Wonders of the Sun

Student Guide

2017-2018

NEED

National Energy Education Development Project

ELEMENTARY

Solar Energy

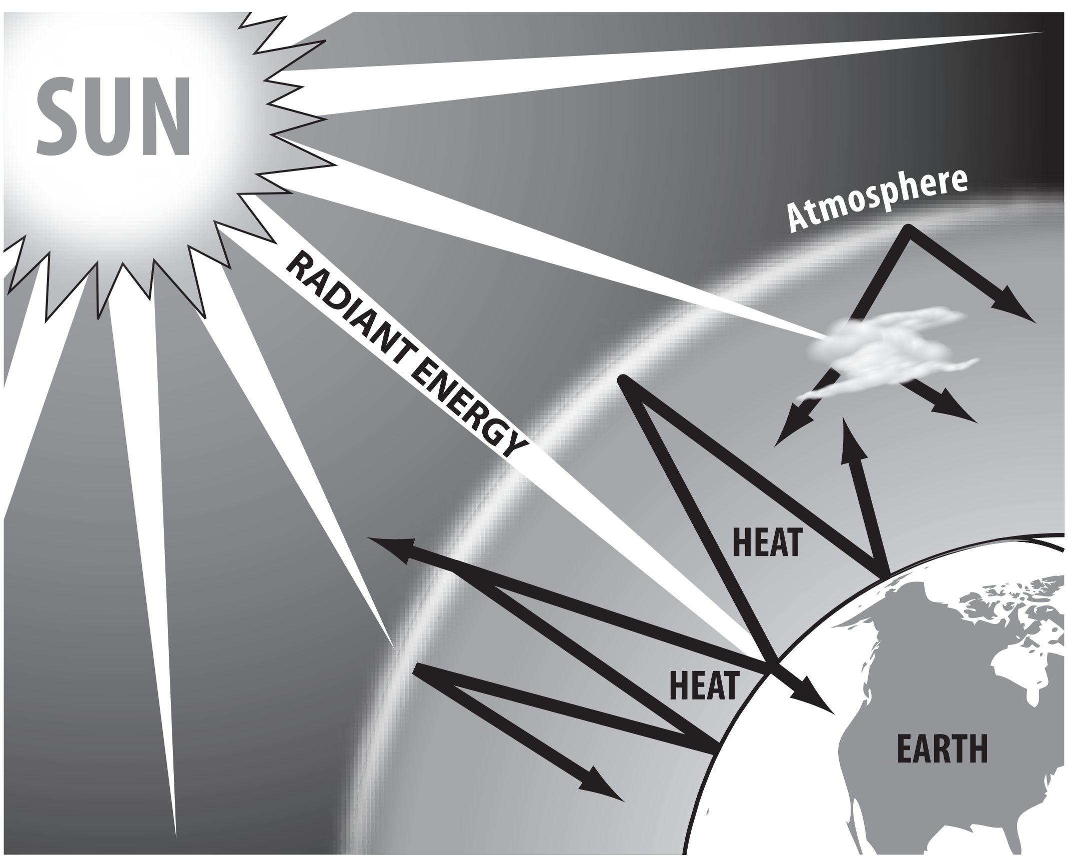
Our Earth gets most of its energy from the sun. We call this energy **solar energy**. The root *sol* refers to the sun.

Solar energy travels from the sun to the Earth in **rays**. Some are light rays that we can see. Some are rays we can't see, like x-rays. Energy in rays is called **radiant energy**.

The sun is a star, made of mainly hydrogen and helium. It sends out huge amounts of energy every day in every direction. Most of this energy goes off into space. Even though only a tiny fraction of the sun's energy reaches the Earth, it is still more energy than we can use.

When the rays reach the Earth, some bounce off clouds back into space—the rays are **reflected**. The Earth **absorbs** most of the radiant energy. This solar energy becomes **thermal energy**, which warms the Earth and the air around it, the **atmosphere**. Without the sun, we couldn't live on the Earth—it would be too cold. This is called the **greenhouse effect**.

The Greenhouse Effect



Solar Energy is Important

We use solar energy in many ways. During the day, we use sunlight to see what we are doing and where we are going. The amount of light you receive depends on the season, the location, and the weather. Solar energy is also important to nature.

FOOD

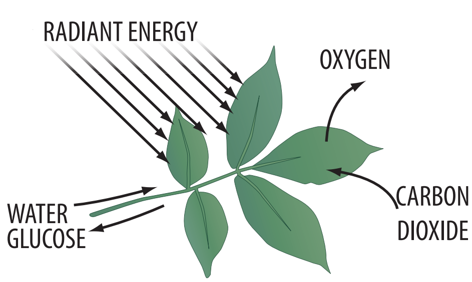
Plants use the light from the sun to grow. Plants absorb (take in) the solar energy through their leaves and use it to grow. The plants keep some of the solar energy in their roots, fruits, and leaves. They store it as **chemical energy**. This process is called **photosynthesis**.

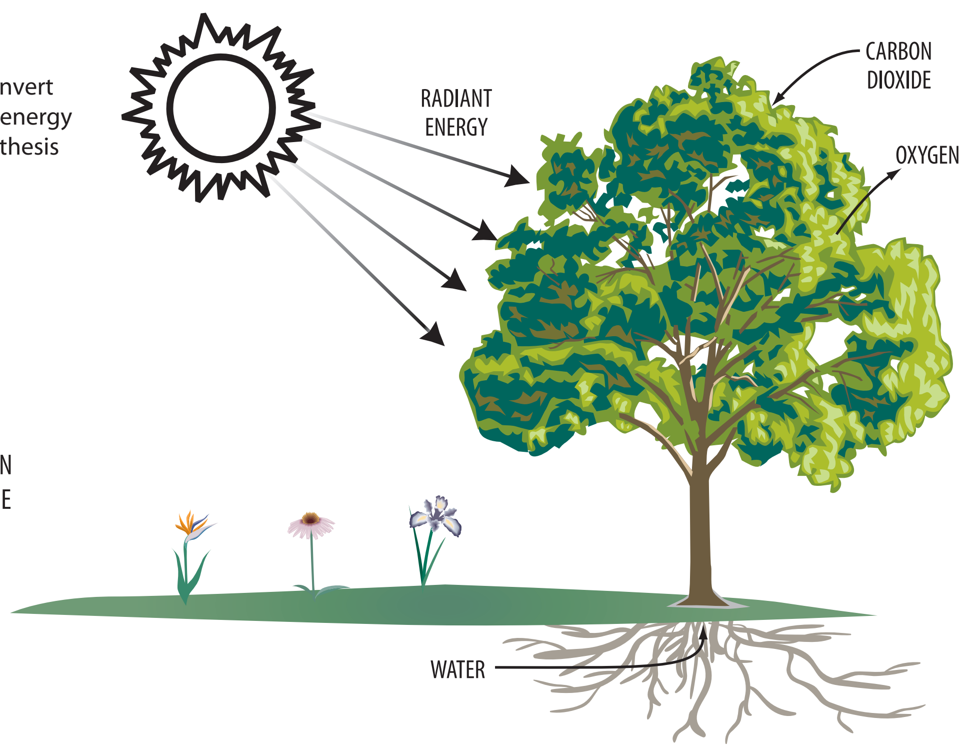
The energy stored in plants is the beginning of most food webs. When **herbivores** and **omnivores** eat plants and food made from plants, this solar energy is stored in their bodies. We use the energy to grow and move. We use it to pump our blood, think, see, hear, taste, smell, and feel. We use energy for everything we do.

