# MASTER 3.1

## WHAT DO YOU KNOW ABOUT ROOTS?

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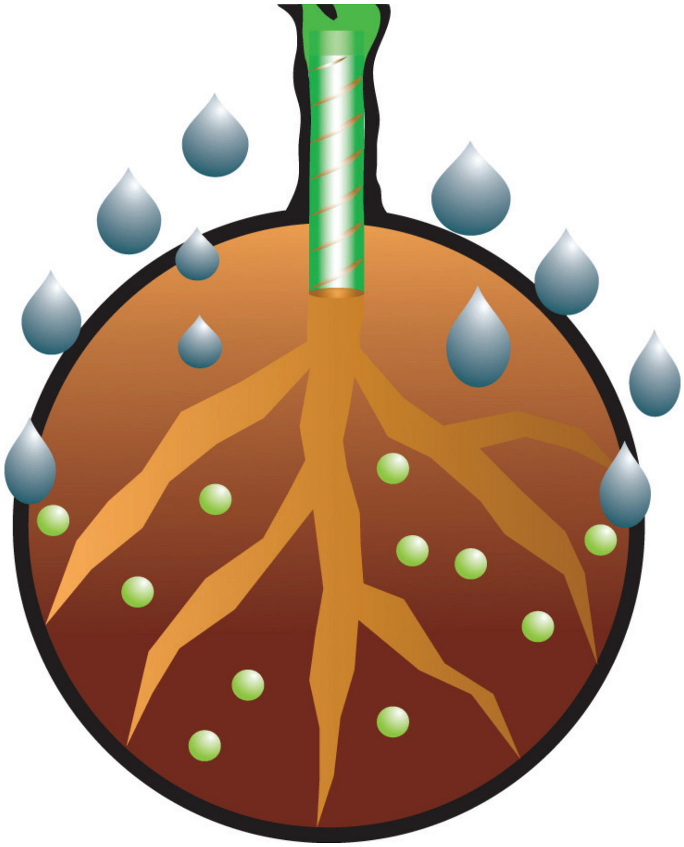

1. Plant roots have tiny hairs that absorb water.

2. Plant roots use energy to pump water into the plant.

3. Nutrients enter root cells through the process of Diffusion.

4. Nutrients enter root cells through the process of Active Transport.

5. Plant roots grow until they find water.

# MASTER 3.2

## MOVING WATER AND NUTRIENTS INTO ROOTS

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## PROCEDURE

**STEP 1** Fill the cup about 1/2 full of water.

**STEP 2** Place the cup of water into the center of the larger container.

**STEP 3** Fill the larger container with water until its level is the same as that in the cup.

**STEP 4** Add several drops of food coloring to the water in the larger container and gently mix the water until the color is evenly distributed through the water. Do not add food coloring to the water in the cup!

**STEP 5** Using a sharp pencil, poke 2 holes in the cup, opposite each other.

**STEP 6** Watch the water in the cup for 5 minutes and record your observations in the following space.

**OBSERVATIONS**

# MASTER 3.3

## EXPERIMENTS WITH ROOTS

NAME

DATE

## EXPERIMENT 1

Scientists measured the concentrations of various essential elements in the soil and inside the root hairs. They found that some essential elements had concentrations up to 100 times greater inside the root hairs as compared with the soil.

What process can move a substance against its concentration gradient?

## EXPERIMENT 2

The data from Experiment 1 caused the scientists to suspect that active transport was responsible for concentrating some essential elements in the root hairs. They next exposed the living roots to a chemical that stops the synthesis of ATP. Once again, they measured concentrations of essential elements in the soil and inside the root hairs.

What do you think they observed?

