# PULL MY ROOTS

Plant Science

*This grab and go lesson will focus on how gravity impacts a plant's growth.*

**Grade Level**
3rd - 5th Grades

**Lesson Length**
90-120 Minutes

**STEM Careers**
- Gardener/Horticulturist
- NASA Scientist
- Plant Scientist
- Ag Technician

**Life Skills**
- Critical Thinking
- Decision Making
- Planning/Organizing

**Related Activities**
- Seed Dissection

**Learn More**
- Visit Raising Nebraska *raisingnebraska.unl.edu*
- Visit Hastings Museum *hastingsmuseum.org*

**Virtual Fun**
- http://solar-center.stanford.edu/activities/

## LEARNING OBJECTIVES

By the end of the lesson, students should be able to:
- Become familiar with the basic needs of a plant
- Determine how a plant grows in response to light

## EDUCATIONAL STANDARDS SUPPORTED

- NE 5.3.1.b Identify how parts of plants and animals function to meet basic needs (e.g., leg of an insect helps an insect move, root of a plant helps the plant obtain water)
- NGSS 4-LS1-1 Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

## MATERIALS LIST

- Fibrous root (corn, grasses, marigolds) systems & Tap root system (soybeans, radish, parsley, dandelion)
- Clear CD/DVD case (a plastic sheet cover may be used)
- Paperclips (if using a plastic sheet cover)
- Paper towels
- Bean seeds or other quickly sprouting seeds (radish, tomato, etc.)
- Water
- Spray bottle
- Marker
- Dark Area
- Root Dissection Lab Report (end of lesson)
- Plant Science Investigation Journal (end of lesson)
- Modeling clay (or something to hold the CD/DVD case vertical)
- Rulers
- Optional: String
- Optional: Protractor

## PREPARATION

- Grow plants with a fibrous and tap root system (or purchase) enough of both kind for youth to work in groups of 4
- Soak bean seeds in water 24 hours prior to the lesson

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# DO

## INTRODUCTION

Plants are able to sense the environment around them and respond accordingly. In fact, they are in constant motion as they develop, search for light and nutrients and reproduce. Plants have mechanisms that determine up from down to produce shoots and roots in the correct orientation and also have mechanisms to measure time to know when to produce flowers at the right time of the year, become seasonally dormant and even determine night from day. Light is an important environmental cue to which plants are especially sensitive. Different levels of light will stimulate dramatic differences in growth pattern, leaf size and shape.

Plants move through tropisms which are vital to plants' survival. In general, tropisms involve cell elongation on one side of a plant, causing the plant to grow in a particular direction.

**Geotropism**

Roots respond to the direction of gravity by growing downward (example of geotropism). Roots growing downward is called positive geotropism and stems growing upward against gravity is called negative geotropism. Plant roots will also grow toward water, displaying hydrotropism.

**Gravity and Earth**

Gravity can happen between any two objects that have mass. The reason it seems like gravity on Earth holds you down is because the Earth has a larger mass and therefore has a much stronger pull. Your gravitational pull is much too weak to fight the Earth in any way. The Earth's pull on the moon is what keeps the moon orbiting the Earth. The sun's pull on Earth is what keeps the Earth in orbit.

Without gravity, we likely would not be able to live on Earth. We have just the right give and take to stay warm without burning up and to have fresh water.

## OPENING QUESTIONS

- What is the function of plant roots?
- How does a root know to grow downward?
- Can you plant a seed upside down?
- What happens to a seed planted in space?

Today we are going to be a plant scientist and explore how plant roots function in order to better understand the biology of plants. You will also be deciding if gravity impacts a plant's growth. Let's get started……

**Fun Fact**

Seeds can sense gravity and will always grow up.

**Did You Know?**

Isaac Newton was the first to truly study gravity in the 1680s. His theory stated that gravity is a force that acts on all matter on Earth. He also noted that the matter's mass and distance played a role in how gravity effected that object.

**Fun Fact**

Geotropism comes from the word "geo" which means earth or ground and "tropism" which means a plant movement triggered by a stimulus.

**Gravity Information**

Things that effect gravity are the size of the objects involved and the distance between the two objects. More mass means more gravitational pull. The further away the two objects are, the less of a pull they have with each other.

## ACTIVITY 1: ROOTS UP CLOSE

Three main functions of roots is to: anchor the plant, provide support for the plant and absorb water and nutrients. Some roots also store sugar and starch, which provide food for the plant. Roots are the first part to emerge from a seed.

As plant scientists, let's compare and contrast two plant root systems. (Be sure to have each root labeled in some way to tell them apart; consider putting them in cups labeled 1 & 2, but don't tell the youth what the plants are or anything about the roots.)

Working in small groups, have them complete the Root Dissection Lab Report. After youth have had time to explore, have them report to the group.

Discuss with youth how they came to their conclusion. Key points to cover could include:

- Tap roots are difficult to transplant because of their large "main root". They can be difficult to pull out of the ground since the shoot system is securely anchored to the tap root. Tap roots grow deeper than fibrous roots. Examples include dandelions, carrots, radishes, beets, alfalfa and soybeans.
- Fibrous roots don't really have a "central root." If there is it is hard to find because of all the roots around it are the same size. These roots branch out in all directions and can form a tangled mass. Examples of fibrous root plants are grasses, corn, onions and some flowers such as a marigold.

