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Introduction

Teachers from the Nebraska Math & Science Initiative's PEERS (Promoting Excellence in Education Regionally and Statewide) Academy provided the impetus for *Bursts of Energy*, a project to promote energy-related education. The Initiative compiled and published this resource with funds from the Nebraska Energy Office. The partnership between the Nebraska Energy Office and the Initiative seeks to strengthen and enhance science education with an emphasis on energy education.

As a part of this partnership, energy educators have presented lessons at K-6 PEERS Academy workshops across the state for four consecutive summers. These lessons were developed and adapted with feedback from many of the more than 2000 teachers who participated in these workshops.

Bursts of Energy is meant to be a starting point for teachers as they begin, with their students, to investigate energy-related topics. Each lesson contains sections which provide important information for teachers who wish to do the lesson with their students. A suggested grade level for the activity is provided at the top of each lesson along with a goal for student learning.

A section for each lesson is dedicated to process skills especially relevant to the content presented in the experiment. Scientists use process skills whenever they define scientific concepts. We, as teachers and students, use them whenever we hear, read, think interact with our environment, or communicate information. The material presented in *Bursts of Energy* attempts to provide self-contained projects which enable a process skills approach to science instruction. That is, the learning emphasizes the use and development of intellectual skills in addition to the introduction of science content. Process skills (e.g. classifying, observing, inferring, generalizing) are practiced in scientific situations which deal with content. Additionally, each lesson references the *Nebraska State Frameworks for Science*. This document is available to teachers in each elementary school building and includes more energy-related information and background on science topics.

The remaining sections aid teachers doing the activity with their students. A "Materials" section lists materials needed for each student or student group–care has been taken to use only easily obtainable, inexpensive, and safe materials. The "Teacher Background" section of each lesson gives pertinent information to assist teachers in discussing the experiments with students. Detailed instructions for doing the lesson with students are provided in the "Procedure" section, along with illustrations and tips for making the activity successful. The "Extensions" and "Discussion" sections provide more activities and discussion topics for teachers who wish to expand on the activities. The "Teacher Resource" section lists published tradebooks (fiction and non-fiction) relevant to the concepts discussed along with a short description of content. These books serve as references. The emphasis in the lessons is on hands-on activities for students with concrete materials.

It is hoped *Bursts of Energy* will send many teachers and students on exciting energy adventures.

Preface

The activities in this packet have certain things in common. They all, we think, will be interesting and fun for the children; they require equipment which is inexpensive and easily found; and they all deal with the concept of energy. These activities look at energy from many different viewpoints, and can be used to supplement a variety of topics. Lessons on plants might use activities on biomass fuels. The study of weather could be enriched by activities involving wind and sun. As a by-product, the students can learn that some words have technical meanings different from their everyday meanings.

What is energy? Of all the concepts in physics, that of energy is perhaps the most important. A glib, one-sentence definition of energy would not be a good idea at this point, since it would not be understandable to anyone who does not already understand the concept. The idea has to be developed.

We will start by listing some of the different forms of energy: mechanical, electrical, chemical, thermal (heat), and nuclear. Of utmost importance is the fact that these forms of energy can be converted one to the other. Chemical energy in a battery produces electrical energy. Electrical energy to a heater produces thermal energy. Electrical energy to a motor produces mechanical energy. Heat energy in a steam engine produces mechanical energy. A lump of coal contains chemical energy, which can be converted to heat. Friction converts mechanical energy to heat. Light is a form of electrical energy, and sound is a type of mechanical energy of the air.*

Conservation of energy. In physics, energy *is* conserved, absolutely. This means that it can not be created nor destroyed, although it can be converted from one form to another, or moved to another place. The total amount of energy does not change. However, from an *economics* point of view, we are interested in conserving *useful sources* of energy. So "energy conservation" means something different in the two fields. For example, the heat energy which leaves a house in winter due to poor insulation is wasted from an economic point of view, since it just heats the atmosphere; and an electric motor produces less mechanical energy than the amount of electrical energy that goes into it, since some of the input energy becomes heat, warming the motor. Many of the activities in this booklet involve energy transformations, and these can be interesting subjects for class discussion.

