SEEDS AND ROOTS

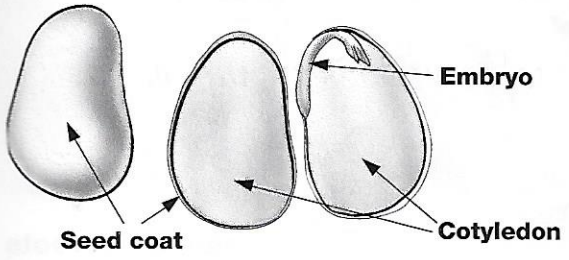
Think for a moment about growing a garden. The first rows might be radishes and some beets. Next to those some greens and cabbages. Then a row of tomatoes, cucumbers, and beans. If the weather is on the cool side, perhaps some peas and lettuce, and if it is hot, some melons, peppers, and squash. Yum! And finish the whole thing off with a border of marigolds. Now that's a garden.

The next step in turning this garden vision into reality is a trip to the hardware store or nursery. The little envelopes and boxes that you bring home hold some of the marvels of this planet—seeds. With a little care and planning, and some luck, you just might make a handful of seeds of different sizes, shapes, and colors into the great garden described above.

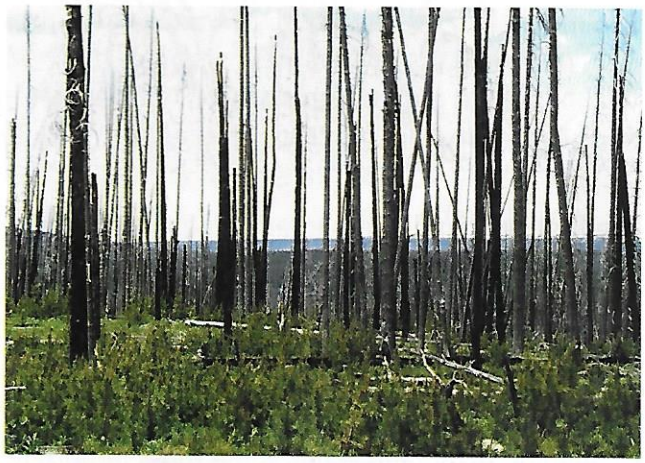
Seeds are living organisms. They are as alive as dogs, horses, butterflies, pigeons, elm trees, trout, and corn stalks. It's easy to overlook the fact that seeds are alive because they don't do anything that we usually associate with life; they don't move, eat, drink, reproduce, or anything else. They just lie there.

DORMANCY

Seeds are living organisms in a **dormant** or inactive stage. The outside of the seed is a tough, almost airtight covering called the **seed coat**. Inside is the **embryo** of a new plant and an energy supply in the form of starch in the **cotyledon** (cot•ul•EED•un). The cells in the tiny embryo are alive; they are filled with water, they are exchanging gases, consuming energy, and expelling waste, just like every other living cell, but the cells in the seed are doing it *very* slowly.



Some seeds remain dormant for only a few weeks or months. Other seeds can remain dormant for many years. Long dormancy is a useful trait if the plant lives in a region that has little rain. In years when there is not enough rainfall, the seeds can rest on the ground without sprouting. The oldest known seed that has germinated is a date palm seed that was found in Israel and planted in 2005. The seed was carbon dated at about 2,000 years old!

