Grade Level: Seventh

Piagetian Level: Concrete/Formal

Learners at the concrete operations stage of development with emerging formal operations are suited for this activity.

STEM *Science, Technology, Engineering, & Mathematics*

Learn & Grow Educational Series℠

Energy Transference in Plants

Instructional Goals: Following instruction and participation in the learning activities, students will explain how light energy is used by plants to create glucose and oxygen from water and carbon dioxide in an endothermic reaction; they will further explain that this endothermic reaction is a product of photosynthesis and results in the creation of food energy from light energy that is used to help the plant grow and is then passed into the food chain when plants are consumed by animals.

Lines of Inquiry:

- *How do plants convert energy from sunlight into food energy for their own growth?*
- *What is an endothermic reaction?*
- *How do plants use the process of endothermic reaction during photosynthesis?*
- *What do plants do with the oxygen created during photosynthesis and why is this important to human life?*
- *What do plants do with the glucose created during photosynthesis and why is this important to human life?*
- *What happens to baby plants when they are deprived of light during their early development?*

Materials:

Assignment 1 -

- *Research & reference tools & materials*
- *Tools & materials to produce the assigned work product, whether it is a written report, PowerPoint® presentation, video, poster, or some other method of demonstrating mastery of the instructed concepts*

Assignment 2 -

- *Tools & materials for building out one self-watering container per student (see http://learn-and-grow.org for instructions & materials)*
- *Organic potting soil with compost or fertilizer mixed into it—enough for each container*
- *Enough green bean seeds to provide each student with 5 each for his/her self-watering container*
- *Water for each self-watering container's reservoir*
- *Two clear plastic disposable drinking cups per student*
- *Two dark-colored, non-transparent disposable drinking cups per student*
- *One standard metric school ruler (ruled in centimeters) per student*
- *One data collection sheet & pen/pencil per student*
- *Colored pencils (4 different colors) per student*

Common Core Standards:

- RST.6-8.1: Cite specific textual evidence to support analysis of science and technical texts.
- RST.6-8.2: Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or operations.
- RST.6-8.7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).
- RI.8.8: Trace and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient to support the claims.
- WHST.6-8.1: Write arguments to support claims with clear reasons and relevant evidence.
- WHST.6-8-2: Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.
- WHST.6-8.9: Draw evidence from informational texts to support analysis, reflection, and research.
- SL.8.5: Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.

CA State Standards—Science:

- MS-LS1-6: Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.
- MS-LS1-7: Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.
- MS-LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
- MS-LS2-3: Develop a model to describe the cycling of water and flow of energy among living and nonliving parts of an ecosystem.
- MS-LS2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

Grade: Seventh Piagetian Level: Concrete/Formal

Energy Transference in Plants, continued...

Instructions:

Start by having students read the following passage in their hand-outs:

Energy from sunlight is necessary for plants to grow. You may already know that, but do you really understand *why*? The process of photosynthesis transforms energy from one type to another, which is actually pretty amazing when you think about it. How can plants turn sunlight into food for their own bodies?

Here's how they do it: inside the leaves and stems of most plants are cells that contain little *organelles* called *chloroplasts*. Organelles are the "guts" of cells, like our internal organs are our "guts." Inside the chloroplasts is a substance that is produced by the plant called *chlorophyll*.

Chlorophyll is a chemical that traps the energy of the sunlight and uses it in a process called an *endothermic reaction* to break apart water and carbon dioxide molecules. An endothermic reaction is a chemical reaction in which heat is driven inwards towards where the reaction is happening rather than outward. (A chemical reaction in which heat is expelled outward is called an *exothermic reaction*.)

The plant drinks in water through its roots and inhales carbon dioxide from the air around it, which is how plants have those materials on hand for the endothermic reaction of photosynthesis. When the light energy from the sun gets trapped in the chlorophyll along with the water and carbon dioxide, it triggers the endothermic chemical reaction.

Animals, including people, breathe *in* oxygen and breathe *out* carbon dioxide. Plants need breathing animals to help create carbon dioxide for them to use during photosynthesis.