Energy and work: definitions. We are using these two words in their technical sense–not as in everyday language. Energy is defined as the "capacity to do work." This definition now requires a definition of *work*. When a force is exerted on an object, and the object moves, the work done by that force on the object is found by multiplying the force by the distance moved. In the ordinary English-system, force is measured in pounds (lb) and distance in feet (ft), so that the unit of work is ft-lb. In the metric system, force is in newtons (N) and distance in meters (m), so the unit of work is N-m, which has another name: joule (J). (In the definition of work, use only

*Classifying forms of energy this way is useful for things of everyday size. But at the level of individual atoms, there is no such thing as chemical and heat energy–it is all mechanical and electrical. At the still-smaller scale of the atomic nucleus, there is also nuclear energy.

the distance which is in the same direction as the force. Note that if nothing moves, there is zero work, no matter how large the force.) Energy is measured in the same units as work.

Examples. (a) A moving object can do work on something that it meets, since it will exert a force on it and perhaps push it for some distance. This mechanical energy of the moving object is called kinetic energy; it depends on the mass of the moving object and its speed. (b) If you lift something to a height, you are doing work on it, since you exert a force to keep it from falling under gravity, and it moved some distance in the direction of that force. The object is then said to have potential energy. If it is released, it falls and gains kinetic energy as it loses potential energy. (c) Another kind of potential energy is in a stretched rubber band. You do work on it to stretch it, and you can convert the resulting potential energy into kinetic energy, for example by shooting a paper wad. (But maybe you should not demonstrate that to your class!)

Source: Ed Pearlstein, Professor Emeritus, UN–L Department of Physics and Astronomy

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Biomass

Did you ever wonder where all the energy comes from that keeps you going, warms your home, or lights your cities? Nearly everything that moves, heats, or lights depends on energy from fuel, most of which is (or has been) potential energy from biomass. The rice farmer in China, wine maker in France, and friends around the fireplace are participating in what is probably the largest industry and the most common practice among humans–using biomass. It is at the foundation of cultures worldwide.

Most of the people in the world still depend on burning wood to prepare meals and warm their homes. We all consume plant and animal products for energy. All the energy in food is biomass energy, as are the wool and cotton in our clothes. Fossil fuels represent biomass from millions of years ago. Coal and natural gas contain energy to power our cars, as do the fruits and vegetables consumed to power our bodies. Every day energy is being converted from biomass to support the activities of the world.

All material that is now or once was alive is part of the greatest energy complex on the planet. Plants, animals and microbes live in a network of life that involves energy changes that are as small as a leaf making sugar for its own use or as large as the entire plant world feeding all other life forms over the eons of time.

Understanding biomass well enough to help us make good personal decisions about using the energy available to us is an important part of everyday living. This includes seeing yourself as part of a food chain, knowing how to grow and care for plants and animals, and finding efficient ways to convert biological waste into useful fuels and nutrients for current and future members of the web of life.

Life In A Mini Ecosystem

Recommended grade levels: K-6

Goal: Students will explore a food chain and comprehend our dependence on the sun as a source of energy.

Process skills:

Collecting data
Communicating
Controlling variables
Estimating
Hypothesizing
Making graphs
Observing
Predicting

Frameworks: Diversity, Interdependence, Universe

Materials: (per student group)

- one terrarium (2 or 3-liter soda bottle cut 2" to 3" from base, aquarium, or other suitable container)
- potting soil, sand, charcoal, sphagnum moss
- plants (grass, moss, cactus, duckweed, etc.)
- one small thermometer

Teacher background information:

Since humans are consumers, we depend on the survival of the organisms in our food chain, which are dependent on the sun as their source of energy. Our food chain can be preserved only if we take care of our environment and are conservative in our consumption of food. Any disruption in a food chain, such as a toxin in the environment, will affect the entire chain.

Procedure:

1. Whole class discussion: Start with a toad or other animal brought in by a student or teacher. Discuss what needs to be done to keep the animal in the classroom for a few weeks. Generate a list of animal survival needs and how they can be met. The discussion should include these topics: habitat, temperature, moisture, soil type, water, air, food, and food chains.
2. Groups of students will construct terraria and plant grass, etc. Students will place terraria in a sunny place. Make sure each group includes a thermometer in their terrarium in a position where they can read it from the outside.
3. Over the next two to four weeks, students will log observations of the habitats, noting temperature, condensation, and changes in the plants. Students will compare the different habitats they have created.
4. During the same period, students will do research on their habitat, noting especially the kinds of animals present and whether they are consumers or decomposers.