# MASTER 3.4

## THE PLANT VASCULAR SYSTEM

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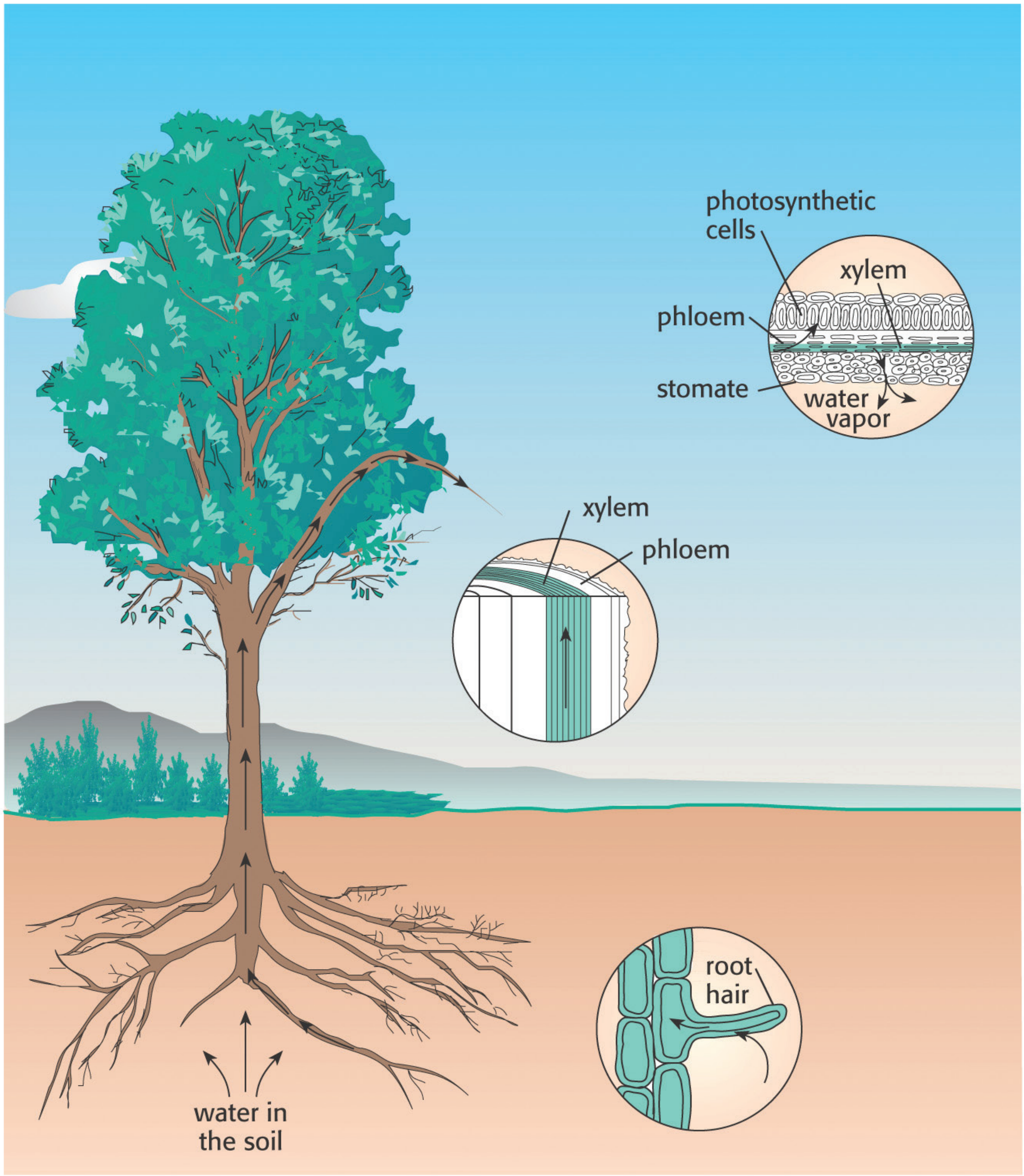


1. **XYLEM** transports water **up** from the roots.
2. **PHLOEM** transports sugars produced in the leaves during photosynthesis **down** the plant.

