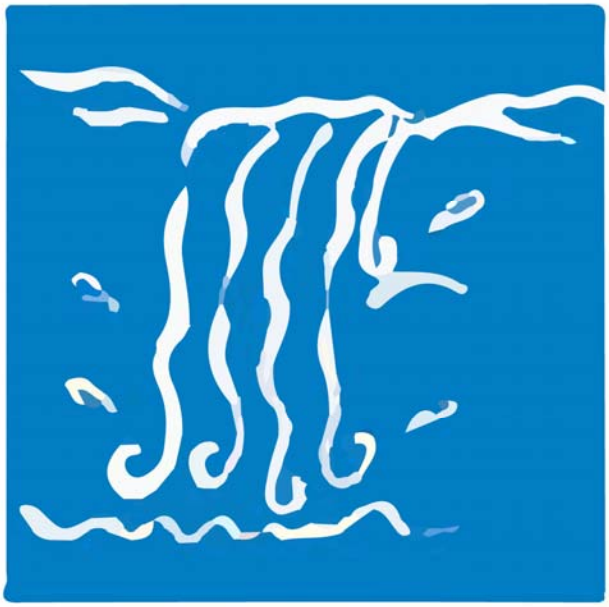
Renewable Energy and Biodiesel



Curriculum for
8-12 Years

Student Workbook

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

Table of Contents

Biodiesel Education Program
University of Idaho
PO Box 440904, Moscow, ID 83844-0904
208-885-7626
biodiesel@uidaho.edu
www.BiodieselEducation.org

Design and illustration by Melissa Rockwood, Rdesign, 208-882-5472, rdesign@moscow.com

Lesson 1

What is Energy?

You probably have some ideas about energy already. You know some sources of energy around the house, and you know some of the things energy can do.

1. Take a tour of your building to find sources of energy. Don't forget to go outside, if possible, to look for energy sources there.
2. After your tour, add any other sources of energy that you know about, but that you didn't see on your tour.
3. Using your list, work in small groups to come up with some **definitions** of energy.
4. Compare your definitions of energy.
5. Check to see if your definitions take into account all the sources of energy you came up with.
6. What are the difficulties of trying to define something like energy?
7. Ask your leader how scientists define energy.

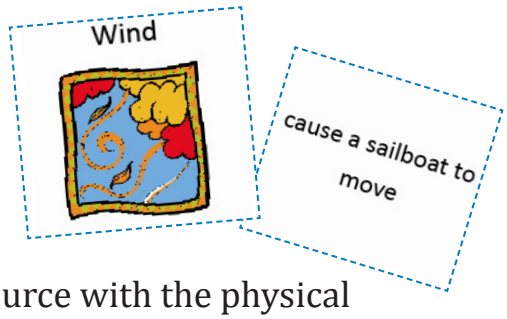
Scientists came up with their definition of energy in much the same way that you did—by observing things that seemed to be energy sources; coming up with a definition; and checking to see if that definition fit all the things they observed.

How do your definitions compare with the scientific definition?

Did You Know?

Energy cannot be created or destroyed. It can only be converted from one form to another. For example, solar energy is converted to plant energy. The plant is eaten by an animal which is used to plow a field. The animal gives off heat energy as it works. The heat energy is released into the atmosphere.

When you play the Energy Matching Game, notice that one source of energy can be converted into another source of energy. (For example, hydropower can generate electricity).



Energy Matching Game

This is a cooperative game—everyone wins!

The goal of this game is to match each energy source with the physical change that can be caused by that form of energy. Another way of looking at it is to match the energy source with the work that it can do. There are many right answers (as well as some wrong answers).

To play the game:

1. Place the game pieces face down on a table, arranging them so the "energy source" game pieces are in one section, and the "physical change/work" pieces are in another section.
2. The first player picks up one energy source card and one work card.
3. Show the cards to the other players.
4. Discuss whether the energy source can cause that physical change or do that kind of work.
5. If so, set the pair aside. If not, put the pieces face-down again.
6. Aim to create matches between energy sources that are likely to perform that kind of work or cause that kind of physical change in real life.
7. As much as possible, aim to create matches between energy sources that can more or less directly perform this kind of work or physical change (without first being transformed into another form of energy).
8. As a group, you should be able to explain why you matched an energy source with the work it can perform. How can that energy source perform that kind of work?
9. Take turns picking up cards and discussing them until all possible pairs have been formed.

