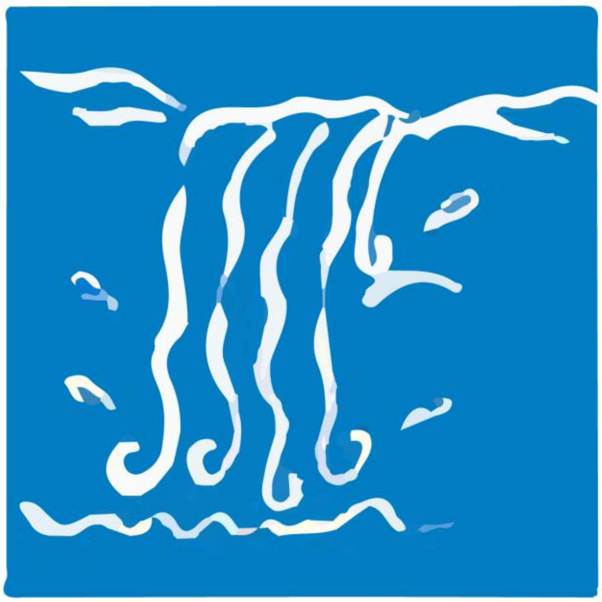
Renewable Energy and Biodiesel



Curriculum for
8-12 Years

Instructor's Manual

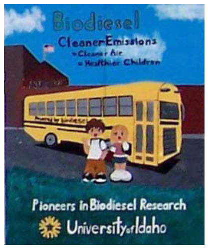
Created by the University of Idaho's
National Biodiesel Education Program

University of Idaho

Biodiesel Education Program
Department of Biological Engineering

National Biodiesel Education Program
Sponsored by USDA

College of Engineering



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Introduction to Instructor's Manual

This curriculum for 4-H is divided into seven lessons.

Each lesson is designed to take about 1.5 to 2 hours.

Each lesson builds on the previous lesson, so it would be best to do them in order if possible.

Biodiesel Basics

Youth will be guided to learn about energy and biodiesel through these lessons. As the facilitator, you should be somewhat familiar with biodiesel so you can answer questions. Below is some basic information about biodiesel. More information can be found in the Biodiesel section of eXtension's Farm Energy web site: http://www.extension.org/pages/Farm_Energy_Biodiesel_Table_of_Contents

What is biodiesel?

Biodiesel is a diesel fuel substitute that can be made from a variety of oils, fats, and greases. Biodiesel is not the same as straight vegetable oil or animal fat. A normal diesel engine will eventually be damaged through the use of straight vegetable oil or straight animal fat fuel. Vegetable oils or animal fats must be converted into biodiesel by reacting the oil or fat with an alcohol and a catalyst.

Biodiesel is also not the same as ethanol. Ethanol is an alcohol made from fermented sugar and is best used in engines that run on gasoline. Biodiesel, on the other hand, is made to be used in engines that normally use diesel fuel.

What is biodiesel made from?

Biodiesel can be made from any vegetable oil or animal fat. In the United States, common biodiesel feedstocks include soybean oil, rapeseed/canola oil, used (waste) vegetable oils, and tallow (animal fat). Warm climate tree oils such as palm oil and jatropha are used as biodiesel feedstocks in some parts of the world.

Biodiesel is produced and used in the United States

Biodiesel is an accepted fuel and fuel additive in the United States and around the world. Hundreds of governments, national parks, school districts and utility companies in the United States use biodiesel blends to run their fleets.

In 2011, 1 billion gallons of biodiesel were made in the United States.

Right now, there is not enough land to grow enough oilseeds to make biodiesel to replace all the fossil diesel fuel we use in the United States. The supplies of waste grease and animal fat are limited. Currently, biodiesel can replace just a small portion of fossil diesel. However, scientists are researching new methods to produce biodiesel feedstocks, such as algae, that are not dependent on land.

Biodiesel blends

Biodiesel can be blended with petroleum diesel in any percentage — from B1, which is 1 percent biodiesel mixed with 99 percent petro-diesel, to pure biodiesel, known as B100.

Facilitating the Journaling Activities

The point of the journaling activities is to help students learn, understand, and reflect on the material in the lesson. The point is not to write "correctly" according to English language conventions. Therefore, instructors are reminded not to criticize the grammar or spelling of youth. Criticizing their grammar or spelling at this stage will tend to shut down their communication and creativity.

Youth are sometimes reluctant to engage in journaling. They may complain that they "don't know what to write" or that they are "bad at writing." Here are some tips to help the journaling portion of the lesson proceed smoothly:

- Provide lots of scratch paper so youth can write or draw freely, without feeling like they have to "get it right" the first time.
- Youth should work independently on this activity. Each person should have the opportunity to do their own reflection.
- If some participants say they can't think of what to write or draw, try this:
    - Offer to time them for one minute. During that minute, ask them to make a list of any and all ideas (related to the topic) they can think of.
    - The only rule is that they must keep their pen or pencil moving during the entire minute. They must start when the timer starts, and not stop writing until the time is up. If you see them stop during the minute, quietly encourage them to keep writing.
    - Tell them that the **number of items on their list** is more important than what they write. The reason for this is that the more items they list, the more likely it is that they will come up with something they like.
    - At the end of one minute, ask them: how many items did you write down? (Any number of items is fine, but sometimes youth enjoy the feeling of accomplishment from stating the number.)
    - Praise them for the number of items (whatever it is).

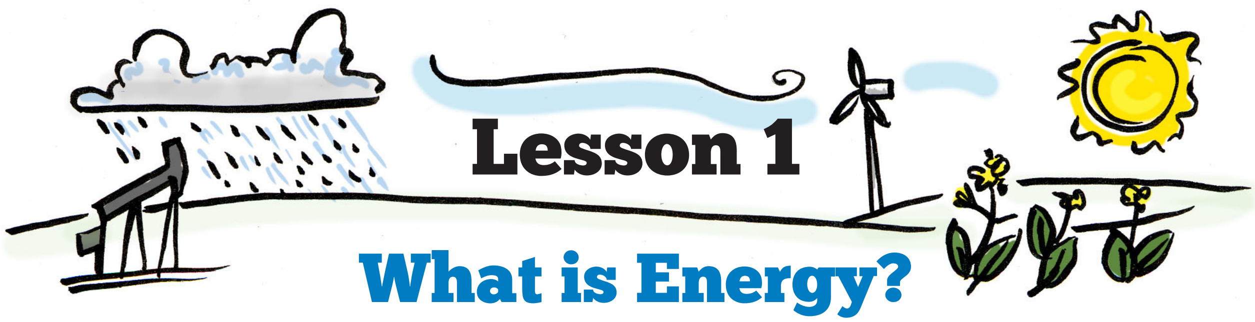
- Then ask them to look over the list, pick one, and write or draw.

