Bioenergy Conversion

This bioenergy education curriculum was created through Ohio's 4-H Cloverbud program and the Ohio BioProducts Innovation Center (OBIC) to inform and educate future consumers and supporters of bio-based energy and its products. The curriculum was developed with support from the Northeast Regional Sun Grant Initiative, with a grant from the U.S. Department of Transportation: US DOT Assistance #DTOS59-07-G-00052.

The material consists of three bioenergy curriculum pieces in the content areas of 1) bioenergy sources, 2) bioenergy conversion, and 3) bioproducts. Each curriculum piece contains about nine educational activities.

Ohio State University Extension's 4-H Cloverbud program is designed to meet the developmentally appropriate needs of children ages 5 to 8, or in kindergarten through the second grade. However, this curriculum **is recommended for youth through fifth grade.** The Cloverbud youth development program emphasizes overall well-being by empowering young children with successful learning and positive social interaction through cooperative learning in non-competitive environments.

OBJECTIVES

- Understands how bioenergy sources are changed to bioproducts (such as fuel, electricity, plastics, and insulation)
- Becomes familiar with various ways that bioenergy sources are changed into bioproducts (such as squeezing the energy out of biomass)
- Learns key words that describe how bioenergy sources become bioproducts

GROUP SIZE

6 to 8 children per adult volunteer

LIFE SKILL AREAS

- Expands social skills
- Develops decision making and critical thinking skills
- Develops learning-to-learn skills
- Enhances eye-hand coordination and fine motor skills
- Improves self-confidence
- Improves the ability to make hypotheses about activity outcomes

VOLUNTEER TIPS

- Complete the first "Getting Started" activity for introductory purposes, and then choose one of the activities from each section.
- Create a fun, engaging atmosphere using pictures and video clips related to the activities.
- The length of time given to complete each activity is an estimate. Set a relaxed pace while completing each activity, allowing time for creativity and experimentation.
- For each section, choose a balance of activities, including movement, sitting down, and problem solving so that children are engaged in a variety of learning settings.
- Encourage children to make predictions or hypotheses (educated guesses) about what will happen as they complete the activities.

Bioenergy Conversion

TIME FRAME

This lesson is designed for a group meeting between 30 and 60 minutes. Each activity takes 5 to 15 minutes to complete.

BACKGROUND

Bioenergy sources typically need to be changed (or converted) to become bioproducts. For instance, wood (a bioenergy source) can be burned (one method of conversion) to create electricity (a bioproduct). The fire can be used to heat water, which makes steam. The steam can then power turbines to make electricity.

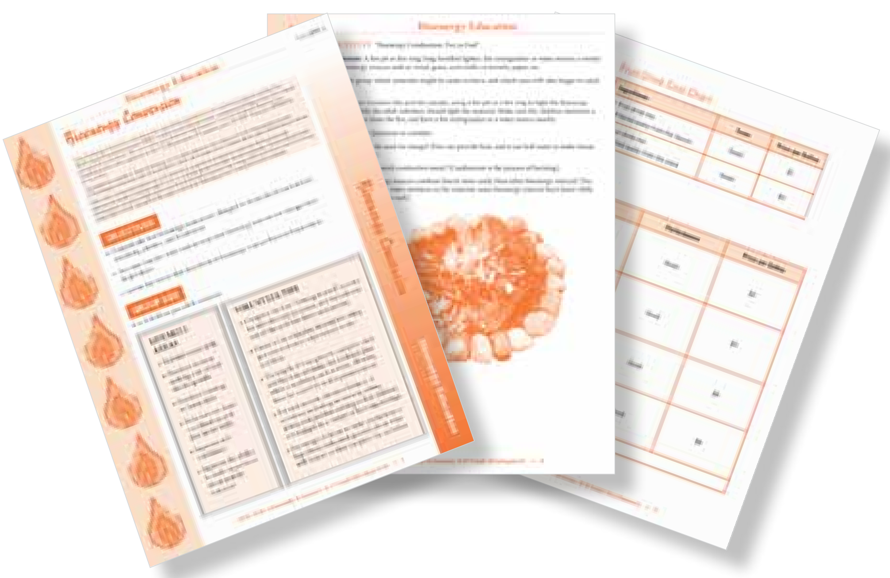
Many bioenergy sources are changed into bioenergy products through processes such as combustion, biodigestion, fermentation, and esterification. These are big words, but not too difficult to understand when explained in the right context. The following activities will do just that.

