SIEMENS STEM DAY | Science Technology Engineering Math

SIEMENS STEM DAY ACTIVITY

I DON'T NEED YOU SOIL

1 HOUR OVER 15 DAY GROWING PERIOD

REAL-WORLD SCIENCE TOPICS

- An explanation of hydroponic farming and the impact it has on food production in regions with limited space for production.
- An exploration of how plants, especially plant cuttings from food scraps, can be "recycled" and used to grow more plants rather than being thrown away.

ADDRESSES NGSS

LEVEL OF DIFFICULTY

1

GRADE RANGE

3–5

OVERVIEW

In this activity, students learn that plants acquire their material for growth chiefly from air and water rather than from soil. Students learn about hydroponic gardening and how plants do not necessarily need soil to grow. During this activity students conduct an experimental investigation to determine if plants grow best using only sunlight and water, or if soil somehow plays a positive role in their growth and development.

TOPIC

Matter and Energy Flow in Plants Real-World Science Topics

OBJECTIVE

After completing this activity, students will be able to explain that plants primarily get the materials needed to grow from the air and water. They will be able to recognize that in addition to these essential nutrients from the water and air, plants also need anchoring/support as well as certain types of mineral nutrients typically provided by the soil for long-term survival. They will see that there are alternative methods growers can use to support/anchor plants and provide plants with these mineral nutrients. Students will have an understanding of hydroponics and its advantages.

NGSS THREE-DIMENSIONS

Science and Engineering Practices	Disciplinary Core Idea	Crosscutting Concepts
Engaging in Argument from Evidence Engaging in argument from evidence in 3–5 builds on K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s). Support an argument with evidence, data, or a model. (5-LS1-1)	**LS1.C: Organization for Matter and Energy Flow in Organisms** Plants acquire their material for growth chiefly from air and water. (5-LS1-1) **LS2.B: Cycles of Matter and Energy Transfer in Ecosystems** Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. Organisms obtain gases, and water, from the environment, and release waste matter (gas, liquid, or solid) back into the environment. (5-LS2-1)	**Energy and Matter** Matter is transported into, out of, and within systems. (5-LS1-1) Systems and System Models A system can be described in terms of its components and their interactions. (5-LS2-1 **Patterns** Patterns of change can be used to make predictions. (3-LS1-1)

BACKGROUND INFORMATION

Where do plants chiefly get the materials/matter needed for growth?

Plants primarily get the matter they need for growth and development from air and water. Water and carbon dioxide from the air provide plant with three essential nutrients: carbon (C), hydrogen (H), and oxygen (O). During the process of photosynthesis, water and carbon dioxide are converted into organic matter known as sugar or starches using energy from the sun. This organic matter, often called food, is the chief source of matter and energy needed for growth. It is important to understand that plants need other supplemental materials, often referred to as mineral nutrients, to orchestrate a variety of physiological functions including growth. These mineral nutrients are taken into the plant through the roots.

How can plants grow without soil?

Soil is a mixture of minerals, organic matter, gases, liquids, and a variety of organisms that together have the ability to support plant life. Other than the 3 primary nutrients (C, H & O) needed for growth, plants need about 13 nutrients known as mineral nutrients. For most plants, these mineral nutrients come from the soil. These nutrients are dissolved in the water moisture found in soil and are absorbed through a plant's roots. However, a plant can grow in the absence of soil as long as these nutrients are supplemented in other ways. For example, a plant can grow in a simple solution of water mixed with various nutrients. Products that provide these mineral nutrients are often called fertilizers. Because a plants primary source of matter needed for growth comes from air and water, they can survive for short periods of time in the absence of these mineral nutrients. However, for long-term, sustained life, a plant must take in mineral nutrients through their root system.

What is hydroponics?

The word hydroponics comes from two Greek words 'hydro' meaning water and 'ponos' meaning labor. It is a method of growing plants in a liquid solution enriched with nutrients rather than in soil. In this method, artificial media such

as clay, coir, perlite, vermiculite, brick shards, polystyrene packing peanuts, and wood fiber may or may not be used as a support or anchor for the plant. Hydroponic systems can either be liquid or aggregate. Liquid systems have no supporting medium for the plant roots; whereas, aggregate systems have a solid medium of support. Hydroponics has been recognized as a viable method of producing both vegetables and ornamental crops.

