

LESSON 2

Energy Transformation and Flow

Overview

In this lesson students will observe two demonstrations in which energy is not lost, but rather transformed/converted from one form to another. Students will also trace the pathway of energy flow from sun, to plant, to animal (through their bodies' digestion system), to light and movement.

Student Learning Targets

- I can explain how one type of energy transforms into another type and give examples from my everyday experiences.
- I can trace the energy flow through a system and explain how it works.
- I can compose and justify a hypothesis in response to a question related to a change in/transfer of energy.

NGSS

MS-PS3-4.

Plan an investigation to determine the relationships among the energy transferred, type of matter, mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.

[Clarification Statement: Examples of experiments could include comparing final water temperatures after different masses of ice melted in the same volume of water with the same initial temperature, the temperature change of samples of different materials with the same mass as they cool or heat in the environment, or the same material with different masses when a specific amount of energy is added.] [Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred.]

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. [Clarification Statement: Emphasis is on tracing movement of matter and flow of energy.] [Assessment Boundary: Assessment does not include the biochemical mechanisms of photosynthesis.]

Background

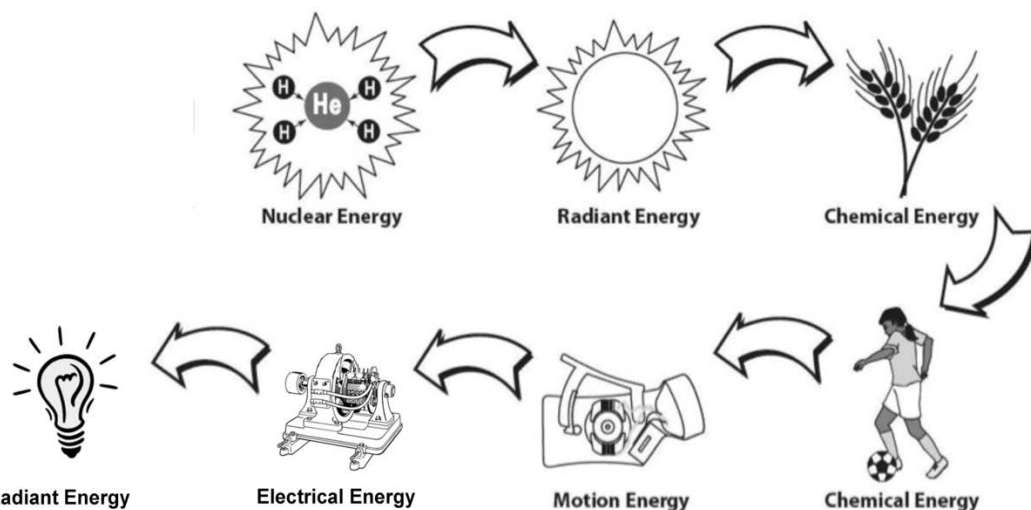
Energy cannot be created or destroyed, but it can change forms. The energy we use is stored in different forms: thermal, radiant, motion, sound, electricity, gravitational, mechanical, nuclear, and chemical. For example, radiant energy from the sun is transformed into heat energy absorbed by objects (including humans) on earth, which explains why you feel warmer in the sun than in the shade. Likewise, when your body converts the chemical energy stored as fat in your cells to body movement or the sound of your voice, energy has been transformed from chemical energy to motion and sound energies. If you trace work

done or a change back to its original energy source, you can demonstrate the **flow of energy**.

Almost all energy on earth starts with the sun. Inside its core, hydrogen atoms are fused together to form helium atoms (a nuclear fusion reaction). Because the mass of the helium atoms is less than that of hydrogen atoms, the remaining mass is converted into radiant energy. Wind, hydropower, and biomass can be traced back to the sun. Radiant energy from the sun that results in air and land temperature differences causes wind. The sun drives the water cycle through evaporation, and biomass results from photosynthesis (the conversion of radiant energy to glucose - chemical energy in the form of plants). Energy stored in fossil fuels (coal, natural gas, oil, propane, petroleum) is chemical energy that can be traced back to ancient plants and animals from millions of years ago that started as radiant energy from the sun.

In fact, all energy can be traced back to **nuclear energy**: fusion, fission, or radioactive decay. As noted above, the nuclear fusion in the sun produces huge amounts of energy, and can be converted into wind, hydropower, biomass, and radiant energy. Geothermal energy comes from the radioactive decay of elements in the earth's core. Nuclear fission can produce electricity through the fission (splitting) of heavy uranium atoms into lighter atoms in a nuclear power plant. The missing mass is converted into thermal energy to generate electricity.