- It may take some youth more than one “timed” session for them to get into this technique. If youth write the same word over and over, or if they write irrelevant things, encourage them to try again.

Should journal papers be kept?

Leaders may wonder whether to encourage youth to keep their journal papers in a single folder or binder, and bring them to meetings so new pages can be added. Some youth may be organized enough to do this, and may enjoy doing this. Leaders can facilitate this by providing binders or folders. For example, pressboard binders with fasteners are available at office supply stores. These allow students to add more pages to their journal. Once added, the pages are held securely by the fastener.

Other youth may not care to save their work after they’re finished with it. Learning can happen even if youth choose not to keep their writing or drawing. The important thing is that youth are encouraged to write or draw some kind of reflection.



Lesson 1

What is Energy?

SET Abilities: collaborate, observe, collect data, evaluate, summarize, question

Life Skills: critical thinking, contributions to group effort, communication

Success Indicator: ability to provide a working definition of energy, along with sources of energy in the scientific sense

Materials needed

- White board, chalk board, or large pieces of paper taped to the wall
- Markers or chalk
- A building to tour
- Energy Matching Game pieces should be photocopied in advance of the meeting
- Scissors
- Scratch paper (three-hole notebook paper if possible) for journaling
- Pens, pencils, colored pencils, markers, crayons
- Pressboard binders or folders for saving journal entries (optional)

Overview

"Energy" is a difficult concept to define because it is used in so many ways.

In terms of science and engineering, **a dictionary definition of energy is: something that causes a physical change in something else.** For example, energy causes something else to move, heat up, grow, or emit light.

NOTE: The physical change caused by an energy source does not need to be beneficial or helpful. For example, rocks falling during an avalanche are a form of energy. However, the change they cause may be destructive. Wind is a form of energy that can be beneficial (when turning a windmill) or destructive (when causing a tree to fall over).

Another common definition is: energy is the ability to do work. (One problem with this definition is that if you get a bunch of scientists in the room together, they could spend all day arguing over the definition of "work"!) However, since this is a common definition, you could introduce it. "Work" is another way of saying "physical change."

Theoretically, any physical object has the potential to be a source of energy, because it can be burned, fall on something else, or be eaten by something else, to cause a physical change.

(Recall Einstein's famous theorem, $E=mc^2$. The "E" is energy, the "m" is mass, and the "c" is the speed of light. So anything with mass can theoretically be converted to energy. You may not want to bring up this theorem with your youth, but you can be aware of it yourself!)

If any physical thing can theoretically be a source of energy, what then is not a source of energy in the scientific sense? Things that are not physical, such as ideas, imagination, music, and stories, are not sources of energy in the scientific sense.

In practical terms, many things that have mass have no useful energy. For example, it would be difficult to extract useful energy from the following physical objects: burned ash; still water at the lowest level of earth; and reacted nuclear waste.

Facilitating the Energy Source List

Keep a list of all sources of energy that youth come up with during and after the tour—even if you think they are wrong.

Sources of energy that youth may list or find around a house or building include:

1. natural gas: gas stove
2. electricity: outlets
3. steam: whistling tea-kettle; radiators
4. wax: candles
5. gasoline: car engine
6. diesel fuel: truck engine
7. wood: fireplace
8. paper: fireplace
9. batteries
10. energy from food: vegetable garden and fruit trees
11. animals: pulling things, transportation
12. humans: biking, cleaning, gardening, etc.
13. sunlight: can be transformed into food energy, wood energy, solar heating, photovoltaic electricity
14. wind to power windmills
15. water to power watermills or dams
16. a rock dropped from a high place can be used to crush or break something (like breaking the shell of a nut)

After youth have come up with their own definitions and compare their definitions, read them the scientific definition above. Allow them to discuss and compare their definitions with the scientific definition.

Facilitating the Energy Matching Game

Provide help in photocopying and cutting out the game pieces.

Make sure the game pieces are laid out in two different sections (energy sources, and work done).

Make sure youth understand how the game is to be played. Lead them in reading the instructions out loud at least once.

NOTE: You might want to remind youth that there are many possible matches in this game. This is why discussion is important. The goal of this game is to encourage discussion about energy sources and the work that energy does.

Allow participants to play the game, conduct the discussions, and make the matches, without any input on your part (although if they are unfamiliar with a source of energy, you may want to give them a short explanation).

If necessary, remind them that the game is cooperative, and that the matches belong to the whole group, rather than to any individual player. Remind them, if necessary, to allow everyone to participate in the discussion.

After they've make all their matches, help them check their matches against the list of possible correct matches (see below).

Facilitating the Journaling Activity

See the Introduction for tips on facilitating the journaling activity.

The Science Behind the Activities

This activity allows participants to see that scientific definitions might differ from common definitions.

Participants will also see that it is sometimes not easy to define a concept that is common and seems self-evident.

Youth will understand that energy sources can be used for a wide variety of work, and that one energy source can be converted into another energy source.

This activity provides a broad base of understanding for subsequent activities.

Energy Matching Game Possible Correct Answers

Animal power — carry equipment and supplies on a hiking trip; cause a tree to fall over; damage buildings; pull a carriage or cart; pull a plow

Battery — cause a bicycle to go; power a computer; power a flashlight; power a remote-control car; power lights

Biodiesel — fuel a motorboat; fuel a tractor; fuel a truck; heat a building

Coal — cook food; transform into electricity; heat water

Diesel fuel — fuel a motorboat; fuel a tractor; fuel a truck

Electricity — cause a bicycle to go; cook food; cool a building; dry clothes; heat a building; heat water; power a computer; power a lawn mower; power lights; power a vacuum cleaner; start a fire

Ethanol — fuel a motorboat; fuel the family car

Energy from food — power a human to do work; power an animal to do work

Gasoline — fuel a motorboat; fuel the family car; power a lawn mower

Human power — carry equipment and supplies on a hiking trip; cause a bicycle to go; cause a raft to move; cause a tree to fall over; cause a whistle to sound; damage buildings; power a lawn mower; pull a carriage or cart; pull a plow

Hydropower — cause a raft to move; cause a tree to fall over; convert into electricity; damage buildings; turn a mill wheel

Lightning — cause a tree to fall over; transform into electricity; damage buildings; start a fire

Natural gas — cook food; convert into electricity; dry clothes; heat a building; heat water