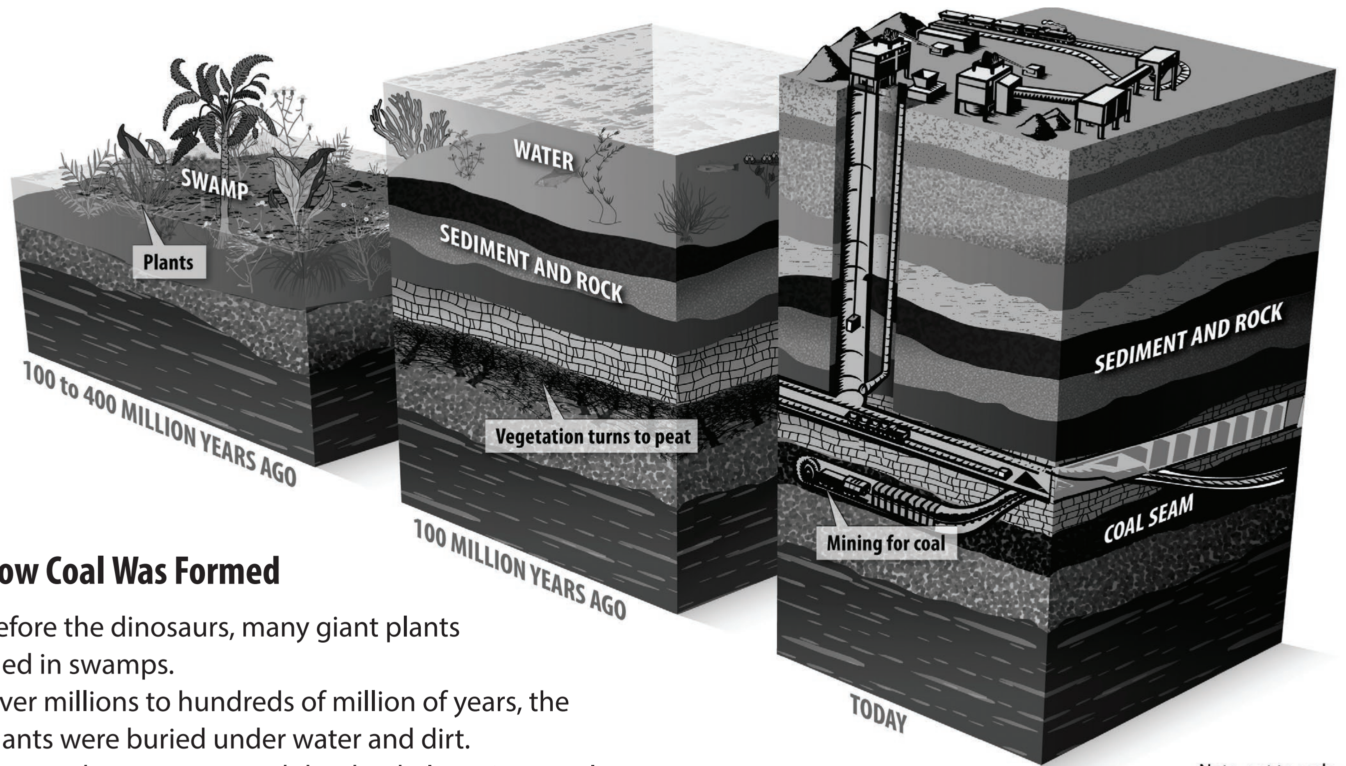
When **carnivores** and omnivores eat meat, it also can be traced to the sun. Animals eat plants to grow. The animals store the plants' energy in their bodies. The energy moves from **producers** to **consumers** through the food chain.

Photosynthesis

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







How Coal Was Formed

Before the dinosaurs, many giant plants died in swamps.
Over millions to hundreds of million of years, the plants were buried under water and dirt.
Heat and pressure turned the dead plants into coal.

FOSSIL FUELS CONTAIN ENERGY FROM THE SUN

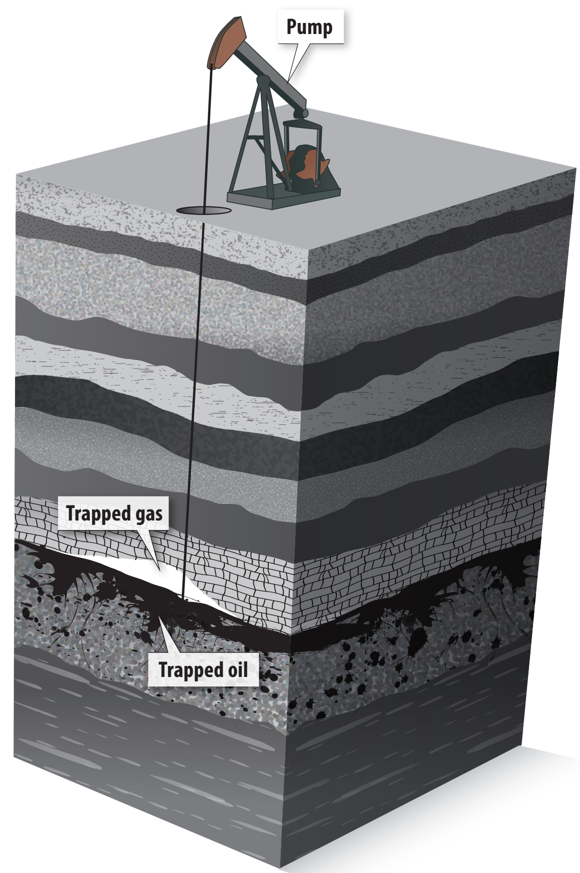
Coal, oil, and natural gas are called **fossil fuels** because they were made from prehistoric plants and animals. The energy in the plants and animals originally came from the sun.

We use the energy in fossil fuels to cook our food, warm our homes, run our cars, and make electricity. Most of the energy we use today comes from fossil fuels.

THERMAL ENERGY

We also use the energy stored in plants to stay warm. We burn wood (**biomass**) in campfires and fireplaces. Early humans burned wood to provide light, cook food, make tools, scare away wild animals, and stay warm.

