Effects of the Sun on Our Planet

Supplemental science materials

for grades 5 - 8

Stanford SOLAR Center

These supplemental curriculum materials are sponsored by the Stanford SOLAR (Solar On-Line Activity Resources) Center. In conjunction with NASA and the Learning Technologies Channel.

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Teacher Overview

Objectives

- Students will observe how technology (through a greenhouse and photovoltaic cells) can enhance the solar energy Earth receives.
- Students will observe how the sun's radiant energy causes evaporation.
- Students will develop an understanding of the role evaporation plays in the weather cycle.
- Students will develop an understanding of the importance of the Earth's Magnetosphere.
- Students will observe the effects of the sun's energy on the Magnetosphere.
- Students will develop an understanding of the various solar phenomena (flare, coronal mass ejections or CME, radiation) and their effect on the sun's output of radiant energy.
- Students will observe the effects of various solar phenomena (flare, coronal mass ejections or CME, radiation) on the Earth.
- Students will recognize the difference between true north and magnetic north.
- Students will develop an understanding of how solar cells convert solar energy to electricity.

Science Concepts

- Energy from the sun provides Earth with light, heat, changes in the atmosphere and evaporation.
- Solar energy can be converted to other forms of energy such as electricity and food.
- The sun's heat affects our weather cycle through the process of evaporation.
- We can control the amount of the sun's heat through a greenhouse.
- A solar scientist studies the effects of the sun's energy on the Earth using various instruments.
- Solar phenomena such as solar flare, coronal mass ejection (CME), and radiation affect the Earth's magnetosphere by disrupting radio communication, shortwave operation, compass readings, space satellites, telecommunications satellites, prospecting equipment, navigation equipment, etc.
- The Earth's magnetosphere is integrally connected to solar activity and human technological usage.
- The Earth's magnetosphere is affected by magnetic storms from the sun.
- The sun gives off electromagnetic energy that affects the Earth's atmosphere.

Teacher Overview

Correlation to the National Science Standards

This segment of the Webcast *All About the Sun,* "Effects of the Sun on Our Planet", is brought to you by a correlation to the National Science Standards for grades 5 - 8 as delineated below.

Grades 5 - 8

Unifying Concepts and Processes

- Systems, order and organization
- Evidence, models and explanation
- Change, constancy and measurement

Science as Inquiry

- Abilities necessary to do scientific inquiry
  - Ask a question about objects, organisms, and events in the environment
  - Plan and conduct a simple investigation
  - Employ simple equipment and tools to gather data and extend the senses
  - Use data to construct a reasonable explanation
  - Communicate investigations and explanations
- Understandings about scientific inquiry

Physical Science

- Properties and changes of properties in matter
- Transfer of energy

Life Science

- Regulation and behavior
- Populations and environments

Earth and Space Science

- Structure of the Earth system
- Earth in the Solar System

Science and Technology

- Abilities of technological design
  - Identify a simple problem
  - Propose a solution
  - Implementing proposed solutions
  - Evaluate a product or design
  - Communicate a problem, design and solution
- Understandings about science and technology

Correlation to the National Science Standards (continued)

Science in Personal and Social Perspectives
- Risks and benefits
- Science and technology in society

History and Nature of Science
- Science as a human endeavor
- Nature of science
- History of science

Segment Content/On-line Component Review

Teacher Overview

Materials List

Science Exploration

- **Sunlight and Plant Life**
  - 3 - 6 identical small plants (per group)
  - 2 - 5 boxes (large enough to cover plants, per group)
  - camera and film for class (optional)
  - observation chart (one per group)

- **Life in a Greenhouse**

  Note: *Materials listed are per group. Exploration can be accomplished with two jars: one with a clump of moist grass and the other empty. Place one air temperature thermometer outside jars for temperature reading and then one inside each jar. Or it can become more complex using one empty and one grass clump jar placed in each location.*

  - 2 - 4 clumps of grass
  - 4 - 8 identical glass jars with lids that screw on tightly
  - 3 - 9 air temperature thermometers
  - observation chart

- **Evaporation: How fast?**

  Note: *Materials listed are per class. The number of containers used is dependent upon the number of places the class wishes to observe.*

  - # of water containers (about the size of a standard glass or clear, plastic cup)
  - # of thermometers (dependent upon the number of places the class wishes to place)
  - pen (to mark water level on containers)
  - observation chart

- **Evaporation: Where does the water go?**

  Note: *Materials listed are per class.*

  - large, aquarium (with the ability to be fairly airtight)
  - 2” deep pan that fits in one-half of the aquarium
  - high-watt, narrow focused desk lamp
  - 2 frozen ice packs
  - 1 air temperature thermometer
  - water

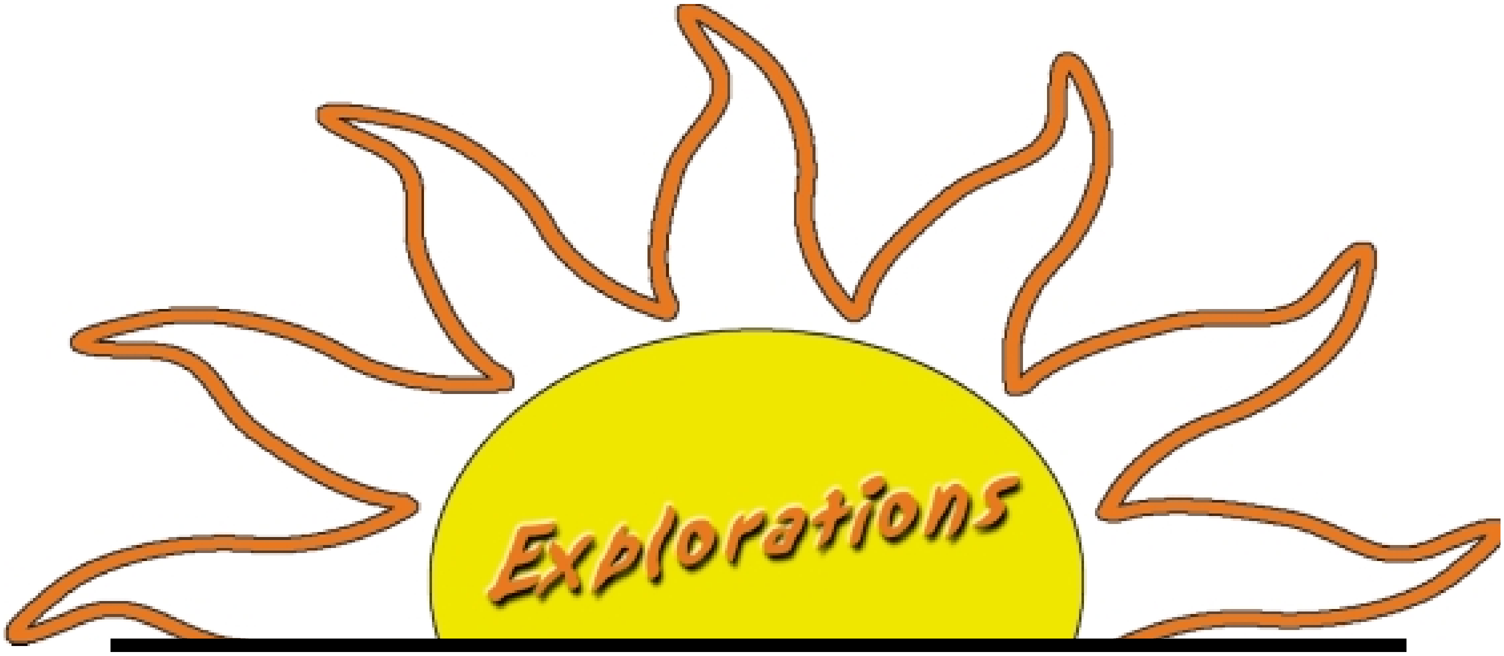
Materials List (continued)