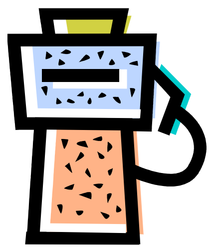
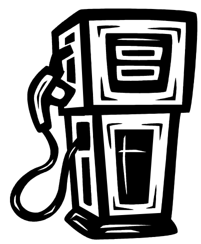
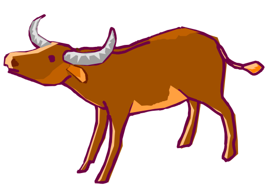
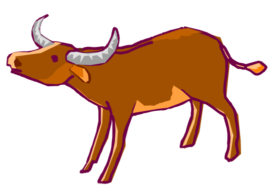
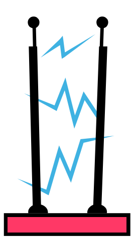
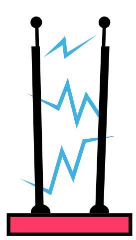
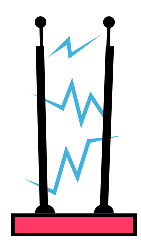
Nuclear fission (note: this is the energy in nuclear power plants and nuclear bombs) — cause a tree to fall over; transform into electricity; damage buildings

Sunlight — cook food; convert into electricity; dry clothes; enable photosynthesis; heat a building; heat water; start a fire

Wind — cause a sailboat to move; cause a tree to fall over; cause a whistle to sound; cause a windmill to turn; cool a building; convert to electricity; damage buildings; dry clothes

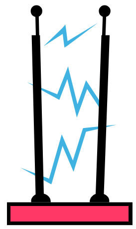
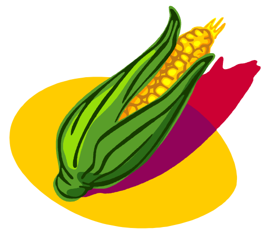
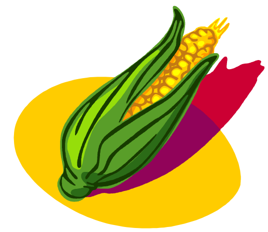
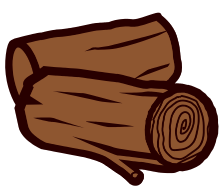
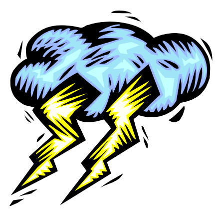
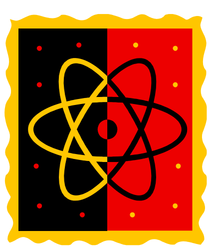
Wood —cook food; heat a home; heat water

Energy Sources

Sunlight 	Sunlight 	Sunlight 
Ethanol 	Gasoline 	Diesel fuel 
Biodiesel 	Human power 	Human power 
Animal power 	Animal power 	Human power 
Electricity 	Electricity 	Electricity 

What is Energy?

Energy Sources

Electricity 	Energy from Food 	Energy from Food 
Hydropower 	Hydropower 	Wind 
Wood 	Lightning 	Wind 
Nuclear Fission 	Wind 	Battery 
Battery 	Natural gas 	Coal 

Physical Change/Work

carry equipment and supplies on a hiking trip	cause a bicycle to go	cause a sailboat to move
power a remote-control car	cause a tree to fall over	cause a whistle to sound
cause a windmill to turn	cook food	cool a building
convert to electricity	damage buildings	enable photosynthesis
fuel a motorboat	fuel a tractor	fuel a truck

Physical Change/Work

fuel the family car	heat a building	heat water
power a vacuum cleaner	power a computer	power a flashlight
power a human to do work	power a lawn mower	cause a raft to move
power an animal to do work	power lights	pull a carriage or cart
start a fire	turn a mill wheel	dry clothes

Lesson 2

Liquid Fuels as Energy Sources

SET Abilities: predict, build/construct, collaborate, summarize, observe, question

Life Skills: teamwork, contributions to group effort, communication, critical thinking

Success Indicators: understands and is able to use the scientific method; is able to list several liquid fuels and know why liquid fuels are useful

Materials needed

- Cotton balls (make sure they are 100% cotton)
- Vegetable oil
- Water
- Rubbing alcohol
- Liquid animal fat, such as melted butter or bacon grease (optional)
- Other liquids, such as milk or honey (optional)
- Small metal or ceramic bowls (small empty tin cans, such as tuna cans, can be used; little ceramic bowls meant for soy sauce would also work
- Spoons
- Matches
- Scratch paper (three-hole notebook paper if possible) for journaling
- Pens, pencils, colored pencils, markers, crayons
- Scissors
- Small paper bag (such as a lunch sack)

Overview

Liquid fuels are one type of energy source. Youth will investigate liquid fuels via an experiment; a discussion; and a tour of a gas station.

Helping Youth Make and Light the Candles

Make sure all participants read the instructions FIRST. You may want to read them out loud as a group. Go over the scientific method to make sure everyone understands it.

NOTE: Do not hand out the matches to the youth. The leader should be in charge of lighting the candles.

Youth can work in pairs or groups. Provide each group with three or more small bowls or tuna cans (one bowl or can per liquid tested); several cotton balls; and spoonfuls of water, vegetable oil, rubbing alcohol, and any other liquid you are choosing to test.

Provide help as necessary to set up the candles. Each group will make at least three candles: one with water, one with oil, and one with rubbing alcohol. The groups can choose to make additional candles with other liquids as well.

BEFORE they light their candles, each group should discuss what they think will happen when the candles are lit, and write down their hypotheses on the chart.

After lighting the candles, each group should record on their chart what actually happened, and compare that to their hypothesis. Was the hypothesis correct or incorrect? Why?

Encourage students to compare their results with the results from other groups, and discuss the results.

Why did some liquids burn, while others did not?

Help students understand that the oil candle (or animal fat candle) remained lit because oil and fat contain energy that can be burned (resulting in light energy). Alcohol can also be burned for energy. Both oil and alcohol are liquid fuels. Both have high levels of chemical energy that will burn.

Water, on the other hand, cannot be burned for energy. Water simply does not have enough energy to burn. Other common liquids, such as milk and honey, have a high proportion of water, so they also will not burn.

Facilitating the Liquid Fuels Discussion

As a group, list as many liquid fuels as you can think of. Liquid fuels include: petroleum, gasoline, diesel fuel, kerosene, plant oils, animal fats, biodiesel, alcohol (such as ethanol), and liquid hydrogen.

Liquid fuels are useful because they have a high energy content; they are portable; they can be stored for future use; they can be used in smaller engines (such as the engines in cars and trucks); and they are relatively safe.

Facilitating the Gas Station Tour

Make arrangements in advance to tour a nearby gas station. Try to make sure the person who will give the tour is articulate and willing to answer questions.