Oil and Natural Gas Production



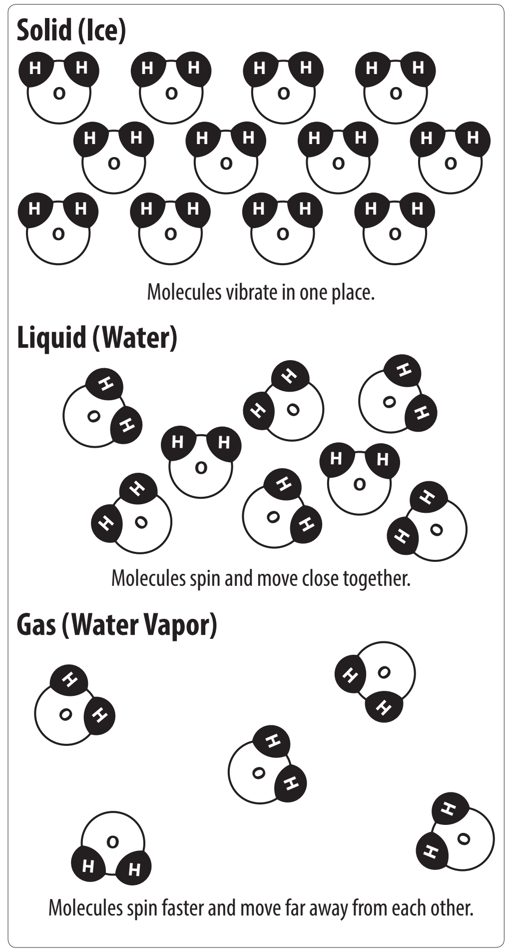
All objects are made of very tiny particles called **atoms**. Atoms are too small to see with a microscope! When solar energy hits objects, it transforms, or changes, into thermal energy. Just like when you move faster, you feel warmer; as the atoms move faster, they get warmer. We feel warmer in the sun than the shade because solar energy makes atoms move faster.

THERMAL ENERGY OF SOLIDS AND LIQUIDS

Everything is made of atoms. Atoms combine to form **molecules**. When the substance is a solid, the atoms or molecules are fixed in one location and just vibrate back and forth in place. This is why solids stay the same shape.

The atoms or molecules in a liquid move around much more, and often tumble around each other. However, the molecules do not have enough energy to completely get away from each other. This is why a liquid spreads itself out to the shape of the container, but does not necessarily fill the container.

The molecules in a gas have enough energy to move all over the place and get away from each other. Gases spread out to completely fill whatever container they are in. Gas molecules are moving very fast and bump into each other as well as other objects. You cannot feel air molecules bumping into you because they are very small.



What are the advantages and disadvantages of an electric clothes dryer vs. a solar clothes dryer?

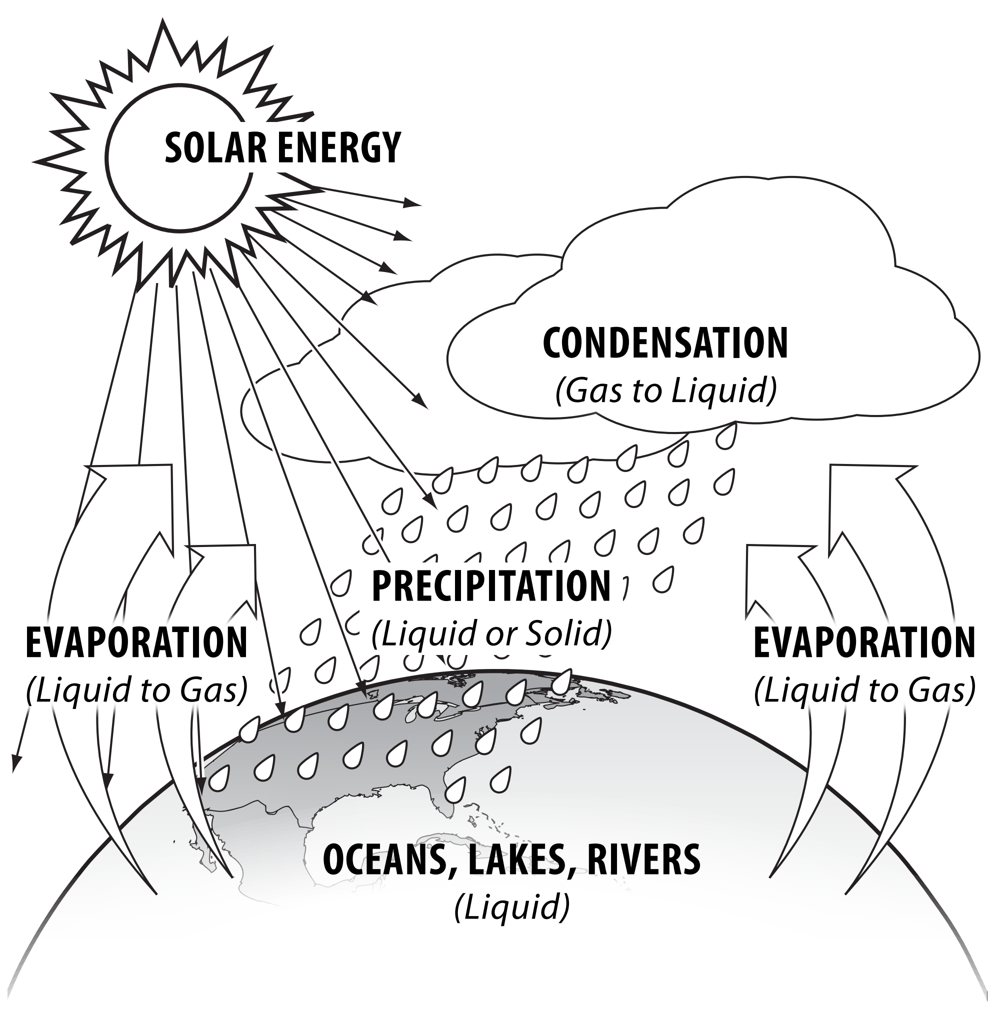
WATER CYCLE

Solar energy powers the **water cycle**. The water cycle is how water moves through the atmosphere and the Earth's surface. The sun heats water on the Earth. The water **evaporates**—it turns into **water vapor** and rises into the air. The air in the atmosphere is cool. The water vapor **condenses** into liquid water to form clouds. The water falls from the clouds as **precipitation**—rain, sleet, hail, or snow.

When water falls on high ground, **gravity** pulls it to lower ground. There is energy in the moving water. We can capture that energy with dams and use it to make electricity. The electricity made from moving water is called **hydropower**.

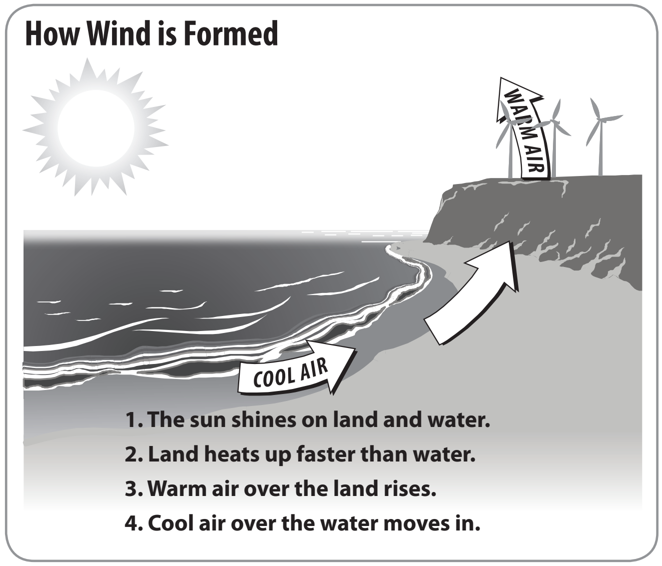
The amount of water on Earth does not change. All of the water is found in one of four places: in the atmosphere as a gas or moving through the water cycle; in bodies of water as a liquid; in the ground as a liquid; or frozen solid in ice and snow. When precipitation falls, it either adds to ice and snow, is pulled by gravity into streams and rivers, or filters into the ground, collecting in **aquifers**.

