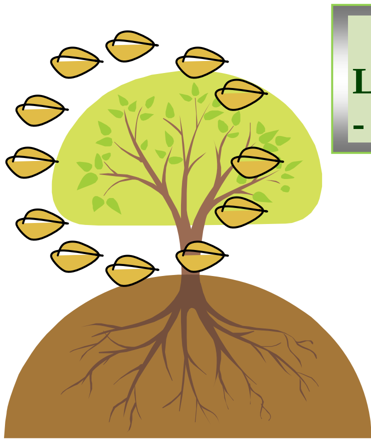

Lesson Title: Roots to the Center of the Earth - Geotropism!

Grade: 4-6

Duration of Lesson:
1 introductory 50 minute class.
10 days (10 minutes each day)
1 – 50 minute final class period

Materials:

- Paper towels
- Wheat berries (also called wheat seeds, these can be purchased at your local health food store)
- Empty CD "jewel" cases, one for each student

- Permanent marker
- Plastic napkin holder or binder clips 
- Shallow pie plates or container for water
- Clock (non-digital)
- Rulers
- Journals

Key Terms

- Germination
- Roots
- Gravity
- Geotropism
- Viable
- Counterclockwise

Standards/ Objectives

Montana State Standards:

Science: Content Standard 1. Students, through the inquiry process, demonstrate the ability to design, conduct, evaluate, and communicate results and reasonable conclusions of scientific investigations. **Content Standard 2 -** Students, through the inquiry process, demonstrate knowledge of properties, forms, changes and interactions of physical and chemical systems. **Content Standard 3 -** Students, through the inquiry process, demonstrate knowledge of characteristics, structures and function of living things, the process and diversity of life, and how living organisms interact with each other and their environment.

Math: Content Standard 1.5 Length, Time, and Temperature: Select and apply appropriate standard units and tools to measure length, time, and temperature within relevant scientific and cultural situations, including those of Montana American Indians.

Content Standard 3.4 Linear Measurement: Estimate and measure linear attributes of objects in metric units such as centimeters and meters and customary units such as inch, foot, and yard.

Understanding(s) /Big Ideas: Students will understand understanding gravity's influence on root formation. Students will glean information on germination success.	**Essential Question(s):** Does gravity determine if roots grow downward or upward? Does every planted seed germinate?
Students will know: One of the key parameters that every plant must respond to is the direction of gravity: roots go down (in the same direction as the force of gravity) and stems go up (opposite to the pull of gravity).	**Students will be able to:** Perform an inquiry based science experiment about the effects of gravity on seeds. Students will be able to assess germination rates.

Performance / Observations

Performance Task(s): Students will use the image of a clock to determine a pattern and seed spacing in the jewel case. Students will rotate the jewel case to inquire about the pattern of root growth based upon gravity and observe root growth patterns.	**Other Evidence:** Students will determine the germination success of seeds through math and observation.

Learning / Inquiry Activities

Introduction for Instructor:

Roots have four primary functions:

- Anchorage - roots permeate the soil to locate water and minerals. In doing so, they anchor the plant in one place for its entire life unless disturbed.
- Storage - roots store large amounts of energy.
- Absorption - roots absorb large amounts of water and dissolved minerals from the soil.
- Conduction - roots transport water and dissolved nutrients to and from the shoot. The

roots of plants even transport carbon dioxide for photosynthesis.

Geotropism (also called *gravitropism*) *is the directional growth of an organism in response to gravity*. Roots display positive geotropism when they grow downward, while shoots display negative geotropism when they grow upward. Among the first scientists to study geotropism was Charles Darwin.

Geotropism provides several benefits that help plants to survive. Plants draw water from the soil with their roots and synthesize sugar from sunlight, water and carbon dioxide in their leaves, meaning that roots must grow underground and leaves must have access to sunlight.

Geotropism exerts dramatic effects on plants. You may take a walk outside and see if you can find any plants that have a fallen stem that is still connected to the plant, if so you will see that the plant sends leaf shoots upwards toward the sun instead of down into the ground, and some plants actually grow roots on the underside of the stems.