# MASTER 3.5
SOIL HORIZONS

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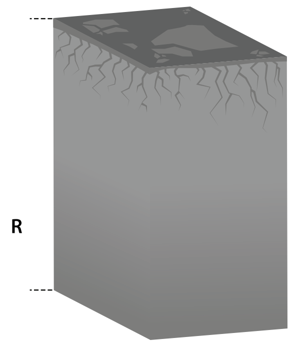
# MASTER 3.6

## WHERE DOES SOIL COME FROM?

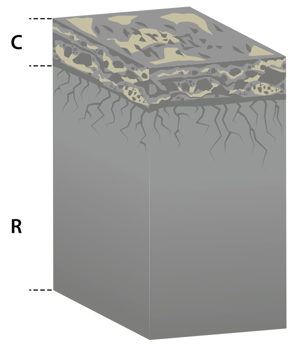
NAME

DATE

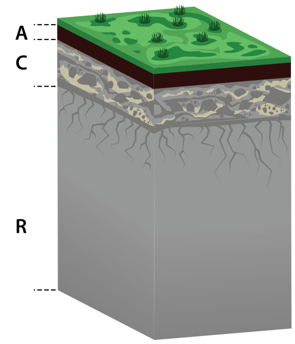
1 0 years




2 ~10 years




3 ~100 years

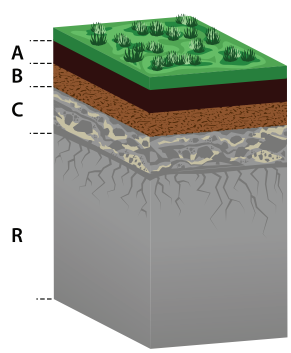



1

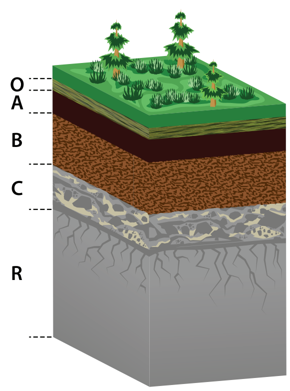
2

3

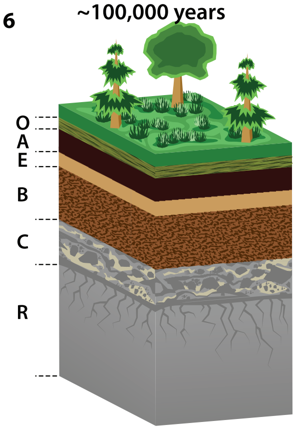
4 ~1,000 years




5 ~10,000 years




6 ~100,000 years

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5

6

# MASTER 3.7

## SOIL FORMATION

NAME

DATE

Why are there layers in soil? Why doesn't soil look the same throughout its depth? The answers to these questions relate to how soil forms. Soil layers are called soil horizons. Soil formation actually starts with the parent material. When the parent material is rock, it may also be called bedrock. In this example we assume soil forms from rock, but parent material can also be loose sediment deposited by a river. Over time, the top layers of the parent material (R) start to break down into smaller pieces called regolith. This layer of smaller rocks and gravel form the C layer. Very few plant roots penetrate into this layer; very little organic material is found in this layer.

As time continues, plants start to grow on the surface. The growth and then death of these plants start to add organic matter to the forming soil. This organic matter mixes with minerals to form the A layer. The A layer is usually the darkest layer of soil because of the organic matter it contains. The A layers also contain a great deal of organisms, particularly microorganisms, that can help break down dead plant and animal remains to release their minerals into the soil. The A layer is often referred to as topsoil.

As more time passes, the A horizon may continue to thicken as more organic material and minerals mix. A layer of organic material (O layer) may form above the A layer. The O horizon is made up of leaf litter and humus (decomposed organic matter with fewer minerals than in the A horizon). As the A and O horizons continue to form, the C layer continues to move downward.

The next layer to form is the B horizon—also called the subsoil. This layer often has a coarser structure and is more varied in color than other layers. The B horizon contains clay and mineral deposits (including iron oxides, aluminum oxides, and calcium carbonate). These minerals leach out of materials in the layers above into the water. The water then drips into the B horizon.

The E horizon forms between the A and B horizons. The leaching of minerals, including more highly colored minerals like iron, out of the A horizon materials into the water, and into the B horizon is particularly intense at the bottom of A horizon. The B layer can become darker and the bottom of the A horizon lighter, this light colored, highly leached horizon is the E layer. The E horizon is made up mostly of sand and silt and contains less organic matter than the A horizon.

