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SOLARVILLE EDUCATOR'S GUIDE

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INTRODUCTION

This guide introduces concepts and activities for teachers to use with their students centered on the APS Solarville exhibit of the Arizona Science Center, Phoenix, Arizona. This guide is divided into standards aligned activities based on grade level. There are three types of activities in this guide. The first type introduces students to concepts found in Solarville and provides them with background experiences that will enhance their field trip and understanding. The second type of activities are those that students can perform during a field trip. These include interactive notebooks and scavenger hunts for the gallery. The final type of activity allows for review and reflection of the experiences following a field trip. This curriculum guide encourages the use of the 5 E's of inquiry by encouraging students, teachers, and chaperones to **Engage, Explore, Explain, Elaborate, Evaluate** as they explore Solarville.

Solarville Gallery Exhibits

- **Discover Algae Fuel:** Watch a video about how scientists are making fuel out of algae. Learn that this is a sustainable source of energy because the algae uses carbon dioxide from the air as it grows.
    - Concepts: Renewable energy, sustainability, carbon cycle
- **Road to Renewable Energy:** Visit the kiosk to watch short videos explaining how we get energy from solar, wind, water, biomass, and geothermal sources. Also read signs on the pros and cons of both renewable and nonrenewable energy sources.
    - Concepts: Renewable energy, sustainability, nonrenewable energy sources
- **Wind Power:** Turn on the wind and watch as it spins the turbine to light an LED!
    - Concepts: Renewable energy, kinetic energy, wind power
- **Poop to Power:** Did you know that a cow's poop can light up your house? Learn how waste is turned into biogas!
    - Concepts: Renewable energy
- **Muscle Match:** Race the solar panel! Crank the handle on your side to make the ball rise to the top of the tube, and see if you can beat the solar-powered tube.
    - Concepts: Renewable energy, solar power

- **How A Solar Panel Works**: Investigate the different layers of a solar panel and how they are combined to help us trap the sun's energy and create electricity!
    - Concepts: Solar energy, electrons, electricity
- **Smart Windows:** Test an energy-saving window that goes from clear to opaque with the flip of a switch.
    - Concepts: Saving energy, sustainability
- **Why Birds Don't Get Zapped:** Why can birds sit on telephone wires and not get electrocuted?
    - Concepts: Electricity
- **Make A Spark:** Use heat to create a spark that travels up the Jacob's ladder, then cool it off and see what happens.
    - Concepts: Electricity
- **Compact Your Carbon:** Learn about solar trash compactors with our replica. Solar energy allows us to squeeze more garbage into our trash cans, which means the garbage trucks don't need to burn fossil fuels to collect the trash as frequently!
    - Concepts: Trash collection, solar power, climate change
- **Skin Tones:** Different areas of the world have different amounts of sunlight, which is why we see a variety of skin tones as people have adapted to their climate.
    - Concepts: Sun, adaptation
- **Pedal Power:** Ride a bike and use your own power to light up 3 different kinds of light bulbs: incandescent, fluorescents, and LEDs. Which one takes the most energy?
    - Concepts: Electricity, energy, sustainability
- **Biosphere:** Our colony of shrimp has been surviving in a self-contained glass sphere for over 12 years! The shrimp eat algae, which grows in the sunlight, and bacteria break down waste.
    - Concepts: Ecosystems
- **Screen the Sun:** Test different materials, like sunscreen and denim, to see which one lets more UV light through.
    - Concepts: Ultraviolet light, sun protection
- **Urban Heat Island:** Compare the temperatures of concrete and plants. Is one warmer than the other? Why? What does that mean for cities like Phoenix?
    - Concepts: Urban heat island effect, sustainability

- **Unplug!** Did you know that most Americans have vampires in their homes? That's right – energy vampires, plugs that suck up energy when they are left plugged into the wall! Experiment with different appliances to see which use the most energy.
    - Concepts: Electricity, sustainability
- **Desert Dwellings:** Examine different materials that are commonly used to build homes in the desert. Which materials would keep your house the coolest in the hot summer sun?
    - Concepts: Sustainable buildings, heat capacity
- **Recycling:** Take a quiz to see how much you know about recycling, and pick up some tips on how to recycle more in your life.
    - Concepts: Recycling
- **Why is the Sky Blue?** Take a look at how sunlight shines through the sky, and learn about why the sky appears blue.
    - Concepts: Light spectrum, sun
- **Solar At Work:** Head out to the APS Solar Terrace to get a view of the solar panels that Arizona Science Center uses to power our annex building.
    - Concepts: Solar power

Essential questions

These questions provide the framework for guiding learning through Solarville.