- **Now We're Cookin'!**
  Note: The materials listed need to be gathered in large enough amounts to be used by entire class as per each group's decision on their design for a solar cooker.

  - aluminum foil
  - small mirrors
  - clear and dark glass jars
  - shoe boxes
  - lightweight wire
  - toothpicks
  - cardboard
  - tape
  - plastic wrap
  - reflecting material

- **What I can do with Solar Energy!**
  Note: Materials will vary based upon students' designs.

- **Riding a Radio Wave**
  - Student Observation Chart
  - AM Radio



Science Explorations

- Sunlight and Plant Life
- Life in a Greenhouse
- Evaporation: How fast?
- Evaporation the Sequel: Where does the water go?
- Now We're Cookin'!
- What I Can Do with Solar Energy
- Riding a Radio Wave

Career Explorations

- Solar Scientist

Science Explorations

- **Sunlight and Plant Life**

  Purpose: Students design a classroom experiment to determine in which kind of light it is best for plants to grow. Students will observe the effects of different types of light upon plant growth.

  Activity description:
  Engage the students in a discussion about what plants provide humans and how important plant life is to our basic needs. Move from there to discussing the needs of plants for survival (water, nutrients and light). Have them consider the importance of light to plants by sharing observations they have previously made about light, plants and their growth. Lead them to entertain the idea of what kind of light is best for plants. Guide them through the process of designing an experiment to test their ideas (see the Student Handout "Sunlight and Plant Life Guidesheet"). Encourage them to think of all different types of light (fluorescent, full spectrum lightbulbs, blacklights, lasers, sunlight, no light, different wattage of household lightbulbs, different colored lightbulbs).

  Set up as many different test sites as possible to test each type of light using large boxes, small identical plants, different types of lighting. Assign a small group or partners to each test site and have that team observe, record and report their observations. Run the experiment for as long as necessary in order for the students to observe a change in the plants' growth. Take photos every other day for comparison. Measure the size of the leaves and/or stems, or measure the height of each plant every other day. Have the students create charts or graphs displaying the information and at the end of the test draw conclusions about the effects of sunlight and artificial light on plant growth.

- **Life in a Greenhouse**

  Purpose: Students create 2 mini-greenhouses one with plant life and one without, measure the temperature inside and outside of each, and compare the readings. Students will observe what a "greenhouse effect" is.

Science Explorations (continued)

- **Life in a Greenhouse (continued)**

  Activity description:
  Using large, clear glass jars with lids that firmly screw on, punch a hole in the top of each lid. For a variation to this use two glass jars made of brown or green glass. Make sure that the hole is just large enough through which to slide an air temperature thermometer. Wrap a piece of clear tape a few times around the thermometer at its halfway point and it will keep the thermometer from accidentally slipping all the way through the hole when taking a reading. Using 2 long strands of tape secure the air temperature thermometer to each lid. Note: Students may choose to substitute smaller size jars, an aquarium, a terrarium or a well-sealed, clear plastic cup.

  Using the 2 identical jars, place a clump of very moist dirt with grass in one jar (make sure that the jar is not more than one-third to one-half full) and leave the other one empty. Screw on the lids tightly and insert an air temperature thermometer into each hole making sure that the thermometers are safely secured. Place tape around the hole to seal the hole as much as possible. Set the two jars in the windowsill where sunlight can reach them or place them in direct sunlight outside during the day (make sure they are brought in at night). Next to the 2 jars place another air temperature thermometer. During the week (whether it is sunny or not) take hourly readings and record the temperatures of all 3 thermometers. Also, record any observations regarding the weather, type of sunlight reaching the jars as well as the appearance of the inside of each jar. Record these observations on large chart paper.

  At the week's end have the students make a graph depicting each thermometer's readings per day noting the highest temperature and the lowest temperature recorded per day. Or have a daily graph that shows all 3 thermometer readings noting the highs and lows.

  At the week's end discuss the following points with the class as the exploration's conclusions are being drawn:
  - Compare the temperatures:
    - Which thermometer recorded the highest temperatures?
    - Which thermometer recorded the most consistent temperature throughout each day?
    - Which thermometer recorded the greatest difference between high and low readings each day?
    - How was the appearance of dirt and grass jar different from that of the empty jar?
    - What do you think caused that difference in appearance?
    - Why do you think the glass jars had higher temperatures than the outside thermometer?
    - If the lid on the jars had another hole that was not blocked, do you think the temperature inside the jar would be higher or lower? Why?
    - In your own words describe the effect that happens inside a greenhouse.

Science Explorations (continued)

- **Evaporation: How fast?**

  Purpose: Students will observe the rate at which water evaporates in different environments and at different temperatures.

  Activity description:
  Using 4 identical, clear beakers or glasses, pour the same amount of water into each container (Record the amount of water used) and mark on the container the water's level. Place the containers as indicated below:
    - container #1 in the refrigerator (uncovered)
    - container #2 in the classroom (uncovered and not in direct sunlight)
    - container #3 outside in direct sunlight (uncovered, but not left exposed to precipitation on days of inclement weather)
    - container #4 in a "mini-greenhouse" or terrarium environment

  During the course of the next week or two, at the same time each day observe the water level in each container and record the level by marking the water's level directly on the container. After the last day, measure the amount of water remaining in each container and record.

  Have students create a graph or chart that depicts the changes in the water level for each container. Use the *Science Exploration Guidesheet: Evaporation: How Fast?* from the **Answer Keys** section as students process through this exploration.

- **Evaporation (the Sequel): Where does the water go?**

  Purpose: Students will determine what happens to the water that evaporates, where it goes so to speak, and how it can change from a liquid to a gas and back to a liquid as it moves through the "atmosphere".

