GY 112 Lecture Notes
Evolution of the Plants

Lecture Goals:
A) The first "plants" (Archean-Proterozoic)
B) Diversification (Paleozoic-Mesozoic)
C) Domination (Mesozoic-Cenozoic)

Textbook reference: Levin (7th edition) Chapter 4 (p. 141-142); Chapter 10 (p. 334-338); Chapter 12 (p. 417-422)

A) The first plants

The question of when the first plants evolved depends upon your definition of what exactly a plant is. Today, most people envision plants to be **photosynthetic** life forms that you plant in the ground. Most have **roots** and **leaves**. These features took time to evolve. The first plants, like the first animals, were far less complex. In fact, they were likely single-celled organisms.

Let's go back to the beginning, when the first prokaryotes were just starting to evolve. This will be review for most of you as we previously talked about this material when we first dealt with evolution. Well, we need to talk about it again.

The earliest **bacteria** were probably **heterotrophs**, single-celled organisms that were incapable of manufacturing their own food. Instead, they digested other bacteria through the use of enzymes and fermentation reactions. The conversion of sugar into ethanol and carbon dioxide is an example of this type of process. Heterotrophs run the risk of eventually running out of food, so this is not the best strategy for a life form to be locked into. The next step was the evolution of **autotrophs**, single-celled bacteria that are capable of manufacturing their own food through various chemical reactions. These prokaryotes has a big advantage over their heterotrophic cousins as they could use plentiful chemicals to turn into their own food supply. We now know of 3 major types of autotrophic bacteria:

1) **Nitrifying bacteria –** use ammonia (NH_3) to manufacture their food

2) **Sulfur bacteria** – use hydrogen sulfide (H_2S) to manufacture their food

3) **Photosynthetic bacteria –** use CO_2 and sunlight to manufacture their food.

The third type of bacteria are known as **photoautotrophs** and the basic reaction they used is the same reaction today used by plants:

$$CO_2 + 6\ H_2O + sunlight \Rightarrow C_6H_{12}O_6 + 6CO_2$$

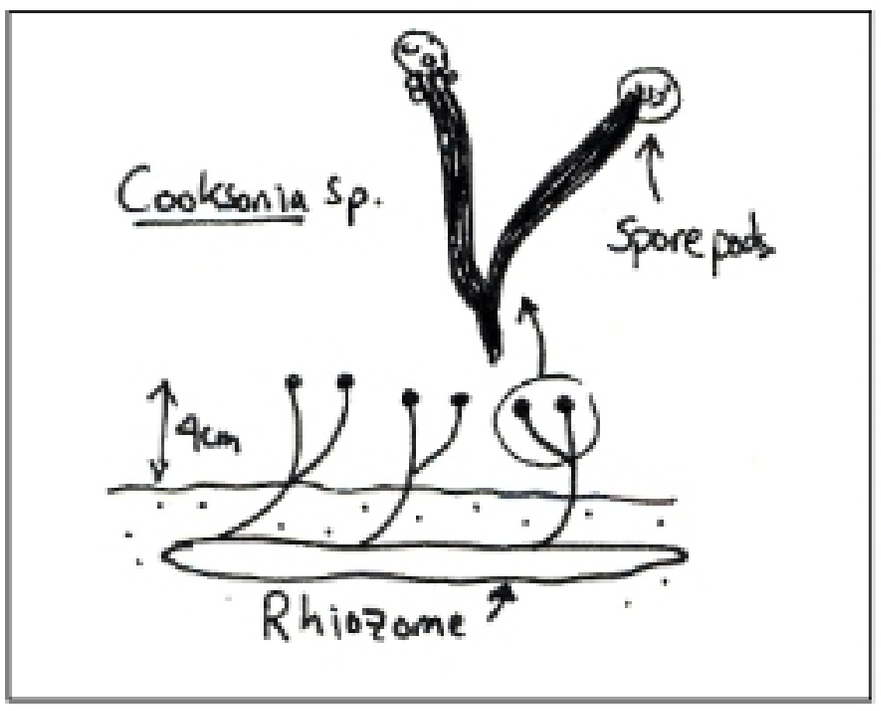
The most well know prokaryotic photoautotrophs are of course the stromatolites which first evolved in the early Archean are still around today. As far as the plants are

concerned, the next major development probably occurred simultaneously with evolution of **eukaryotes**. This, as I'm sure you all remember, was the development of larger cells with enclosed nuclei that propagated through sexual reproduction. The most accepted hypothesis for this development is that one prokaryote assimilated another without actually digesting it. Perhaps this was a **symbiotic** relationship at first, but overtime, the assimilated prokaryote developed into a nucleus and the assimilating prokaryote became the enclosing cell and was contained within a membrane. Those eukaryotes containing an assimilated photoautotroph are likely the ancient ancestors of the plants.

The first photosynthetic eukaryotes were the **chorophytes** which today include **green algae**. They would likely have developed in the shallow oceans, like the stromatolites. Eventually these algae would have begun to populated terrestrial lakes and streams, but when this occurred is very difficult to determine. Green algae do not fossilize particularly well. Like the animals, for plants to fossilize, they need to have parts that can be preserved in the rock record. This did not really occur until the Paleozoic.

