Energy Flow

PURPOSE: To understand to need for and uses of energy and how it is transferred to plants and animals from it's source, the sun.

OBJECTIVE:

1. To determine the origin of all the earth's energy.
2. To understand how energy is converted from the sun through photosynthesis in plants.
3. Illustrate the transfer of energy through the energy pyramid.
4. Identify renewable and nonrenewable resources.

CONCEPTS:

photosynthesis energy pyramid renewable resources non-renewable resources

MATERIALS NEEDED:

Food Factory props (sugar, sun, H2O, leaf, CO2)
Web of life props (long string, habitat cards)

PROCEDURE:

Overview

1. Introduction
2. Photosynthesis
3. Web of life/Energy pyramid
4. Energy conservation/Alternatives
5. Conclusion
6. Appendix

Introduction

What is the source of all energy on earth? How do we use energy? How can we use it more efficiently? All of the earth's energy comes from the sun. But in order to re-energize ourselves do we stand outside in the sunlight? No, as a matter of fact our body has to work (use energy) to cool itself in direct sunlight. Discuss with the students where our energy comes from and identify the links in the chain between the sun's energy and people for example:

sun > plants > herbivore(human) > omnivore/carnivore(human)

Break down the chain and discuss each part with regard to where it receives its energy and then where it passes its energy on to. We depend on the plants in our world to convert the sun's energy into energy we can use on earth.

Photosynthesis

Photosynthesis is a chemical process that takes place in the cells of green plants. Scientists know the ingredients that go into green plants and they know what comes out of green plants but they do not know how the conversion works once inside the plant. The photosynthesis equation looks like this:

$$\textbf{sunlight} + \textbf{CO2} + \textbf{H2O} = \textbf{sugar} + \textbf{O2}$$

You can illustrate this more by creating a *Food Factory* (outlined in <u>Sunship Earth</u>). Instead of constructing a large food factory as described in the text create a small scale model of a leaf with a green bag or box. Ask the students to read the ingredients that go into a green leaf [sun, CO2, H2O]. After adding each one, pull out the product that is created [C6H12O6, O2]. Be creative with the props you use to make a visual impression.

Plants are also known as producers or "self-feeders" since they can manufacture nutrients themselves for energy. In terrestrial ecosystems producers are green plants and in aquatic ecosystems most producers are phytoplankton. Open up a discussion regarding the importance of plants independently and as communities like forests.

In the chain plants receive energy from the sun and consumers receive energy from the plants and the energy is passed on through the chain. Unfortunately there is poor efficiency in energy transfer. Show the students a gallon of liquid labeled "sun energy". Explain that at each link in the food chain a lot of energy is lost. Each plant or animal consumes energy in order to grow and survive, so we are going to see how much of the sun's energy is lost at each link in the food chain.

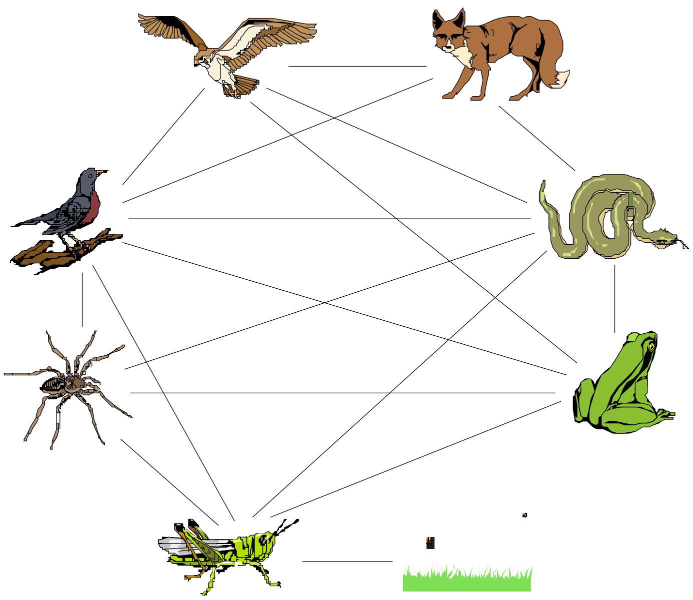
Give the second student in line a tablespoon and glass. Ask the "plant" to take 2½ tablespoons of energy from the "sun" as plants only absorb 1% of the sunlight that hits them. The plant uses 90% of this energy to grow so the next member of the food chain can only take 3/4's of a teaspoon or 10% from the plant. Again the next member in the chain only receives 10% or 1 drop from the consumer before it. The animals at the end of the food chain get a very small portion of the original amount of the sun's energy. Are there more plants or animals on earth? This is a good segue into the food pyramid. (See appendix for alternate photosynthesis activity.)