  Activity description:
  Use an empty aquarium (at least 1' x 1') with a glass or metal lid. Place a large bowl of water (uncovered) inside the aquarium at one end. Place the cover on the aquarium. Directly opposite the cup, but outside of the aquarium, place a small desk lamp with a narrowly focused beam. Shine that light directly on the cup of water. At the opposite end of the aquarium on the aquarium's lid, place a large frozen blue ice pack (Note: this blue ice pack might have to be removed and another

Science Explorations (continued

- **Evaporation (the Sequel): Where does the water go? (continued)**

  Activity description (continued):
  frozen pack put in its place to maintain the cold temperature. Let stand and observe periodically throughout the day the level of the water in the bowl. Also, observe what forms underneath the lid just under where the frozen pack is located.

  The radiant heat from the light will cause the water in the bowl to evaporate. As the water vapor rises it will encounter the "cold front" of the frozen ice pack on the lid. The water vapor will condense and form water droplets. This is a model of what happens in the earth's atmosphere. This evaporation process is cause by radiant energy from the sun which evaporates water, heats the atmosphere and causes movement of the air.

  Use the *Science Exploration Guidesheet: Evaporation: Where does it go?* from the **Answer Keys** section as students process through this exploration.

- **Now We're Cookin'!**

  Purpose: Students will use the process of technological design to create a "solar-powered" method to cook a small slice of hotdog meat. Students will also develop an understanding for how the technological design process works to solve problems and affect our lives in a positive way.

  Activity description:
  Given a choice of materials listed below, students will design a "solar cooker" that will cook the quarter-inch thick, slice of hotdog in the quickest amount of time possible. Use the *Science Exploration Guidesheet: Now We're Cookin'!* from the **Answer Keys** section as students process through this exploration. This guidesheet will provide students with back-ground information on solar energy and the technological design process from which they can derive and test their designs.

  Materials: aluminum foil, small hand-sized mirrors, large jars with lids, small shoebox-sized boxes, lightweight wire, toothpicks, pieces of cardboard various sizes, tape, plastic wrap, and any other which the students and teachers can safely consider for use.

Science Explorations (continued)

- **What I Can Do with Solar Energy**

  Purpose: Students will use the process of technological design to create a "solar-powered" method to perform a routine task or solve a problem. They will develop an understanding of how solar cells convert solar energy to electricity and how that energy can be used in the technological design process. Students will also develop an understanding for how the technological design process works to solve problems and affect our lives in a positive way.

  Activity description:
  For this activity the teacher will need to purchase enough solar cells and peripherals to engage each student group in their particular design pursuit. Or after a brief exhibition by the teacher or a guest speaker of what solar cells are, how they work and ways in which they can be used, students can simply follow the *Science Exploration Guidesheet: What I Can Do With Solar Energy* from the **Answer Keys** section and develop their solar design on paper only.

Science Explorations (continued)

- **Riding a Radio Wave**

  Purpose:
  Students will observe a difference in clarity and strength of radio signals received when comparing daylight and night time reception.

  Activity description:
  Place an AM radio in an appropriate area of the classroom where it will receive good reception. Divide the class into small groups and assign each group a bandwidth to survey (for example 500 – 600, 1400 – 1500) or as a class choose one section of the AM band to survey once an hour. Assign each group a time each hour (3 minutes maximum) during which they monitor their assigned band's reception. Adjust the volume to a reasonable listening level. Each hour of the day have the class or small groups survey the chosen bandwidth and note each radio station's call sign and call number. Have the students arbitrarily rate the station's reception for clarity and strength with an agreed upon rating system (such as weak, good, strong, or very weak, weak, audible strong, very strong).

Science Explorations (continued)

- **Riding a Radio Wave (continued)**

  Also have the students note where within there area they receive steady or sporadic static (and have them describe the static) Use the graph provided in the **Student Handouts** section or have the students design their own graph with which to record their observations. (Note: If possible once an hour check the Web site given below for current solar and magnetosphere activity. This information can then be used to verify the type of reception being observed. Also, have the students locate each signal's source on a map and determine the distance from the area.

  http://www.set.noaa.gov/today.html

  For homework have the students make 2 – 6 observations for their assigned AM band section during the night time hours and record their observations.

  During the next class session, have students in small groups discuss their findings, comparing night time reception to daytime reception. Ask them to hypothesize about any differences or anomalies they observed. Encourage them to include in their hypothesizing local weather data concerning electrical storms as well as solar activity data from the Web site given above.

  Teacher Notes:
  Students should find that radio reception improves during the night time hours due to less direct solar energy entering the earth's atmosphere on the night side of the Earth. This solar energy would affect pulsations of loudness as well as steady static. Sporadic static can be accounted for through electrical storms in proximity to the radio signal's place of origin.

  This project could continue as a once a week activity for a longer period of time. When compared with solar activity information gathered on those same days, the students will be able to clearly perceive a correlation. Also, keeping track of electrical storms that occur within proximity, students will also be able to note a correlation to possible sporadic crackles and popping noises heard during their observations.