- How has our electricity use changed over time?
- What are new technologies that promote renewable resources?
- How is solar energy stored by living things?
- Compare two types of renewable resources demonstrated by the gallery.

Educator Resources

- APS - Arizona Public Service Educator Site
- Solar Town Kids - How to make a solar oven at home and other solar activities
- Solar Activity - Windows to the Universe - Explanation of how the sun produces energy
- National Geographic Society Educator Guide to Renewable Resources
- Energy Kids- Energy facts and educator resources
- Renewable Energy Activities - Choices for Tomorrow
- Kids Corner- Information and safety with solar energy
- Renewable Energy Activities - Choices for Tomorrow

4TH GRADE STANDARDS COVERED IN SOLARVILLE

Strand 1

Concept 1: Observations, Questions, and Hypotheses Observe, ask questions, and make predictions.
PO 1. Differentiate inferences from observations.

Concept 2: Scientific Testing (Investigating and Modeling) Participate in planning and conducting investigations, and recording data.
PO 2. Plan a simple investigation that identifies the variables to be controlled.
PO 4. Measure using appropriate tools (e.g., ruler, scale, balance) and units of measure (i.e., metric, U.S. customary). (See M04-S4C4-03 and M04-S4C4-07)

Strand 2

Concept 1: History of Science as a Human Endeavor Identify individual and cultural contributions to scientific knowledge.
PO 1. Identify how diverse people and/or cultures, past and present, have made important contributions to scientific innovations (e.g., Margaret Mead [anthropologist], supports Strand 4; Nikola Tesla [engineer, inventor] supports Strand 5; Michael Faraday [scientist], supports Strand 5; Benjamin Franklin [scientist], supports Strand 5).

Strand 4

Concept 3: Organisms and Environments Understand the relationships among various organisms and their environment.
PO 1. Describe ways various resources (e.g., air, water, plants, animals, soil) are utilized to meet the needs of a population.
PO 2. Differentiate renewable resources from nonrenewable resources.
PO 3. Analyze the effect that limited resources (e.g., natural gas, minerals) may have on an environment.
PO 4. Describe ways in which resources can be conserved (e.g., by reducing, reusing, recycling, finding substitutes).

8TH GRADE STANDARDS COVERED IN SOLARVILLE

Strand 1

Concept 1: Observations, Questions, and Hypotheses Formulate predictions, questions or hypotheses based on observations. Locate appropriate resources.
PO 1. Formulate questions based on observations that lead to the development of a hypothesis. (See M08-S2C1-01)
PO 2. Use appropriate research information, not limited to a single source, to use in the development of a testable hypothesis. (See W08-S3C6-01, R08-S3C1-06, and R08-S3C2-03)
PO 3. Generate a hypothesis that can be tested.

Concept 3: Analysis and Conclusions Analyze and interpret data to explain correlations and results; formulate new questions.
PO 1. Analyze data obtained in a scientific investigation to identify trends. (See M08-S2C1-08)
PO 2. Form a logical argument about a correlation between variables or sequence of events (e.g., construct a cause-and-effect chain that explains a sequence of events).
PO 4. Formulate a future investigation based on the data collected.
PO 6. Identify the potential investigational error that may occur (e.g., flawed investigational design, inaccurate measurement, computational errors, unethical reporting).
PO 8. Formulate new questions based on the results of a previous investigation.

