2018-2020

The Sun and Its Energy

Hands-on investigations and language arts activities that introduce primary students to the basic concepts of solar energy, and how solar energy can power the water cycle, produce wind, and create heat and electricity.

Grade Level:

Pri Primary

Subject Areas:

Science

Language Arts

NEED

National Energy Education Development Project

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In support of NEED, the national Teacher Advisory Board (TAB) is dedicated to developing and promoting standards-based energy curriculum and training.

Energy Data Used in NEED Materials

NEED believes in providing teachers and students with the most recently reported, available, and accurate energy data. Most statistics and data contained within this guide are derived from the U.S. Energy Information Administration. Data is compiled and updated annually where available. Where annual updates are not available, the most current, complete data year available at the time of updates is accessed and printed in NEED materials. To further research energy data, visit the EIA website at www.eia.gov.

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National Energy Education Development

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The Sun and Its Energy

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The Sun and Its Energy Kit

- 30 Pipe cleaners
- 1 Package UV beads
- 1 Large demonstration thermometer
- 10 Student thermometers*
- 1 Solar balloon
- 1 Solar oven
- 1 Oven thermometer
- 1 Solar house kit
- 1 Package of NaturePrint® Paper
- 1 Radiometer
- 1 Package clay

**Student thermometers in the kit are safety thermometers containing alcohol, not mercury.*

Table of Contents

- Standards Correlation Information 4
- Differentiating Instruction K-2 5
- Materials 6
- Teacher Guide 7
- Science Notebook Skills Checklist 15
- How to Make a Pizza Box Solar Oven 16
- Annual Average Solar Concentration 17
- Vocabulary Cards 18
- Solar Energy Informational Text 24
- Solar House 44
- My Plant Investigation Science Notebook 45
- Student Worksheets 48
- Evaluation Form 59

Standards Correlation Information

www.NEED.org/curriculumcorrelations

Next Generation Science Standards

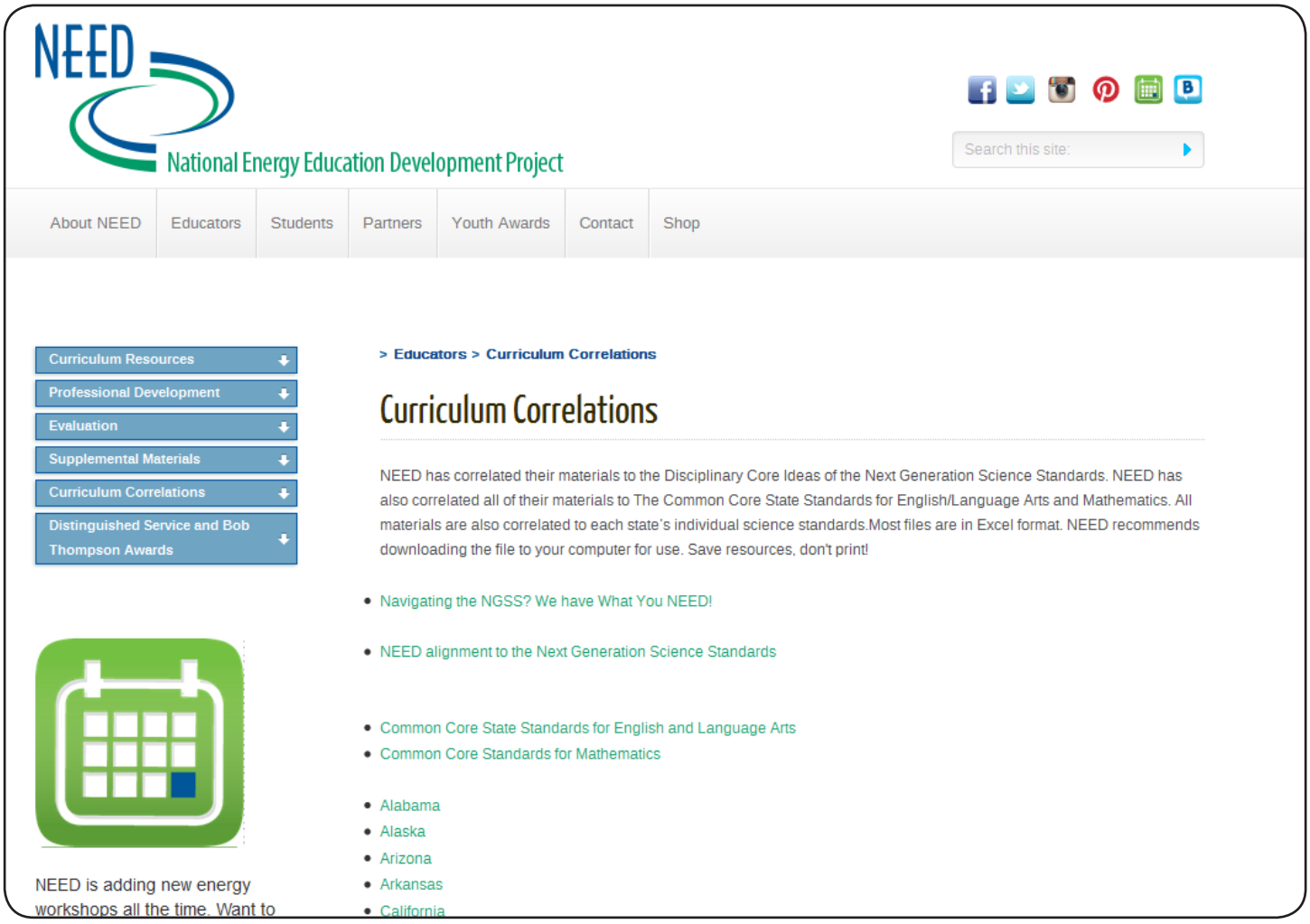
- This guide effectively supports many Next Generation Science Standards. This material can satisfy performance expectations, science and engineering practices, disciplinary core ideas, and cross cutting concepts within your required curriculum. For more details on these correlations, please visit NEED's curriculum correlations website.

Common Core State Standards

- This guide has been correlated to the Common Core State Standards in both language arts and mathematics. These correlations are broken down by grade level and guide title, and can be downloaded as a spreadsheet from the NEED curriculum correlations website.

Individual State Science Standards

- This guide has been correlated to each state's individual science standards. These correlations are broken down by grade level and guide title, and can be downloaded as a spreadsheet from the NEED website.



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Differentiating Instruction K-2

Students' abilities in Kindergarten through second grade are varied, as are the abilities of individual students within each classroom. Here are some suggestions for using this curriculum across the K-2 setting.

Reading

The student text for *The Sun and Its Energy* can be found within this guide. Depending on your students' reading level, you may want to make a master copy to read the text aloud to your class. You can also download the guide from shop.NEED.org and project the text onto a screen that the entire class can see. Older children may be able to read the text independently.

Writing

Kindergarten

As much as possible, students should be interacting with materials and investigating individually or with partners. Students can each have their own science notebook or individual worksheets. Teachers may choose to create a classroom set of worksheets or science notebook. Drawing scientific or realistic pictures should be modeled to the students and attempted in their work. Students should be encouraged to label pictures with as many sounds as they can hear, even if this is only the initial consonant at first. Students' individual observations can be glued into a classroom notebook made of large construction paper or chart paper. The teacher should write a summary sentence or two in the class science notebook based on the students' discussion and observations. While the teacher can assess students' pictures, listening to students to gauge their understanding is important. Parent volunteers can be a valuable resource during this unit, helping with investigation management, preparing materials, and being a scribe for students.

First Grade

Depending on the time of year that you teach this unit, you may find yourself using some of the Kindergarten strategies or moving toward second grade strategies. In general, students should be able to follow directions and work independently or with partners on investigations. Each student should have his or her own science notebook or individual worksheets, and be encouraged to communicate his or her thinking in pictures and words, although allowing dictation for non-writers is appropriate. Pictures should be realistic in nature and include labels as needed. It is suggested that teachers create a word wall with pertinent vocabulary for the unit that students can use as a resource. Parent volunteers continue to be a good support for investigation management and preparing materials.

Second Grade

As second graders become more comfortable with the inquiry process, teachers are encouraged to extend the investigations further, exploring student generated questions. Second graders should be given more opportunities to record measurable data and units such as degrees Celsius. With direction, students will also be able to be more independent in designing and creating solar ovens and houses they will be testing throughout the unit.

Solar Energy Writing Introduction

Have students start thinking about the sun by integrating it into your writing unit. Depending on whether you are focusing on fiction or nonfiction, you may want to use one of the following prompts:

Personal Narrative: Tell me about a sunny day. Describe how you knew it was sunny. What did you see? How did it feel? What did you do on this day? How did it make you feel?

Fictional Narrative: Pretend you are a sun-loving plant or animal. Write a story describing a day in your life and how the sun is a part of your life.

Science Notebooks

You are encouraged to have students record their thinking in science notebooks during this unit. There are many different looks to science notebooks, ways to use them, and ways to assess them. If you currently use student notebooks (or journals) in your classroom you may have your students continue using these as they learn about solar energy. If you are not using science notebooks, you can make them out of paper that your students are familiar using. If you would like more structure to your science notebooks, you can copy the worksheets included in this guide and staple them together, or have students glue these pages into their existing science notebooks.

A checklist for assessing science notebooks can be found on page 15. Carrying the checklist with you as you circulate among your students will allow you to make some notes for formative assessment and guide your conversation with students as you help them become stronger scientists. You may want to customize the checklist based on your state standards.

The Sun and Its Energy Materials

ACTIVITY	MATERIALS IN KIT	ADDITIONAL MATERIALS NEEDED
Plant Investigation		▪Small potted plants ▪Water ▪Rulers ▪Magnifying lenses (optional)
The Radiometer	▪Radiometer	▪Bright light source**
Reading a Thermometer	▪Large demonstration thermometer ▪Student thermometers*	
Light-to-Heat	▪Student thermometers*	▪Black and white construction paper ▪Scissors ▪Tape ▪Bright light source**
UV Beads	▪UV beads ▪Pipe cleaners	▪Sunny day ▪Colored pencils/crayons
NaturePrint® Paper	▪NaturePrint® Paper	▪Plastic bin or tub ▪Water ▪Sunny day
Solar Balloon	▪Solar balloon	▪Sunny day
Solar Oven	▪Solar oven ▪Oven thermometer	▪Cookie dough or other food to cook ▪Plate or pan to cook on ▪Plastic wrap ▪Sunny day
Solar House	▪Solar house kit ▪Clay	▪Sunny day or bright light source** ▪Cardboard box ▪Scissors ▪Transparency film or plastic wrap ▪Tape

**Student thermometers in the kit are safety thermometers containing alcohol, not mercury.*

****NOTE**: Consider the bulbs used to complete the activity. For most heat-centered activities, energy efficient bulbs like CFLs and LEDs will not produce the amount of thermal energy needed in the time allotment. Sunlight, most traditional incandescent, halogen incandescent, "work", and heat lamp bulbs should work for these activities. Call NEED for more information on bulbs and troubleshooting.

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Teacher Guide

Background

The Sun and Its Energy is an inquiry-based unit for primary students. Hands-on investigations and explorations introduce primary students to the basic concepts of solar energy. This all-inclusive guide contains activity sheets for students, a teacher guide, teacher background information, and student text that can be read aloud or copied for strong readers. This guide can also be downloaded as a PDF or an e-reader document for readers with tablet or computer access. *The Sun and Its Energy* Kit contains most of the materials necessary to complete the investigations that reinforce student learning about solar energy.

★Concepts

- The sun produces radiant energy (light) that travels through space to the Earth.
- The sun's energy makes life possible on Earth.
- We use the sun's energy to see.
- Plants convert the sun's energy to sugars to provide food for growth and life.
- We use the sun's energy to produce heat.
- Radiant energy from the sun powers the water cycle and produces wind.
- It is difficult to capture the sun's energy because it is spread out—not concentrated in any one area. We can capture solar energy with solar collectors that convert the energy into heat.
- Photovoltaic (solar) cells convert radiant energy directly into electricity.

Time

Twelve 15-30 minute class periods.

Preparation

- Familiarize yourself with the information in the guide. Highlight the information and discussion questions on pages 25, 29, 35, 40, and 43 that you want to use with your students.
- Familiarize yourself with the materials included in the kit. Gather any materials needed for the activities using the materials chart on page 6.
- Prepare the cardboard box to look like a house before the *Solar House* activity (see page 44).
- Vocabulary cards related to solar energy can be found on pages 18-23. Copy the cards onto card stock and incorporate these into an existing energy word wall, or start a new one.

Grade Level

- Primary, grades K-2

Additional Resources

The following guides can be used to enhance and extend your solar energy unit and can be downloaded from shop.NEED.org:

- *Primary Energy Infobook*
- *Primary Energy Infobook Activities*
- *Energy Stories and More*
- *Energy Games and Icebreakers*

Web Resources

American Solar Energy Society
www.ases.org

Energy Schema Solar Energy Animations
www.NEED.org/solarmaterials

Energy Information Administration
www.eia.gov

EIA Energy Kids
www.eia.gov/kids

National Renewable Energy Laboratory
www.nrel.gov/solar

U.S. Department of Energy, Solar Energy
https://energy.gov/science-innovation/energy-sources/renewable-energy/solar

U.S. Department of Energy, Solar Energy Technologies Office
http://energy.gov/eere/solar/solar-energy-technologies-office

Activity 1: Light is Energy

Objectives

- Students will be able to describe activities that the sun's energy helps to occur.
- Students will be able to describe what their lives would be like without the sun.

Materials

- Sunny day

Time

- 20 minutes

Procedure

1. Begin a discussion with the class. Talk about day and night and how we must use artificial light at night to see. Compare cloudy and sunny days. Compare length of daylight in winter and summer. Explain how we can see when light bounces off objects and into our eyes. If we close our eyes, we can't see because no light can enter. What would our lives be like without the sun?
2. Turn off the lights in the classroom and observe the light from the sun. Close the blinds and observe how much harder it is to see clearly when there is less light.
3. Read pages 24 and 26 to the class, and discuss the concepts with students using page 25 as a guide.

Activity 2: Plant Investigation

Objectives

- Students will be able to make observations using their senses.
- Students will be able to explain that plants require sunlight to grow.