Learning Activities:

In this exercise we will be working with wheat berries or wheat seed. High quality wheat is grown in Montana, and is Montana's #1 agriculture commodity. Read the *Story of Wheat* to familiarize students with the parts of the wheat seed, wheat growth cycle, and uses of wheat. If you do not have a copy, the book is located at the following link:

http://wbc.agr.mt.gov/consumers/Teachers_students/StoryofwheatMT2006.pdf

Pre-assessment:

Ask student to think about the direction that roots grow, in most cases do they grow down into the soil? Why do roots grow into the soil? What is it that roots need from the soil? The food that we eat is all connected to plants, and roots are often the part of the plant that we eat. Ask students to give examples of the roots that we eat. Is the part of the wheat plant that we eat a root? If not, why is wheat roots important? Let students know that they will be doing an experiment to see what they can point out about root growth, and why they might grow into the soil.

Hands on activities:

Next inform students that they are going to force roots to grow in the shape of a square or rectangle without touching the roots, they are simply going to alter the roots direction with gravity. Students may work in teams or individually on this project. Have students journal the steps of the inquiry and the outcome.

1. Hand out jewel cases and paper towels to the students. Students will be cutting the paper towels down to fit into the jewel cases, use two layers of paper towels or blotter paper. Moisten the paper towels before placing them in the jewel cases.

2. Hand out 12 wheat berries to each student/group (you may also hand out 4 other small seeds such as radishes for use at the center of the case. Radishes will sprout sooner than wheat).

3. Ask students to carefully examine wheat berries, if any of them look damaged (partial seed) ask them to replace it with one that is whole. Ask students to remember the illustration of the wheat seed in the *Story of Wheat*.

4. Ask student to think of the inside center ring of the jewel case as a clock, and to place one wheat berry at each of the hours on the clock.

5. Ask students to place any other seed varieties that you have chosen evenly near the center of the jewel case.

6. With the case lying flat on the table, take a permanent marker and write # 1 at the 12:00 spot on outside of the jewel case and draw an arrow pointing up at the #1. Inform students that they are not marking time places on the clock, they are numbering the jewel case for a turning sequence. (Illustration of finished box below).

7. Write # 2 at the 3:00 spot and draw a horizontal arrow pointing to the #2 spot.

8. Write # 3 at the 6:00 spot and draw an arrow pointing down at the #3 spot.

9. Ask students what number would come next in this sequence and at what time on the clock? (It would be #4 at the 9:00 time spot).

10. Close the lid and make sure it snaps in place. Write the date on the top of the jewel case. Set the jewel cases erect in a tray of water so that the water level is <u>just above the bottom of the jewel case</u>, the #1 should be at the top. If your cd cases slip down, set them in a napkin holder and place the napkin holder in the water tray. The seeds need to stay moist, and the paper towel will wick water from the tray. If you do not have a napkin holder or another means of keeping the case upright, you can use the binder clips as feet on the case for holding them upright in a tray of water.

Water Tray

11. Carefully watch the jewel cases over the next few days. Wheat seeds sprout in 3-5 days. Inform students that it is time to measure the wheat roots when the roots are ½ inch long. Ask students to measure in both standard and metric measurements and to sketch this step and all others in their journals. Ask the students where the gravitational force is, and to infer if gravity might be determining the direction roots grow? Have them turn the case counterclockwise so that the #2 is on the top. Ask the question: where is the gravitational pull now, has the direction of the gravitational pull changed from the first position, what direction do the students estimate that the root will grow? Journal the predictions.

12. Repeat the steps until the roots have grown ½ inch in this position, and then turn the case counterclockwise so the #3 spot is on top. After the roots have grown ½ inch turn the case counterclockwise so the #4 spot is on top until roots have grown ½ inch. What is the final outcome? Ask students to sketch the shape of the root growth, why is the root not growing in a straight line? Ask students to journal how they would explain the root growth.

Take a moment to look at other seed factors that can be examined from this experiment. We can calculate the percentage of seeds that were viable. To do this we need to count the number of seeds that were planted to begin with, if you did not add any other seeds the number would be 12. If 10 of those sprouted (were viable) what is the percentage that was viable?

For elementary students graph the data.

For middle school students calculate data.

$$\frac{10}{12} = .83 \text{ or } 83\%$$

Notes:

The key idea of this experiment is to understand the unique relationship between roots and the pull of gravity. Ask students in what direction the roots always grew? (Towards the bottom of the case). Why? How is root growth connected to gravity?

The secondary idea is to determine how many seeds were viable. If you have instructed students to grow other varieties of seeds use the process above and test viability for those varieties as well.

Notes:

Extension for advanced students:

Ask students to germinate seeds and spell their name with the roots using block letters.

And…

http://www.sciencebuddies.org/science-fair-projects/project_ideas/PlantBio_p034.shtml