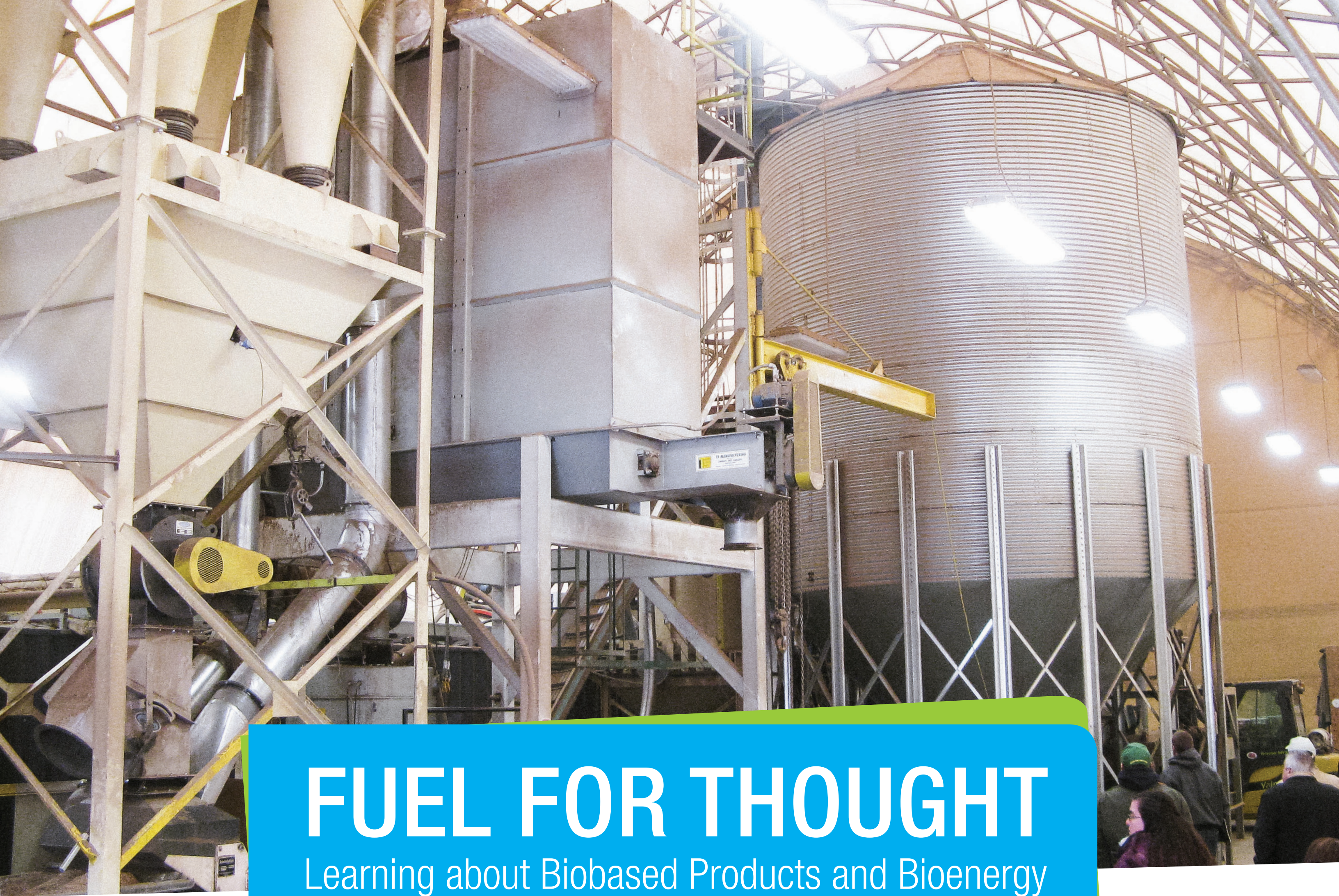

FUEL FOR THOUGHT

Learning about Biobased Products and Bioenergy

Facilitator's Guide | 4-H Curriculum

PennState Extension

ACKNOWLEDGMENTS

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INTRODUCTION

Thank you for volunteering to help youth learn about biobased products and biofuels. Renewable resources are becoming more important and prevalent in society as we use up more of our traditional fossil fuels. Having a working knowledge base about these products can help young people prepare for careers in the field and help them be more informed consumers and citizens as they get older. Your involvement and interest in the topics will help them learn about biobased products and bioenergy (science, engineering, and technology skills [SET]), but just as important, they will practice essential life skills, such as researching, planning, and public speaking, along the way.

You don't have to be an expert in bioenergy or biobased products to serve as a facilitator. The styles of learning used in these activities basically enable the youth to teach themselves by doing, with your guidance and eye toward safety. Each activity begins with a question or challenge, and then guides youth to develop answers to the question. Using this technique, youth practice asking intelligent questions, devising methods to answer questions, and learning how to learn.

HOW YOU CAN HELP

- Read through the facilitator's guide and the youth guide. Note that some activities can require materials that may take several weeks or a month to obtain by mail, so be sure to allow appropriate lead time.
- Assist the young people as they work through and personalize the activities to suit their interests.
- Help youth use the activities to identify their strengths and weaknesses.
- In the table at the front of the youth guide, date and initial the activities for each youth as they are completed.

ABOUT THE CURRICULUM

This guide is designed for young people in grades six through twelve. It is ideal for use in 4-H club settings, schools, other afterschool activities, scout troops, camps, or even individually or as a family. Some activities are better suited to younger youth and some for older youth. The guide includes twelve activities, of which at least six, including at least one from each chapter and the first activity in chapter 2, should be completed to officially finish this project. Each activity may be personalized to suit the time, place, resources, youth interests, and your experiences. We have tried to show some of the variation possible, but feel free to go beyond the outlines laid out here, as circumstances allow.

Youth learn best by doing, so each activity is hands on. You can help best by letting the youth explore and make changes or (harmless) mistakes. Draw out answers from the youth rather than feeding them answers.

Each youth participant should keep a project notebook for answering questions in the activities and jotting down their questions and thoughts.

Each youth activity includes:

- Background
- Directions
- Think It Through: reflection questions (for written or discussion response, as you and/or the youth prefer)
- Beyond the Basics: optional activities for youth or groups who want to explore a topic further; these may also serve as alternative activities to those featured in the book

Each activity in the facilitator's guide includes:

- List of skills the youth will practice (including SET skills)
- Short summary of the activity
- Materials and time needed
- Preparation guidelines
- Notes on facilitation
- Background on the science in the activity

A glossary of terms can be found at the back of each book, and terms to know appear in bold on first use in the book. Learning these terms will help youth build scientific literacy, which is necessary for not just youth who want to pursue science as a career but all people, so they can be informed citizens. Encourage youth to use the Internet and print resources to further explore current usage of glossary terms. Especially in a highly dynamic field such as this, the vocabulary changes often. A list of resources is also provided at the back of the book.

The Next Generation Science Standards (**www.nextgenscience.org**) recently released by the National Research Council emphasize the importance of inquiry-based learning in science instruction.

This curriculum addresses the following Next Generation Science Standards:

Middle School	High School
Matter and Its Interactions	Matter and Its Interactions
From Molecules to Organisms: Structures and Processes	Energy
Ecosystems: Interactions, Energy, and Dynamics	Ecosystems: Interactions, Energy, and Dynamics
Earth and Human Activity	Earth and Human Activity
Engineering Design	Engineering Design

EXPERIENTIAL AND INQUIRY-BASED LEARNING WITH YOUTH IN NONFORMAL SETTINGS

In this project, facilitators will use both experiential and inquiry-based learning. Experiential learning involves youth having a concrete experience, a reflection phase where the learner's observations and reactions are shared and discussed, and a phase where the learner's new knowledge and skills are applied in a real-life setting.

Inquiry-based learning is a teaching strategy where individuals are engaged in learning-centered activities that involve observing and manipulating objects and phenomena and acquiring or discovering knowledge. The process is steeped in experience and focuses on developing logical thinking abilities and learning and applying content knowledge.

How Are Experiential Learning and Inquiry-based Learning Similar?

Meaningful learning occurs when learners make connections between prior knowledge and new experiences and skills within real-world contexts. This "construction of knowledge" view is that learners do not merely memorize the disciplinary content that needs to be learned. Rather, learners construct their own learning by selecting the information that is most meaningful to them.

How Are These Methods Different?

A notable difference between the two methods is the subset of general inquiry called scientific inquiry, which is a way of exploring the natural world guided by the learner's previous understanding, assumptions, or personal beliefs. This learning method helps novice learners pull scientists' "thinking processes" into a concrete "experience" and then transfer this skill and the learning that can follow. As such, this involves three categories: (1) learning to do what scientists do, (2) learning to think like scientists, and (3) identifying the methods that instructors (or adult facilitators) use to provoke inquiry. To help a learner think and process like a scientist, include these four phases of learning processes in activities: (1) forming hypotheses, (2) designing experiments, (3) interpreting outcomes, and (4) communicating results.

Key Concepts

- **Experiential learning:** constructing learning through hands-on experiences that are highly social in nature.
- **Inquiry-based learning:** constructing learning through hands-on experiences that provide evidence about phenomena in the world.
- **Scientific inquiry:** how scientists investigate the natural world and construct explanations based on evidence.

Types include:

- **Structured:** facilitator provides scientific questions and methods for youth to follow to answer the questions; youth are expected to reach the same outcomes.
- **Guided:** facilitator provides one or more questions; youth design investigations in order to answer questions; results may be different.
- **Open:** youth form their own questions, design investigations to answer their questions, and reach their own outcomes or results.
- **Science process skills:** include observing, measuring, recording, interpreting and generalizing data, and communicating results.

THE NEWBIO PROJECT

The development of this learning guide was funded through the NEWBio project. The Northeast Woody/Warm-season Biomass Consortium (NEWBio) is a network of universities, businesses, and governmental organizations dedicated to building robust and sustainable biomass energy systems in the Northeast. The consortium's goal is to overcome barriers and drastically increase the sustainable supply of biomass energy sources while reducing greenhouse gas emissions, bettering the environment, and building strong communities.

Led by Penn State, NEWBio includes partners from Cornell University, SUNY College of Environmental Science and Forestry, West Virginia University, Delaware State University, Ohio State University, Rutgers University, the U.S. Department of Agriculture's Eastern Regional Research Center, and the U.S. Department of Energy's Oak Ridge National Laboratory and Idaho National Laboratory.

CHAPTER 1: BIOBASED PRODUCTS

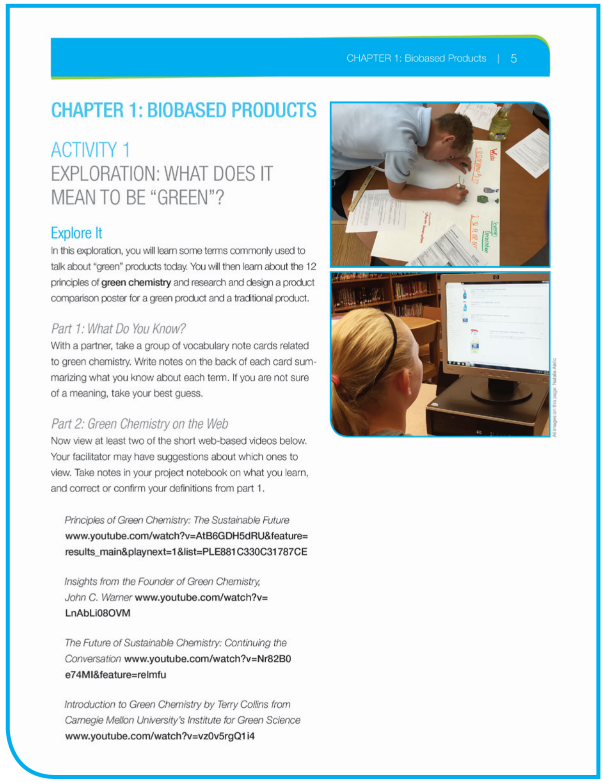
ACTIVITY 1
EXPLORATION: WHAT DOES IT MEAN TO BE "GREEN"?

Summary: This lesson will give youth a fuller picture of what a "green" product means today.

SET Skills: Research

Life Skills: Teamwork, cooperation, critical thinking, public speaking

Measuring Success: Completes product comparison poster



CHAPTER 1: BIOBASED PRODUCTS

ACTIVITY 1
EXPLORATION: WHAT DOES IT MEAN TO BE "GREEN"?

Explore It

In this exploration, you will learn some terms commonly used to talk about "green" products today. You will then learn about the 12 principles of **green chemistry** and research and design a product comparison poster for a green product and a traditional product.

Part 1: What Do You Know?