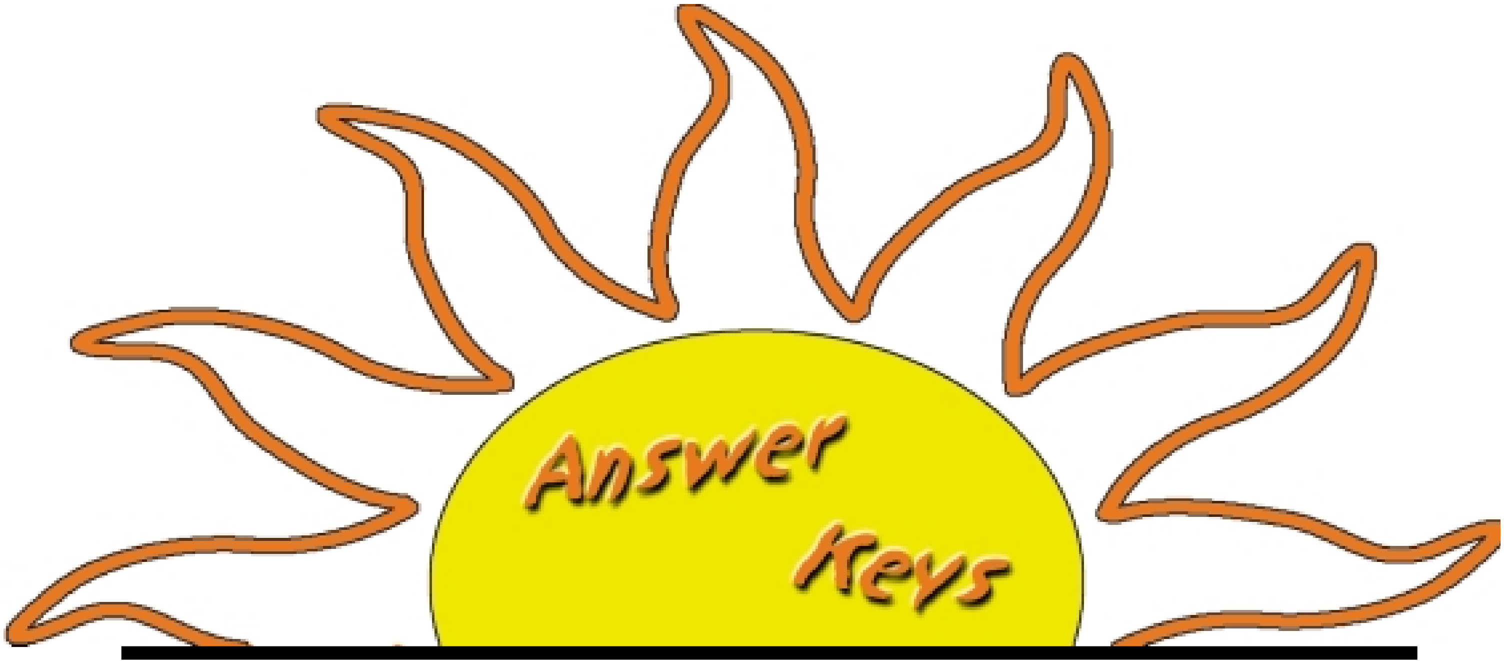
Career Explorations

- Web site review
  Have the students read the brief biographies found on the Web site

  http://solar-center.stanford.edu

  to become more familiar with solar scientists and their work.

- Web cast review
  After the students view the Web cast on-line or participate in an on-line question and answer session, have them complete the Career Exploration Guidesheet: *Solar Scientist*



- Student Worksheet: *Sunlight for Our Life*
- Science Exploration Guidesheet: *Sunlight and Plant Life*
- Science Exploration Guidesheet: *Life in a Greenhouse*
- Science Exploration Guidesheet: *Evaporation: How fast?*
- Science Exploration Guidesheet: *Evaporation: Where does the water go?*
- Science Exploration Guidesheet: *Now We're Cookin'!*
- Science Exploration Guidesheet: *What I Can Do With Solar Energy*
- Science Exploration Guidesheet: *Riding a Radio Wave*

Student Worksheet

Sunlight for Our Life - Key

Directions: Use the reading *Sunlight for Our Life* to help you answer the questions below.

1. Name 2 ways the sun's energy affects Earth.
   - *Sunlight is used by plants for photosynthesis*
   - *Heats the atmosphere and causes the wind*
   - *Causes changes in the weather*
   - *Causes the evaporation cycle*

2. Name 2 ways that we harness the sun's energy.
   - *Windmills*
   - *Wind turbines or wind machines*
   - *Solar cells*

3. Name and describe 1 type of solar phenomenon and tell how it affects the Earth.
   - *Sunspots = huge regions of magnetic fields that are cooler than the surrounding regions. At their peak they release highly charged particles into space and disrupt communications.*
   - *Solar flares = these originate from sunspots and release a tremendous amount of energy all at once . This also disrupts communications.*
   - *CME = coronal mass ejection emits large plasma clouds that release magnetic energy into the magnetosphere*

4. What is the magnetosphere?

   Located about 60 miles above the Earth's surface it is where the lines of magnetic force flow from south to north

Science Exploration Guidesheet

Sunlight and Plant Life - Key

Directions: Decide how you and your partner or group will explore the effects of light on plant growth by answering each question below.

Teacher's note: Below is simply a general idea of the kind of responses you would be looking for as students work through this exploration.

1. **What science idea does your class want explore?**
   The importance of sunlight or light on plant growth.

2. **What question or questions do you want answered by this science exploration?**
   - *What kind of light do plants grow best in?*
   - *Is there a difference between sunlight (natural light) and other kinds of light (artificial light) on plant growth?*
   - *Can plants grow in light other than sunlight?*
   - *Do plants need light to grow?*

3. **Describe in general how your class will answer this question or explore this idea?**
   We will take the same kinds of plants and put them under different types of light and no light and observe their growth over a certain amount of time.

4. **List step-by-step how you will answer this question.**
   - *Gather materials (see list below)*
   - *Decide what we will observe and measure*
   - *Set up each test station the same way and be clear on how many minutes of light each plant will get*
   - *Make and record observations at the same time each day (or at a pre-determined interval)*
   - *Share and discuss findings*

5. **List the materials you or your group will need to follow those steps.**
   - *# of identical plants*
   - *#same number from above for light sources*
   - *same number as above for boxes (with the exception of the direct sunlight plant)*
   - *Observation charts for recording*

Sunlight and Plant Life - Key (continued)

6. **What kind of observations will you make during this science exploration?**
   - *Measure the height of the plant (What units will you measure with?)*
   - *Color of the plant's leaves and stems*
   - *Size of the plant's leaves*
   - *Length of each plant's stem*
   - *Take photos*

7. **What kind of measurements will you make during this science exploration?**
   - *Measure the height of the plant (What units will you measure with?)*
   - *Size of the plant's leaves*
   - *Length of each plant's stem*

8. **On a separate sheet of paper create a chart which you will use to record your observations.**
   See next page for a sample.

   - **Record your observations on the chart and report your findings to the class.**

   - **At the end of the science exploration create a special report to give to the class. Follow the form your teacher gives you.**
     See sample next page.

   - **What did you learn from this science exploration?**
     That plants grow best in sunlight or natural light. That artificial light does not seem to give the plants all that sunlight gives. That plants need light to grow because without light this plant dies.

- **Does this lead you to any other questions? Write down one or two of your questions below.**

   - *Does sunlight have something special that plants need and that artificial light does not have?*
   - *Will a plant grow more if it gets more sunlight?*
   - *Is direct sunlight better than indirect sunlight for plant growth?*

Plant Observation Chart

Type of Light: ______________________________

Type of plant: ______________________________

Question to be answered:

Starting measurements and data:

Plant height: ______________ Plant width: ______________

Leaf sizes: Leaf #1 ______ Leaf #2 ______ Leaf #3 ______

Stem lengths: Stem #1 ______ Stem #2 ______ Stem #3 ______

Description of overall condition of plant:

Photo of plant:

Date/Day # of Test Time	measurements (same as above)	description of plant condition	photo

Special Report Form

Show the plant photos of each observation and briefly give a description of the plant's overall condition.

Create a chart or graph that shows the growth of the plant (height, width, stem/leaf size, color)

Give a conclusion based upon your data and answer the question from this science exploration.

Science Exploration Guidesheet

Life in a Greenhouse - Key

Directions: Decide how you and your partner or group will explore these science ideas by answering each question below.