NATIONAL SCIENCE STANDARDS

- Characteristics of organisms
- Ability to do scientific inquiry
- Understand scientific inquiry

SUCCESS INDICATORS

- Identifies bioenergy conversion processes
- Understands the differences between bioenergy conversion processes
- Understands the importance of converting bioenergy sources into bioenergy product



LEARNING ACTIVITIES

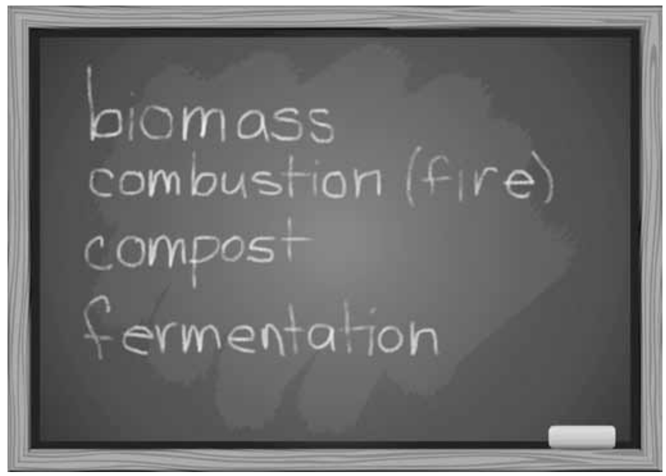
1. Getting Started

ACTIVITY "It's Not Magic: It's Bioenergy Conversion"

Materials: Paper and pencils or chalk and chalkboard.

Write these words on paper or on a chalkboard and read them aloud: *biodigestion, combustion, compost, esterification, fermentation,* and *landfill gas*. Ask the children to repeat these words together with you. Read one of the definitions below without matching it to a word. Then, ask the children to figure out which word goes with the definition. Repeat this until all words have been defined.

Bioenergy Terms



Biodigestion: the process of *biomass* breaking down. For example, grass clippings and leaves rot and produce methane gas. A similar process happens when we eat and burp later.

Biomass: plant or animal matter that uses sunlight to store energy. It can be used for many purposes. For example, corn can be used to make fuel for cars.

Combustion: fire or the process of burning. For example, burning wood makes heat.

Compost: mixture of decaying plants or poop.

Esterification: the chemical reaction between an acid (e.g., plant oil) and an alcohol. In bioenergy, it is the process of converting plant oils (such as soybean, algae, or corn) to biodiesel fuel.

Fermentation: the process of yeast turning sugar into alcohol. For example, yeast converts grape juice to ethanol and carbon dioxide as part of the wine-making process.

Landfill gas: the mix of gases created by the breakdown of *biomass* in a landfill.

Application: Explain to the group that most, but not all, bioenergy sources (biomass) need to be converted from their original state to useable energy forms. Ask the children if they can think of any bioenergy sources that need to be (or sources that don't need to be) converted from their original state to useable energy forms. [Soybean and corn oils cannot be used as fuel for vehicles until they are changed into biodiesel through a chemical process (esterification); however, wood can be used in its natural state to create heat/steam by burning it.]

ACTIVITY "Bioenergy Combustion: Fire as Fuel"

Materials: A fire pit or fire ring; long-handled lighter; fire extinguisher or water source; a variety of bioenergy sources such as wood, grass, corn stalks or kernels, paper, etc.

Ask the group which materials might be easier to burn, and which ones will take longer to catch fire.

Safety Note: Conduct this activity outside, using a fire pit or a fire ring to light the bioenergy sources. Only the adult volunteer should light the material. Make sure the children maintain a safe distance from the fire, and have a fire extinguisher or a water source nearby.

Application: Questions to consider:

- How can fire be used for energy? [Fire can provide heat, and it can boil water to make steam for electricity.]
- What does the word *combustion* mean? [Combustion is the process of burning.]
- Do some bioenergy sources combust (burn) more easily than other bioenergy sources? [Yes. Depending on the water moisture in the material, some bioenergy sources burn faster while others don't burn as well.]