With a partner, take a group of vocabulary note cards related to green chemistry. Write notes on the back of each card summarizing what you know about each term. If you are not sure of a meaning, take your best guess.

Part 2: Green Chemistry on the Web

Now view at least two of the short web-based videos below. Your facilitator may have suggestions about which ones to view. Take notes in your project notebook on what you learn, and correct or confirm your definitions from part 1.

Principles of Green Chemistry: The Sustainable Future **www.youtube.com/watch?v=AtB6GDH5dRU&feature=results_main&playnext=1&list=PLE881C330C31787CE**

Insights from the Founder of Green Chemistry, John C. Warner **www.youtube.com/watch?v=LnAbLi08OVM**

The Future of Sustainable Chemistry: Continuing the Conversation **www.youtube.com/watch?v=Nr82B0e74MI&feature=relmfu**

Introduction to Green Chemistry by Terry Collins from Carnegie Mellon University's Institute for Green Science **www.youtube.com/watch?v=vz0v5rgQ1i4**

Materials Needed

- Note cards with the following terms: sustainability, green chemistry, renewable, solvent, feedstock, hazardous waste, side product, catalyst (one full set for each group)
- Pencils/pens and paper
- Flipchart paper
- Markers
- Internet access
- Poster board and additional materials to make displays
- A variety of soaps, detergents, other cleaning products, personal care products, and cosmetics, both biobased and traditional

The table below gives some suggestions of "green" brands to explore. It's best if you can supply a biobased and a traditional option for each type of product you choose. You don't have to buy everything. You can collect empty bottles and packages from friends, family, or neighbors—just make sure the bottles are rinsed and caps are fastened tightly for hazardous chemicals. The ingredient label is what's most important here. **You will use these products/containers again in the next activity of this chapter (How Do You Spot a Biobased Product?), so hang on to them.**

Product Category	Samples of "Green" Product Brands*
Dish soap, laundry detergent, cleaners	Ecos, Green Works, Mrs. Meyer's Clean Day, Nutek, Seventh Generation, Simple Green, Soy Green
Personal care products and cosmetics	Beauty by Earth, Burt's Bees, Jason, Kiss My Face, Tom's of Maine, The Organic Face, Physicians Formula Organic Wear

*All brands were available through Amazon (**amazon.com)** as of January 2016.

Time Needed

- Part 1: What Do You Know?, approximately 35 minutes
- Part 2: Green Chemistry on the Web, approximately 50 minutes
- Part 3: Product Comparison Poster, approximately two hours, including research time

Preparation

Read the activity in the youth guide and gather the materials needed. Prepare the vocabulary note cards. Preview the web links.

Facilitation Notes

Part 1: What Do You Know?

Before handing out the vocabulary note cards, ask youth to close their project books (there's a glossary in back).

Once all groups have completed definitions, use a flipchart to display all ideas from the teams. One way to do this is to have each team write their ideas on the flipcharts under each word. Discuss all definitions as a group, noting where there is overlap or conflicting ideas.

Part 2: Green Chemistry on the Web

Youth should view at least two of the web links below. You can suggest some of these rather than others, and you can decide whether they should view them on their own before your meeting or you will view them as a group.

Principles of Green Chemistry: The Sustainable Future
www.youtube.com/watch?v=AtB6GDH5dRU&feature=results_main&playnext=1&list=PLE881C330C31787CE

Insights from the Founder of Green Chemistry, John C. Warner
www.youtube.com/watch?v=LnAbLi08OVM

The Future of Sustainable Chemistry: Continuing the Conversation
www.youtube.com/watch?v=Nr82B0e74MI&feature=relmfu

Introduction to Green Chemistry by Terry Collins from Carnegie Mellon University's Institute for Green Science
www.youtube.com/watch?v=vz0v5rgQ1i4

Discuss important points learned from the videos.

Give the youth time to reconsider their earlier definitions in light of what they've learned. Discuss as a group how some definitions for the words given in Part 1 may have changed.

Discuss the 12 principles of green chemistry in the Science Background section below. Now ask the youth to give examples of as many of the 12 principles as they can with products they are aware of.

Part 3: Product Comparison Poster

Help the youth complete a product comparison poster, working alone or in pairs. When they're done, have them briefly present their findings to the group. Then take a group vote about which green products the youth feel most inclined to try. Lead a discussion about what influences their decisions.

Science Background

Many products on the market today are designated "green." These products range from cars and cleaning products to fabrics and foods. In general, "green" refers to products produced in a more environmentally friendly manner. Their production relies on a "green" approach to the chemical processes used to make these materials. **Green chemistry** embraces 12 principles developed by chemist John C. Warner:

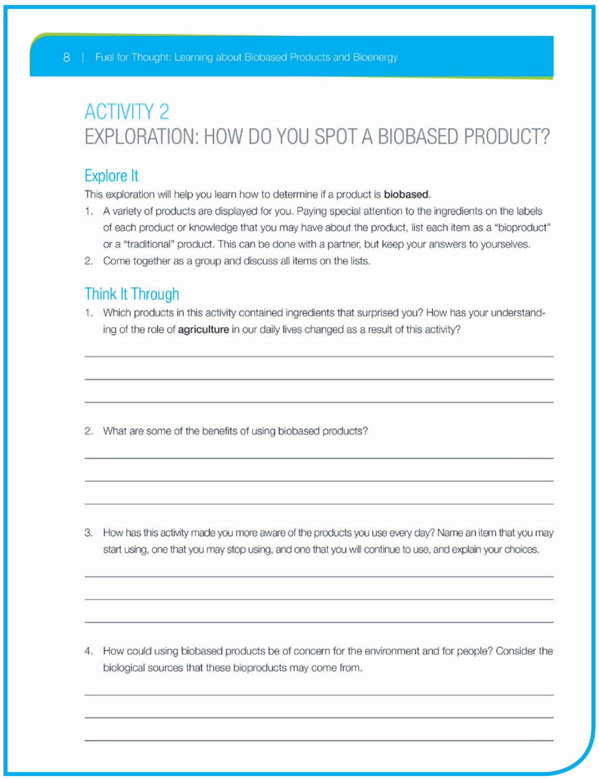
1. Prevent waste
2. Maximize economical production
3. Reduce the synthesis of hazardous chemicals
4. Design safer chemicals
5. Use safer solvents
6. Use energy more efficiently
7. Use **renewable** feedstocks
8. Reduce unutilized side products that require additional chemicals to process
9. Use catalysts to speed up processes instead of using additional feedstock
10. Design products that decompose into safe products
11. Monitor processes to avoid hazardous waste production
12. Use safer chemicals to prevent accidents

To understand the full economic and environmental impacts of biobased products, it is important to understand the processes by which they are made.

SET Skills: Research

Life Skills: Teamwork, healthy lifestyle choices, decision making, critical thinking

Measuring Success: Distinguishes between biobased products and traditional products


8 | Fuel for Thought: Learning about Biobased Products and Bioenergy

ACTIVITY 2

EXPLORATION: HOW DO YOU SPOT A BIOBASED PRODUCT?

Explore It

This exploration will help you learn how to determine if a product is **biobased**.

1. A variety of products are displayed for you. Paying special attention to the ingredients on the labels of each product or knowledge that you may have about the product, list each item as a "bioproduct" or a "traditional" product. This can be done with a partner, but keep your answers to yourselves.
2. Come together as a group and discuss all items on the lists.

Think It Through

1. Which products in this activity contained ingredients that surprised you? How has your understanding of the role of **agriculture** in our daily lives changed as a result of this activity?
2. What are some of the benefits of using biobased products?
3. How has this activity made you more aware of the products you use every day? Name an item that you may start using, one that you may stop using, and one that you will continue to use, and explain your choices.
4. How could using biobased products be of concern for the environment and for people? Consider the biological sources that these bioproducts may come from.

ACTIVITY 2

EXPLORATION: HOW DO YOU SPOT A BIOBASED PRODUCT?

Summary: In this exploration, youth will learn to distinguish between **biobased** products and traditional products.

Materials Needed

- Paper
- Pens/pencils
- The products and containers you gathered for the previous activity (What Does It Mean to Be "Green"?)

Time Needed: one hour, depending on number of products examined (not including your collection of materials before the activity, if needed)

Preparation

Read the activity in the youth guide and gather a variety of products for examination.

Facilitation Notes

Explain to the youth that they will learn how to determine whether a product is biobased or traditional. Start by asking them to think of terms used on packaging to indicate biobased products. Have them complete the exploration. Then come together for a discussion of the potential benefits of using biobased products rather than traditional products, and how the information they learned might change their buying habits.

Science Background

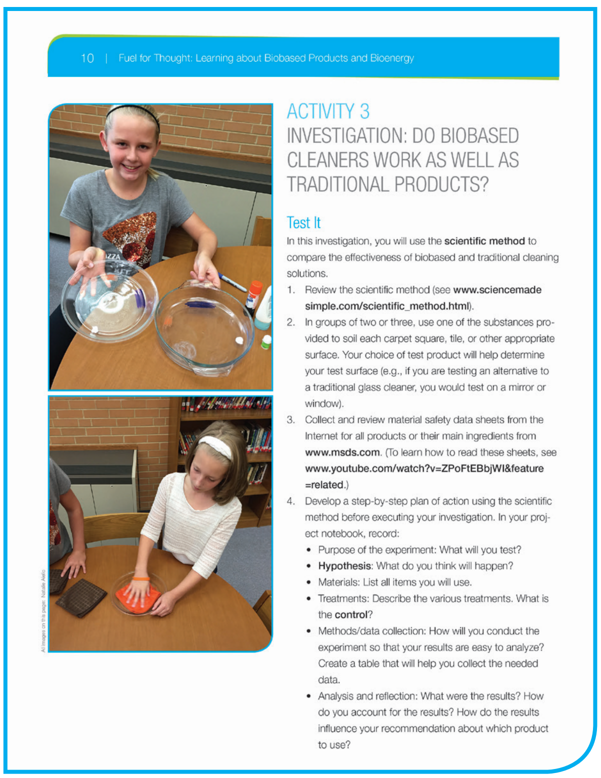
Many products on the market today contain biobased materials or have been created through the use of biobased materials. Biobased products are composed entirely or partly of biological ingredients, which can include renewable plant, animal, marine, or forest materials. Some of the more common biological ingredients include soy, animal fat, animal hair, algae, wood, and plant nutrients. These products differ from the more traditional products, such as those based on petroleum.

There is much discussion about the environmental and health effects of biobased products versus their traditional counterparts. These products may reduce dependence on nonrenewable fossil fuels, increase opportunities for rural communities, reduce greenhouse gas emissions, increase environmental health by reducing toxicity, and offer alternative medicines.

SET Skills: Apply the scientific method in an experiment

Life Skills: Teamwork, cooperation, decision making, critical thinking, wise use of resources

Measuring Success: Completes experimental design process, interprets data, adjusts experiment accordingly, and makes a reasonable argument for or against the use of a biobased product



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ACTIVITY 3
INVESTIGATION: DO BIOBASED CLEANERS WORK AS WELL AS TRADITIONAL PRODUCTS?

Test It

In this investigation, you will use the **scientific method** to compare the effectiveness of biobased and traditional cleaning solutions.

1. Review the scientific method (see **www.sciencemadesimple.com/scientific_method.html**).
2. In groups of two or three, use one of the substances provided to soil each carpet square, tile, or other appropriate surface. Your choice of test product will help determine your test surface (e.g., if you are testing an alternative to a traditional glass cleaner, you would test on a mirror or window).
3. Collect and review material safety data sheets from the Internet for all products or their main ingredients from **www.msds.com**. (To learn how to read these sheets, see **www.youtube.com/watch?v=ZPoFtEBbjWI&feature=related**.)
4. Develop a step-by-step plan of action using the scientific method before executing your investigation. In your project notebook, record:
   - Purpose of the experiment: What will you test?
   - **Hypothesis**: What do you think will happen?
   - Materials: List all items you will use.
   - Treatments: Describe the various treatments. What is the **control**?
   - Methods/data collection: How will you conduct the experiment so that your results are easy to analyze? Create a table that will help you collect the needed data.
   - Analysis and reflection: What were the results? How do you account for the results? How do the results influence your recommendation about which product to use?

ACTIVITY 3
INVESTIGATION: DO BIOBASED CLEANERS WORK AS WELL AS TRADITIONAL PRODUCTS?

Summary: In this investigation, youth will use the **scientific method** to compare the effectiveness of biobased and traditional cleaning solutions.