Facilitating the Journaling Activity

See the Introduction for tips on facilitating the journaling activity.

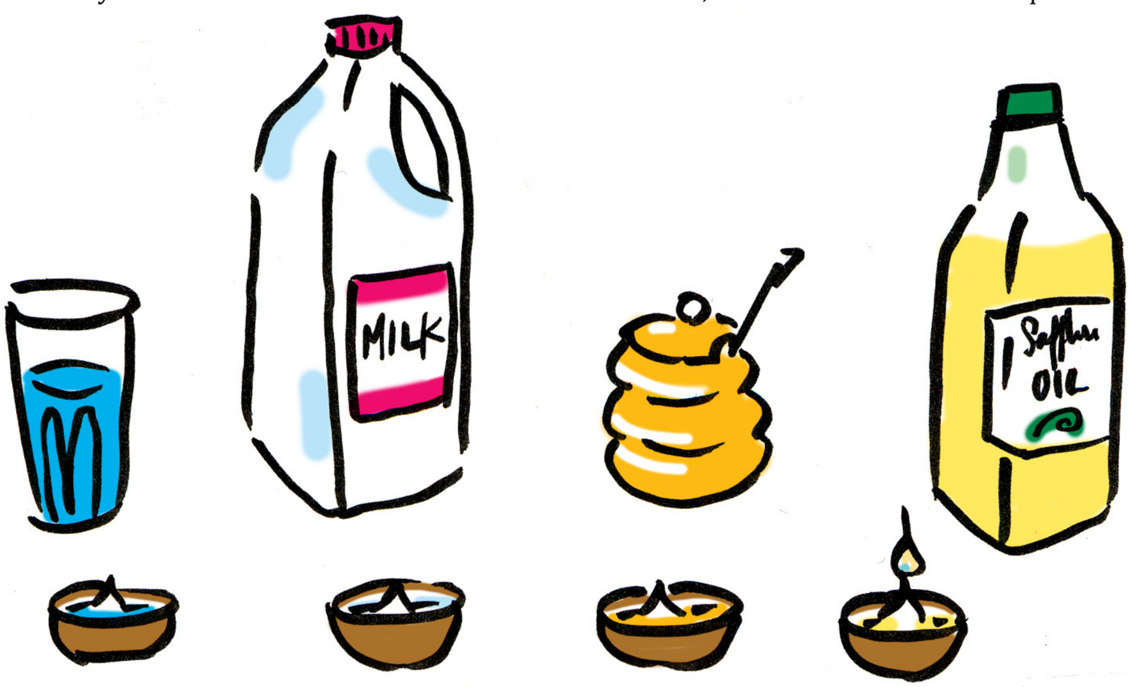
The first part of the activity involves writing questions. It might be helpful (and efficient) for you to time them for one or two minutes and encourage them to keep writing questions during the entire time. **The number of questions they write is more important than the quality of the questions.** The more questions they write, the better chance that there will be at least one good question among the bunch. They only need to cut out one question to share with the group.

The Science Behind the Activities

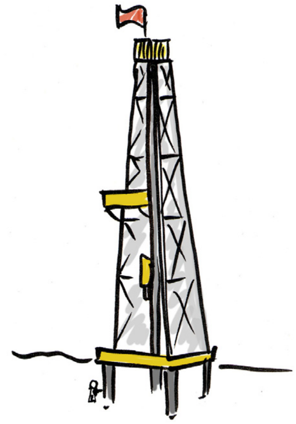
This activity allows participants to use the scientific method to predict what will happen when the candles are lit, and then test their hypothesis.

Participants will understand that while almost anything can be a source of energy, not all energy sources are equally usable in various situations. For example, wood cannot be used to fuel a normal car engine. Water can be source of energy when it moves (as in a waterfall or tidal waves), but it cannot be burned for energy.

This activity leads into lessons on biodiesel and fossil diesel, which are two kinds of liquid fuels.



Lesson 3
Fossil Fuels



SET Abilities: communicate, model, use numbers, summarize, question

Life Skills: teamwork, communication, planning/organizing, mentoring/providing guidance, critical thinking

Success Indicators: understands what fossil fuels are, what they are made of, when they were created, and how they are used. Understands the advantages and problems associated with fossil fuels.

Materials needed

- White board, chalk board, or easel paper
- Adding machine paper rolls (available at office supply stores)
- Meter sticks or rulers with centimeter marks
- Colored pencils/pens
- Scratch paper (three-hole notebook paper if possible) for journaling

Overview

Students will learn when fossil fuels were first created; how they were created; when they were discovered; how they are used; and the advantages and disadvantages of fossil fuels.

Note that fossil fuels are currently being created under the earth, but it takes so long to create them, and we are using them up so fast, that we will run out. Therefore fossil fuels are not renewable.

Facilitating the Fossil Fuels Discussion

BEFORE the youth open their workbooks, discuss these and similar questions:

1. What are fossil fuels?
2. What do they look like?
3. What are they made of?
4. When were they created?
5. When were they discovered?
6. How are they used today?
7. Why are they important in our world?
8. What are some problems associated with using fossil fuels?

Write down the answers from the participants on the white board, chalk board, or easel paper.

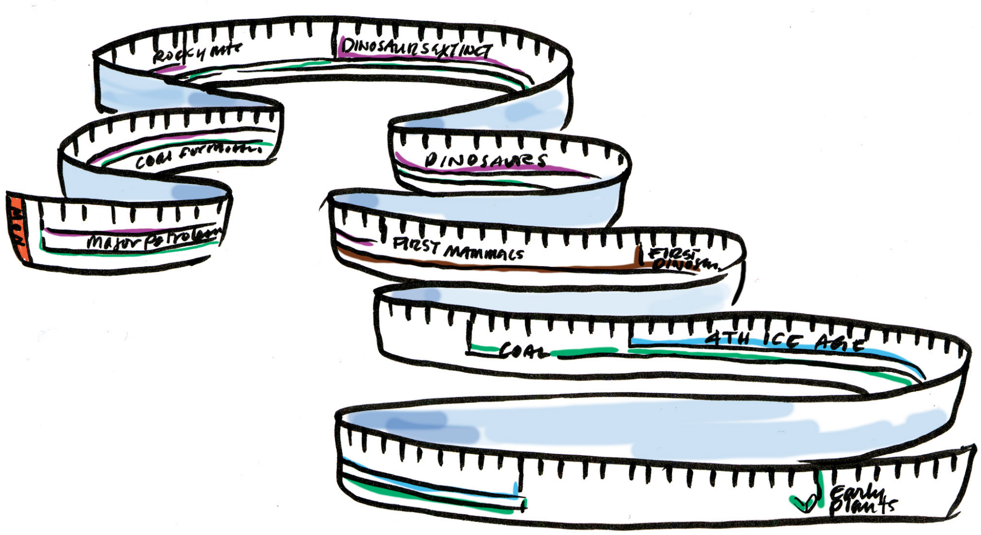
Ask them to look at the facts in their workbooks. How do the workbook answers compare with theirs? Ask them to correct any answers on display.