1. **What science idea does your class want explore?**

   A greenhouse is used to grow plants and it has something to do with the sun.

2. **What question or questions do you want answered by this science exploration?**
   - *Why is a greenhouse used to grow plants?*
   - *What makes a greenhouse different from my house?*
   - *What's so special about a greenhouse?*
   - *Is there a relationship between the sun and a greenhouse and plants?*

3. **Describe in general how your class will answer the question(s) or explore this idea.**

   Our class will visit a greenhouse, talk to people who grow plants, and do some other kinds of research about greenhouses. We will build a model of a greenhouse and observe what happens inside it.

4. **List step-by-step how you will answer the question(s).**

   - *Gather materials (see list below)*
   - *Decide what we will observe and measure*
   - *Set up our greenhouses*
   - *Place them in different settings around the classroom or outside*
   - *Make and record observations at the same time each day or at pre-determined intervals*
   - *Share and discuss findings*

Life in a Greenhouse - Key (continued)

5. List the materials you or your group will need to follow those steps.

    - *# of identical clumps of moist dirt with grass*
    - *# (twice the amount of grass clumps) of glass jars (or whatever the students choose as a substitute)*
    - *3 thermometers per group (1 per mini-greenhouse and one for outside of the greenhouses)*
    - *observation chart for recording*

6. What kind of observations will you make during this science exploration?

    - *Appearance of inside and outside of jar*
    - *Temperature inside both mini-greenhouses and outside*

7. What kind of measurements will you make during this science exploration?

    - *Temperature inside both mini-greenhouses and outside of each*

Life in a Greenhouse - Key (continued)

8. On a separate sheet of paper create a chart which you will use to record your observations.

    See next page for a sample.

9. Record your observations and report your findings to the class.

10. At the end of the science exploration create a special report to give to the class. Follow the form your teacher gives you.

    See next page for a sample.

11. What did you learn from this science exploration?

    That the temperature of a greenhouse is warmer inside than the air temperature outside whether the sun is shining or not. The heat from the sun must get trapped in the greenhouse and that is why it stays warmer inside than outside. The mini-greenhouse with plants had moisture inside the mini-greenhouse (condensation on glass), but not the empty mini-greenhouse. The plants must have an effect on moisture in the mini-greenhouse.

12. Does this lead you to any other questions? Write down one or two of your questions below.

    - *Will darker glass on the greenhouse make it cooler or warmer inside?*
    - *If the greenhouse is in darkness will it still be warmer inside than outside?*
    - *Is there a way to increase the amount of heat the greenhouse could keep in to make it even hotter?*

Evaporation: How fast? - Key

Directions: Decide how you and your partner or group will explore the effects of the sun's energy on water.

1. **What science idea does your class want explore?**
   Evaporation

2. **What question or questions do you want answered by this science exploration?**
   - *Does water evaporate at different rates?*
   - *What factors effect the evaporation rate of water?*
   - *Does the environment have an effect on how fast water evaporates?*
   - *Does the air temperature have an effect on how fast water evaporates?*
   - *Does the amount of sunlight have an effect on how fast water evaporates?*

3. **Describe in general how your class will answer the question(s) or explore this idea.**
   We will pour the same amount of water in the same kind of container, mark the water level and place the containers in different areas in the classroom and outside. Some of the containers will be in the sun and some will be in shade. Some of the containers will be in cold places some in warm places. We will mark the change in the water level each day at the same time.

4. **List step-by-step how you will answer the question(s).**
   - *Gather materials (see list below)*
   - *Decide the location of each container (list those)*
   - *Decide how long*
   - *Measure and pour the same amount of water into each container (give the amount)*
   - *Record the beginning amount of water and the location of each container on your observation chart*
   - *Mark on each container the beginning water level*
   - *Place each container at its location and next to each container place an air temperature thermometer (if this information will assist in answering the question)*
   - *Observe each container at the same time each day (give the time)*
   - *Mark the water level on each container during those observations*
   - *Note the temperature reading on the thermometer*
   - *Note any other observations (amount of sunlight or type of sunlight)*

Evaporation: How fast? - Key (continued)

4. List step-by-step how you will answer the question(s).
   - *Record your observations*
   - *At the end of the exploration, measure the remaining amount of water in each container and record*
   - *Discuss the result*

5. List the materials you or your group will need to follow those steps.
   - *# of containers (dependent upon # of places the class wishes to place)*
   - *# of thermometers (dependent upon # of places the class wishes to place)*
   - *pen (to mark water level)*
   - *observation chart*

6. What kind of observations will you make during this science exploration?
   - *Type of day*
   - *Amount of sunlight*
   - *Air temperature*
   - *Water level*

7. What kind of measurements will you make during this science exploration?
   - *Air temperature*
   - *Water level*

8. On a separate sheet of paper create a chart which you will use to record your observations.

   See sample below

9. Record your observations and report your findings to the class.

10. At the end of the science exploration create a special report to give to the class. Follow the form your teacher gives you.

Evaporation: How fast? - Key (continued)

11. What did you learn from this science exploration?

- *The warmer the air the faster the evaporation rate*
- *The drier the air the faster the evaporation rate*
- *The more moisture in the air the slower the evaporation rate*
- *The more direct sunlight the faster the evaporation rate*

12. Does this lead you to any other questions? Write down one or two of your questions below.

- *Does the surface area of the water effect the rate of evaporation?*
- *Does the type of direct sunlight effect the rate of evaporation?*
- *Which has a greater effect on the evaporation rate, direct sunlight or heat?*

Sample Observation Form

Note: Use one observation form per container and have each group or partner monitor one container.

Container # _______

Location: ____

Question to be answered by this exploration:

Day #	Daily Observation	Air Temperature	Water Level Start	Water Level End

Science Exploration Guidesheet

Evaporation: Where does the water go? - Key

Directions: Decide how you and your partner or group will explore the evaporation cycle by answering each question below.

Note: The evaporation cycle model and exploration your class designs might look something like this and might not. This is merely one way of modeling the cycle. This exploration can be done as one whole class observation done every half hour or hour during the course of a day or students working in groups develop their own evaporation cycle model.

1. **What science idea does your class want explore?**
   We can tell that water "disappears" from puddles, but we don't know what happens to the water after that.

2. **What question or questions do you want answered by this science exploration?**
   - *Where does water go after it evaporates?*
   - *Does the air temperature (caused by the heating of the sun's energy) have an effect on where the water goes after it evaporates?*

3. **Describe in general how your class will answer the question(s) or explore this idea.**
   Place water in an enclosed area and try to trap it to see where it might go after it evaporates.

