

# Sun Animals

by Duane Keown



## Overview

With the evolution of photosynthesis, some organisms on earth were able to store the sun's energy. Most life on the planet depends upon photosynthetic organisms that store light energy in chemical bonds. Students explore how photosynthesis captures energy for life. They see that through photosynthesis fossil fuels contain sun energy we use to build and run tractors, construct skyscrapers, and even develop and power computers.

## Objectives

Students should:

- explain how the sun's energy, through photosynthesis in plants, is responsible for the energy that is stored in organic compounds.
- be able to relate the sun, through fossil fuels, as the energy source for the industrial and technological revolutions.
- explain why fossil fuels are a finite resource and will be a transitional energy source toward sustainable energy sources for our modern society in the future.
- be able to describe ways to save fossil fuels and ways to produce energy from sustainable sources.

## Grade Levels:

7-12

## Time Needed:

One 45 minute class period

## Subjects to Integrate:

Science, History

## Topics:

Photosynthesis, industrial and technological revolutions, fossil fuel reserves, energy, geologic time

## Skills:

Kinesthetic concept formation, observation, social

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## Goals and Concepts

**A** 5, 7,8, 23; **B** 3; **C** 2, 8, 9, 10, 13, 19, 25; **E** 7, 14, 15, 17; **F** 10

## Materials

Large poster of a tractor, truck, or automobile obtainable from dealers  
Seeds of a long-lived tree: oak, ponderosa pine, blue spruce or engelmann spruce are examples. (A good seed to obtain if you can is a redwood or a bristle cone pine because these trees live so long. Tree seeds may be ordered from Carolina Biological Supplies, 2700 York Road, Burlington, NC 27215-33980

House plant with a few dead leaves  
Piece of coal (See activity "Wyoming Coal  
Mines/Power Plant")  
Ground-up limestone or Alka Seltzer

Break the limestone into chips with a hammer.  
Rubber or plastic laboratory hose (18 in.x 1/4 in.  
diameter)  
Rubber stopper for gas collection jar (pictured in  
the Procedure)  
Deep pan to hold water for gas collection  
100 ml flask  
1000 gas collection cylinder (graduated cylinder  
works well)  
Candle and dish to hold the candle upright  
Dilute hydrochloric acid, acetic acid, or citric acid  
Flat lid to cover gas collection bottle opening  
Bunsen burner or propane torch  
Tripod or ringstand with a gauze pad  
Mouse trap

## Background

Explain to the students that to build anything requires energy, and then it takes energy to make it operate. Give examples of cars, tractors, homes, even false teeth. In physical science the second law of thermodynamics states that the **entropy**, or the disorganization of an isolated system, spontaneously tends to increase. Entropy as it relates to this activity means the state of disorganization of matter. Entropy, or the state of disorganization of the matter, increases as a newly manufactured tractor begins to age and continues to "wear out." Iron of the tractor rusts. Even the aluminum and the copper oxidizes in time. The highly organized system that once was a tractor becomes less organized over time. There is a corresponding loss of energy in the system. It took energy to produce the steel in the tractor and the copper of the electrical system. It required input of energy to produce and spread the paint and to construct all of the systems that make the pistons move to do the work of tractors. Entropy, or movement from a state of organization to a state of less organization, occurs throughout the universe. It happens with humans also. Cells, tissues, organs, and organ systems begin to fail as we age. We die and then the entropy of the once functioning human progresses rapidly. We know the entropy (or amount of disorder) of the universe is increasing. It is the Second Law of Thermodynamics.

With this activity students discover the significance of photosynthesis as a process that counters or reverses entropy by trapping light energy to organize disorganized matter. Students compare a new tractor that has very organized matter — new paint, new tires, diesel tanks full of diesel, engine running, all ready to work a field — with a growing tree. The tractor is driven into a field and left running. What will the tractor be in 1000 years? By contrast, a seed of a long-lived tree, like a redwood, is planted in the field beside the new tractor, and it germinates. Students contrast the condition of the tractor and the tree after 1000 years. The tree uses the sun's energy, and organizes disorganized matter into a very organized and sophisticated form of matter, a redwood tree. Students learn that the process of photosynthesis traps the sun's energy and channels the energy to arrange matter in a particular way. The organization is dictated by the DNA structure, the genetic blue print of the species.