The Water Cycle



The Sun Makes the Wind

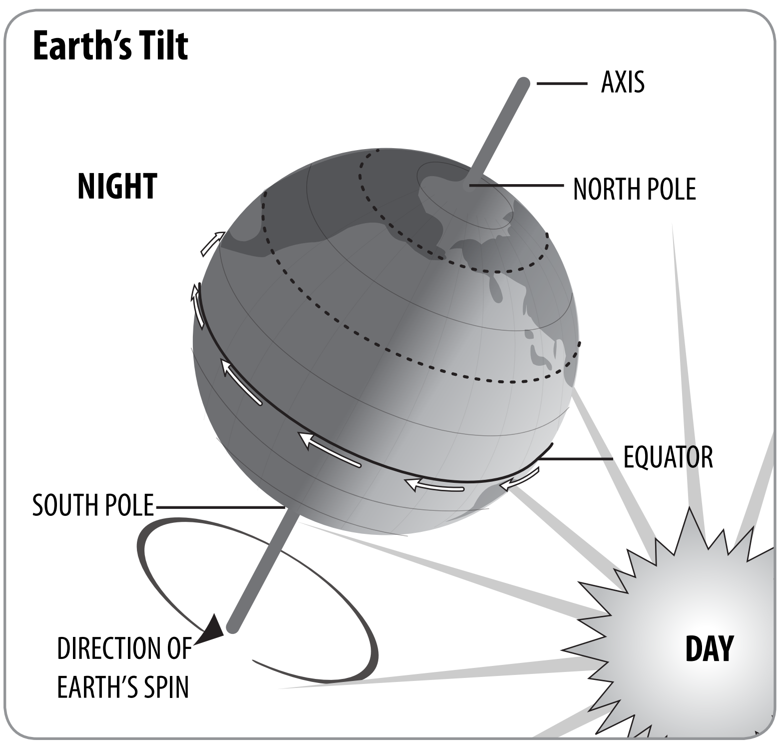
Solar energy is responsible for the winds that blow over the Earth. The sun shines down on the Earth. Some parts of the surface heat up faster than others. Land usually heats more quickly than water. Areas near the **Equator** receive more direct sunlight. These areas get warmer than regions near the North and South Poles. When air is warmed, it becomes less dense and rises. Cooler air moves in to replace the warm air that has risen. This moving air is called **wind**.



Wind **turbines** can capture the wind's energy. The wind turbines turn the energy in moving air into electricity. The wind pushes against the blades of the turbine and they begin to spin. A **generator** inside the turbine changes the motion into electricity.

Latitude and Intensity of Solar Energy

The Earth is not standing still in space. It moves around the sun in an orbit, taking one year to make a full **revolution** around the sun.



The Earth is slightly tilted on an **axis**. This tilt, combined with its revolution around the sun, are what cause the seasons of spring, summer, autumn, and winter. People who live in the southern **hemisphere**, south of the Equator, experience their hottest summer days when the northern hemisphere is experiencing winter.

The Earth also rotates on its axis. This **rotation** is what gives us sunlight during the day and darkness at night.

Why are areas closer to the Equator usually warmer than areas closer to the North or South Pole? This is due to the location's **latitude**, or distance from the Equator. The sun strikes different latitudes at different angles. Even during spring or fall, areas near the poles receive less direct sunlight than the Equator. This is because the Equator is always receiving its sunlight directly from overhead. As you move away from the Equator, you are actually walking on the surface of a sphere, and moving so the sun is no longer directly overhead.

Sunlight is most intense when it is directly overhead, and least intense when it is coming in from a low angle in the sky. This is why the hottest part of the day is when the sun is at its highest point compared to where you are, and why the days are cooler at sunrise and sunset.

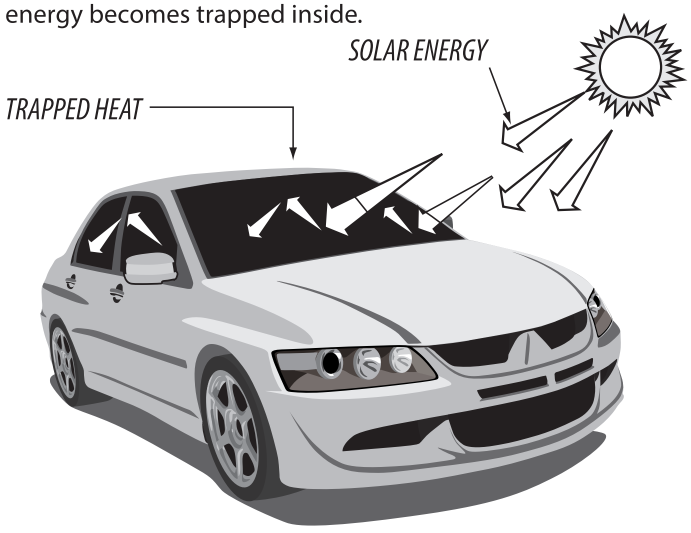
Solar Energy is Renewable

Solar energy is free and clean. Solar energy is **renewable**. We will not run out of it. The sun will keep making energy for millions of years.

Why don't we use the sun for all our energy needs? We don't have the technology to do it yet. The hard part is capturing the sun's energy. Only a little bit reaches any one place. On a cloudy day, some of the solar energy never reaches the ground at all. Although the sunlight is free, the equipment needed to capture and store the energy can be expensive. Scientists and engineers are working to create more efficient technology.

Solar Collector

On a sunny day, a closed car becomes a solar collector. Light or solar energy passes through the window glass, is absorbed by the car's interior, and converted into thermal (heat) energy. The heat energy becomes trapped inside.



We Can Capture Solar Energy

Lots of people put **solar collectors** on their roofs. Solar collectors capture the energy from the sun and turn it into heat. People heat their houses and their water using the solar energy. A closed car on a sunny day is a solar collector.

Solar Energy Can Make Electricity

Photovoltaic (PV) **cells** turn the sun's energy into electricity. The root *photo* means light, and *volt* is a measure of electricity. Most PV cells are made of pieces of **silicon**, the main component in sand. Each side of the silicon has a different chemical added. When radiant energy from the sun hits the PV cell, the sides of the silicon work together to change the energy into electricity. Scientists are always researching other materials to use in PV cells.

Some toys, calculators, and outdoor lights use small PV cells instead of batteries. Large groups of PV cells can make enough electricity for a house. They can be expensive, but are good for houses far away from power lines, or for homes that want to save energy costs.

Some schools have PV cells on their roofs or on the school grounds. The electricity helps reduce the amount of money schools must pay for energy. The students learn about the PV cells on their school buildings.

Today, solar energy provides only a tiny bit of the electricity we use. In the future, it could be a major source of energy. Scientists are constantly working on new ways to capture and use solar energy.