Strand 3

Concept 1: Changes in Environments Describe the interactions between human populations, natural hazards, and the environment.
PO 1. Analyze the risk factors associated with natural, human induced, and/or biological hazards, including: • waste disposal of industrial chemicals • greenhouse gases
PO 2. Analyze possible solutions to address the environmental risks associated with chemicals and biological systems.

Concept 2: Science and Technology in Society Develop viable solutions to a need or problem.
PO 1. Propose viable methods of responding to an identified need or problem.
PO 2. Compare solutions to best address an identified need or problem.
PO 3. Design and construct a solution to an identified need or problem using simple classroom materials.
PO 4. Compare risks and benefits of the following technological advances: • radiation treatments • genetic engineering (See Strand 4 Concept 2) • airbags (See Strand 5 Concept 2)

BOOK YOUR FIELD TRIP TODAY!

If you have a group of 15 or more, you are eligible for group discounts! To schedule a visit, call 602.726.2000 ext. 128 or email reservations@azscience.org

Please see below for rate information:

School Groups
Students - $6*
Chaperones - $6*
AZ State Certified Educators - free
*General Admission is waived for Focused Field Trip Certified Educators, their students, and chaperones (40%+ free lunch = Title 1)

General Groups
Children (ages 3 - 17) - $6
Adults - $7

Add-ons
Traveling Exhibitions- Price Varies, Click here for details
CREATE - $4/student (chaperones/teachers are free as they are not participating in the challenges)
Planetarium - $4/person
IMAX - $5/person

Educator Professional Development
Freeport- MacMoran Foundation Center for Leadership in Learning

Science Classroom Experiences
Science on Wheels
STEM Club

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ACTIVITY ELODEA O_2

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INTRODUCTION

TITLE: ELODEA O2

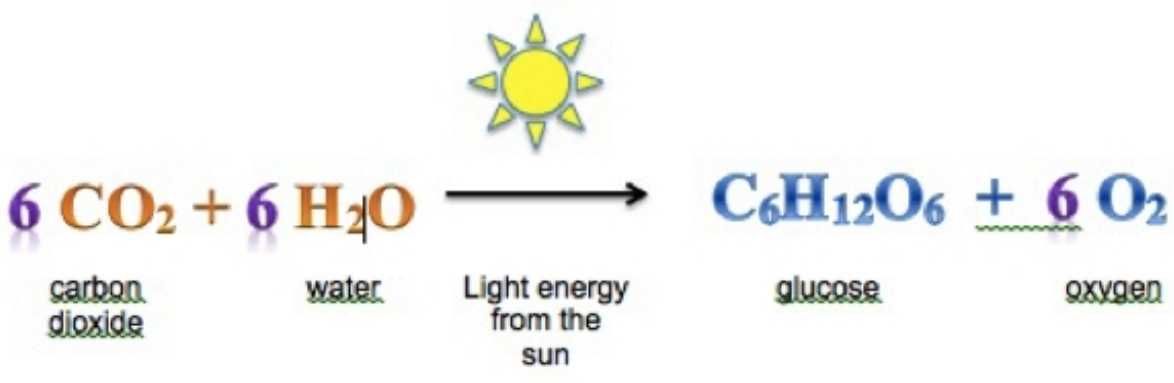
Gallery:	Solarville
Audience:	All grade levels. Standards focused on 4th and 8th grades
Author(s):	Al Pajak
Date Developed:	11/20/2015

OVERVIEW/DESCRIPTION

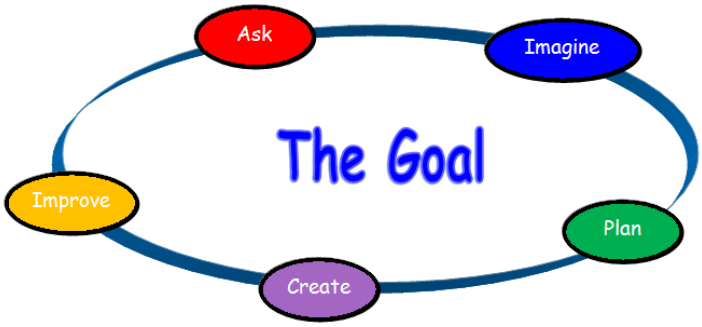
In order to gain a better understanding of how plants use and store solar energy, they will develop an experiment to collect oxygen produced by an elodea plant. This activity centers around photosynthesis, but is appropriate with modifications for any grade level. The students, using the Engineering Design Process, develop a testing and collection device.