What are the advantages and disadvantages of hydroponic gardening?

Hydroponics may be used in underdeveloped countries or heavily populated regions for food production in limited space with little access to soil. Growing hydroponically is also useful in areas with poor soil conditions, such as deserts. Below, is a more extensive list of advantages and disadvantages of growing hydroponically.

Advantages:

- It can be used in places where in-ground agriculture or gardening is not possible (for example, dry desert areas or cold climate regions).
- More complete control of nutrient content, pH and growing environment.
- Lower water and nutrient costs associated with water and nutrient recycling.
- Faster growth due to more available oxygen in root area.
- Elimination or reduction of soil related insects, fungi and bacteria.
- Much higher crop yields.
- No weeding or cultivation required.
- Some crops, such as lettuce and strawberries, can be lifted from ground level to a much better height for planting, cultivation and harvesting. This gives improved working conditions and hence lowers labor costs.
- Crop rotation/fallowing is not necessary.
- Transplant shock is reduced.

Disadvantages

- Initial and operational costs are higher than soil culture.
- Skill and knowledge are needed to operate properly.
- Some diseases can spread quickly through the system.

KEY VOCABULARY

Cutting—a piece of the stem or root cut from a plant that can be placed in a medium such as moist soil, potting mix, or nutrient rich water; the cutting produces new roots, stems, or both, and thus becomes a new plant independent of the parent

Hydroponics—a method of growing plants using a nutrient rich water solution instead of a traditional dirt/soil medium

Essential nutrients—these nutrients include carbon (C), hydrogen (H), and oxygen (O); these 3 elements are needed for plants to make sugar/starch (food) during the process of photosynthesis; plants get these from water and atmospheric carbon dioxide

Mineral nutrients—the additional 13 nutrients (other than the 3 essential nutrients) needed by plants to carry out a variety of physiological functions; typically taken in by roots from soil

Roots—functions as an organ of absorption, aeration, and food storage and as a means of anchorage and support

Soil—is the mixture of minerals, organic matter, gases, liquids, and the variety of organisms that together support plant life

MATERIALS NEEDED FOR ACTIVITY

- Chart paper
- Marker for chart paper
- Materials per group of 3 or 4:
    - 5 green onions
    - 5 clear plastic or glass cups
    - Petroleum jelly (ex: Vaseline)
    - Scissors
    - Potting mix soil (enough to fill one cup)
    - Marker
    - Marbles
    - Water
- 1 to 3 celery bundles
- Knife
- 1 to 3 clear containers large enough to fit a celery bundle
- Windowsill or other light source

TEACHER PREPARATION

Day 1

- 2 to 3 weeks prior to beginning this lesson, cut the top 2/3 off of a bundle of celery. Place the bottom 1/3 in a container. Add enough water to cover the bottom 2 or 3cm of the bundle. Place in windowsill or other well lit area and water as needed. You may choose to grow 2 or 3 cuttings to make sure at least one grows well.
- (**Alternative:** In step 2, images can be used in place of showing an actual cutting regrowing.)
- At the top of 2 large sheets of chart paper, write, “I Think Animals Need…” and “I Think Plants Need…”
- Make copies of the *What Is It You Need?* Handout (1 per group of 3 or 4)
- Gather materials for groups to complete their *What Is It You Need?* investigation
- If soil/potting mix is dried out, add water and mix until moist throughout.

Day 15

- Locate and bookmark several images of hydroponic gardens by doing a web search for “hydroponic garden” or “hydroponic farming”.
  Possible sites to reference for images:

  http:/ www.gardening.cornell.edu/factsheets/growflow/images/flowlitl.jpg
  http:/ www.uky.edu/Ag/NewCrops/introsheets/hydrolettuce.pdf
  http:/ edis.ifas.ufl.edu/LyraEDISServlet?command=getImageDetail&image_soid=FIGURE%201&document_soid=HS184&document_version=37708

http:/ edis.ifas.ufl.edu/LyraEDISServlet?command=getImageDetail&image_soid=FIGURE%209&document_soid=HS184&document_version=37708

- If you do not know a lot about hydroponic gardening/farming, make sure you have read the background section on hydroponics and reviewed the advantages and disadvantages.

