Your Plan for Environmental Teaching
GM Environmental Science Club

No Fossils in This Fuel

Your PlanET

Sixth through Eighth Grades
(Can be easily adapted to any elementary/middle school level)

Ingredients: Yeast, sugar … what are you making? Sweet rolls? Not in Science Class! You're blending these ingredients to make an innovative form of *fuel!* That's right … when these two simple ingredients are mixed, the yeast — a simple, living organism — breaks the sugar down into ethyl alcohol, or *ethanol*, and carbon dioxide. While you won't be burning the fuel to prove its usefulness, you can share with your students how ethanol is being used *right now* to power some of today's vehicles! Students will be able to experiment with the activity, and they will see how the fermentation that occurs can blow up a balloon. The yeast-sugar combo is also a great example of a renewable resource … because there are ***"No Fossils in This Fuel"!***

—Bill Nye
GM Environmental Science Club

Overview:
Yeast and sugar go beyond the pantry and into a fuel experiment! These ingredients can be combined to create a natural fuel: ethanol. Students will watch as yeast breaks down the corn syrup into ethanol and carbon dioxide and causes a balloon to inflate over time.

Background Information:
Fossil fuels supply about 90% of the energy needs of the United States and other industrialized nations. Coal, oil, and natural gas are nonrenewable energy resources, and are being consumed rapidly. Alternative sources of energy include: solar, wind, biomass, hydroelectric, geothermal, nuclear, and tidal energy. Many of these alternative energy sources are renewable energy sources. They are replaced naturally, such as plant life; or are readily available, like sun and wind.

Burning fossil fuels (oil, coal, gasoline, and natural gas) produces carbon dioxide gas. Carbon dioxide is one of the main greenhouse gases that contribute to global warming. Burning coal and gasoline also produces pollution that contributes to smog and acid rain. Using renewable energy sources (solar, wind, biomass, geothermal, and hydropower) could help prevent global warming and reduce pollution and acid rain. Nuclear energy also is a renewable energy source; however, it requires storing radioactive waste created by nuclear power plants.

In parts of the United States, ethyl alcohol is blended with gasoline to make a fuel called gasohol. Gasohol burns cleaner than pure gasoline. Ethyl alcohol is a renewable energy source because it is made from fermenting grains.

This Activity Teaches the Following National Science Standards:
- "Resources are things that we get from the living and nonliving environment to meet the needs and wants of a population."
- "People continue inventing new ways of doing things, solving problems, and getting work done. New ideas and inventions often affect other people; sometimes the effects are good and sometimes

they are bad. It is helpful to try to determine in advance how ideas and inventions will affect other people."
- "The supply of many resources is limited."

Science Skills
- making predictions
- experimenting with variables
- making observations
- recording data
- weighing/measuring
- making conclusions

Purpose:
To learn more about renewable resources.
To explore how grains can be used to create fuel through fermentation.

Time Frame:
10-15 min. for brainstorming and vocabulary review
5 min. for experiment setup
Observations after mixing: 1-5 minutes, 1 hour, 2 hours, and 24 hours (if possible)
10-15 min. for conclusion writing and wrap-up discussion

Materials:
- one package of yeast (to mix with water and corn syrup)
- water (to mix with yeast and corn syrup)
- corn syrup (to mix with yeast and water)
- empty and label-free 2-liter plastic bottle (to hold and mix yeast, water, and corn syrup)
- balloon — works best if it has been stretched (to test the presence of gas)
- funnel (to add corn syrup to mixture)
- measuring spoons or metric beaker (to measure solids accurately)
- measuring cup or metric beaker (to measure liquids accurately)
- sink or bucket (to contain spillage of mixture and allow easy clean up)
- rubber gloves (to protect hands)

Preparation:
Teachers should prepare a sample balloon and bottle before students arrive, and place it out of view. This will allow students to observe the experiment at different stages and times. After students have made their predictions, and have made observations for 1-5 minutes, have them observe your sample balloon and bottle. The fermentation process takes time, and students should be encouraged to observe without disturbing the mixture. Rubber gloves and hand washing with soap and water is recommended after this activity. Students will need a copy of the "No Fossils in This Fuel Predictions, Observations & Conclusions" worksheet.

