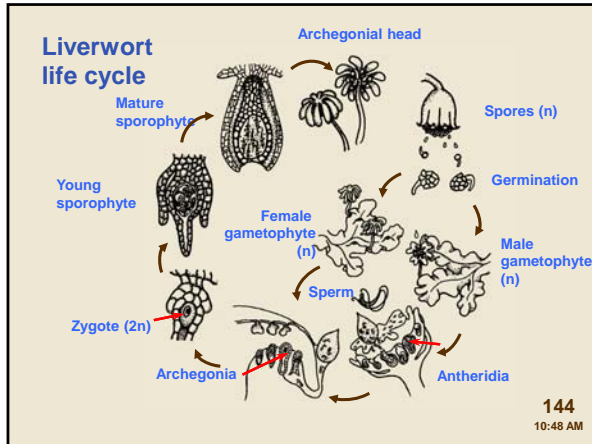
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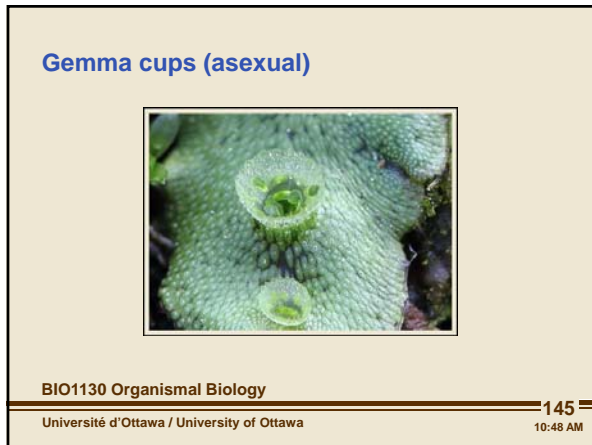
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The archegonia are elevated on stocks (umbrella-like). The eggs are underneath the umbrella hanging down. All on the top also has flattened structures called antheridia which contain the sperm.

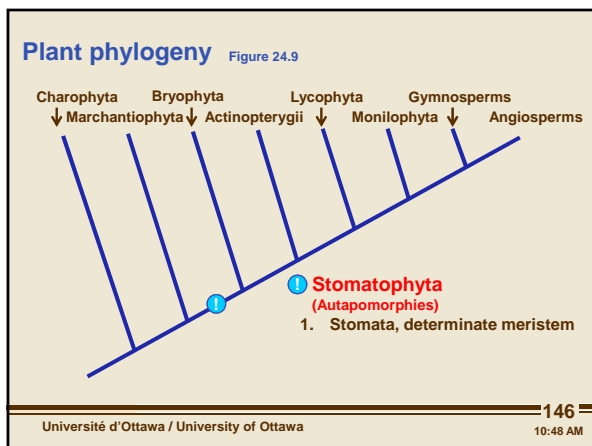
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The sperm has to get from the antheridia to the archegonia. When rain hits the splash cup and splashes up in the air carrying sperm in the water to the umbrellas above. This plant self fertilized. Once its fertilized the zygote becomes a sporophite but stays attached the the umbrella. It still grows and inside it under goes meiosis and thousands of mitosis. They then drop into the air and are carried in the air current. When they hit the ground they begin to grow.



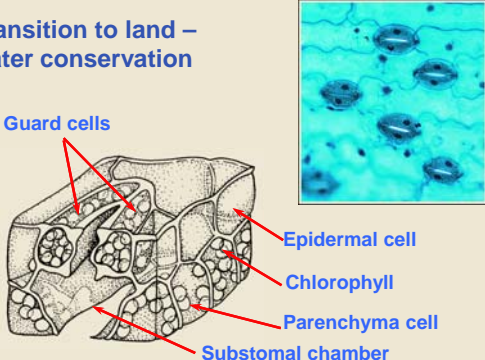
Inside this splash cup with little disks of tissue there are little cups where is the rain hits them they pop out and germinate



A major innovating is stomata to close the opening.

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Transition to land – water conservation



Guard cells

Epidermal cell

Chlorophyll

Parenchyma cell

Substomal chamber

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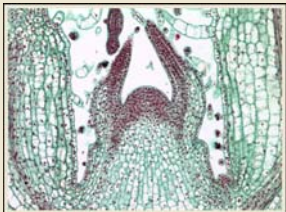
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Plants open the stomata when the sun is out and shut it down so that they don't lose water. They always consist of 2 guard cells. The micro fibrils of cellulose have been laid down so that the shape change is regulated when the plant pumps salt into the cells they cell and then end up closing.

Meristem

- **Determinate**
- **Indeterminate**




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The secret to plants. It is a set of cells that we would consider to be stem cells. They can turn into anything. They are sitting at the end of a growth structure (stalk) it can go for so long and then stop growing the the meristem cells are still there. The indeterminate meristem can grow infinitely. It gives the potential at the growing tips to build anything. Thats why you can cut off of a plant and put it in water and it'll grow by building a root. The tip of every branch of a plant is a brand new organism being formed from raw stem cells. They are their own new organisms which are not the same any more because they are subject to mutations. Every single tip of a plant is genetically different than the rest. They survive because they are a multiple of organisms staked on top of each other with a similar growing stems. This is how plant attain their genetic

