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Using Blackberries to Create a Solar Cell

Using Blackberries to Create A Solar Cell

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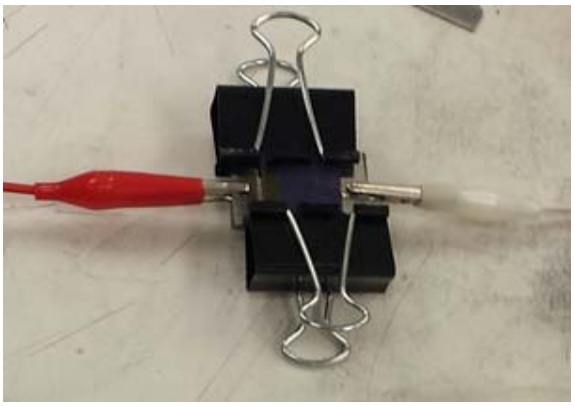


Grade Level 6th or 7th

Goals and Objectives:

Activity Dependency
This lesson is based on the premise that teachers have addressed the concepts associated with scientific investigation and energy prior to this lesson.

Time Required Two 85-minute block sessions

Group Size 24 students (6 groups of 4 students)

Expected Cost per Group US $140.00

Summary of Lesson

This interactive lesson allows students to be exposed to hands-on learning where students learn how they could use the dye from blackberries to create a device that can convert light/solar energy into electric energy. This process is done by allowing students to create a solar device and use a multimeter to calculate its photovoltaic output. Students will be able to apply engineering concepts associated with this lesson by working together to create a device able to generate electricity. Students will also be able to discern that these concepts used by many engineers could be applied within the field of engineering on a much larger scale in a variety of areas.

Engineering Connection

Within today's society, efforts are continually centered on conserving energy or finding various means of harvesting solar energy. To address growing energy needs, many engineers are focused on optimizing efficiency in harvesting solar energy. In many instances, the costs associated with such devices can be enormous. Consequently, the need to explore other or additional mechanisms is essential.

Florida Educational Standards

State STEM Standard

6th Grade

SC.6.N.1.1 – Design a problem from the sixth grade curriculum: use appropriate reference materials to support scientific understanding; plan and carry out scientific investigations of various types, such as systematic observations or experiments, identify variables, collect and organization data; interpret data in charts, tables, and graphics, analyze information, make predictions, and defend conclusions.

LAFS.69.RST.1.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

ITEEA Standard

Standard 9. Students will develop an understanding of engineering design. **Grade Level 6-8.** In order to comprehend engineering design, students should learn that. **F.** Design involves a set of steps, which can be performed in different sequences and repeats as needed. **G.** Brainstorming is a group problem-solving design process in which each person in the group presents his or her own ideas in an open forum. **H.** Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.

NGSS Standard

MS.Engineering Design. Students who demonstrate understanding can:

MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

MS-ETS1.4. Develop a model to generate data for iterative testing and modification of a proposed object, took, or process such that an optimal design can be achieved.

CCSS Standard

LAFS.6.W.3.7 Conduct short research projects to answer a question, drawing on several sources and refocusing the inquiry when appropriate.

LAFS.68.RST.3.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

Course Outline/Overview

This lesson allows teachers to provide students with hands-on learning about various applications in the field of engineering. Students are presented with a problem and using the concepts associated with the scientific method, are able to follow a series of steps to come up with a feasible solution. Students are able to reflect on many of the issues within society that relates to energy conservation and more specifically, how many engineers engage in research and scientific investigation to uncover ways to gain energy without using nonrenewable resources.

Keywords/Vocabulary Terms

anode, anthocyanin, cathode, electrolyte, nonrenewable energy, renewable energy, solar cell, photovoltaic, conductor, catalyst, solar energy, energy, energy transfer, energy conversions.

Guided Lesson Plan/Activities

Learning Objectives

After this lesson, students should be able to:

- Identify the variables in an experiment.
- Define energy.
- Define solar (photovoltaic) cell.
- Explain how energy can be transformed from the sun (solar energy) and converted to power a device (electrical energy).
- Describe how energy can be converted from one form into another.
- Define renewable and nonrenewable energy.