Day 1

1. **Warm-up Activity:** Display the prepared "*I Think Animals Need*…" and "*I Think Plants Need*…" graphic organizers on chart paper for students to clearly see. Lead a discussion with students about what living things need to grow and develop. Ask:

   Have you ever planted a seed and watched it grow and develop into a large plant?
   What things do you think a plant MUST have to grow and develop?
   Do you think there are things that help a plant grow and develop but are not absolutely necessary?
   What is different about what humans need for growth and development as opposed to plants?

   As students share their thoughts, compile a list on each of the graphic organizers.

   After they share ideas, tell the students they are going to do an investigation to determine if the list they came up with is accurate. Leave the chart paper hanging for students to reference throughout the lesson. It will be revisited at the end of the lesson.

2. Show students a full bundle of celery with the leafy portion still attached. Cut the top 3/4 of the celery stalks bundle off and hold up what is left of bottom portion of the bundle as well as a few stalks. Ask students if they think any of these pieces of celery will regrow and why or why not. Give students an opportunity to discuss.

   Explain to students that plants can grow from a seed but that they can also grow from what are called cuttings. Show them the celery cutting you have been regrowing for several weeks. Before showing, be sure to remove the celery from the water it has been growing in as you do not want to reveal to them at this point that plants can grow in only water rather than soil.

   (Alternate Method: If you have not had time to regrow celery cuttings to display, a picture of one can be easily found online. Again, at this point it is important that you find a picture that does not show the celery growing in only water.)

3. Next, refer back to the "*I Think Animals Need*…" and *"I Think Plants Need*…" charts. Discuss with students that just like humans have to get certain materials from food, water and air to grow and develop, plants must also acquire certain material for growth. Tell students that they will set up an experiment to answer the following question.

   Where do plants acquire the material they need for growth?

4. Give each student group a *What Is It You Need?* Handout. Ask students to complete the prediction portion of the handout as a group. You may want to select a few groups to share out their predictions.

   Provide students with access to the materials listed on the handout and ask them to study the data table and the instruction section of the handout and proceed with setting up their experiments. Notice that there are some instructions provided but not so many that the students do not have to think through their design process. Move around the room and facilitate the set up process and clarify as needed.

Important Setup Notes:

Make sure…

- there is enough water in the marbles to at least reach the roots.
- students do not over water the plant growing in the soil, as there are not holes to drain the excess water; soil should not be completely water saturated. You may choose to have students place a few holes in the bottom of that cup and explain that in this cup they just want soil that is nice and moist with water rather than saturated completely.
- the petroleum jelly is coating the entire stalk of the plant so no air exchange can happen on the surface of the plant.
- plants get watered every 1 to 3 days.
- any new growth that happens on the petroleum jelly covered onion should get coated with additional petroleum jelly.
- the soil that you provide for use is nice and moist. If it is dried out, add water and mix until it is moist throughout.

5. After students have set up their experiment, ask them to answer the questions under the "Instructions" section of their handout. Once students have had a chance to discuss the questions, have a whole group discussion about each question. At this point, it is important that you do not answer the questions for them. Allow them to find their answers from the experiment. Students should take measurements and record data every 5 days for 15 days.

Day 15

6. After 15 days and the last data recording, continue with the lesson. Have students use their data to answer the conclusion questions at the end of their handout. Remind them that all conclusions *must* be supported with data/evidence from their experiment.

   (6th Grade Extension: Before students answer the questions, have them construct a line graph depicting the change in growth over time. Their line graph should include 5 data lines, a title, a key, and labels on the X and Y axis.)

7. Allow several students the opportunity to share their conclusions supported by data. Make sure to clarify any misconceptions or undeveloped concepts about where plants get materials for growth. Some main points to discuss include:

   - The materials that plants need to grow primarily come from water and air rather than soil. These materials are called essential nutrients.
   - For higher grade levels, explain that the essential nutrients that plants get from water and carbon dioxide (CO_2) in the air are carbon (C), hydrogen (H), and oxygen (O).
   - Soil is important in providing plants with mineral nutrients (similar to what we think of as vitamins for humans) and supporting the plant so that is it able to "stand up" and grow toward the light. Explain that mineral nutrients are important in growth and helping the plant function to it fullest potential, but that they are not the primary source of material needed for growing larger.
   - If a plant cannot get water or air they will quickly die.

- Plants do not get material or matter from the sun, but they do need the sun's energy to convert materials from water and the air into "food". This means the 3 main things plant must have for growth and development are: water, air (gases), and sun, however, they also need mineral nutrients and structural support as well.