Materials

- 2 Small potted plants of the same variety that require bright sunlight
- Water
- Rulers
- Magnifying lenses (optional)
- *Plant Investigation Science Notebooks*, pages 45-47

Time

- 30 minutes + ongoing time for data collection

Preparation

- Make a *Plant Investigation Science Notebook* for each student using pages 45-47. Copy page 47 multiple times front to back to increase the number of observations your students will make.

Procedure

1. Show the plants to the students. Ask them to describe the plants. Talk about color, shape, height, and other plant characteristics. Record descriptive vocabulary on the board.
2. Ask the students, "What will happen if we place one plant in sunlight and one plant in the dark? What do you think will happen to the plants?" Let students share what they think will happen with a partner.
3. Pass out the *Plant Investigation Science Notebooks* you have constructed. Have students record their prediction on the first page. On the next page have students record Day 1 observations, drawing realistic pictures of the plants in their notebooks. Students should write individual words or complete sentences about their initial observations.
4. Put one of the plants in a location where it will receive direct sunlight. Put the other plant in a location where it will receive no light.
5. Explain to the students that the plants will be watered with the same amount of water, so the only thing different in the investigation is whether or not the plant is receiving light.
6. Students should record new observations in their *Plant Investigation Science Notebooks* every 2-3 days.

CONTINUED ON NEXT PAGE

7. Once there is a noticeable difference between the plants, discuss with students what has happened and why they think this is. Have students write conclusions in their *Plant Investigation Science Notebooks*.
8. Read pages 27-28 and 30-33 to the class, and discuss the concepts with students using page 29 as a guide.

Activity 3: The Radiometer

✪ Objectives

- Students will be able to describe how the sun's energy can make things move.
- Students will be able to describe how the position and motion of objects can be changed by pushing or pulling.

Materials

- Water
- Bright light source
- Radiometer
- *Radiometer* worksheet, page 48

Time

- 20 minutes

Preparation

- Make a copy of the worksheet for each student.

✔ Procedure

1. Show students the radiometer. Ask students, "What do you think will happen when we place the radiometer in the sun?"
2. Have them observe what happens when the radiometer is in the sunlight outside or in the bright light source.
3. Change the amount of sunlight hitting the radiometer and point out how the spinning slows as less radiant energy (light) hits the radiometer. Have students explain what is happening in their own words in their science notebooks, or using the *Radiometer* worksheet.
4. See page 32 for an explanation of how the radiometer works.

Activity 4: Reading a Thermometer

✪ Objectives

- Students will be able to explain that heat is energy.
- Students will be able to explain that a change in temperature indicates a change in the amount of thermal energy (heat) in a substance—the higher the temperature, the more energy.

Materials

- Large demonstration thermometer
- 10 Student thermometers
- *Reading a Thermometer* worksheet, page 49

Time

- 20 minutes

Preparation

- Divide the students into five groups.
- Set up five stations, each with two thermometers.
- Make a copy of the worksheet for each student.

CONTINUED ON NEXT PAGE

✔ Procedure

1. Give each student a copy of the *Reading a Thermometer* worksheet.
2. Use the large demonstration thermometer to show the students how to read a thermometer. Explain that the thermometer works because the liquid inside expands as its temperature increases. Understanding and recording the exact numbers is not important—the concepts of being able to measure temperature and compare temperatures are what should be emphasized.
3. Have the students shade or color the tubes of the thermometers on their worksheets to show the temperatures of their thermometers. All the thermometers should read the same room temperature. Discuss the possible causes of any discrepancies (faulty equipment, one in the sun and one in the shade, people handling the thermometer, etc.).

Activity 5: Light-to-Heat

✪ Objectives

- Students will be able to explain that heat is energy.
- Students will be able to describe how light is reflected or absorbed by certain objects, listing examples of items that do either.
- Students will be able to describe how colors can play a role in an item's absorption or reflection and temperature.
- Students will be able to explain that a change in temperature indicates a change in the amount of thermal energy (heat) in a substance—the higher the temperature, the more energy.

Materials

- 10 Student thermometers
- Black and white construction paper
- Scissors
- Tape
- Bright light source(s) or sunny day
- *Black and White* worksheet, page 50

Time

- 20 minutes

Preparation

- Divide the students into five groups.
- Label five thermometers "A" and five thermometers "B."
- Set up 5 stations, each with scissors, tape, and black and white paper. Each station should also include one thermometer labeled "A" and one labeled "B". Each station should also have access to a bright light source or the outside.
- Make a copy of the worksheet for each student.

✔ Procedure

1. Give each student a copy of the *Black and White* worksheet.
2. First, have each group determine and record the temperature of each thermometer on their individual sheets.
3. Instruct the groups to make small pouches with the construction paper and cover the bulbs of the thermometers as shown in the pictures on the worksheet.
4. Instruct the groups to put the thermometers in bright light for five minutes, then record the temperatures on their worksheets.
5. Discuss as a class the change in temperature for the A and B thermometers. Review the objectives above and allow students to record conclusions.

Activity 6: UV Beads

Objective

- Students will be able to describe how solar energy can cause changes (chemical) within objects.

Materials

- One solar bracelet for each student (UV beads and pipe cleaners)
- Sunny day
- Colored pencils or crayons
- *Color Changing Bracelet* worksheet, page 51

Time

- 30 minutes

Preparation

- If necessary, assemble a solar bracelet for each student in your class ahead of time. String approximately five UV beads onto a pipe cleaner and twist the ends together to make a loose fitting bracelet.
- Make sure the classroom blinds are closed so that there is little sunlight entering the room. The overhead lights may be on.
- Make a copy of the worksheet for each student.

Procedure

1. Have students assemble a solar bracelet using 5 UV beads and a pipecleaner or distribute a pre-made bracelet to each student. Say to the class, "The beads on the bracelet change color, can you find out how to make them change colors?"
2. When some of the students have figured out that the beads change color in sunlight, open the blinds or take the students outside to observe the colors of the beads in sunlight.
3. Have students record their observations using color in their science notebooks, or on the *Color Changing Bracelet* worksheet.
4. Read page 34 to the class using page 35 as a guide.

Extensions

- Investigate how well your sunglasses block UV rays. Put two solar beads under a pair of sunglasses. If the beads change to a bright color, UV rays are getting through the lens and not protecting your eyes from UV rays.
- Investigate how well your sunscreen protects your skin from UV rays. Place two beads in a sealable plastic sandwich bag. Coat the outside of the bag with sunscreen. If the beads change to a bright color, the sunscreen is not working. If the beads do not change colors, the sunscreen is working. If your sunscreen is not working, check the expiration date. Sunscreen does expire.
- Track the UV report each day from your local news, or from EPA's UV Index page at www.epa.gov/sunwise/sunsafety.

Activity 7: NaturePrint® Paper

Objective

- Students will be able to describe how solar energy can cause changes (chemical) within objects.

Materials

- 1 Piece of NaturePrint® Paper for each student
- Tub of water
- Sunny day
- *NaturePrint® Paper* worksheet, page 52

Time

- 30 minutes

Preparation

- Fill a tub or container with warm water.
- Make a copy of the worksheet for each student.

CONTINUED ON NEXT PAGE

✔ Procedure

1. Take the students outside on a bright, sunny day to a large, flat area. Instruct each student to find a leaf with an interesting shape, a twig, or other small, flat natural object with which to make a print. (You can also have students cut designs from construction paper before going outside.)
2. Distribute one piece of NaturePrint® Paper to each student. Instruct the students to place their paper flat on the ground and place their objects in the center of the paper—and then not to move them. Direct the students to observe the color of the paper that is exposed to the sun for two to three minutes, until it fades to a pale blue.
3. Take the papers inside quickly without further exposing them to direct sunlight. Soak the papers in a container of water for one minute and lay flat to dry. Observe the image on the paper.
4. Students should describe how solar energy was used to make a design on their paper in their science notebooks, or using the *NaturePrint® Paper* worksheet. When their NaturePrint® Papers are dry, students can glue them into their science notebooks, or onto the worksheet in the space provided.

Activity 8: Solar Balloon

✪ Objectives

- Students will be able to explain that heat is energy.
- Students will be able to describe how light is reflected or absorbed by certain objects, listing examples of items that do either.
- Students will be able to describe how colors can play a role in an item's absorption or reflection and temperature.
- Students will be able to explain that a change in temperature indicates a change in the amount of thermal energy (heat) in a substance—the higher the temperature, the more energy.
- Students will be able to describe that heat rises, because as items heat up they expand and float or rise.

Materials

- Solar balloon with string
- Sunny day
- *Solar Balloon* worksheet, page 53

Time

- 30 minutes

Preparation

- Make a copy of the worksheet for each student.

✔ Procedure

1. Take the students outside on a bright, sunny day.
2. Tie off one end of the solar balloon with a small piece of the string.
3. Line up your class in two rows. Have them stand facing each other with their arms held out in front of them and the balloon on top of their arms. Open the other end of the balloon and air will flow inside. When the balloon is full, tie off the open end of the balloon.
4. Tie two strings (each about four meters—or twelve feet—long) to the ends of the balloon and put the balloon in the sun. Secure the balloon to a stationary object, or let students hold onto the strings.
5. Watch as the balloon rises. Explain to the students that the air inside the balloon heats up and expands. It becomes less dense than the air around it, causing the balloon to rise.
6. Have students record their observations in their science notebooks, or on the *Solar Balloon* worksheet.

Activity 9: Solar Oven

✪ Objectives

- Students will be able to describe how light is reflected or absorbed by certain objects, listing examples of each.
- Students will be able to describe how reflected light can be concentrated on an object to perform a task like cooking or lighting fires.

Materials

- 1 Solar oven
- Oven thermometer
- 1 Package of refrigerated cookie dough or other food to cook
- Plate or pan to cook on
- Plastic wrap
- Sunny day
- *How to Use a Solar Oven* worksheet, page 54

NOTE: Dark plates or pans may work more efficiently for cooking.

Time

- 20+ minutes as needed

Preparation

- Make a copy of the worksheet for each student.
- Select a sunny day to complete the activity. For some climates it may be helpful to set up the oven ahead of time to allow the oven to pre-heat or give the food a head start to cook.

✔ Procedure

1. Read pages 36-39 to the class. Discuss concepts with students using page 40 as a guide.
2. Arrange small portions of the food on the plate or pan.
3. Take the students outside on a bright, sunny day. Set up the solar oven and place the pan of food inside. Place the oven in the sun so that the light is focused on the food.
4. Cover the oven with plastic wrap and periodically observe the food as it bakes. Use the thermometer to measure oven temperature. Allow the students to sample the food when they are finished.
5. Have students write an expository piece explaining how to use a solar oven using the worksheet. Make sure their written work includes transition words such as first, next, and last.

Extension

- Have your students make their own solar ovens. Use *How to Make a Pizza Box Solar Oven* on page 16 to lead your students in this activity. Parent helpers may be helpful if students must do any cutting.

Activity 10: Solar House

✪ Objective

- Students will be able to describe what a solar cell looks like and that when sunlight hits the solar cell, electricity is generated.

Materials

- Cardboard box
- Bright light source or sunny day
- Scissors
- Transparency film or plastic wrap
- Tape
- Clay
- Solar house kit
- *Solar House* worksheet, page 55

Time

- 20 minutes

CONTINUED ON NEXT PAGE

Preparation

- Prepare the cardboard box to look like a house and follow the steps on page 44 to set up the house.
- Make a copy of the worksheet for each student.

✔ Procedure

1. Read pages 41-42 to the class. Discuss the concepts using page 43 as a guide.
2. Show the students the solar cell and explain that it turns sunlight into electricity.
3. Put the solar cell on the cardboard box and hook it up to the fan motor and light, as shown in the diagram on page 44. Explain to students how you constructed the house.
4. Place the solar house in bright light and allow the students to observe the fan turning and the light shining inside.
5. Vary the amount of light hitting the solar cell and the angle of light and have the students observe the speed of the fan.
6. Discuss other electrical items that electricity from the solar cell might operate—at home and at school.
7. Have students write about the solar house in their science notebooks or on the *Solar House* worksheet.

Extension

- Assign students to design and/or build their own solar home. Students will need to explain how their house will use as much solar energy as possible.

Activity 11: Solar Cells (optional)

Objective

- Students will be able to describe what a solar cell looks like and that when sunlight hits the solar cell, electricity is generated.

✔ Procedure

1. Take the students to see a working solar panel. If you have solar panels on your school, show the cells and monitoring equipment to the students and discuss what they do.
2. Have students write and/or draw how the solar panel works.

☑Reflection, Assessment, and Evaluation

Materials

- *Evaluation Form,* page 59

Time

- 20 minutes

✔ Procedure

1. Ask the students, "How do you know the sun is energy?" Have students share their learning in groups or on chart paper.
2. Discuss that energy causes change and does work, and the types of change and work they learned about and observed the sun doing over the last two weeks.
3. Have students write about what the sun's energy does. Compile the writings and make a class book about solar energy.
4. Assess student writing and work using the skills checklist on page 15.
5. Complete the unit *Evaluation Form* with the students and return the form to NEED as indicated.

Science Notebook Skills Checklist

Designed to be a formative assessment tool, you may find this checklist useful as you work with students. Put all of your students' names down the left hand side. When you look at a child's worksheets or science notebook and see a skill demonstrated, put a dot in the box. Decide how many times (typically 3–5) you want to see the student use the skill independently before checking off the box as a sign that the student has mastered this skill.

Student Name	**Drawings**	Picture is realistic (colors, shape, size)	Includes appropriate labels	**Notes and Observations**	Uses senses to record observations	Observations are "big picture"	Observations focus on details	**Graphs and Charts**	Data is accurate	Includes appropriate labels	Clear presentation	**Communication**	Communicates verbally	Communicates in writing	Makes predictions	Makes predictions with reasoning	Uses evidence to support reasoning	Compares and contrasts	Communication is personal

How to Make a Pizza Box Solar Oven

Materials

- 1 Small pizza box
- Plastic wrap
- Aluminum foil
- 1 Wood skewer
- Marker
- Ruler
- Scissors
- Tape
- 1 Sheet black construction paper
- Food to cook
- Paper plate

✔ Procedure

1. On the top (lid) of the pizza box, use a marker to draw a square one inch from all sides of the box. See Diagram 1.
2. Use scissors to cut along the front and sides of the square you just drew. Leave the fourth side along the box's hinge uncut, as indicated on Diagram 1.
3. Tape aluminum foil to the inside surface of the new flap you just cut, with the shiny side visible. Smooth out any wrinkles. See Diagram 2.
4. Tape plastic wrap over the hole you cut into the lid. Seal all four of the edges with tape. See Diagram 2.
5. Open the entire box lid and tape black construction paper to the bottom of the inside of the box to help absorb the incoming sunlight. See Diagram 2.
6. Cover any air leaks around the box edges with tape. Make sure that the box can still be opened to place food inside or remove it later.
7. Go outside in the sunlight and place the box on a flat, level surface.
8. Place food on a paper plate and place inside the oven.
9. Tape one end of the skewer to the reflector lid, and attach the other end to the pizza box to adjust the reflector. See Diagram 3.
10. Let food cook, and check the reflector angle periodically to make sure sunlight is getting inside the solar oven.