Resource/Materials List

Each Group needs

- Conductive glass (2)
- Titanium Dioxide Paste
- Isopropanol
- Chem Wipes
- Pencils (1)
- Binding clips (2)
- Tape
- Stirring Rod
- Stop Watch
- Hot Plate
- Electrolyte Solution
- Multimeter
- Alligator clips (2)
- Dropper
- Beaker
- Aluminum Foil
- Tweezers
- Water (5 ml)

Note: To complete this lab activity, teachers can order the Dye Sensitized Solar Cell Kit, Product #P6-2150 from http://www.arborsci.com/ for approximately $140.00 (not including shipping and handling costs. The kit comes with all the materials needed to complete this activity.

Introduction/Motivation

The past few weeks, we have been discussing scientific methods and investigation and how many scientists, engineers, and researchers conduct experiments on a variety of topics, many of which, are focused on improving conditions for us here on Earth. Who can tell me some of the improvements that we have gained today because of scientific exploration? (Possible Answers: technology, hybrid cards, satellites, health care and medicine, etc…). Today, we are going to conduct an experiment on energy. Can anyone define energy for me? (Answer: energy is the ability to do work). Where does the energy here on Earth come from (Answer: The Sun). We all get our energy from the sun. There are many resources right here on Earth that we use to obtain energy. We get energy from burning fossil fuels, by eating various foods such as plants, and from the radiation of the Sun.

Now, in order to make sure we remember the concepts we previously discussed on energy and the various types of energy, we will do a quick review of some of the new vocabulary words for this lesson that we should have some understanding about before we get started. First, photovoltaic (Everybody repeat this word after me) relates to the ability to produce electrical current at the junction of two substances exposed to light. What this means is that two substances are combined together and once exposed to sunlight, electricity is created. Sounds kind of difficult to do doesn't it? (Responses will vary). Well, today that is exactly what we are going to do.

It is also important for us to recognize that when many of us go home after school, we watch TV, play on our Play Station 4 and X-Box games. However, what we do not realize is that the energy that we are receiving from the electricity provided is coming from somewhere. Can anyone tell us where (Answer: Power Plants that burn coal and other fossil fuels for electricity). Well, the problem is that many of these fossil fuels that are used cannot be replaced. What this means is that when they are all used up there is no way of producing them again. Because of this, research like what we are going to do today are conducted in an attempt to save some of the resources that we call limited. Limited resources are nonrenewable because once they are all gone, there is no more of it left. Now, renewable resources like water can be used over and over again.

Because of this, efforts are constantly centered on conducting research to find additional ways to generate energy before all of our nonrenewable resources all gone. Now, I already mentioned water, can anyone else tell me some of the other renewable resources that we can use for energy? (Answer: wind, air, and solar).

Okay, so we mentioned some examples of renewable energy and solar was one of them. Can anyone tell me what is a solar (we also refer to solar energy and photovoltaic energy) cell? (Answer: A solar cell is a device that converts sunlight directly into energy).

Why do you think it would be good to get energy from the sun rather than just getting electricity by plugging in electrical devices in our homes? (Answer: Because many of the resources used to generate the electricity we get in our homes are limited). The energy we get in our homes in many instances comes from a large power plant that

burns natural gases or coal in order to provide the energy needed to power up devices in our home. Has anyone ever seen the power plant in their neighborhood? (Note: Teacher can tell the students depending on where they reside the location of the power plant in their neighborhood).

It is important for us to reminder that natural gases, fossil fuels, and coal are resources that have been made by certain conditions and changes over Earth that occurred millions of years ago. Now, what this means is that should it run out, it would take millions of years to be created again. This is why these resources are referred to as nonrenewable resources.

Who uses batteries in here to power up a device? (Students should raise their hands). Can anyone tell me a battery that they use at home to power up a device. (Answers will vary but can include: cell phone, flashlight, remote control, toys, etc…). Now, what happens once all of the energy it has is gone. It dies right? Yes, of course, and because of this, we have to go out and get new batteries. The bad thing about this is the disposal of these batteries can result in contamination and there is also the fact that many of resources required to make these batteries also come from nonrenewable resources such as nickel, lead and calcium.