Web of Life / Energy Pyramid

Ask students to name the natural parts of St. Croix (i.e. trees, deer, soil, air, sun, etc). As the students are naming different parts, list them on the board to discuss later. Next divide the items from the list into biotic (living) or abiotic (non-living). Have students sit or stand in a circle, each one holding a card that identifies them as a member of the natural community at SCEC. The ball of string represents energy.

Hand the end of the string to the sun, since all of the energy of Earth originated from the sun. Ask the sun to pass the ball of string to a member of this community who depends on the sun's energy. This person takes the ball of string, holds on to a part of the string, and passes the ball on to someone she/he gives energy to or gets energy from. When everyone is connected in this manner, ask what they have formed. A web, or food web, more specifically.

Ask one student to pull very gently on the string she/he is holding. As each student feels that tug they should also start to gently pull on the string until all students are pulling. From this demonstration, what happens to all aspects of the web if only one part of it is initially affected? Ask students for examples of this sort of situation in real life.



Energy Conservation and Alternatives

Ask the students to close their eyes and imagine they are at home sleeping in bed. It is early morning and the alarm clock goes off to get ready for school. You rollover turn off the alarm clock and switch on the light. You climb out of bed, get dressed and walk to the kitchen. You prepare a bowl of Cheerios, open the refrigerator for milk a end juice and slip a piece of bread into the toaster. Within minutes you are sitting at the kitchen table reading the paper and listening to the days forecast on *101.3* FM.....

On and on your story goes till the person is on the bus or in school etc. When you are finished with the story ask the students to review the story and list what objects from the story required the use of energy i.e. alarm clock (electricity), brush teeth (water and electricity). Chances are pretty good that wind, water, solar power will not be noted as energy sources. Ask them if there are any sources they are missing to fill in the gap. Introduce the terms renewable resources and nonrenewable resources as well as their pros and cons.

As an activity divide the group into small groups of 2-3. Send each group to a building on site for approximately 20 minutes and ask them to conduct an energy survey require energy (light bulb) or are a source of energy (outlet). When everyone returns discuss energy efficiency in each building and how St. Croix conserves energy in day-to-day practices. Some things they may not be aware of are the photocells on trail lights that automatically shut off when the sun comes up or sky lights in the office. See appendix for more information.

Conclusion

Challenge students to study their home and determine if there is anything they can do to become more energy efficient.

Appendix

The Missing Piece (photosynthesis game): Introduce the process of photosynthesis to the group. What is the purpose of photosynthesis? (Plants produce their own food-sugar) What does a plant need to make photosynthesis work? (The basics are sunlight, water, carbon dioxide) Where does photosynthesis take place?

After a brief discussion, break the group up into groups of four. Tell each group that they are going to become a plant, and that as a plant they are going to have to produce their own food. One pair of students from each group will become the roots of the plant, and their job is to locate water. The other pair from each group will become the leaves, and they must locate carbon dioxide. Water and carbon dioxide are represented by puzzle pieces that can be hidden in a small area before class. All of the groups must start from the same place. The roots are sent out first to find two pieces, one piece with an H2 on it, and one piece with an O on it. Once they have found the water (H2O) they need, they must return to the start and tag the “leaves” of their plant. They leaves must find two more pieces, One with a C on it, and one with an O2 on it. When the leaves have found the carbon dioxide (CO2) they need, they rejoin the roots. The group must then try to fit the four pieces together to make a square. Give them a few minutes to work at it, then after they see that it won’t work, give them the fifth sun piece. The group will find that they can make a square with the pieces they have, but the O2 piece does not fit.

Review how the process of photosynthesis works, and what ingredients are needed.

CO2	+	H2O	=	CH2O	+	O2
carbon dioxide		water		simple sugar		oxygen

This process can’t happen without sunlight. Why didn’t the O2 piece fit into the puzzle? (Oxygen is a byproduct of photosynthesis, and is given off by plants. Oxygen molecules always come in pairs, never as individual molecules.)

Energy Survey: You will need a white board or flip chart paper, journal page or scrap paper and pencils or pens

Split your group into smaller groups of two or three. Give each group a piece of paper and a pencil, a location to survey, and a list of specific things to look for or count. Create a chart that will compile all the groups' findings.