Energy is stored in the organized matter through the connections of atoms. Burn a stick and the sun's energy that was stored in chemical bonds in the cells is released in heat and light. Or burn a piece of coal. This energy from the sun was stored by the process of photosynthesis millions of years ago. The activity leads the students to see that their bodies, the bodies of corn plants or palm trees, and most of the material objects they own, are the products of the sun's energy being channeled. A computer is a very highly organized machine that results from channeling the sun's energy to form the computer (in some regions of the earth the energy may have come from nuclear energy). Their own body represents energy and matter, channeled from photosynthesis, to form a human.

In our modern society the sun's energy is not the only source of energy humans use. Nuclear energy is a new energy source of the twentieth century, with an uncertain future. But even wind energy and the energy of falling water is caused by the sun.

## Procedure

1. Hang the large picture of a tractor on the wall and beside it tape the seed of a long-lived tree. The concrete examples allow students to build a bridge to the abstract idea of entropy. Ask the students to imagine they are in the rich black-soil field when the new tractor is driven into the field. Beside the

tractor, with the motor running, the tiny tree seed is planted. We walk away and do not come back for 1000 years. What will the future hold for the tractor and the seed? Hand out the Student Activity Sheet. First individually, then in teams, and finally as a class, students discuss the questions and answers.

Note: Following are answers to questions 1, 2, 3, and 4 of the Student Activity pages.

(1) In 1000 years the redwood tree would be full grown. It could be 300 feet tall (the length of a football field) and 50 feet in circumference).

(2) The tractor would be very disorganized. Metals would be oxidized. Even the plastics would have been destroyed by sunlight. It would be in a higher state of entropy (disorganization) than its materials represented when it was new.

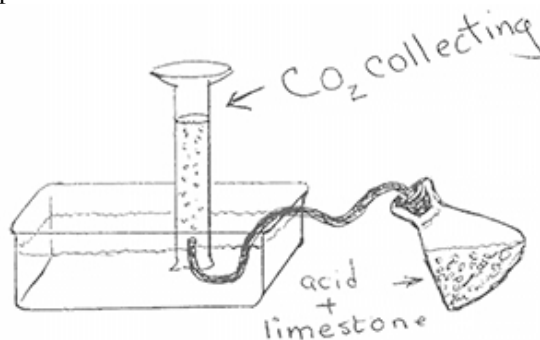
(3) As the sun warms the oceans, the water is evaporated by the heat and escapes into the atmosphere. Each moving molecule of water in the atmosphere has energy in its movement that was caused by the sun's radiation, primarily light rays, transformed to the heat energy of the motion of water molecules. Winds deliver the molecules to the tops of mountains and hills. Atop the mountains they have the stored energy of position and when they run off of the mountains, they release the stored energy. So it is the sun again giving us the energy stored behind dams to produce hydroelectricity.

(4) Uneven heating of the atmosphere causes uneven air pressures in the atmosphere. When we say that there is greater air pressure in one area than another, we are really meaning that in the area of lesser pressure, molecules are not striking surfaces with the same total impact than they are in another area. Air moves from areas of higher pressure to areas of lower pressure and the different pressures are caused by the sun's unequal heating of the atmosphere. When we harness the wind using turbines to make electricity, it is the sun that heated the air to cause high and low atmospheric pressure areas, and thus the wind.

2. A good summation of the activity is to make carbon dioxide, an essential compound used in photosynthesis to store energy. The carbon of the carbon dioxide molecule is used in photosynthesis to make the carbon chain molecules of life. Carbon dioxide is an invisible heavy gas that is less than one tenth of one percent of the gas of the atmosphere. But it is increasing in the atmosphere as fossil fuels are burned in large amounts. Because of its weight, and the fact that it is relatively unreactive, it is sometimes used to put out fires. It smothers the fire, cutting off the oxygen.

Students may assist with this demonstration or a team of students may do the demonstration for the class. First, light a candle in the area where you are going to produce the carbon dioxide. You will later douse the flame with the invisible carbon dioxide that is produced in the process described below.