2. Digging Deeper

ACTIVITY "Don't Pass Gas: Convert That Biomass"

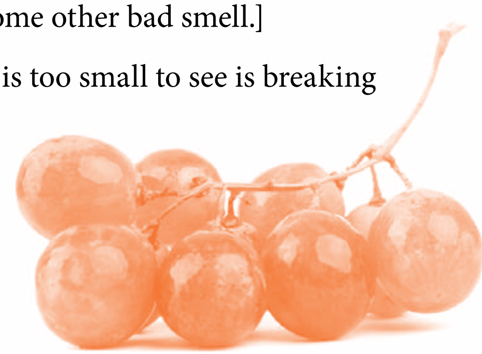
Materials: Compost items: grass clippings, leaves, food scraps, etc.; food storage plastic bags; water.

Children can complete this activity in groups or on their own. Ask them to gather the compost items, mix the items in a food storage plastic bag, and then add a little water. Have the children leave the plastic bags open so that air can circulate. Allow the bags to sit until the next meeting (one to two weeks), and then check for changes in the compost.

Share with the children that composting is an example of biodigestion—a process that converts biodegradable materials to nutrient-rich soil while producing methane gas, a bioenergy fuel product.

Application: Questions to consider:

- How does the compost look? [Crumbly and dirt-like.] Do you think it will look the same after one week? [Answers will vary.]
- How does it smell? [It might smell foul, like rotten eggs or some other bad smell.]
- What is causing the plant material to change? [Bacteria that is too small to see is breaking down and eating the material.]
- Does your stomach do the same thing? [Yes.] How do you get rid of that gas? [The digestive system breaks down food and creates and releases gas in the process.]



ACTIVITY "Ethanol Fuel: It's All About the Sugar"

Materials: Bioenergy sources (grapes, sugar cane, apples, oranges, etc.), small cups, paper, pencils. Be aware of allergies in your group.

Crush or mush the bioenergy sources to produce juice. Keep the juices separate by placing the juice in small cups. Ask the children to taste the juices. Rate the juices from the sweetest to the least sweet (more sweetness=more sugar). Then, rank bioenergy sources based on their sugar content from high to low. Is there agreement about the ratings of the juices?

Share with the group that ethanol, a bioenergy fuel, is derived from glucose or sugar, and that it is often mixed with gasoline to fuel motor vehicles. Explain that some vehicles can use fuel primarily consisting of ethanol (E85 or 85% ethanol can be found at Giant Eagle gas stations), and that the greater the sugar content of the biosource, the greater the amount of ethanol that can be produced. Tell the group that most gasoline contains 10% ethanol.

Application: Questions to consider:

- Which of the bioenergy sources used in this activity contains the greatest sugar content? [It depends on the sources used; grapes have more sugar than oranges and strawberries.]
- Which would produce the most ethanol fuel? The least? [Typically, plant material with the greatest sugar content will create the most ethanol fuel, and plants with low sugar content will create the least ethanol fuel.]

3. Looking Within

ACTIVITY "Fermentation: Sugar to Fuel"

Materials: For each child: one large balloon, one packet of dry yeast, 2 tablespoons of sugar, 1 cup of warm water (about 115°F), one empty plastic water bottle, and a thermometer (if available).

Have each child stretch out his or her balloon, blow it up a few times, and then set it aside. Have each child add his or her yeast and sugar to his or her cup of warm water and stir. Each child should pour the mixture into his or her water bottle, and then attach his or her balloon to the bottle. Ask the children to note how the yeast and sugar interact as the water bubbles. You may need to do another activity to allow time for this process.

Explain to the group that when yeast feeds on sugar, it produces carbon dioxide and ethanol (alcohol). Explain that the carbon dioxide in the bottle has nowhere else to go, so it blows up the balloon.

Application: Questions to consider:

- What happens if more sugar is used? [The balloon will get bigger and more alcohol will be created.]
- Does the temperature of the water make a difference? What happens if hot or cold water is used? [Hot water will speed up the reaction process, but if the water is too hot, it will kill the yeast.]

ACTIVITY "Biodiesel: From French Fry Oil to Fuel"

Materials: For each child: ¼ cup vegetable oil, ¼ cup water, one water bottle with the label removed.

Ask the children to pour equal parts vegetable oil and water (represents methanol) into their water bottles. Ask everyone to tightly close their bottles and shake them. The oil and water combine, simulating this chemical process (esterification). Ask the children to place their bottles on a table, let them sit, and then make observations about what happens. The oil and water should separate.

Share with the group that in a true esterification, some type of plant oil (e.g., corn or soybean oil) would be mixed with methanol (alcohol). Explain that the liquids would react with each other and separate producing biodiesel, water, and glycerin (used to make soap).