Some schools use solar panels on their roofs to generate electricity.

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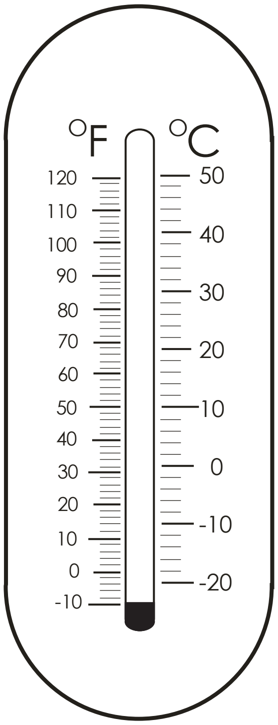
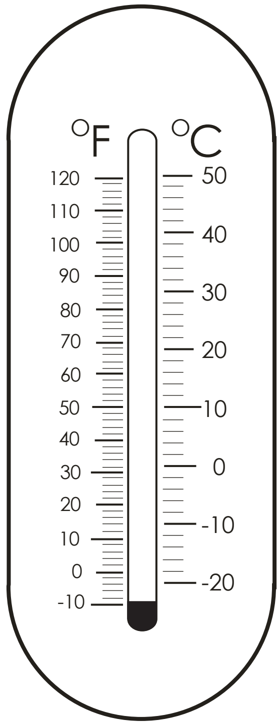
Reading a Thermometer

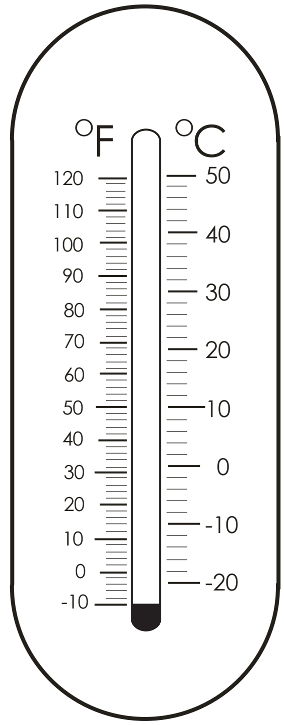
Freezing
Water
32ºF



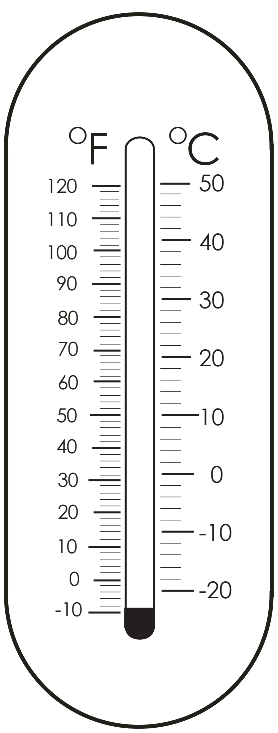
Body
Temperature
98-99ºF



Warm
Summer Day
89ºF



Very Cold
Winter Day
10ºF



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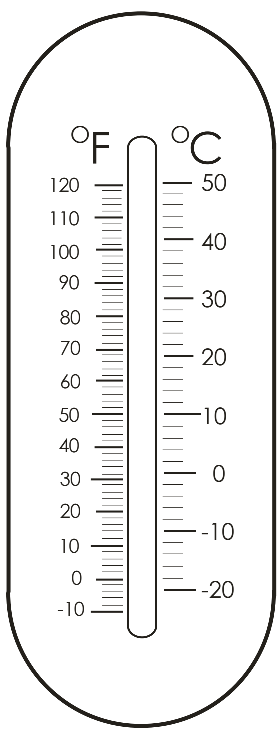

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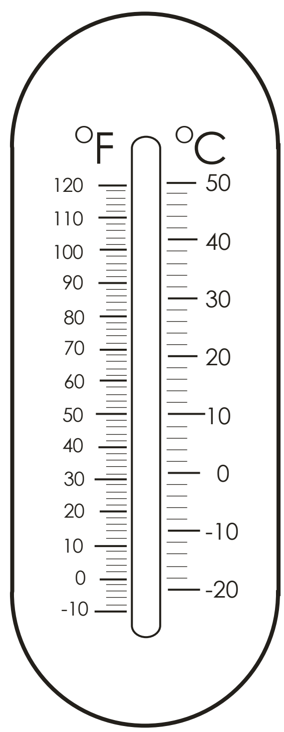


B L A N K P A G E

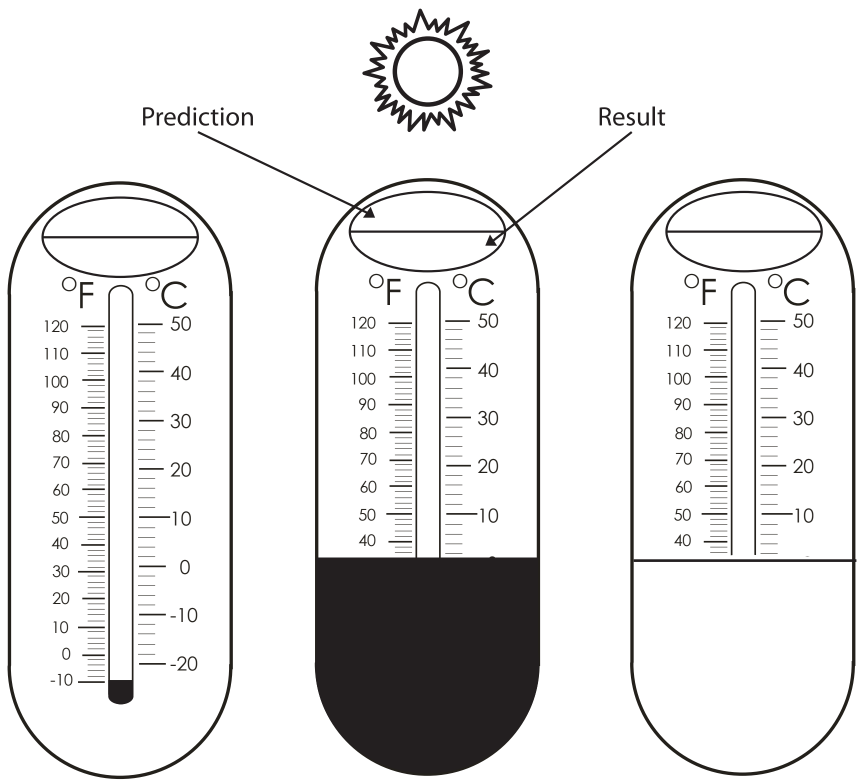
Solar Energy to Heat

Question

What is the relationship between absorbed solar energy and color?

Hypothesis

Before going outdoors, predict which thermometer will be the hottest by numbering the thermometers 1-3. Label the hottest with a 1 and the coolest with a 3.



Procedure

1. Put three thermometers in a sunny or bright place.
2. Cover the bulb of one thermometer with black paper. Cover the bulb of one thermometer with white paper. Leave the bulb of the third thermometer uncovered.
3. Complete *Reading a Thermometer* activity.
4. Record your results by coloring the tubes of the thermometers to show their temperatures.
5. Look at the results and re-number the thermometers 1-3 with 1 as the hottest, and 3 as the coolest.