Use a deep pan, like a bread baking pan (or a pneumatic trough as it is called in science equipment language) as shown below. Fill the pan about 1/2 full of water. Fill a 1000 ml cylinder (a pint fruit jar will do) with water to the brim. Now, into a 100 ml flask place ground-up limestone — at least three tablespoons. Alka Seltzer tablets will produce carbon dioxide in water. Usually two tablets will displace the water in the cylinder. Prepare a stopper and rubber (or plastic) hose as shown. You are ready with your students to produce and collect CO<sub>2</sub>.



Place the flat lid over the water bottle so that very little air is between the lid and the water surface. Hold the lid tightly to the top of the jar and invert the water bottle into the water in the pan as shown above. Remove the lid and air pressure will hold the water up in the bottle.

Thread the hose into the mouth of the cylinder or jar submerged in the pan, as shown. Completely

cover the ground up limestone in the 100ml flask with dilute hydrochloric acid (or drop the Alka Seltzer tablets into the water). Quickly stopper the flask. The CO<sub>2</sub> produced by the HCL and the limestone will replace the water in the bottle.

Now the trick will be to remove the bottle of carbon dioxide from the pan without losing it. Remove the hose and slide a jar lid or piece of flat glass under the mouth of the cylinder or jar. Turn the bottle right side up. Carbon dioxide is heavy and it will stay in the bottle for a while. You may even take the lid off and tell the student the CO<sub>2</sub> is in the bottle. They will have to believe you because they cannot see it. Pour the CO<sub>2</sub> onto the burning candle. The fire will be extinguished by the heavy, but invisible, CO<sub>2</sub> gas. Tell students that the gas that put the flame out is the main raw material plants are made of. Plants absorb carbon dioxide in their leaves. Use a potted plant as you discuss photosynthesis.

The other main raw material used in the photosynthetic process is water taken in by the roots. The CO<sub>2</sub> enters the leaf through tiny holes called stomates. In the chloroplasts inside the leaf, carbon dioxide and water are disassembled and reunited in the process of photosynthesis to become sugar used for the energy the plant needs. In the process the sun's energy is stored, like setting a mouse trap, except the energy is stored in chemical bonds created in photosynthesis. Some sugar molecules and other elements from the soil, through other reactions, become molecules that make structures the plant uses for carrying on its life processes. Some are stem cells that make vascular tissue, flower tissue cells for reproduction, and root cells for absorbing water and minerals. Tell students that scientists believe photosynthesis evolved in the ocean about half the age of earth ago (2.5 billion years ago), and today most of photosynthesis still goes on in the water bodies of earth. Remind students that in photosynthesis the water molecule is split. The hydrogen atoms become part of the plant molecules and the oxygen of the water is released into the air or water body. Organisms that must have oxygen depend upon this source of oxygen. Before there was photosynthesis, there were no oxygen-using organisms.

## Extending the Activity

1. Most students do not realize it is the sun that allows them to run, their hearts to beat, and the big

cranes to operate that are used to build skyscrapers. With a Bunsen burner or propane torch, burn some plant material (dry leaves from the potted plant) and coal to let the heat and light energy of the sun escape. The heat and light is truly the energy of the sun. In burning coal, gas, or wood, the sun does work for us. Students can feel the heat and light of the sun escape. It may have been stored for millions of years (in the case of coal) in chemical bonds in the coal. The burning is best carried out on a tripod or ring stand with a wire gauze pad. A darkened room makes the demonstration more dramatic. Be sure to point out that the sun's energy was stored in the coal millions of years ago, and today it is turned to heat and light for our lives. The earth has a finite supply of fossil fuels. We must find sustainable energy sources if we are to maintain our modern society. Fossil fuels will be a transitional fuel to sustainable energy sources because they are only renewable in geologic time.

2. Explain that energy may be stored in many ways. Store energy in a mouse trap and let it be released to let students see energy being stored and released. Ask the students where the energy came from that is stored in the mouse trap. It came from the person that loaded the trap, but where did that person get the energy? By eating food, which came directly or indirectly from plants. The sun's energy is stored in the mouse trap.

3. Ask students how much of the sun's energy gets to the earth. Have them imagine the small column of energy that travels 93,000,000 miles to fall on earth. It is only one half of a billionth of the sun's energy that reaches earth. Plants store about 50-100 million watts of the sun's energy each day.