Note to the volunteer: The National Biodiesel Board has developed a useful biodiesel information sheet, available here: **www.biodiesel.org/docs/ffs-basics/biodiesel-for-kids.pdf?sfvrsn=4**.

Application: Questions to consider:

- After the mixture has been left to stand a while, are the liquids within still mixed together? [No, the liquids have separated.]
- What happened to the water and oil? [The water and oil separated. This is similar to what happens when biodiesel is made. The liquids separate into water, glycerin, and biodiesel.]
- Could the water and oil be separated now? [Yes, by carefully pouring the oil off the top. The oil floats on top of the water because it is not as dense as water. This means that water weighs more than oil.]

4. Bringing Closure

ACTIVITY "How Much Does It Cost?"

Materials: Fruit Drink Cost Chart and Biodiesel Cost Chart (included at the end of this activity), fruit drink, small cups, play money (use singles).

Explain to the group that bioenergy sources and bioproducts are better for the planet but there is a cost in dollars and time. Explain that as energy experts try to figure out how bioenergy can meet the energy demands of the U.S. and the world, they must consider the costs involved in changing bioenergy sources to bioproducts.

Use the Fruit Drink Cost Chart to illustrate that something as simple as a fruit drink can vary in price based on ingredient costs. For example, fruit drink made with bottled water from the store costs more than fruit drink made from filtered water from the faucet. But both taste the same.

Pour the fruit drink into the small cups and separate the cups into two groups: one representing the fruit drink made with filtered water from the faucet, and one representing the fruit drink made with bottled water from the store. Give each child five one-dollar bills in play money. Ask the children which drink they would prefer to buy. Then, "sell" a cup to each of them. Ask the group if price matters. [Because the taste is the same for both samples, the lower-priced option is the best choice.]

Refer the children to the Biodiesel Cost Chart to find out what each source of biodiesel (waste vegetable oil, new vegetable oil, soybean oil, and algae oil) costs per gallon. Ask the group which biodiesel they or their parents would prefer to buy for their family car. [The performance for all four fuels is good, so the lowest-priced fuel is the best choice.]

Application: Questions to consider:

- Why are certain bioenergy fuels used instead of others? [Biodiesel made from used cooking/ vegetable oil costs much less than biodiesel made from new soybean or algae oil.]
- Does the fuel's performance change depending on the biosource? [In general, the fuel's performance does not change.]

5. Going Beyond

ACTIVITY "Ask the Experts"

Materials: Guest speaker.

Check with your local college about potential speakers who could talk about bioenergy with your group. A good source for contact information in Ohio is the Ohio BioProducts Innovation Center (OBIC) at The Ohio State University (614-292-2922). If you are outside Ohio, check with your state's land-grant university, state soybean council, or community college.

Application: Before the guest speaker arrives, talk with the group about the bioenergy questions that they would like to ask. Encourage them to inquire about careers in bioenergy, the future of bioenergy, how the speaker got started in the field, and anything else they are curious about exploring.

Reading Adventures

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Web Links

www.eia.gov/kids/energy.cfm?page=biomass_home-basics

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www.sciencenewsforkids.org/2006/04/microbes-at-the-gas-pump-3

www.alliantenergykids.com/EnergyandTheEnvironment/RenewableEnergy/022398

Author: Scott D. Scheer, Professor, Agricultural Communication, Education, and Leadership, State Specialist, Ohio State University Extension

Contributing Author and Student Associate: Barbara Fox, Undergraduate Student, The Ohio State University

Curriculum Content Specialist: Dennis Hall, Assistant Director, Ohio BioProducts Innovation Center, The Ohio State University

Curriculum Production: Jane Wright, Curruculum Manager, Ohio State University Extension, 4-H Youth Development

Reviewers: Rhonda Williams, Extension Educator, Ohio State University Extension, 4-H Youth Development; Demetria Woods, Extension Educator, Ohio State University Extension, 4-H Youth Development

Illustrator: Patrick O'Toole (http://otoons.net)

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Fruit Drink Cost Chart

Ingredients	Taste	Price per Gallon
• Fruit drink mix • Filtered water from the faucet	Good	$1
• Fruit drink mix • Bottled water from the store	Good	$3

Biodiesel Cost Chart

Source	Performance	Price per Gallon
Waste Vegetable Oil 	Good	$2
New Vegetable Oil 	Good	$3
Soybean Oil 	Good	$4
Algae Oil 	Good	$8
Source: U.S. Department of Energy, Energy Efficiency and Renewable Energy Reports		