B) Diversification (Paleozoic)

The first fossilized plants were found in late Silurian sedimentary rocks, and as far as plants go, they were pretty unimpressive. They were small (maybe 5 cm high) and had very few features that you would today associate with plants growing in your back yard. No leaves, no branches, not even true roots. Yet they were far more advanced than the chorophytes that they were derived from. These plants were metazoans (multicellular) and looked something like this species, *Cooksonia* sp.:



The major evolutionary advance that these plants had was a **vascular** stem. Vascular plants are called **Tracheophytes** and are important improvements over non-vascular plants (**Bryophytes**) as they had porous stems that allowed water to be rapidly moved from the soil throughout the plant. There are still bryophytes today. They include mosses and liverworts. Modern tracheophytes also have roots and leaves, but these features took time to evolve. There were no leaves that we know of in *Cooksonia* sp., nor were there roots. Instead, *Cooksonia* sp. had a **rhizome** from which individual stems sprouted. Reproduction was done through **spores** which each plant had stored in protected spore pods or **sporangia** near the tips of the stems. When ripe, they would split spreading spores over a large area. *Cooksonia* sp. Might have looked like a bunch of wooden match sticks sticking out of the ground.

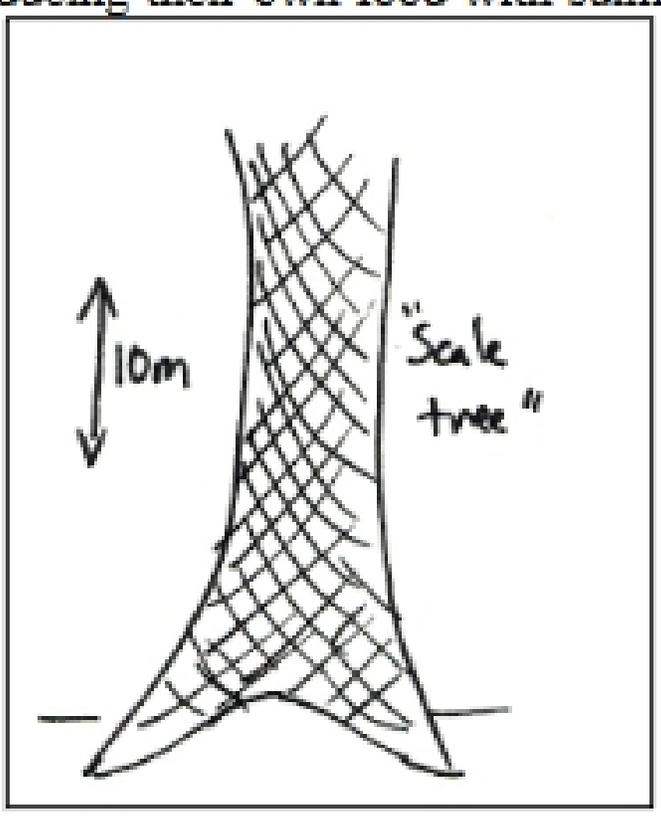
Reproduction through spores is still done by a lot of plants, but it does suffer from one important limitation. Spores need water to reproduce, lots of it, and today, most spore-bearing plants live near swampy areas where they can be guaranteed a steady supply of

H_2O. Once released and in the ground, each spore develops into a tiny root-like structure (**prothallus**) that lives entirely below ground feeding on rotting substances. This is where the sex cells develop. Male cells develop in the **antheridium** and female cells develop in the **archegonium**. Male cells are released into the water and fertilize a single egg within the archegonium repeating the process over and over again.

In GY 112 you don't really have to worry too much about the reproduction of spore-producing plants. Nor do you have to remember a lot about plant taxonomy which is similar to (but not identical) to the taxonomy that we have already discussed for the animals. Botanists prefer to use **Divisions** instead of **Phyla** and in the case of plants like *Cooksonia* sp., they are classified as members of Division **Psilophyta**. Most people just call them the **psilopsids**

Another psilopsid was *Rhynia* sp. which developed in the middle Devonian. There is better evidence of the vascular system in this plant than *Cooksonia* sp., but the general consensus is that the psilopsids first developed in the late Silurian. From then on, the colonization of the terrestrial environments of the planet began in earnest. Before this time, the land masses were largely devoid of all life forms. No vascular plants, no animals, no insects. Rain fell, rivers flowed, the wind blew, glaciers advanced and retreated and hurricanes and tornados wandered around. But this happened over an empty landscape. Kind of weird wasn't it? Don't forget that the oceans were teaming with life by the time the first vascular plants started to develop on land. It was a far better place to live, but once we get to the Devonian, things are really going to change in both the oceans and on the land. The Devonian is known as both the **Age of the Fishes** and the **Age of the Plants**. Since this lecture is concentrating on plants, we'll concentrate on the latter.

The next major development of the plants occurred in the early Devonian (perhaps the late Silurian). It was the appearance of **leaves**. Leaves allow plants to increase the **surface area** for photosynthesis. Since they are producing their own food with sunlight, the more food you produced, the better off you are. The first leaves were small and developed close to stem of the plants. Sporangia shifted to the underside of the leaves. Plants were also getting much larger and by the middle Devonian, some stood 30 m (100 feet) high. This is another advantage of a vascular system. You can get water up a long way up from the ground. The taller the tree gets, the more sunshine it gets[1].



The Devonian is known as the age of the plants because of the appearance of a bunch of new plant divisions. Some were really cool like those in division **Lycopsida** (the **lycopsids**). This division

[1] This has nothing to do with being closer to the sun – if you are taller than your neighbors, you get the sun and they get the shade. Competition in evolution is not just restricted to animals with teeth and claws.