

# 15.1: Introduction to the Plant Kingdom DRAFT

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## Lesson Objectives

- Identify traits of plants.
- Explain the importance of plants.
- Give an overview of the plant life cycle.
- Outline major events in plant evolution.
- Describe how plants are classified.

## Vocabulary

- alternation of generations
- angiosperm
- cone
- flower
- fruit
- gametophyte
- germination
- gymnosperm
- lignin
- ovary
- plant
- rhizoid
- seed
- sporophyte
- vascular tissue
- vegetative reproduction
- weed

## Introduction

Like the skunk cabbage, most of the plants you are familiar with produce flowers. However, plants existed for hundreds of millions of years before they evolved flowers. In fact, the earliest plants were different from most modern plants in several important ways. They not only lacked flowers. They also lacked leaves, roots, and stems. You might not even recognize them as plants. So why are the earliest plants placed in the plant kingdom? What traits define a plant?

## What Are Plants?

Plants are multicellular eukaryotes with cell walls made of cellulose. Plant cells also have chloroplasts. In addition, plants have specialized reproductive organs. These are structures that produce reproductive cells. Male reproductive organs produce sperm, and female reproductive organs produce eggs. Male and female reproductive organs may be on the same or different plants.

## How Do Plants Obtain Food?

Almost all plants make food by photosynthesis. Only about 1 percent of the estimated 300,000 species of plants have lost the ability to photosynthesize. These other species are consumers, many of them predators. How do plants prey on other organisms? The Venus fly trap in **Figure below** shows one way this occurs.



Venus fly trap plants use their flowers to trap insects. The flowers secrete enzymes that digest the insects, and then they absorb the resulting nutrient molecules.

## What Do Plants Need?

Plants need temperatures above freezing while they are actively growing and photosynthesizing. They also need sunlight, carbon dioxide, and water for photosynthesis. Like most other organisms, plants need oxygen for cellular respiration and minerals to build proteins and other organic molecules. Most plants support themselves above the ground with stiff stems in order to get light, carbon dioxide, and oxygen. Most plants also grow roots down into the soil to absorb water and minerals.

## The Importance of Plants

The importance of plants to humans and just about all other life on Earth is staggering. Life as we know it would not be possible without plants. Why are plants so important?

- Plants supply food to nearly all terrestrial organisms, including humans. We eat either plants or other organisms that eat plants.

- Plants maintain the atmosphere. They produce oxygen and absorb carbon dioxide during photosynthesis. Oxygen is essential for cellular respiration for all aerobic organisms. It also maintains the ozone layer that helps protect Earth’s life from damaging UV radiation. Removal of carbon dioxide from the atmosphere reduces the greenhouse effect and global warming.
- Plants recycle matter in biogeochemical cycles. For example, through transpiration, plants move enormous amounts of water from the soil to the atmosphere. Plants such as peas host bacteria that fix nitrogen. This makes nitrogen available to all plants, which pass it on to consumers.
- Plants provide many products for human use, such as firewood, timber, fibers, medicines, dyes, pesticides, oils, and rubber.
- Plants create habitats for many organisms. A single tree may provide food and shelter to many species of insects, worms, small mammals, birds, and reptiles (see **Figure below**).



Red-eyed tree frogs like this one live in banana trees.

We obviously can’t live without plants, but sometimes they cause us problems. Many plants are weeds. **Weeds** are plants that grow where people don’t want them, such as gardens and lawns. They take up space and use resources, hindering the growth of more desirable plants. People often introduce plants to new habitats where they lack natural predators and parasites. The introduced plants may spread rapidly and drive out native plants. Many plants produce pollen, which can cause allergies. Plants may also produce toxins that harm human health (see **Figure below**).