Facilitating the Fossil Fuels Timeline

Youth can work in pairs. It might be helpful to pair older participants with younger ones, so the older ones can help and mentor the younger ones. Make sure the older youth are not doing all the work, but are allowing the younger ones to help.

Go over the directions with the group. Make sure everyone understands the instructions.

Give each pair at least 4 meters of adding machine tape, a meter stick, and some colored pencils or pens.



Facilitate the Closing Discussion

Ask youth to reflect on what they learned from creating the timeline. What insights did they gain? What questions do they still have?

Facilitating the Journaling Activity

See the Introduction for tips on facilitating the journaling activity.

Answer to the How Long? Question

4.5 billion years is equal to 4500 million years. Since our model uses one meter for every 100 million years, an adding machine tape timeline from the beginning of the earth to the present would be 45 meters long (about half the length of a football field) .

The Science Behind the Activities

The timeline provides a visual model of the amount of time it has taken from the time fossil fuels started to form, to the time humans started to use them. The model is linear, because fossil fuels are not renewable at the rate we are using them. This will contrast to the circular model of biofuels that youth will create in the next lesson.

Youth should begin to understand the vast amount of time that it took for fossil fuels to form.

Sources for facts in this lesson:

U.S. Department of Energy, Energy Lessons, http://fossil.energy.gov/education/energylessons/index.html

"Fuels, Fossil" – Encyclopedia Britannica, v. 19, 2010

Petroleum Geology for Geophysicist and Engineers by Richard Selley. Boston: International Human Resources Development Corp., 1983.

Lesson 4
Renewable Energy

SET Abilities: communicate, model, compare/contrast, summarize, question

Life Skills: teamwork, communication, planning/organizing, mentoring/providing guidance, wise use of resources, critical thinking

Success Indicators: understands what renewable energy is, and is able to compare fossil energy to renewable energy.

Materials needed

- White board, chalk board, or easel paper
- Stiff paper (old manila folders could be used; heavyweight drawing paper would also work)
- Scissors
- Colored pencils/pens
- Rulers
- Compass (large enough to draw a circle 8” in diameter), and/or round lids or containers to trace around
- Scratch paper for journaling

Overview

Students will learn about renewable energy, and will make a model of the biodiesel production cycle.

Facilitating the Renewable Energy Discussion

BEFORE the youth open their workbooks, discuss these and similar questions:

1. What is renewable energy?
2. What are some sources of renewable energy?
3. What is a biofuel?

4. What are some examples of biofuels?
5. What is biodiesel?
6. What is biodiesel made from?

Write down the answers from the participants on the white board, chalk board, or easel paper.

Ask them to look at the facts in their workbooks. How do the workbook answers compare with theirs? Discuss any incorrect answers, and correct them on the white board or chalkboard.

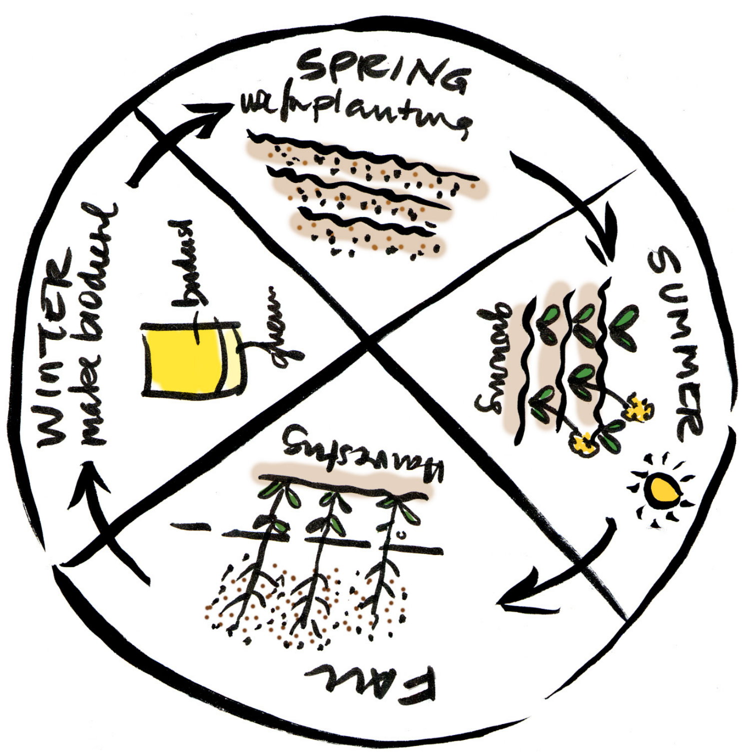
Facilitating the Renewable Fuel Model

Youth can work in pairs. It might be helpful to pair older participants with younger ones, so the older ones can help and mentor the younger ones. Make sure the older youth are not doing all the work, but are allowing the younger ones to help.

Go over the directions with the group. Make sure everyone understands the instructions.

Go over the information on the biodiesel timeline table. Allow youth to ask questions and discuss anything on the table before they make their models.

Give each pair some stiff paper, scissors, and some colored pencils or pens.



Facilitating the Comparing Models Discussion

Allow youth to discuss this largely on their own, and help them by listing their answers on the white board or easel paper.

The point is that the biodiesel model represents one year, whereas the fossil fuels model represents millions of years. Biodiesel is a renewable fuel because it can be made within one year, and we can keep making it as we use it up. Fossil fuels are not renewable because it takes millions of years to make fossil fuels, and we cannot make them as fast as we are using them up.

What can we do to reduce our use of fossil fuels? Youth may suggest things like:

- Don’t drive so much
- Carpool
- Use the bus
- Ride a bike or walk
- Turn down the thermostat at home
- Turn off lights when you leave a room
- Make cars that get more miles to the gallon
- Make solar-powered vehicles
- Make hybrid cars
- Make electric cars

Facilitating the Journaling Activity

See the Introduction for tips on facilitating the journaling activity.

The Science Behind the Activities

Youth make a visual model of the biodiesel production process. The model is circular, because biodiesel is a renewable fuel. Biodiesel can be used in growing the feedstock (oilseeds) in order to make more biodiesel, creating a circular process. This contrasts with the linear model of fossil fuels that youth created in the previous lesson, in which fossil fuels were formed underground millions of years ago, and are now being consumed.

