Roots

Background Information

Roots are plant parts that grow downward and, in most cases, anchor land plants in the soil. Roots absorb water and dissolved nutrients and transport these to parts of the plant where they are needed. They do not, generally, produce leaves or buds.

Most plants have roots, but there are some exceptions. The exceptions are bryophytes and the groups of green algae that are classified as plants. Bryophytes have root-like structures called rhizoids for absorbing water, but because rhizoids lack vascular tissue they are not considered roots.

The first root of a plant, called the **primary root**, arises from a part of the seed called the **radicle**, and emerges when the seed **germinates** — when it emerges from its dormant state and begins to grow. As the roots develop, they form one of two types of root systems:

- A taproot system forms when the primary root grows directly down into the soil and becomes the main root, or **taproot**. Smaller roots, known as **secondary roots** or **lateral roots**, branch from the primary root. Most dicotyledons such as beans, carrots, and oak trees have taproots.
- A **fibrous root system** forms when the primary root is replaced by a number of roots, all of similar thickness. These roots look like a mass of fibers growing into the soil in all directions. Monocotyledons such as grasses and corn have fibrous roots.

The main functions of most roots are

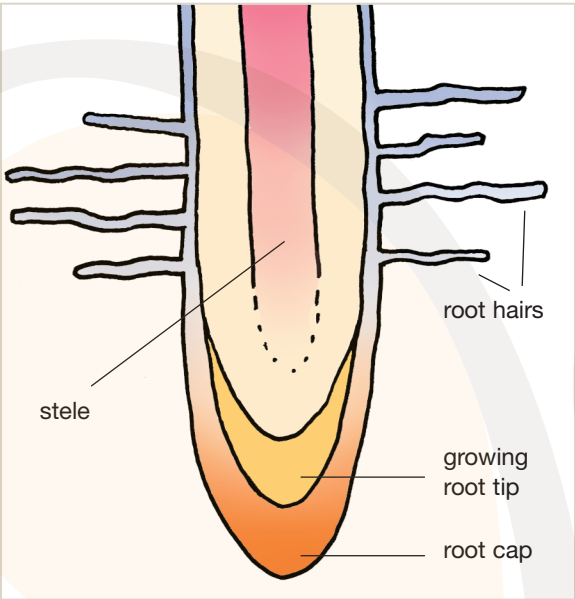
- to absorb water and dissolved nutrients from the soil.
- to transport water and dissolved nutrients to other parts of the plant.
- to anchor the plant so that it does not fall over.

The structure of a root is, like all things in nature, related to its function. This means roots must have a structure suitable for absorbing moisture and they must grow continuously. Through growing, roots not only anchor the increasingly heavy plant in more soil, but also reach new supplies of nutrients or moisture when the area surrounding them becomes dry or depleted of nutrients.

The part of the root associated with growth is the root tip, and this is covered and protected by the **root cap**, which is made of tiny cells that are constantly rubbed off and replaced as the root penetrates new areas of soil. Scientists have shown that, apart from protecting the root tip, these cells play an important role in causing roots to grow downward.

The parts of the root associated with absorbing water and dissolved nutrients are the **root hairs**, tiny hair-like outgrowths that grow from the outer surface of the root behind the root cap. Root hairs dramatically increase the surface area of the root, creating a large area for absorbing water and nutrients from the soil. Inside the root is a core of vascular tissue called the **stele**, that helps transport water and dissolved nutrients from the roots to other parts of the plant.

Structure of a Root Tip



Roots anchor plants in soil by growing between the soil particles and pressing outward. As the upper parts of the plant grow, the roots grow to compensate for the increasing height and weight of the plant. Roots do this effectively when the soil has structure and strength. They are less effective when the soil is waterlogged or sandy, which explains why trees in these types of soil can sometimes blow over in heavy winds. Even the roots of floating aquatic plants function to keep the plants upright by hanging downward, stabilizing the plants in the water, so the leaves face up toward the light.

In addition to anchoring plants and absorbing water and nutrients, some roots perform functions such as storing food and water, breathing, or adding extra support to the plant. Each of these functions is an adaptation, a development that helps organisms survive in the environment where they live.

Storage roots are modified for storing food or water, a modification that allows a plant such as a carrot or a beet to survive dormant periods. Storage roots may be one of three shapes:

- conical, or cone shaped e.g., carrots
- napiform, meaning they are broader than they are long e.g., turnip
- fusiform, meaning they are swollen in the middle and tapered at both ends e.g., white radishes

Tuberous roots are also storage roots, but unlike carrots and beets where the whole root is modified for storage, tuberous roots involve the swelling of only part of the root. Sweet potatoes are an example of a plant with a fibrous root system that produces tuberous storage roots. (Note: potatoes are modified stems, not roots, because potatoes produce buds.)

Breathing roots are produced by plants that grow in waterlogged soil where oxygen is scarce. For most plants, waterlogged soil is a serious problem that can kill them. Plants such as mangrove trees inhabit swampy areas and solve this problem by producing breathing roots called pneumatophores. Pneumatophores grow upward from the submerged roots and have pores that allow for gases to pass between the submerged roots and the atmosphere.