Diagram 1

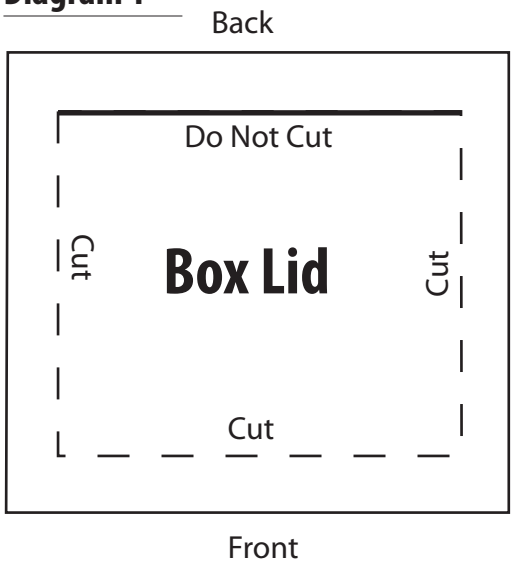


Diagram 2

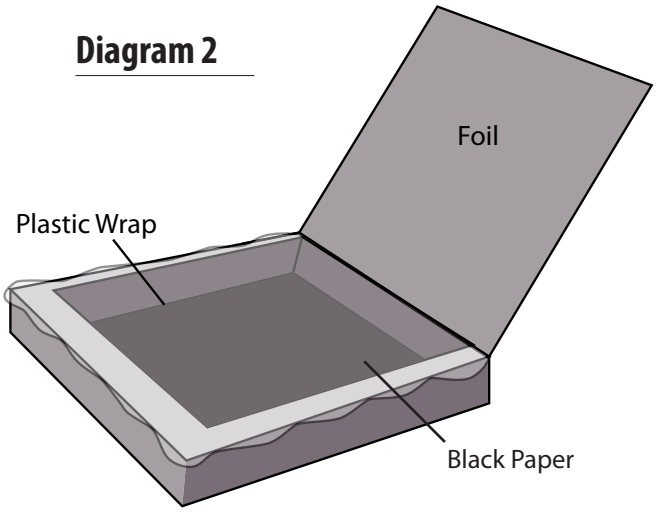
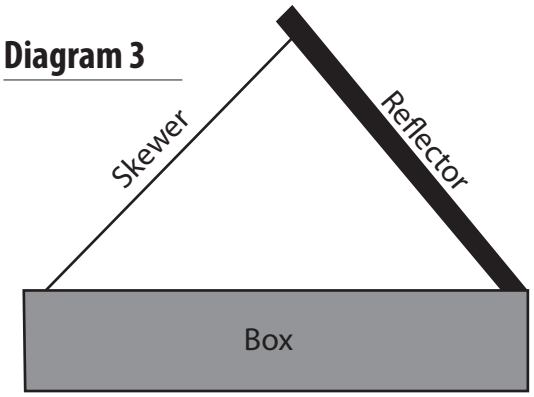


Diagram 3



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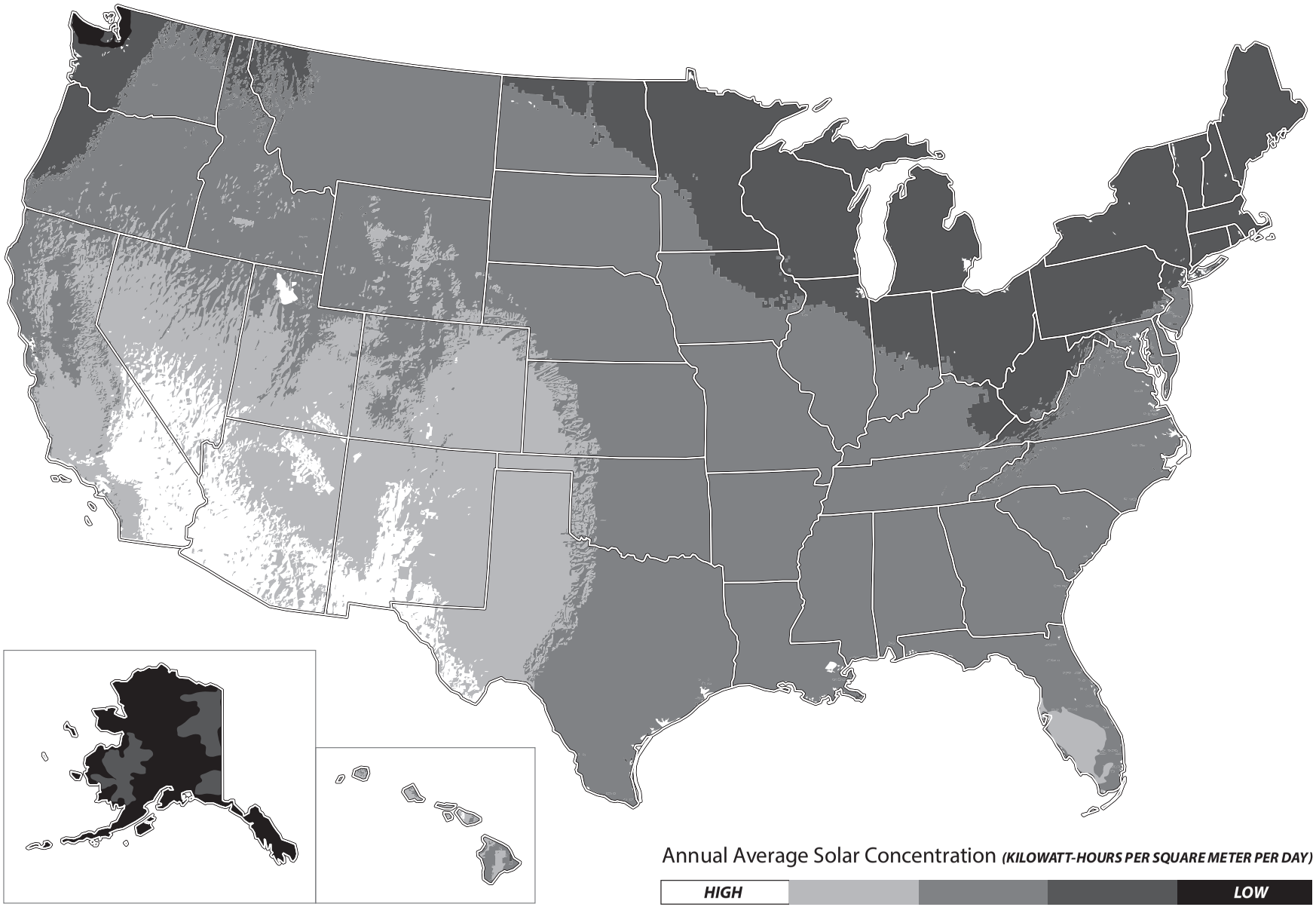
Annual Average Solar Concentration



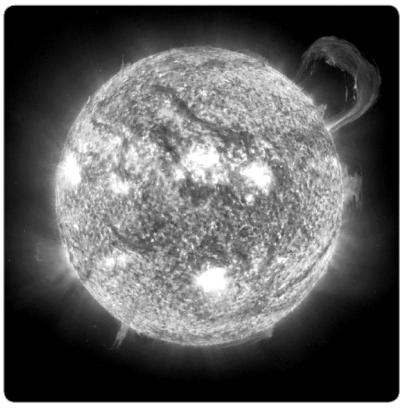
Annual Average Solar Concentration *(KILOWATT-HOURS PER SQUARE METER PER DAY)*

HIGH				LOW
More than 6	5 to 6	4 to 5	3 to 4	Less than 3

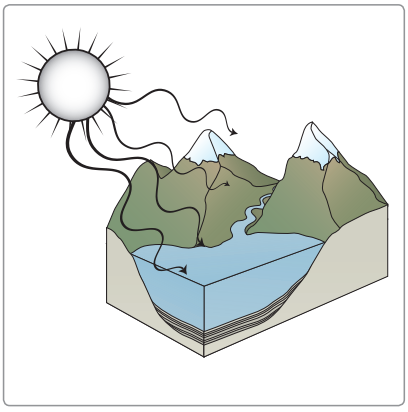
Note: Alaska and Hawaii not shown to scale
Data: NREL

sun

solar energy



radiant energy



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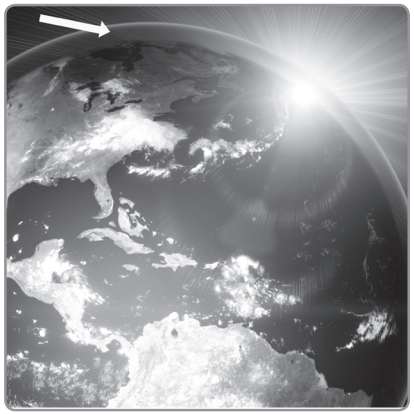
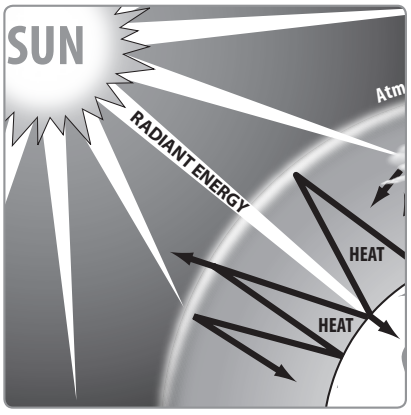
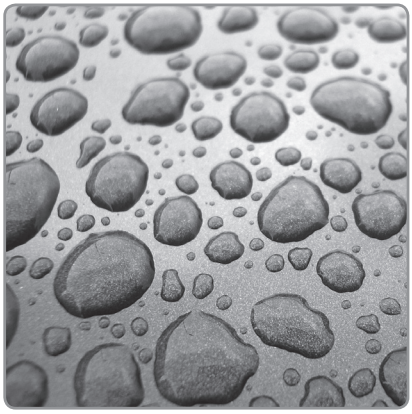
atmosphere



greenhouse effect



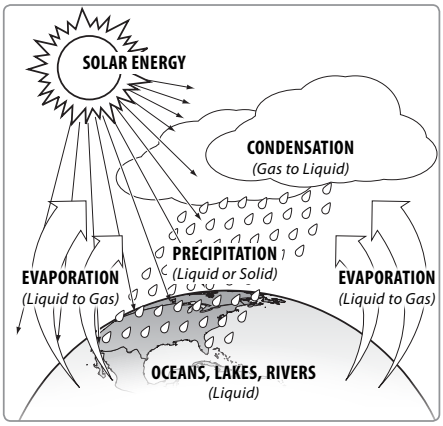
condensation



precipitation

evaporation

water cycle



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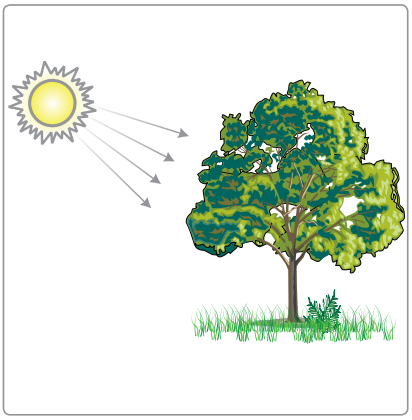
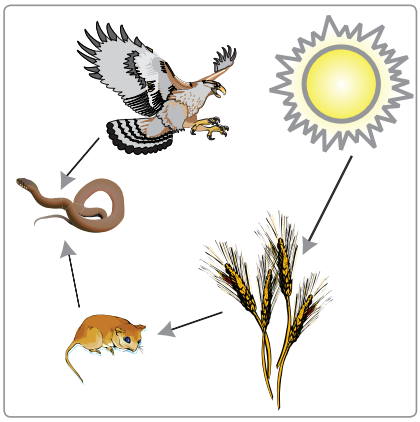
wind

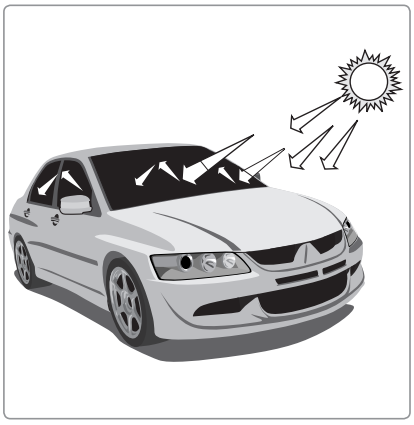
photosynthesis



food chain

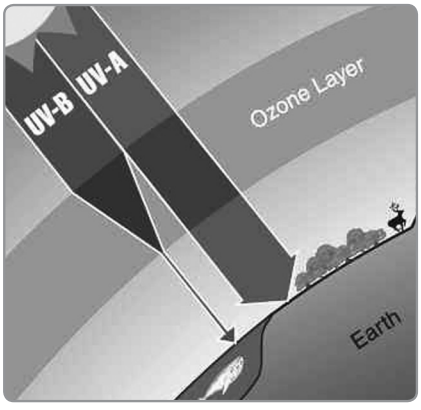


solar collector



photovoltaic (PV) cell

ultraviolet radiation



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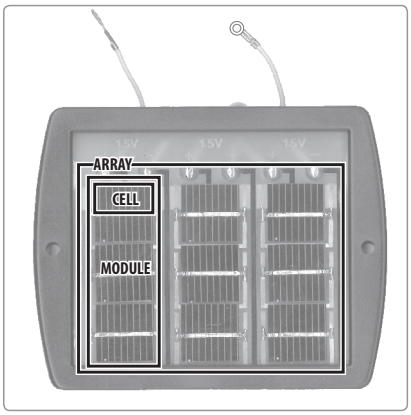
PV module



PV panel

energy

The Sun and Its Energy

Some of the sun's energy reaches Earth. Most of it goes into space. Image courtesy of NASA

The sun sends out light all of the time. The sun's light is called solar energy, or radiant energy.