Youth then compare and contrast their two models. These activities should help them understand the concept of “renewable” vs. “non-renewable” energy sources.

Vegetable Oil and Animal Fat as Sources of Energy

SET Abilities: collect data, evaluate, model, communicate, observe, measure, summarize, question

Life Skills: self-motivation, teamwork, critical thinking

Success Indicators: youth understand that seeds store energy in the form of oil

Materials needed

- Small amounts of a number of different food substances, such as nut butters, oil, water, applesauce, honey, butter, skim milk, cream, jam, and vinegar
- White board or easel paper and markers
- One or more kitchen scales that will show weight in grams
- About half a cup of oil (enough so each group of youth can weigh out 10 grams of oil, or about a tablespoon)
- About half a cup of sugar (enough so each group of youth can weigh out 10 grams of sugar, or about a tablespoon)
- Spoons
- Small bowls
- Scratch paper (three-hole notebook paper if possible) for journaling
- Pens, pencils, colored pencils, markers, crayons
- See additional materials below (depending on what activities you choose)

Overview

Oil and fat are forms of stored energy that are used by plants and animals. This form of energy can also be transformed into an engine fuel (biodiesel). Youth will gain an understanding of oil and fat as forms of energy through experiments, discussion, and possible field trips.

Facilitating the Opening Experiment

Have all the items gathered, and help youth place the items into separate containers. Groups of four can use the same small containers. Each youth can dip and dab on their own sheet of paper.

Read the instructions aloud as a group, and make sure everyone understands what they are to do.

Provide paper towels or wipes.

Provide a place to store the papers so they can dry during the meeting.

Facilitating the Opening Discussion

Allow youth to discuss and answer the questions on their own, while you write down their thoughts and answers.

After the discussion, provide them with some answers (see below).

- Oils and fats can be difficult to define. It might be easier to define them by talking about where they come from and what they do.
- Oils and fats are an important part of living things.
- Oils and fats can be burned for heat and light.
- Oils and fats are not soluble in water. For example, when you make salad dressing, the oil stays separate from the vinegar. Oil floats on water.
- Animals and plants store energy in the form of fats and oils.

- Animals also use fat as insulation against the cold.
- Oils tend to be liquid at room temperature, and fats tend to be solid.
- They feel slippery.
- They are hard to wash off with water alone.
- Some plant oils are edible and used for frying, sautéing and baking.
- Some plant oils are not edible, such as tung oil. The non-edible oils might be used to lubricate machinery or to make biodiesel.

Oils and fats also called “triglycerides” because they are composed of three fatty acids attached to a glycerin backbone. Another word for oils and fats is “lipids”.

All seeds and nuts contain at least some oil. The oil provides energy for the seed to grow into a plant.

An oilseed is a seed or crop grown mostly for its oil content. Such crops include: soybeans, canola, oil palm, and safflower. Other plants are grown partly for oil production, and partly for other uses, such as olives, sunflowers, and peanuts.

Our bodies convert excess food energy (calories) into fat, in order to store that energy for future use.

Facilitating the ”How Many Calories?” Discussion

Help youth with their weighing. Help them figure out how to add the weight of the bowl to the weight of the substance so they end up with the correct amount. If you have only one scale, the groups can take turns using the scale.

Allow them to guess how many calories are in the oil and the sugar. Write down their guesses.

The answer is: 10 grams of oil contain 90 calories, and 10 grams of sugar contain 40 calories.

NOTE: The word “calorie” has two meanings. In a scientific sense, one calorie equals the amount of energy needed to cause a rise of one degree Celsius in one gram of water. But food calories are actually “kilocalories” – they represent the amount of energy that can cause a rise of one degree Celsius in one kilogram of water. So technically, 10 grams of oil contain 90 kilocalories, and 10 grams of sugar contain 40 kilocalories. Even though food calories are technically “kilocalories,” we still tend to call them just plain “calories.”

Ask the group: are you surprised that the oil has more than twice as many calories as the sugar, even though it weighs the same? Point out that fat and oil are very concentrated forms of energy.

Possible additional activities for this lesson

You may want to include some or all of these activities in your lesson.

- Have a farmer visit to talk about the kinds of oilseed crops that could be grown in that region. Advance preparation needed:

  Arrange with a farmer to visit your club meeting.

  Before the farmer's visit, youth should come up with a list of questions for the farmer.

  Ask the farmer to bring actual seeds if possible, as well as photos of the plants in the field.
- Tour a field where oilseed crops are grown. Advance preparation needed:

  Arrange with a farmer to tour a field.

  Before the tour, youth should come up with a list of questions for the farmer.
- Plant seeds in pots for youth to take home and grow. Advance preparation needed:

  Bring in seed packets, pots or paper cups, and soil.
- Have a nutritionist visit to explain how a person's body uses fat. Advance preparation needed:

  Arrange with a nutritionist to visit the meeting.

  Before the nutritionist's visit, youth should come up with a list of questions.
- Look at food labels. How many grams of fat are in common foods, such as butter, milk, meat, eggs, cheese, oil, vegetables, fruits, grains, and nuts? Advance preparation needed:

  Have youth bring in a variety of food packages (or at least the labels from packages).

Facilitating the Experiment Results Discussion

Allow youth to record on their tables whatever they notice. Make sure everyone holds the paper up to light! Allow them to discuss reasons for what they notice.

The point is that substances with oil or fat will leave a translucent, "wet-looking" spot on the paper, even after the paper has dried, because the oil doesn't evaporate. If the substance has some fat (such as whole milk), there might be a translucent ring around the spot.

Facilitating the Journaling Activity

See the Introduction for tips on facilitating the journaling activity.

The Science Behind the Activities

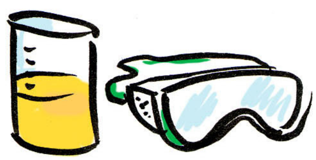
This lesson allows youth to understand that oil and fat provide energy. This energy is used by sprouting plants, by animals who store fat for later use, and as food for humans and animals.

By measuring an equal weight of oil and sugar, and then finding out that the oil has more than twice the calories, youth learn that fat is a very concentrated source of energy.

Oil or fat can also be used to fuel vehicles. This lesson leads into the next lesson on making biodiesel from oil or fat.

Sources for information in this lesson:

The opening experiment was adapted from: *Simple Science Experiments with Everyday Materials* by Muriel Mandell, Sterling Publishing Company, 1989, p. 77.



Lesson 6

How is Biodiesel Made and Used?

SET abilities: observe, infer, predict, build/construct, summarize, question

Life Skills: teamwork, critical thinking

Success Indicators: students will understand that biodiesel is made from vegetable oil or animal fat in order to remove the glycerin from the fatty acids, and thus make a product that works better in engines.