Remind the students to be respectful of the people working in the spaces that they are surveying. Use the adults to help supervise in the various locations. Send the groups out to do the survey.

When the groups return, plug the gathered information into the chart. As a large group, determine whether the spaces surveyed are energy efficient. What can be done to improve efficiency in these spaces? What has already been done?

River Center: The long overhanging roof is architecturally designed to increase exposure to low winter sunlight and shade from high, hot, summer sun.
Dining Hall: Windows on the south side allow natural lighting, and an angled roof increases heat efficiency.
Bathhouse: Radiant heating in the floor is efficient because it utilizes the principle that heat rises (Trail building has same floor). Timed or sensor faucets reduce water waste.
Cabins: Adjustable heat allows for minimal energy use when cabins are empty.

Example Chart:

Trail Building							
River Room							
A Vacant Cabin							
Any Bathroom							
Your classroom							
dining hall							

Stewardship Project: This could be a great follow up activity to the energy survey. Make signs for the buildings you have just surveyed. Sometimes people need a gentle reminder to conserve resources. At St. Croix we would like to put up signs where people will see them to remind our users to help us conserve.

You may need the following equipment: Magic markers, scrap paper, crayons, construction paper and tape/staple gun/tacks.

Go to your assigned building(s) and determine sign needs- # of light switches, water faucets, thermostats, doors, windows, etc. Measure the sizes of space available for the signs.

Make signs. Be creative! Use the scrap paper to practice on if needed. Laminate signs if possible. Put up your handiwork for all to see!

Live Wire: This is a simple, fun game to play. It requires one coin and one throwable (or other unbreakable object). The goal is for your entire team to rotate through the line before the other team completes their rotation.

For the set up split your group into two even lines. Everyone but the people on the ends close their eyes. Place the throwable at one end of the lines and the coin at the other. Have a teacher or chaperone supervise the throwable end of the lines. Instructor should supervise the coin end of the lines. (See diagram 1)

To play flip the coin. If it lands heads up the first people in the line send an *impulse down the line. When the last person gets the impulse they try to grab the throwable. Play stops. The team that grabbed the throwable gets to shift one space. The last person becomes the first and everyone moves down the line one space. (See diagram 2) Play begins again when movement has stopped and the coin is tossed. If the coin lands tails up no impulse should be sent. If an impulse is sent, despite the tails, and the throwable is grabbed the other team advances one.

Note: Once an impulse is sent there is no taking it back. Be careful of bonking heads at the throwable end. An impulse is a gentle squeeze of your neighbor's hand. Activity may also be found under the title of "Shock Wave" or "Impulse" in some experiential activity reference books.

Consider the following metaphor: Each of your lines is an electrical wire connecting a light bulb and the switch. The coin is the switch. If it is heads, then someone has just flipped on the switch and you need to light the bulb by grabbing the throwable. If the throwable is grabbed and the switch wasn't flipped on then we know that there has been a short circuit in our system. The goal is to minimize short circuits and maximize the amount of times the light is correctly turned on!

Potential vs. Kinetic Energy: This is an activity to demonstrate the difference between the two. You will need the following props: marble, ruler with a groove, piece of flip chart paper, marker and books/wooden blocks of equal width.

To set up lay the flip chart paper flat on the ground. Place a book / block at on end of the paper. Use the ruler, groove side up, like a ramp connecting the paper and the book / block (See diagram).

Place the marble at the one inch mark on the ruler - this will be your measurement of potential energy. Release the marble. Let the marble roll down the ruler and onto the paper. Mark where it stops - this will be your measurement of kinetic energy. Repeat the experiment starting the marble at different locations on the ruler and marking their ending points on the paper.

What happened when you changed the potential energy? What are some other ways of changing the potential energy? What do you think your results will be if you make that change? Try it!

Note: Potential Energy: stored energy; energy waiting to be used
Kinetic Energy: energy of motion

As potential energy is increased so is kinetic energy (a.k.a.: the higher you start the marble the further it will roll).

Resource Relay Game: Create a list of resources. Place them on cards for play. Make sure you have four bins or bags. The object is to distinguish between renewable and nonrenewable resources.