Most of the sun's energy goes into space. Some of the energy from the sun reaches Earth.

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Solar Energy

The Earth gets most of its energy from the sun. We call this energy solar energy. *Sol* means sun. Solar energy travels from the sun to the Earth in rays. Some are light rays that we can see. Some are rays we cannot see, like x-rays. Energy that travels in rays is called radiant energy.

Like all stars, the sun is a giant ball of gas. It sends out huge amounts of radiant energy every day. Most of the rays travel into space. Only a small portion reaches the Earth.

When the rays reach the Earth, some bounce off clouds back into space—the rays are reflected. The Earth absorbs most of the solar energy and turns it into heat. This heat 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.

The sun's energy can be converted, or changed, to heat. People, animals, and plants can live on Earth because it is just the right temperature for life.

More Information

Every day, the sun radiates (sends out) an enormous amount of energy. It radiates more energy in one day than the world uses in a year. This energy comes from within the sun itself. Like most stars, the sun is a big gas ball made up mostly of hydrogen and helium atoms. The sun makes energy in its inner core through a process called nuclear fusion.

During nuclear fusion, the high pressure and temperature in the sun's core cause hydrogen (H) atoms to come apart. Hydrogen nuclei (the centers of the atoms) combine, or fuse, to form one helium atom. During the fusion process, radiant energy (light) is produced.

It can take 150,000 years for the radiant energy in the sun's core to make its way to the solar surface, and then just a little over eight minutes to travel the 93 million miles to Earth. The radiant energy travels to the Earth at a speed of 186,000 miles per second, the speed of light.

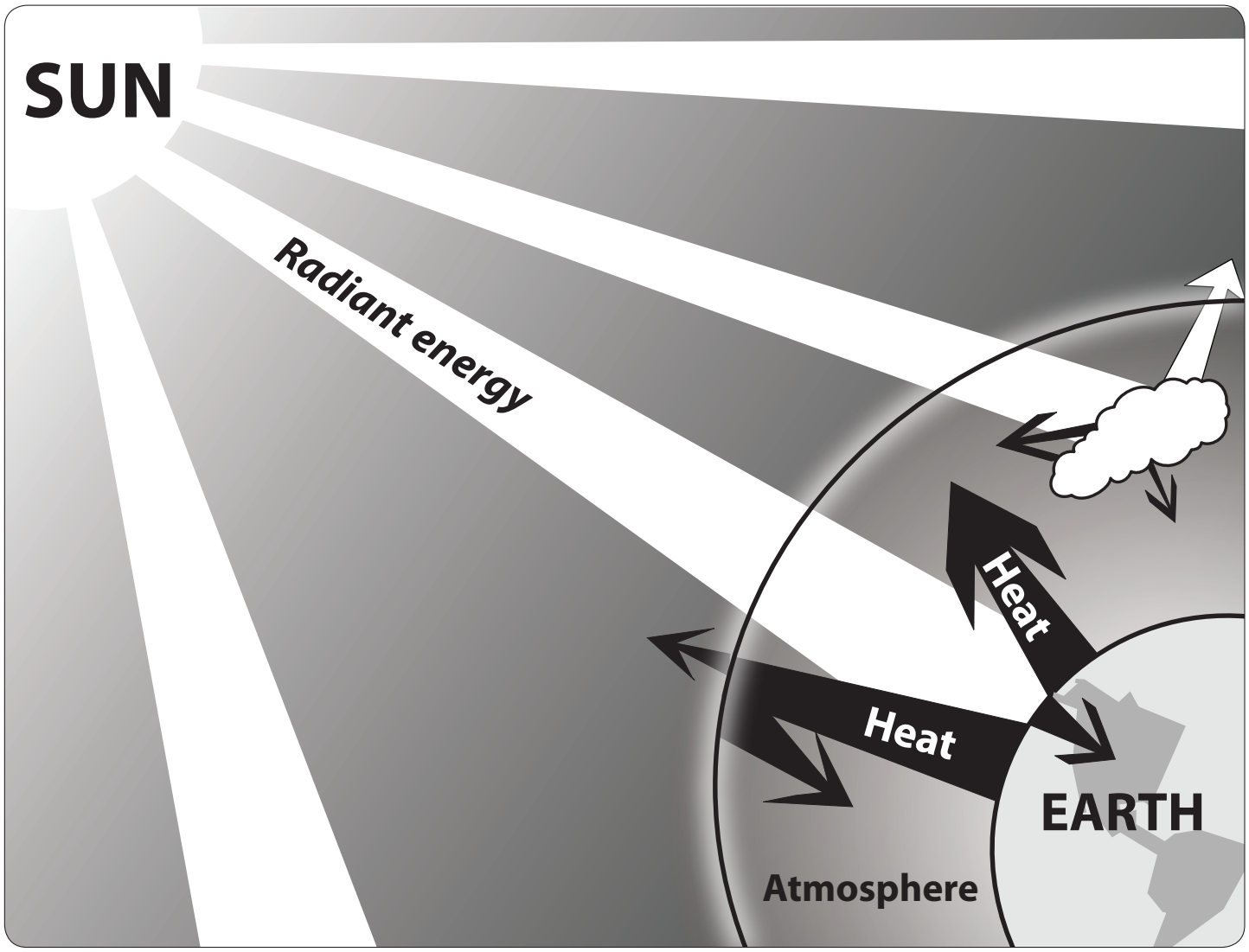
Only a small portion of the energy radiated by the sun into space strikes the Earth, one part in two billion. Yet this amount of energy is enormous. The sun even provides more energy in an hour than the United States uses in a year. About 30 percent of the radiant energy that reaches the Earth is reflected back into space. Another 25 percent is used to evaporate water, which is lifted into the atmosphere and produces rainfall. Radiant energy is also absorbed by plants, the land, and the oceans.

Discussion Questions

1. How do we know the light from the sun is energy? *(Energy makes change or gives us the ability to do work. The light from the sun allows us to see—without light it would be dark—light is a change—it is energy. We can feel it when it touches our skin—the light energy turns into heat—that is a change. We know it makes plants grow—growth is a change—plants die without the energy in sunlight.)*

2. What would the Earth be like without the sun? *(The Earth would be very cold with no living things. There would be no water cycle, no wind.)*

Greenhouse Effect



Some of the sun's energy that reaches Earth is transformed from light to heat. The atmosphere traps the heat and keeps our planet warm. This is called the greenhouse effect.

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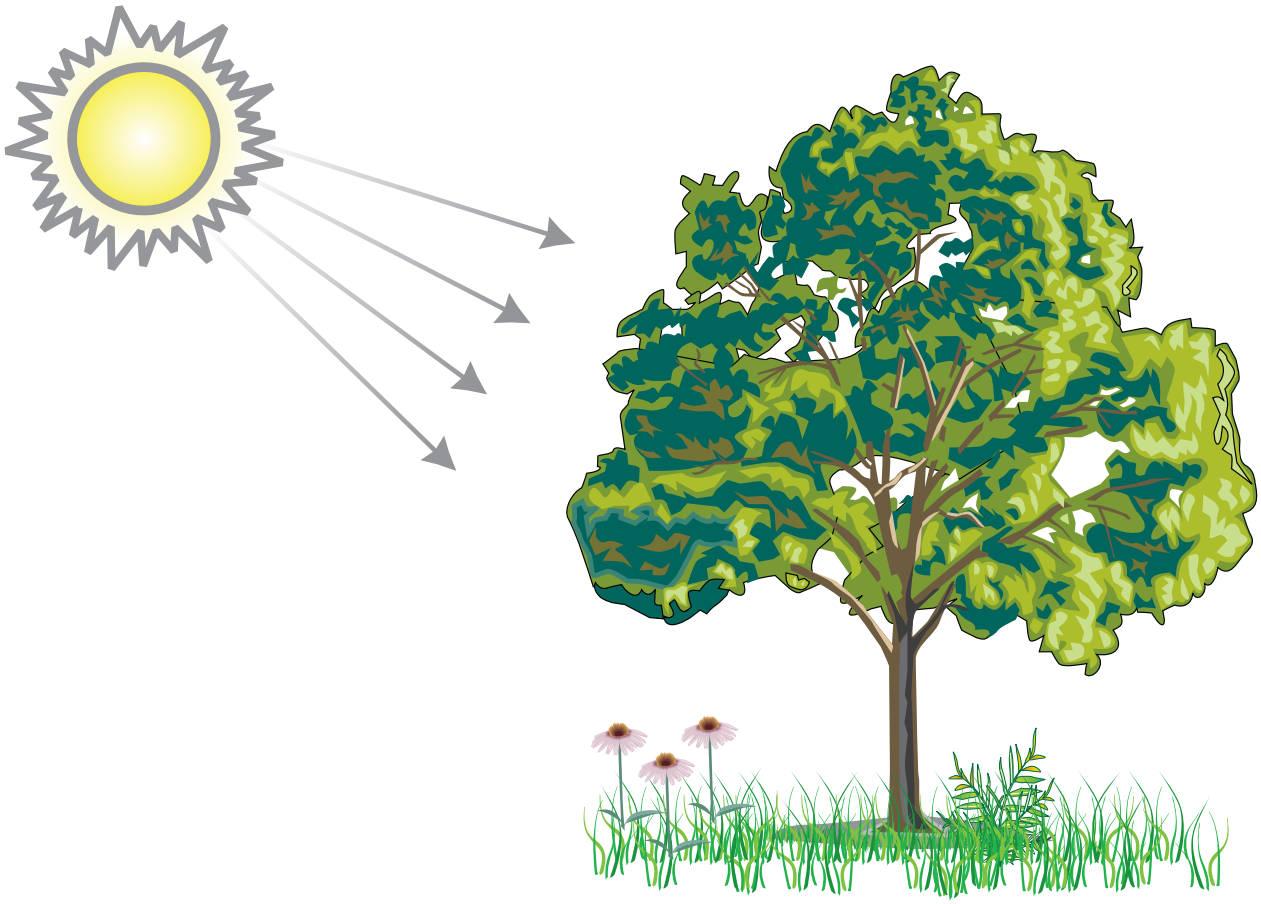
Nature Uses Solar Energy

The sun is very important to nature.

Photosynthesis



Plants turn sunlight into sugars. This provides energy for the plants to grow. Plants store the sugars in their leaves, stems, fruits, and roots.

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Using Solar Energy

We Use Solar Energy In Many Ways

We use solar energy in many ways. During the day, we use sunlight to see what we are doing and where we are going.

Plants use the radiant energy (light) from the sun to grow. Plants absorb the radiant energy and turn it into glucose or simple sugars. The plants keep some of the sugars in their roots, stems, fruits, and leaves. It is chemical energy. The energy stored in plants feeds every living thing on the Earth. When we eat plants, and food made from plants, we store the energy in our 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 the energy for everything we do.

The energy in the meat we eat also comes from plants. Animals eat plants to grow. They store the energy in their bodies.

We also use the energy stored in plants to make heat. We burn wood in campfires and fireplaces. Early humans used wood to cook food, scare away wild animals, and keep warm.

Solar energy turns into heat when it hits objects. That is why we feel warmer in the sun than in the shade. The light from the sun turns into heat when it hits our clothes or our skin. We use the sun's energy to cook food and dry our clothes.

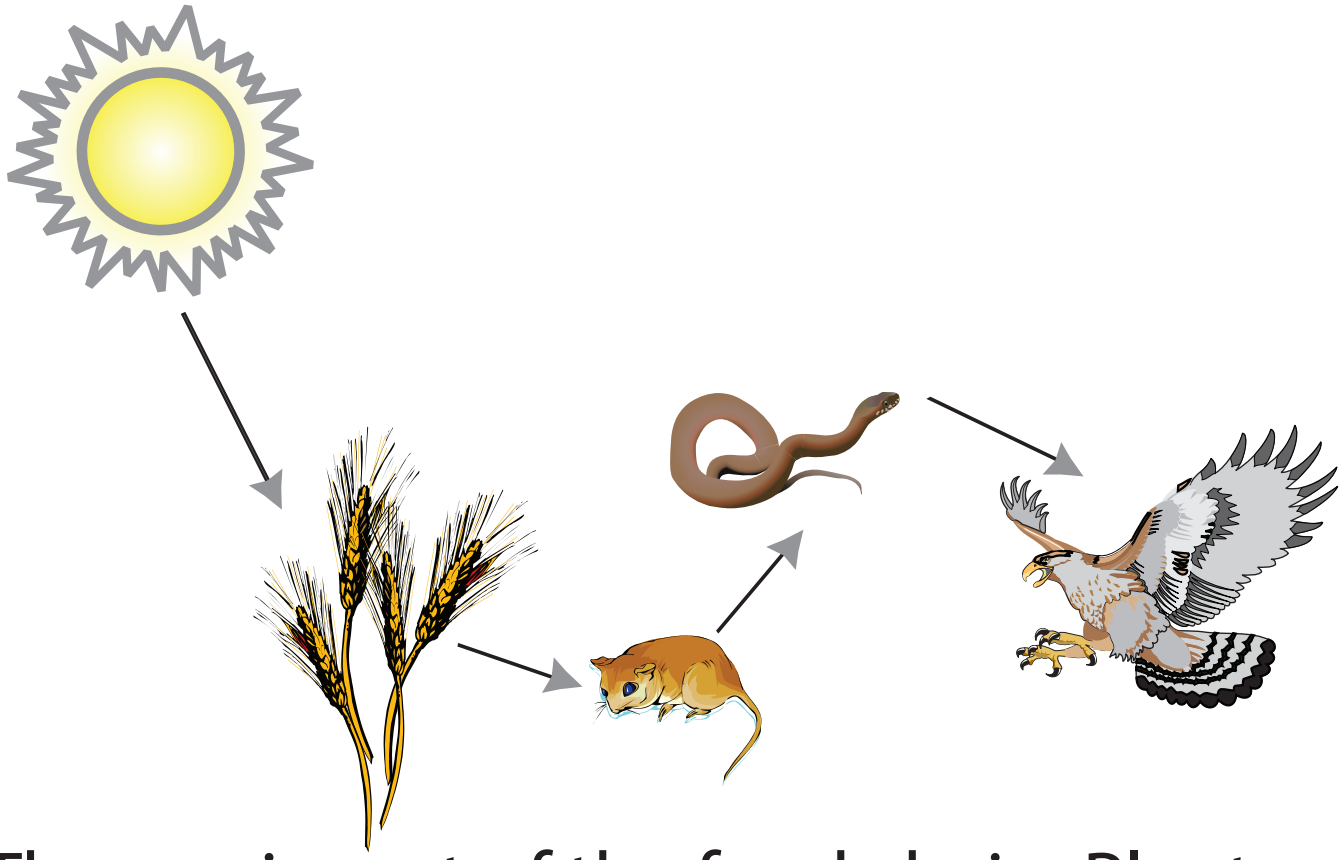
Solar energy powers the water cycle. The water cycle is how water moves from clouds to the Earth and back again. The sun heats water on the Earth. The water evaporates—it turns into water vapor and rises into the air to form clouds. The water falls from the clouds as precipitation—rain, sleet, hail, or snow. When the precipitation falls to Earth, gravity pulls it to lower ground. There is energy in the moving water.