BACKGROUND

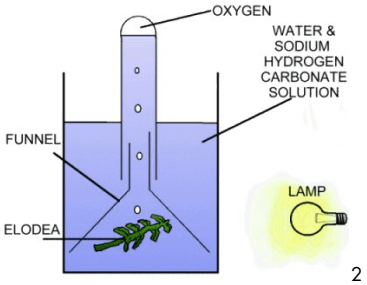
Biofuels[1], or fuels produced from living things, provide a clean and highly renewable source of energy. In this activity, students explore how plants convert solar energy into energy through photosynthesis. The by-product of this reaction is oxygen, which is released as a gas, and sugar, which the plant uses for energy.
Elodea is a fast growing aquatic plant that quickly converts CO2, water, and sunlight into energy. A simple device to collect and measure oxygen produced by photosynthesis must be designed by the students using the supplies provided.



[1] "NREL: Learning - Biofuels Basics." 2005. 20 Nov. 2015 <http://www.nrel.gov/learning/re_biofuels.html>
[1] <http://www.sciencewindows.com/wp-content/uploads/2015/03/THE-CHEMISTRY-OF-PHOTOSYNTHESIS.jpg>



The Engineering Design Process



[2]

Sample Experimental Apparatus

PROCEDURE:

Begin by demonstrating how a submerged piece of elodea begins producing bubbles once it interacts with a light source. Ask guiding questions that lead the students to begin to develop observations and inferences.

ASK: Why do you think the bubbles are forming from the plant?
How could you measure the gas produced by the elodea?

Show the students the supplies available to build a testing stand. Review the Engineering Design Process with your students and ask them to develop a system that could collect and measure the gas bubbles.
Have the students build and test their collection system.

VOCABULARY

Photosynthesis
Solar Energy
Stored Energy
Carbon Dioxide
Oxygen

[2] <https://moodle.beverleyhigh.net/pluginfile.php/7482/mod_resource/content/0/assets/images/ks4/elodea.gif>

ESSENTIAL QUESTIONS

How do plants store solar energy for later use?
How do we measure the amount of stored solar energy?

ENGINEERING GOAL

By using the engineering design process, design a device that can capture and measure the gaseous oxygen produced by a 5 centimeter long sample of elodea.

STEM CONCEPTS

Science: Photosynthesis, Chemistry, Solar Energy
Technology: Students can measure and graph their results
Engineering: Students need to design their oxygen collection apparatus and the system for measuring the amount of oxygen produced.
Math: Students can measure and graph the results of their experiment.

5 E'S OF INQUIRY (Engage, Explore, Explain, Elaborate, Evaluate)

Engage: Students will develop, and design the experiment to test how much oxygen is produced by the Elodea.
Explore: Students discover how changes in light effects oxygen production.
Elaborate: Students describe their improved understanding of the process of photosynthesis as it relates to stored solar energy.
Evaluate: Students explain and reflect on effectiveness of their testing procedure and compare their methods to other groups.

TAKE HOME MESSAGES

Students have a better understanding of how plants produce, store, and use energy they receive from the sun.

SUPPLIES - Per group

- Elodea (available at most pet and aquarium stores) or other aquatic plant.
- Funnel
- Graduated cylinder or test tube
- Recycled Materials (glass jar, water bottles, card board, rubber bands, wire) which the students use to build their testing apparatus.
- Metric Ruler
- Permanent Marker

RESOURCES

- Photosynthesis in Elodea - YouTube Video - It is not recommended that you show the students this video. They should develop their own experimental design.
- Using Aquatic Plants to Demonstrate Photosynthesis - Carolina Biological