Discuss with youth that the roots of a plant will grow down in the soil to find water and nutrients while the stem will always grow up to find sunlight so the plant can produce its own food through photosynthesis.

### Vocabulary

**Tap Root** – consists of a main root that goes straight down

**Fibrous Roots** – Branch out in all directions

Tropism – growth of a plant toward or away from a stimulus

**Geotropism** or **gravitropism** –the directional growth of an organism in response to gravity (shoots grow upwards & roots grow downwards in response to gravity)

**Auxins**- plant hormones that in high concentrations stimulate growth and elongation of cells in stems, while slowing growth of root cells.

**Mass** - the quantity of matter in a body regardless of its volume or of any forces acting on it

**Weight** – Measurement of the gravitational force acting on an object

## ACTIVITY 2: IT'S ALL ABOUT THE SEED

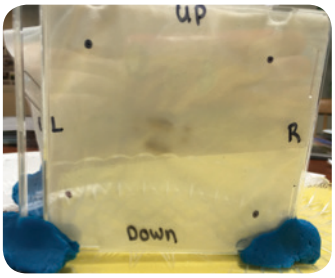
Watch the following video from NASA as a way to introduce this activity:

**https://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/How_Plants_Grow_in_Space.html**

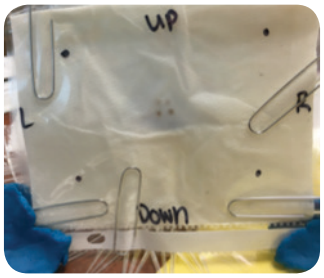
*Note: Depending on the size of your class and the amount of supplies available, consider having students work with a partner or the teacher can demonstrate this and involve youth with the process.*

1. Place a paper towel inside the CD/DVD case.
2. Spray the paper towel with water until damp (not dry or dripping wet)

3. Place 3-4 seeds in the middle of the CD/DVD case and close. Be sure the seeds are evenly spaced. (If you are using a sheet protector, follow the same procedure, but close it with paperclips to keep it moist.)
4. Label the case as follows: up, down, right, left and put dots in-between each of those words to form a "circle." See picture below.



Seeds in a CD/DVD Case



Seeds Using a Sheet Protector

5. Place the CD/DVDs in a dark area (with "up" being at the top). You will want the case setting vertical, not flat. So, taping them to a door, closet wall or placing the cases in a hanging pocket organizer. You can use modeling clay for the CD/DVD case in a container.

**Variation to activity:**
You can add two more tests to this activity by preparing the seeds in the case as described above, but placing the case as follows:

- Place another case/sheet protector lying horizontally. (These roots cannot grow in the direction of gravity.)
- Place another case/sheet protector upright (with "up" being at the top), as you did in the first one, with "up" on the top. You will rotate these seeds every 2 days to see how this changes the direction of root growth.

6. Observe the seed daily. Use a spray bottle to keep the seed moist
7. Have students identify the root and the stem of the plant. Which way is each part growing?

**Day 1** - Mark on the case with a marker where the root & stem are at. Have the student measure how much the root & stem has grown. What ways can the measurement be taken? (The root will not grow straight) Record their measurement in the Plant Investigation Journal.

**Day 2** – Observe & record root and stem growth. (If doing the variation: Turn the case 90 degrees.)

**Day 3** – Observe & record root and stem growth. Did it change directions? Yes or No. Why did it change direction? At what angle is the root growing now compared to prior day growth?

### Fun Fact
The very end of the root is called the **root cap**. The root cap makes the roots turn downward as they grow. Thus the root cap is essential for geotropism because it contains the cell called statoliths or "sensor" cells. Statoliths always settle to the lowest part of the root cap in response to the pull of gravity. This makes the cell expand faster in a downward direction.

### Tip for Root Measurement
Measure and record the length of the root growth for each seedling daily.

If the root is straight, use a ruler.

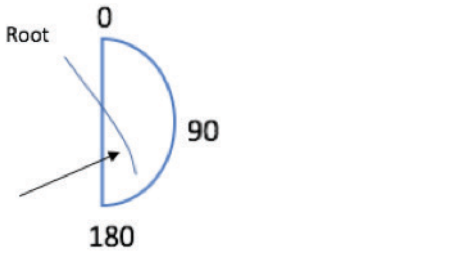
If the root is curly, cut a tip of string and cut the string at the root tip and measure the length of the string.

You could measure the angle of growth daily with a protractor. Use the direction directly toward the bottom edge, "down" as 0 degrees; to the left as 90 degrees; directly up as 180 degrees and to the right as 270 degrees.

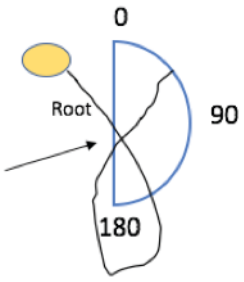
**Day 4** – Observe & record root and stem growth. (If doing the variation: Turn the case 90 degrees.)