Solar energy makes the winds that blow over the Earth. The sun shines down on the land and water. The land heats up faster than the water. The air over the land gets warm. The warm air rises. The cooler air over the water moves in where the warm air was. This moving air is wind.

Discussion Questions

1. What are some foods made from plants? *(Breads, pastas, rice, vegetables, fruits, etc.)*
2. How does the energy in a hamburger come from the sun? *(A hamburger is made from beef from a cow that ate grass—the grass absorbed energy from the sun.)*
3. Should you wear a white shirt or a black shirt on a hot, sunny day? *(A white shirt—dark colors absorb more light energy and turn it into heat.)*

The Food Chain



The sun is part of the food chain. Plants can turn sunlight directly into food, but animals cannot.

A mouse gets its energy from the plant, which got its energy from the sun. A snake gets its energy by eating the mouse. A hawk gets its energy by eating the snake. The sun's energy flows through them.

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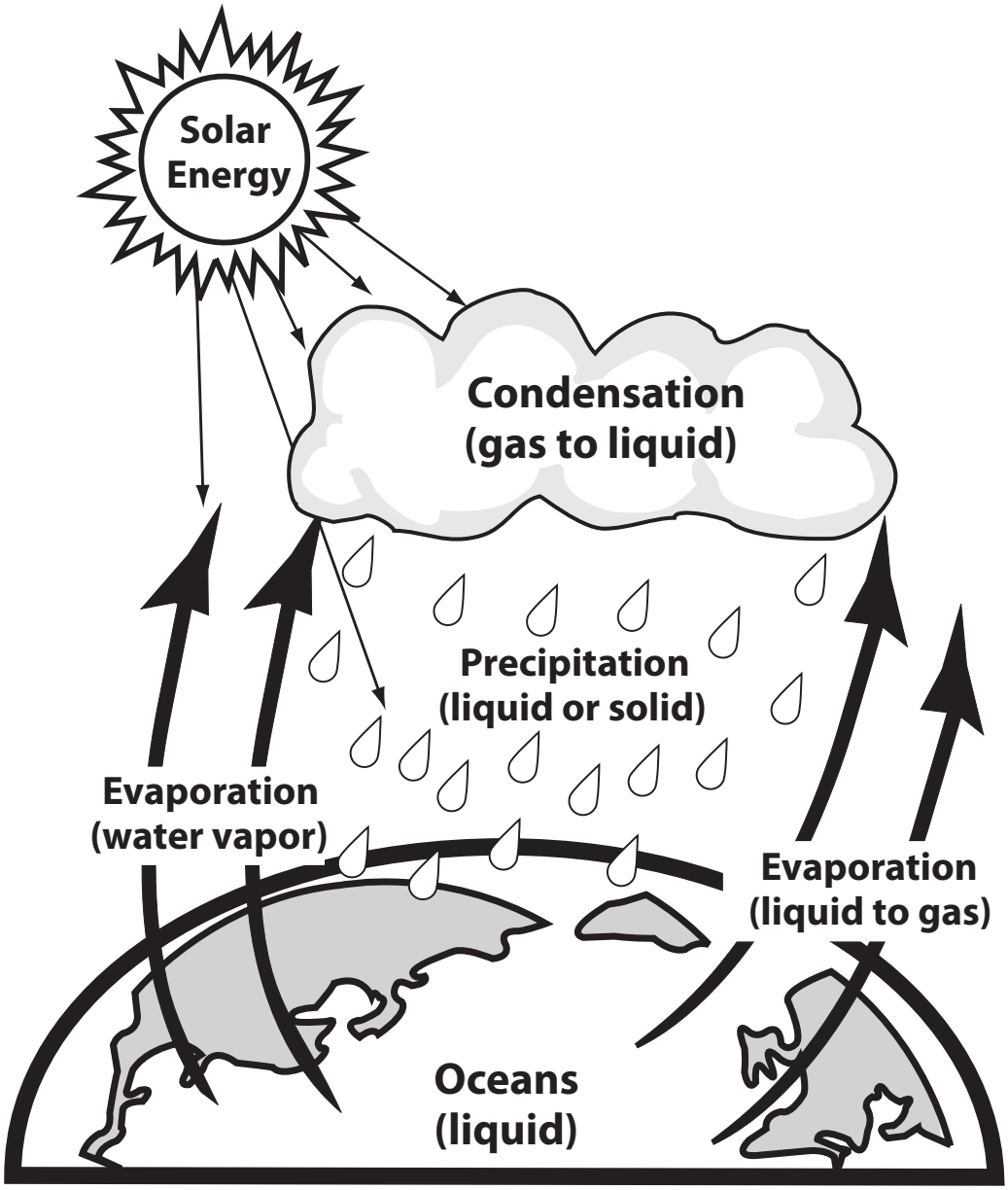
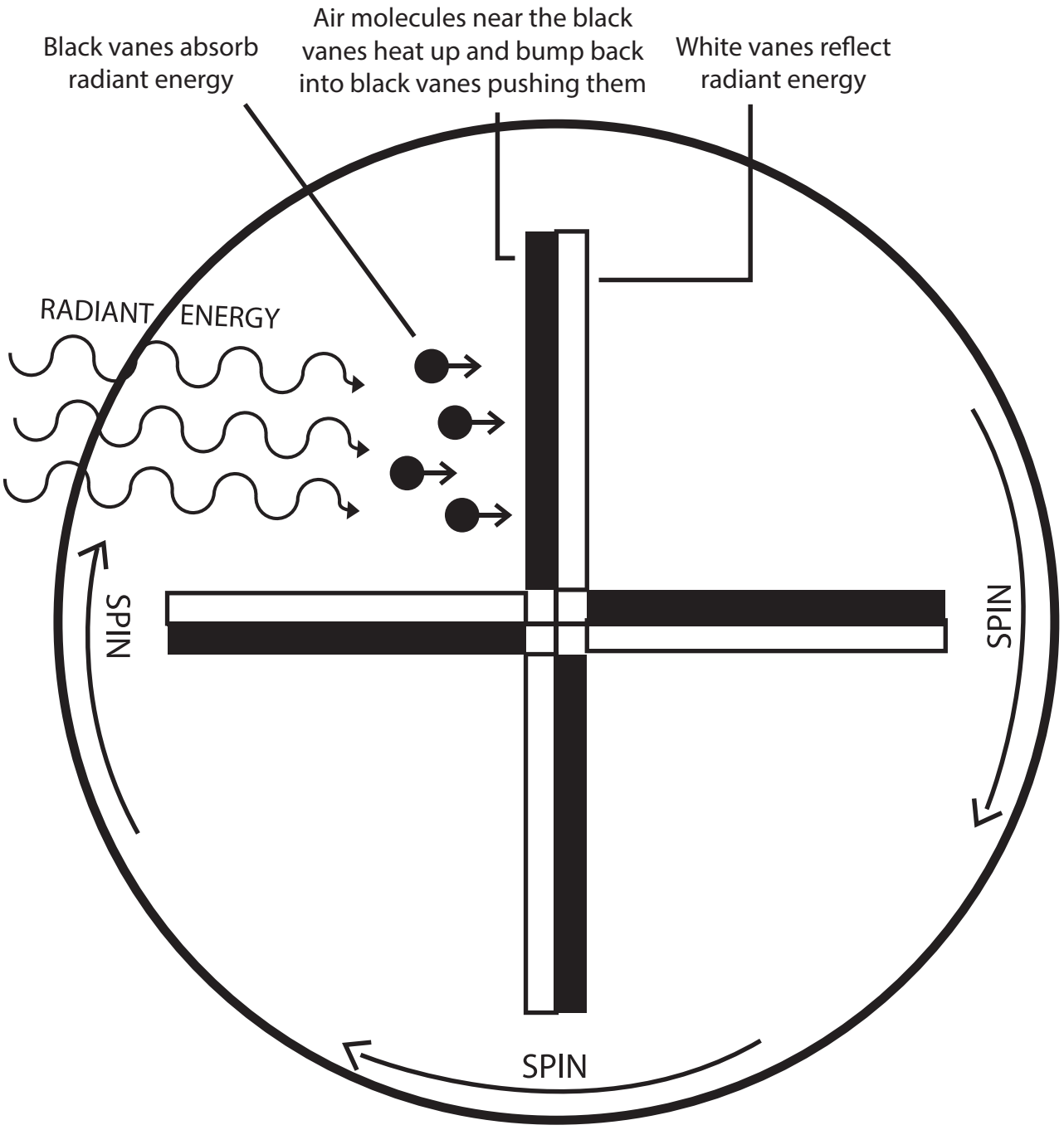
The Water Cycle



The sun is important to the water cycle. Solar energy causes water to evaporate.

Top View of Radiometer



When the air molecules hit the white sides of the vanes, they push a little. When the air molecules hit the black sides of the vanes, they push a lot. Since there is more of a push on one side than the other, the vanes begin to turn.

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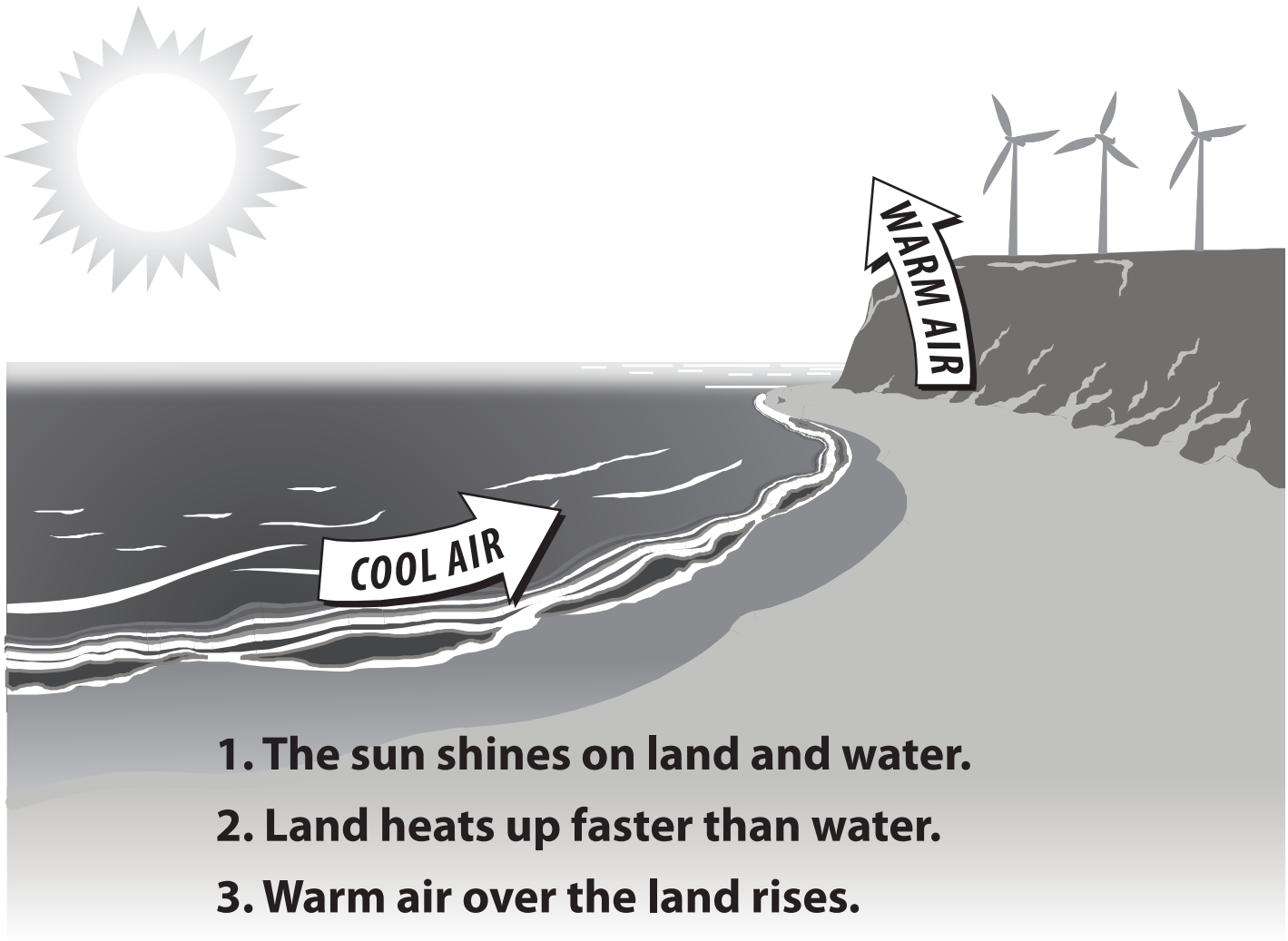
How Wind is Formed



1. The sun shines on land and water.
2. Land heats up faster than water.
3. Warm air over the land rises.
4. Cool air over the water moves in.

Solar energy causes wind to form.

Ultraviolet Radiation

The sun's energy travels in rays or waves. This is called radiation. The sun's waves have different lengths and different names. One type of wave is called ultraviolet, or UV radiation.

Too much UV radiation is harmful. It can damage your eyes, cause your skin to burn, or make you sick. We need to protect ourselves from UV radiation.

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Ultraviolet Radiation

The sun's energy travels in waves. The movement of energy in waves is called radiation. There are many types of radiation. Some radiation helps us see, some radiation you can feel, and some you cannot see or feel. One type of radiation is ultraviolet (UV) radiation. UV radiation has a shorter wavelength and higher energy than visible light. You cannot see or feel UV radiation.

