

## Important Landmarks in the Evolution of Land Plants

Moving out onto the land was a huge step for plants.

In the water, plants were supported. Every cell had contact with the ocean water, which brought water and nourishment that could be absorbed through the cell wall. Reproduction was simple: plants released their eggs and sperm cells into the water where they could meet and form tough little capsules called zoospores. These zoospores could then float in the ocean and find new places to live.

On land, all this changed. Plants cast up on the sea shore or trapped in evaporating ponds were subjected to drying winds and often to large temperature swings. At first they probably just died, but over millions of years a few plants were able to resist short periods of dryness and live on. These became the ancestors of our land plants.

Let's look at some of the big strides that plants made as they began to make the transition into land plants.

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About 425 million years ago, plants began to adapt to life on land. They developed

- **a waxy cuticle** to protect their leaves from drying out. (Think how we put a coat of wax on furniture to protect it. This is the same strategy.)
  - **stomata** -- pores (think of the pores in your skin) on the undersides of their leaves that allowed and regulated exchanges with the gas molecules of the atmosphere
  - ways to **protect their reproductive cells from drying out (seed coats)**
  - **vascular structures** so that nutrients and fluids could be circulated



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Lichens were among the early land dwellers. There are many species of lichens in the world today, and they can be found in all the terrestrial biomes. These tough little organisms are made up of a partnership between an alga and a fungus: the fungus provides an environment, and the algal cells make food with their chloroplasts.

Lichens are often found clinging to rocks, like the ones in the picture. They may be green, orange, nearly black, or yellow. They have no roots, and they absorb moisture from the rain that falls on them, and from the air. In dry seasons they



become dry and brittle, but are revived when moisture returns. Though lichens grow very slowly, they nonetheless provide food for animals and sometimes for people.

Mosses were also among the first land plants. They belong to a family called Bryophytes. They form low mats, and the little plants, grouped tightly together, can absorb water like sponges. They do not have roots, although a cell at the bottom of each sprig forms a rhizoid that clings to rocks and other surfaces. Mosses do not have vascular structures (tubes like our veins for moving fluids around inside themselves), but they do have an effective method of reproduction called alternation of generations. This method protects and nurtures the vulnerable zygote. A zygote is the new cell that is produced by the union of the genetic material from two parents. It is the cell from which a new and unique organism will grow. Mosses found a way to keep the zygote moist and alive. The zygote grows into a structure that makes spores, and the tiny spores float away in the air.

Although mosses invented a way to protect their reproductive processes, they do not have vascular structures. Vascular structures permit the distribution of fluids and nutrients inside living organisms. This, in turn, allows cells to specialize. If the leaves of a plant are making glucose, sending some of that glucose to the cells in the roots keeps the root cells alive and allows them to grow. In return, the root cells can gather water and nutrients that are deep in the soil, and can share these resources with the leaves.

Ferns are the plants that developed vascular systems. Some ferns still have rhizoids, but they also have roots. This makes it possible for ferns to grow into large plants.

Ferns do not have true seeds. They reproduce by alternation of generations. When you turn fern fronds over, you can often see little dots on the underside. These dots are groups of spores. When the dots are brown, the spores are getting ripe and will soon be released from the plant. Spores are tiny, and will float away. Some of them will come down in a new place that is favorable for fern growth.

In ancient times the ferns diversified and spread. Some grew into tree ferns. (Tree ferns still grow in New Zealand and Hawaii, and are sometimes seen in California gardens.) Other groups of vascular plants that do not make seeds include the club mosses and the horsetails. Nourished by the fluids that circulated in their bodies, the vascular plants grew in size and variety. The rocky, barren earth had gained another color: green.

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The land that these early plants colonized was different from dry land today. It was covered with rocks of all sizes, with sand, and perhaps with mud and banks of clay. Sand and mud are not soil. Soil is a complex mixture of organic debris, rock particles and minerals, and living soil bacteria and protozoans. It is full of living organisms, such as nematode worms and the much larger earth worms. Soil is literally a living layer, a very precious resource on the earth. The first plants began the deposition of organic matter as



they died. Bacteria evolved that could break down the dead organic material and make the nutrients available to roots again.