4. Nuclear energy is not the stored energy of the sun's radiations that reach the earth, though theoretical the energy in atomic nuclei is stored when elements are synthesized in stellar interiors. Elements are also synthesized in super nova explosions. Harnessing of the energy released in the process of atomic fission (atoms breaking up) accounts for about 2 percent of the total energy used in the U.S. In some countries without fossil fuel resources, atomic fission accounts for a much larger percentage of the total energy used.

## **Student Assessment**

Let the completed Student Activity handout sheet be the assessment for the activity. Be sure to discuss answers to the questions. Much is gained from the guided discussion of answers with other students.

## **Additional Resources**

"Photosynthesis" is a video available from the Audio-Visual/Media Service, Coe Library, University of Wyoming, Laramie, WY 82071 (307) 766-3184

The Union of Concerned Scientists produces materials about sustainable energy sources, including a set of slides that shows methods.  
Union of Concerned Scientists

26 Church St.

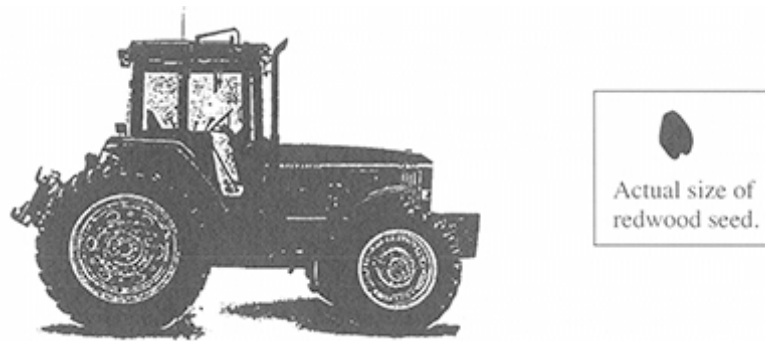
Cambridge, MA 02238 (617) 547-5552

*Power Surge*, by Christopher Flavin and Nicholas Lenssen, in the World Watch Environmental Alert Series, examines scenarios in the transition to sustainable energy resources. It is published by W.W. Norton and Company and may be obtained from World Watch Institute, P.O. Box 6991, Syracuse, NY 13217-9942

# Sun Animals

## The John Deere and the Redwood

Below are pictured the seed of a giant redwood tree and a new John Deere tractor. A hypothetical situation follows that will allow you to develop a better understanding of energy storage in photosynthesis and our use of stored solar energy that allows us to be alive and make things.



The new John Deere tractor is fresh out of the factory and its diesel fuel tanks are full. The new tractor is driven into a field in California that has the proper conditions to grow redwood trees, and the engine is left running. Twenty feet from the tractor you plant the viable seed of a giant redwood. A redwood seed is the actual size of the one pictured above. You walk away from this scene and do not return for 1000 years.

Answer the questions about the fate of the seed and the new tractor.

1. If the seed germinated and the tree it produced remained healthy, what can you imagine the tree would look like in 1000 years?
2. The tractor was not maintained by anyone for 1000 years. How would it probably appear?

The tree was able to counter or resist **entropy**. Without the assistance of humans putting energy into the systems, the tractor could not counter entropy. Entropy describes the state of disorganization of matter. It took much energy to organize a tractor: energy to refine the metals and shape them into parts for the tractor, energy to make the nylon, plastics and tires,

and then energy to assemble the many components. Without humans to maintain the organized condition of the tractor, it would run out of fuel and finally become rust and other

## Student Activity, Page 2

oxidized metals. In 1000 years it would be a mass of simpler, disorganized molecules on the ground: rust, copper oxide, aluminum oxide — kind of like your bedroom a while after you clean it and organize your belongings. Entropy in the field of physics describes the Second Law of Thermodynamics. Systems alone tend to lose energy and become less organized.

The entropy of a system is a measure of its disorganization. But the seed countered entropy. Using the sun's energy it was able to take disorganized matter like minerals of the soil, carbon dioxide from the air, and water from the soil, and organize the disorganized matter into a redwood tree. The evolution of the process of photosynthesis, nearly half the life of earth ago, or more than two billion years ago, allowed some simple organisms like bacteria to begin storing the sun's energy in the process of photosynthesis. The sun's energy was channeled to assemble disorganized matter into the living structures of cells. Photosynthesis also began producing free oxygen, first in the water environment of the earth. Free oxygen is necessary for most kinds of organisms to live, but it wasn't necessary for the first life on earth.