The inward build-up of heat caused by trapping the light energy in the chlorophyll and forcing an endothermic reaction to occur is necessary in order for the water molecules to break down. Once they've been broken down, their hydrogen atoms come together with the carbon dioxide molecules to form glucose as one product and unattached oxygen atoms as another product.

The plant doesn't need the oxygen for anything, so it exhales it back out into the atmosphere through its leaves. This is how all the plants in the world together make the oxygen we breathe; it's another very important reason besides food as to why we need plants so much. This also goes to show just how inter-dependent plants and animals are on each other to support life on this planet. They make what *we* breathe and we make what *they* breathe.

The remaining product of photosynthesis is glucose, which is a simple sugar. Sugar is stored energy, or food energy, that helps living things grow. Plants use glucose and the energy it stores to grow new cells, which allows plants to grow bigger, produce more leaves, produce flowers, and, ultimately, fruit. This is much the same way people's bodies absorb the nutrients of the foods they've eaten so their bodies can grow new cells when they need them, such as in developing children and healing wounds.

Plants capture the energy from the sun in the first place; whatever eats them then captures the energy within its own body that is then used to nourish it, whether it is a caterpillar, a deer, or a human. Even a piece of beef includes food energy captured from the sun; grains, hay, and the green grasses of the fields are all sources of energy that were originally captured from light by plants. When a person eats beef, the energy that transferred from the plants to the cow then transfers from the cow to the person.

This is how energy from the sun is captured by and transferred throughout a food chain. Without this process, people would have no way to capture the energy of the sun into their own bodies to grow new cells and they would have no source of oxygen to breathe.

Assignment 1:

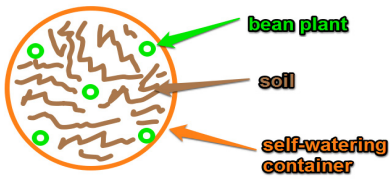
1. *Have your students research and create a diagram (digital illustration, poster, drawing, etc.) of the cycle of energy transference used on photosynthesis (see http://www.kidsdiscover.com/infographics/infographic-photosynthesis-for-kid/ for a good example).*
2. *With their classmates, have your students share their respective illustrations and discuss as a group how access to sunlight or the lack thereof may affect the growth of the plants in your class' self-watering container garden based on what they understand about photosynthesis after reading the above passage. Ask your students about energy transfer in plants, with questions such as:*
   a. *If light energy is necessary to provide a plant with glucose for food that it can use to fuel the growth of its body, how much growth can be expected of a plant that gets little light compared to a plant that gets full sunlight?*
   b. *If a plant gets enough light energy but not enough water, can it still engage in photosynthesis? How can self-watering containers help with photosynthesis?*

Energy Transference in Plants, continued…

Assignment 2:

1. *Have students build out a self-watering container garden (see http://learn-and-grow.org for instructions and a materials list), building one self-watering container per student. Each student will care for the same container for the remainder of this experiment.*
2. *Have them fill the upper chambers of their containers with soil and the reservoirs with water.*
3. *Give each student 5 green bean seeds and have them plant them one inch deep in the soil of their containers at four points equally distant from each other close to the outer edge of the container and one in the center. For this experiment, only four plants are needed, but a fifth seed is suggested in case one of the others does not sprout.*