Now, when we look at the issues that can arise from the continued use of nonrenewable resources, it makes us wonder what's going to be left for us when we get older. Surely, these resources cannot last forever.

This is why scientists and engineers are working every day to come up with new ways to harvest energy without using up all of our limited resources. The most significant source of energy on Earth comes from the Sun. So, why not try to come up with ways that the energy from the Sun can be used to generate the electricity needed? Well, that is what scientists and engineers continually conduct research and investigations on. The great thing is that today, we are going to see just how that process works. Students you will be presented with the following problem: You are out with your friends one day and your cell phone goes out and there is no electrical outlet available; what can you do to obtain electricity? (Answer: find an alternative source of energy like solar energy).

For this lab activity, you all will be working in groups using blackberries to create a solar (photovoltaic) cell. Many of you may wonder, why are we using blackberries? Well blackberries have anthocyanin (Repeat that word after me). Anthocyanin is an organic compound that is extracted from plants like cherries, blackberries and raspberries through a process of boiling them and extracting the dye. For our lab, we are going to extract the purple dye from the blackberry. The interesting thing about this purple dye is that because of its purple color, it can be used to absorb energy in the form light from the Sun, which can then be turned into electrical energy.

To complete this lab, we are going to use to glass sides where we are going to follow a series of step to create a device with a conductive side (cathode) with Titanium dioxide. This chemical is used to help us extract as much of the dye as possible from the blackberry. The conductive side is where electrical current can flow from a device. We

will take another glass and gently scratch the surface with a pencil to get the graphite, which is the anode (an electrode through which electrical current flows into a device).

After this, we will use an electrolyte solution to provide the connectivity needed between the two slides to generate electricity. An electrolyte is a substance that has free ions, which allows it to be a good conductor of electricity. Now, once we have completed all of the steps and create our device, we will be able to test the electricity/voltage it provides and possibly see if it can even power a small device. I also want to remind you all to remember laboratory safety and make sure that you are very careful as we complete each step.

Solar energy is radiant light and heat from the Sun that is harnessed using a range of ever-evolving technologies such as solar heating, photovoltaics, solar thermal energy, solar architecture and artificial photosynthesis. It is an important source of renewable energy.

The **Photovoltaic effect** is the effect observed when electromagnetic radiation, particularly visible light from the sun, falls on a thin film of one solid deposited on the surface of a dissimilar solid producing a difference in potential between the two materials. The photovoltaic process converts light energy into electrical energy. Generally, these photovoltaic structures are used to provide power to small devices that can include calculators, wristwatches and satellites.

Blackberries contain anthocyanin which is a compound found in plants. What is interesting about blackberries in particular is that through the process of boiling them, the purplish dye generated from this process can be extracted and used to absorb solar/light energy, which can then be converted into electricity.

A **solar cell** is a photovoltaic cell that converts sunlight directly into electricity. Larger solar panels are used in many homes to reduce energy costs. Photovoltaic (Solar) panels have no greenhouse gas emissions once manufactured, and have typical operating lifespans of 20-25 years. Besides providing electricity directly for a building, solar panels power street and garden lights. The most common type of solar panel is developed from silicon.

Vocabulary / Definitions

Word	Definition
Anode	An electrode through which electric current flows into a device.
Anthocyanin	A compound found in plants that can be boiled to extract the purple-red dye which can be used to absorb solar energy.
Cathode	The electrode from which a electric current flows out of a device
Electrolyte	A substance that has ions that are electrically conductive.
Nonrenewable energy	A natural resource that cannot be re-made or re-grown at a scale comparable to its consumption.
Renewable energy	Natural resources that can be replenished in a short period of time.
Solar (photovoltaic) cell	A device that converts solar/light energy into electricity.
Conductor	An object, substance or material allowing the flow of an

	electrical charge.
Catalyst	A substance that increases the rate of a chemical reaction without itself undergoing any permanent chemical change
Solar energy	Radiant energy emitted from the Sun.
Energy	The ability of a system to perform work.
Energy transfer	Energy is transferred from one object to another when a reaction takes place. Energy comes in many forms and can be transferred from one object to another as heat, light or motion.
Energy conversions	Energy can be changed from one form into another.