Mosses

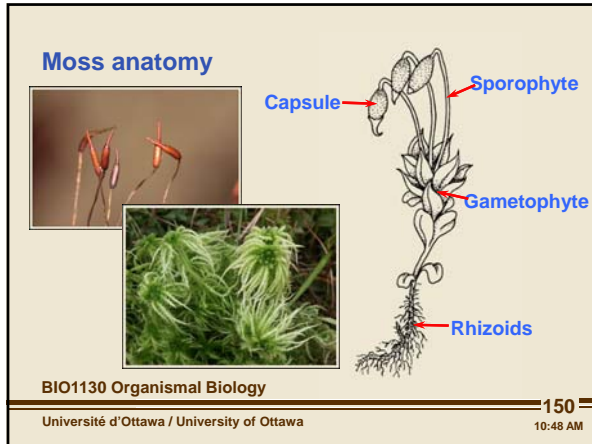


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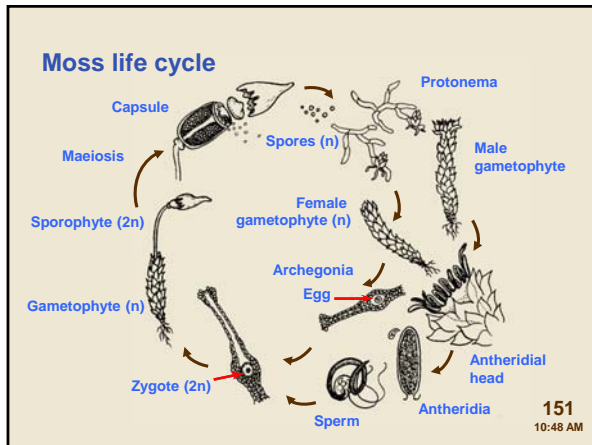
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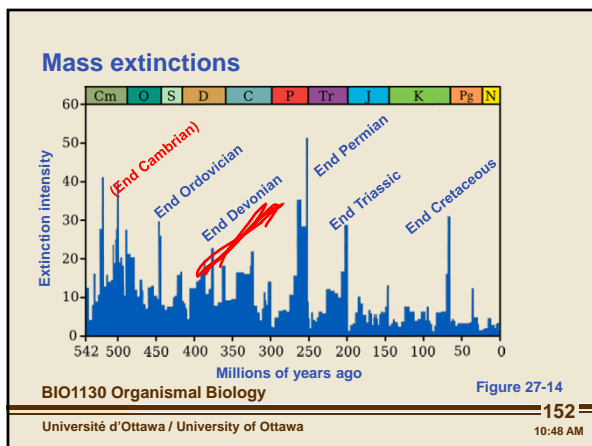
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In moss the meristem is determinant. It is at the base which produces a stalk and pushed a capsule into the air. Moss elevate their spores into the air and release them. The gametophyte is leafy but have no vascular tissue. They have to absorb all of their water through the leafy tissue and wicking cellulose in a cell wall. In the summer, sea mosses completely dry out. When it rains the moss can all of the sudden go green when it absorbs the water. They have a protective mechanism for the cellulose in the cell wall from being degraded by bacteria. The deposition of antibacterial compounds happens in the cell wall. They are typically phenolics that in pregnant them within the cell walls. Some folk cultures use

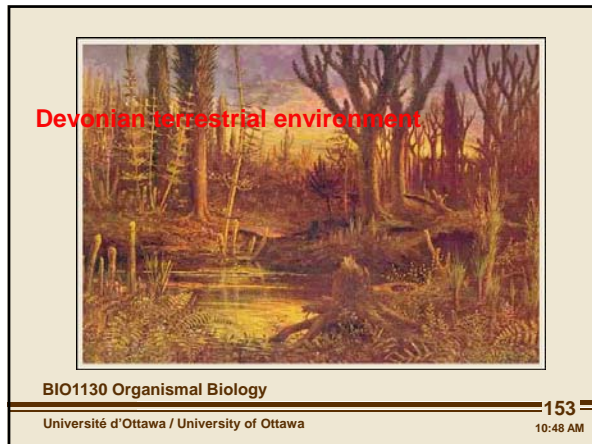


They splash and embedded on the disk of a female plant is the egg. The sperm lands on the disk of the female and fertilizes the egg. The egg becomes multicellular and out of the gametophyte grows the sporophyte. It then gets pushed up into the air and produced the spore with the genetic material inside.

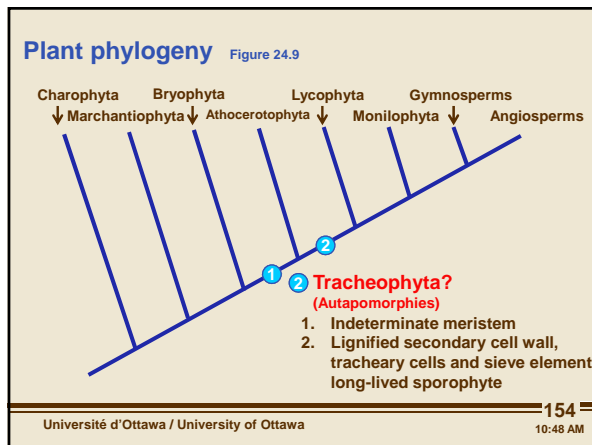


At this time most of the reef systems in the world collapse. There's not much that happens to plant in this mass extinction.

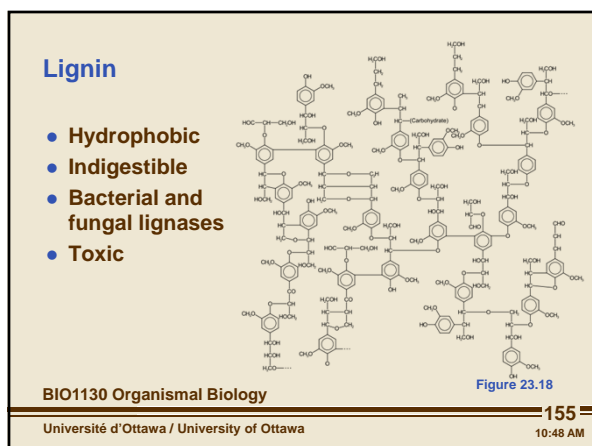
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Devonian plants are usually pretty small and simple. There are tree like structures but they are held up differently.

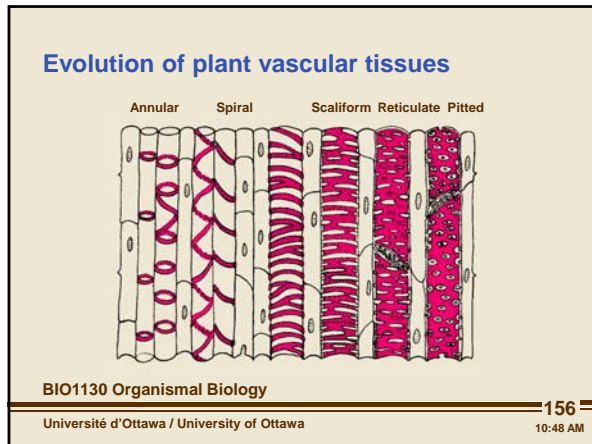


Then the shift to indeterminate meristem happens and growth can grow forever. The cell wall also gets 2 layers, each a different type of cells. The tracheophyta breaks free from the gametophyte and can live independently.