More Information

There are three types of UV radiation—UVA, UVB, and UVC. The ozone layer absorbes some of the UV radiation before it reaches the Earth. UVC is completely absorbed by the ozone layer and atmosphere, so people don't need to worry about its effects. However, both UVA and UVB reach the Earth's surface. UVA radiation levels are more constant year round. The amount of UVB reaching the surface varies greatly depending on the time of day, time of year, latitude, altitude, weather conditions, and reflection of the surface in your location.

The National Weather Service and the Environmental Protection Agency developed the UV Index. This index indicates the strength of UV radiation on a scale from 1 to 11+, with 1 being low, and 11 being extremely high. UV Index forecasts are often published in newspapers in the weather section. You can also enter your zip code to obtain the UV forecast for your area or download the EPA's free UV Index Smartphone app at https://www.epa.gov/sunsafety.

Overexposure to UV radiation can cause skin damage, including skin cancer, eye damage, and other health problems. However, students, and adults, should not let concerns over UV radiation stop them from going outside. Proper protection from UVA and UVB radiation allows everyone to enjoy the outdoors without worry.

Steps you can take to protect yourself from overexposure to UV radiation are:

- Check the UV Index forecast. Even on cloudy days you can get a sunburn.
- Generously apply sunscreen so you do not burn.
- Wear protective clothing and sunglasses.
- Seek shade, especially when the sun's UV rays are strongest between 10 a.m. and 4 p.m.
- Be extra careful near water, snow, and sand, which have high reflective properties.

Discussion Question

1. What do you do to protect yourself from UV radiation? *(Wear sunscreen, sunglasses, hat, protective clothing, seek shade, etc.)*

Note: Information for this section has been taken from the U.S. Environmental Protection Agency. For more information, visit https://www.epa.gov/sunsafety.

People Use Solar Energy

We use solar energy for many things.

Solar energy provides light so we can see during the day.

We can dry clothes with solar energy.

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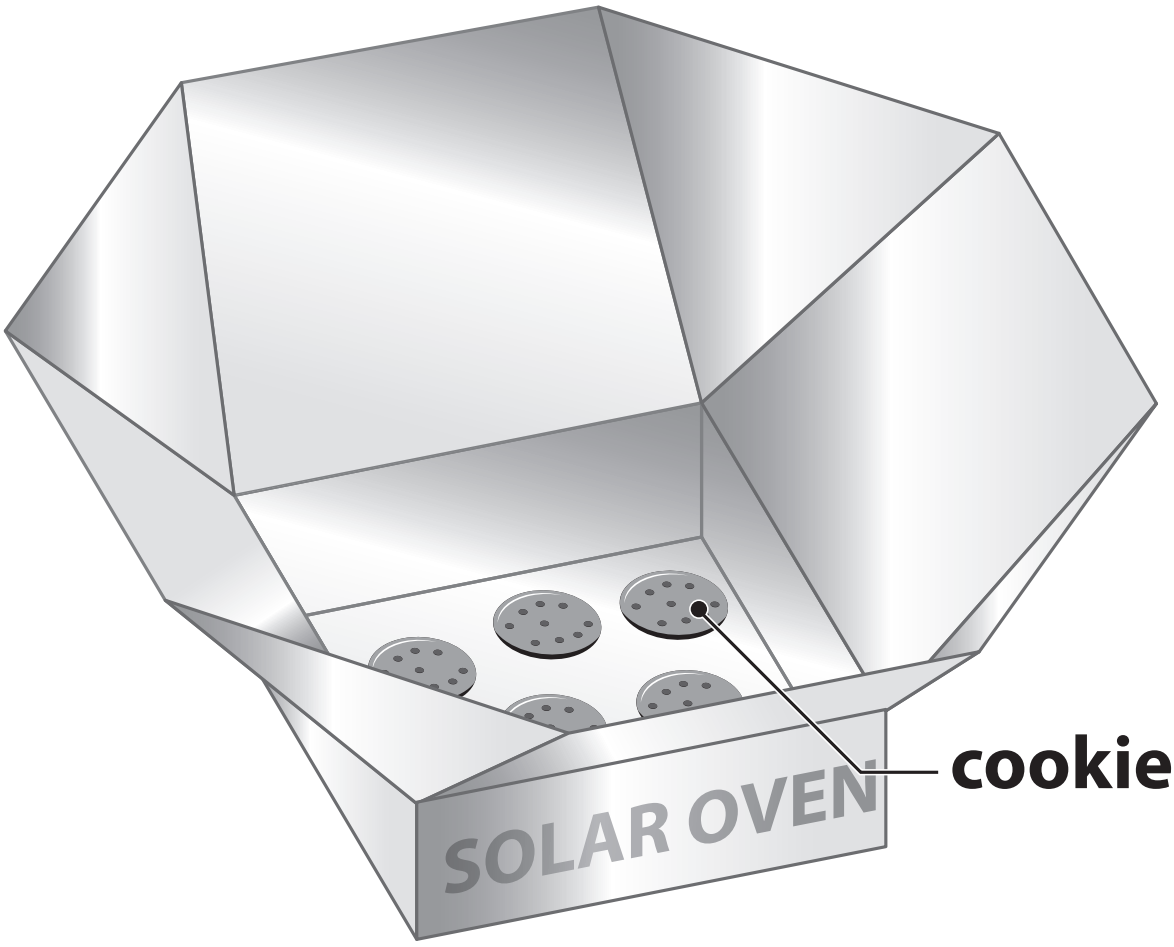
We burn plants like wood to turn their energy into heat.

We eat plants that have stored solar energy.

Solar Oven



We can cook food with solar energy.

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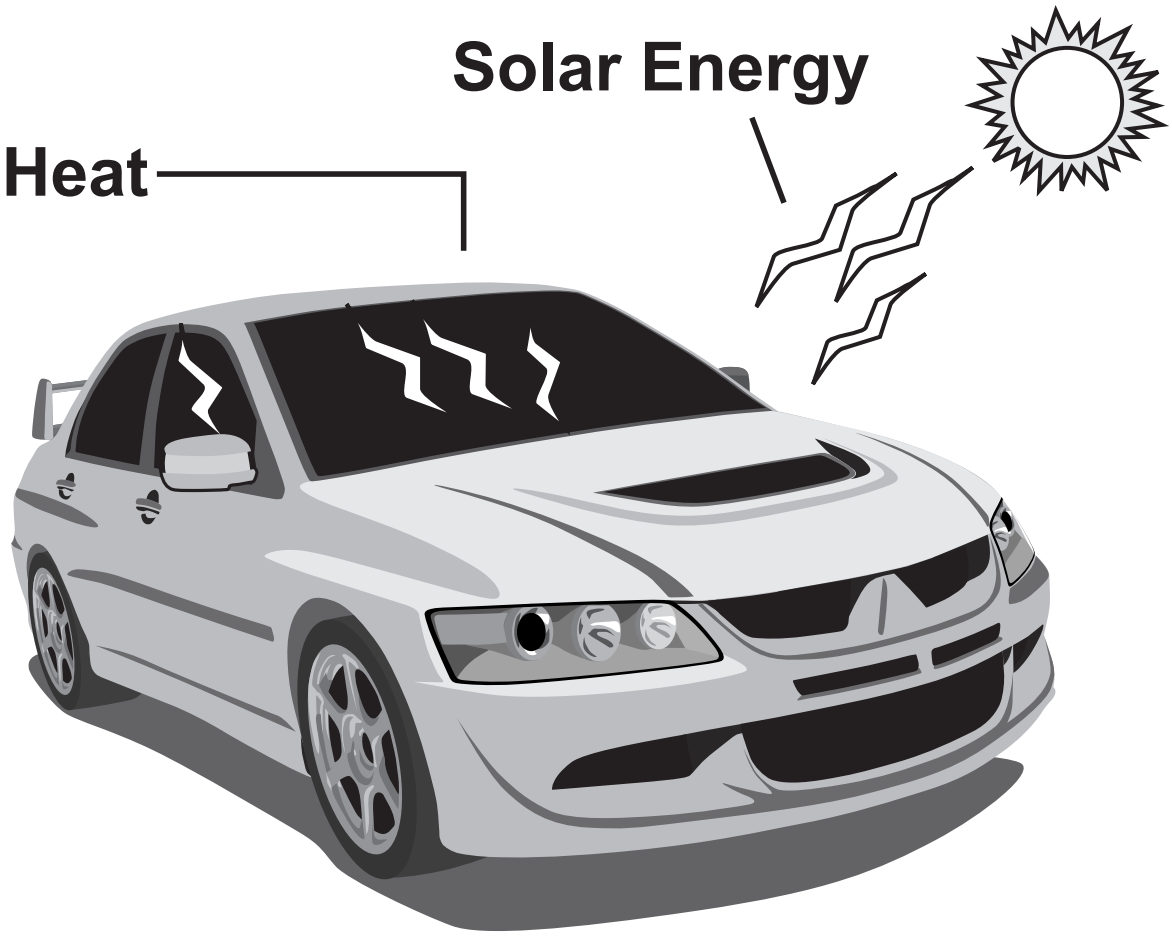
Solar Collector



Light from the sun passes through the window and hits the inside of the car. It turns into heat and is trapped inside.

Collecting Solar Energy

Why don't we use the sun for all our energy needs? We don't know how to yet. The hard part is capturing the energy. Only a little bit reaches any one place. On a cloudy day, most of the solar energy never reaches the ground at all.

Lots of people put solar collectors on their roofs. Solar collectors capture the energy from the sun and turn it into heat. People can heat their houses and water using solar energy.

More Information

Heating with solar energy is not as easy as you might think. Capturing sunlight and putting it to work is difficult because the solar energy that reaches the Earth is spread out over a large area. The amount of solar energy an area receives depends on the time of day, the season of the year, the cloudiness of the sky, and how close it is to the Earth's Equator.

A solar collector is one way to capture sunlight and change it into usable heat energy. A closed car on a sunny day is like a solar collector. As sunlight passes through the car's windows, it is absorbed by the seat covers, walls, and floor of the car. The absorbed energy changes into heat. The car's windows let radiant energy in, but they do not let all the heat out.

Space heating means heating the space inside a building. Today, many homes use solar energy for space heating. A passive solar home is designed to let in as much sunlight as possible. It is like a big solar collector. Sunlight passes through the windows and heats the walls and floor inside the house. The light can get in, but the heat is trapped inside. A passive solar home does not depend on mechanical equipment, such as pumps and blowers, to heat the house.

An active solar home, on the other hand, uses special equipment to collect sunlight. An active solar home may use special collectors that look like boxes covered with glass. These collectors are mounted on the rooftop facing south to take advantage of the winter sun. Dark-colored metal plates inside the boxes absorb sunlight and change it into heat. (Black absorbs sunlight better than any other color.) Air or water flows through the collector and is warmed by the heat. The warm air or water is distributed to the rest of the house, just as it would be with an ordinary furnace system.

Solar energy can be used to heat water. Heating water for bathing, dishwashing, and clothes washing is the second biggest home energy cost. A solar water heater works a lot like solar space heating. In our hemisphere, a solar collector is mounted on the south side of a roof where it can capture sunlight. The sunlight heats the water and stores it in a tank. The hot water is piped to faucets throughout a house, just as it would be with an ordinary water heater. Installing a solar water heater can save up to 50 percent on water heating bills.

Discussion Question

1. Where on the Earth do you think it would be easy to capture solar energy? *(The desert, near the Equator, any place where it is sunny most of the time.)*

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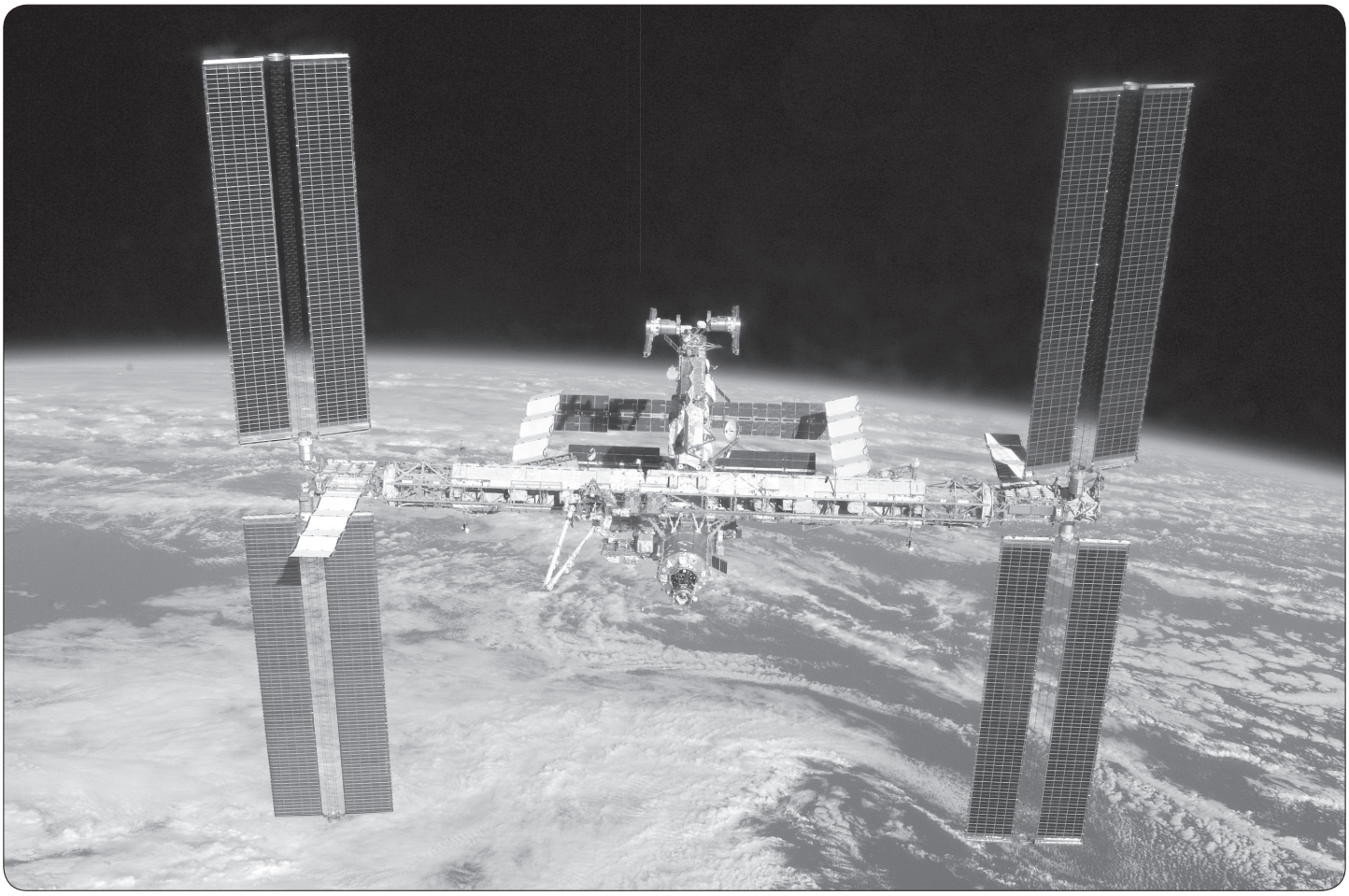
Electricity from the Sun

Scientists invented solar cells. Solar cells convert the sun's energy into electricity.

