



# Kansas Corn: Roots and Shoots: Which Way is Up?



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# Kansas Corn: Roots and Shoots - Which Way is Up?

## Grade Level: Middle School

### Overview

Many students have previous experience germinating seeds, but in my experience, few have thought much about how plants grow in the correct orientation. How do plants send roots into the soil and shoots up to gather light? This activity is designed for students to propose and design experiments as well as identify the stimulus that plants rely on to determine which way is up.

### Kansas College and Career Ready Standards

- **MS-LS1-5.** Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

### Learning Objectives

- Students will propose testable hypotheses to explain a phenomenon.
- Students will design investigations and test their hypotheses.
- Students will analyze the results of their investigations and evaluate their hypotheses.
- Students will explain gravitropism as a mechanism plants use to orient their growth while under the soil.

### Materials

- Untreated corn seeds that will germinate
- Potting soil
- Various containers for planting seeds
- Turntable
- 9-in. pie tin
- Light source (regular fluorescent bulbs work fine)
- Water
- Heat source (optional)

### Safety Considerations

While this lab doesn't typically pose significant risk, all lab safety procedures should be followed. Teachers will need to use judgment in allowing students to follow their own proposed experimental procedures.

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### Procedures for Instruction

Establish that plants can orient themselves vertically during germination. This can be done by watching the time-lapse video ([https://www.youtube.com/watch?v=LmTY\\_VrxGLA](https://www.youtube.com/watch?v=LmTY_VrxGLA)) or by experiment repeating the set up shown in the video.

### *Length of Time for Preparation*

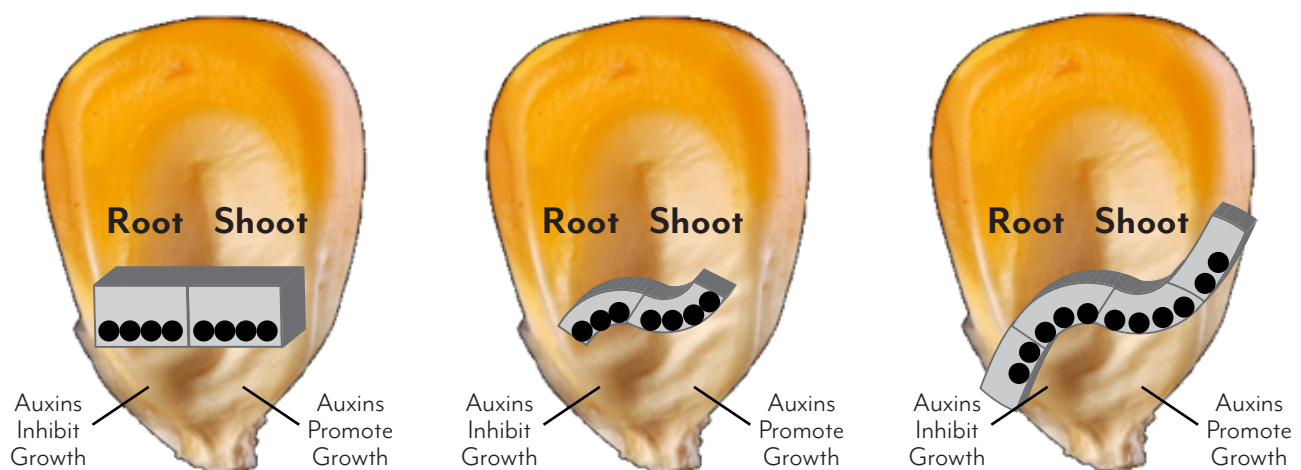
Students will prepare their own experiments. Providing requested materials will be the only preparation needed.

### *Length of Time for Classroom Teaching*

Two to three class periods to allow students to develop ideas and set up experiments to test their hypothesis. Observations will require approximately 2 weeks for plants to germinate and see results.

### Background Information

Gravitropism is the mechanism that plants use to determine which way is up. This enables a seed to push its leaf-producing shoots up out of the soil and send its water-seeking roots down into the soil. The mechanism is driven by plant hormones called auxins. Gravity causes these molecules to settle in the bottom of cells, which make contact with the cell wall. The auxins cause the cell wall on the bottom side of a shoot to grow or elongate. This growth bends the cell in the upward direction. The auxins have the opposite effect on the root side. That is, they prohibit the bottom side of the cell wall from growing. The top of the cell wall grows at a normal rate, bending the cell in the downward direction.



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### Classroom Discussion

Introduce the topic and assess students for prior understanding. Let students discuss their ideas and guide the discussion without telling them if they are right or wrong.

- Ask students to describe previous experience with germination, this could be growing plants in the garden, in a previous science class, or raising crops.
- Have students describe the environment of the seed when it is planted in the soil.
- Ask students if they have ever seen a plant growing upside down, sending roots into the sky.
- Ask them to propose several hypotheses to explain how plants know which way is up so they can send roots down into the soil and green shoots up toward the sun. If they have trouble, have them close their eyes and explain how they can determine their orientation. Some possible explanations that students should provide are:
  - Light penetrating the soil,
  - Temperature difference,
  - Gravity, and
  - Other explanations are possible.

### Procedure for Lab

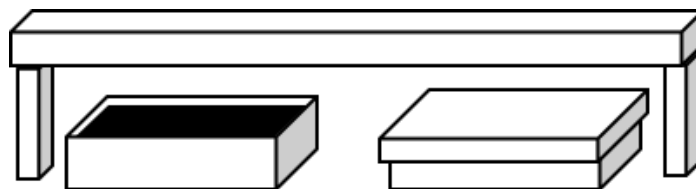
- Assign or let students choose one hypothesis to test, making sure that all hypotheses are tested.
- When seeds have germinated and results collected, have each group present results and conclusions to the class.