Let's explore the energy flow to light a bulb from a hand-cranked flashlight. Let's start with radiant energy, or light from the bulb as a result of electricity (electrical energy) produced by the motion of our bodies cranking the flashlight handle. Where did our bodies get the energy to crank the handle? From the food we ate. How is energy stored in food? It is stored as chemical energy in the bonds of the molecules. The chemical energy stored in plant food comes from the process of photosynthesis which captured radiant energy from the sun. Sunlight, or radiant energy, changes water and carbon dioxide into glucose and oxygen in plants. Glucose is a sugar with lots of chemical energy. And of course, the radiant energy started as nuclear fusion energy in the sun. All transformation can be traced back to nuclear energy.



Adapted From *Energy Flows*. Manassas, VA: NEED Project, 2007. 10. Print.

Vocabulary

Nuclear energy, **fusion**, fission, chemical energy, radiant energy, photosynthesis, glucose, transformation, energy flow diagram, **digestion**, **combustion**, **chemical reaction**, **electrical energy**, independent variable, dependent variable, control

Materials

For class

- White board or newsprint pad
- Overhead projector
- Overhead: "Hand-cranked Flashlight"
- Three light sticks of the same color (or 3/student team)
- 3 thermometers or 3/student team (must be able to withstand very hot water)
- One serving of dried fruit
- Beaker with cold water or 1 per team
- Beaker with room temperature water or 1 per team
- Hand-cranked flashlight/radio
- Beaker with hot water or 1 per team

Per student

- Science journal
- Pencil or colored pencils
- Science Investigation Report

Preparation

Prepare demonstrations for light sticks and hand-cranked flashlight

Time

60 minutes

Procedure

1. Review definitions of energy, potential verses kinetic energy, and energy forms with students.

Ask for a student volunteer to crank the flashlight. Ask students, "What form of energy is coming from the bulb of the flashlight? Did the light energy just appear? Where did it come from?" Facilitate a classroom discussion that traces the light back to nuclear fusion of hydrogen atoms in the sun. Show students Overhead 1 so that they can visually trace the route energy took.

2. Using Overhead 2, explain to students Einstein's quote, "Energy cannot be created or destroyed; it can only change form." Ask students to write this statement in their science journal. Explain "We are going to follow energy as it changes from one form to another." Remind students about the toy boat that powered around the dish of water. Ask "Can you remember the forms of energy that made the boat work? What was the energy source and what form of energy was it?"

Answer: wax candle (chemical energy)

Explain that chemical energy of the candle is being burned which converts/transforms the chemical energy into thermal and radiant energy.

The thermal energy is boiling the water in the boat to produce steam. The steam leaving the boat exhaust pipe pushes the boat across the water. The moving steam and boat are energy of motion.

Diagram the steps on the board and tell students we call this an **energy flow diagram**. An energy flow diagram shows how energy changes from one form to another to another and so on. It shows us the path that energy has taken to do work or cause something to change.

3. Demonstration: Ask for a student volunteer and give them some dried fruit. Using Overhead 3, tell students that they will draw the energy flow diagram in their notebooks starting with the fruit eaten by the volunteer. Tell them that the fruit contains energy. Let them know that they will need to fill in the energy boxes (on Overhead 3) from the sun to the fruit, and then from the fruit to an activity the student volunteer plans to do after class.

Begin by asking “what form of energy do you think the fruit contains?” Write your answer next to the drawing of the fruit’s plant (in box 1 on Overhead 3).

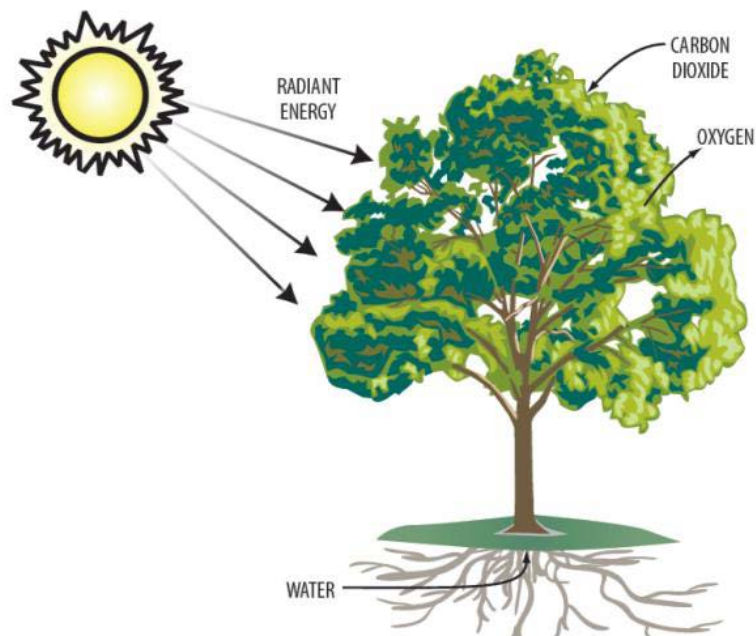
Answer: chemical energy.