Many solar cells together make a module. Many modules connected together make a panel. Some people put solar panels on their homes so they can generate electricity from the sun.

Solar panels can be expensive, but electricity from the sun is clean and free.

Electricity in Space



The International Space Station in orbit. Image courtesy of NASA

Many solar panels make a solar array. Solar arrays are used to make electricity for cities. Solar arrays are used on the International Space Station to provide electricity for the astronauts.

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Solar Energy Can Make Electricity

Photovoltaic (PV) cells turn the sun's energy into electricity. *Photo* means light and *volt* is a measure of electricity. PV cells are made of silicon, the main ingredient in sand. Each side of the silicon wafer has a different chemical added. When radiant energy hits the PV cell, the chemicals make electricity. Some toys and calculators use small PV cells instead of batteries. Big PV cells can make enough electricity for a house. They are expensive, but good for houses far away from power lines.

Some schools are adding PV cells to their roofs. The electricity helps lower the amount of money schools must pay for energy. The students learn about the PV cells on their school buildings. Today, solar energy provides about one percent of the electricity we use. In the future, it could be a major source of energy. Scientists are always researching and looking for new ways to capture and use solar energy.

More Information

Photovoltaic cells are also called PV cells, or solar cells, for short. You are probably familiar with photovoltaic cells. Solar-powered toys, calculators, and roadside telephone call boxes all use solar cells to convert sunlight into electricity.

Solar cells are made of a thin piece of silicon—the substance that makes up sand and the second most common element on Earth. One side of the silicon wafer has a small amount of boron added to it, which gives it a tendency to attract negatively charged electrons. It is called the p-type silicon because of its positive tendency. The other side of the silicon wafer has a small amount of phosphorous added to it, giving it an excess of free negatively charged electrons. We call this n-type silicon. It has a tendency to give up its electrons. When the two sides have both been chemically modified, some electrons from the n-type silicon flow to the p-type silicon, forming an electric field between the layers. The p-type silicon now has a negative charge and the n-type silicon has a positive charge.

When the PV cell is placed in the sun, the radiant energy energizes the free electrons. If a circuit is made connecting the sides, electrons flow from the n-type silicon through the wire to the p-type silicon. The PV cell is producing electricity—the flow of electrons. If a load, such as a light bulb, is placed along the wire, the electricity will do work as it flows. The conversion of sunlight into electricity takes place silently and instantly. There are no mechanical parts to wear out.

Discussion Questions

1. Have you seen a solar cell? Where did you see it?

2. What did it power?

Solar House

A photovoltaic (PV) cell changes radiant energy into electricity. Electricity can run a motor to make motion and make light. A solar collector absorbs radiant energy and turns it into heat. A solar collector can heat water. A water storage tank painted black can store hot water and keep it hot by absorbing radiant energy.

Step 1: Use a cardboard box to make a house with big windows and a door in the front.

Step 2: Use clear transparency film to cover the windows.

Step 3: Use black construction paper to make a round water storage tank. Attach it to the side of the house with tape as shown in the Front View diagram below.

Step 4: Make two holes in the top of the box like in the Top View diagram below. Each hole should be about one centimeter (1 cm) in diameter.

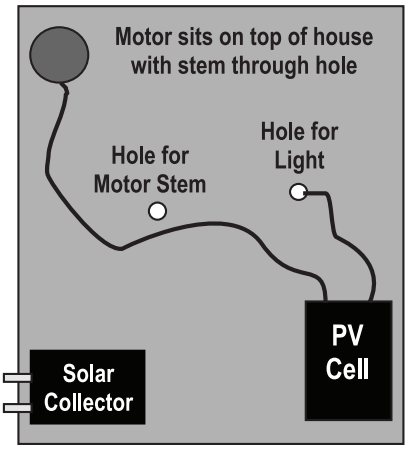
Step 5: Place the solar collector on top of the house as shown in the diagrams below. Put the tubing from the solar collector into the water storage tank.

Step 6: Place the PV cell on top of the house. Insert the light through the hole as shown in the diagram. Put the stem of the motor through the other hole for the motor stem.

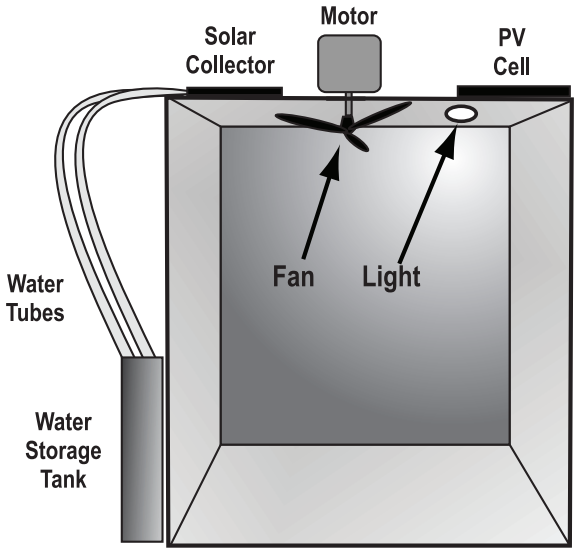
Step 7: Put a tiny bit of clay into the hole of the fan and push it onto the stem of the motor that is sticking through the ceiling.

Step 8: On a sunny day, place the house in the sun with the front facing south.

Step 9: Observe the light shine and the fan turn as the PV cell turns radiant energy from the sun into electricity. The solar collector shows how a real solar house could heat and store water. It doesn't really work.



Top View of House



Front View of House

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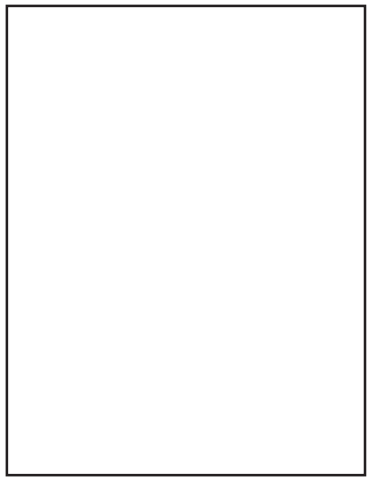
Date _____

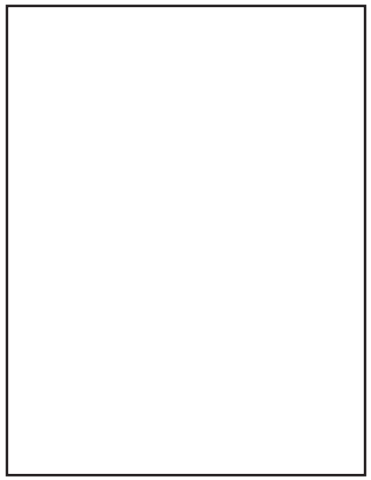
Question:
What happened when we put one
plant in the sunlight and one plant in the dark?

Draw a picture of the final result.

Sunlight



Dark



Explain what you observed. What did you learn?

_____

_____

_____

_____

_____

_____

_____

_____

My Plant Investigation Science Notebook

_____

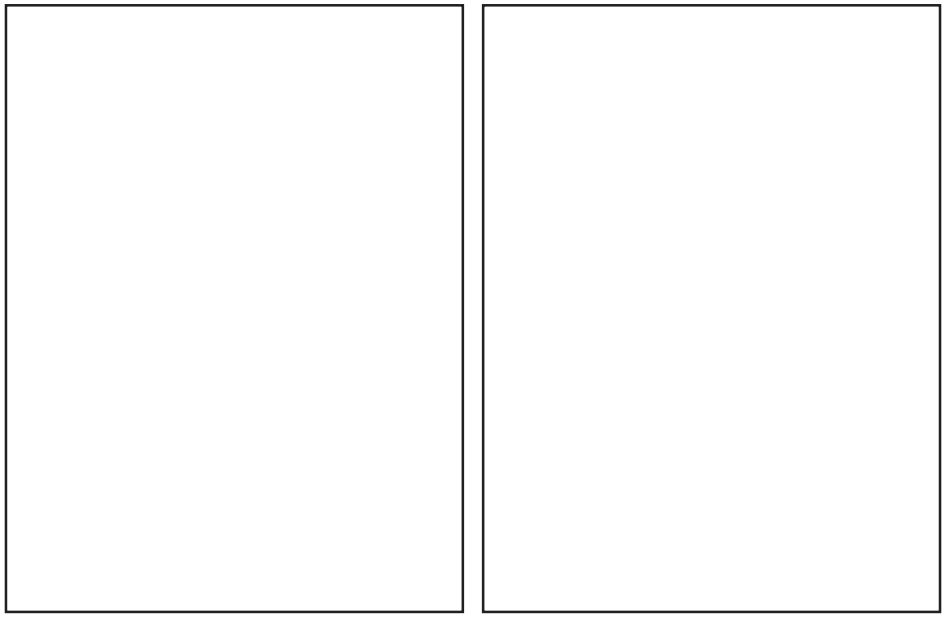
Name

Date _____

Day _____

Observations:
Draw a picture of the plant in the sunlight and a picture of the plant in the dark.

Sunlight *Dark*



What do you notice about the plants? _____

_____

_____

_____

_____

_____

Date _____

Question:
What will happen if we put one plant in the sunlight and one plant in the dark?

Prediction:
I predict _____

_____

_____

_____

_____

because _____

_____

_____

_____

_____

Date _____

Day _____

Observations:

Draw a picture of the plant in the sunlight and a picture of the plant in the dark.

Sunlight *Dark*

What do you notice about the plants? _____

_____

_____

_____

_____

_____

Date _____

Day _____

Observations:

Draw a picture of the plant in the sunlight and a picture of the plant in the dark.

Sunlight *Dark*

What do you notice about the plants? _____

_____

_____

_____

_____

_____

Name _____ Date _____

Radiometer

Draw a picture of the radiometer below and label the parts.

What happens when you put the radiometer in the sun?

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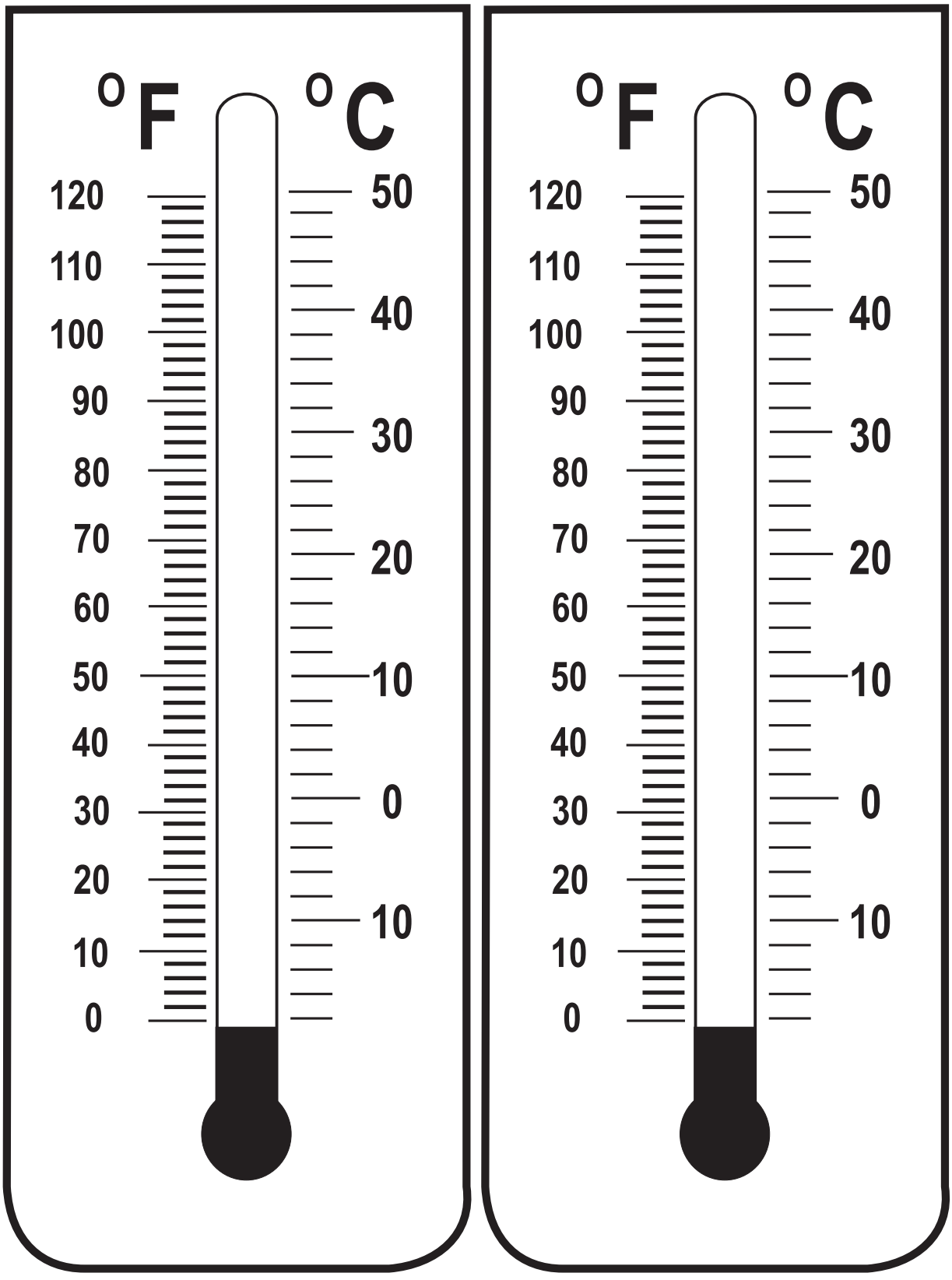
Reading a Thermometer



Name _____ Date _____

Black and White

Question: What will happen to the temperature if we place one thermometer in a black pouch and one thermometer in a white pouch?