For perhaps two billion years, photosynthesis has been storing energy in organisms that can carry on this process, and a waste product is free oxygen. The green color of organisms that carry on photosynthesis is caused by chlorophyll, integral to the process. Scientists believe that photosynthesis evolved in the oceans. For their energy needs, those organisms that cannot carry on photosynthesis must live off of the ones that can trap light energy. Today there are more kinds of organisms on earth that do not carry on photosynthesis than those that do. We get our energy for life from the plants that carry on photosynthesis, whether we take it directly from fruits and vegetables, or indirectly from animals that eat plants.

Today, most photosynthesis still goes on in the oceans and the water bodies of the earth. In fact, were it not for the photosynthesis in the oceans and the free oxygen that diffuses out into the atmosphere, there would be much less than half the oxygen concentration in the atmosphere and land life as we know it would not be possible.

At death, if organisms get trapped and are not decomposed by bacteria and fungi, which turns them into very disorganized molecules, the sun's energy in their bodies may be trapped and remain partially organized in storage for a very long time. Buried in the earth's crust with the weight and pressure of dirt and rock on them, once living organisms change their looks. But the energy may remain in the modified molecules of the once living plants and animals. Such is the condition of oil, tar sands, natural gas, and coal.

When a wheat farmer in Kansas plows a large field with a tractor, the farmer is using energy captured in the process of photosynthesis millions of years ago. When the farmer harvests the wheat, he is taking the stored energy of the sun so we may transform the energy in the wheat into the things humans do: keeping our bodies alive, playing basketball, building

computers, making a factory to build computers, using the stored energy of the sun in bulldozers, and thinking. We are sun animals, all of us: fish, whales, mice, cougars, rats, and fleas.

### Student Activity, Page 3

When fossil fuels are burned, or an animal is decomposed, energy is released, their state of entropy is increased, and the molecules become less organized. In burning fossil fuels, carbon dioxide, sulfur dioxide, nitrogen compounds, and water are the main products produced. Other elements of life remain as ash. Most meteorologists, scientists who study the atmosphere, believe that the great increase of carbon dioxide in the atmosphere humans are causing in burning fossil fuels will increase the temperature of the atmosphere because of the greenhouse effect. An increase of only a few degrees could have serious consequences.

Humans are the only organism on the planet that are able to deliberately use more energy in their lives than the amount they need to supply their physiological needs. When a beaver stores energy behind a dam, it does not use the energy. But when humans store water behind a dam, energy of the water may be changed to mechanical energy or electrical energy to perform the many operations of modern humans: run a water wheel, run motors, light homes, and even toast bread and build computers.

3. Is the energy in water stored behind a dam related to the sun? Explain.

4. How about the winds that blow across the earth's surface? Are they too related to the sun?  
Explain.

Nuclear energy is the energy in the nuclei of atoms. Most of the matter in the universe is not in the form of atoms, but as sub atomic particles such as protons, neutrons, electrons, etc. When stars are born and cool, atoms form. If the nuclei of atoms are split, like in the splitting of uranium atoms, or reformed to make other nuclei, as in nuclear fusion, energy is released. Power plants using fission of uranium atoms have been in use to make electricity since 1957.

Fusion of hydrogen atoms occurs in the sun and in hydrogen bombs. The energy of nuclear fusion has been released in hydrogen bombs, but the energy of nuclear fusion has not been harnessed for uses other than the uncontrolled blast of a bomb. The temperatures that occur with nuclear fusion, temperatures equal to those on the surface of the sun, have not yet been contained on earth in a way to harness the fusion energy.

Student Activity page 4

5. It is important to consider the kinds of uses we have for fossil fuels if we try to conserve quantities for future generations. Make a list beginning with one (1) for the most important use of fossil fuels, two (2) for the next most important use, 3, 4, 5.....up to 24 for the least important use.

1	2	3	4	5	6
7	8	9	10	11	12
13	14	15	16	17	18
19	20	21	22	23	24

7. Make another list. Think of ways that you may save fossil fuel supplies for future generations. Put a check (  ) by the action if it will also help control the increase of carbon dioxide into the atmosphere and help control global warming.