Brainstorm a group list of things we do each day which require energy, for example, watching T.V., riding the bus, cooking dinner, heating water for a shower. Ask students to pick a few activities from the list and determine where the energy comes from that makes that activity possible. Discuss the terms “renewable resource” and “nonrenewable resource”. Label two bins renewable resources and two bins nonrenewable resources. Split your group into two teams. Give each team a stack of resource cards and a set of bins

Player draws a card from their team’s stack of resource cards. Player decides whether the major energy source for the resource on the card is renewable or nonrenewable and places the card in the appropriate bin. The first team to appropriately place all of their cards is the “winner”.

Take time to discuss results and listen to reasons- all the cards do not need to be not completely obvious or one way. Which activities from their list depend on renewable natural resources for their major energy source and which depend on nonrenewable resources?

Definitions

Renewable Resource: sources of energy which do not run out - solar, wind, water

Nonrenewable Resource: sources of energy which do not “grow back” after being harvested - oil, coal, metals, petroleum

Energy Sources: Here is some background information.

Sun- The Sun is the most abundant source of energy available to us. Solar energy equivalent to burning 500,000 billion barrels of oil enters our atmosphere every year, though some of this is absorbed by the atmosphere. Nevertheless, the same amount of solar energy reaches the ground in an hour as we consume as fuel in a year. Unfortunately, making use of this gift from nature is difficult, for although plentiful, sunlight is not concentrated. Scientists are now developing ways to concentrate solar energy. First, there are collectors. These are mirrors that focus the Sun=s rays on to water tanks which are heated to generate steam and run turbines. Photovoltaic cells-the other main type of generator- turn sunlight directly into electricity. Each system has different uses.

Wind and Waves- No one who has witnessed the ferocity of a gale or a storm at sea could doubt there is enormous energy in winds and waves. Indeed, for centuries, we have exploited these sources of energy, in particular, harnessing wind with mills that grind wheat and pump water. But these machines were inefficient compared to steam and gasoline engines, which have replaced them. However, modern technology is finding new ways to develop effective wind and wave generators. In particular, scientists are experimenting new lightweight, but strong, alloys to build giant generators that can withstand 200 kph (125 mph) hurricane gusts and sea storms. Such machines might some day be powerful enough to supply small towns with electricity.

The Ground- Deep below the Earth's surface are rocks heated to temperatures that would melt metals. This vast source of power is normally beyond our reach, except in countries where an unstable geology has brought hot rocks near the surface. One such country is New Zealand. There, water, heated naturally, is used to generate 10 percent of the nation's electricity. However, engineers are now drilling deep into the ground in order to exploit geological energy reservoirs almost anywhere in the world. Scientist claim that power generated in this way could one day become important economically, particularly in remote regions.

Oil and gas- No source of energy has had such a dramatic impact on the world as oil. It was hardly used 100 years ago. Today oil provides 38 percent of the world's energy. Oil has become popular because it is a liquid and can be easily transported in tankers and via pipelines. It is also light enough to be carried as fuel for cars and aircraft. Crude oil can even be make into plastics and tars. But dependence on this "black gold" may be dangerous. Oil deposits- formed millions of years ago out of the remains of prehistoric plants and animals- may soon run out. Every day, 30 million barrels are burned, and supplies may only last to 2050. As a result, engineers have developed new technologies to obtain oil even in remote and dangerous places, for example in the frozen land of Siberia and Alaska, and on the seabed. They have also turned to other sources, such as shale, to maintain supplies. In addition, underground natural gas has also become an important fuel.

Coal- We have used coal as an energy source for more than 2,000 years. Roman soldiers even burned it to keep warm in the cold north. However, it was not until the 18th century that coal became important, when it powered the Industrial Revolution. Coal supplied the heat that made the steam to drive the factories and trains. Coal was formed, like oil, out of plants and animals which thrived in sunlight that shone millions of years ago. (This is why coal and oil are called fossil fuels.) When we burn coal today we release that ancient solar energy. But coal is dirty and dangerous to mine, so scientists are trying to improve mining machinery and make coal easier to handle.

Nuclear Power- Energy produced in reactors by splitting the heart, or nucleus, of atoms, the tiny particles of which matter is made. This is difficult to do with atoms of most chemicals. However, the atoms of a heavy metal called uranium 235 are different. They can be made to split by a process called fission. Vast amounts of energy can be released during fission. However, controlling this release is awkward because many dangerous, radioactive substances are also produced. For this reason, engineers are trying to make nuclear plants safer and more reliable. (McKie, 1989)

References

McKie, Robin 1989. Science Frontiers: Energy Hampstead Press New York.