Materials Needed

- Review of the scientific method (see **www.sciencemadesimple.com/scientific_method.html**)
- Safety gear, including goggles, aprons, and gloves
- Material safety data sheets downloaded from the Internet for all products or their main ingredients from **www.msds.com** (To learn how to read these sheets, see **www.youtube.com/watch?v=ZPoFtEBbjWI&feature=related**.)
- Carpet squares and/or tile squares or other appropriate surfaces (two for each group)
  Youth may wish to test some of the products featured in their posters from the previous activity. They should choose a surface to clean that is suitable for the product being tested (e.g., if they are testing an alternative to a traditional glass cleaner, they could clean a mirror).
- One or more kinds of "green" cleaner (see suggestions in the What Does It Mean to Be "Green"? activity of this chapter)
- One or more kinds of traditional cleaner
- Various substances to soil test surface (suggestions: red or purple juice, dirt, crayons, cooking oil, permanent marker, glue, crayons, skin lotion, stickers)
- Moist rags for scrubbing
- Computer(s) with Internet access for product research

Time Needed: approximately two hours

Preparation

Read the activity in the youth guide and gather the materials needed.

Facilitation Notes

Explain to the youth that they will test the effectiveness of at least one kind of green cleaning solution against a more traditional solution. Facilitate a discussion of the factors that influence people's decisions about which products to buy and use. Review the scientific method and help as needed in its application to the investigation. The **control** for the experiment should be applying the soiling substance to the test surface and wiping it with just a moist cloth. Note that some of the soiling substances will more effectively cling to some surfaces than others.

Science Background

Biobased products are composed entirely or partially from biological ingredients, including renewable plant and animal, marine, or forest materials. Many biobased products are created through the processing of soybeans, including ink toner, paint, cleaning products, carpet, and insulation.

It's not enough to be only biobased. After all, some poisons are biobased. However, biobased products do tend to be more recyclable, nontoxic, and energy efficient than synthetic products.

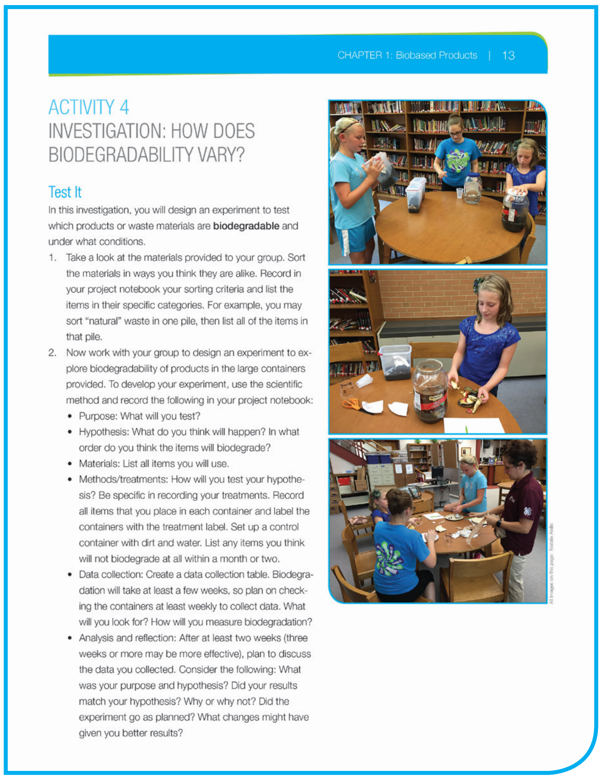
Many traditional or "non-biobased" products are based on oil or **petroleum**, which are not renewable resources and may raise concerns for human and environmental health. These products are not readily biodegradable or compostable.

It is also important to consider performance and price when comparing traditional products to biobased products.

SET Skills: Apply the scientific method in an experiment

Life Skills: Teamwork, cooperation, decision making, critical thinking

Measuring Success: Completes experimental design process, interprets data, adjusts experiment to improve success, and presents results



CHAPTER 1: Biobased Products | 13

ACTIVITY 4
INVESTIGATION: HOW DOES BIODEGRADABILITY VARY?

Test It

In this investigation, you will design an experiment to test which products or waste materials are **biodegradable** and under what conditions.

1. Take a look at the materials provided to your group. Sort the materials in ways you think they are alike. Record in your project notebook your sorting criteria and list the items in their specific categories. For example, you may sort "natural" waste in one pile, then list all of the items in that pile.
2. Now work with your group to design an experiment to explore biodegradability of products in the large containers provided. To develop your experiment, use the scientific method and record the following in your project notebook:
   - Purpose: What will you test?
   - Hypothesis: What do you think will happen? In what order do you think the items will biodegrade?
   - Materials: List all items you will use.
   - Methods/treatments: How will you test your hypothesis? Be specific in recording your treatments. Record all items that you place in each container and label the containers with the treatment label. Set up a control container with dirt and water. List any items you think will not biodegrade at all within a month or two.
   - Data collection: Create a data collection table. Biodegradation will take at least a few weeks, so plan on checking the containers at least weekly to collect data. What will you look for? How will you measure biodegradation?
   - Analysis and reflection: After at least two weeks (three weeks or more may be more effective), plan to discuss the data you collected. Consider the following: What was your purpose and hypothesis? Did your results match your hypothesis? Why or why not? Did the experiment go as planned? What changes might have given you better results?

ACTIVITY 4
INVESTIGATION: HOW DOES BIODEGRADABILITY VARY?

Summary: Youth will use the scientific method to explore differences in biodegradability of various materials.

Materials Needed

- Soil (one option is to test biodegradability in soil from a backyard versus in sterilized potting soil)
- Water
- Plant waste materials (fruit or vegetable scraps, peels, lawn trimmings, etc.)
- Waste materials containing **polylactic acid (PLA)** (most plastics with recycling code 7; sample brands include Earth's Natural Alternative, Eco-Products Green Stripe, Perfect Stix, Repurpose, Susty Party, Seventh Generation, Trellis Earth*)
- Waste materials containing PETE (nonbiodegradable, petroleum-based plastics with recycling number 1)
- Other waste materials (Styrofoam, paper, etc.; you might want to compare the biodegradability of traditional and biodegradable packing peanuts—brand names SendSupplies, StarchTech, Storo*)
- A number of large pickle jars (or other large jars, preferably with a sealing lid) and/or buckets (5 gallon or less) with covers (an aquarium could also be used, with wood or other material for a cover)
- Paper
- Pencils or pens
- Gloves for sorting
- Sticks or spoons for mixing

*All products were available from Amazon (**amazon.com**) as of January 2016.

Time Needed

- Set up and initial lesson: approximately one hour
- Overall project: at least two weeks (waiting for items to biodegrade, and short weekly checks to monitor biodegradation experiments)

Preparation

Read the activity in the youth guide and gather the materials needed.

Facilitation Notes

Explain to the youth that they will use the scientific method to explore the different rates at which various materials biodegrade under different conditions. Have them start by listing some items that are packaged in plastic. Discuss why plastic is often used for packaging. Discuss what happens to plastic packaging after it is used. Where does it go? If you don't know, conduct some Internet research and/or see Beyond the Basics suggestions 5 and 6 (in the youth guide) for ways to learn more and ideas on expanding the amount of plastic we recycle and reuse.

Next lead a discussion of factors important in breaking down materials. **Biodegradable** items are broken down by bacteria, which are found in dirt. The dirt used in this activity should be kept moist for faster biodegradation. Amounts of dirt and water can vary, but all jars should include both.

Youth should consider testing factors such as the types of waste materials in the jars, the amount of water and/or dirt and/or light and/or air the jars receive, the temperature at which they're kept, or the amount of handling (e.g., daily mixing or none).

Youth should measure the degree of biodegradation of the waste materials. Some methods of measurement might include estimated percent of original volume of material remaining, relative strength of odor as an indicator of decomposition, or any increase in the brittleness of plastic materials.

Science Background

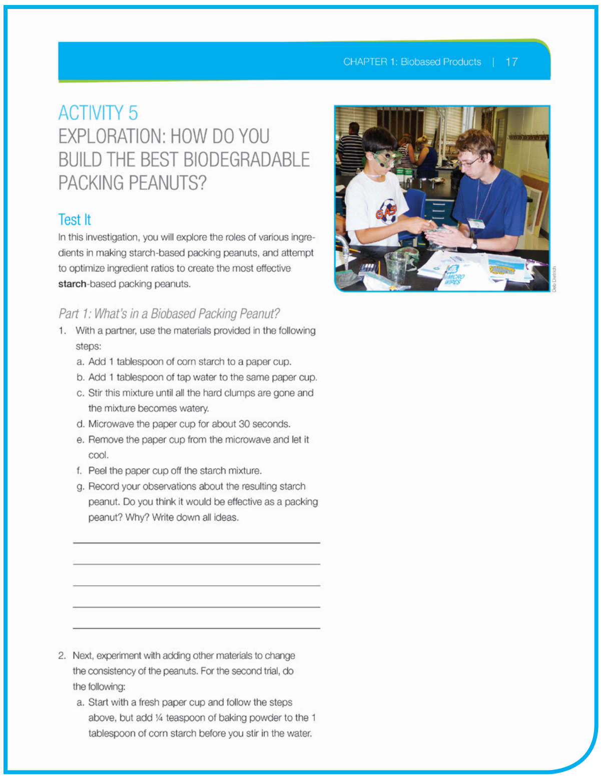
The term "biodegradable" is used widely when considering the environmental benefits of biobased products. If something is biodegradable, it will, over time, break down in the environment and leave harmless materials in its place. Biodegradable products are usually made from renewable resources.

Polylactic acid (PLA) is a biodegradable plastic made from corn starch or sugar cane. The mechanical properties of PLA are similar to those of polyethylene terephthalate (PETE), which is a petroleum-based plastic. The renewable inputs to PLA help offset some of the pollution caused by petroleum-based packaging. Biobased plastics like PLA are nontoxic and **compostable**, decomposing into carbon dioxide, water, and mineral-rich organic matter, which can provide valuable nutrients to the soil and plants.

SET Skills: Designing and carrying out an experiment

Life Skills: Teamwork, cooperation, decision making, critical thinking

Measuring Success: Completes experimental design process



CHAPTER 1: Biobased Products | 17

ACTIVITY 5
EXPLORATION: HOW DO YOU BUILD THE BEST BIODEGRADABLE PACKING PEANUTS?

Test It

In this investigation, you will explore the roles of various ingredients in making starch-based packing peanuts, and attempt to optimize ingredient ratios to create the most effective **starch**-based packing peanuts.

Part 1: What's in a Biobased Packing Peanut?

1. With a partner, use the materials provided in the following steps:
   a. Add 1 tablespoon of corn starch to a paper cup.
   b. Add 1 tablespoon of tap water to the same paper cup.
   c. Stir this mixture until all the hard clumps are gone and the mixture becomes watery.
   d. Microwave the paper cup for about 30 seconds.
   e. Remove the paper cup from the microwave and let it cool.
   f. Peel the paper cup off the starch mixture.
   g. Record your observations about the resulting starch peanut. Do you think it would be effective as a packing peanut? Why? Write down all ideas.

_____
_____
_____
_____
_____

2. Next, experiment with adding other materials to change the consistency of the peanuts. For the second trial, do the following:
   a. Start with a fresh paper cup and follow the steps above, but add ¼ teaspoon of baking powder to the 1 tablespoon of corn starch before you stir in the water.

Deb Dietrich

ACTIVITY 5
EXPLORATION: HOW DO YOU BUILD THE BEST BIODEGRADABLE PACKING PEANUTS?

Summary: Youth will explore the roles of various ingredients in making **starch**-based packing peanuts, and attempt to optimize ingredient ratios to create the most effective starch-based packing peanuts.

Materials Needed

- Corn starch
- Baking powder
- Glycerol
- Microwave oven (possibly more than one, depending on group size)
- Tap water
- 3-ounce paper cups
- Measuring spoons
- Polystyrene (traditional) packing peanuts (a few, for comparison)

Other Possible Materials

- Computer(s) with Internet access
- Oven mitts

Time Needed

- Part 1: What's in a Biobased Packing Peanut?, approximately 60 to 90 minutes
- Part 2: Design Your Own Experiment: To Build a Better Packing Peanut, approximately 60 to 90 minutes

Preparation

Read the activity in the youth guide and gather the materials needed.

Facilitation Notes

Introduce the science background below. Lead the group in a discussion of the benefits of starch-based versus traditional petroleum-based packing peanuts.

Because the power of microwave ovens varies, adjust the cook time as needed so the mixture solidifies but is not excessively hot.

For part 2, note that the amount of powder (corn starch + baking powder) in the cup should **NOT** exceed 1 tablespoon + ¼ teaspoon. If the youth would like to change the ratio and add more baking powder, they should reduce the amount of corn starch for that trial. The amount of liquid (glycerol + water) should **NOT** exceed 3 teaspoons. If the youth would like to change the ratio and add more glycerol, they should reduce the amount of water for that trial.