Vocabulary:
alternative - another choice, option, or possibility.

biodiesel fuel - fuel made from soybeans and is used in buses, trucks, and other vehicles that burn diesel fuel.

biomass - any organic plant or animal matter (wood, wood wastes, agricultural residues, animal wastes, micro-algae and other aquatic plants) that can be used for energy; it is usually inexpensive, renewable, and found all over the world; it puts out some of the same pollutants as fossil fuels in the form of carbon dioxide, smoke, ash and odors.

bioenergy - a term for the energy stored in organic wastes that can be converted into useful energy; the processes commonly used to convert biomass into fuels are heat, mixing with chemicals, compacting, or changing the microorganism digestion.

carbohydrates - starches in the case of grains or sugar from sugarcane juice.

carbon dioxide - a heavy, colorless, odorless gas present in the atmosphere or formed when any fuel containing carbon is burned; a gas that traps heat near the earth's surface.

carbon monoxide - a colorless and odorless poisonous gas formed when carbon burns with an insufficient supply of air. It is given off when fossil fuels are burned and as a part of the exhaust gases of automobile engines.

coal - a fossil fuel created mostly from decaying vegetable matter, such as primitive swamp plants that fell into a marsh or bog millions of years ago; soil, rock and volcanic ash piled on top, becoming heavier and heavier, squeezing out water and making it very hot, turning the vegetable matter into hydrocarbons and then coal. There are many types of coal, from brownish-red lignite to harder, darker bituminous, and anthracite, which is black, shiny and very hard. It is pit- and strip-mined and used as a fuel.

compressed natural gas (CNG) - the gaseous form of a fossil fuel that is extracted from underground reservoirs; it consists mainly of methane, with smaller amounts of ethane, propane, butane, carbon dioxide, nitrogen and helium; both CNG and its liquid form can be used as a vehicle fuel; gas — rather than liquid — is more commonly used as an automotive fuel.

conservation - preserving from harm or decay; protecting from loss or from being used up.

distillation - the heating of a liquid or solid to condense the vapor or gas given off so as to purify or concentrate it; gasoline is distilled from crude oil.

emission – something — such as any form of gas — that is discharged. For example, gases released from the burning of coal to create electricity are forms of emissions.

ethanol or ethyl alcohol - grain alcohol; another alcohol fuel with the potential of becoming a widely used automotive fuel; it can be made from a variety of feedstocks, mainly grains and forest residues; most often it is made from fermenting corn or sugarcane.

fermentation - the process of rotting or the breaking down of complex substances into simple ones, as in yeast decomposing carbohydrates into ethyl alcohol and carbon dioxide.

fossil fuel - a fuel formed a long time ago from the remains of dead plants or animals; nonrenewable energy sources used to create power such as coal, oil and natural gas; they cause pollution and create carbon dioxide, which is a major contributor to global-warming problems.

gasoline - a vehicle fuel produced from chemically changing and separating refined oil; it contributes to carbon dioxide, hydrocarbon and nitrogen oxide levels, which — when combined with sunlight — form ground-level ozone.

global warming - the threat of a gradual warming of the earth's atmosphere, which some scientists believe could take place if the greenhouse effect increases.

greenhouse effect - the trapping of the sun's heat in the earth's atmosphere through the buildup of gases such as carbon dioxide.