### *Hypothesis #1*

Shoots grow toward light penetrating the soil.

Set up 1:

1. Plant two identical groups of corn plants.
2. Cover one group with aluminum foil so no light can enter from above.
3. Place the other under a grow light.
4. Water plants regularly and observe for signs of plant growth.



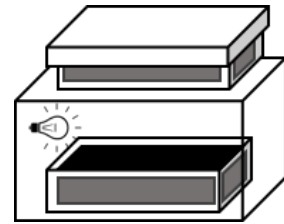
**Prediction:** If the light indicates which direction the plants should grow, then the plants grown in the dark will not grow the same direction as those placed under the light.

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Set up 2:

1. Plant two identical groups of corn plants in transparent glass bowl or pan.
2. Place about 1.5 in. of soil in the bowls and plant the seeds  $\frac{3}{4}$  in. deep. They should be an equal distance from the top and bottom of the soil.
3. Cover one group with aluminum foil so no light can enter from above.
4. Place it above a light source so that the light hits the soil under the plant.
5. Place the other under the same light source.
6. Water plants regularly and observe for signs of plant growth.



**Prediction:** If the light indicates which direction the plants should grow, then the plants grown above the light should grow upside down while those under will grow normally.

### *Hypothesis #2*

The plants will grow toward the side that senses the warming from the sun.

Set up 1:

1. Plant two identical groups of corn plants in transparent glass bowls.
2. Place about 1.5 in. of soil in the bowls and plant the seeds  $\frac{3}{4}$  in. deep. They should be an equal distance from the top and bottom of the soil.
3. Cover one group with aluminum foil so no light can enter from above.
4. Place it above a heat lamp so that it heats the soil under the plant.
5. Place the other under the heat lamp source.
6. Water plants regularly and observe for signs of plant growth.

Set up 2:

1. Plant two identical groups of corn plants.
2. Place both under a grow light.
3. Put an under tank reptile heater under one group.
4. Water plants regularly and observe for signs of plant growth.

**Prediction:** If the heat indicates which direction the plants should grow, then the plants grown above the heat source should grow upside down while those under will grow normally.

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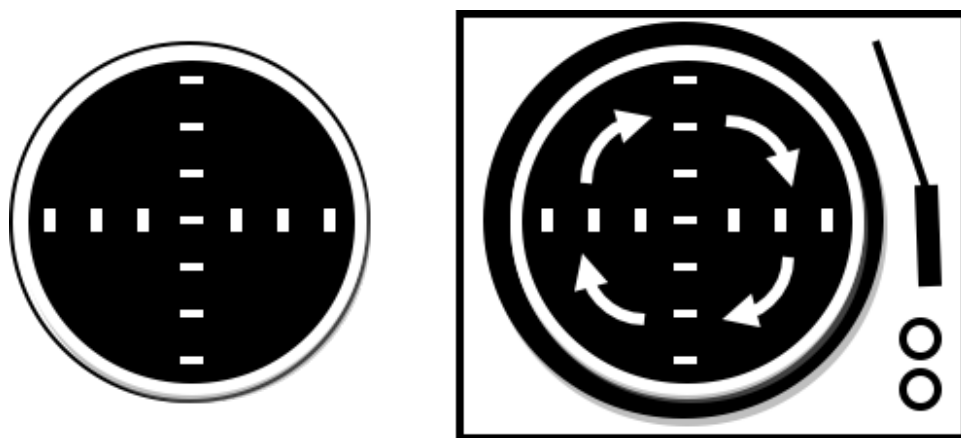
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### *Hypothesis #3*

The corn plant responds to gravity, sending roots toward the force and shoots up away from the force.

Set up:

1. Fill two 9-in. pie tins with potting soil.
2. Plant corn plants in a cross pattern across each tin.
3. Place one tin on a turntable under a grow light and turn the table to 75 RPM.
4. Place the other tin at the same level under the light.
5. Water plants regularly and observe for signs of plant growth.



**Prediction:** If the gravity signals which direction the plants should grow, then the plants grown on the turntable should lean toward the center while those not spinning will grow normally.

### Teacher Resources

There are many other setups that students may come up with to test these variables. They may also come up with other possible variables to test.

### Lab Analysis

Have groups develop a presentation of their experiment including the results and conclusions. They should clearly state if their results support their hypothesis or if it should be rejected based on their results.

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### Reflection and Conclusion

Have groups present these, then try to develop a consensus among the class as to the explanation of how plants determine which way is up.

### Assessment

Have students research tropisms in plants and make a presentation explaining which form was used by the corn plants and how it works.

### Science and Agriculture Careers

To learn more about agriculture careers visit [www.agexplorer.com](http://www.agexplorer.com). You can also find career profiles at [www.kscorn.com](http://www.kscorn.com).

### Sources

- Plants For Kids: Bringing the Science of Plants to the Classroom (<http://herbarium.desu.edu/pfk/page8/page9/page9.html>)
- Paul Adams, Ph.D., Dean of Education, Fort Hays State University

Any educator electing to perform demonstrations is expected to follow *NSTA Minimum Safety Practices and Regulations for Demonstrations, Experiments, and Workshops*, which are available at <http://static.nsta.org/pdfs/MinimumSafetyPracticesAndRegulations.pdf>, as well as all school policies and rules and all state and federal laws, regulations, codes and professional standards. Educators are under a duty of care to make laboratories and demonstrations in and out of the classroom as safe as possible. If in doubt, do not perform the demonstrations.