Science Background

Traditional packing peanuts are made from polystyrene, which is industrially produced using petroleum, a fossil fuel. Fossil fuels are made over millions of years below ground from the ancient remains of animals, plants, and other organisms. This means we categorize fossil fuels as nonrenewable resources.

About 45 million pounds of traditional packing peanuts are created yearly, and most of them are disposed of in landfills. Some of these peanuts have been found buried in soil for more than 32 years with no sign of biodegradation, so we know they accumulate in landfills.

An alternative to polystyrene peanuts is starch-based peanuts. These peanuts contain glucose, which is a natural polymer found in plants such as corn and potatoes. Plant crops are renewable resources and can easily be replenished. Starch-based packing peanuts are also biodegradable, compostable, and easily dissolve in water. These packing peanuts are much better for the environment than polystyrene peanuts.

CHAPTER 2: BIOENERGY

ACTIVITY 1
EXPLORATION: BIOENERGY SELF-ASSESSMENT

SET Skills: Identifying knowledge

Life Skills: Record keeping, acknowledging personal growth

Measuring Success: Completes the bioenergy self-assessment; understands some key terms

Summary: This activity will help youth assess what they know about bioenergy. Their responses will help you tailor the activities and lingo to their level.

Materials Needed

- Pens/pencils
- Easel (optional; one for entire group)
- Marker(s) (optional)
- Chalkboard or whiteboard (optional; one for entire group)
- Computer with Internet access

Time Needed: approximately 30 minutes

Preparation

Read the activity in the youth guide and gather the materials needed.

If you need to brush up on bioenergy basics, you could start with these two short videos, which are also to be viewed at the end of the youth exploration:

Energy 101: Biofuels (from the U.S. Office of Energy Efficiency and Renewable Energy)
energy.gov/eere/videos/energy-101-biofuels

Energy 101: Feedstocks for Biofuels and More (from the U.S. Office of Energy Efficiency and Renewable Energy)
energy.gov/eere/videos/energy-101-feedstocks-biofuels-and-more

Facilitation Notes

After the youth complete the bioenergy self-assessment, facilitate a group discussion of the Think It Through questions. One way to do this is to use a large flipchart on an easel and have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CHAPTER 2: BIOENERGY

ACTIVITY 1
EXPLORATION: BIOENERGY
SELF-ASSESSMENT

Explore It: What Do You Know about Bioenergy?
In the checklists below, check off the items that you know something about. This activity will help you measure the skills, knowledge, and experience that you have right now in the area of **bioenergy**. There are no right or wrong answers. In your project notebook, jot down a sentence or two summarizing your knowledge about each item you check.

Types of bioenergy feedstock:
__ Algae
__ Biogas
__ Canola
__ Corn
__ Flax
__ Manure
__ Miscanthus
__ Sawdust
__ Soybeans
__ Straw
__ Sugarbeets
__ Sugarcane
__ Sunflower
__ Switchgrass
__ Trees
__ Used cooking oil
__ Willow
__ Wood chips
__ Wood pellets
__ Other: ____________________

Steve Williams
Doug Schaufler
Greg Roth

youth write down all their ideas for each question. Encourage them to think of local examples whenever possible to help them see how bioenergy fits into their lives.

You can now tailor the rest of the activities to match the group's general level of knowledge about and interest in bioenergy.

Science Background

We're hearing more about bioenergy lately. Bioenergy is renewable energy produced from living or recently living things.

The northeastern United States includes some of the country's largest metropolitan regions, but much of the land area from New England to the Ohio River consists of rural communities with an agricultural base. The region contains more than three million acres of idle or low-cost agricultural land and disturbed mine land. These lands could grow perennial energy crops, such as willow, and warm-season grasses, such as switchgrass, to create a sustainable bioenergy future for the region. (Perennial crops regrow yearly once they are established.) Planting these lands for bioenergy crop production would help lessen U.S. dependence on foreign and nonrenewable fuels, thereby increasing our national security. Many bioenergy crops are hardy and will grow in marginal locations with little care—land that is not suitable for traditional farm crops and activities.

ACTIVITY 2

INVESTIGATION: PLANTING BIOENERGY SEEDS

Summary: In this investigation, youth will use the scientific method to test how various factors affect seed germination and growth of some common bioenergy crops.

SET Skills: Apply the scientific method in an experiment

Life Skills: Planning and following through, planting and caring for seeds and plants, teamwork, cooperation, decision making, critical thinking

Measuring Success: Plants bioenergy crop seeds and completes self-designed experiment

Materials Needed

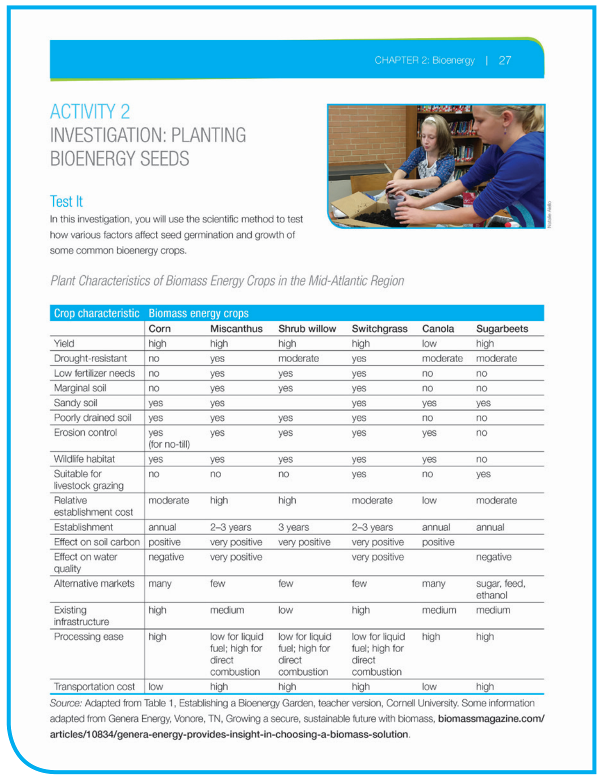
- Two or three kinds of seeds for bioenergy crops*
- Seeding containers
- Soil
- Water
- Pens/pencils
- Labels
- Plastic bags (optional; to fit over seeding containers)
- Coated wire (optional; cut to fit over seeding containers)
- Grow lights (optional)
- Chemical fertilizer (optional)
- Manure (optional)

*Available from Ernst Conservation Seeds (**www.ernstseed.com**) and other suppliers. Penn State's leaders of the NEWBio grant can supply limited quantities of biomass crop seed for this activity. Contact Dan Ciolkosz (**dec109@pu.edu** or 814-863-3484) a few weeks before you need the seed. If you can't obtain bioenergy crop seeds, an alternative is to use two kinds of grass seed, one that tolerates shade and one that prefers full sun.

Time Needed: approximately one hour for planting and setup, and additional time in following weeks to record growth and analyze results

Preparation

Read the activity in the youth guide and gather the materials needed.



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ACTIVITY 2

INVESTIGATION: PLANTING BIOENERGY SEEDS

Natalie Aiello

Test It

In this investigation, you will use the scientific method to test how various factors affect seed germination and growth of some common bioenergy crops.

Plant Characteristics of Biomass Energy Crops in the Mid-Atlantic Region

Crop characteristic	Biomass energy crops					
	Corn	Miscanthus	Shrub willow	Switchgrass	Canola	Sugarbeets
Yield	high	high	high	high	low	high
Drought-resistant	no	yes	moderate	yes	moderate	moderate
Low fertilizer needs	no	yes	yes	yes	no	no
Marginal soil	no	yes	yes	yes	no	no
Sandy soil	yes	yes		yes	yes	yes
Poorly drained soil	yes	yes	yes	yes	no	no
Erosion control	yes (for no-till)	yes	yes	yes	yes	no
Wildlife habitat	yes	yes	yes	yes	yes	no
Suitable for livestock grazing	no	no	no	yes	no	yes
Relative establishment cost	moderate	high	high	moderate	low	moderate
Establishment	annual	2–3 years	3 years	2–3 years	annual	annual
Effect on soil carbon	positive	very positive	very positive	very positive	positive	
Effect on water quality	negative	very positive		very positive		negative
Alternative markets	many	few	few	few	many	sugar, feed, ethanol
Existing infrastructure	high	medium	low	high	medium	medium
Processing ease	high	low for liquid fuel; high for direct combustion	low for liquid fuel; high for direct combustion	low for liquid fuel; high for direct combustion	high	high
Transportation cost	low	high	high	high	low	high

Source: Adapted from Table 1, Establishing a Bioenergy Garden, teacher version, Cornell University. Some information adapted from Genera Energy, Vonore, TN, Growing a secure, sustainable future with biomass, **biomassmagazine.com/articles/10834/genera-energy-provides-insight-in-choosing-a-biomass-solution**.

Facilitation Notes

If you plan to rely on sunlight as the source of light, it's best to do this activity in the spring or summer. At other times of year, seeds could be placed under a grow light.

Begin by reviewing what plants need to live (sunlight, oxygen, water, a medium in which to grow). Help the youth brainstorm various experiments they could do with the bioenergy seeds. Once they run out of ideas, you could hint at some of the ideas below and see where the discussion leads. The kinds of experiments possible vary greatly with access to seeds; time, space, and resources available; and the plans for the plants once they have grown to about 5 inches high.

Ideas for experiments:

- Investigate the effects of different frequency of watering or fertilizing
- Investigate the effects of different kinds of fertilizer (chemical versus biological or different kinds of manure)
- Start seeds in soils from various sources (e.g., potting soil, play sand, roadside soil) to compare growth
- Germinate in sunlight versus artificial grow light

Some groups may be able to set up small long-term test plots of a few kinds of biomass energy crops. Compare growth of a monoculture plot of one kind of plant versus a mixed culture plot containing various kinds of biomass energy plants. What might be some advantages and disadvantages of each planting plan?

Note: Some bioenergy crops can be invasive, so you may not want to plant them in your backyard once they're bigger. If you do, you may have to mow them frequently to keep them from spreading.

Science Background

(*Adapted from Minnesota 4-H Nutrition Program's Gardening Module: Germination Lesson)*

New plants germinate, or sprout from seeds, if they are given oxygen, water, warmth, and energy (often sunlight). **Germination** occurs when the seed takes in water through the seed coat, which enlarges and breaks, and first a root and then a shoot appears. The seed coat helps protect the plant embryo from drought and rough conditions.

Germination requires the right set of circumstances. A seed that is planted too deeply will use up the limited amount of energy within the seed before the shoot reaches above the ground. A seed planted in conditions that are too dry won't germinate because the seed coat won't be broken. A seed planted where it is too wet will not have enough oxygen and may rot before germinating.

Processing bioenergy crops into energy sources could reduce our need for foreign fossil fuels and increase national security. Plants used for bioenergy tend to be hardy, requiring little care, and will grow almost anywhere—for example, switchgrass will even grow on disturbed mine lands. Switchgrass tolerates poorly drained soils, flooding, and high water tables, and doesn't require as much fertilizer as traditional crops.

ACTIVITY 3
EXPLORATION: HOW DO GRASS PELLETS COMPARE TO WOOD PELLETS?

Summary: Youth will test the properties of pellets made of wood, switchgrass, and miscanthus or other bioenergy crops.

SET Skills: Measuring; drawing conclusions

Life Skills: Teamwork, cooperation, decision making, critical thinking

Measuring Success: Understands the different properties of wood and bioenergy grass pellets, and some of the issues hampering widespread use of bioenergy grass pellets

Materials Needed

- Computer with Internet access to watch selected videos
- A few cups each of wood pellets and pelletized grasses* (about ¼ cup per team of two to three youth)
- Two or three small sealing plastic containers per group
- Timer or stopwatch
- Two ¼-cup measures
- Hammers

*Does someone you know have a wood pellet stove? If so, ask if you could have 2 or 3 cups of pellets. You could also check with a pellet retailer to see if they'd give you a torn bag. Another possible source is Ernst Conservation Seeds (**www.ernstseed.com** or 800-873-3321). Penn State's leaders of the NEWBio grant can supply limited quantities of bioenergy crops pellets for this activity. Contact Dan Ciolkosz (**dec109@psu.edu** or 814-863-3484) a few weeks before you need the pellets. If you can't get bioenergy crop pellets, you could use two types of wood pellets, preferably one softwood (pine) and one hardwood (oak, etc.), or rabbit food pellets.