Before the Activity

- Remind students to remember laboratory safety rules.
- Have students decide who going to perform specific roles in their group:
    - **Project Director (PD)** The Project Director is responsible for the group. This person reads directions to the groups, keeps the group on task, is the only member allowed to talk to the teacher, and assists with conducting lab procedures. This person also shares summary of group work and results with the class.
    - **Materials Manager (MM)** The Materials Manager is responsible for obtaining all necessary materials and/or equipment for the lab. This person picks up needed materials, organizes materials and/or equipment in the work space, facilitates the use of materials during the investigation, assists with conducting lab procedures, and returns all materials at the end of the lab to the designated area.
    - **Technical Manager (TM)** The Technical Manager is in charge of recording all data. This person is responsible for recording data in tables and/or graphs, completes conclusions and final summaries, assists with conducting lab procedures, and assist with the cleanup.
    - **Safety Director (SD)** The Safety Director is responsible for enforcing all safety rules and conducting the lab. This person assists the PD with keeping the group on-task, conducts lab procedures, reports any accidents to the teacher, keeps track of time, and assists the MM as needed. (Dadeschools.net, n.d.).

- Prior the introduction of this lesson and activity, students should watch the Study Jams Scholastic http://studyjams.scholastic.com/studyjams/jams/science/energy-light-sound/heat.htm.

Conduct the Solar Cell Lab Activity with students following the steps outlined below:

Activity Lesson Instructions/Step-by-Step Procedures

Step 1). Put blackberries (4) into beaker and add 5 ml of water and 5 ml of Isopropanol.

Step 2). Using the multimeter, test the conductivity of one glass to make sure it is on its conductive surface side.

Step 3). Scratch over the surface of the conductive side of the other glass with a pencil to roughen its surface (Anode). The graphite in the pencil will serve as a catalyst.

Step 4). Put the tape around the conductive surface (Cathode) on the other glass that does not have the pencil scratchings.

Step 5). Add the Titanium Dioxide Paste gently within the area not tapped.

Step 6). Use the stirring rod to smooth the surface.

Step 7). Remove the tape.

Step 8). Put on hot plate at 400°C to allow the paste to dry for approximately 7-10 minutes. The substance should turn from a white color to a yellow to brownish color and then back to white again during this time. This is the sintering process. Once it turns back to white you can get ready to take the glass off of the hot plate.

Step 9). Using the tweezers, take glass off of the hot plate and place it on aluminum foil and let it cool for about 5 minutes.

Step 10). Once it cooks, place the glass inside the blackberry dye in the beaker and let it sit for 5 to 7 minutes. The chemicals from the dye will bind with the paste and absorb on the surface.

Step 11). Take the glass out of the dye, rinse it with water and Isopropanol. Then put the glass on a chem wipe and fold it to pat it dry softly. You should see a color change to purple meaning the dye absorbed on the surface, so the Titanium is synthesized with the dye.

Step 12). Take glass with the pencil scratched surface (anode) and clamp it to the pasted surface of the other glass with the binder clips.

Step 13). Add the electrolyte drops at the top end corner of the device and gently move the clamps until the electrolyte covers the whole surface.

Step 14). Wipe the extra liquid off the sides with a chem wipe.

Step 15). Now, you are ready to test your device. Get your multimeter and place one alligator clip to the cathode side (one with pencil scratchings) and one alligator clip to the anode side (purplish substance). Set the multimeter to 20 or 200 and list the voltage output found.

Step 16). After this, take a flash light or the flash light on your cell phone and record the voltage obtained from the multimeter.

Step 17). Test your device to see if it can power other devices and document findings.