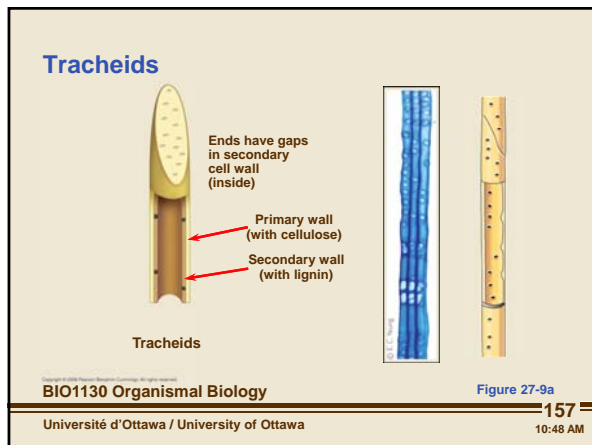


As this material build ups it is hydrophobic. It is also very indigestible. That toxicity of bacteria is also important

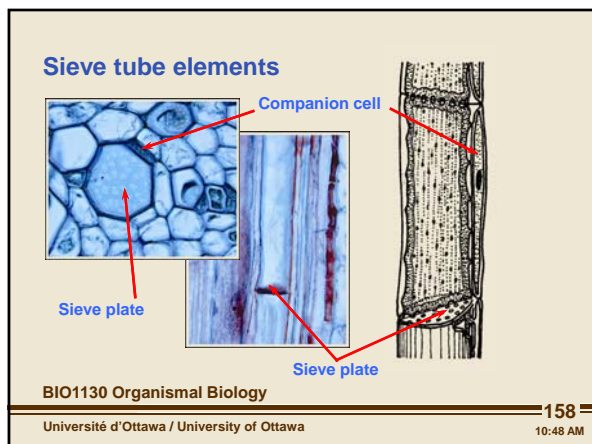
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The second cell wall is associated with lignan. They get the ability to strengthen the cell and hold it upright. Then cells could attach together end to end and withstand gravity. Finally the rings become a solid lining of lignan that is connected end to end.

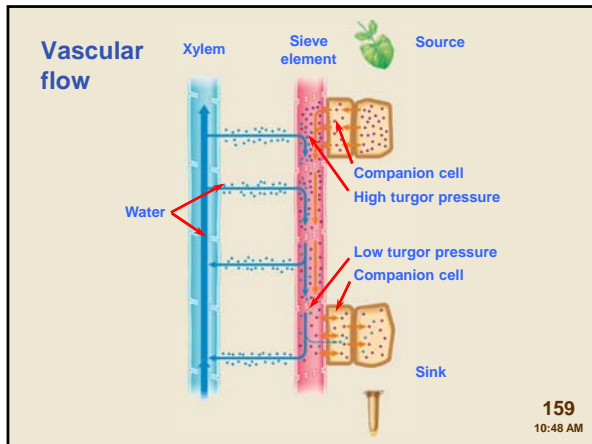


These cells are hollow and die when they mature. This causes a hollow cell followed by hollow cell creating a hollow straw. If at the top of the plant we are using water and getting evaporation and getting it from the root, we bring the water up these straws. They have a very fine drinking straw that is perfectly set up to let water evaporated in the leafy structures and at the root level they suck water from the soil. This allows them to move into the photosynthetic zone,

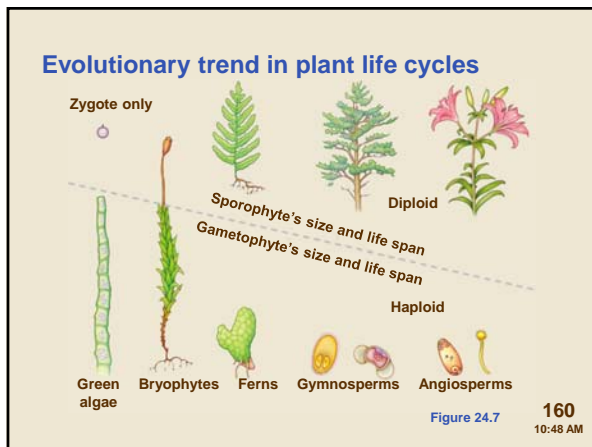


This cell is alive with cytoplasm. It has a set of cells that are cytoplasmically connected to each other called sieve plates where they connect. It moves sugar around the plant.

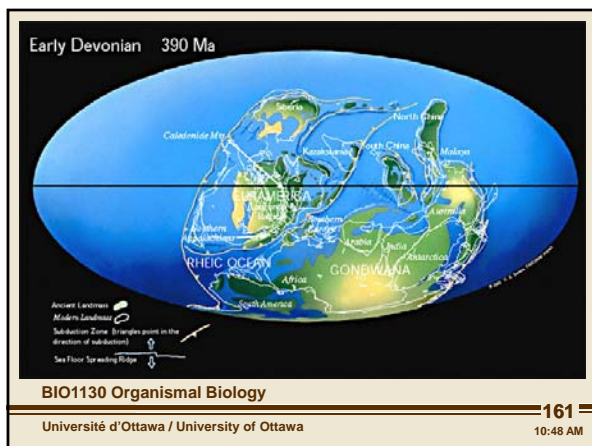
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The companion cell uses ATP pumps sugar into the sieve element. Because the sugar concentration is high the water is drawn in. This is rigid and pressure will build up forcing the materials down one sieve element to the next. Somewhere else it is using ATP to pull the sugar out and putting them into the sink to be stored. This means that the sugar is then at a low concentration and the water will return to the tracheal cells. Use a concentration gradient and water pressure gradient to force the sugar to be stored.

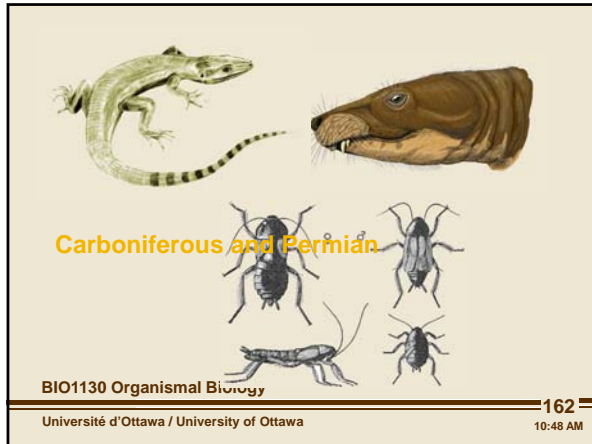


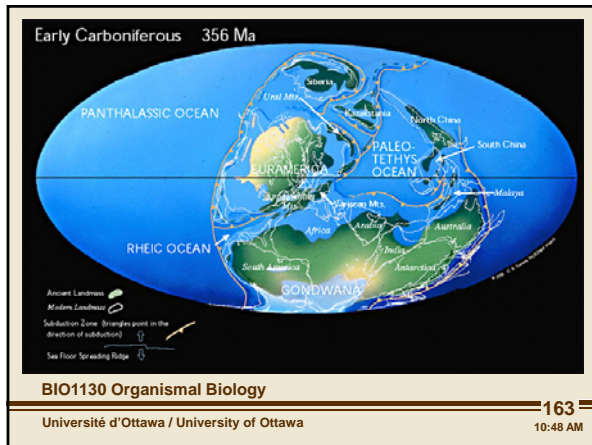
That occurred primarily with the sporophyte. It then becomes dominant over the gametophyte.