Many plants have aerial roots that rise above the ground, are either partly or fully exposed to the air, and which serve one of several purposes. Examples of plants with aerial roots include corn, orchids, trees in rainforests, and dodder, a yellowish

parasitic plant — a plant that grows on another plant and harms it. Dodder has thread-like stems that wind around crops such as alfalfa and potatoes.

Corn plants and palm trees grow tall and slender and may produce aerial roots called prop or stilt roots, which rise from the stem and grow down into the soil to help anchor and stabilize the plant. Large trees growing in rainforests, or any area where the soil is shallow, sometimes produce buttress roots, which are strong, woody, plank-like roots that provide extra support for the trees by functioning to make the base of the trees wider.

Orchids are epiphytic plants that grow on other plants, but do not obtain food, moisture, or nutrients from the host plants, and do not harm them. Epiphytes typically grow in humid areas and unbranched aerial roots grow down from the plant toward the ground. These aerial roots absorb moisture from the atmosphere and anchor the epiphyte to the host plant.

Like epiphytic plants, parasitic plants grow on other plants, but unlike epiphytes, parasitic plants harm the host plants. Parasitic plants produce structures called haustoria that penetrate the host plant and absorb food and moisture from the host. Although not all haustoria are roots, the haustoria of dodder are modified roots.

All aerial roots and most fibrous roots are known as adventitious roots, meaning they are roots that do not come from the primary root but, instead, come from stem tissue or sometimes from leaf tissue. The ability of many plants to grow roots from leaf and stem tissue is used by horticulturists, people involved in plant cultivation, to grow new plants from cuttings of existing plants.

Note to the Teacher – Preparing for Activity 1 and Experiment 1

Experiment 1 and Activity 1 use young plants that have been growing for 2 weeks prior to the activity date. Prepare the seedlings ahead of time as follows.

- For Experiment 1, plant two bean seeds and two corn seeds in a small container. Repeat with a second small container. The students will use these plants to demonstrate that roots absorb moisture from the soil.
- For Activity 1, plant one package of bean seeds in a seed tray containing good potting soil. Follow the instructions on the seed package, and ensure the seeds are planted far enough apart that their roots do not entwine. Repeat the process using a package of corn seeds. The students will compare the roots of the bean and corn plants.

ACTIVITY 2

Investigating Modified Roots

Purpose

To investigate modified roots and their functions.

Material

Examples of storage roots: radish, carrot, turnip, sweet potato.

Orchid with aerial roots.

Pictures of plants with prop roots and buttress roots.

Pictures of dodder, or a live specimen, if possible.

Labels: taproot system; fibrous root system; storage roots; conical root e.g., carrot; napiform root e.g., turnip; fusiform root e.g., radish; tuberous root e.g., sweet potato; prop roots; buttress roots; haustoria; epiphyte; aerial roots; pneumatophores.

Chart, Summary of root functions (see NAMC's CSM).

Chart, Summary of root types (see NAMC's CSM).

Whiteboard and marker.

Self-testing review sheet: Modified roots (see NAMC's CSM).

Books and pictures of plant roots.

Botany journals and pencils.

Presentation

- Most Montessori teachers present this concept in Year 5.
- Announce to the students that they will have the opportunity to explore various types of modified roots and the functions these roots perform for the plant.
- Review the three main functions of roots with the students.
- Explain that in addition to these functions, some roots are specially adapted to perform other functions, such as storing food and water, supporting the plant, helping other roots breathe, or even parasitizing other plants.

Part 1: Storage Roots

- Introduce the four storage roots, placing them on a table in front of the students. Arrange the roots so that all the taproots are placed together. Above the four roots, place the label, Storage roots.
- Discuss the three types of storage taproots: conical, fusiform, and napiform. Place the appropriate labels next to each specimen. Repeat with the tuberous root.
- Discuss why plants have storage roots and how humans use these roots.

Part 2: Roots with Special Functions

- Introduce the orchid and place it next to the storage roots. Explain the nature of epiphytic plants. Define and discuss aerial roots. Place the label Aerial Roots above the orchid, and the label Epiphyte, next to the orchid.
- Introduce, one at a time, the other examples of aerial roots.
- Discuss the functions of these roots and how they benefit plants. Place the appropriate label next to each specimen or photograph. Encourage the students to practice saying new words as they are introduced.
- On the whiteboard, write the term adventitious roots. Pronounce it clearly and invite the students to repeat it.
- Define and discuss the term, adventitious roots (roots that do not arise from the primary root) with the students. Ask the students to indicate examples of adventitious roots from the specimens and photographs on display.
- Demonstrate the chart, Summary of root types, and review with the students the terminology used to describe roots.
- Demonstrate the chart, Summary of root functions. Explain that this chart lists most of the functions that roots can perform for a plant. These include the three basic functions, as well as the specialized functions of modified roots.
- Leave the display of modified roots on the table and encourage the students to visit it over the next couple of days.
- Demonstrate the resource material and the self-testing review sheet on modified roots. Encourage the students to complete a review sheet.
- Ask the students to use their journals to write three illustrated paragraphs, each describing a different type of modified root and how it helps the plant survive.

Extensions

- Prepare edible storage roots to sample.
- Research one type of modified root such as buttress or pneumatophores.
- Find and prepare a soup using edible storage roots.