Data Collection

Device	Multimeter Reading
Solar Cell	
Solar Cell exposed to cell phone flash light	
Other Device (Optional)	

Safety Issues/Concerns

- It is suggested that teachers use the hotplates when conducting this activity and have the Materials Manager from each group assist when the glass cools.

Troubleshooting Tips

It is recommended that you order the kit from Arbor Scientific as listed above as it comes with all the materials needed to successfully complete this activity.

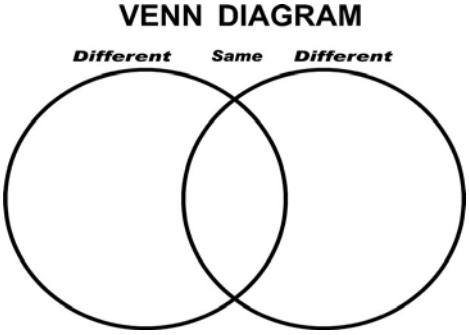
Suggested Activities

BellRinger: Interactive Journal Writing

Students will respond to the following questions in their Interactive (IA) Journals

1). What is energy?

2). Use a Venn Diagram (see example below) to compare nonrenewable and renewable resources.



Monitor Students

Teacher should be walking around the groups using the vocabulary words listed in this lesson and applying it to the lab so that students can apply these concepts with their hands-on experience. Teachers should also ask questions to allow to students connect applications to the learning concepts presented as it relates to energy. Teachers can also conduct visual observations of each group during the activity as a form of assessment.

Lab Summary Questions

1). Did your device work? (Students should answer yes)

2). What did you observe? (Students should indicate they observed an electrical charge)

3). What happened when you increased the amount light the device was exposed to? Why do you think this happened? (Students should respond that as they increased the amount of light the device was exposed to; more electricity was generated from the multimeter reading).
4). Was your device able to power any other device? Why? (Students should indicate if their device was able to power the other objects provided during the activity).

Claim/Evidence Reasoning Activity
Have students complete the Claim-Evidence-Reasoning section to explain the components of experimental design and how to apply them into an experiment with an "everyday phenomenon." Prompt them to develop their claim statements based on the main objective of this research.

Blackberry Solar Cell Claim, Evidence, & Reasoning Report

Research Question: (What was question being posed in the research) "Can the juice from blackberries be used to absorb light that can be converted into electrical energy?
Claim: (Make a statement that answers the research question, based on what you observed in the lab you performed) Sample Claim: The juice from blackberries can be used to absorb solar/light that can be converted into electrical energy.
Evidence: (Support your claim by citing data you collected in your lab procedure) **Observations/Data:** Sample Evidence: The evidence was obtained from the data collection through completion of the lab where the conductive glass was placed in the juice from the blackberries and when tested using the multimeter, it produced an electrical charge.
Reasoning: (Describe the science concepts that explain why or how the evidence you presented supports your claim) Sample Reasoning: The claim that the juice from blackberries can be used to absorb light is true because our group completed a lab activity where we used conductive glass and when it was placed in the juice and dried, we obtained a reading from the multimeter indicating that it was electrically charged. This shows that blackberries contain anthocyanin which can be used to absorb solar energy and convert it into electrical energy.

Reflection Question Activity
Have students reflect on their results by answering the following questions:
1). Is a solar cell effective in generating electricity? (Answers will vary but can include: Yes, solar cells can be very effective in generating electricity. In fact, many scientists use solar panels to generate electricity because it reduces the use of nonrenewable resources like coal. I conducted a lab activity where I was able to place conductive glass with the use the juice from blackberries and generate electricity).