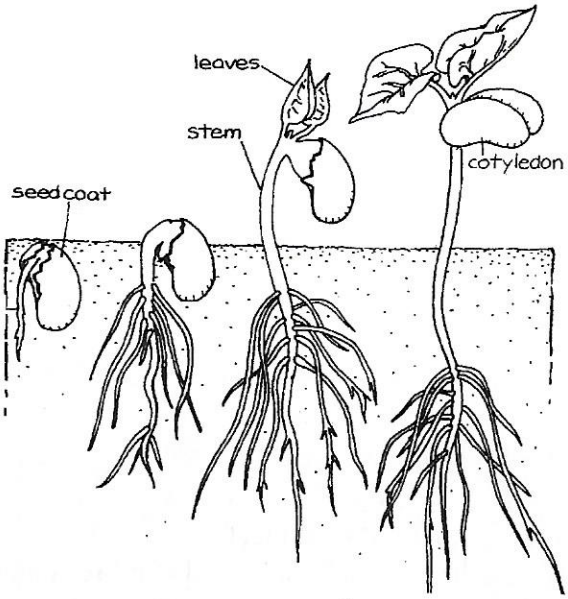


Other seeds remain dormant until they have been exposed to some extreme conditions. For example, some species of pine trees produce two types of seeds. One type sprouts under normal conditions, and the other type sprouts only if it has been exposed to high heat. This adaptation assures that the tree species will survive after a forest fire. In 1989 intense forest fires scorched Yellowstone National Park. The next spring

thousands of lodgepole pine seedlings appeared in the burn area. The heat-adapted seeds were growing.

GERMINATION

Germination is the start of growth and development of a seed. Germination is initiated by water. Water softens the seed coat. The cotyledons then soak up water, swell, and split the seed coat. The embryo begins to grow.

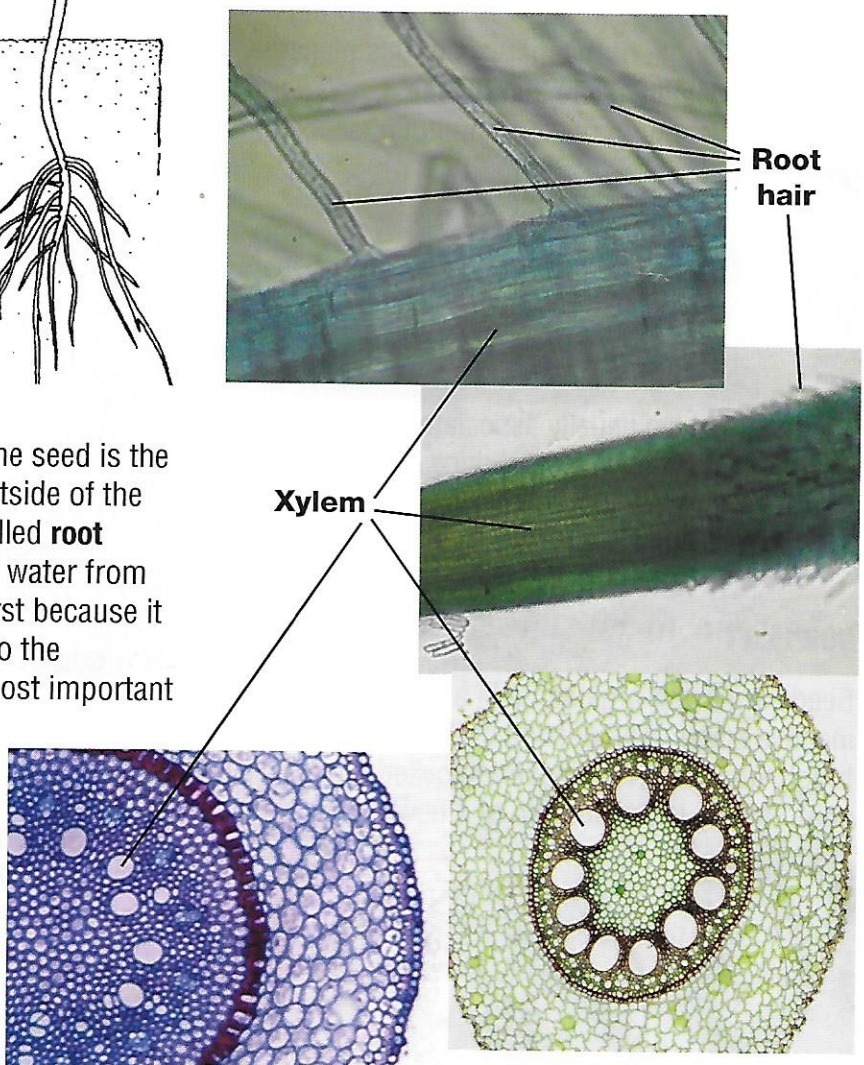


The first structure to emerge from the seed is the **root.** Right away the cells on the outside of the root develop thin hairlike fingers, called **root hairs,** that are effective at absorbing water from the environment. The root grows first because it is the structure that brings water into the developing plant, and water is the most important resource for growth.