The six main factors that interplay to form soil are:

- the type of parent material (bedrock or sediments),
- environmental conditions,
- terrain,
- living organisms,
- time, and
- human activities.

# MASTER 3.7

## SOIL FORMATION

| NAME |
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Because these factors differ across the world and develop at different times, the characteristics of soil can be different in different places. Any given soil may have all, none, or a few of these horizons.

**PARENT MATERIAL:** The parent rock or sediment is important for ultimately determining whether the soil is sandy, loamy, or high in clay. The nature of the parent material also influences the length of time it takes to form soil. It can take hundreds of years just to form one centimeter of soil if the parent material is very hard. If it is not as hard, soils can form more quickly.

**ENVIRONMENTAL CONDITIONS:** Temperature and amount of water (rainfall) are important influences on the formation of soil. Higher temperatures increase the rate at which the parent material breaks down. This also increases the rate at which nutrients are released into the soil. The freezing and thawing of water can also help break down the parent materials. Greater amounts of water carry nutrients deeper into the soil. Soils tend to be deeper in hotter, wetter environments (such as the tropics) and shallower in colder environments (such as the Arctic).

**TERRAIN:** The soil on steep slopes is generally shallower than in the valleys below or on the plains. The soil that does develop on hills or mountains often is carried downhill into the land below.

**LIVING ORGANISMS:** Living plants and microorganisms that decompose dead vegetation can release acids that act to break down the rock on which the soil is forming. The decaying plant (and animal) remains contribute nutrients to the soil. Animals like earthworms make channels through the soil that can help roots grow and water and nutrients move. Other organisms, especially microbial decomposers, play important roles in the recycling of organic matter and the release of nutrients into the soil.

**TIME:** Soils can be millions of years old in some areas of the world. In other areas, soils may be much younger. Geologic events, such as earthquakes, may disrupt the environment and cause soil formation to begin anew in the affected area.

**HUMAN INFLUENCES:** Farmers have cultivated and tended their soils for centuries, and farmed soils differ in many respects to those that have not been disturbed. Agricultural practices such as plowing and fertilizer use can change the topsoil (A horizon). In other areas, human practices have led to soil erosion that changes the soil horizons.

# MASTER 3.8

## DISRUPTING THE SOIL HORIZONS: THE DUST BOWL

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## THE DUST BOWL

During the late 1800s, an unusual amount of rain fell on the Great Plains. This led farmers and agricultural experts to overestimate how much rainfall the region could expect. This unusually wet period caused more people to settle in the area and begin farming. Starting at the beginning of the twentieth century, a large wave of European settlers came to the Great Plains to farm. As demand for wheat increased, farmers sought to increase their profits by cultivating more and more land. The United States government encouraged more farming in the Great Plains. Homesteaders in western Nebraska were granted 640 acres of land to farm. Farmers elsewhere in the Great Plains were granted 320 acres.

The Russian Revolution and World War I caused crop prices to rise. Farmers began to use mechanized farming to plow fields and harvest crops over an ever-expanding area. For example, in eastern New Mexico and northwestern Texas, the area of farmland doubled between 1900 and 1920. It tripled again between 1925 and 1930. Agricultural experts recommended that farmers use drought-resistant strains of wheat and practice so-called “deep plowing.” As the name suggests, in deep plowing the land is plowed to a greater depth than usual. It is designed to help the roots of grain crops use moisture in the topsoil more efficiently.

In the 1920s and early 1930s, most farmers plowed their fields right after the previous harvest. Deep plowing removed the native grasses that grew in the fields before the farmers began farming. This left the soil unprotected for months until the next planting. When the weather was wet, this method of farming worked well. However, in 1930 an extended drought began that caused crops to fail. The dry soil was plowed into fine particles that were easily blown away by the near-constant wind.