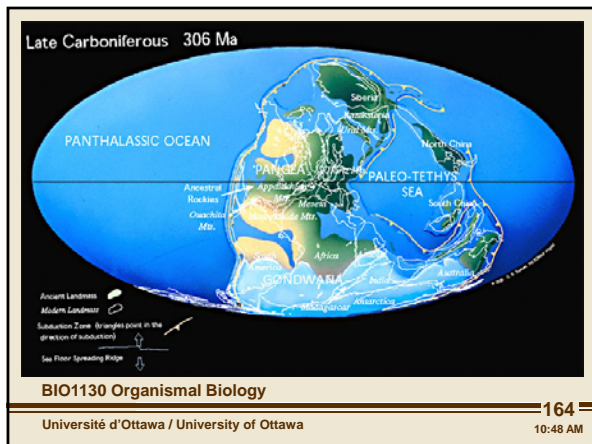


Soon pangea will happen.

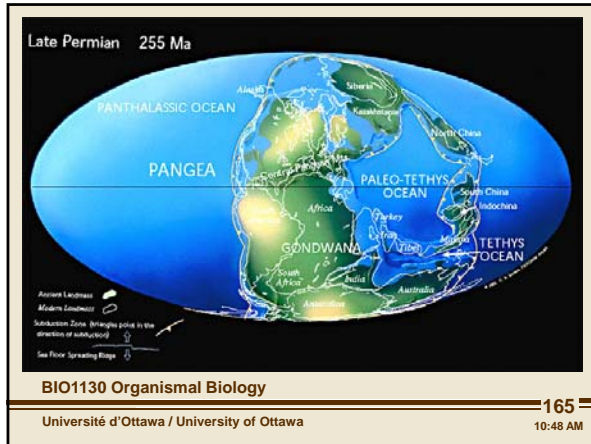
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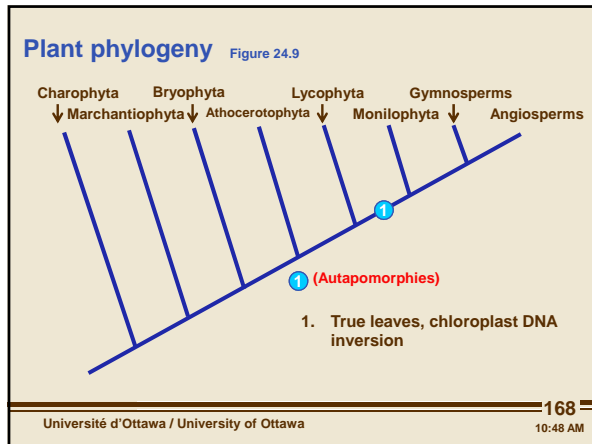






These were originally the size of trees. These plants developed vascular tissue with all of its advantages. They were the absence of seeds. They have spores and not seeds.

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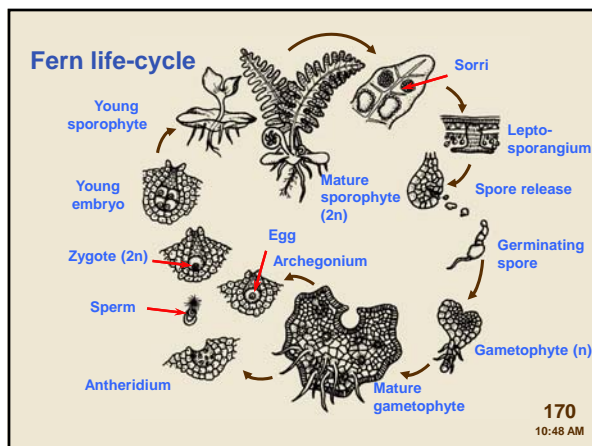


Now that the leaves have vascularization they changes to true leaves

The chloroplast DNA is changed.

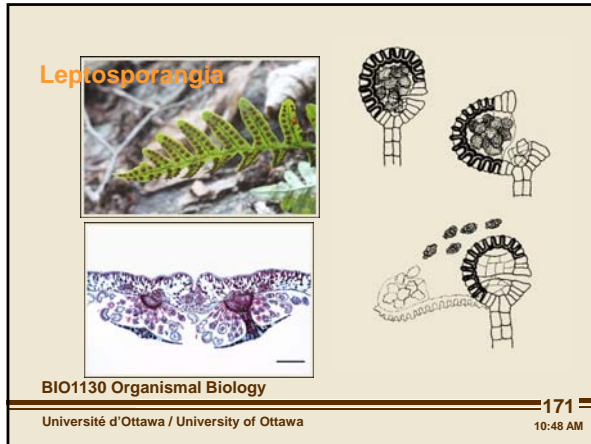
There was a lot of debate on how they evolved until this change was found in all of them.



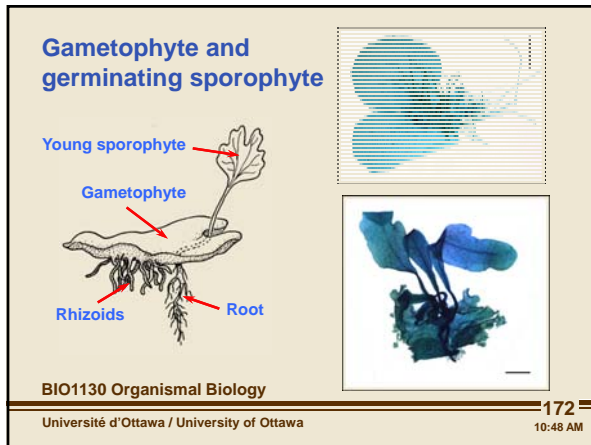


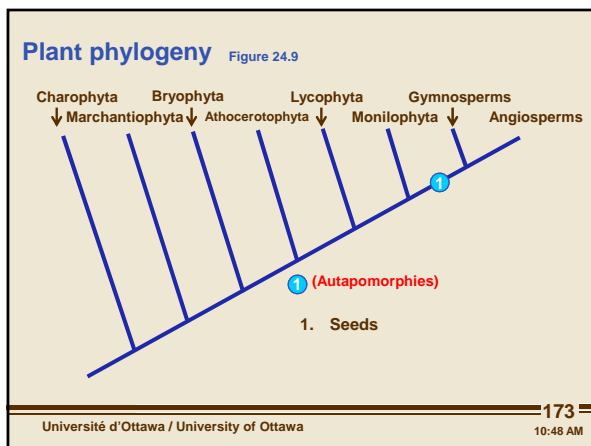
Ferns are a mature sporophyte. They still produce spores. If you turn these leaves over on the bottom side you will see brown spots. These brown spots are sore eye. Inside them is the spore producing tissue. In the taxon that the ferns are in, while everyone else diminished, they all of the sudden increased in diversity.