10. Feel free to re-arrange your pairs to make the maximum number of matches.
11. After the game is finished, check with your instructor to see if you have matched the pairs correctly. Remember, there are many possible right answers.

Did You Know?

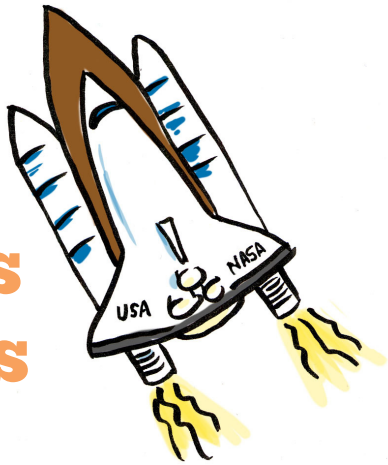
The sun is ultimately the source of almost all energy on earth. The sun's energy is transformed into most of the other sources of energy we use. For example, solar energy is transformed into plant energy, which is then transformed into animal energy. Fossil fuels, such as coal and gasoline, are stored forms of solar energy: the sun originally provided energy to the plants which then died and became fossil fuels over the course of millions of years. Wind is caused by sunlight heating the atmosphere. Hydroelectric energy (waterfalls and dams) depends on the cycle of evaporation and rain. Evaporation is caused by the sun's heat. A few sources of energy do not come from the sun, such as nuclear fission, and energy from ocean tides.

Journaling

If you could discover another form of energy, what would you like to discover? What work would this form of energy do? Use a separate sheet of paper to write or draw your answers.

Lesson 2

Liquid Fuels as Energy Sources



We use liquid fuels every day. In this activity, you will use the scientific method to conduct an experiment involving liquids to determine which ones are the best fuels.

Opening Experiment: Liquid Candles

You will need:

- several cotton balls
- three or more small bowls or tuna cans
- spoons
- water
- vegetable oil
- rubbing alcohol
- any other liquids you are testing

Instructions:

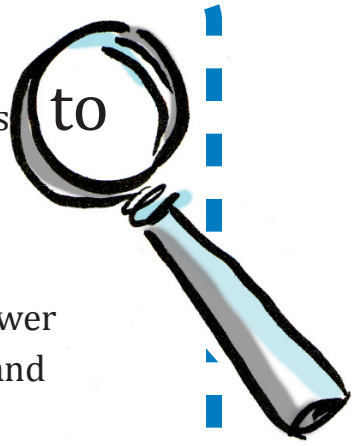
1. Pour a spoonful of water into one of the bowls or tuna cans.
2. Pour a spoonful of vegetable oil into another bowl.
3. Pour a spoonful of rubbing alcohol into a third bowl
4. If you are using other liquids, such as melted butter, milk, or honey, pour a spoonful of each liquid into a different bowl.

5. Make wicks out of cotton balls: divide each cotton ball into halves or thirds, and pinch and twist one part of the cotton into a wick shape. Leave this wick attached to the rest of the cotton, which will sit in the liquid.
6. Put one wick into each bowl with the wick pointing up. Be sure to soak the entire cotton ball and wick in the liquid.
7. BEFORE the wicks are lit, answer this question: what do you think will happen when the wicks are lit? Do you think they will light? How long do you think the light will last? This is your "hypothesis."
8. Fill out the chart below.

Test liquid	**Predict what will happen** ***(hypothesis)***	**What really happened** ***(results)***	**Your explanation for the results**
Oil			
Water			
Rubbing alcohol			
Optional test liquid#1			
Optional test liquid #2			

9. Ask the leader to light the wicks. What happened? Record your observations on your chart.
10. Compare your results with the results of other groups.

Steps in the Scientific Method



Scientists use the "scientific method" to learn answers questions about the universe.

1. Ask a question.
2. Form a hypothesis (your best guess about the answer to the question, based on your experience, ideas, and research).
3. Test the hypothesis by doing an experiment.
4. Was your hypothesis correct? Why or why not?
5. Tell people what you learned.
6. Based on what you've learned, you may come up with a new question, and go through the scientific method again.

Why are Liquid Fuels Useful?

As a group, list as many liquid fuels as you can think of.