Discussion:

1. What type of habitat did you construct?
2. What kinds of animals live in this type of habitat?
3. Which of these animals are consumers?
4. What are the decomposers in this habitat?

Extensions:

Have students:

1. Research an endangered species to explain why it is endangered and possible effects its extinction would have on the food chain. Consider animals from your state or worldwide.
2. Predict what effect pollution and destruction of wetlands will have on animals and their habitats.
3. Write letters to various companies or government representatives expressing concern about endangered animals or pollution and asking what the company policies are in regard to these issues.
4. Keep a log of observations about their mini ecosystem and draw conclusions.
5. Draw and label a food web for the habitats within their state or area.
6. Produce a mural to depict different habitats within their state or area.

Teacher resources:

Ring, Elizabeth. *What Rot! Nature's Mighty Recycler*

Gr. 3-5, younger for reading aloud. Ring talks about the ways that fruits, flowers, and leaves decompose and discusses some of nature's "rotters," such as bacteria and beetles. Following the decay of a log, she describes a variety of molds, fungi, mosses, insects, and animals that help the decomposition process along.

ISBN: 1-56294-671-4

Glaser, Linda. *COMPOST! Growing Gardens from Your Garbage*

Gr. 5-8. Glaser depicts the garden as a blossoming, decaying, living, fertile environment in a celebration of decomposition and renewal.

ISBN: 0-7613-0030-9

Wick, Walter. *A Drop of Water.*

Gr. 4-6. This book covers every aspect of water – molecules, condensation, evaporation, clouds, and snow. A number of water experiments are included.

ISBN: 0-59022-197-3

Find the Food Chain

Recommended grade levels: K-3

Goal: Students will comprehend the interdependence of producers and consumers in a food chain.

Process skills:

Classifying
Communicating
Computation
Data gathering and graphing
Observing
Problem solving

Frameworks: Diversity, Interdependence

Materials: (for whole class activity)

cards (with pictures and information about the sun and examples of producers, consumers, and decomposers)
pins

Teacher background information:

The sun is the energy source for all plant life. Solar energy is stored in plants by photosynthesis. Photosynthesis is the process by which the energy in sunlight is absorbed and used to provide food for plants from carbon dioxide and water. All animals, including humans, feed on plants or other animals that feed on plants. During photosynthesis, plants also produce the oxygen that animals and humans need to live. In digestion, animals break down and recombine the chemical bonds of plant material to provide nutrients for themselves. The waste products of animals become food for the next generation of plants. Plants and animals continuously pass carbon and oxygen back and forth through the processes of plant photosynthesis, animal respiration, and animal digestion. All organisms exist in this web of interdependence that begins with the energy of the sun.

The living organisms in this web are either producers or consumers. Plants are producers. They use the sun's energy to make or produce food for themselves and for animals. Animals are consumers. They eat or consume plants and other animals. Decomposers are a special kind of consumer. They are tiny organisms (fungi, bacteria) that degrade organic substances into chemical components or elements.

Procedure:

1. Discuss the concepts of the sun, producers, and consumers.
2. Prepare cards with a sun, examples of producers (e.g. clover, alfalfa, corn), and consumers.
3. Pin a card on each student's back where they cannot see the card. Have students ask each other questions to try to determine what they are. After they know what they are, they should arrange themselves in a food chain.

Discussion:

1. Describe your food chain. What would happen if any part of the chain disappeared?

Extensions:

Have students:

1. Investigate different animal diets and where their diet places them on the food chain.
2. Make a food chain mobile.
3. Investigate cultures that are primarily vegetarian. What effects does this have on health?

Teacher resource:

Bang, Molly, *Chattanooga Sludge*.
Gr. 3-7. Bang salutes one man's efforts to clean up the most polluted waterway in the southeastern United States. The story gives an overview of the forces of nature that created the Chattanooga Creek and the forces of manufacturing that rendered it toxic with 33 varieties of pollutants. A scientific experiment has never been so driven by suspense.
ISBN: 0-15-216345-X

Biomass Produced from Various Grasses

Recommended grade levels: 4-6

Goal: Students will explore biomass as an energy source and develop skill in measuring the efficiency of biomass sources.