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Inside there the sporangia is being developed. The cells along the outer wall have a very thick wall on the inside but very thin on the outer surface. When they get exposed to the air the water evaporates out. As the cell shrinks it buckles inwards pulling the side cells together. They then curve and straighten out. The all of the sudden it snaps. They can then launch their spores into the wind without relying on these wind currents. They are a major dominant species on the forest floor because of this. When it falls to the floor it becomes a gametophyte. Water landing on it will take the sperm to the egg. The egg becomes egg to zygote to a young sporophyte. It then germinates up and out to produce the fern leaf. It then enlarges and multiplies and gains roots.





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Spores vs. seeds

- **Homosporous**

Sporangia → Spores → Bisexual gametophyte → sperm or eggs

- **Heterosporous**

Microsporangia → Microspores → Male gametophyte → sperm

Megasporangia → Megaspores → Female gametophyte → Eggs

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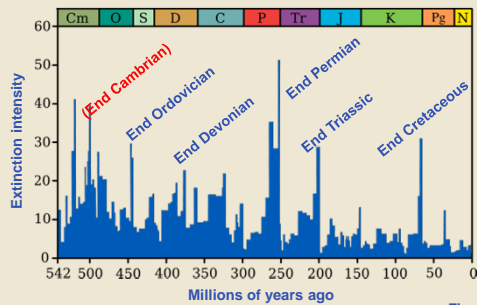
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In some cases they would make the heterossexual spore which causes a size difference between the 2.

In the sporangia that makes the larger spore there is a diploid cell that needs to undergo meiosis to make gametes. It now does meiosis and 3 of the spore disappear and only one survives. It then puts them all into one creating a larger spore. This is the egg.

Mass extinctions



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Gymnosperms Conifers



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Cones (Strobila)



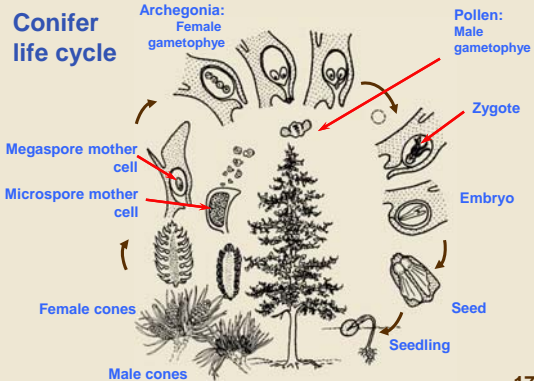
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There are male and female cones. Now the spore is produced but not released. The thing that will germinate from the spore is the gametophyte and it is born on the original plant. Keeping the whole cycle from before but keeping it on the same plant. This also creates pollen. Pollen is when the male gametophyte is developed on the parent plant. Now endosporing happens. Inside pollen is a mature male gametophyte surrounded by a protective coat. It will find its way to another tree and find a sperm.

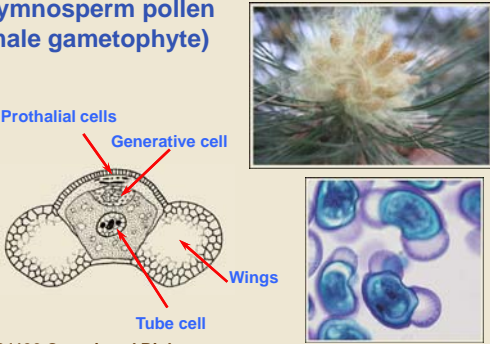
Conifer life cycle



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female cones - top of the tree
Male cones bottom of the tree.

Gymnosperm pollen (male gametophyte)



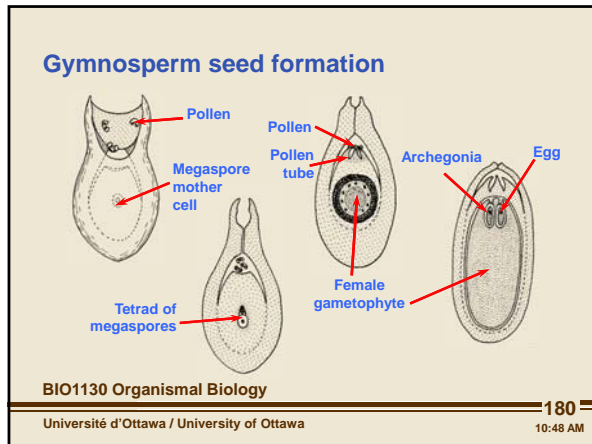
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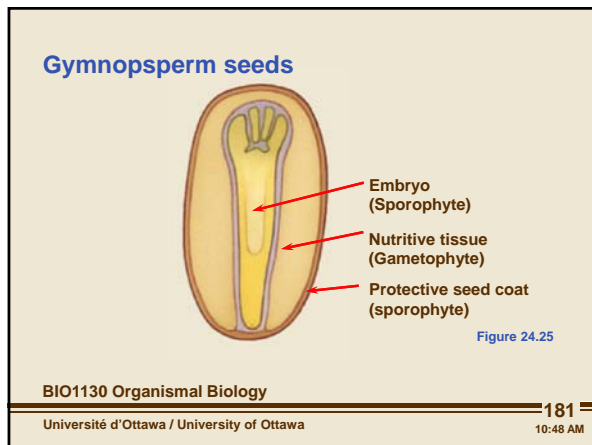
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The fate of each of the 4 cells is different. The sperm nucleus becomes the generative cell. Another builds a special pollen tube. there's support cells. and there's wings. The wind carries it to the open female cones

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When the male lands in the cone it closes. The megaspore will undergo its meiotic divisions to become the gametophyte and then keeps going to make tissue to surround the egg. All without leaving the female cone. It is an archigonia loaded with tissue and a now fertilized egg. LEARN THIS PROCESS.



The whole process takes 2 years. A year and a half to get to the archigonia. Another half a year to open the cone. Once it opens we have mobile flying male gametophytes.




These were around and were simple but then when they could break down lignin they then diversified. They do this because they are absorptive heterotrophs. When they invaded land they didn't need to get tall because they don't use light. They are already buried in their food.

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Unique fungal terms

- **Septa, hypha and mycelia**



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Strands of single cells, not clusters. This organism spends most of its time as a haploid. Heterotrophs that live in their food.

these are haplontic with a short lived diplontic part



The fungi just chose not to have a cell wall as a haploid. They have unusual mitosis because in fungi that all happens inside the nucleus but it never disappears. The nuclear envelope goes through nuclear division into 2 nuclei which get dragged into position.