NEXT GENERATION SCIENCE STANDARDS

4TH GRADE

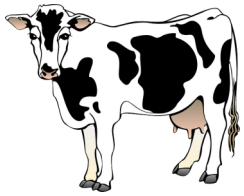
4-PS3-4.	Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.
4-ESS3-1.	Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.
4-PS4-3.	Generate and compare multiple solutions that use patterns to transfer information.
ETS1.C:	Optimizing The Design Solution Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (secondary to 4-PS4-3)
PS3.D:	Energy in Chemical Processes and Everyday Life
ESS3.A:	Natural Resources
ETS1.A:	Defining Engineering Problems

8TH GRADE

MS-LS1-6.	Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.
MS-LS1-7.	Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.
MS-LS2-3.	Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
MS-PS1-2.	Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

How do you turn manure into electricity?

Draw the manure map and discover how.



Solarville Scavenger Hunt

Name _____

School _____

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Time to get ready for your trip to Solarville!

Pre– Field Trip Vocabulary

- Electrons
- Lipids
- Solar Panel
- Photovoltaic
- Non– renewable
- Renewable
- Ecosphere

Essential Questions:

1.

2.

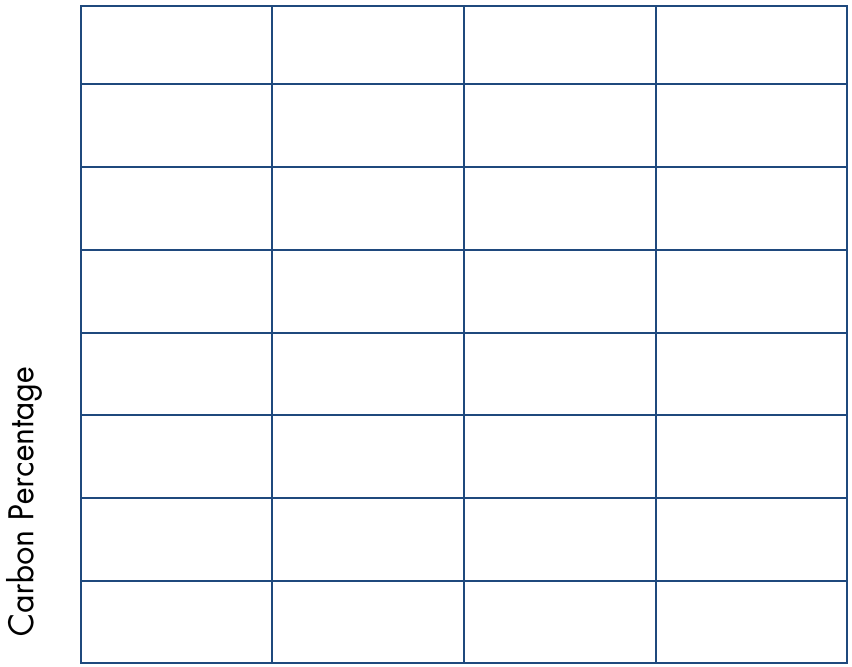
Fold

Carbon Dioxide

Find the CO_2 and graph the sources of carbon dioxide.

Use this word bank to label the bar graph.

Residential, Commercial, Industrial, Transportation



What causes each of these to make CO_2?

Back at School

Write a friendly letter about what you learned from Solarville and send it to APS.

Date: _____

Dear _____,

Sincerely,

APS Address:

400 N 5th St #2, Phoenix, AZ 85004

back

Ecosphere

Using this word bank, draw and label the Ecosphere.

Word Bank: **algae, water, rock and shrimp.**

This Ecosphere is 11 years old. The shrimp live up to 4 months and have up to 300 offspring every 4 days. Estimate the number of shrimp that have lived in the sphere.

Resource: http://learn.genetics.utah.edu/content/gsl/artemia/

Solar Panel

How does a solar panel work?

List each layer

1.

2.

3.

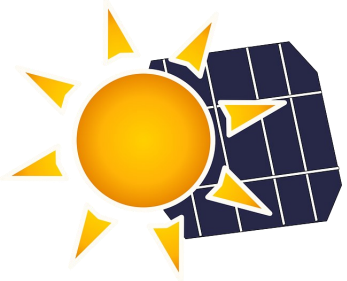
4.