**Day 5** – Observe & record root and stem growth.

*Depending on time allowed, or results, you can repeat this activity for more days.*




Measure from after the turn to the tip of the root




If your root wraps around, measure at the tip and follow the root until it begins to turn and is no longer straight. Measure the angle from the beginning of the turn to the tip of the root.

Once the students have all of their data and measurements recorded, use the data to discuss the following:

- Did the seedlings grow faster when growing in the direction of gravity vs. growing horizontally?
- How quickly did the growing root tips respond to the change in the direction of gravity?
- If a stem formed on your experiment, which direction did it grow?
- Based on your observations, does gravity affect the direction of root growth? If so, how?
- How would light impact this experiment?

**How does a root "know" which way is down?**
Statoliths in the root cap cell tend to settle on the bottom side of the cell which stimulates the release of auxins.

In a root placed horizontally, the bottom side contains more auxin than the top side. This makes the bottom side grow less than the top side, causing the root to bend in the direction of the force of gravity.

In a shoot placed horizontally, the bottom side contains more auxin than the top side. This makes the bottom side grow more than the top side, causing the shoot to bend and grow against the force of gravity.

**Did You Know?**
Roots will change direction when a plant is tipped on its side. Roots will also change direction when they face a dense object such as a stone. Concentrations of auxin will accumulate on the lower side of the roots which allows the roots to change direction and find a way around the rock or object so that normal growth can resume.

**Fun Fact**
NASA scientists have experimented with a variety of plants to determine how they react to different types of lighting, carbon dioxide levels and temperature. In fact, people who live and work in space can use plants as a reliable source of oxygen, carbon dioxide removal and water purification!

## ACTIVITY 3: WHAT HAPPENS IN ZERO GRAVITY?

We experience gravitational pull every day on Earth. Does a plant grow differently when there is no gravitational pull? Can we run a study in the classroom with zero gravity?

NASA conducted experiments on the International Space Station to record and observe how seeds germinated and grow in little to no gravity.

There are videos available on the NASA website (link below) that can be shared with students to show what happens in zero gravity.

**https://ww.nasa.gov/audience/foreducators/topnav/materials/listbytype/Evaluating_Experimental_Treatment.html**

**Extension**
Check out more studies that NASA is doing with plants in space at https://www.nasa.gov/.

# REFLECT

What are the functions of plant roots?

- Anchor the plant, provide support for the plant and absorb water and nutrients. Some roots also store sugar and starch, which provide food for the plant.

What happens when the seedling is twisted 90 degrees?

- The root changes direction so it is pointing downward again.

How did the roots grow with zero gravity?

- The plants grew in all directions. The roots did not always grow downward.

What influences plant roots to grow downward?

- Gravity is the main influence. In the root cap, the statoliths (sensor cells) always are pulled to the lowest part of the root cap due to gravity.

# APPLY

Now that you have successfully observed how a plant root grows. You are on track to being a great plant scientist – someone who studies plants or even an NASA scientist who studies plant interactions in space!

Can you plant a seed upside down?

- No matter how a seed is placed into the ground, the roots will always go downward and the stems upwards.

How do you think we can grow plants in zero gravity on the international space station?

What are the benefits of having plants on space? Why is it important?

- Provide nutritious food for astronauts as well as some comfort, both physically and psychologically

Who depends on plant research?

- NASA Astronauts, farmers, landscaping professionals, golf course managers, and all of us. Remember if you eat, it was impacted by plants!

What are other careers that relate to planting seeds other than what we have discussed?

- Plant breeder, geneticist, nursery, soil scientist, agronomist, pathologist, entomologist, etc

**References**

Vogt, G. M. (2012). BioEd Online. (J. P. Denk, Ed.) Retrieved May 10, 2017, from Science Teacher Resources from Baylor College of Medicine: http://bioedonline.org/tasks/render/file/index.cfm?fileID=115007AC-B089-42B4-090919576D3F8680

NASA website at https://www.nasa.gov/

**We want to hear from you!**

Let us know what you thought of the lesson or send us a picture of youth participating in the lesson.

**#NE4HSTEM #ECLIPSE2017**

# ROOT DISSECTION LAB REPORT

Pull My Roots

NAME

DATE

**Plant Scientist:** Your role in the lab is to report on the two different root systems. You may draw your observations, measure the length of the roots and describe what you see. Finally, based on your observations and any data you might have obtained, determine what type of root systems you have.

## Plant Root System #1

Sketch the Roots

Length of the Roots

Root Description

Conclusion: Fibrous or Tap Root?

Pros/Cons of This Type

## Plant Root System #2

Sketch the Roots

Length of the Roots

Root Description

Conclusion: Fibrous or Tap Root?

Pros/Cons of This Type



Extension is a Division of the Institute of Agriculture and Natural Resources at the University of Nebraska-Lincoln cooperating with the Counties and the United States Department of Agriculture.
The 4-H Youth Development program abides with the nondiscrimination policies of the University of Nebraska-Lincoln and the United States Department of Agriculture.

# PLANT SCIENCE INVESTIGATION JOURNAL

Pull My Roots

NAME

DATE



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