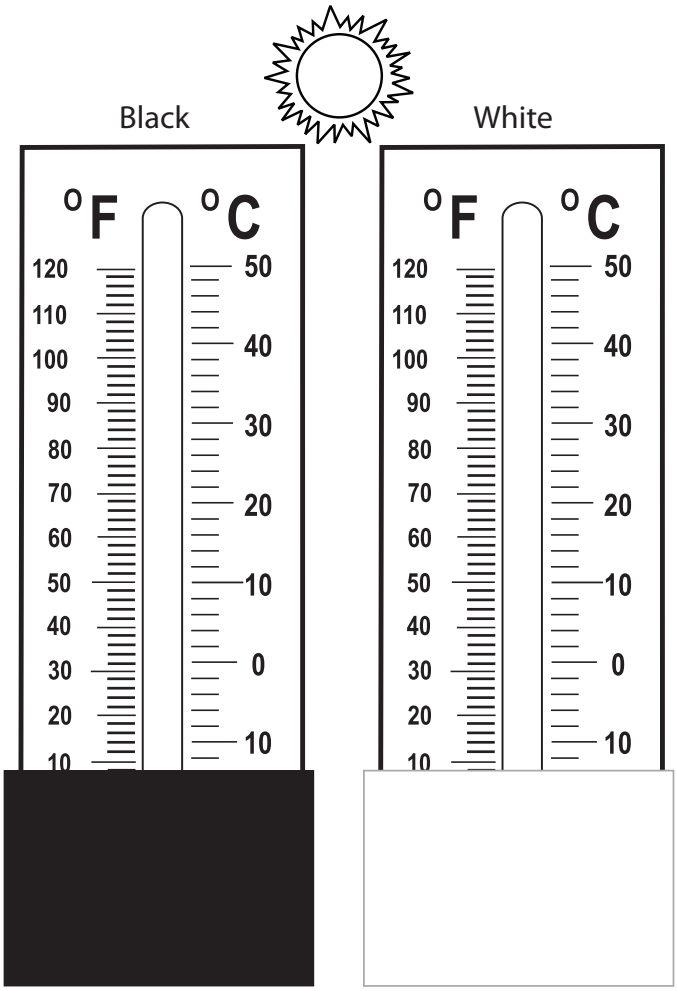
Prediction:

Starting Temperatures: _____
Thermometer A

_____
Thermometer B

Ending Temperatures: _____
Thermometer A

_____
Thermometer B



Thermometer A **Thermometer B**

Conclusion:

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Name _____ Date _____

Color Changing Bracelet

Before

After

Where were you when the beads were white? Where were you when the beads changed color? What makes the beads change color?

Name _____ Date _____

NaturePrint® Paper

How did solar energy make the design on your NaturePrint® Paper?

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Name _____ Date _____

Solar Balloon

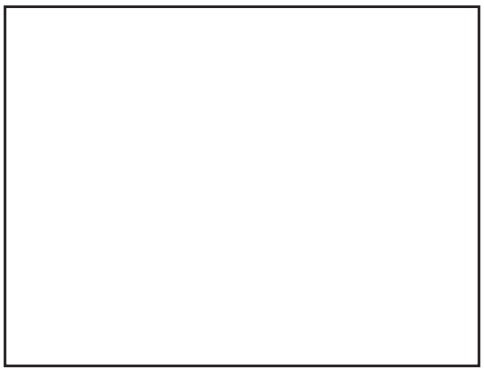
Before

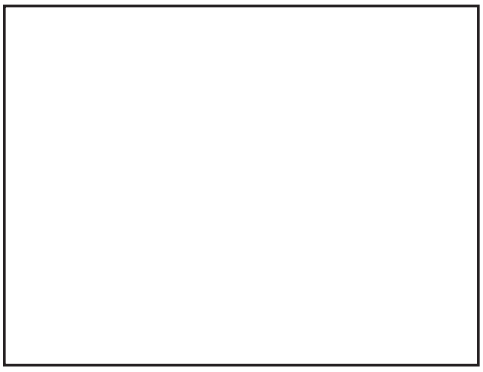
After

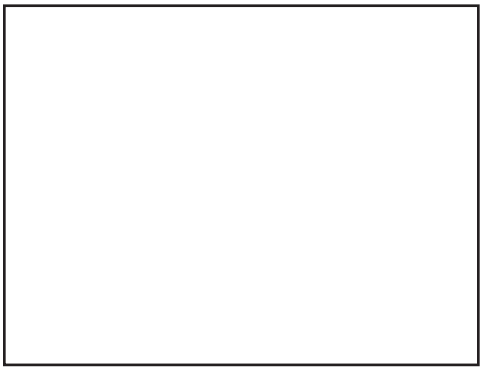
What happens when the solar balloon is left in the sun? Why?

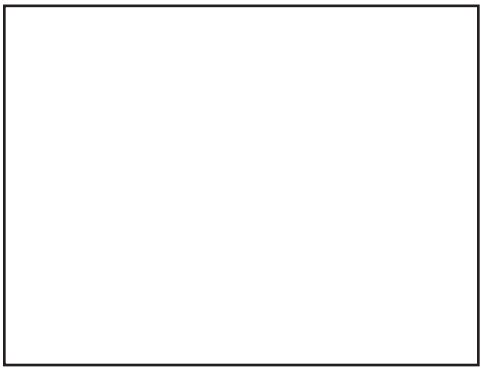
Name _____ Date _____

How to Use a Solar Oven









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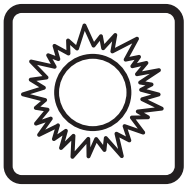
Name _____ Date _____



Solar House

Draw a picture of the solar house and label the parts.

Explain how the house uses the sun's energy.

Games, Puzzles, and Activities

Looking for some fun energy activities? There are plenty of fun games, puzzles, and activities available at www.NEED.org/games.

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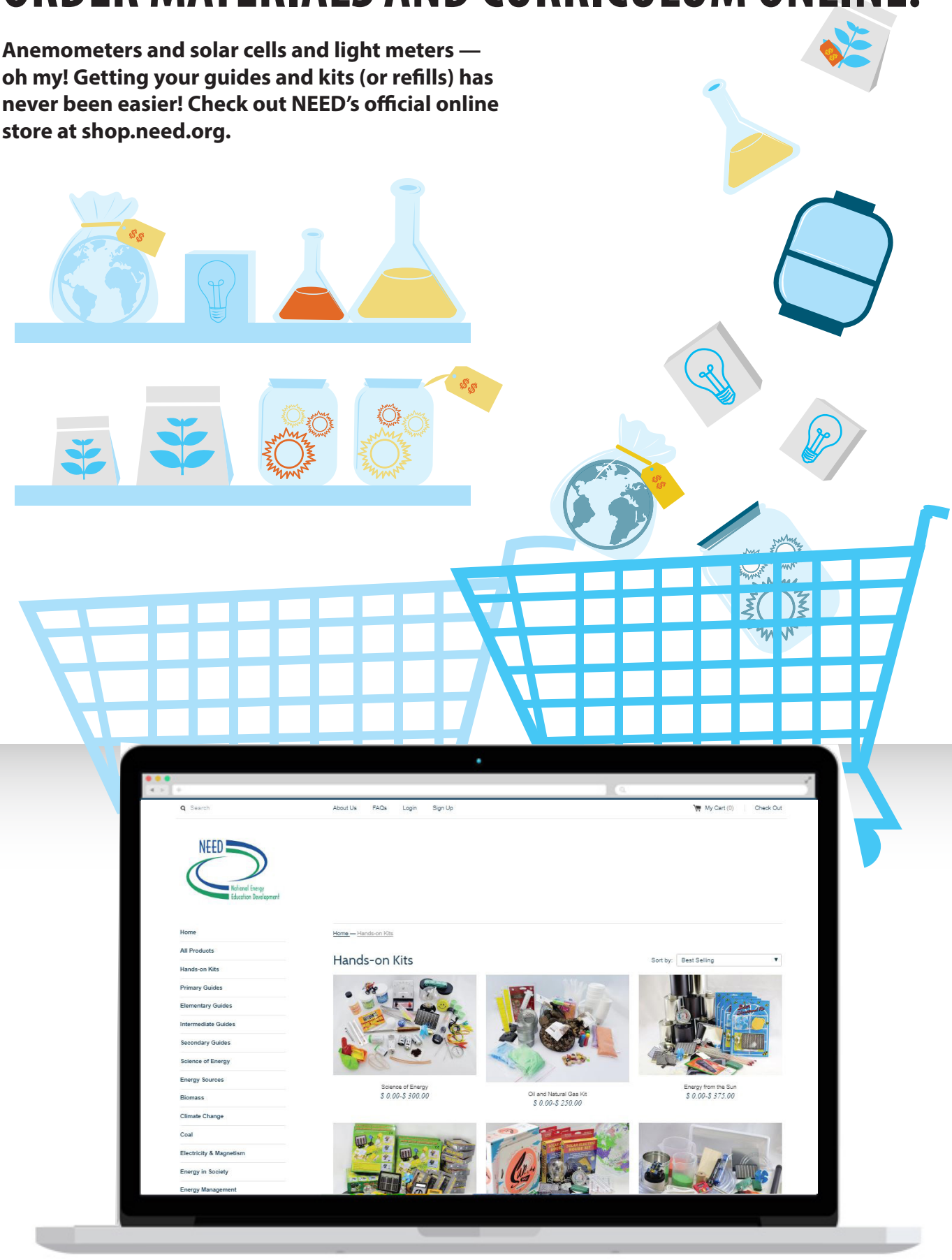
ORDER MATERIALS AND CURRICULUM ONLINE!

Anemometers and solar cells and light meters — oh my! Getting your guides and kits (or refills) has never been easier! Check out NEED's official online store at shop.need.org.



NEED's Online Resources

NEED'S SMUGMUG GALLERY

http://need-media.smugmug.com/

On NEED's SmugMug page, you'll find pictures of NEED students learning and teaching about energy. Would you like to submit images or videos to NEED's gallery? E-mail info@NEED.org for more information.
Also use SmugMug to find these visual resources:

Videos

Need a refresher on how to use Science of Energy with your students? Watch the Science of Energy videos. Also check out our Energy Chants videos! Find videos produced by NEED students teaching their peers and community members about energy.

Online Graphics Library

Would you like to use NEED's graphics in your own classroom presentations, or allow students to use them in their presentations? Download graphics for easy use in your classroom.

SUPPLEMENTAL MATERIALS

Looking for more resources? Our supplemental materials page contains PowerPoints, animations, and other great resources to compliment what you are teaching in your classroom! This page is available under the Educators tab at www.NEED.org.

THE BLOG

We feature new curriculum, teacher news, upcoming programs, and exciting resources regularly. To read the latest from the NEED network, visit www.NEED.org/blog_home.asp.

EVALUATIONS AND ASSESSMENT

Building an assessment? Searching for standards? Check out our Evaluations page for a question bank, NEED's Energy Polls, sample rubrics, links to standards alignment, and more at www.NEED.org/evaluation.

E-PUBLICATIONS

The NEED Project offers e-publication versions of various guides for in-classroom use. Guides that are currently available as an e-publication will have a link next to the relevant guide title on NEED's curriculum resources page, www.NEED.org/curriculum.

SOCIAL MEDIA

Stay up-to-date with NEED. "Like" us on Facebook! Search for The NEED Project, and check out all we've got going on!

Follow us on Twitter. We share the latest energy news from around the country, @NEED_Project.

Follow us on Instagram and check out the photos taken at NEED events, instagram.com/theneedproject.

Follow us on Pinterest and pin ideas to use in your classroom, Pinterest.com/NeedProject.

NEED ENERGY BOOKLIST

Looking for cross-curricular connections, or extra background reading for your students? NEED's booklist provides an extensive list of fiction and nonfiction titles for all grade levels to support energy units in the science, social studies, or language arts setting. Check it out at www.NEED.org/booklist.asp.

U.S. ENERGY GEOGRAPHY

Maps are a great way for students to visualize the energy picture in the United States. This set of maps will support your energy discussion and multi-disciplinary energy activities. Go to www.NEED.org/maps to see energy production, consumption, and reserves all over the country!

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The Sun and Its Energy Evaluation Form

State: _____ **Grade Level:** _____ **Number of Students:** _____

1. Did you conduct the entire unit?	❑ Yes	❑ No
2. Were the instructions clear and easy to follow?	❑ Yes	❑ No
3. Did the activities meet your academic objectives?	❑ Yes	❑ No
4. Were the activities age appropriate?	❑ Yes	❑ No
5. Were the allotted times sufficient to conduct the activities?	❑ Yes	❑ No
6. Were the activities easy to use?	❑ Yes	❑ No
7. Was the preparation required acceptable for the activities?	❑ Yes	❑ No
8. Were the students interested and motivated?	❑ Yes	❑ No
9. Was the energy knowledge content age appropriate?	❑ Yes	❑ No
10. Would you teach this unit again?	❑ Yes	❑ No

Please explain any 'no' statement below

How would you rate the unit overall?	❑ excellent	❑ good	❑ fair	❑ poor
How would your students rate the unit overall?	❑ excellent	❑ good	❑ fair	❑ poor

What would make the unit more useful to you?

Other Comments:

Please fax or mail to: **The NEED Project**
8408 Kao Circle
Manassas, VA 20110
FAX: 1-800-847-1820

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National Grid
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National Ocean Industries Association
National Renewable Energy Laboratory
NC Green Power
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New Mexico Landman's Association
NextEra Energy Resources
NEXTracker
Nicor Gas
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North Carolina Department of Environmental Quality
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Oklahoma Gas and Electric Energy Corportation
Opterra Energy
Pacific Gas and Electric Company
PECO
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Phillips 66
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