Ask “Where did the energy in the fruit come from and how? Draw a picture showing where the energy in the fruit came from in box 2, label the form of energy and write down the process next to the plant that caused the energy to change forms.”

Answer: radiant energy from the sun through the chemical process of **photosynthesis**. Note: depending on age some students might trace the route back to nuclear fusion.

If necessary, review the process of photosynthesis using Overhead 4 graphic of “Photosynthesis.”

Photosynthesis



In the process of photosynthesis, plants convert radiant energy from the sun into chemical energy in the form of glucose (or sugar).

water + carbon dioxide + sunlight → glucose + oxygen

$6 \text{ H}_2\text{O} + 6 \text{ CO}_2 + \text{radiant energy} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{ O}_2$

Energy Flows. Manassas, VA: NEED Project, 2011. 12. Print.

5. Instruct the volunteer to eat the fruit and students to finish their energy flow diagrams showing what happens to the fruit’s energy (box 3). Ask them to “draw the path energy takes from chemical

energy in the fruit to chemical energy in their bodies to a form of energy their bodies need to do or change something.”

Ask students how the chemical energy in food is converted to chemical energy in our bodies.

Answer: through **digestion**. Chemical energy in our bodies in the form of fat and protein are converted to other forms such as motion, sound, and heat through **combustion** or burning the fat and proteins.

Have adult volunteers work with individual students to facilitate completion of their energy flow diagrams.

6. Ask student volunteers to share their energy flow diagrams with the other students. Help facilitate knowledge of any missed or unexplained steps. Ask students if they have any questions about how energy changes forms, but never disappears.
7. **OPTIONAL:** Demonstration and Teacher Led Science Inquiry Experiment; Glow Sticks (*Note: if students are more advanced, have them each do this experiment on their own, or in teams rather than as a demonstration*).
 - a. Distribute copies of the “Science Investigation Report” (Overhead 5) to each student and have them write their name on top. Tell students “we are going to conduct an energy experiment around light sticks. I have a beaker of cold water, a beaker of hot water, beaker of water at room temperature and three light sticks of the same color. Please write these materials on your report under “MATERIALS.”
 - b. Ask students if anyone knows how light sticks work?
 - c. Explain that the light sticks have potential energy because they contain chemicals that when mixed together give off light. Ask students “How do we get those chemicals to mix together?” and “The chemicals are what form of potential energy?”
 - d. Explain that there is a small glass tube inside the plastic light stick with a chemical and when broken, by bending the light stick, the chemical in the glass tube mixes with another chemical in the plastic light stick.

- e. Activate (or ask a volunteer student to) the light stick and show students. Ask “What kind of kinetic energy do you know see and why?”

Answer: the chemical energy has been converted into light energy.

Activate the second and third light sticks to review.

- f. Now, tell students that you want to see what happens when you put an activated light stick in cold water, room temperature water, and hot water. Ask “What kind of energy is needed to make the water hot?”

Answer: thermal energy

Ask students to help you come up with a question for the Science Investigation Report. Make sure the question is in the form of a testable question, and can be answered by taking measurements. The "**dependent variable**" represents the output or effect, or is tested to see if it is the effect. The "**independent variable**" represents the inputs or causes, or is tested to see if they are the cause.

Example: Does temperature change the brightness of light given off by a light stick? The independent variable is temperature and the dependent variable is brightness of the light stick.

Once you have a question, write it on the board for students to copy.

- g. Have students brainstorm a **hypothesis**. Explain that a hypothesis is simply an educated (based on prior knowledge and experience) guess of what a scientist thinks will happen and why with regard to the question being asked. Students may have different hypothesis so long as they are logical. Challenge them to think about energy forms to explain why they made their prediction. Ask students to share their responses; students record their hypothesis on their Science Investigation Report.