5.

Which layers move electrons?

_____ _____ _____

How does the solar panel make electricity?

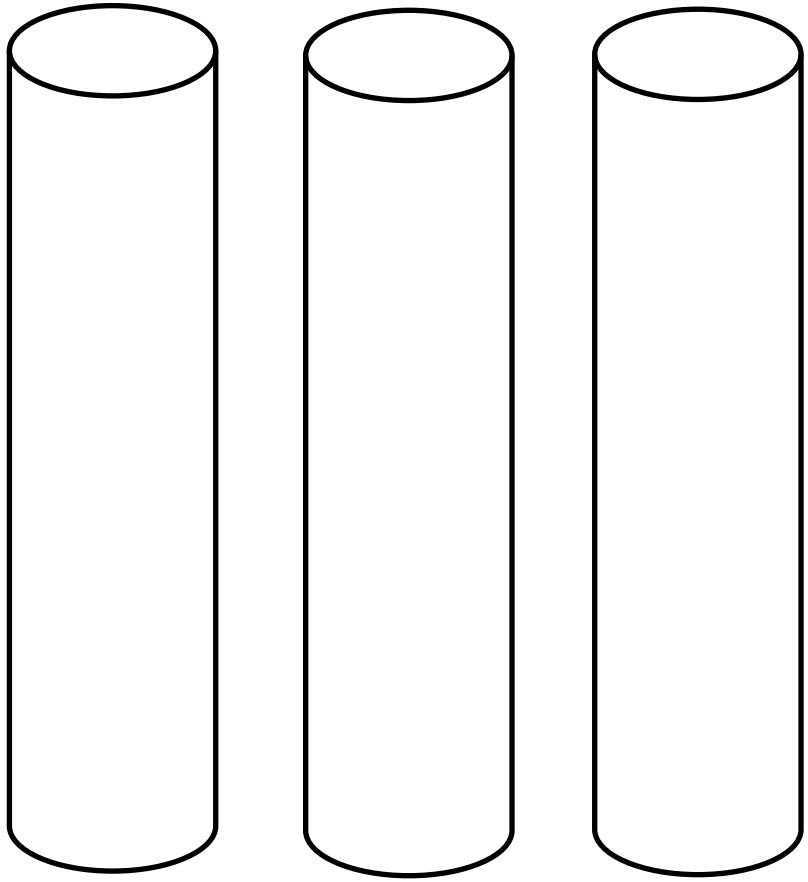


Fold

Algae Fuel

What are the steps to create fuel from algae?

Use this picture to show how it works.



Pedal Power:

PEDAL FAST! Which type of light is easier to power?

What type do you have more of at home?

What does this tell you about your energy use?

Draw a house and show where you would put solar panels. Make sure to add the sun!

Fun Facts

Find each of these fun facts as you walk through Solarville.

Bird Zap: What keeps birds safe on powerlines?

What are the three R's?

1. _____

2. _____

3. _____

What are the 8 Types of Energy listed in Solarville?

1. _____

2. _____

3. _____

4. _____

5. _____

6. _____

7. _____

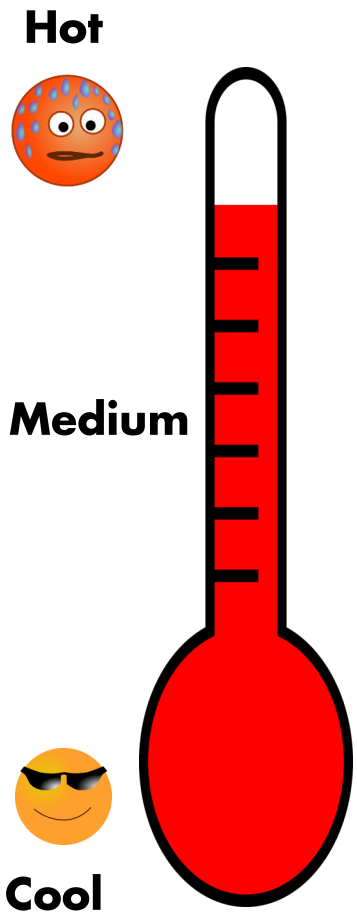
8. _____

6 Circle the three types of energy create waste or pollution?

Fold

Desert Dwellings

On the scale below, rank the building materials from cool to hot.