There were advantages to coming out onto the land. More light was available, and at first there were no animals to feed on the plants and steal the energy that they had captured. Minerals were available to the plants.

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The seed is invented. Gymnosperms appear.

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Ferns and mosses are still dependent on water for reproduction. Their sperms have to swim through water to fertilize the eggs, and the fertilized eggs must be kept damp until they grow and release their spores. Land plants cannot always count on having water available when they need it. ~~The invention of the seed was a major achievement which made it possible for land plants to spread to new environmental niches.~~

The first seed-bearing plants are called gymnosperms. Gymnosperm means "naked seed" because these seeds have only a dry, thin covering instead of a sturdy protective seed coat. Let's think about how the reproductive process changed for plants.

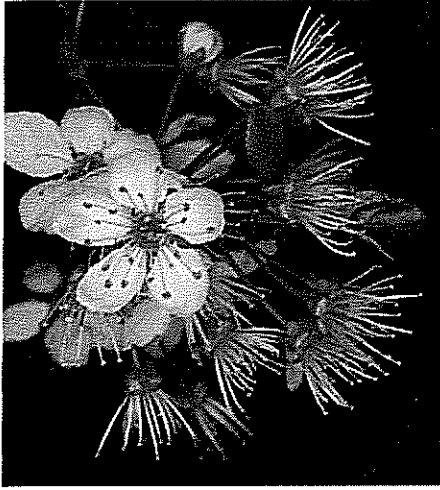
## Pollen

One important change was the development of pollen to replace the swimming sperm. Pollen could float on the wind and was not damaged by the dry air. The plants made pollen cones which made only pollen and small, tough woody cones in which the female half of the process could be protected. (See picture with blue-green cones below.) The pollen fell on these woody cones and grew tubes down to find the ovules (eggs). After the eggs were fertilized, they developed and matured in the cone. The seed that resulted could survive drought in a dormant state. It could wait for a favorable season to begin its growth. It had a package of food to draw on when it germinated. These seeds were well adapted to the land.

Ferns and gymnosperms flourished and diversified on the earth for more than 200 million years before another innovation appeared. During part of this time, the Carboniferous Period, the abundant plant life provided the organic matter that was later transformed into coal.

Ferns and gymnosperms still grow on the earth today. The huge coniferous forests that cover about 25% of the land surface of the earth are dominated by gymnosperms. Most of our lumber and paper are made from their wood. Ferns flourish in many tropical and temperate places around the world.

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**Flowering plants appear and flourish. These are the Angiosperms.**

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About a hundred and thirty million years ago, a new kind of plant appeared. This plant developed two innovations.

- ♦ First, the new plants produced flowers. Flowers allowed the plants to form partnerships with insects, and insects, in exchange for pollen and nectar, greatly increased the efficiency of the plants' pollination.
- ♦ Second, the parent plant provided a protective covering for the seed. Sometimes this covering took the form of a burr or a fruit, which improved the dispersal of the seeds to other places.

Today, most of the plant species on earth are flowering plants.

**There are two kinds of angiosperms, monocotyledons and dicotyledons. Read about them on these pages.**

**This chart is a quick summary of the development of land plants.**

Millions of Years Ago	Plant Developments	Age
130	Spread and Diversification of Flowering Plants	Cretaceous
	Flowering Plants Appear	
323	<i>Cool Forests</i>	Jurassic
		Triassic
		Permian
		Carboniferous
362	Origin of the Seed Gymnosperms (Conifers)	Mississippian
408	<i>Vascular Plants diversify</i>	Devonian
440	Land Plants - cuticle, vascular tissues	Silurian
510	Plants begin to appear on land	Ordovician
		Cambrian