Conclusion

1. Which color absorbed the most energy? What evidence from the activity shows you this?
2. How should this information affect your clothing choices?
3. Which will be hotter on a sunny day, a car with a dark blue interior, or a car with a light gray interior? How do you know? Use your results to explain your answer.

NaturePrint® and Construction Paper

Question

How does sunlight affect the chemicals in different kinds of paper?

Hypothesis

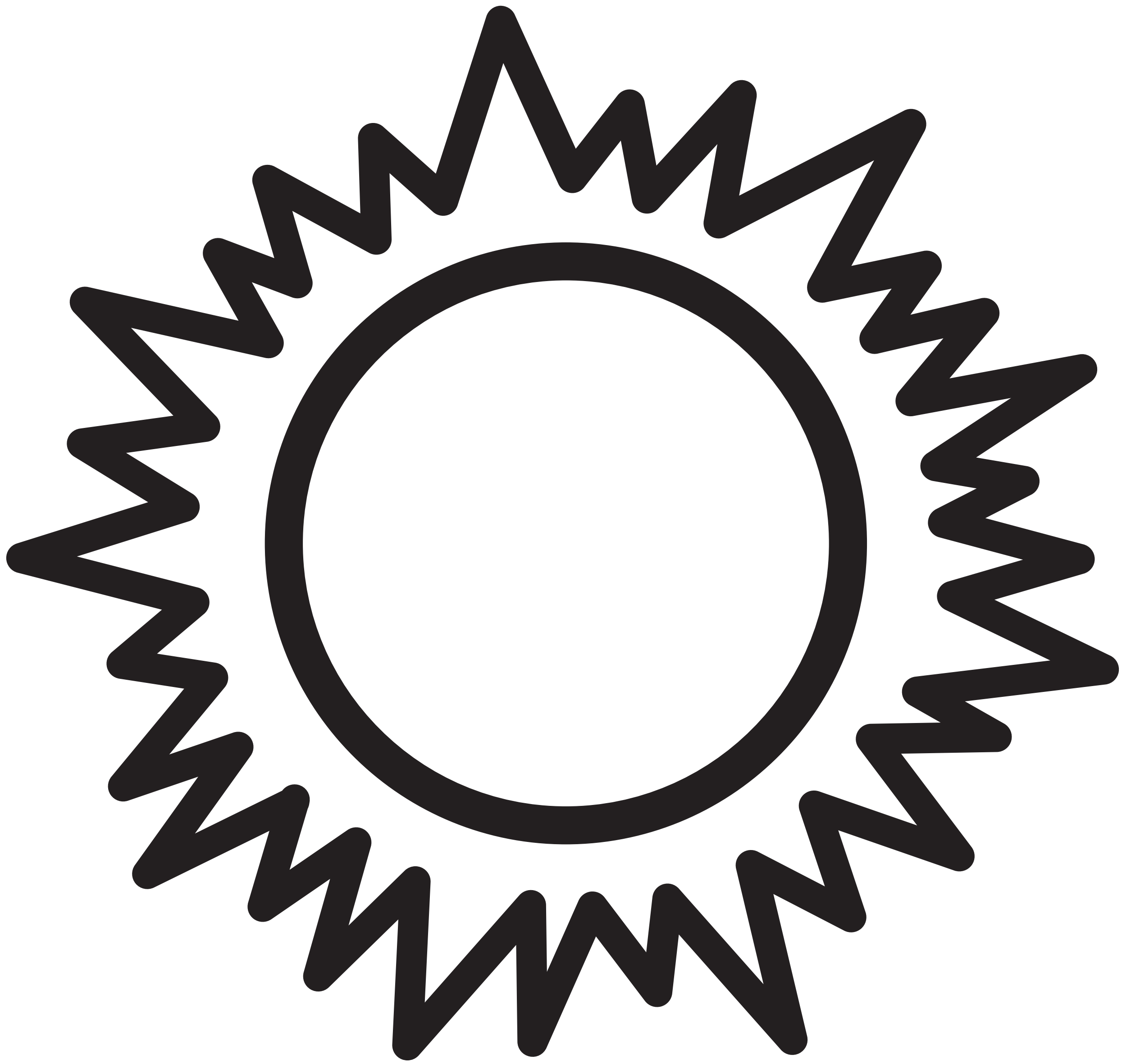
Predict how sunlight will affect construction paper.

Predict how sunlight will affect NaturePrint® Paper.

Predict whether a plastic bag will make a difference in how the sunlight will affect NaturePrint® Paper.

Materials

- 1 Cut-out of the sun
- 2 Sheets of NaturePrint® Paper
- Objects found outside or brought from home
- One plastic bag
- Sunscreen
- Pencil or pen
- Shallow pan of water
- Watch or stopwatch



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✔ Procedure

Part A

1. Cut out the sun picture on page 15.
2. Place the sun picture and/or your objects on the NaturePrint® Paper.
3. Place the piece of paper in direct sunlight.
4. After two minutes, pick up the NaturePrint® Paper and carefully carry it to the shade.
5. Remove the objects and sun picture and place the NaturePrint® Paper in water for one minute.
6. Allow the NaturePrint® Paper to dry.

Part B

1. Place a new piece of NaturePrint® Paper inside a plastic bag. Leave a half inch of the NaturePrint® Paper outside of the plastic bag exposed to the sun.
2. Take the plastic bag and apply sunscreen in a design to cover approximately half of the NaturePrint® Paper.
3. Arrange one of your objects on the plastic bag over the NaturePrint® Paper beside the sunscreen, but not touching the sunscreen, and place in direct sunlight.
4. Observe and record what you see every 30 seconds for two minutes. Make sure to note any color differences between the paper within the plastic bag and the paper outside of it.
5. After two minutes, pick up the NaturePrint® Paper and carefully carry it to the shade.
6. Remove the object and take the paper out of the plastic bag. Place the paper in water for one minute.
7. Allow the NaturePrint® Paper to dry.

Part C

1. Record what you see when looking at your dried NaturePrint® Papers on your observation charts.

Part D

1. Look at the five pieces of construction paper your teacher prepared. Observe similarities and differences. Record your observations.

Observations

Make a diagram of your first piece of dried NaturePrint® Paper below.

Side with Sun Cutout	Side with Objects You Chose

Make a diagram of your second piece of NaturePrint® Paper placed within the plastic bag below.

Side with Sunscreen	Side with Objects You Chose

Data

NaturePrint® Paper with the sunscreen and plastic bag at 30 second intervals

Time in the Sun	Appearance of NaturePrint® Paper within the plastic bag	Appearance of NaturePrint® Paper outside of the plastic bag
Beginning	Solid Blue	Solid Blue
30 Seconds		
60 Seconds		
90 Seconds		
120 Seconds		

Analysis

Use your data table above to describe how the NaturePrint® Paper changed over time.

Why did this happen?

Construction Paper Data

Make a diagram of your final observation of the construction paper sheets below.

Construction Paper

Time in the Sun	Appearance of Construction Paper
0 Hours	
1 hour	
2 hours	
3 hours	
4 hours	

⁂ Conclusions

Write your conclusions using complete sentences.