4. **List step-by-step how you will answer the question(s).**
   Note: Your class' procedures should be more specific than this.
   - *Gather materials (see list below)*
   - *Decide what will be observed and measured*
   - *Set up model of evaporation cycle*
   - *Make and record observations at the same time each day*
   - *Share and discuss findings*

5. **List the materials you or your group will need to follow those steps.**
   - *Large, empty aquarium with the ability to be fairly airtight*
   - *2" deep pan that fits in one-half of the aquarium*
   - *high-watt, narrow focused desk lamp*
   - *2 frozen ice packs*
   - *1 air temperature thermometer*

Evaporation: Where does the water go? - Key (continued)

6. **What kind of observations will you make during this science exploration?**
   - *Water level of pan*
   - *Condition of inside wall and underneath the lid of the aquarium*
   - *Air temperature by water*

7. **What kind of measurements will you make during this science exploration?**
   - *Water level of pan*
   - *Air temperature by water*

8. **On a separate sheet of paper create a chart which you will use to record your observations.**
   Have the class develop their own observation chart.

9. **Record your observations and report your findings to the class.**

10. **At the end of the science exploration create a special report to give to the class. Follow the form your teacher gives you.**

11. **What did you learn from this science exploration?**

    The water seems to disappear into air. What it does is turn from a liquid into a vapor or gas and floats around in the warm air. When the air cools on the other side of the aquarium the vapor turns back into water and condenses on the glass or underneath the lid.

    This must be what happens in our atmosphere. The sun's energy warms the earth's surface and causes the water on the Earth to evaporate and float in the air. When the warm air cools, the vapor condenses and becomes a liquid again. This liquid takes the form of precipitation.

12. **Does this lead you to any other questions? Write down one or two of your questions below.**
    - *What would happen to the Earth if the sun's energy did not warm up the Earth very much?*
    - *Does the heating and cooling of the Earth have something to do with wind or the movement of air?*

Science Exploration Guidesheet

Now We're Cookin'! - Key

Directions: Decide how you and your partner or group will explore ways in which the sun's energy can be used to do things like cook food by answering each question below.

1. **What science idea does your class want explore?**
   The sun's energy can be used to perform work for us. We can use it to do such things as cook.

2. **What question or questions do you want answered by this science exploration?**
   How can the sun's energy be used to cook food?

3. **Describe in general how your class will answer the question(s) or explore this idea.**
   The class will research information about the sun's energy and materials that can be used to construct a solar cooker. We will then design a solar cooker that uses the sun's energy to cook a slice of hot dog the fastest way possible.

4. **List step-by-step how you will answer the question(s).**
   - *Research information about the sun's energy (radiant energy)*
   - *Research information about solar cookers and materials that are used to harness the sun's radiant energy.*
   - *List the many types of household items that could be used to develop a solar cooker*
   - *Draw a diagram for a solar cooker*
   - *List the materials needed to make your solar cooker*
   - *Gather the needed materials*
   - *Make your solar cooker (prototype) and test it*
   - *Revise its design based upon test*
   - *Present your design to your fellow classmates*

Now We're Cookin'! - Key (continued)

5. **List the materials you or your group will need to follow those steps.**

   Types of materials the class could use:

aluminum foil	*small mirrors*	*clear and dark glass jars*
shoe boxes	*lightweight wire*	*toothpicks*
cardboard	*tape*	*plastic wrap*
reflecting material		

6. **What kind of observations will you make during this science exploration?**
   Test the cooker for generation of heat, thoroughness of cooking process, and total cooking time.

7. **What kind of measurements will you make during this science exploration?**
   Heat temperature, time the cooking process

8. **On a separate sheet of paper create a chart which you will use to record your observations.**
   Students should be encouraged as part of the technology design process to devise their own observation or prototype test data sheet.

9. **Record your observations and report your findings to the class.**
   Students results will vary dependent upon their technological design.

10. **At the end of the science exploration create a special report to give to the class. Follow the form your teacher gives you.**

11. **What did you learn from this science exploration?**
    - *How are commercially-made solar cookers constructed?*
    - *In what other ways is solar energy harnessed for our use?*
    - *How do scientists and researchers envision that solar energy will be used in our future?*

12. **Does this lead you to any other questions? Write down one or two of your questions below.**

Science Exploration Guidesheet

What I Can Do With Solar Energy - Key

Directions: Decide how you and your partner or group will explore other ways solar energy can be used by answering each question below.

1. **What science idea does your class want explore?**
   Learn how solar cells work and how this technology can be used.

2. **What question or questions do you want answered by this science exploration?**
   - *How do solar cells change solar energy into electricity?*
   - *How can solar cells be used to do work?*

3. **Describe in general how your class will answer the question(s) or explore this idea.**
   The class will research solar cells, observe how solar cells operate and can be used in machines. The class will then design a machine that uses solar cells to do work or power some machine.

4. **List step-by-step how you will answer the question(s).**
   - *Research information about the sun's energy (radiant energy)*
   - *Research information about solar cells*
   - *List the many types of machines that solar cells could power*
   - *Draw a diagram for a solar powered machine*
   - *List the materials needed to make your solar powered machine*
   - *Gather the needed materials*
   - *Make your solar powered machine (prototype) and test it*
   - *Revise its design based upon test*
   - *Present design to fellow students*

5. **List the materials you or your group will need to follow those steps.**
   Materials will vary based upon students' designs.

6. **What kind of observations will you make during this science exploration?**
   Students will observe how well their prototype operates checking connections, angle of cells to sun's energy, etc.

7. **What kind of measurements will you make during this science exploration?**
   Students will need to determine this based upon their product design.

What I Can Do With Solar Energy - Key (continued)

8. On a separate sheet of paper create a chart which you will use to record your observations.

   Students' results will vary dependent upon their technological design.

9. Record your observations and report your findings to the class.

10. At the end of the science exploration create a special report to give to the class. Follow the form your teacher gives you.

11. What did you learn from this science exploration?

    Students should be able to articulate some of the following points:
    - *the design process for developing technological tools*
    - *the process of evaluating a new technological design (prototype) ways in which the sun's energy can be harnessed*

12. Does this lead you to any other questions? Write down one or two of your questions below.

    - *How are commercially-made solar machines constructed?*
    - *In what other ways are solar powered machines used?*
    - *How do scientists and researchers envision that solar powered machines will be used in our future?*

Science Exploration Guidesheet

Riding a Radio Wave

Directions: Decide how you and your partner or group will explore these science ideas by answering each question below.

1. **What science idea does your class want to explore?**
   The effects of solar energy on our atmosphere.

2. **What question or questions do you want answered by this science exploration?**
   Does solar energy affect the radio signals we use?
   Can we detect fluctuations in solar energy by monitoring a radio?

3. **Describe in general how your class will answer the question(s) or how your class will explore this idea.**
   Monitor a certain part of the AM radio band during the day and night time hours, then compare the reception.