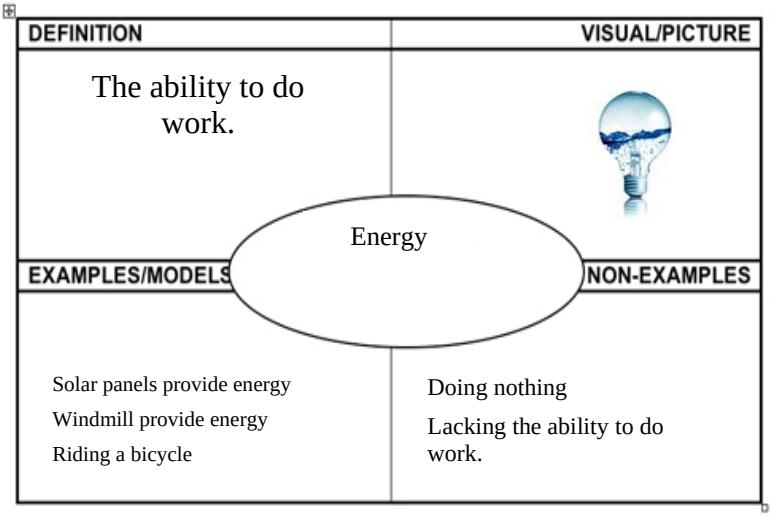
2). Did your device perform well or not? Why do you think this happened? (Students should indicate whether they were able to generate electricity and if not, should state that they did not follow the steps correctly).

3). If you were given an opportunity to enhance your device or make it perform better, what would you do differently or change? (Students may answer that they would like to use a bigger piece of conductive glass and/or more juice from the blackberry to generate a greater amount of electricity).

Frayer Model Activity

Have students define words using the Frayer Model where they provide the definition, an illustration, examples, and non-examples to show their understanding of the word. Students should use this model to define: solar cell, solar energy, energy, and energy transfer.

Frayer Model



Engineering Connection Questions

1. What technology exists today to create solar energy? (Student responses should state that solar panels are used by science and engineers to power homes and businesses. Students can also respond that solar tower technologies use a ground-based field of mirrors to focus direct solar irradiation onto a receiver mounted high on a central tower where the light is captured and converted into heat).
2. How was this activity lab similar? (Student responses should include that in this lab the juice (anthocyanin) in the blackberry was used to act as a medium for electricity to flow out of a device).
3. How is this cell similar to a photovoltaic cell? (Student responses should indicate that a photovoltaic cell takes energy from the sun and converts it into electrical energy and in this lab we used the blackberry juice to absorb energy from the light to convert it into electrical energy).

Home Work Assignment
News/Article Connection Activity
Have students engage in research to find articles that relate to solar energy and/or advancements in engineering and write a one-page summary report in their own words.

Additional Multimedia Support
PowerPoint on Energy:
https://www.google.com/?gws_rd=ssl#safe=strict&q=energy+forms+and+changes+powerpoint
Teachers can watch this video to familiarize themselves with this experiment:
https://www.youtube.com/watch?v=YGBWEy6KjH8

Students can review concepts associated with matter and energy. Teachers can visit Study Jams Scholastic and watch the following video on matter and energy. The URL is as follows: http://studyjams.scholastic.com/studyjams/jams/science/matter/energy-and-matter.htm

Teachers can also visit the following websites for additional information:
http://www.sciencebuddies.org/science-fair-projects/project_scientific_method.shtml
https://www.teachengineering.org/activities/view/nyu_measuringp_activity1
http://science.dadeschools.net/middleSchool/essentialLabs.html
https://science.nasa.gov/science-news/science-at-nasa/2002/solarcells

Classroom Assessment Suggestions
Formative assessment during instruction allows the teacher to provide feedback, to reflect on teaching and make adjustments and modifications to ensure that students were learning. This is also evident when asking the students indirect/direct questions and engaging in small discussions before, during and after this activity.

Students can be given the **Claim, Evidence and Reasoning** as a summative form assessment at the end of this activity to determine mastery of the content presented. Students can also be given the **Frayer Model Vocabulary Sheet** to show an understanding of the energy concepts/terms being presented during this lab activity.

Student also can complete a district-wide assessment on energy to determine their level of mastery of all the concepts being presented. Students can also be given the extension assignment where they select or identify an article relating to solar energy or any topic within the field of engineering and write a one-page reflection.

Acknowledgments
Dr. Bilal El-Zahab, Amir Chamaani, and Wahajat Quadri

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