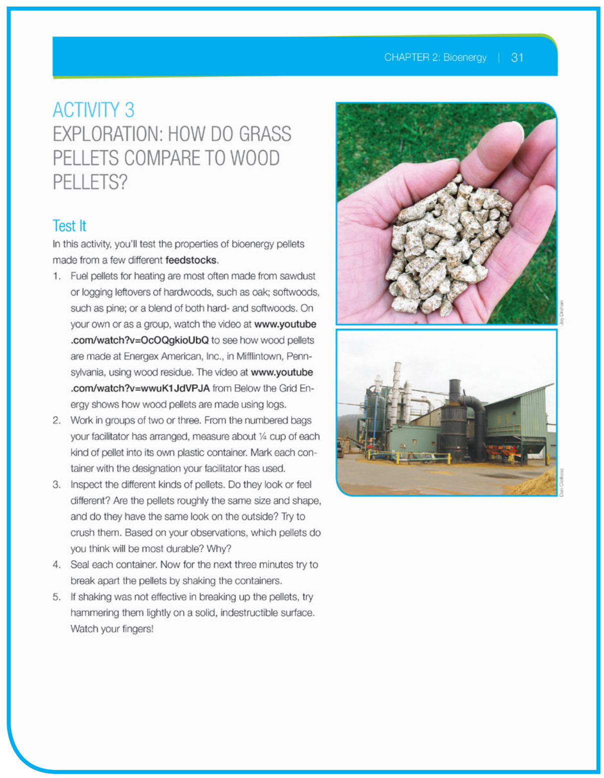
Time Needed: approximately one hour

Preparation

Read the activity in the youth guide and gather the materials needed. Place each kind of pellet in a plain bag marked only with a number. Note to yourself which kind matches which number. Share this information only after all tests are completed.

Facilitation Notes

Begin with a discussion of the youths' experience with energy pellets. Some people heat their homes with them. Others even use them for their absorption abilities, such as in cat litter.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ACTIVITY 3
EXPLORATION: HOW DO GRASS PELLETS COMPARE TO WOOD PELLETS?

Test It

In this activity, you'll test the properties of bioenergy pellets made from a few different **feedstocks**.

1. Fuel pellets for heating are most often made from sawdust or logging leftovers of hardwoods, such as oak; softwoods, such as pine; or a blend of both hard- and softwoods. On your own or as a group, watch the video at **www.youtube.com/watch?v=OcOQgkioUbQ** to see how wood pellets are made at Energex American, Inc., in Mifflintown, Pennsylvania, using wood residue. The video at **www.youtube.com/watch?v=wwuK1JdVPJA** from Below the Grid Energy shows how wood pellets are made using logs.
2. Work in groups of two or three. From the numbered bags your facilitator has arranged, measure about ¼ cup of each kind of pellet into its own plastic container. Mark each container with the designation your facilitator has used.
3. Inspect the different kinds of pellets. Do they look or feel different? Are the pellets roughly the same size and shape, and do they have the same look on the outside? Try to crush them. Based on your observations, which pellets do you think will be most durable? Why?
4. Seal each container. Now for the next three minutes try to break apart the pellets by shaking the containers.
5. If shaking was not effective in breaking up the pellets, try hammering them lightly on a solid, indestructible surface. Watch your fingers!

After completing the durability test, use the background information below to lead the youth in a discussion of the challenges facing the adoption of bioenergy grass pellets. You could begin with a discussion of factors that make a product successful.

Science Background

Many homeowners prefer pellet stoves or boilers over traditional wood-fired equipment because of their relative ease of use. As a result, the demand for fuel pellets has grown quickly since about 2005.

Fuel pellets for heating are most often made from sawdust or logging leftovers of hardwoods, such as oak; softwoods, such as pine; or a blend of both hard- and softwoods.

Show the group the video at **www.youtube.com/watch?v=OcOQgkioUbQ** to show them how wood pellets are made at Energex American, Inc., in Mifflintown, Pennsylvania, using wood residue. The video at **www.youtube.com/watch?v=wwuK1JdVPJA** from Below the Grid Energy shows how wood pellets are made using logs. You could instead ask them to watch the videos on their own before your meeting.

Wood is not the only suitable **feedstock** for manufacturing pellet fuel. (A feedstock is a material used to make energy.) Bioenergy crops, such as switchgrass or miscanthus, can also be pelletized and burned for fuel. Pellets are made by chopping the fuel into very fine pieces, then forming them into small, very dense pellets using high heat and pressure. This process of densification simulates in a few hours what takes place underground over millions of years when plant material dies and is buried underneath tons of soil and rock, eventually forming oil.

As of April 2016, only a few manufacturers throughout the country were selling bioenergy pellets made of materials other than wood. The process of manufacturing them economically and at large scale is still being refined. For bioenergy grass pellets to be a real alternative to wood pellets, there must be a steady, reliable supply, which depends on an established base of growers, efficient harvesting equipment, and a reliable, cost-effective process for producing durable pellets. Pellets must be able to stand up to transportation, rough handling, and long-term storage without breaking apart. Pellets that crumble before they're burned contribute to clogged equipment, poor combustion efficiency, and dust hazards. Bioenergy crop pellets are softer and less durable than wood pellets, so they make more ash. Most wood pellet stoves cannot burn bioenergy crop pellets without some modification because of the increased ash production.

Go to **www.papellets.com/faq** for a glossary and frequently asked questions about pellets.

ACTIVITY 4
EXPLORATION: HOW ARE FEEDSTOCKS CONVERTED TO BIOFUELS?

Summary: Youth will follow a common feedstock through its production pathway to understand the processes that occur and determine some of the issues that may arise in its processing to a usable biofuel.

SET Skills: Research, identifying conversion pathways to biofuels, recognizing interconnecting pathways and the flexibility of biological feedstocks

Life Skills: Teamwork, cooperation, decision making, critical thinking, wise use of resources

Measuring Success: Completes a "road map" showing knowledge of one specific feedstock to fuel cycle; explains process to group

Materials Needed

- Glossary (at back of this guide)
- Pencils, markers, crayons, or other writing utensils
- Copy of the "Race to the Pump" game board from Cornell University (go to **nesungrant.cornell.edu/institute-of-excellence/education** and scroll down)
- Access to Internet for researching specific pathways and processes
- Large poster boards

Time Needed: 1 to 1.5 hours

Preparation

Read the activity in the youth guide and gather the materials needed.

Facilitation Notes

See the list of resources at the back of this book for places to find information about conversion pathways. Begin the activity by sharing the science background below.

Science Background

Various biological feedstocks can be used to produce bioenergy. Some of the most common biological feedstocks include wood and wood residues, animal manure, grasses, oil seed crops, waste oils, and algae. These can be converted into a variety of different biofuels, including ethanol, biodiesel, methane, and biohydrogen. Each feedstock has a different conversion pathway as it becomes an economically usable fuel.

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ACTIVITY 4
EXPLORATION: HOW ARE FEEDSTOCKS CONVERTED TO BIOFUELS?

Explore It

You will follow a common bioenergy feedstock through its production pathway to understand the processes that occur and determine some of the issues that may arise in its processing to a usable biofuel.

1. Download a copy of the "Race to the Pump" game board from Cornell University for reference from **nesungrant.cornell.edu/institute-of-excellence/education** (scroll down). Now choose a conversion pathway to explore.
   - Farm waste (manure) → **Fuel cell technology**
   - Farm waste (manure) → Natural gas (CNG)–ready engine
   - Trees and mill waste → **Flex-fuel engine** (regular car engine)
   - Perennial grasses → Flex-fuel engine (regular car engine)
   - **Oil seed crops** → Diesel engine
   - Waste oil → Diesel engine
   - Algae → Diesel engine
2. With a partner, begin to research and lay out a typical conversion pathway. Use the Internet and the glossary at the back of this book as needed.
3. Create a general outline or road map of your **conversion process**. Once this is created, transfer it to a larger piece of poster board.

Deb Dietrich

Greg Roth

The conversion pathway is the process of taking a feedstock from its original form and converting it to a usable biofuel. These pathways include processes such as collection or harvest, extraction of important components, purification, manipulation of molecular makeup, separation and removal of components, and transportation and delivery of the final product to potential markets and users. The overall goal is to create a biofuel that is energy efficient, economically viable, environmentally sustainable, and grown and processed in the United States.

ACTIVITY 5
EXPLORATION: DEBATE—BIOENERGY IN A SMALL TOWN

Summary: Youth will research and debate whether a cellulosic ethanol company using switchgrass as a feedstock should be allowed to open in town.

SET Skills: Research, communication, problem solving

Life Skills: Teamwork, cooperation, decision making, critical thinking, wise use of resources, nurturing relationships, sharing, empathy, concern for others, conflict resolution, communication

Measuring Success: Takes steps to become an informed citizen, develops points based on accurate facts, and effectively argues a point

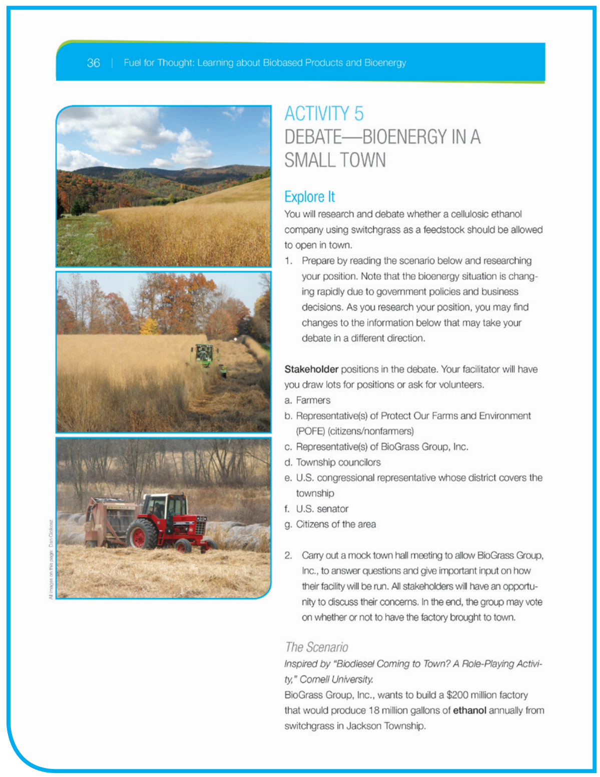
Materials Needed
- Computers with Internet access
- Pens/pencils
- Paper
- Speaker's podium (optional)

Time Needed
- Pre-activity work: Students research their specific stakeholder positions (1 hour)
- Discussion activity: 1 to 1.5 hours

Preparation
Read the activity in the youth guide and gather the materials needed. Write each stakeholder position on a paper and fold it for use in drawing lots to assign the positions. You could instead let youth volunteer for positions.

Note that the bioenergy situation is changing rapidly due to government policies and business decisions. As the youth research their positions, they may find changes to the information below that may take the debate in a different direction. If you have time, you may wish to do some preliminary research before facilitating this activity to see what's new. If you find that cellulosic ethanol is not being used or developed further, instead of this debate, you could have youth investigate why that happened.

Facilitation Notes
More than one person can represent farmers; the citizens' group Protect Our Farms and Environment (POFE); BioGrass Group, Inc.; the township councilors; and citizens. During the debate, make sure stakeholders stick to fact-based arguments. Jump in if they stray into personal attacks or opinions.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ACTIVITY 5
DEBATE—BIOENERGY IN A SMALL TOWN

Explore It
You will research and debate whether a cellulosic ethanol company using switchgrass as a feedstock should be allowed to open in town.
1. Prepare by reading the scenario below and researching your position. Note that the bioenergy situation is changing rapidly due to government policies and business decisions. As you research your position, you may find changes to the information below that may take your debate in a different direction.

Stakeholder positions in the debate. Your facilitator will have you draw lots for positions or ask for volunteers.
a. Farmers
b. Representative(s) of Protect Our Farms and Environment (POFE) (citizens/nonfarmers)
c. Representative(s) of BioGrass Group, Inc.
d. Township councilors
e. U.S. congressional representative whose district covers the township
f. U.S. senator
g. Citizens of the area

2. Carry out a mock town hall meeting to allow BioGrass Group, Inc., to answer questions and give important input on how their facility will be run. All stakeholders will have an opportunity to discuss their concerns. In the end, the group may vote on whether or not to have the factory brought to town.

The Scenario
Inspired by "Biodiesel Coming to Town? A Role-Playing Activity," Cornell University.
BioGrass Group, Inc., wants to build a $200 million factory that would produce 18 million gallons of **ethanol** annually from switchgrass in Jackson Township.

Science Background

Many issues need to be considered when a new factory is constructed in an area. These focus mainly on economic, social, environmental, and health implications of the business. It is important for state and local governments and citizens to consider implications from a variety of different perspectives before agreeing to the introduction of a new factory. Stakeholders need to have data that support their statements and ideas. They must be able to offer solutions to concerns and educate the public on specific changes that might occur with introduction of the new factory.

The information below, which also appears in the youth guide, will help brief you on where the cellulosic ethanol industry is now in the United States.