The developing root is programmed to grow downward. At the same time the shoot begins growing upward toward the Sun. This growth and development requires a lot of energy. Starch in the cotyledons provides the energy during the early days of growth. As the energy stored in the cotyledon is used up, the cotyledons begin to wither. After the young plant's true leaves appear and begin producing food through photosynthesis, the cotyledons' role is over, and they drop off.

ROOT SYSTEMS

Roots are the hidden parts of the plant, so it's a little difficult to see what they are up to. If you have pulled weeds, you know that one thing roots do is keep the plant in place. The spreading root system reaches around and through the soil particles, becoming locked into the structure of the soil. The primary reason that roots reach and probe is to increase the plant's access to water and minerals. In the process the plant gets anchored in the soil.



Cross section of roots

Water in the soil is taken up by the root hairs. Once water enters the outermost cells of the roots, it passes from cell to cell, going deeper in the root structure until it enters tiny hollow tubes called **xylem** (ZY•lem).

The xylem is made of the cell walls of very long cells that have died. These cell walls are connected end to end to form long, strawlike tubes. The xylem carries water upward through the stems, into the leaves. In the process it carries water to every cell in the plant.

Plants usually have one of two basic types of root systems. Grasses have **fibrous root** systems with many small roots extending into the soil from the base of the plant. Many other plants have **taproot** systems, one or more large roots extending into the soil with smaller roots branching off.

Fibrous roots

Taproot

WATER

The amount of moisture in the soil and the amount of rainfall will influence the growth pattern of roots. Some plants growing in areas with little rainfall have roots that extend 15 meters (50 feet) or more into the soil to reach water far underground. Other desert plants might have very shallow roots that spread out widely just below the surface. Some sprout, grow, flower, and produce seeds in a matter of only 4 or 5 weeks. This does not give the plant time to send roots deep into the soil, so it produces very shallow roots to capture any rainfall or moisture that soaks into the top few centimeters of soil. Some plants in the same area have both deep and shallow roots. They take advantage of both underground water sources and occasional showers.

SUPPORT

The coastal redwoods of California and Oregon are the tallest living things on Earth. They can grow to heights of over 100 meters—taller than a 30-story building. The area where they grow receives most of its moisture from fog and misty rains. The fog condenses on the leaves and drips to the forest floor, keeping the soil moist. The soil along these coastal areas is often shallow, with solid rock a few meters below the surface. The roots for these huge plants seldom go more than 3 or 4 meters deep. How can roots this shallow keep these giants from falling over?

Redwood tree roots normally spread out 30 meters or more from the tree. The roots intertwine with those of other redwoods. These intertwined roots lock together all the redwood trees in an area, helping them support each other even in big storms.

Other plants have specialized roots for support. A corn plant has **prop roots** at the base of the stalk to brace the stalk and keep it upright. Another plant with prop roots is the banyan tree, a large tree found in tropical climates. As its

Banyan tree

limbs reach out from the tree, they send down prop roots for support. The limbs continue to grow out from the tree, dropping more prop roots as they grow. These roots grow into the soil and look like tree trunks. A single tree can look like a forest because of all the prop roots coming down from the limbs. One tree in Hawaii covers an area larger than five football fields. Is this the largest organism on Earth?

ENERGY STORAGE

Although getting water and anchoring the plant are the two most important functions of roots, they also do more. Roots can act as food storehouses. Trees, like the sugar maple, store a reserve of sugars and starches in the roots over the winter. When the trees leaf out in the spring, this stored sugar flows up from the roots in the form of sweet sap and is used as a source of energy to produce the new leaves. Food from the roots may also be called upon in the fall to enrich the cotyledons in the ripening seeds.

Perennial grasses (those that live for many years) use sugars stored in their roots to send up new shoots each spring, and to regenerate stems and leaves after being eaten by a grazing animal or burned by a grass fire. Some plants, such as carrots, radishes, and turnips, store large amounts of food in the form of starch in their roots. People eat these roots as a source of energy.

Root Out the Answer

1. Describe the process of germination from the time a seed is planted to the time it is an established new plant.
2. Discuss the role played by roots in the lives of plants.