Revisit the "*I Think Plants Need*…" charts that was constructed in the Warm-up Activity. Ask students if they would like to modify the list based on their investigation.

8. **Wrap-up Activity:** Prompt student discussion by saying, "Plants need structural support and micronutrients to survive and thrive long term. They typically get these two things from the soil. Do you think there are other ways plants could get these two things if soil was not available for use?

   Allow students to share their thoughts. Use this discussion as a lead into explaining hydroponic gardening. To help support your explanation and give students a visual of what these gardens look like, show a few images of these types of gardens that you already bookmarked. (As a reminder, a simple web search of "hydroponic gardens" will provide you with numerous images to choose from, but it is a good idea to bookmark these images before the class period begins.) Make sure students understand that the water that is used in hydroponic farming and gardening has a special blend of micronutrients added to it. Also, be sure to point out that there must be some sort of material used to hold the plants in place and provide structural support. Use the images to point out these different types of materials.

   Ask students if they can think of any advantages or disadvantages of soil-less gardening. Allow a few students to share ideas. Conclude by explaining a few of the advantages and disadvantages of hydroponic gardens.

EXTENSION ACTIVITY

Challenge students to regrow leftover vegetable cuttings at home with the goal being to regrow a usable product for cooking. Explain that they should use scraps from meal preparation and try to regrow the plant enough to use it again. Some suggested scraps to try regrowing might include: celery, onions, potatoes, lettuce, pineapple, garlic, or ginger. You may want to point out that starting the growing process in water and a good light source is a great way to stimulate root growth in some plants. After roots have begun growing, they may want to transfer them to soil.

Have students document the growth of their scraps in pictures, videos, journals, etc. Designate one day a week as a "garden share" day, and invite students to email you photos and videos of their gardens. Some suggested scraps to try regrowing might include: celery, onions, potatoes, lettuce, pineapple, garlic, or ginger.

SOURCES

http://pods.dasnr.okstate.edu/docushare/dsweb/Get/Document-6839/HLA-6442web
http://12.000.scripts.mit.edu/mission2014/solutions/hydroponics
https://www.ncagr.gov/agronomi/pdffiles/essnutr.pdf

WHAT IS IT YOU NEED?

INVESTIGATION QUESTIONS

Where do plants acquire the materials they need for growth?

PREDICTIONS

I think that plants acquire the materials they need for growth from _____

_____.

I believe this is true because _____

_____.

MATERIALS

- 5 green onion stalks
- Scissors
- Water
- Soil
- 5 clear plastic cups
- Petroleum jelly
- Marbles
- Markers

EXPERIMENT

	Experiemental Setup	Height (centimeters)			
		Beginning	5 days	10 days	15 days
Control	Plant in no water				
Test 1	Plant in water only				
Test 2	Plant in soil with water added				
Test 3	Plant in marbles with water added				
Test 4	Plant in water only but with petroleum jelly covering all of the plant except the root area				

WHAT IS IT YOU NEED?

Instructions:

1. Cut the top part of the green onions off leaving only about 7 or 8cm of the onion (bottom part).
2. Use the materials listed to set up the control and the 4 test plants.
3. Once all plants are set up and labeled, place the plants in a windowsill or under a light source. Make sure they are all in the same location with equal amounts of light.
4. Discuss as a group the answer to the following questions:

   Why is it important to have a control in the experiment?

   What do you think the petroleum jelly is preventing?

   Which plant do you expect to grow the most? Why?

   Which plant do you expect to grow the least? Why?

   Why is it important that plants go under a light source?

   Why is it important that plants go under the same light source all with equal light?

Data Collection:

Make sure to add water to plants every couple of days. Take measurements of your plants at Day 5, Day 10, and Day 15. Record measurements in the data table.

Analysis and Conclusion:

After 15 days of recording data, analyze your results and answer the following questions: Which plant grew the most?

Must a plant have soil to grow? What data supports this?

Does soil contribute to the plant growing better? What data supports this?

Of the 4 test plants, which grew the least? Why did this happen?

Fill in the blanks:

Based on your experiment, the materials that a plant needs for growth mostly come from_____

and_____. The nutrients and the structural support that the_____
provides is helpful in the long-term growth process, but is not the primary contributor of the materials needed

for growth.