Top-Down View of Green Bean Seed Placement



4. *Once they have covered their planted seeds loosely with soil, have the students lightly dampen the soil from the top to start germination and ensure that the wicking action from lower down in the bucket percolates up to the planted seeds. Have students place their containers in the area designated for their garden and clean up.*
5. *After 2 days, have the students begin checking their plants daily to see when they sprout and monitor their growth. Once the plants have deployed their first set of leaves, have each student place clear plastic cups over two of the plants and dark, non-transparent cups over two of the other plants in his/her container. The clear cups should be marked "1" and "2," as should the dark cups (see data sheet for clarification). Each cup should cover the same spot, even after seedlings appear for the purpose of accurate data collection.*
6. *Once seedlings begin to appear, have students take data daily (or when class meets, if on a block schedule) on how tall each seedling is over a period of three weeks. If any of the plants become too tall for the cups during that time, the cups can be removed, but the date the plants become too tall and the cups are removed should be indicated on the data sheet.*
7. *At the end of three weeks, have students graph their data on their data sheets and describe in a paragraph the quantitative and qualitative differences between the plants grown under the clear cups and the plants grown under the dark cups.*
8. *Have your students remove all the cups from their containers and allow their plants to grow on their own for the next week without being moved or rearranged.*
9. *Next, have your students rotate their containers so that the leaves are facing in the opposite direction from where they were facing before. Take pictures of each student with his/her rotated container.*
10. *Have your students leave the containers unmoved or rotated for the next week. Return with your students and again take individual pictures of each student with his/her container.*
11. *Collect the images and create a slide show that puts each image of each student and his/her container at the time of the rotation and one week later side-by side on a single slide that shows how the leaves on the bean plants reoriented to the sun after being moved.*
12. *Show everybody's pre- and post- comparison slides in class and then discuss what changes everyone observed in the pre- and post- photos. Ask your students questions such as:*
    - *How much energy do you think it takes for plants to move their bodies towards the light? If it takes more energy to reorient themselves to the light than just standing in place, what does that tell us about how important sunlight is to plants?*
    - *What makes the leaves on green bean plants a lot like solar panels? How do the three individual leaves in the 3-leaf configuration work together to create a broad surface area for light collection?*
13. *Have your students tend their garden until harvest and pick the green beans once they have reached maturity. Your class should have already decided at this point what will become of your picked green beans, whether they go to the school cafeteria, go home with the students, or are made part of a dish served during a class party.*
14. *Green bean plants, depending on the variety, may produce one round of beans and die, though you can keep them producing a little longer so long as you keep picking the beans as they come in and it remains warm enough outside. Once your bean plants have died, have your students pull them up and put them into a composter. Have your students stir fresh compost or fertilizer into the soil in their containers and re-use them for another self-watering container gardening activity.*

Where possible, children should be encouraged to eat the fruits and vegetables they grow in order to make the cognitive connections between growing food, where food comes from, how food provides fuel to the human body, and how healthy foods make a difference in how the mind and body feel and work. This also gives them a sense of empowerment and control over their environments that encourages their intrinsic motivation to eat healthy foods.

Learn & Grow Educational Series℠

KPS4Parents™ Knowledge Powers Solutions for Parents

Grade: Seventh Piagetian Level: Concrete/Formal

Energy Transference in Plants - Assignment 1 & 2 Student Instruction & Data Sheet

Introduction:

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Chlorophyll is a chemical that traps the energy of the sunlight and uses it in a process called an *endothermic reaction* to break apart water and carbon dioxide molecules. An endothermic reaction is a chemical reaction in which heat is driven inwards towards where the reaction is happening rather than outward. (A chemical reaction in which heat is expelled outward is called an *exothermic reaction*.)

The plant drinks in water through its roots and inhales carbon dioxide from the air around it, which is how plants have those materials on hand for the endothermic reaction of photosynthesis. When the light energy from the sun gets trapped in the chlorophyll along with the water and carbon dioxide, it triggers the endothermic chemical reaction.

Animals, including people, breathe *in* oxygen and breathe *out* carbon dioxide. Plants need breathing animals to help create carbon dioxide for them to use during photosynthesis.

The inward build-up of heat caused by trapping the light energy in the chlorophyll and forcing an endothermic reaction to occur is necessary in order for the water molecules to break down. Once they've been broken down, their hydrogen atoms come together with the carbon dioxide molecules to form glucose as one product and unattached oxygen atoms as another product.

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The remaining product of photosynthesis is glucose, which is a simple sugar. Sugar is stored energy, or food energy, that helps living things grow. Plants use glucose and the energy it stores to grow new cells, which allows plants to grow bigger, produce more leaves, produce flowers, and, ultimately, fruit. This is much the same way people's bodies absorb the nutrients of the foods they've eaten so their bodies can grow new cells when they need them, such as in developing children and healing wounds.