MSW - municipal solid waste; paper, food and yard wastes, plastics, wood, tires.

methanol - wood alcohol; a liquid alcohol fuel that can be made from biomass (especially wood products), natural gas, or coal; it is colorless and odorless and can be used as an automotive fuel.

natural gas - a non-renewable fossil fuel made mostly of methane; a gas produced from rotting vegetation, mixed with lesser amounts of other gases; when used as vehicle fuel its one major advantage over most other fossil fuels is that it burns almost completely, releasing very little soot or smoke into the atmosphere; it has both liquid and gaseous forms.

nonrenewable sources of energy - energy resources that, once they have been used up, cannot be replaced.

octane - a designation of "anti-knock" quality in different types of gasoline; higher-octane gasoline is thought to be better for some vehicles.

oil - a fossil fuel formed similar to coal, though the liquid hydrocarbons remained within the hot, buried mass of vegetation and stayed in fluid form, instead of hardening. It appears as a thick, blackish liquid, a brown, light-textured liquid, or a black, sticky tar. It is usually found underground along with natural gas or in a rock called shale. It is mined by drilling wells to bring the oil from under land or the sea. Later it is transferred to a refinery where it is chemically changed or separated into needed products, such as gasoline.

renewable sources of energy - any naturally occurring sources of energy, such as solar, tidal or wind power, that can be used again and again.

yeast - masses of tiny one-celled fungi which grow quickly in liquids containing sugar and cause fermentation.

Exploration:

1. Brainstorm with students about renewable and non-renewable resources. What are fossil fuels? Are they renewable?
2. Discuss vocabulary so students are familiar with the definitions.
3. Have students complete the "prediction" portion of the worksheet.

4. Pour 2 cups (500 ml) of water and one package of yeast (1/4 oz or 7g) into the 2-liter bottle. Swish the bottle to mix these ingredients. Observe the mixture, and record your observations on worksheet.
5. Place funnel in the mouth of the bottle. Then add 1/4 cup (50 ml) of corn syrup, and mix again.
6. Stretch the deflated balloon over the top of the bottle, and place in sink or bucket.
7. Observe the mixture and balloon. Record your observations.
8. Check the bottle and balloon after 1 hour. Record your observations.
9. Check the bottle and balloon after 2 hours. Record your observations.
10. Check the bottle and balloon after 24 hours. Record your observations and make conclusions.
11. When finished with the experiment, remove the balloon and pour the contents of the bottle down the sink. Then rinse the bottle and sink with water.
12. Share your observations and conclusions with the class.

No Fossils in This Fuel
PREDICTIONS, OBSERVATIONS & CONCLUSIONS

Name_____ **Date** _____

Predictions:
What do you think will happen when the balloon is placed over the mouth of the bottle? How long do you think it will take to notice a change in the mixture? How long do you think it will take to observe a change in the balloon? Explain.

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Observations:
Describe the water and yeast mixture. What color is it? Are gas bubbles evident? Is the mixture transparent, translucent or opaque? What else do you observe?

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Describe the water, yeast and corn syrup mixture. What color is it? Are gas bubbles evident? Is the mixture transparent, translucent or opaque? What else do you observe?

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What happens to the balloon and mixture? Does the balloon grow larger or smaller over time? Are there gas bubbles evident in the mixture? What else do you observe?

Time Frame	Observations
1 - 5 minutes	
1 hour (approximately)	
2 hours (approximately)	
24 hours (approximately)	

Conclusions:
What can you conclude based on your observations and class discussions?

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Extension:
Try this experiment using 1 tablespoon (11g) of sugar instead of corn syrup. What do you observe?

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Expected Outcome:
Students will discover that the yeast, water, and corn syrup mixture causes the balloon to inflate over time. Yeast is breaking down the corn syrup through fermentation. Foam and gas bubbles will rise to the surface of the mixture. The gas bubbles in the mixture are carbon dioxide. The balloon expands and becomes inflated because it traps the carbon dioxide gas being produced. As the yeast population increases the balloon gets larger. The ethyl alcohol that is made during fermentation stays in the liquid mixture. When the fermentation process is finished (24 - 48 hours), the liquid mixture usually contains about 13% ethyl alcohol. The remaining liquid is mostly water.
Note: Sugar will have similar results.