High winds carried massive amounts of topsoil eastward. Throughout the 1930s, the area including the Texas and Oklahoma panhandles plus parts of New Mexico, Colorado, and Kansas experienced a series of huge dust storms. Some of these storms blew dust all the way to Chicago and eventually Cleveland, Buffalo, Boston, and New York City. During the winter of 1934–1935, snow fell in New England that was red because of the dust it contained.

Such large dust storms could be deadly. People who were caught outside during a severe dust storm ran the risk of being suffocated by breathing in large amounts of dust. However, most of the damage to human health was caused by living in the presence of dust for extended periods. The dust found its way into the homes, clothing, and lungs of the people living in the affected areas. Many people suffered from what became known as “dust pneumonia.” Dust that settled in the lungs caused inflammation and produced symptoms such as fever, chest pain, difficulty breathing, and coughing. Young children and the elderly were especially vulnerable to dust pneumonia. It has been estimated that hundreds of people died from it.

Starting in 1930, the country began its decade-long economic struggle known as the Great Depression. This near economic collapse combined with the overproduction of wheat and severe drought hit farmers in the Great Plains like a perfect storm. Prices for wheat crashed. Many farmers could not pay their bills and had their mortgages foreclosed by the banks. Many people became homeless and left the area to look for work. Many farms were abandoned and the barren land was subject to erosion by high winds.

# MASTER 3.9

FARMING PRACTICES

NAME

DATE

## FARMING PRACTICES

The cruel lesson of the Dust Bowl is that topsoil is a precious resource that must be protected. Some of the challenges associated with maintaining healthy soils include nutrient depletion, erosion, and water runoff. Different farming practices have been developed to address these challenges.

For each farming practice described below, write down which challenge(s) the practice is designed to address. Be sure to include an explanation of your reasoning.

## CROP ROTATION

Long ago, farmers discovered that growing the same crop in the same field year after year led to unhealthy plants and decreased crop growth. To address this problem, farmers use crop rotation. They plant crops with different nutrient requirements one after the other in the same field. The aim is to strike a balance so that not all of the crops are depleting any given nutrient in the soil.

## STRIP FARMING

This practice involves dividing the field into parallel, long, narrow strips. The strips are organized so that they are perpendicular to the prevailing winds. Every other strip is planted with seed while the strips in between are left unplanted.

## CONTOUR FARMING

Contour farming involves plowing a field along its elevation lines. This means that the ruts formed by the plow run perpendicular to the slopes. The furrows form level curves around the field. This keeps rain from running rapidly downhill, causing erosion.

# MASTER 3.10

DUST STUDY

NAME

DATE

## ARE SOIL HORIZONS STILL IN DANGER?

The amount of dust blown across the landscape has increased over the last 17 years in large swaths of the West, according to a study led by the University of Colorado, Boulder.

For the new study, the research team set out to determine if they could use calcium deposition as a proxy for dust measurements. Calcium can make its way into the atmosphere—before falling back to Earth along with precipitation—through a number of avenues, including coal-fired power plants, forest fires, ocean spray, and, key to this study, wind erosion of soils.

The amount of calcium dissolved in precipitation has long been measured by the National Atmospheric Deposition Program (NADP), which began recording the chemicals dissolved in precipitation in the late 1970s to better understand the phenomenon of acid rain.

Brahney and her colleagues reviewed calcium deposition data from 175 NADP sites across the United States between 1994 and 2010, and they found that calcium deposition had increased at 116 of them. The sites with the greatest increases were clustered in the Northwest, the Midwest, and the Intermountain West, with Colorado, Wyoming, and Utah seeing especially large increases.

Other areas of the world are more affected by dust movement than is the US. For example, satellite images have tracked large amounts of dust moving all the way from Africa to South America.


**REFERENCES**

Brahney, J, Ballantyne, A P., Sievers, C., and Neff,, J. C. (2013). Increasing Ca2+ deposition in the western US: The role of mineral aerosols. Aeolian Research, 10, 77–87.

Amount of dust blown across the West is increasing, says CU-Boulder study. (June 10, 2013). Retrieved from http://www.colorado.edu/news/releases/2013/06/10/amount-dust-blown-across-west-increasing-says-cu-boulder-study