Process skills:

Collecting data
Communicating
Hypothesizing
Making graphs
Observing
Predicting

Frameworks: Diversity, Matter, Universe

Materials: (per student group)

wheat seeds
corn seeds
rye seeds
oats (whole only, not milled)
potting soil
one metric ruler
four half-gallon milk cartons
grow-type fluorescent lamp or south-facing windows

Teacher background information:

Out of all the energy a plant absorbs from the sun, only 3% is used for plant growth. Plant growth depends on many factors, so not all plants use sunlight with the same efficiency. The most efficient energy-converting plants are the most suitable if biomass is to be considered as an energy source. In this activity, biomass efficiency will be measured by the size (height) of a plant.

Note: *For suggestions on obtaining half-gallon milk cartons, see the "Water-Powered Boats" unit, p. 63.*

Procedure:

Students will:

1. Cut milk cartons in half and poke drainage holes in the bottom.
2. Fill cartons with potting soil and plant the seeds. Plant the same number of seeds for each grain. Keep soil moist, but do not over-water.
4. Place plants under a grow-lamp or in direct sunlight.
5. Record results (sample table on p. 8).

Plant Growth and Development

Germination					Average Height								
Plant	Date plants planted	Date of 1st sprout	Date of 10th sprout	Date of 20th sprout	2 days	4 days	6 days	8 days	10 days	11 days	12 days	13 days	14 days
Wheat													
Corn													
Rye													
Oats													

Discussion:

1. Which plant do you think is the best converter of solar energy to biomass? Why?
2. Would the results be different if your plants were allowed to mature?
3. What other factors might influence how efficient a plant is as an energy source (e.g. weight or composition)?

Extensions:

1. Discuss what is done with most of the corn and wheat grown in the U.S. What might happen if a major portion of our grain was used to produce energy?
2. Use the chart above to make a graph.

Teacher Resource:

Oakridge Associated Universities. "Biomass I"
Gr. 4-6. From the *Science Activities in Energy* series, "Biomass I" is designed to illustrate principles and problems related to biomass and its development, use and conservation. Materials are available from the U.S. Department of Energy, Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN 37831.

Hot Weeds

Recommended grade levels: 4-6

Goal: Students will comprehend how plant matter is used as an energy source.

Process skills:

Collecting data
Estimating
Hypothesizing
Making graphs
Measuring
Observing
Predicting

Frameworks: Diversity, Matter, Universe

Materials: (per group)

- one calculator
- two garbage bags
- scissors
- one meterstick
- one metric scale
- string
- stakes/sticks
- weedy area (vacant lot)

Teacher background information:

Biomass is the oldest source of energy known: people have burned wood to heat their homes and cook their food for centuries. Today, biomass provides approximately 5% of our nation's energy needs, and as much as 70% of the energy needs in the developing countries of Africa. Biomass—plant material and animal waste—can be used as a fuel because plants have captured and stored energy from the sun through photosynthesis while they were living. Energy is produced by burning various forms of biomass to produce steam for making electricity or to provide heat for industries and homes.

Note: *Students should work in cooperative groups for this activity.*

Procedure:

1. Outside, student groups will measure and mark an area equal to one square meter where they can collect weeds. They will mark the corners with stakes and the sides with string.
2. Using scissors, students will trim their area's weeds to a height of about two centimeters. Groups should collect the trimmings, cut them into short pieces, and place them in their garbage bag. (The second garbage bag is for cleaning up any trash that is found.)
3. Back in the classroom, groups will weigh the their weeds (with the garbage bag) and record the fresh weight of their weed collection on a table.

4. Groups will leave the bags open to expose the weeds to the air. They will place the open bag in a sunny area for one week, turning over and shaking the weeds each day.
5. At the end of the week, groups will close their bags and weigh them again. Groups will record the dry weight on their tables.
6. Groups will compute the weight loss and record it on their tables.