More fungal terms

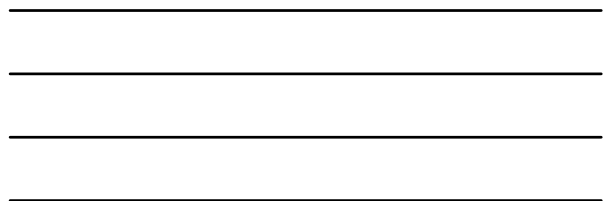
- **Plasmogamy**
 - Dikaryote cells
- **Karyogamy**
 - Diploid cells
- **Meiosis**
 - Haploid cells

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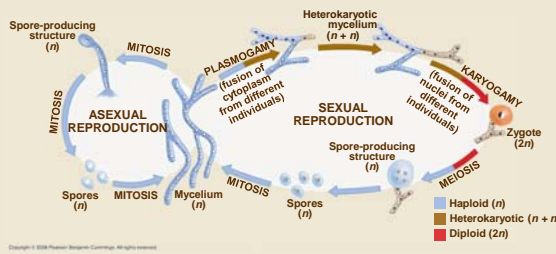
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When 2 fungi meet they keep their nuclei separate. This is a dikaryote state of haploid nuclei. There is a period of time where fungi mate and keep the nuclei separate. They will only fuse when meiosis needs to happen.



Typical fungal life cycle

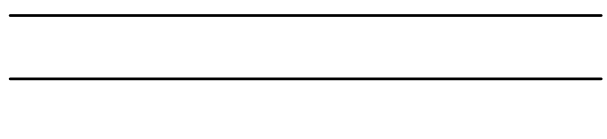


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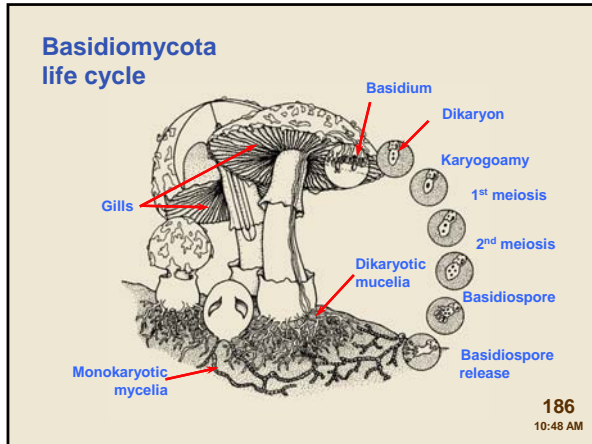
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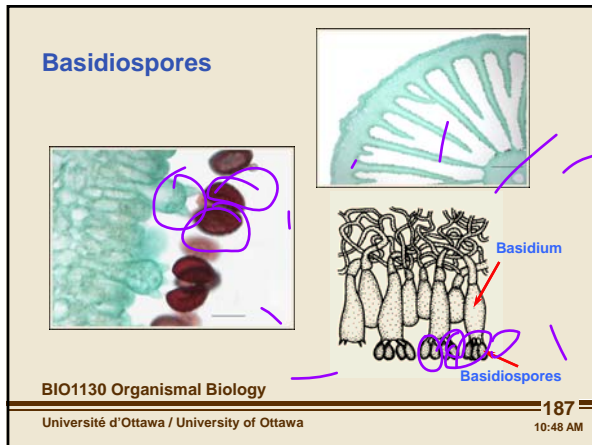
At some point a fungus of the opposite mating type and fuse to create a new cell through plasmogamy and became dikaryotic. This can keep dividing and branching for a very long period of time, but a point will come where the 2 nuclei need to be combined. That's when we get karyogamy and the nuclei fuse to create a diploid zygote.



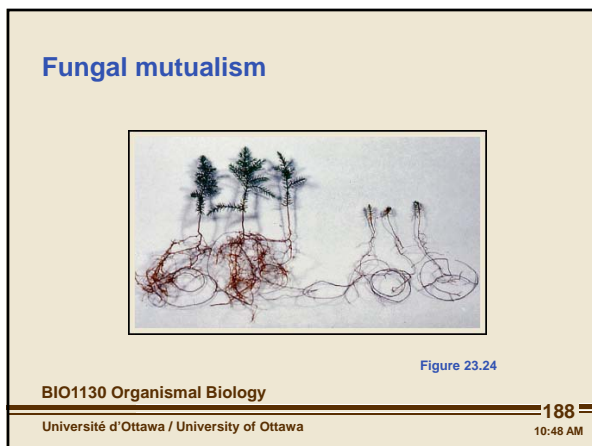
Phanerozoic - Paleozoic



Under the soil there are monocaryotic mycelia woven together and have also fused to become dikaryotic mycelia. Then as the mycelia absorb water and project the fungi above ground so that it can release spores into the wind. They all of the sudden appear at once because they already have they whole structure packed under the soil and just need to inflate it.

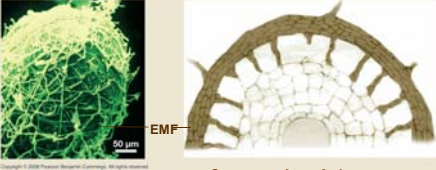


If you look at the undersurface of a mushroom their are millions of these dikaryotic cells just sitting there that then fuse their nuclei and turn into a spore. Each of those events it a recombination of 2 haploid nuclei. They then do meiosis and all occur differently. When the mushroom releases these, thousands of cells make millions of genetically different spores. They were able to survive as haploids



Phanerozoic - Paleozoic

Types of fungal mutualism
Ectomycorrhizal fungi (EMF)



50 µm

EMF

Cross section of plant root

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When plants first invaded the land environment, they set up a mutual relationship with fungi since they are unable to extract minerals from the soil. The fungi would dissolve the minerals that the plants wanted and the plants would supply the fungi with the photosynthesized sugars. over 95% of the plants have this association.

Types of fungal mutualism
Ectomycorrhizal fungi (EMF)




Figure 23.24a

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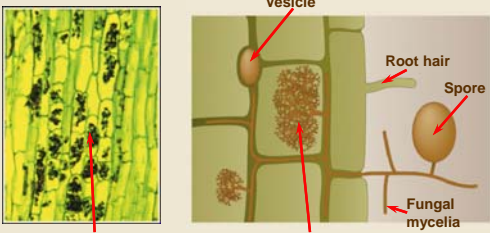
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All the rest is fungi feeding the roots. The invasion of plants onto earth would not have happened without fungi

Types of fungal mutualism
Arbuscular mycorrhizal fungi (AMF)



Vesicle

Root hair

Spore

Fungal mycelia

Arbuscule

Arbuscule

Figure 23.11

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Some fungi can live inside plants in order to get their nutrients.