Extension:
Field Trip: Students could visit an alternative-fueled car team at a nearby high school or college. If a team does not exist in the area, students could search on-line. What is the fuel source for the team's car? How many miles per gallon does the car get? What is the top speed? What are the pros and cons of this alternative-fueled car?

Reading & Further Research: Students can read these books for added research or they can be a part of an in-class project.

Bernardy, Catherine J. *Fuel*. Creative Education. Mankato, MN. 1999.
Chandler, Gary and Kevin Graham. *Making a Better World: Alternative Energy Sources New Ways to Power Vehicles*, pages 49-60. Twenty-First Century Books, New York, NY. 1996.
Wellington, Jerry. *The Super Science Book of Energy*. Thomson Learning, New York.1994.

Math: Students could conduct a survey of gas stations to see how many sell gasoline with ethanol. The gas pump will list the percentage of ethanol in the gasoline. Do more stations sell gas with ethanol or without? What is the range of ethanol percentage in gasoline? What is the mode and mean of ethanol percentage in gasoline? Chart and share your results.

Language Arts: Describe the transportation of the future. What will transportation be like in the year 3000? How is it powered? Does it use a renewable source of energy?

Research the other forms of vehicle power, such as electric and solar, including fuels mentioned in this activity, and make a poster or chart with advantages, disadvantages, and availability of each.

Design a plant-powered machine: Make your own design for a machine that is powered by plant energy. Make a drawing of it and show on the drawing how it works. What sort of plants would it use?

Science: These experiments help show how burning fossil fuels produces carbon dioxide, which contributes to global warming:

1. Use a ball of modeling clay to hold a short candle upright in the middle of a metal pan with a rim. Set a 1-quart (1-liter) glass jar upside down over the candle. In a short time the candle goes out. What does the fire need in air? Why didn't the flame go out immediately?
2. Light a match and hold it near the mouth of the upside-down jar. Tilt the jar slightly to let the gases inside it pour out toward the flame. What happens? Did water vapor condense in droplets on the inside of the jar?
3. Candle wax contains carbon and hydrogen, the same elements that make up the hydrocarbons in coal and oil. The hydrogen combined with oxygen to form water inside the jar. When wax burns, the carbon given off combines with oxygen in the air to form carbon dioxide, a major contributor to global warming.

Home: Try this experiment at home using sugar (1 Tablespoon or 11 g) instead of corn syrup. Are the results the same? What do you think would happen if you had added more sugar to the yeast? What do you think would happen if you had used just half the amount of yeast? How does the size of the balloon change from the first day to the second? What do you think would happen if you left the balloon on for more days?

Internet Links:

Energy Quest http://www.energy.ca.gov/education

The Energy Story - Biomass Energy http://www.energy.ca.gov/education/story/story-html/story.html/chapter14.html

Energy Ed http://www.ergon.com.au/energyed/

Energy Match http://www.energymatch.com

Power Kids http://www.miltonhydro.com/kids.html

Office of Transportation Technologies Kid's Page http://www.ott.doe.gov/kids.html

Automotive Learning On-Line http://www.innerauto.com/default.html

Carolina EV Challenge http://www.rtpnet.org/`ev/

Resources:

Harcourt ScienceTeacher Edition; Harcourt School Publishers.

Environmental Experiments About Renewable Energy by Thomas R. Rybolt and Robert C. Mebane; Enslow Publishers, Inc.

Energy Quest http://www.energy.ca.gov/education

Science Made Simple by Alain Chirinian; Frank Schaffner Publications.

Renewable Energy: A Concise Guide to Green Alternatives (chapters on Biomass Energy and Renewable Automobile Fuels, pages 98-126) by Jennifer Carless; Walker and Company, New York, NY. 1993.

Fueling the Future by Janet Pack; Childrens Press. Chicago. 1992.

American Gas Association; 1515 Wilson Boulevard, Arlington, VA 22209; 703.841-8660 (Will send various information for further research).