Formula:

First step:	Number of square meters in a hectare	X	Dry weight of a square meter of weeds ____ kg	X	Dry weight of a hectare of weeds ____ kg
	10,000 m^2/hectare	X	____ kg/m^2	=	____ kg/hectare
Second step:	Biomass energy per kilogram of dried weeds	X	Dry weight of weeds from a hectare (from first calculation)	X	Biomass energy from a hectare of weeds ____ J/hectare
	12 MJ/kg	X	____ kg/hectare	=	____ MJ/hectare

MJ = MegaJoule (12 MJ/kg =12,000 Joules/kg) hectare = 10,000 square meters

Discussion:

1. What happened when you dried the weeds?
2. Why do you think this happened?
3. Were the weeds a better fuel before or after the drying? Why?
4. How much energy could you get from an acre of weeds like yours?
5. Could the weeds in your town be useful as a source of energy?
6. What is normally done with weeds in your town? Are there any new uses for weeds in your town?

Extensions:

1. Have students explore whether it would be better to also dig up the roots when you collect biomass.
2. The U.S. uses 19,000,000,000,000,000 kilocalories of energy per year. Discuss how many acres it would take to grow that energy as biomass and what problems this could present.
3. Have students compare the biomass produced in an acre of weeds to an acre of cultivated growth such as clover, barley, or grass.
4. Have students try cultivating weeds. Have them investigate whether weeds grow better with additional fertilizer and water, the difference between their weeds and a cultivated crop, and which plants survive best under unfavorable conditions (such as lack of rain, disease, or poor soil).

Teacher resource:

Oakridge Associated Universities. "Biomass I"
Gr. 4-6. From the *Science Activities in Energy* series, "Biomass I" is designed to illustrate principles and problems related to biomass and its development, use and conservation. Materials are available from the U.S. Department of Energy, Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN 37831.

Trash to Energy

Recommended grade levels: 4-6

Goal: Students will investigate how biomass, recovered from trash, can be used as an energy source.

Process skills:

Collecting data
Hypothesizing
Making graphs
Observing
Predicting

Frameworks: Matter, Universe

Materials: (per student group)

- plastic gloves
- one aluminum pie pan
- scissors
- waste paper
- water
- matches
- safety goggles

Teacher background information:

Biomass describes all solid material of animal or vegetable origin. Plants and plant products (such as paper, wood, and peanuts) and animal products (such as manure) are examples of biomass fuels. Municipal solid waste, which is mostly cellulose, is also considered biomass. Biomass can be burned, fermented, or treated chemically to release energy.

Note: *(This activity works best outside. Step #1 should be supervised by an adult. Step #6 involves fire and* ***should be completed outside*** *on a paved surface!)*

Procedure:

Student groups will:

1. Wearing gloves, carefully rummage through their trash cans at home, looking for paper or cardboard items that are not too dirty. Students should bring these items to class.
2. Cut the items into pieces that will fit into an aluminum pie pan.
3. Soak the paper items in warm water until they are soggy.
4. After layering the soggy paper in the pans, press the paper layers together to force out excess water and drain the water from the pan. They should stop adding layers when the pile has been built about one inch thick.
5. Allow several days for the compressed mass to dry completely.
6. Break some of the compressed mass into chunks and place them back into the aluminum pan to see if they will burn.

Burning should take place under adult supervision and out of the wind, away from the building. Safety rules should be strictly enforced. Safety goggles are highly recommended.

Discussion:

1. How might this process relieve the strain on landfills?
2. What are some problems associated with using trash for fuel?

Extensions:

Have students:

1. Research and compare the amount of heat energy produced by the compressed waste paper to other forms of biomass (corn husks, branches, peanut shells, weeds, cow dung).
2. Graph their findings.
3. Research and report on issues related to landfills in their community and county.

Teacher resources:

Foster, Joanna. *Cartoons, Cans, and Orange Peels: Where Does Your Garbage Go?*
Gr. 4-6. A brief, visually appealing introduction to garbage–where it comes from and where it goes. Especially interesting is a chapter on how a materials recycling facility sorts and processes trash by using sorting machines that shake, blow, and apply magnets. Composting and methane gas recovery are described briefly.
ISBN: 0-8368-0707-3

Rickard, Graham. *Bioenergy*
Gr. 4-6. From the *Alternative Energy Series*, this book describes the various kinds of bioenergy, ways we are using it today, and its advantages and disadvantages.
ISBN: 0-83-680710-3