Cellulosic Ethanol—Challenges, Opportunities, Benefits

State of the Industry

The Project Liberty plant, one of the nation's first commercial-scale cellulosic ethanol plants, opened in Emmetsburg, Iowa, in September 2014. The plant converts baled corn stover—the cobs, leaves, husks, and stalks left behind in the field after the crop is harvested—into the same high-octane fuel as ethanol made from corn. The collaborating companies began pilot-scale production of cellulosic ethanol in 2008.

Informative videos about cellulosic ethanol and the Project Liberty factory can be found at **poetdsm.com/liberty**. The site **poetdsm.com/biomass** targets farmers who may want to sell their corn residue to the Project Liberty factory, but it is broadly informative about the challenges and potential benefits of the operation.

The video at **www.desmoinesregister.com/story/money/agriculture/2014/02/22/costs-and-benefits-of-producing-cellulosic-ethanol/5748599** features a spokesman for the Project Liberty plant.

A commercial-scale cellulosic ethanol plant using corn harvest waste (**stover**) was opened in 2014:

- Quad County Corn Processors cellulosic ethanol plant opens in Galva, Iowa: **www.desmoinesregister.com/story/money/agriculture/green-fields/2014/09/09/second-ethanol-plant-adds-next-generation-technology/15332293**

Another corn stover cellulosic ethanol plant became operational in October 2015:

- DuPont in Nevada, Iowa: **www.dupont.com/products-and-services/industrial-biotechnology/advanced-biofuels/cellulosic-ethanol/nevada-iowa-cellulosic-ethanol-plant.html**

Also see the DuPont Industrial Biosciences *Biofuels Digest 5-Minute Guide* at **www.biofuelsdigest.com/bdigest/2015/04/19/dupont-industrial-biosciences-biofuels-digests-2015-5-minute-guide**.

Benefits of Cellulosic Ethanol

Moving toward increased use of cellulosic ethanol will help increase national security and decrease the severity of global climate change. Cellulosic ethanol is expected to contribute only about 10 percent of the **greenhouse gases** that gasoline does. The shift to alternative feedstocks—bioenergy crops such as switchgrass, miscanthus, and biomass sorghum that are not also used as food—helps to negate the food versus fuel debate that applies to corn ethanol. These crops tend to grow well even on poor sites with very little input of fertilizer or water. Cellulosic ethanol processes convert waste plant material into fuel while using less fertilizer and water than for corn ethanol. Plants worldwide make an estimated 100 billion tons of cellulose each year, so learning to efficiently produce a clean-burning fuel from this material is clearly an energy economy game-changer.

Challenges

The industry still faces some major hurdles. Cellulosic ethanol, especially using alternative feedstocks such as switchgrass and biomass sorghum, still relies heavily on governmental subsidies and grants. It is more complicated and currently more expensive to make than corn ethanol, which is more expensive to make than traditional gasoline. The industry also needs to build its distribution and sales network, something that “Big Oil” (the large multinational oil companies such as Exxon Mobile) is certainly not going to help with.

But the greatest hurdle to the industry may be policy uncertainty. In 2007 the Energy Independence and Security Act passed Congress. The Renewable Fuel Standard within this legislation required the United States to replace 36 billion gallons of its fuel per year with renewable fuels by 2022. In November 2015, the U.S. Environmental Protection Agency finalized the Renewable Fuel Standard for 2016. It requires that in 2016 more than 18 billion gallons of biofuels are blended into the fuel supply. This is about 4 billion gallons less than the levels Congress proposed in 2007, but slightly more than EPA’s initial proposal in May 2015. The alternative fuels industry emphasizes that renewable and alternative fuels are essential in helping us (1) meet emissions reductions to head off climate change and (2) reduce dependence on foreign oil.

The alternative fuels industry is understandably unsettled. They cannot continue to attract investors and build capacity to produce alternative fuels without clear and consistent regulations.

If the auto industry produced more flexible-fuel vehicles, which can run on up to 85 percent ethanol, that would drastically increase the demand for ethanol. But the oil industry is unlikely to endorse this change. It would require significant changes in infrastructure to transport fuel to fueling stations and store it there, as well as significant changes in vehicles.

The cellulosic ethanol industry needs to educate farmers about the pros and cons of growing bioenergy crops and overcome their resistance to changing crop residue management practices. With corn stover, for instance, farmers have traditionally plowed the residue into the soil or let it lay in the field to decompose as a fertilizer and guard against soil erosion. If it is harvested for bioenergy, 20 to 25 percent of corn stover is removed. For farmers the benefits of selling corn stover for bioenergy feedstock include increased income; reduced soil tilling, which reduces erosion; and better management of crop residue, which has been steadily increasing as farmers plant more intensively.

Essentially No Commercial Production Yet of Cellulosic Ethanol Using Alternative Bioenergy Crops

The market for cellulosic ethanol from alternative crops such as switchgrass and miscanthus has even farther to go toward success than the corn stover cellulosic ethanol market. There is essentially no commercial production yet of liquid fuel using the alternative crops in the United States.

Some critics worry about the amount of land that would be required to fulfill the nation’s potential appetite for cellulosic ethanol. An engineer at the National Renewable Energy Lab in Golden, Colorado, estimated that about 18 million acres of switchgrass would be needed to reach the original goal of the

2007 Energy Independence and Security Act. This is an area a little larger than West Virginia. But, as mentioned above, focusing on alternative bioenergy crops that grow well even on poor sites may help dismiss this concern.

The alternative crops cellulosic ethanol industry needs to perfect equipment to ensure that soil compaction from biomass harvesting does not harm future crop production. The industry must streamline and increase the efficiency of collecting and transporting feedstock materials to the plant for conversion.

Ultimately, the alternative crops market that survives may be for biobased chemicals other than fuel. A number of companies are now concentrating on these chemicals because they may bring higher prices than fuel.

Sources:

"Advanced Biofuels Industry Leaders: Obama Baits and Switches on Clean Energy," *Biofuels Digest*, September 19, 2015, **www.biofuelsdigest.com/bdigest/2015/09/19/advanced-biofuels-industry-leaders-obama-baits-and-switches-on-clean-energy**.

Alexander, P. "As EPA Hands Down New Rules on Renewable Fuel Standard, Critics Say 'Blend Wall' a Fiction Created by Big Oil," *Huffington Post*, June 29, 2015, **www.huffingtonpost.com/paul-alexander/as-epa-hands-down-new-rul_b_7685190.html**.

Nasr, Susan L. "How Cellulosic Ethanol Works," HowStuffWorks.com, June 3, 2009, **science.howstuffworks.com/environmental/green-tech/energy-production/cellulosic-ethanol.htm**.

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U.S. EPA Renewable Fuel Standard Program, **www2.epa.gov/renewable-fuel-standard-program**.

Wilson, D. (manager, POET Biorefining), "EPA Puts Oil Industry's Agenda Ahead of American Farmers," Letter to editor of *Emmetsburg Reporter/Democrat*, 2015, **www.emmetsburgnews.com/page/content.detail/id/524761/EPA-Puts-Oil-Industry-s-Agenda-Ahead-of-American-Farmers.html**.

CHAPTER 3: CAREERS IN THE FIELD

ACTIVITY 1
EXPLORATION: WHAT HAPPENS ONSITE?

Summary: Youth will research local facilities that process or manufacture with biobased products or bioenergy, visit one such site, and summarize what they learn.

SET Skills: Investigating the bioenergy and biobased products industries in your area

Life Skills: Social skills, self-motivation, decision making, listening, note-taking

Measuring Success: Researches bioenergy/biobased products facilities in local area, formulates questions for field trip, completes field trip, and joins in group discussion of field trip

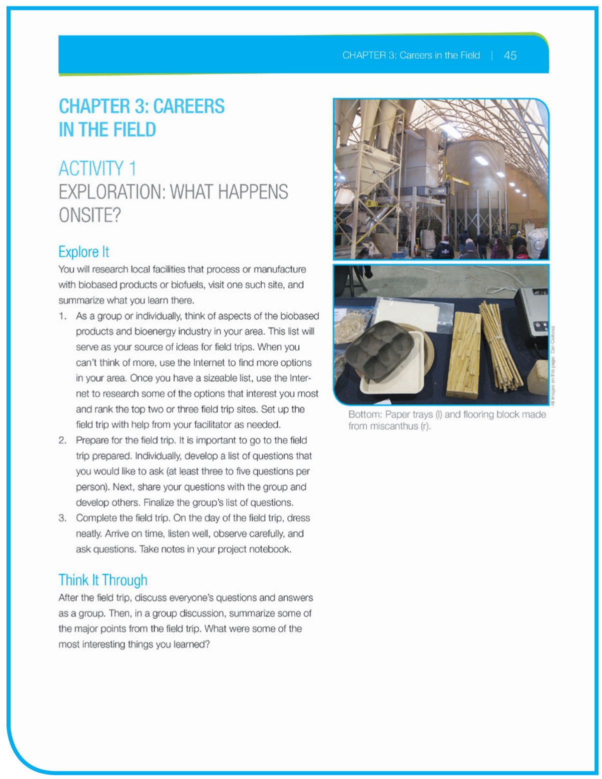
Materials Needed

- Paper
- Pen/pencil
- Computer(s) with Internet access to research possible field trip sites
- Easel (optional)
- Marker(s) (optional)
- Chalkboard or white board (optional)

Time Needed

This is a multiday activity.

- Part 1: Brainstorm bioenergy and biobased products facilities in your area, use the Internet to research options, and organize the trip—approximately 90 minutes (may occur over more than one session)
- Part 2: Prepare for the field trip by writing research questions—30 to 45 minutes (note that youth might also complete the next activity, What Careers Are Available in the Field?, during the field trip)
- Part 3: Complete the field trip—30 to 60 minutes (not including travel time)
- Part 4: Think It Through—wrap up by discussing answers to the questions with the group—approximately 30 minutes (depending on group size)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CHAPTER 3: CAREERS IN THE FIELD

ACTIVITY 1
EXPLORATION: WHAT HAPPENS ONSITE?

Explore It

You will research local facilities that process or manufacture with biobased products or biofuels, visit one such site, and summarize what you learn there.

1. As a group or individually, think of aspects of the biobased products and bioenergy industry in your area. This list will serve as your source of ideas for field trips. When you can't think of more, use the Internet to find more options in your area. Once you have a sizeable list, use the Internet to research some of the options that interest you most and rank the top two or three field trip sites. Set up the field trip with help from your facilitator as needed.
2. Prepare for the field trip. It is important to go to the field trip prepared. Individually, develop a list of questions that you would like to ask (at least three to five questions per person). Next, share your questions with the group and develop others. Finalize the group's list of questions.
3. Complete the field trip. On the day of the field trip, dress neatly. Arrive on time, listen well, observe carefully, and ask questions. Take notes in your project notebook.

Think It Through

After the field trip, discuss everyone's questions and answers as a group. Then, in a group discussion, summarize some of the major points from the field trip. What were some of the most interesting things you learned?

All images on this page: Dan Ciolkosz

Bottom: Paper trays (l) and flooring block made from miscanthus (r).

Preparation

Read the activity in the youth guide and gather the materials needed. It would be helpful to conduct some preliminary Internet research about potential field trip sites in your area.

Facilitation Notes

Part 1: Brainstorm

Youth will brainstorm locations of the bioenergy or biobased products industries in your area. The preference is to have them visit a bioenergy facility, if possible. Have someone act as a scribe (preferably on a poster-sized piece of paper on an easel or a chalkboard or white board) as they come up with ideas. They might name specific businesses or farms or more general categories of the industry, such as equipment manufacturers. Another option would be for each youth to come up with his or her own list first, then share and expand with the group. If they get stuck, prompt them to go further with the list below of some resources in Pennsylvania. This list can supplement the group's ideas for field trips and/or informational career interviews (the next activity, What Careers Are Available in the Field?).

The list below is not exhaustive, and facilities will change over time. The bioenergy and biobased products industries have a more rapid turnover than most industries. New technologies are constantly being tested. Some don't achieve economic feasibility and disappear. Others are more successful, and the companies may be acquired by larger companies. Make sure the youth understand this.

Do a web search for "biofuels," "bioenergy," and/or "biobased products" along with your county and/or region and state name to find options in your area. If you live near the border with another state, don't forget to check that state, too.

There is a recent push to develop alternative markets for biomass crops as feedstocks for packaging, building materials, mulch, bedding, sorbents, and substrate material. Pursuing information about these markets may provide other avenues for field trips.

Some Producers, Growers, Businesses, and Users of Bioenergy and Biobased Products in Pennsylvania and Surrounding States

Look for facilities like the ones listed below in your area.