Phanerozoic - Paleozoic

Fungi - Lichens



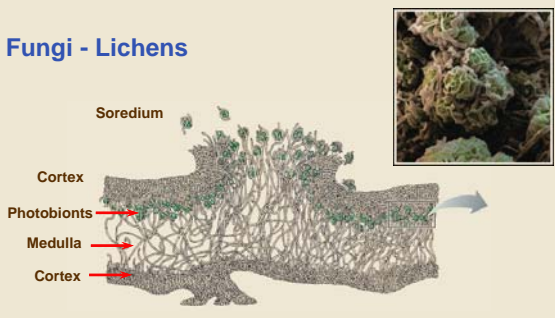
BIO1130 Organismal Biology Figure 23.22 c & d

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Lichens have a very close relationship with fungi

Fungi - Lichens

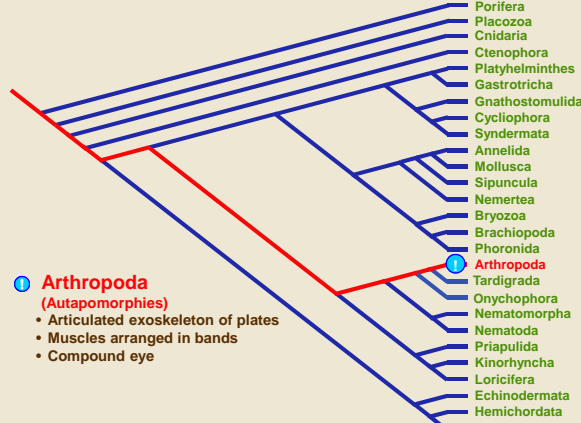


BIO1130 Organismal Biology Figure 23.22

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Photobionts get trapped in a mesh of fungal lichens. They are able to dry out and lose their colour until water comes along, allowing them to come back to life by making the photosynthetic organisms kick in. They create grooves in rocks by slowly dissolve the minerals in the rocks.



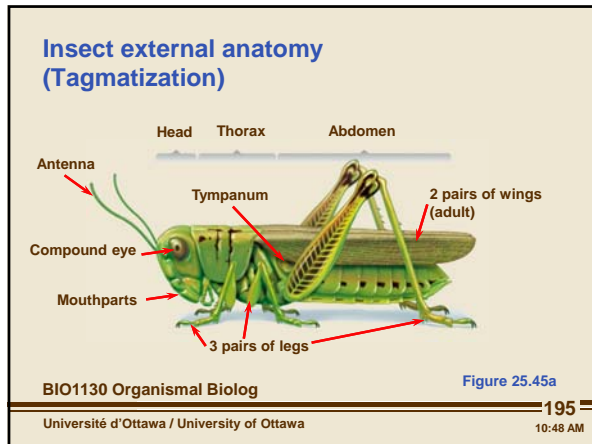
1 Arthropoda (Autapomorphies)

- Articulated exoskeleton of plates
- Muscles arranged in bands
- Compound eye

Other groups listed on the right: Porifera, Placozoa, Cnidaria, Ctenophora, Platyhelminthes, Gastrotricha, Gnathostomulida, Cycliophora, Syndermata, Annelida, Mollusca, Sipuncula, Nemertea, Bryozoa, Brachiopoda, Phoronida, Arthropoda, Tardigrada, Onychophora, Nematomorpha, Nematoda, Priapulida, Kinorhyncha, Loricifera, Echinodermata, Hemichordata, Chordata.

The first arthropods then move up on land.

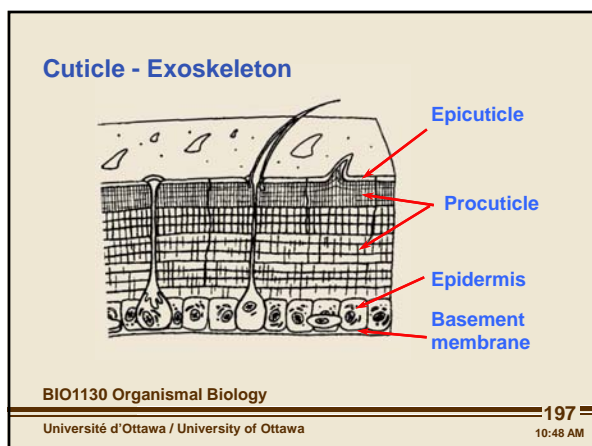
Phanerozoic - Paleozoic



Insects become the most dominant arthropod to come up on land. They were the first to colonize the terrestrial environment and even dominate still today. They use that tagmatization. The head is dedicated only to food acquisition and sensing the environment. The thorax segment has legs and is for movement and will eventually get jumping and wings. The final segment the abdomen are used to take to organs and put them in an expandable case so that they can enlarge when needed (feeding, eggs). There are always 6 with the head 13 with the thorax and 12-13 in the abdomen.





This is the first group in the terrestrial environment to get up into the air. They ended up with a great advantage because they were eating new food, they could migrate, they could also escape.



this is how they water proof themselves. The cuticle now has a procuticle and an epicuticle. The epicuticle is an outer layer prevents any evaporation of the water from within the insect. It is so effective that shellack is made out of animal cuticle.

Phanerozoic - Paleozoic

Insect reproduction



Internal fertilization - spermatophore

Insect egg shell

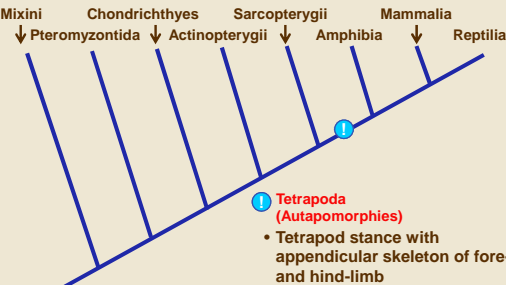
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They use the lock and key mechanism to mate. The female produces eggs with a waterproof casing on them. There is one opening on every egg and only one sperm can fertilize the egg.

Vertebrate phylogeny



Mixini Chondrichthyes Sarcopterygii Mammalia
↓ Pteromyzontida ↓ Actinopterygii ↓ Amphibia ↓ Reptilia

1 Tetrapoda (Autapomorphies)

- Tetrapod stance with appendicular skeleton of fore- and hind-limb

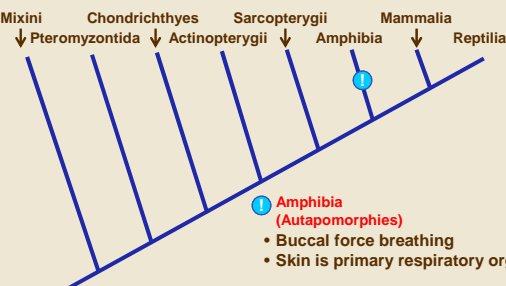
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Meanwhile by putting their heads out of the water to breath. They almost adapted to land but dint (amphibians).