1. How does sunlight affect construction paper?

2. Compare the amount of time required for the NaturePrint® Paper to change to the amount of time for the construction paper to change.

3. You and your little sister receive the same plastic toy as a gift. You keep yours in your room on a shelf, carefully taking it down to play. Your little sister leaves it outside over summer vacation. At the end of vacation, you both take your toys and compare them. Explain the differences you see and what might have caused them.

UV Bead Activity

Question

What factors affect the amount of sunlight that reaches plants?

Background

UV stands for ultraviolet light, a type of electromagnetic radiation that travels in a wave-like pattern. UV light is found within sunlight, but is invisible. You are probably aware of the effects of UV radiation because you wear sunscreen and sunglasses to protect you from it. UV light causes chemical reactions that can make a substance glow or your skin to burn or tan. It also causes the formation of Vitamin D, an essential vitamin for humans and other organisms. A good amount of harmful UV radiation is blocked by the Earth's ozone layer, but the little amounts that get through will cause these chemical changes. UV beads contain special color-changing pigments that are sensitive to UV light from the sun and other sources.

Hypothesis

Predict how sunlight will affect the UV beads.

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Predict how sunlight affects plant growth.

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Materials

- 5 UV beads
- 1 Pipe cleaner
- Writing utensil
- Plant information sheets

Procedure

1. String the UV beads onto the pipe cleaner. Twist the pipe cleaner into a loosely-fitting bracelet and wear on your wrist.
2. Bring your bracelet, plant information sheet, and materials for mapping outside.
3. Draw a map of the outdoor area where your teacher directs you to explore. On your map, label which locations are sunny, partially shaded, and full-shade areas, and show where you would plant each type of plant using a key you create.
4. On page 24 or in your science notebook, write a letter to your principal explaining how you used the UV beads to discover and decide which plant would grow best in which area.

Data

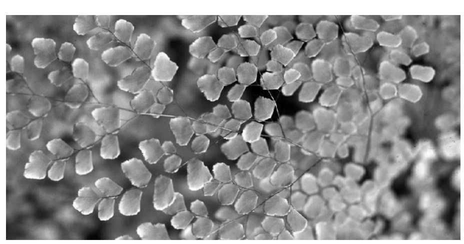
Map of the assigned area

Key

( )Sunny Area
( )Partially Shaded Area
( )Fully Shaded Area

( )Plant #1 Sunflower
( )Plant #2 Maidenhair Fern
( )Plant #3 Impatiens

The Sunflower is a plant native to the Americas. To grow best, sunflowers need full sun.



The Maidenhair Fern is a fern native to the Americas that thrives with no direct sun.
Source: Smithsonian Institute

Impatiens are a plant which prefer partial shade.
Source: Smithsonian Institute

Write a letter to your principal explaining how you used your beads to discover which plant would go in which area.

Radiometer Activity

Question

How does color affect the direction of a radiometer's spin?

Background

A radiometer has four vanes. One side of each vane is white, the other side is black. When radiant energy hits the vanes of the radiometer, they begin to spin. One side of the vanes gets hotter than the other. The air near the hotter side of the vanes gets hotter and pushes against the vanes. The radiometer changes radiant energy to heat, then to motion.

Hypothesis

Predict the direction the radiometer will spin by shading in the appropriate prediction arrow on the diagram below.

Materials

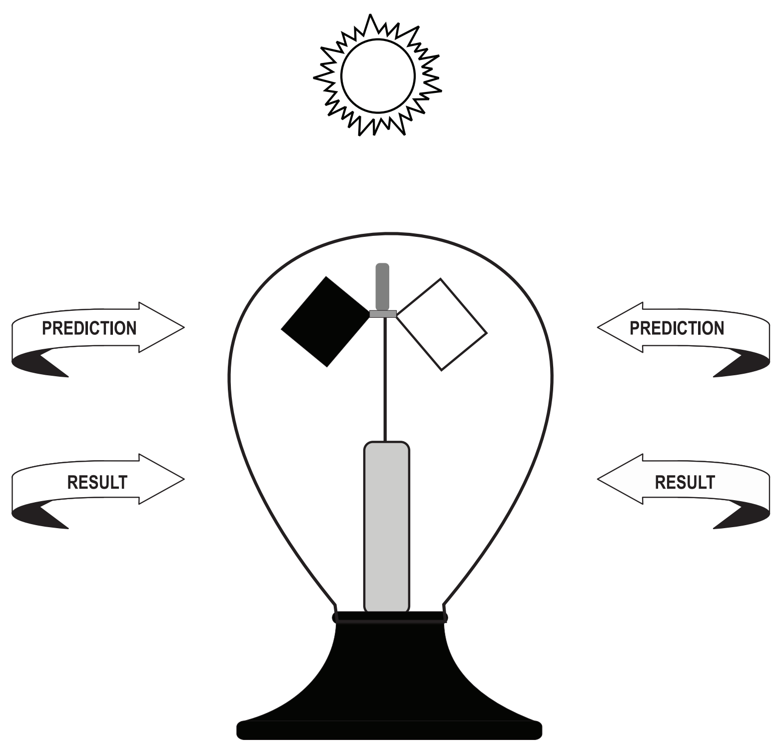
- Radiometer
- Bright sunlight, or a bright source of light

Procedure

1. Put the radiometer in bright sunlight or another bright light source.
2. Observe the radiometer.
3. Record your results.
4. Color the result arrow that shows the direction the vanes are spinning in the diagram below.

Conclusions

1. Explain why the radiometer spins in the direction you observed.
2. Make a diagram showing how the radiometer transforms energy.



Solar Oven Activity

Question

How can solar energy be used to cook food?

Materials

- Solar oven
- Oven thermometer
- Dish on which to cook food
- Food to cook

Procedure

1. On a very sunny day, take the solar oven outside and put it in a sunny place.
2. Place the food and thermometer in the oven.
3. Observe how long it takes to cook the food and how warm the oven becomes.

Observations

Draw a diagram of the solar oven. Use arrows to show how solar energy cooks the food.

Record your observations below. How long did it take to cook the food? How did the food change in appearance or smell as it was cooking?

Conclusion

Describe when a solar oven would be useful.

Solar House

Question

How can solar energy be used in your house?

Materials

- Cardboard box
- Scissors
- Clear transparency film or plastic wrap
- Black construction paper
- 2 Sheets of white paper
- Clay
- Tape
- Solar house kit
- Ruler

Procedure

1. Using the scissors, cut large windows and a door on one side of the box.
2. Tape clear transparency film over the windows if you have it. Use plastic wrap as a substitute.
3. Make a round water storage tank from black construction paper. Attach it to the side of the house with tape.
4. Make two holes 1 cm in diameter in the top of the box.
5. Push the shaft of the motor through one of the holes.
6. From the inside of the house, attach the fan blades to the motor. Make sure there is enough room above the blades for the fan to turn without bumping the ceiling. Use a strip of tape to hold the motor in place.
7. Push the LED through the other hole and tape it in place.
8. Attach the PV cells to the fan and LED.
9. Lay the PV cell with tubing on top of the house with the tubing extending down to the black water storage tank. Tape in place, or use clay to hold in palce.
10. Carefully carry the house model into the sun. Observe the speed of the fan and the brightness of the LED. Tilt the PV cells so they are directly facing the sun. How does this affect the speed of the fan? Use a piece of clay under the PV cells to leave them in this position.
11. Simulate a bright, overcast day by placing a single sheet of white paper over the PV cells. Observe the speed of the fan and the brightness of the LED.
12. Simulate a very cloudy day by placing two sheets of white paper over the PV cells. Record your observations of the fan speed and LED brightness.
13. Simulate nighttime by placing a piece of cardboard over the PV cells. Record your observations of the fan speed and LED brightness.