If you could build your own house, which building material would you choose and why?

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Instructions for Activities and Answer Sheets

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ACTIVITY: ELODEA

This activity helps students to gain a better understanding of how plants use and store solar energy, they will develop an experiment to collect oxygen produced by an elodea plant. This activity centers around photosynthesis, but is appropriate with modifications for any grade level. The students, using the Engineering Design Process, develop a testing and collection device.

This activity may be done before the field trip to peak interest in solar energy or after visiting Solarville to reinforce what they have learned after exploring the gallery.

Student Guides:

Click **HERE** to download a student guide
Please click **HERE** for video assembly instructions of the Student Guide.

Written Instructions for Assembly of a Student Guide

- Print the guide front to back (double sided) so that page 2 is on the back of the cover.
- Fold the pages in half.
- Remind the students to cut only the dashed lines.
- The center cut is the most difficult. On the pages with the center cut, do not cut beyond the dashed line. Simply trim the dashed line from the center of the page. The finer the cut, the better your journal will hold together. This step will take practice.
- Next cut the edge cut lines. Some pages have dashed lines on the top and bottom of the pages. Only cut this lines and do not go past the end of the line.
- Gently roll these pages and slide them through the center cut front page.
- Check to make sure the pages are in the correct order.

The Student Guide is designed to be a tool used before, during, and after your visit to Solarville.

Pre- Field Trip Activity: The activities planned before the trip introduces students to concepts found in Solarville and provides them with background experiences and vocabulary that will enhance their field trip and understanding. You can find the vocabulary for Solarville on page 2 of the interactive notebook.

During the Field Trip Activity: The second type of activities are those that students can perform during a field trip. These are also included in the student guides and scavenger hunts for the gallery. Pages 3-11 of the interactive notebook.

Post Field Trip Activity: The final type of activity allows for review and reflection of the experiences following a field trip and can be found on the last page of the Student's Interactive Notebook. You can find this activity on the last page (BACK) of the interactive notebook.

ANSWER KEY FOR APS SOLARVILLE STUDENT INTERACTIVE NOTEBOOK

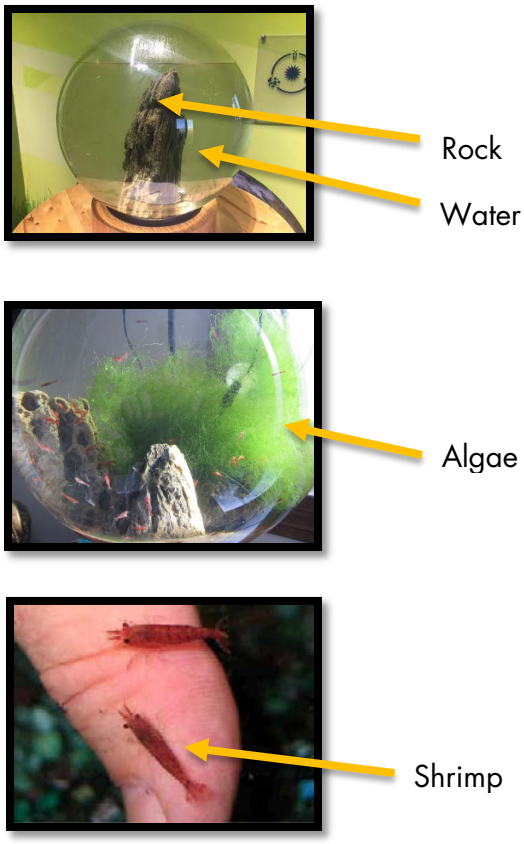
Page 2

PRE- FIELD TRIP ACTIVITY

Page 3

Label your drawing below using this word bank: **algae, water, rock, and shrimp**

Drawing of the Ecosphere should look similar to this:



Page 4:

How does a solar panel work?