Materials needed

- Biodiesel starter kit (available for $19.75 + $11 shipping from Utah Biodiesel: http://utahbiodieselsupply.com/starterkits.php) – this will provide all the materials and supplies necessary to make about 1.5 cups of biodiesel.
- Microwave or heating pad
- One cup of biodiesel (you will use the biodiesel you make with the kit)
- One cup of vegetable oil
- One cup of glycerin (buy this from the store – do not use the glycerin that results from making biodiesel, because that will be dark and full of impurities)
- Clear plastic drinking straws (three straws for each group of youth)
- Thin permanent markers or ball-point pens
- Paper towels (for clean-up in case some liquids get spilled)
- Tape
- Narrow, tall drinking glasses or bottles (three for the three liquids)
- Dry mugs or cups (one per group, to hold the finished viscosity wands)
- Scratch paper (three-hole notebook paper if possible) for journaling
- Pens, pencils, colored pencils, markers, crayons

Overview

This lesson will help youth understand why and how oil is transformed into biodiesel. If oil is a liquid energy source, why did scientists and engineers bother to transform it to biodiesel—another liquid energy source? Youth will also understand how diesel engines are different from gasoline engines.

Making Biodiesel

NOTE: **It takes about half an hour to mix the chemicals, and then an additional hour for the glycerin to settle out of the biodiesel**. During this time, plan to do other activities, such as:

- Opening discussion
- Optional activity with caps and candles
- Engines discussion
- Start the viscosity wands activity and make the wands from oil and glycerin; once the biodiesel is ready, make the wands with the biodiesel.
- Feel free to let the biodiesel sit for longer than an hour. It will remain stable for six months or so. If needed, you can mix up the chemicals at one meeting, and use the biodiesel to make the viscosity wands at a later meeting.

Biodiesel is actually quite simple to make. You can purchase a small kit to make about 1.5 cups of biodiesel from Utah Biodiesel (see the link above, in the “Materials Needed” box). The kit provides oil, methanol, and potassium hydroxide, as well as a thermometer, gloves, a face mask, safety glasses, and complete instructions.

SAFETY NOTE: While biodiesel is a relatively safe product (it is non-flammable and biodegradable), some of the chemicals used to make it are dangerous. Be sure to wear the gloves, safety glasses, and face mask when handling the chemicals in this kit. Do not allow youth to handle the chemicals. Methanol and potassium hydroxide are both poisonous. Methanol is flammable and can cause blindness if ingested. Potassium hydroxide is corrosive. It can burn unprotected skin and kill nerve cells before pain can be felt. When sodium hydroxide or potassium hydroxide is mixed with alcohol and stirred, a fine mist can be produced which can cause irritation to the respiratory tract.

See this link: http://utahbiodieselsupply.com/starterkits.php for a five-minute video that takes you through the process of making biodiesel. Watch the video yourself beforehand to familiarize yourself with the process.

Start the process at the beginning of the meeting. The mixing process takes about half an hour, and then the mixture must sit for about an hour in order for the biodiesel to separate from the glycerin.

During the half an hour of biodiesel making, here are ways to keep youth involved in the process:

- Explain the different parts of the kit: the vegetable oil, methanol, chunks of potassium hydroxide (KOH), the thermometer, and the safety equipment: gloves, face mask, goggles.
- When you add the potassium hydroxide to the methanol and shake it, the container will become warm. If you like, you can invite the kids to touch the outside of the container to feel the warmth. You can explain that this warmth is caused by an exothermic chemical reaction.
- You will need to heat the oil in a microwave or a heating pad. You can assign a couple of older kids to be in charge of this. Other kids can take turns using the thermometer to see how warm the oil is. It must reach 130 degrees F..
- Once you add the methanol-KOH mixture to the oil, you must shake it for one minute and let it sit for five minutes, and you must repeat this process four times. You can assign some youth to be in charge of timing the shaking and settling.
- During the five minute breaks between shaking, start the opening discussion, and perhaps show one or more videos about how internal combustion engines work.

Facilitating the Engines Discussion

It may be difficult to find real engines that youth can look at. These days, some vehicle engines are covered up, so it is difficult to see even the top of the engine.

However, you may have better luck looking at a lawn-mower engine (gasoline-powered) and a tractor engine (powered by diesel). Alternatively, you can show youth videos and online simulations (see links below).

Try to arrange for someone to explain the engines to the youth.

Here is a 1.5 minute video about internal combustion engines (both diesel and gasoline engines are internal combustion engines, although the video only talks about gasoline engines): http://auto.howstuffworks.com/engine.htm

Here is a 5-minute video about internal combustion engines: http://auto.howstuffworks.com/engine1.htm

You can show one or both videos. Ask the youth: what did they learn from the video? Have them share their answers.

For animated models of a diesel engine and a gasoline engine, see:
http://auto.howstuffworks.com/engine1.htm and
http://auto.howstuffworks.com/diesel1.htm

Facilitating the Optional Activity

This activity is optional because it may not be legal in all states to buy and use caps (since they are a form of fireworks). If it is legal in your state, caps can be easily bought online. Look up "roll caps," "strip caps," or "ring caps."

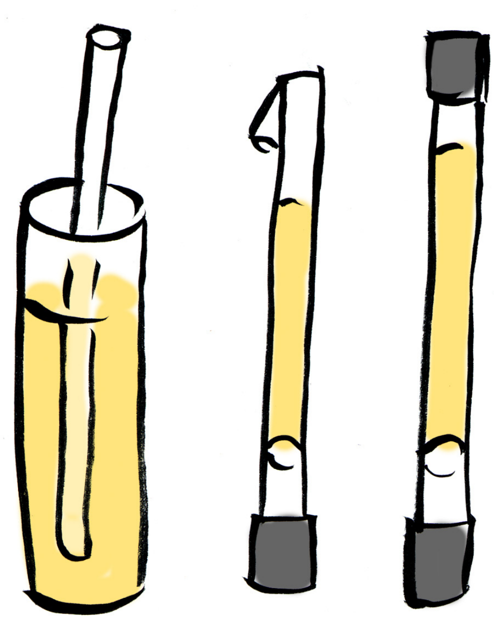
Facilitating the Second Biodiesel Discussion

The main point that youth should take away is: In the biodiesel reaction, oil and methanol (a kind of alcohol) are converted into biodiesel and glycerin.

Biodiesel can be used in any diesel engine.

Students might be curious about how the glycerin can be used. The glycerin that results from biodiesel production is polluted with methanol and other impurities. It can be purified and used in food, cosmetics, and pharmaceuticals. However, purification can be expensive.

Researchers are working on cost-effective ways to convert the crude glycerin resulting from biodiesel production into higher-value products.