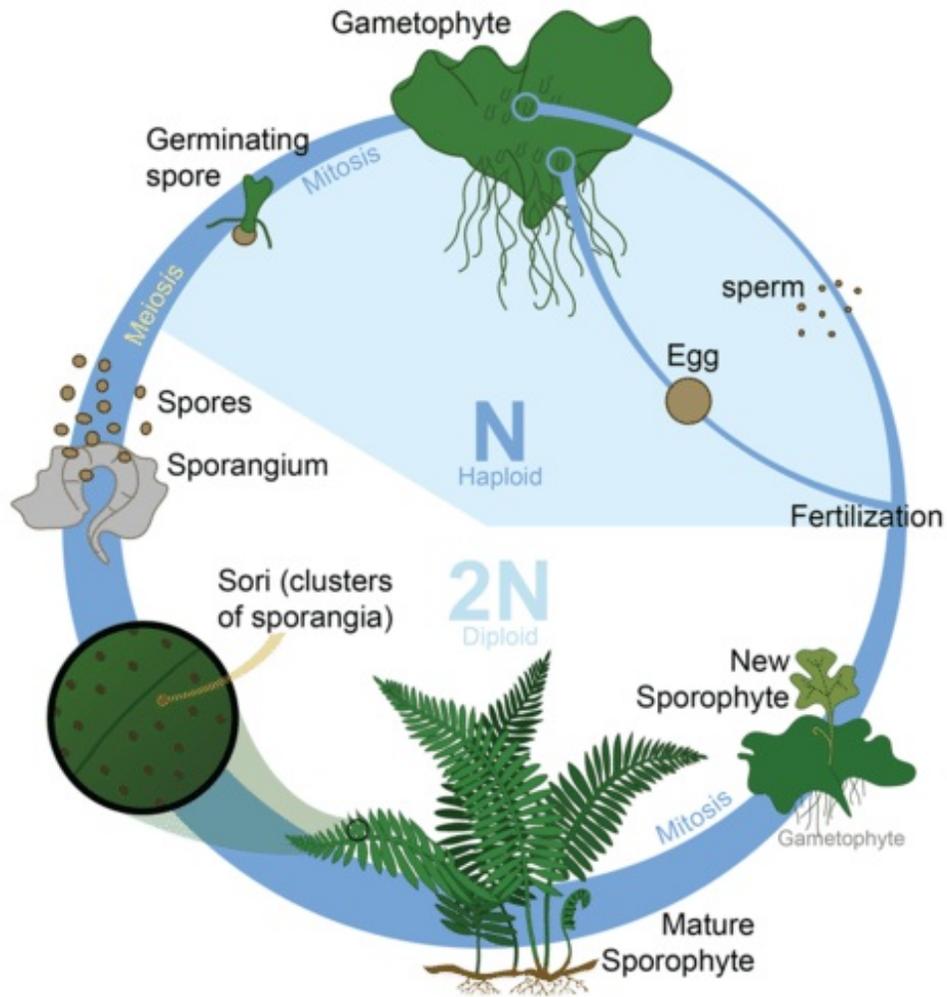
Poison ivy causes allergic skin rashes. It’s easy to recognize the plant by its arrangement of leaves in groups of three. That’s the origin of the old saying, “leaves of three, leave it be.”

## Life Cycle of Plants

All plants have a characteristic life cycle that includes **alternation of generations**. Plants alternate between haploid and diploid generations. Alternation of generations allows for both asexual and sexual reproduction. Asexual reproduction with spores produces haploid individuals called **gametophytes**. Sexual reproduction with gametes and fertilization produces



diploid individuals called **sporophytes**. A typical plant's life cycle is diagrammed in **Figure below**.



Life Cycle of Plants. This diagram shows the general life cycle of a plant.

Early plants reproduced mainly with spores and spent most of their life cycle as haploid gametophytes. Spores require little energy and matter to produce, and they grow into new individuals without the need for fertilization. In contrast, most modern plants reproduce with gametes using pollen and seeds, and they spend most of their life cycle as diploid sporophytes. Many modern plants can also reproduce asexually using roots, stems, or leaves. This is called **vegetative reproduction**. One way this can occur is shown in **Figure below**.