Example: If a light stick is heated up, then it will get brighter because the thermal energy will cause the chemicals to mix more.

Have students volunteer the various steps they would take with the materials provided to test their hypothesis. Write on the board and have them copy, or write their own steps, under

“Procedure.” If short on time, this step can be more teacher directed.

Example: 1. Activate three light sticks of the same color; 2. Put one light stick in a beaker of cold water (160 ml); 3. Put the second light stick in a beaker of hot water (160 ml). 4. Put the third light stick in the beaker of room temperature water (160 ml).

8. Compare the light given off from the three light sticks.

Show students how to complete the DATA COLLECTION part of their report with a brief sentence or two of what they observed, and by indicating with an “X” their results on the chart.

Example: the light from the light stick in cold water was less bright (dim). The light stick in the hot water was even brighter yet.

	Dim	Bright	Dazzling/Brilliant
Hot H ₂ O Temp ____			
Cold H ₂ O Temp ____			
Control H ₂ O Temp ____			

For the CONCLUSION ask students what they learned and why they think the results were that way? Tell them that for the analysis they are basically answering their original question. Have them reread their question on their Science Investigation Report.

Assessment

Explain that a scientist uses an analysis of the data to provide evidence that explains why the experiment results happened. Ask students to think back to everything they learned about different energy forms and transformation of energy from one form to another to explain why there was a difference in the amount of light when the water temperature changed. Help facilitate them reaching the correct answer through hints.

Example: Does hot water have energy? In what form? As the hot water cools, where does that energy go? How about if the light sticks have more energy than the water, what happens then?

Answer: Heat energy moves from hot to cold. So if the water is hotter than the light stick heat moves to the light stick converting heat energy to light energy. The higher thermal energy of the hot water increases the internal kinetic energy of the chemicals in the light stick, causing an increase in the radiant energy it gives off. Conversely, the lower thermal energy of the cold water decreases the kinetic energy of the chemicals in the light stick, causing a decrease in the radiant energy.

1. Have students draw the flow/path of energy from the sun to an activity they like to do.
2. Have students write a short paragraph explaining why energy and the transformation (or flow) of energy are so important to their lives.
3. Score their Science Investigation Reports.
4. Have students form their own question and science inquiry investigation around light sticks; score for understanding and completeness of the science inquiry process. Have students share with the class and ask class to give constructive comments on how they might improve the investigation process.

RESOURCES:

Short Videos that demonstrate energy

Circus Physics: Conservation of Energy

<http://video.pbs.org/video/1607934869/> 02:08

Website with video plus questions for the above video

<http://www.pbs.org/opb/circus/classroom/circus-physics/conservation-energy/>

Drinking Bird video....maybe above the students' level but very informative for teachers and FUN for understanding transformation of energy.

<http://www.watchknowlearn.org/Video.aspx?VideoID=8322&CategoryID=6313>

Teacher resource, If you need to brush up on any aspect of energy before you teach your students, here is a site that will help.

<http://www.learner.org/workshops/energy/workshop3/>

INTERACTIVE

Fun interactive pictures with questions you can use for your entire class. Poke around and see where you can use these. **Energy Transformations Animations Questions** [1](#) [2](#) [3](#) [4](#) [5](#) [6](#) [7](#) [8](#) [9](#) [10](#) [11](#) [12](#) [13](#) [14](#) [15](#)

<http://www.poweringourfuture.com/students/energy/1.html>

A webpage of all kinds of games and interactive concepts for energy especially electricity.

In the rectangle above, you will find the fundamental concepts and principles that underlie this standard. Below you will find a list of recommended "learning tools" for this standard. All links are in yellow, just click the link.

<http://www.learningscience.org/psc2ctransferenergy.htm>

EXTENSION ACTIVITIES

Website that has many lessons and activities you might want to use as you get more comfortable with the curriculum and topics.

<http://sciencenetlinks.com/lessons/>

To introduce students to energy through the idea of energy transformations and conversions, and to develop students' ideas of what energy is and how it can be measured.

<http://sciencenetlinks.com/lessons/converting-energy/>

Dependent and Independent Variables

EXPERIMENTAL VARIABLES

What in the World Are Variables?

Well... a variable, in science, can be anything. More specifically, in an experiment, a variable can cause something to change, be the result of something that changed, or be controlled so it has no effect on anything.

http://mathxscience.com/scientific_method_variables.html

Animated YouTube about experiments. 8:05min, *need to skip ad*

<https://www.youtube.com/watch?v=x2606GQmDqY>