Vertebrate phylogeny



Mixini Chondrichthyes Sarcopterygii Mammalia
↓ Pteromyzontida ↓ Actinopterygii ↓ Amphibia ↓ Reptilia

1 Amphibia (Autapomorphies)

- Buccal force breathing
- Skin is primary respiratory organ

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Phanerozoic - Paleozoic

Amphibians



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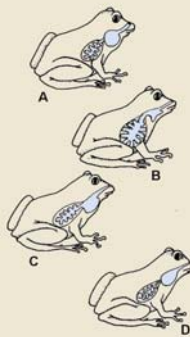
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Massive diverse variations of amphibians took over the environment on land.

Buccal force respiration



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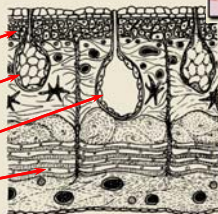
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Very unique way of breathing. they swallow and gulp air and force it into their lungs. they then squeeze their body to let the air out. This is the first organisms with lungs and the beginnings of protecting the respiratory surface.

Amphibian skin

Epidermis
Mucus gland
Poison gland
Dermis



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They breath through their skin still and needs to keep their skin moist. They have glands that either release moisture for their skin or they can also have glands that produce poisons to kill predators that try to eat them. They can interfere with the nervous system. As soon as the predator tastes them they will produce hallucinogenic chemicals.

Phanerozoic - Paleozoic

Amphibian food



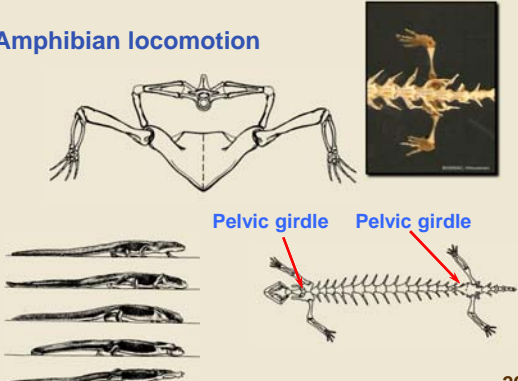
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They began to feed on the insects that were flying around. They did this by using their tongue to feed. They are able to flip it out to capture their prey. This is one of the first groups to tap this food source.

Amphibian locomotion

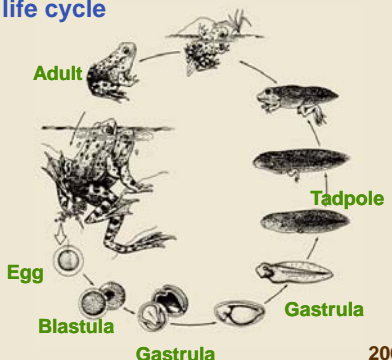


Pelvic girdle Pelvic girdle

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Their limbs are stuck out of the sides of their body. To be able to move they had to lift themselves up of the ground to move. They also still breath through their skin and have to go back to the water to lay their eggs. These are a partial step in the invasion of land by vertebrates.

Amphibian life cycle



Adult

Egg

Blastula

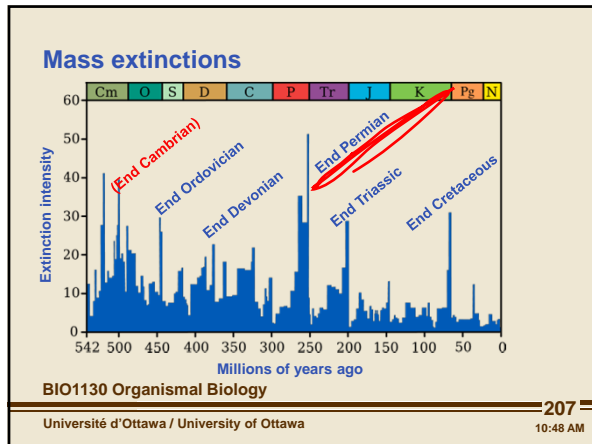
Gastrula

Gastrula

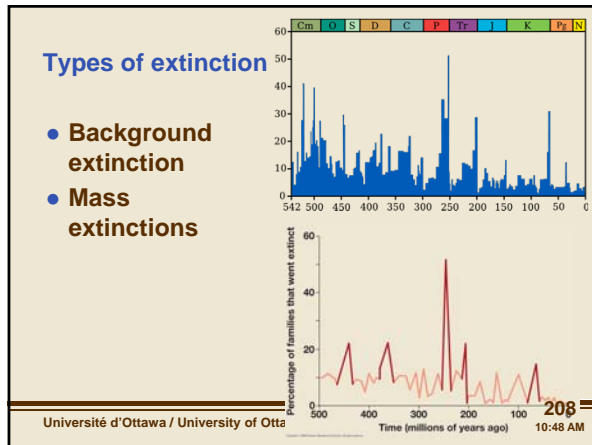
Tadpole

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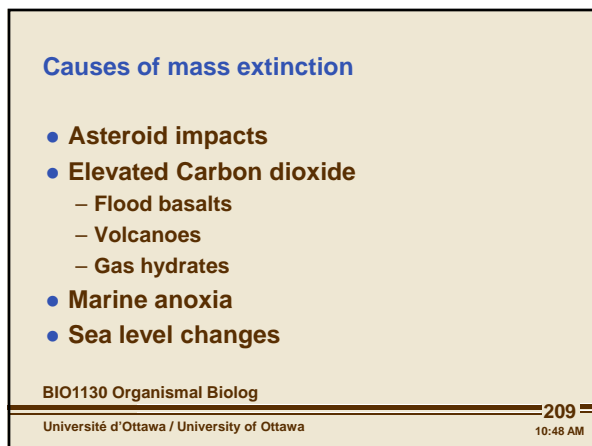
Phanerozoic - Paleozoic



LEARN THE MASS EXTINCTIONS.



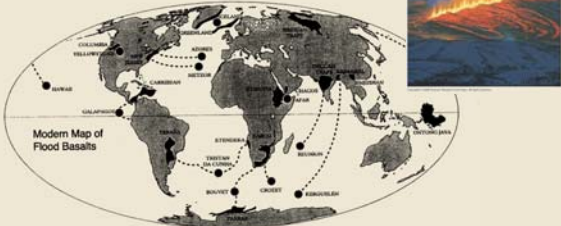
Mass extinction - 50% of the population
Background extinction - small populations.
Small organisms are not as sensitive to extinctions.



Phanerozoic - Paleozoic

Flood basalts

video



Modern Map of Flood Basalts

Figure 27-15

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Surviving mass extinctions

- **Plants**
- **Insects**
- **Small size and global distribution**
- **Generalist life style**

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