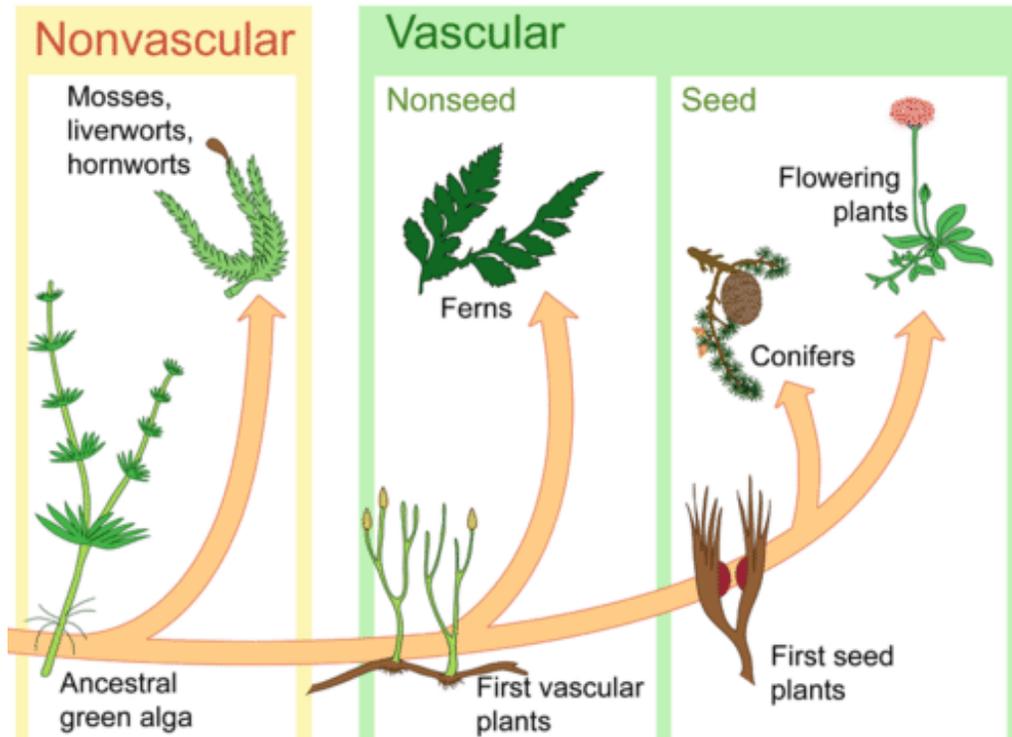


Strawberry plants have horizontal stems called stolons that run over the ground surface. If they take root, they form new plants.

## Evolution of Plants

As shown in **Figure below**, plants are thought to have evolved from an aquatic green alga. Later, they evolved

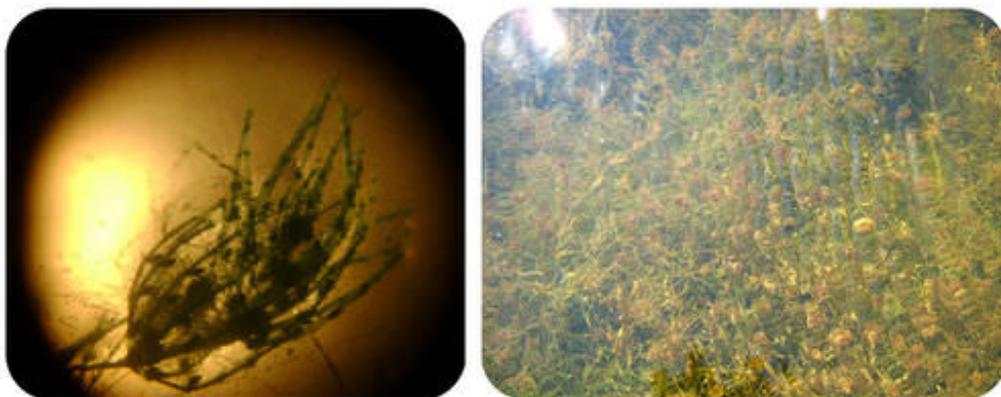
important adaptations for land, including vascular tissues, seeds, and flowers. Each of these major adaptations made plants better suited for dry land and much more successful.