Biodiesel distributors: **bit.ly/1PpSY1U**

Biodiesel producers:

- Hero Bx, Erie, Erie County, PA, **www.herobx.com** (biofuels production company)
- Solazyme, Hanover, York County, PA, **solazyme.com** (renewable oil production company and a leader in algal biotechnology)

Biodiesel users:

- Public transportation authorities that use biofuel vehicles

Buildings with biomass heating systems (schools and other public buildings can sometimes receive grants to convert to bioenergy):

- Elk Regional Health Center, St. Marys, Elk County, PA, **www.pafuelsforschools.psu.edu/case_studies/elk.asp**
- Hughesville High School, Hughesville, Lycoming County, PA, **bit.ly/1uFWKcj** (biomass boiler and hybrid willow growing and harvesting)
- Penns Valley School District, Spring Mills, Centre County, PA, **www.youtube.com/watch?v=eQe3zLBohUI**
- Sullivan County School District, Laporte, PA, **biomassmagazine.com/articles/5575/sullivan-county-school-district-to-get-biomass-system**

Equipment makers (pellet boilers, driers, and pelletizers for biomass):

- Abbott Furnace, St. Marys, Elk County, PA, **www.abbottfurnace.com**
- Advanced Recycling Equipment, LLC, St. Marys, Elk County, PA, **www.advancedrecyclingequip.com**
- AFS Energy System, Lemoyne, PA, **www.afsenergy.com** (makes and sells renewable energy biomass systems)
- Harman Stoves, Halifax, Dauphin County, PA, **www.harmanstoves.com** (residential biomass stove manufacturing facility)

Ethanol plants:

- Helios Scientific, LLC, Curwensville, Clearfield County, PA, **gust.com/companies/helios_scientific_llc** (demonstration cellulosic ethanol production plant)
- Pennsylvania Grain Processing, LLC, Clearfield, PA, **www.pagrain.com/en/home**

Makers of biobased products:

- Manufacturers of goat's milk soap (check your local farmers markets)
- Manufacturers of honey-based soaps and beauty products (check your local farmers markets)
- Renmatix, King of Prussia, Montgomery County, PA, **renmatix.com**

Other manufacturers and products:

- Any farmer
- Beekeepers
- Farmers markets
- Firewood suppliers
- Grocery stores
- Hybrid car manufacturers
- Paper mills
- Seed and feed stores

Pellet plants (**biomassmagazine.com/plants/listplants/pellet/US**):

- Energex American, Inc., Mifflintown, Juniata County, PA, **www.energex.com**
- Alexander Energy, Inc., Kane, McKean County, PA
- Allegheny Pellet Corporation, Youngsville, Warren County, PA, **agmap.psu.edu/Businesses/index.cfm?fid=1819**
- Appalachian Wood Pellets, Kingwood, WV, **www.appalachianwoodpellets.com**
- Barefoot Pellet Company, Troy, Bradford County, PA, **www.barefootpellet.com**
- Greene Team Pellet Fuel Company, Garards Fort, Greene County, PA, **www.greeneteampellets.com**
- PA Pellets, Ulysses, Potter County, PA, **www.papellets.com**
- Pellheat, Inc., Glen Hope, Clearfield County, PA
- Penn Wood Products, Inc., East Berlin, Adams County, PA, **www.pennwoodproducts.com**
- Tri State Biofuels, Lemont Furnace, Fayette County, PA, **www.tristatebio.com**
- Wood Pellets C&C Smith Lumber, Summerhill, Cambria County, PA

Pellet retailers:

- Stores that sell woodstoves, including the large chain home improvement stores

Private growers of miscanthus, shrub willow, or switchgrass:

- Aloterra Energy, Conneaut, Ashtabula County, OH, **www.aloterrallc.com** (harvesting and bailing mature miscanthus)
- Celtic Energy Farm, Cape Vincent, Jefferson County, NY, **celticenergyfarm.com/index.html** (growing and harvesting shrub willow)
- Double A Willow, Fredonia, Chautauqua County, NY, **www.doubleawillow.com** (growers and distributors of shrub willow)
- Ernst Conservation Seeds, Meadville, PA, **www.ernstseed.com** (biomass seed supplier and pellet manufacturer)
- Mobinol Fuel Co., Collegeville, with McDonnell Farm, East Greenville, Montgomery County, PA, **bit.ly/1l21aW3** (partially on-farm switchgrass bioenergy processing)
- Wood Crest Switchgrass Farm (Will Brandeu, grower), Wapwallopen, Luzerne County, PA, **www.youtube.com/watch?v=m9Ny05AXeDs**

University and government research labs:

- Penn State Biomass Energy Center, list of experts, University Park, PA, **bioenergy.psu.edu/people/default.asp**
- Penn State Energy Crop Demonstration Site, State College, PA, **extension.psu.edu/natural-resources/energy/field-crops/resources/bioenergy-crops-demonstration-site**
- U.S. Department of Agriculture, Washington, DC, **www.usda.gov**
- U.S. Department of Energy, Washington, DC, **www.energy.gov**

National Manufacturers of "Cleantech" Products, Fuels, and Feedstocks (not based in Pennsylvania)

- Bio-Amber (MN), **www.bio-amber.com**
- Edeniq (CA, NE), **www.edeniq.com**
- Enerkem (Montreal, Canada), **www.enerkem.com**
- Genomatica (CA), **www.genomatica.com**
- Joule Unlimited, Inc. (NM), **www.jouleunlimited.com**
- LanzaTech (GA), **www.lanzatech.com**
- Marrone Bio Innovations (CA), **www.marronebioinnovations.com**
- NexSteppe (CA), **www.nexsteppe.com**
- Renmatix (PA, GA, IA), **renmatix.com**
- ZeaChem, Inc. (CA, OR), **www.zeachem.com**

Once the youth have settled on one or two places to contact, depending on their ages and the circumstances, you or one of the youth can make the contact. Be sure to discuss with the site contact the characteristics of the group and what you're hoping to accomplish with the visit.

If the youth can't possibly visit a site in person, have them watch the video at **www.youtube.com/watch?v=vHFW1516IsU** from Hero Bx, a bioenergy company in Erie, and read about some kids' field trips to alternative and conventional energy sites at Energy Kids, from the U.S. Energy Information Administration, at **www.eia.gov/kids/energy.cfm?page=field_trips**.

Part 2: Prepare

Ask each youth to think of at least three questions they would like answered about the facility they will visit. When they get stuck, you could encourage them to go deeper with prompts from the list below. Appropriate questions will vary depending on the type of facility visited.

- How did this facility come to be?
- Who started it?
- When did the facility open?
- What did it cost to build or open or start?
- What are operating hours?
- How many people work there?
- What are the raw materials?
- Where do the raw materials come from?
- What factors influence decisions about where to buy raw materials?
- How do the raw materials get to the facility?
- What is the finished product(s)?
- Where are the products sold or used?
- How are the products transported to market or to buyers?
- If local raw materials aren't used or if products aren't sold locally, why not?

- How does this facility affect the environment?
- What ties does the facility have with the surrounding community?
- What is the long-term outlook for the facility? For the company? For the industry?
- Where would the facility's leaders like it to be in 10 years? Ideally, what would be different?
- What has been the most difficult thing about building or operating this business or facility?

Part 4: Think It Through

After the field trip and away from the facility, facilitate a group discussion to summarize what was learned. Youth could discuss the history of the facility, its pros and cons, and its likely future. Ask if they think they would like to work there. Why or why not?

Science Background

What are some local bioenergy or biobased products facilities and what do they do and make?

In this activity, youth will identify places in the local area involved in the bioenergy or biobased products industries. Seeing an actual operation in person will help youth understand the resources, challenges, and opportunities available in these industries.

ACTIVITY 2
EXPLORATION: WHAT CAREERS ARE AVAILABLE IN THE FIELD?

Summary: Youth will conduct an informational interview with someone in a bioenergy/biobased products industries job. Youth will prepare questions, take notes, and present their findings to the group.

SET Skills: Career development

Life Skills: Social skills, self-motivation, decision making, planning, public speaking

Measuring Success: Completes a career exploration interview in bioenergy or biobased products and reports to the group

Materials Needed

- Computer(s) with Internet access to research possible interview sites and careers
- Participant's project notebook
- Pens/pencils
- Chalkboard or whiteboard (optional)
- Easel (optional)
- Marker(s) (optional)
- Tape recorder (optional)

Time Needed

This is a multiday activity.

- Part 1: Brainstorm about whom to interview to explore a bioenergy or biobased products industries career—approximately 30 minutes
- Part 2: Prepare for the interview—approximately 20 minutes
- Part 3: Conduct the interview—approximately 30 minutes (not including travel time, if applicable)
- Part 4: Present findings to the group—varies with group size, approximately five minutes each

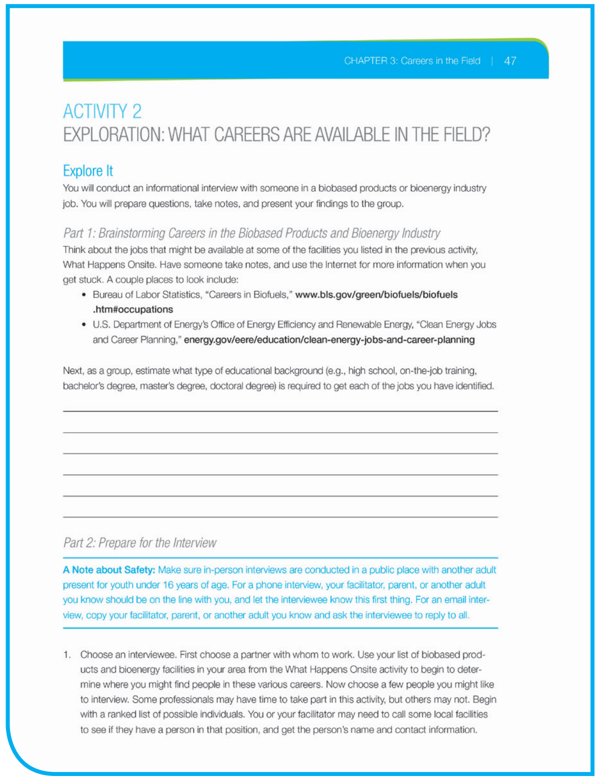
Preparation

Read the activity in the youth guide and gather the materials needed.

Facilitation Notes

Part 1: Brainstorm

Alone, in pairs, or as a group, have youth identify people they'd like to interview either by name or job title. See the list of potential places to find an interviewee in the previous activity (What Happens Onsite?). Have youth share their ideas using the easel or board. If they need help, give them hints from the job list below. Can you think of any others?



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ACTIVITY 2
EXPLORATION: WHAT CAREERS ARE AVAILABLE IN THE FIELD?

Explore It

You will conduct an informational interview with someone in a biobased products or bioenergy industry job. You will prepare questions, take notes, and present your findings to the group.

Part 1: Brainstorming Careers in the Biobased Products and Bioenergy Industry

Think about the jobs that might be available at some of the facilities you listed in the previous activity, What Happens Onsite. Have someone take notes, and use the Internet for more information when you get stuck. A couple places to look include:

- Bureau of Labor Statistics, "Careers in Biofuels," **www.bls.gov/green/biofuels/biofuels.htm#occupations**
- U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy, "Clean Energy Jobs and Career Planning," **energy.gov/eere/education/clean-energy-jobs-and-career-planning**

Next, as a group, estimate what type of educational background (e.g., high school, on-the-job training, bachelor's degree, master's degree, doctoral degree) is required to get each of the jobs you have identified.

Part 2: Prepare for the Interview

A Note about Safety: Make sure in-person interviews are conducted in a public place with another adult present for youth under 16 years of age. For a phone interview, your facilitator, parent, or another adult you know should be on the line with you, and let the interviewee know this first thing. For an email interview, copy your facilitator, parent, or another adult you know and ask the interviewee to reply to all.

1. Choose an interviewee. First choose a partner with whom to work. Use your list of biobased products and bioenergy facilities in your area from the What Happens Onsite activity to begin to determine where you might find people in these various careers. Now choose a few people you might like to interview. Some professionals may have time to take part in this activity, but others may not. Begin with a ranked list of possible individuals. You or your facilitator may need to call some local facilities to see if they have a person in that position, and get the person's name and contact information.

When they have a thorough list, ask the youth what level of education might be required for each job (i.e., high school, on-the-job training, four-year college degree, master's degree, Ph.D. degree). Youth should conduct interviews in pairs.

Part 2: Prepare for the Interview

You can help as needed to set up interviews in person or by phone. You or the youth may need to call some local facilities to see if they have a person in that position and get the person's name and contact information. If you plan in advance, the interview could also be done at the same time as the field trip in the What Happens Onsite? activity.

A Note about Safety

Make sure in-person interviews are conducted in a public place with another adult present for youth under 16. For a phone interview, you, a parent, or another adult known to the youth should be on the line with the youth, and let the interviewee know this first thing. For an email interview, the youth should copy you, a parent, or another adult known to the youth and ask the interviewee to reply to all.