Plants capture the energy from the sun in the first place; whatever eats them then captures the energy within its own body that is then used to nourish it, whether it is a caterpillar, a deer, or a human. Even a piece of beef includes food energy captured from the sun; grains, hay, and the green grasses of the fields are all sources of energy that were originally captured from light by plants. When a person eats beef, the energy that transferred from the plants to the cow then transfers from the cow to the person.

This is how energy from the sun is captured by and transferred throughout a food chain. Without this process, people would have no way to capture the energy of the sun into their own bodies to grow new cells and they would have no source of oxygen to breathe.

Materials:

- Tools & materials for building out one self-watering container per student (see http://learn-and-grow.org for instructions & materials)
- Organic potting soil with compost or fertilizer mixed into it—enough for each container
- Five green bean seeds
- Water for each self-watering container's reservoir
- Two clear plastic disposable drinking cups
- Two dark-colored, non-transparent disposable drinking cups
- A standard metric school ruler (cm ruled)
- Data collection sheet & pen/pencil

Energy Transference in Plants - Assignment 1 & 2 Student Instruction & Data Sheet

- Colored pencils (4 different colors)

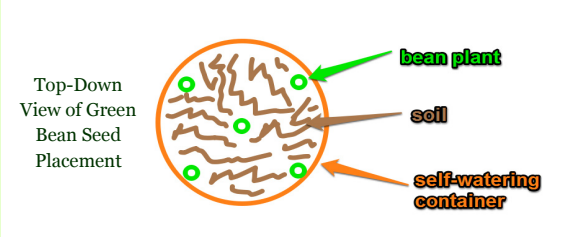
Instructions:

Assignment 1 -

1. *Research and create a diagram (digital illustration, poster, drawing, etc.) of the cycle of energy transference used on photosynthesis (see http://www.kidsdiscover.com/infographics/infographic-photosynthesis-for-kid/ for a good example).*
2. *In a whole-class discussion, share your illustrations with your classmates and discuss how access to sunlight or the lack thereof may affect the growth of the plants in your class' self-watering container garden based on what you understand about photosynthesis.*

Assignment 2 -

1. *With your classmates, build out a self-watering container garden (see http://learn-and-grow.org for instructions and a materials list), building one self-watering container per student. Each student will care for the same container for the remainder of this experiment.*
2. *Fill the upper chamber of your container with soil and the reservoirs with water.*
3. *From your instructor, get 5 green bean seeds and plant them one inch deep in the soil of your container at four points equally distant from each other close to the outer edge of the container and one in the center. For this experiment, only four plants are needed, but a fifth seed is suggested in case one of the others does not sprout.*



4. *Once you have covered the planted seeds loosely with soil, lightly dampen the soil from the top to start germination and ensure that the wicking action from lower down in the bucket percolates up to the planted seeds.*
5. *After 2 days, begin checking your plants daily to see when they sprout and monitor their growth. Once they have deployed their first set of leaves, place clear plastic cups over two of the plants and dark, non-transparent cups over two of the other plants. The clear cups should be marked "1" and "2," as should the dark cups. Each cup should cover the same plant throughout the duration of this experiment for the purpose of accurate data collection.*
6. *Once seedlings begin to appear, take data daily (or when class meets, if on a block schedule) on how tall each seedling is over a period of three weeks. If any of the plants become too tall for the cups during that time, the cups can be removed, but the date the plants become too tall and the cups are removed should be indicated on the data sheet.*
7. *At the end of three weeks, graph your data on your data sheet and describe in a paragraph the differences between the plants grown under the clear cups and the plants grown under the dark cups, both with respect to the measurements you've taken and your observations of your plants as they have grown.*
8. *Remove all cups from your container and allow the plants to grow on their own for the next week without being moved or rearranged. Measure how tall each plant is once all plants have had undisturbed access to sunlight for the full week.*
9. *Next, rotate the containers so that the leaves are facing in the opposite direction from where they were facing before. Your teacher will take individual pictures of each student with his/her rotated container.*
10. *Leave your container unmoved and unrotated for the next week. Return at the end of one week and your teacher will again take individual pictures of each student with his/her container.*
11. *Your teacher will collect the images and create a slide show that puts each image of each student and his/her container at the time of the rotation and again one week later side-by side on a single slide that shows how the leaves on the bean plants reoriented to the sun after being moved.*
12. *After looking at everybody's pre- and post-comparison slides, discuss what changes everyone observed in the pre- and post- photos.*
13. *Tend the garden with your classmates until harvest and pick the green beans once they have reached maturity. Your class should have already decided at this point what will become of your picked green beans, whether they go to the school cafeteria, go home with the students, or are made part of a dish served during a class party.*
14. *Green bean plants, depending on the variety, may produce one round of beans and die, though you can keep them producing a little longer so long as you keep picking the beans as they come in and it remains warm enough outside. Once your bean plants have died, pull them up and put them into a composter. Stir fresh compost or fertilizer into the soil in the container and re-use it for another self-watering*