From a simple, green alga ancestor that lived in the water, plants eventually evolved several major adaptations for life on land.

### The Earliest Plants

The earliest plants were probably similar to the stonewort, an aquatic algae pictured in [Figure below](#). Unlike most modern plants, stoneworts have stalks rather than stiff stems, and they have hair-like structures called **rhizoids** instead of roots. On the other hand, stoneworts have distinct male and female reproductive structures, which is a plant characteristic. For fertilization to occur, sperm need at least a thin film of moisture to swim to eggs. In all these ways, the first plants may have resembled stoneworts.



Modern stoneworts may be similar to the earliest plants. Shown is a field of modern stoneworts (right), and an example from the Charophyta, a division of green algae that includes the closest relatives of the earliest plants (left).

### Life on Land

By the time the earliest plants evolved, animals were already the dominant living things in the ocean. Plants were also constrained to the upper layer of water that received enough sunlight for photosynthesis. Therefore, plants never became dominant marine organisms. But when plants moved to land, everything was wide open. Why was the land devoid of other life? Without plants growing on land, there was nothing for other organisms to feed on. Land could not be colonized by other organisms until land plants became established.

Plants may have colonized the land as early as 700 million years ago. The oldest fossils of land plants date back about 470 million years. The first land plants probably resembled modern plants called liverworts, like the one shown in **Figure below**.



The first land plants may have been similar to liverworts like this one.

Colonization of the land was a huge step in plant evolution. Until then, virtually all life had evolved in the ocean. Dry land was a very different kind of place. The biggest problem was the dryness. Simply absorbing enough water to stay alive was a huge challenge. It kept early plants small and low to the ground. Water was also needed for sexual reproduction, so sperm could swim to eggs. In addition, temperatures on land were extreme and always changing. Sunlight was also strong and dangerous. It put land organisms at high risk of mutations.

## **Vascular Plants Evolve**

Plants evolved a number of adaptations that helped them cope with these problems on dry land. One of the earliest and most important was the evolution of vascular tissues. **Vascular tissues** form a plant's "plumbing system." They carry water and minerals from soil to leaves for photosynthesis. They also carry food (sugar dissolved in water) from photosynthetic cells to other cells in the plant for growth or storage. The evolution of vascular tissues revolutionized the plant kingdom. The tissues allowed plants to grow large and endure periods of drought in harsh land environments. Early vascular plants probably resembled the fern shown in **Figure below**.



Early vascular plants may have looked like this modern fern.

In addition to vascular tissues, these early plants evolved other adaptations to life on land, including lignin, leaves, roots, and a change in their life cycle.

- **Lignin** is a tough carbohydrate molecule that is hydrophobic (“water fearing”). It adds support to vascular tissues in stems. It also waterproofs the tissues so they don’t leak, which makes them more efficient at transporting fluids. Because most other organisms cannot break down lignin, it helps protect plants from herbivores and parasites.
- Leaves are rich in chloroplasts that function as solar collectors and food factories. The first leaves were very small, but leaves became larger over time.
- Roots are vascular organs that can penetrate soil and even rock. They absorb water and minerals from soil and carry them to leaves. They also anchor a plant in the soil. Roots evolved from rhizoids, which nonvascular plants had used for absorption.
- Land plants evolved a dominant diploid sporophyte generation. This was adaptive because diploid individuals are less likely to suffer harmful effects of mutations. They have two copies of each gene, so if a mutation occurs in one gene, they have a backup copy. This is extremely important on land, where there’s a lot of solar radiation.