4. **List step-by-step how you will answer the question(s).**
   - *Develop a rating system for rating the clarity and strength of a radio signal*
   - *Decide which part of the AM band will be monitored*
   - *Each hour of the day and night monitor the band and note the station's call sign and name*
   - *Locate each signal's source on a map and determine the distance from the area*
   - *Record the observations*
   - *Check a Web site that gives daily updates on solar energy activity and record the observations given there*
   - *Develop a graph or chart to organize the information collected*
   - *Discuss and present the findings*

5. **List the materials you or your group will need to follow those steps.**
   - *AM radio*
   - *Observation chart*
   - *Rating system*
   - *Access to the Internet*

6. **What kind of observations will you make during this science exploration?**
   - *Strength and clarity of radio signals*
   - *Solar energy fluctuations from scientists*

Riding a Radio Wave (continued)

7. **What kind of measurements will you make during this science exploration?**
   - *Using our own rating scale we will rate the clarity and strength of radio signals*

8. **On a separate sheet of paper create a chart which you will use to record your observations.**

   See ***Student Handouts*** *section for an example.*

9. **Record your observations and report your findings to the class.**
   - *Signals are clearer and stronger during daylight hours*
   - *Electrical storms cause sporadic static in reception*
   - *During the evening hours we receive increased number of radio signals from a farther distance*
   - *We get more steady static during daylight hours*
   - *Man-made electrical disturbances might also be observed*

10. **At the end of the science exploration create a special report to give to the class. Follow the form your teacher gives you.**

11. **What did you learn from this science exploration?**
    - *That solar energy does have an effect on the reception of radio signals*
    - *Fluctuations in solar energy can be observed by monitoring radio waves*

12. **Does this lead you to any other questions? Write down one or two of your questions below.**

    - *Does increased sunspot activity cause interference in radio waves?*
    - *Do other types of solar activity interfere with radio reception? If so, what kinds of solar activity does so? (CMEs, etc.)*
    - *How do solar scientists monitor fluctuations in solar energy?*

Grades 5 - 8

- Student Reading: *Sunlight for Our Life*
- Student Worksheet: *Sunlight for Our Life*
- Science Exploration Guidesheet
  (Generic Guidesheet for use with all explorations)
- Riding a Radio Wave: Observation Graph
- Career Exploration Guidesheet: *Solar Scientist*

Student Reading

Sunlight for Our Life

Life on our Earth depends on the energy we get from the sun. Energy from the sun affects the Earth in many different ways. From plant life to navigation, telecommunications, our "high tech" world from the Earth's surface into space is influenced by solar energy.

The sun's constant flow of energy affects our atmosphere and environment. Most plants need sunlight to grow. Using a process called photosynthesis, plants use the energy in sunlight to produce food that nourishes the plant. People and animals depend on plants for food. Without the sun, plants would not grow and we would not have food to eat. The Earth is surrounded by a layer of air called the atmosphere. Radiation from the sun warms parts of the Earth's atmosphere. This causes the air to move around. These weather patterns are predictable and have been mapped. People have used the power of the wind to perform work for thousands of years. For example, sailing ships move goods and windmills pump water. Today, we also use the wind to turn giant turbines that generate electricity. The sun's radiant energy also warms the water in our oceans and lakes. This causes the water to evaporate. The water vapor rises into the atmosphere. Later as the water vapor cools, it returns to the surface of the Earth in the form of precipitation.

Scientists have learned how to use the energy in sunlight. Using solar collectors houses and pools can be heated, or electricity can be generated to power great machinery or a small household appliance. Photovoltaic cells in solar panels are used in space as well as on Earth. Space Stations and most space probes convert solar energy directly into electricity to power their instruments. Scientists speculate that in the future solar space stations could be built to collect sunlight, convert it to electricity and then beam it down to Earth.

Our technology depends upon a stable flow of solar energy, however various solar phenomena sometimes alter the flow of solar energy. Luckily for us, the total energy from the sun changes by less than 1% but, turbulent solar activity can increase the amount of ultraviolet light and X-rays by hundreds of times. From sunspots to coronal mass ejections (CME) the sun seethes and bubbles quickly releasing enormous bursts of energy. Sunspots have been observed since the time of Galileo. These huge regions of strong magnetic field change the flow of heat from the sun's interior, keeping sunspots hundreds of degrees cooler than their surroundings. Sunspots follow a well-known 11 year cycle of rapidly increasing activity followed by slow decrease. At the peak of sunspot activity increased amounts of highly charged particles make their way across the 93 million miles into the Earth's atmosphere. The next activity peak will probably occur in 2000. Also coming from sunspot areas are solar flares. These flares release a tremendous amount of energy all at once. This can alter the Earth's atmosphere interfering with radio reception. Sometimes huge bubble-shaped disturbances are released above solar magnetic regions. These coronal mass ejections (CME) release an expanding plasma cloud weighing billions of tons that moves rapidly through space. Some of this cloud enters the Earth's magnetic field releasing a tremendous amount of magnetic energy into the Earth's atmosphere.

You have probably measured the Earth's magnetic field with a compass. Hundreds to thousands of kilometers above the Earth's surface the atmosphere thins to almost nothing, but the magnetic field is still strong. Here the few remaining particles in the atmosphere are strongly heated by the Sun's rays and ultraviolet light which creates positively charged ions that are easily steered and trapped by the magnetic field lines which surround the Earth. This huge region of space around the Earth is called the Magnetosphere. These lines of force rise from the Earth's southern magnetic pole and flow northward, entering the Earth again near its northern pole. The magnetosphere is affected by fluctuations in the sun's flow of energy.

Scientists, such as solar astronomers, will continue to study the sun and its effects on the Earth's magnetosphere. The information gathered will help us to better understand how the magnetosphere is structured. Studying the sun will also explain how the sun's energy affects fluctuations within the magnetosphere as well as on the Earth's surface.

Student Worksheet

Sunlight for Our Life

Directions: Use the reading Sunlight for Our Life to help you answer the questions below.

1. **Name 2 ways the sun's energy affects Earth.**

2. **Name 2 ways that we harness the sun's energy.**

3. **Name and describe 1 type of solar phenomenon and tell how it affects the Earth.**

4. **What is the magnetosphere?**

Science Exploration Guidesheet

Science Exploration: ___________________________________

Directions: Decide how you and your partner or group will explore these science ideas by answering each question below.

1. **What science idea does your class want to explore?**

2. **What question or questions do you want answered by this science exploration?**

3. **Describe in general how your class will answer the question(s) or how your class will explore this idea.**

4. **List step-by-step how you will answer the question(s).**

5. **List the materials you or your group will need to follow those steps.**

6. **What kind of observations will you make during this science exploration?**

7. **What kind of measurements will you make during this science exploration?**

Science Exploration Guidesheet

Science Exploration: ____

8. On a separate sheet of paper create a chart which you will use to record your observations.

9. Record your observations and report your findings to the class.

10. At the end of the science exploration create a special report to give to the class. Follow the form your teacher gives you.