Data and Observations

Make a diagram of your solar house below. Label the parts.

Data and Observations Continued

Record your observations in the table below.

Light Conditions	Fan Speed	LED Brightness
Bright sunlight, PV cells laying flat		
Bright sunlight, PV cells tilted toward the sun		
Bright overcast (one sheet of paper)		
Cloudy (two sheets of paper)		
Nighttime (cardboard)		

Conclusions

1. Did the PV cells work differently laying flat or pointed towards the sun? Explain which worked better.

2. How would the change in seasons and different location of the sun in the sky affect how well a PV cell works where you live?

Wonders of the Sun Glossary

absorb	to pull into oneself
aquifer	underground reservoir of collected water
atmosphere	mixture of gases surrounding a planet
atom	smallest unit of matter; smallest particle of an element
axis	imaginary line running through the center of the Earth from pole to pole
biomass	renewable energy source from recently living things, such as grass and trees
carnivore	organism that exclusively eats animals
chemical energy	form of potential energy that is used by causing chemical reactions
condensation	process of a gas changing to a liquid
consumer	organism that cannot create its own food and depends on other organisms for nutrients
Equator	imaginary line running around the midpoint of the Earth's surface, halfway between each pole
evaporation	process of a liquid changing to a gas; evaporation is usually accomplished slowly
fossil fuel	nonrenewable sources of energy formed from living things that died many years ago
generator	device that transforms motion energy into electrical energy by rotating a coil of copper between magnets
gravity	force of attraction between two objects; smaller object usually feels a stronger pull toward the larger object
greenhouse effect	when the atmosphere allows light to pass through but traps the energy as heat
hemisphere	one half of a sphere; one half of the Earth
herbivore	organism that exclusively eats plants
hydropower	source of energy obtained from moving water
latitude	imaginary lines of reference that are parallel to the Equator
molecule	two or more atoms chemically bonded together; smallest particle of a compound
omnivore	organism that eats both plants and animals
photosynthesis	process plants use to transform radiant energy from the sun into chemical energy
photovoltaic cell	object that transforms radiant energy into electrical energy; also called a solar cell
precipitation	water falling from clouds to the ground, in solid (snow, sleet) or liquid (rain) form
producer	green plant or organism that makes food from photosynthesis
radiant energy	energy released by stars that travels in rays outward from the star
rays	energy that travels in one direction only, such as from the sun to Earth
reflection	radiant energy striking one surface, and bouncing off that surface in a different direction
renewable	energy sources that are easily replaced, such as biomass, or will never run out, such as wind or solar energy
revolution	the Earth's movement around the sun in its orbit
rotation	the spin of the Earth around its axis
silicon	second most plentiful element on Earth; major component of sand
solar collector	device that collects solar energy and transforms it into thermal energy that is either used or stored
solar energy	radiant energy from the sun
thermal energy	energy found within a solid, liquid, or gas; the particles of warmer substances are moving faster

turbine	device that changes straight-line motion into rotating motion, such as in a windmill or hydropower plant
water cycle	process of evaporation, condensation, precipitation, and runoff of water on Earth
water vapor	gas phase of water (H_2O)
wind	air moving across the Earth's surface

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Central Falls School District
Chugach Electric Association, Inc.
CITGO
Clean Energy Collective
Colonial Pipeline
Columbia Gas of Massachusetts
ComEd
ConEdison Solutions
ConocoPhillips
Constellation
Cuesta College
David Petroleum Corporation
Desk and Derrick of Roswell, NM
Direct Energy
Dominion Energy
Donors Choose
Duke Energy
East Kentucky Power
Energy Market Authority – Singapore
Escambia County Public School Foundation
Eversource
Exelon Foundation
Foundation for Environmental Education
FPL
The Franklin Institute
George Mason University – Environmental Science and Policy
Gerald Harrington, Geologist
Government of Thailand–Energy Ministry
Green Power EMC
Guilford County Schools – North Carolina
Gulf Power
Hawaii Energy
Idaho National Laboratory
Illinois Clean Energy Community Foundation
Illinois Institute of Technology
Independent Petroleum Association of New Mexico
James Madison University
Kentucky Department of Energy Development and Independence
Kentucky Power – An AEP Company
Kentucky Utilities Company
League of United Latin American Citizens – National Educational Service Centers
Leidos
Linn County Rural Electric Cooperative
Llano Land and Exploration
Louisville Gas and Electric Company
Mississippi Development Authority–Energy Division
Mississippi Gulf Coast Community Foundation
Mojave Environmental Education Consortium
Mojave Unified School District
Montana Energy Education Council
The Mountain Institute
National Fuel
National Grid
National Hydropower Association
National Ocean Industries Association
National Renewable Energy Laboratory
NC Green Power
New Mexico Oil Corporation
New Mexico Landman's Association
NextEra Energy Resources
NEXTracker
Nicor Gas
Nisource Charitable Foundation
Noble Energy
Nolin Rural Electric Cooperative
Northern Rivers Family Services
North Carolina Department of Environmental Quality
North Shore Gas
Offshore Technology Conference
Ohio Energy Project
Opterra Energy
Pacific Gas and Electric Company
PECO
Pecos Valley Energy Committee
Peoples Gas
Pepco
Performance Services, Inc.
Petroleum Equipment and Services Association
Phillips 66
PNM
PowerSouth Energy Cooperative
Providence Public Schools
Quarto Publishing Group
Read & Stevens, Inc.
Renewable Energy Alaska Project
Rhode Island Office of Energy Resources
Robert Armstrong
Roswell Geological Society
Salt River Project
Salt River Rural Electric Cooperative
Saudi Aramco
Schlumberger
C.T. Seaver Trust
Secure Futures, LLC
Shell
Shell Chemicals
Sigora Solar
Singapore Ministry of Education
Society of Petroleum Engineers
Society of Petroleum Engineers – Middle East, North Africa and South Asia
Solar City
David Sorenson
South Orange County Community College District
Tennessee Department of Economic and Community Development–Energy Division
Tesla
Tesoro Foundation
Tri-State Generation and Transmission
TXU Energy
United Way of Greater Philadelphia and Southern New Jersey
University of Kentucky
University of Maine
University of North Carolina
University of Tennessee
U.S. Department of Energy
U.S. Department of Energy–Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy–Wind for Schools
U.S. Energy Information Administration
United States Virgin Islands Energy Office
Wayne County Sustainable Energy
Western Massachusetts Electric Company
Yates Petroleum Corporation