Energy Transference in Plants - Assignment 1 & 2 Student Instruction & Data Sheet

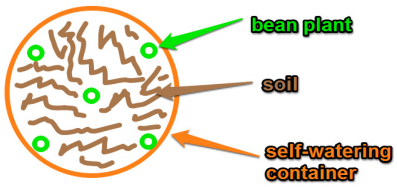
Name: _____

Determine which of your clear cups is #1 and which is #2. Do the same for your dark cups. Determine which plants, when sprouted, will go with each cup.

If it helps, mark them on the diagram at right relative to how you have placed them in your container. Use "C1" for Clear Cup #1, "C2" for Clear Cup #2, "D1" for Dark Cup #1, and "D2" for Dark Cup #2.

In the chart below, record your measurements of your plants' respective heights *in centimeters* at the time they sprout and during your daily data collection for the next three weeks.

Top-Down View of Green Bean Seed Placement



	Sprout Date	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 15
Clear Cup #1		___ cm	___ cm	___ cm	___ cm	___ cm	___ cm	___ cm	___ cm	___ cm	___ cm	___ cm	___ cm	___ cm	___ cm	___ cm
Clear Cup #2		___ cm	___ cm	___ cm	___ cm	___ cm	___ cm	___ cm	___ cm	___ cm	___ cm	___ cm	___ cm	___ cm	___ cm	___ cm
Dark Cup #1		___ cm	___ cm	___ cm	___ cm	___ cm	___ cm	___ cm	___ cm	___ cm	___ cm	___ cm	___ cm	___ cm	___ cm	___ cm
Dark Cup #2		___ cm	___ cm	___ cm	___ cm	___ cm	___ cm	___ cm	___ cm	___ cm	___ cm	___ cm	___ cm	___ cm	___ cm	___ cm

If you have to remove the cups from any of your plants because they've grown too big, mark which cups were removed and the dates they were removed in this chart →

	Date Cup Removed:
Clear Cup #1	
Clear Cup #2	
Dark Cup #1	
Dark Cup #2	

Energy Transference in Plants - Assignment 1 & 2 Student Instruction & Data Sheet

In the chart at right, using a different color pencil for each week, lightly shade in the boxes in the columns to indicate the height of each of your green bean plants *at the end of each week of measurement* to create a visual representation of your plants' growth.

You will use your day 5, 10, and 15 data (or, if on a block schedule the data from the last day of measurement of each week), from the prior page's plant growth data table. Each week's data will stack on top of the prior week's data in the chart until you have the total heights of each plant at the end of your 4 weeks of data collection at the highest points.

Below, describe the differences between the plants grown under the clear cups and the plants grown under the dark cups, both with respect to the measurements you've taken and your observations of your plants as they have grown. Explain how light energy is used by plants to create glucose and oxygen from water and carbon dioxide in an endothermic reaction.

40cm				
38cm				
36cm				
34cm				
32cm				
30cm				
28cm				
26cm				
24cm				
22cm				
20cm				
18cm				
16cm				
14cm				
12cm				
10cm				
8cm				
6cm				
4cm				
2cm				
	Clear Cup #1	Clear Cup #2	Dark Cup #1	Dark Cup #2

Record the height of your plants in the chart, below, after all cups have been removed and they have sat undisturbed for one week :

Height				
	Clear Cup #1	Clear Cup #2	Dark Cup #1	Dark Cup #2