11. What did you learn from this science exploration?

12. Does this lead you to any other questions? Write down one or two of your questions below.

Riding a Radio Wave: Observation Graph

Directions: For each observation time note each station that is received while scanning your assigned section of the AM band (call sign and dial number). Then rate each station's reception in terms of clarity and strength by placing an appropriate mark on the graph below. Note any observations as indicated.

5

4

3

2

1

BAND #: ____________
Call signs: ____________
Location: ____________
Distance: ____________

Date:	Time:
Observations	
Weather Conditions:	
Solar Conditions:	
Other Observations:	

Career Exploration Guidesheet

Solar Scientist

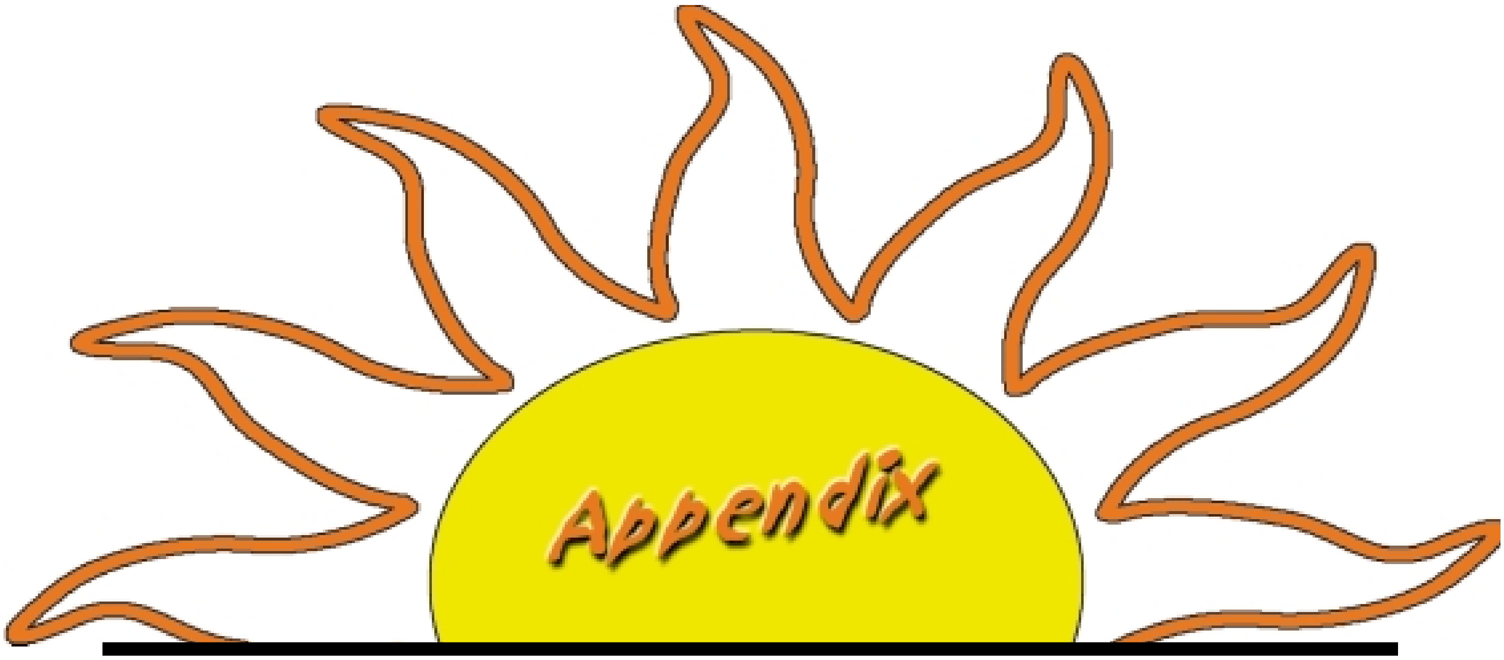
Directions: After listening to the broadcast or visiting the Web site to learn about the work of a solar scientist, answer the questions below.

1. **Tell about one thing you are good at that a solar scientist needs to know how to do.**

2. **Tell one thing about what a solar scientist does that you think is interesting. Explain why that is interesting to you.**

3. **If you were a solar scientist what would you want to learn more about?**

4. **If you could ask the solar scientist one question about his/her job, what would you want to know?**



- Solar Glossary
- Web Work

Appendix

Solar Glossary

coronal mass ejection (CME)	bubble-shaped disturbances that rise above active sunspot regions and send expanding plasma clouds that move rapidly through space
magnetic field lines	the phenomenon of magnetism where electrically charged particles tend to become attached to field lines and spiral around them while sliding along them. These lines of force come together where the field lines are magnetically strong and spread out where the magnetic force is weaker.
magnetic north	the direction toward which the compass needle points indicat-ing north
magnetosphere	Located 60 miles above the Earth's surface where the earth's magnetic lines of force flow
radiation	electromagnetic waves that are emitted by the sun
solar	having to do with the sun
solar energy	energy converted from the sun
solar flares	tremendous eruptions from sunspots that quickly release magnetic energy into space
sunspots	huge regions in the sun's atmosphere of magnetic fields that slow the flow of heat from the sun's interior

Web Work

The following Web sites can be used for additional student activities and for student research.

http://www.star.le.ac.uk/edu/planets/sun.html

A concise overview about the sun: composition, solar eclipse, solar wind.

http://image.gsfc.nasa.gov/poetry

Lots of good information and plenty of links along with interesting student activities.

http://www.rt66.com/r.bahm

Basic introduction to solar energy on this commercial site. It briefly explains the state of solar energy today, future applications and challenges of design. Includes a United States map depicting the annual daily total horizontal solar radiation.

http://www.pvpower.com

Large, interesting resource site about photovoltaics: history, technology, applications and other information.

http://solarcooking.org

Great site with lots of good resource information on solar cooking. Check out the FAQ subsection, interesting history of solar cooking, the Plans section and the Multimedia section.

http://helios.gsfc.nasa.gov

Cosmic and Heliospheric Learning Center NASA/GSFC. Covers the basics of Astrophysics at a challenging level (composition/elements, energetic particles, acceleration, magnetic fields, cosmic rays and an informative write-up about the heliosphere.

Web Work (continued)

The following Web sites can be used for additional student activities and for student research.

http://weknqdc.noaa.gov/stp/

This Web site gives sunspot counts as part of its daily solar activity observations.

http://www.set.noaa.gov/today.html

This Web site gives the space weather forecast that includes solar activity.