Imagine a ray of sunlight as a stream of tiny articles. These particles are called photons. Each time a photon hits a photovoltaic (PV Cell), it knocks an electron loose. A stream of photons (sunlight) creates a stream of electrons (electricity). That's how PV cells create electricity from it.

List the Layers:

1. Photovoltaic (Finished) Layer
2. Resting Layer
3. Silicon Layer
4. Metal Layer
5. Anti-Glare Layer
6. Glass Layer

Which layers move electrons?

Resting Silicon Metal

Page 5:

This is open ended, but the drawing may look similar to this:

Page 6:

Bird Zap: What keeps bird safe on powerlines?

1. Electrical currents flow along a path of least resistance. The bird's feet have a large amount of resistance. The metal in the wire has no resistance, therefore the current continues to travel through the wire instead of detouring through the bird's feet.
2. The bird is not touching and electrical "ground" while in contact with the high-voltage wire which would complete the electrical circuit.

What are the three R's?

1. Reduce
2. Reuse
3. Recycle

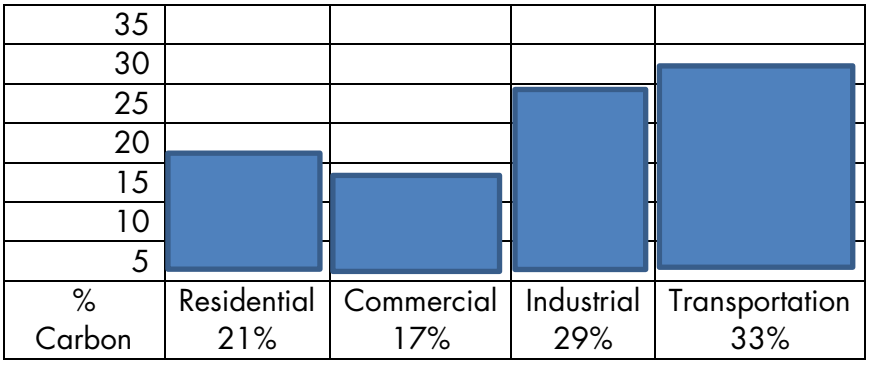
What are the 8 Types of Energy listed in Solarville?

1. **Nuclear**
2. **Natural Gas**
3. **Coal**
4. Solar
5. Geothermal
6. Wind
7. Hydropower
8. Biogas

Circle the three types of energy that create waste or pollution? (See above **BOLDED/Underlined**)

Page 7:

Carbon Dioxide Graph

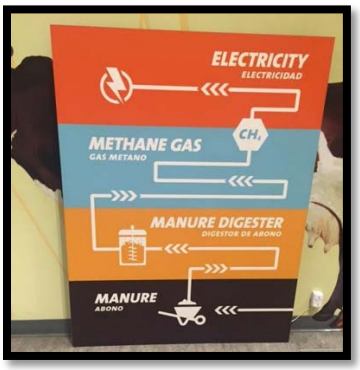


Page 8:

How do you turn manure intro electricity?

Draw the manure map and discover how!

This is open ended, but the drawing may look similar to this:



Page 9:

Desert Dwellings; On the Scale rank the materials from cool to hot

COOL Concrete, Stucco, Adobe, Brick, Cob **HOT**

If you could build your own house, which building material would you choose and why?

Open ended but here are some possible solutions:

- Concrete, to stay cool during the summer months
- Adobe, so I am warm and cool when I need to be
- Cob so I can keep warm all year in cooler climates

Page 10:

Which type of light is easier to power?
In order (easiest to most difficult): LED, CFLS, Incandescent

What type do you have more of at home?
Open ended

What does this tell you about your energy use?
Also open ended but answers could look like this:
Incandescent uses more energy, but cost effective, LEDS are most expensive but least amount of energy.

Page 11:

What are the steps to create fuel from algae?

1. Algae cultures are grown in a lab then taken to an algae farm.
2. Algae is exposed to sunlight and starts multiplying.
3. Lipids from the algae are harvested and used as fuel.