With all these advantages, it’s easy to see why vascular plants spread quickly and widely on land. Many nonvascular plants went extinct as vascular plants became more numerous. Vascular plants are now the dominant land plants on Earth.

## Seed Plants Emerge

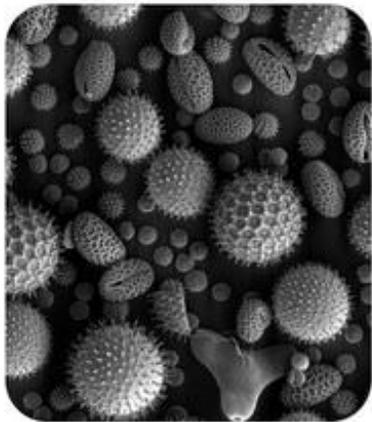
For reproduction, early vascular plants still needed moisture. Sperm had to swim from male to female reproductive organs for fertilization. Spores also needed some water to grow and often to disperse as well. Of course, dryness and other harsh conditions made it very difficult for tiny new offspring plants to survive. With the evolution of seeds in vascular plants, all that changed. Seed plants evolved a number of adaptations that made it possible to reproduce

without water. As a result, seed plants were wildly successful. They exploded into virtually all of Earth's habitats.

Why are seeds so adaptive on land? A **seed** contains an embryo and a food supply enclosed within a tough coating. An embryo is a zygote that has already started to develop and grow. Early growth and development of a plant embryo in a seed is called **germination**. The seed protects and nourishes the embryo and gives it a huge head start in the "race" of life. Many seeds can wait to germinate until conditions are favorable for growth. This increases the offspring's chance of surviving even more.

Other reproductive adaptations that evolved in seed plants include ovules, pollen, pollen tubes, and pollination by animals.

- An **ovule** is a female reproductive structure in seed plants that contains a tiny female gametophyte. The gametophyte produces an egg cell. After the egg is fertilized by sperm, the ovule develops into a seed.
- A grain of pollen is a tiny male gametophyte enclosed in a tough capsule (see **Figure below**). It carries sperm to an ovule while preventing it from drying out. Pollen grains can't swim, but they are very light, so the wind can carry them. Therefore, they can travel through air instead of water.
- Wind-blown pollen might land anywhere and be wasted. Another adaptation solved this problem. Plants evolved traits that attract specific animal pollinators. Like the bee in **Figure below**, a pollinator picks up pollen on its body and carries it directly to another plant of the same species. This greatly increases the chance that fertilization will occur.
- Pollen also evolved the ability to grow a tube, called a pollen tube, through which sperm could be transferred directly from the pollen grain to the egg. This allowed sperm to reach an egg without swimming through a film of water. It finally freed up plants from depending on moisture to reproduce.



Magnified  
Pollen Grain



Bee Peppered with  
Yellow Pollen Grains

Individual grains of pollen may have prickly surfaces that help them stick to pollinators such as bees. What other animals pollinate plants?

## Seed Plants Diverge

The first seed plants formed seeds in cones. **Cones** are made up of overlapping scales, which are modified leaves (see **Figure below**). Male cones contain pollen, and female cones contain eggs. Seeds also develop in female cones. Modern seed plants that produce seeds in cones are called **gymnosperms**.



Gymnosperms produce seeds in cones (left). Each scale has a seed attached (right).

Later, seed plants called **angiosperms** evolved. They produce **flowers**, which consist of both male and female reproductive structures. The female reproductive structure in a flower includes an organ called an **ovary**. Eggs form in ovules inside ovaries, which also enclose and protect developing seeds after fertilization occurs. In many species of flowering plants, ovaries develop into **fruits**, which attract animals that disperse the seeds.