Facilitating the Viscosity Wands Activity

Try to find tall, narrow drinking glasses or bottles to hold the liquids in this activity. A tall, narrow glass will allow each straw to contain more liquid than a short, wide glass.

NOTE: Be sure to keep the cap on the glycerin as much as possible. Glycerin is "hygroscopic" and attracts moisture from the air. This moisture will cause the glycerin to become thinner.

You will pour off or siphon off the biodiesel that you made at the beginning of the lesson, and use it to make viscosity wands. It should be ready to use after it has been sitting around for an hour. If you are doing this lesson in two parts, just save the biodiesel for the next meeting.

Biodiesel is non-toxic, but youth should wear gloves and eye protection when handling this, because there will still be a very small amount of methanol in the biodiesel.

If you would prefer not to have the youth handle the biodiesel, you can make biodiesel wands and hand them out to each group. They will still make the wands with the oil and glycerin.

Here's what should happen when the wands are turned upside down: the air bubbles in the higher viscosity liquids (the thicker liquids) such as glycerin and oil will rise more slowly than the air bubbles in the lower-viscosity liquids such as biodiesel. In fact, the glycerin will probably be so thick that you may not see any movement at all.

The point is that biodiesel has a lower viscosity than oil, because the thick, sticky glycerin has been removed. Therefore, biodiesel works better in an engine than straight oil or fat.

NOTE: when finished with this activity, throw the biodiesel wands away . If you leave them lying around for very long they could leak, because biodiesel tends to degrade many types of plastic.

Facilitating the Journaling Activity

See the Introduction for tips on facilitating the journaling activity.

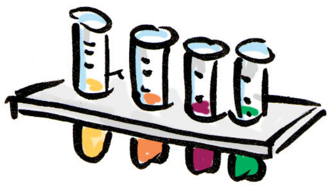
The Science Behind the Activities

Students will understand that chemicals can be reacted in order to create new substances. In this case, oil and methanol reacted to form biodiesel and glycerin.

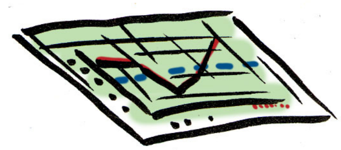
Students will also gain an understanding of how an internal combustion engine works.

Sources for information in this lesson:

The "viscosity wands" activity is adapted from: *Super Science Concoctions* by Jill Frankel Hauser, William Publishing, Charlotte, VT, 1997, pp. 70-71.



Lesson 7



Scientists and Engineers

SET Abilities: compare/contrast, categorize/classify, draw/design, invent solutions, summarize

Life Skills: teamwork, critical thinking, wise use of resources

Success Indicators: youth will understand that biodiesel was invented by scientists and engineers. Youth will explore how they can invent or research something as a scientist or engineer.

Materials needed

- White board, chalk board, or large pieces of paper taped to the wall
- Markers or chalk
- Scratch paper (three-hole notebook paper if possible) for journaling
- Pens, pencils, colored pencils, markers, crayons

Overview

In previous lessons, we have proceeded from a general idea (energy) to a specific form of energy (biodiesel). In this final lesson, we take a step back to look at the history of how biodiesel was developed, and help youth understand that biodiesel was invented by scientists and engineers. Youth will discuss other environmentally beneficial recent inventions, and explore the kinds of things they might like to invent or create if they become scientists or engineers.

Arranging for the Guest Speakers, and Facilitating the Discussion

To find scientists and engineers who could come and speak, talk to local universities and engineering firms. Try to find speakers who have experience with or at least an interest in alternative energy. Ask your speakers if they can bring something that youth can look at or touch.

Scientists and engineers are quite similar. While scientists may focus more on research for the sake of knowledge, and engineers may focus on practical applications of research, still there is a lot of overlap. Don't be surprised if your guest speakers have a lot of trouble coming up with differences between scientists and engineers.

The Science Behind the Activities

This lesson will help youth see scientists and engineers as role models. This lesson will encourage youth to see themselves in the roles of scientists and engineers.

Sources for information in this lesson:

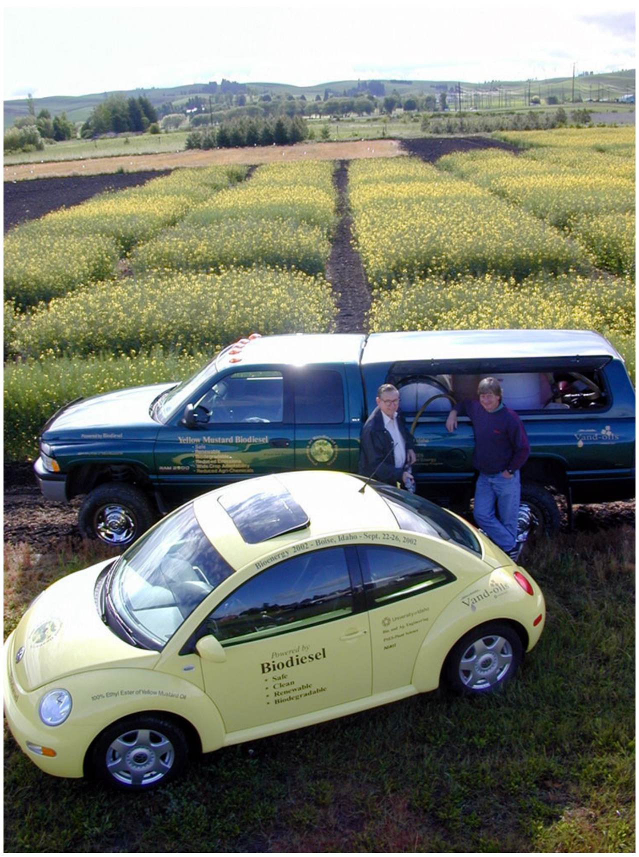
The information on the history of biodiesel is from *The Biodiesel Handbook,* second edition (2010), edited by Knothe, Krahl and Van Gerpen, pp. 12-13

Possible Tours

(if you are near Moscow, Idaho)

Biodiesel lab tour – tours of the University of Idaho biodiesel lab are available on request. Please contact Joe Thompson, the biodiesel lab manager, at: joet@uidaho.edu, or 208-885-5943.

Canola/mustard fields tour – canola and mustard seeds are both used as biodiesel feedstock at the University of Idaho. Tours of the University of Idaho canola and mustard research fields can be arranged by contacting Jim Davis at the Department of Plant, Soil, and Entomological Sciences: jdavis@uidaho.edu, or 208-885-4266.



Two of the vehicles owned by the Biodiesel Education Program. Both of these run on B100 (100% biodiesel) all year round.