If youth get stuck in developing questions, encourage them to go deeper with ideas from the list below. Appropriate questions will vary depending on the type of facility visited and the career chosen. Youth should first develop their own list of questions, then share them among the group and revise their list as desired.

- Please describe your job.
- What educational background is required to land a job like this?
- What are the responsibilities of this job?
- What activities occur in a typical day here?
- What tasks need to be accomplished daily, monthly, seasonally, and yearly?
- Please describe your work history or interests that led you to this job.
- Are there hazards to working here? If so, please describe them and what is done to avoid them.
- What are some of the best and worst things about working here?
- What might be the next steps in career advancement from a job like this?
- Where do you see yourself job-wise in 10 years?
- What steps are you taking to get there?
- What other kinds of jobs are available here and what educational background do they require?
- What are the typical salary and benefits? (This may be a sensitive question. It's probably best to ask in a general way [e.g., "What do engineers at this plant or in this company typically earn?"] at the end of an interview in which the questioner and interviewee have built a good rapport.)

Remind the youth to dress neatly if the interview is in person. Discuss the importance of arriving on time, listening well, and taking notes. Remind them that that they need to ask permission before recording the interview, if they wish to do so. They should take notes during the interview, and summarize the notes as soon as possible after the interview.

Parts 3 and 4: Complete the Interview and Present Findings to the Group

Begin the session by having each youth write a list of five factors they feel are important in a career. For example, they may consider wages, work shift, activity (e.g., desk work versus fieldwork), educational requirements, ease of finding a job, location, prestige, or other factors. Have them rank the factors in order of importance to them. Next have them consider how the bioenergy/biobased products industries job they interviewed about may fulfill these factors. Lead a group discussion of the youths' thoughts and priorities.

Then, have each pair of youth present a short summary of their interview to the group. After all presentations are finished, facilitate a group discussion summarizing any trends seen among the jobs.

Science Background

The bioenergy and biobased products industries employ workers in various jobs. These industries are growing rapidly, and many occupations within them are still developing. The jobs require various educational backgrounds. The technical skills and specialization required bring different salaries.

Job Title	Description	Education Required	Typical Yearly Salary*
Scientist	Conducts research on making fuels more energy- and cost-efficient, and develops new types of biofuels and biofuels processing equipment	Team leader: M.S. or Ph.D. Lab technician: Two to four years of college	$63,000
Engineer	Conducts research on making fuels more energy- and cost-efficient, and develops new types of biofuels and biofuels processing equipment	Entry level: four-year degree Manager: professional engineer license	$85,000
Construction worker/laborer	Builds processing factories and updates heating equipment	On-the-job training	$30,000
Agricultural worker/farmer	Grows and harvests plants that become bioenergy feedstocks and go into biobased products	Work experience and on-the-job training	Worker: $20,000 Farmer/manager: $50,000
Industrial production manager	Oversees laborers and equipment	Four-year degree and supervisory experience	$100,000
Chemical equipment operator	Operates specialized factory equipment	High school or four-year degree and on-the-job training	$49,000
Wholesale and manufacturing sales representative	Sells products	Four-year degree	$83,000

*Data from the U.S. Bureau of Labor Statistics, *Careers in Biofuels* (2011), **www.bls.gov/green/biofuels/biofuels.htm#occupations**.

GLOSSARY

See **www.eia.gov/kids/energy.cfm?page=kids_glossary** (Energy Kids, U.S. Energy Information Administration) for more information.

Agriculture: The growth of crops and/or animals for food, fiber, and/or energy.

Algae: Can be used as an alternative feedstock in making biodiesel.

Alternative energy: An energy source that is an alternative to using fossil fuels. Generally indicates energy sources that are nontraditional and have lower environmental impact than fossil fuels.

Biobased product: A product other than food containing a substantial amount of biological or agricultural material.

Biodegradable: Capable of being broken down over time in the environment by microorganisms into harmless materials.

Biodiesel: Fuel made from plant oils that can be used in diesel engines. Biodiesel fuels are typically made from renewable organic raw materials such as soybean or rapeseed oils, animal fats, waste vegetable oils, or microalgae oils.

Bioenergy: Renewable energy produced from living or recently living things.

Biogas: A combination of methane and carbon dioxide produced during anaerobic breakdown of biodegradable materials. Can be burned for fuel.

Biomass: Renewable organic matter. Can include biological material derived from living or recently living organisms, such as forest and mill wood residue and other wood waste, agricultural crops and waste, fast-growing trees, industrial and municipal waste, and alcohol fuels.

Cellulose: A type of sugar found in plant cells that is tightly interwoven with lignin. After removal of lignin, cellulose can be processed into a biofuel.

Compostable: Capable of being broken down over time by microorganisms in the environment into mineral-rich organic matter.

Control: The part of a scientific experiment to which the treatment is not applied. Having a control allows the experimenter to ensure that the results stem directly from the treatment rather than from some other variable not tested.

Conversion process: The biochemical or thermochemical steps in transforming a crop into a liquid or gaseous biofuel.

Densification: Using high heat and pressure to make pellets from wood or other bioenergy crops.

Enzyme: A class of protein produced by living cells that helps natural processes, such as digestion, to occur.

Ethanol: An alcohol-based fuel produced from bioenergy crops such as corn, sugar cane, or grasses.

Feedstock: Material that is burned as a fuel to produce energy or used as the basis for another product.

Flex-fuel engine: Can operate on gasoline or a mixture of gasoline and up to 85 percent ethanol.

Fuel cell technology: Conversion of a fuel's chemical energy into electricity through a chemical reaction.

Germination: The process by which sprouts emerge from a seed.

Glycerol/glycerin: A sugary, thick, clear, fatty liquid often used in soaps and pharmaceutical products.

Green chemistry: The manufacture of chemicals using 12 principles designed to reduce harm to human or environmental health.

Greenhouse gas: A gas that traps heat in the Earth's atmosphere. The major greenhouse gases include carbon dioxide, methane, nitrous oxide, and fluorinated gases.

Hypothesis: An educated guess about the results of an experiment.

Infrastructure: Buildings, roads, and equipment on which society depends for daily life.

Invasive: A plant that spreads naturally beyond the area where it is planted.

Lignin: A compound that gives plants the ability to stand upright and to withstand weather, insects, and diseases. Lignin is an obstacle to the production of biofuels because it is tightly interwoven with cellulose, which is processed into biofuel.

Material safety data sheet (MSDS): A document containing information about the safe use of a chemical, including information about safe handling, storage, and disposal; reactivity; toxicity; health effects; etc.

Monoculture: The mass planting of a single crop. Can be profitable for farmers because it allows for high yields and cost-effective management. May be risky to farmers because of the possibility that unfavorable weather conditions or disease could wipe out much of the crop.

Oil seed crops: Alternative crops and cover crops such as canola, rapeseed, and camelina grown for conversion into cooking oil and biodiesel.

Perennial: Plant that regrows yearly once it is established. Some species, such as switchgrass, can be burned as a sustainable source of bioenergy.

Petroleum: A kind of oil formed below the ground over millions of years. This fossil fuel is the source of gasoline and other products.

Polylactic acid (PLA): A biodegradable plastic made from corn starch or sugar cane. Use of PLA in packaging is increasing.

Polymer: A chemical composed of large molecules containing many groups of smaller molecules.

Polystyrene: A stiff, lightweight plastic often used for food packaging, to retain heat, or to prevent breakage.

Renewable: Capable of being replaced.

Renewable energy: Energy generated from natural resources, such as sunlight, wind, tides, and geothermal heat, that are naturally replenished. This energy cannot be exhausted.

Scientific method: The process used by scientists to answer questions. Includes formulating a question, conducting background research, devising a hypothesis, conducting a controlled experiment, analyzing results, and summarizing conclusions.

Stakeholder: A person, government, or other party with an interest, or stake, in a decision.

Starch: A substance found in many plants, including wheat, rice, and potatoes.

Sustainable: Capable of being maintained or continued long term.

NATIONAL 4-H CURRICULUM FACILITATOR TIPS

Adapted from the National 4-H Council

Think Safety

Promote an inclusive environment where youth feel safe to have voice and openly share ideas. Remember to also account for physical safety issues, including electrical needs, fire exits, and flow of traffic in and out of the room as related to the work spaces.

Be Prepared

Read through each section of the facilitator guide and the youth guide. Remember that strong, upfront planning of the series of activities will allow you to make connections and see continuity that can be shared with the youth.

Provide Consistent Expectations of Behavior

Provide opportunities for choice and include the strengths of all youth to enrich their experiences. Model clear communication strategies by talking directly to youth, maintaining eye contact, and practicing active listening skills. Provide options for different learning preferences and intelligence types.

Engage Youth

Note when youth are interested—take advantage of their curiosity and catch those "teachable moments." Invite them to be actively engaged through your contagious enthusiasm and sense of humor. Give youth opportunities to ask probing questions and share ideas with one another.

Embed Essential Elements

In 4-H, the critical components of a successful learning experience are a sense of belonging, independence, mastery, and generosity. It is your role as a facilitator to provide guidance and support. Give youth opportunities to become leaders, practice citizenship, and develop a sense of independence and belonging, and time to master the content.

Balance Discussion with Hands-on Activities

Limit the amount of discussion. Interactive mini-lessons, approximately five to ten minutes long, are sufficient to provide core "chunks" of information. 4-H is about learning through doing. Alternate instruction with active hands-on learning. Ask yourself: What is absolutely essential to teach for youth to understand the concepts? What can they discover on their own?

According to youth:
"Least fun was the talking times when we weren't doing anything. We were just sitting in the classroom."
"I like that we get to learn something different. . . . Coming here we can feel good about what we do."

Encourage Career Exploration

Make the connections to careers in the fields of science, engineering, and technology. Make connections with experts in the field and invite them to share their passion for their profession. Use them as a resource for information and current trends and issues.

Focus on Relevance

Encourage youth to demonstrate application to the real world. Model this by using relevant examples that apply to their daily lives.

Go Further

Encourage youth to explore beyond the activity and take learning into their own hands. Notice when they become emerging experts and give them leadership opportunities.

RESOURCES

Some of the following sites contain information, games, and activities geared especially for youth.

Biomass Energy

4-H National Youth Science Day (2009), Biofuel Blast, **4-h.org/parents/national-youth-science-day/biofuel-blast/**

Cornell University College of Agriculture and Life Sciences, "GrassBioenergy.org," **forages.org/index.php/grass-biofuels**

Genera Energy, Vonore, TN, "Genera Energy Provides Insight in Choosing a Biomass Solution," **biomassmagazine.com/articles/10834/genera-energy-provides-insight-in-choosing-a-biomass-solution**

Greenlearning Canada, **Greenlearning.ca** and **RE-Energy.ca**

Ohio State University Extension 4-H Cloverbuds, "Bioenergy Sources, Bioenergy Conversion, Bioproducts," **www.ohio4h.org/volunteers/cloverbud-leaders/curriculum** (scroll down)

PA Biomass Energy Association, **www.pabiomass.org**

Penn State Extension, "Field Crops for Energy," **extension.psu.edu/natural-resources/energy/field-crops**

R.E.A.P.-Canada (Resource Efficient Agricultural Production), **www.reap-canada.com**

University of Idaho Biodiesel Education Program, **www.BiodieselEducation.org**

U.S. Department of Agriculture, "The Bioeconomy Tool Shed," **www.usda.gov/energy/maps/html/energytool.htm**

U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy, "Biofuel Conversion Basics," **energy.gov/eere/energybasics/articles/biofuel-conversion-basics**

U.S. Energy Information Administration Energy Kids, "Renewable Biomass," **www.eia.gov/kids/energy.cfm?page=biomass_home-basics**

Cellulosic Ethanol

Nasr, Susan L., "How Cellulosic Ethanol Works," HowStuffWorks.com, June 3, 2009, **science.howstuffworks.com/environmental/green-tech/energy-production/cellulosic-ethanol.htm**

Ethanol Production

Ethanol Producer Magazine, "U.S. Ethanol Plants," **www.ethanolproducer.com/plants/listplants/US/Existing/Sugar-Starch**

Renewable Fuels Association, "Ethanol Biorefinery Locations," **www.ethanolrfa.org/resources/biorefinery-locations**

Magazines

Biofuels Digest, **www.biofuelsdigest.com**

Biomass Magazine, **biomassmagazine.com**

Ethanol Producer Magazine, **www.ethanolproducer.com**

Renewable Energy

U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy Education Homepage, **www1.eere.energy.gov/education/lessonplans/default.aspx**

4-H PLEDGE

I Pledge my Head
to clear thinking,
my Heart to greater loyalty,
my Hands to larger service,
and my Health to better living,
for my club, my community, my country, and my world.

extension.psu.edu

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