1	2	3	4
5	6	7	8
9	10	11	12

## **Wyoming Science Standards**

### **1. CONCEPTS AND PROCESSES**

**In the context of unifying concepts and processes, students develop an understanding of scientific content through inquiry. Science is a dynamic process; concepts and content are best learned through inquiry and investigation.**

#### **BENCHMARK Grade 8**

#### **EARTH, SPACE, AND PHYSICAL SCIENCE**

**11. Physical and Chemical Changes in Matter: Students evaluate chemical and physical changes, recognizing that chemical change forms compounds with different properties and that physical change alters the appearance but not the composition of a substance.**

**12. Forms and Uses of Energy: Students investigate energy as a property of substances in a variety of forms with a range of uses.**

### **2. SCIENCE AS INQUIRY**

**Students demonstrate knowledge, skills, and habits of mind necessary to safely perform scientific inquiry. Inquiry is the foundation for the development of content, teaching students the use of processes of science that enable them to construct and develop their own knowledge. Inquiry requires appropriate field, classroom, and laboratory experiences with suitable facilities and equipment.**

#### **BENCHMARK Grade 8**

**2. Students use inquiry to conduct scientific investigations.**

- Ask questions that lead to conducting an investigation demonstrating the proficient level, propose new problems, questions, and/or experimental designs based on results or research. Students analyze information to provide new insights**

- Draw conclusions based on evidence and make connections to applied scientific concepts.**

**5. Students properly use appropriate scientific and safety equipment, recognize hazards and safety symbols, and observe standard safety procedures.**

### **3. HISTORY AND NATURE OF SCIENCE IN PERSONAL AND SOCIAL DECISIONS**

**Students recognize the nature of science, its history, and its connections to personal, social, economic, and political decisions. Historically, scientific events have had**

significant impacts on our cultural heritage.

#### **BENCHMARK Grade 8**

- 2. Students explore how scientific information is used to make decisions.**
  - A. The role of science in solving personal, local, and national problems.**
  - C. Origins and conservation of natural resources, including Wyoming examples.**

#### **Wyoming Math Standards**

**1. NUMBER OPERATIONS AND CONCEPTS** Students use numbers, number sense, and number relationships in a problem-solving situation.

#### **BENCHMARK Grade 7**

- 1. Students represent and order rational numbers that are greater than or equal to 0 in a variety of equivalent forms in problem-solving situations.**
- 2. Students use basic operations with integers in problem-solving situations.**
- 3. MEASUREMENT** Students use a variety of tools and techniques of measurement in a problem-solving situation.

#### **BENCHMARK Grade 7**

- 1. Students apply estimation and measurement of length to content problems and convert within the U.S. customary (in, ft, yd, mi) and within the metric system (mm, cm, m, km).**
- 2. Students apply estimation and measurement of weight to content problems expressing the results in metric units (g, kg).**
- 3. Students apply estimation and measurement of capacity to content problems expressing the results in metric units (liters).**
- 4. Students determine the circumference of a circle using models.**

**5. DATA ANALYSIS AND PROBABILITY** Students use data analysis and probability to analyze given situations and the results of experiments.

#### **BENCHMARK Grade 6**

- 2. Students, given a scenario, recognize and communicate the likelihood of events using concepts from probability (i.e., impossible, equally likely, certain) appropriate to grade level.**

#### **Wyoming Social Studies Standards**

**3. PRODUCTION, DISTRIBUTION, AND CONSUMPTION**  
Students demonstrate an understanding of economic principles and concepts and describe the influence of economic factors on societies.

## **BENCHMARK Grade 8**

- 1. Students communicate how economic considerations influence personal, local, state, national, and international decision-making.**
- 3. Students recognize basic concepts of economic systems.**

## **4. TIME, CONTINUITY AND CHANGE**

**Students demonstrate an understanding of the people, events, problems, ideas, and cultures that were significant in the history of our community, state, nation, and world.**

## **BENCHMARK Grade 8**

- 1. Students identify people, events, problems, conflicts, and ideas and explain their historical significance.**
- 2. Students discuss current events to better understand the world in which they live.**
- 3. Students analyze the impact of historical events and people on present conditions, situations, or circumstances.**