## Classification of Plants

The scientific classification of modern land plants is under constant revision. Informally, land plants can be classified into the groups listed in **Table below**. The most basic division is between nonvascular and vascular plants. Vascular plants are further divided into those that reproduce without seeds and those that reproduce with seeds. Seed plants, in turn, are divided into those that produce seeds in cones and those that produce seeds in the ovaries of flowers. You can read more about each of these groups of plants in the next lesson.

Major divisions and types of modern land plants are organized in **Table below**. Why do the first five types of plants require a moist habitat?

Major Division	Types of Plants	No. of Living Species	Description
Nonvascular Plants			
	Liverworts	7,000	
	Hornworts	150	

Major Division	Types of Plants	No. of Living Species	Description
	Mosses	10,000	They lack leaves and roots. They have no stems, so they grow low to the ground. They reproduce with spores. They need a moist habitat.
Vascular Plants			
	Clubmosses	1,200	They have roots and tiny leaves. They have no stems, so they grow low to the ground. They reproduce with spores. They need a moist habitat.
	Ferns	11,000	They have large leaves in fronds. They have stiff stems, so they are tall growing; some are trees. They reproduce with spores. They need a moist habitat.
	Ginkgoes	1	
	Cycads	160	
	Conifers	700	
	Gnetae	70	Most are trees with wood trunks. They have adaptations to dryness such as needle-like leaves. They reproduce with seeds and pollen. They produce seeds in cones.

Major Division	Types of Plants	No. of Living Species	Description
	Flowering Plants	258,650	They have tremendous diversity in size, shape, and other characteristics. They reproduce with seeds and pollen. They produce seeds in the ovaries of flowers. Ovaries may develop into fruits, which enhance seed dispersal.

## Lesson Summary

- Plants are multicellular eukaryotes. They have organelles called chloroplasts and cell walls made of cellulose. Plants also have specialized reproductive organs. Almost all plants make food by photosynthesis. Life as we know it would not be possible without plants.
- All plants have a characteristic life cycle that includes alternation of generations. Asexual reproduction with spores produces a haploid gametophyte generation. Sexual reproduction with gametes and fertilization produces a diploid sporophyte generation.
- The earliest plants are thought to have evolved in the ocean from a green alga ancestor. Plants were among the earliest organisms to leave the water and colonize land. The evolution of vascular tissues allowed plants to grow larger and thrive on land. The evolution of seeds and pollen allowed them to reproduce on land without moisture. Flowering plants evolved flowers with ovaries that formed fruits. They have been the most successful plants of all.
- The most basic division of living plants is between nonvascular and vascular plants. Vascular plants are further divided into seedless and seed plants. Seed plants called gymnosperms produce seeds in cones. Seed plants called angiosperms produce seeds in the ovaries of flowers.

## Lesson Review Questions

### Recall

- What traits do all plants share?
- What do plants need?
- List reasons that plants are important to life on Earth.
- When is a plant considered a weed?
- What are vascular tissues? What is their function?

### Apply Concepts

- Draw a diagram of a typical plant life cycle that illustrates the concept of alternation of generations.

### Think Critically

- Explain why life on land was difficult for early plants. Why did plants need to become established on land before

other organisms could colonize the land?

8. Compare the different types of plants in the **Classification of Living Land Plants** (Table [above](#)). Which type of plants would you say is most successful? Support your answer with data from the table.

9. Which major plant adaptation—vascular tissues or seeds—do you think was more important in the evolution of plants? Choose one of the two adaptations, and write a logical argument to support your choice.

10. Compare and contrast gymnosperms and angiosperms, and give an example of each.

## Points to Consider

Vascular plants are now the most common plants on Earth. However, nonvascular plants should not be ignored. They were the first plants to evolve, and some still survive today.

- In what ways do you think modern nonvascular plants are different from other types of modern plants? In what ways do you think they are similar?
- How might modern nonvascular plants differ from other eukaryotes, such as fungi?