Why are liquid fuels useful? What advantages do they have over other sources of energy (such as wood, coal, sunlight, or wind)?

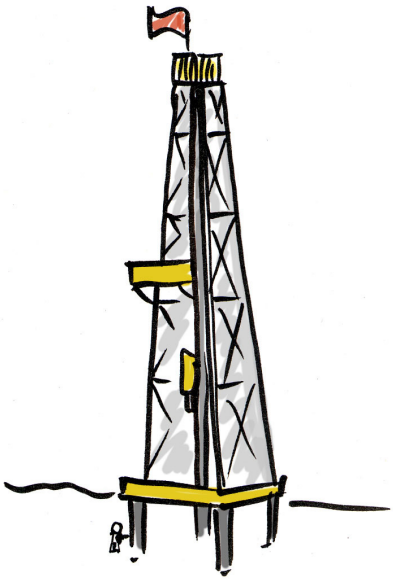
Your leader may have arranged for you to tour a gas station. During the tour, ask about or notice what kind of fuels are available; where the fuel is stored; what the fuel is made from; and what kinds of vehicles use the different kinds of fuel.

Journaling

1. On a separate piece of paper, write down questions you still have about the activities from this lesson.
2. Choose your favorite question (or questions). Cut these questions out.
3. Everyone puts their cut-out questions into a bag. Shake up the questions. Then, without looking, each person pulls out one question.
4. On a separate piece of paper, write or draw a possible answer to this question, and/or write or draw a possible experiment you could conduct to find out the answer.

Lesson 3

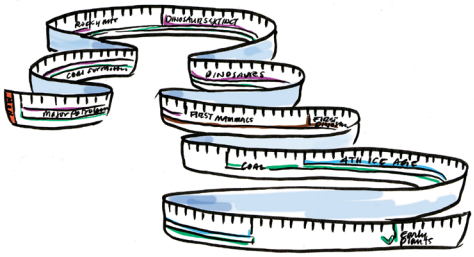
Fossil Fuels



What Do You Know About Fossil Fuels?

Without turning the page, discuss what you already know about fossil fuels. Then, turn to pages 10 and 11. Look at the facts about fossil fuels. See how these facts compare to your answers during the opening discussion.

Fossil Fuels Timeline



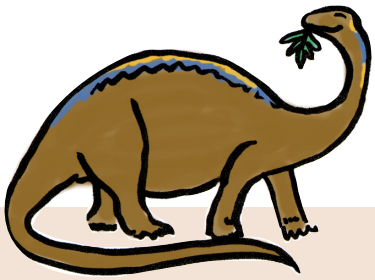
You will make a long timeline, starting when fossil fuels first began to be created, and ending at the present time.

You will need:

- at least 4 meters of adding machine tape
- a meter stick or ruler with centimeter marks
- colored pencils or pens

Instructions:

1. You will be working in pairs.
2. One person should hold the adding machine tape flat, and the other person should mark off centimeters along the edge of the adding machine tape.
3. Every five marks, write the number near the mark (such as 5, or 10).
4. You will have a total of 400 marks (400 centimeters). Each centimeter represents one million years.
5. Using the facts in the Fossil Fuel Timeline Facts box, add facts to your timeline.
6. You can also draw pictures if you like.



Fossil Fuels Timeline Facts

400 million years ago – ancient trees, plants, and animals died and eventually turned into fossil fuels (400 centimeter mark)

360 to 245 million years ago – first major period of coal formation (360 to 245 centimeter marks)

225 million years ago to 65 million years ago – Dinosaurs (225 centimeter mark to 65 centimeter mark)

200 million years ago – the first mammal, a small mouse-like creature (200 centimeter mark)

200 million years ago to 2.5 million years ago – major period of petroleum formation (200 centimeter mark to 2.5 centimeter mark)

135 million to 1.5 million years ago – second major period of coal formation (135 to 1.5 centimeter marks)

130 million years ago – flowering plants evolved and became widespread (130 centimeter mark)

2.5 million years ago – appearance of *Homo habilis*, earliest human (2.5 centimeter mark)

200,000 years ago – the first modern humans (*Homo sapiens*) evolved in Africa (1 centimeter mark)

1900s AD – Fossil fuel use became widespread throughout the world (1 centimeter mark)

How Long?

Scientists believe that the earth is 4.5 billion years old. If you wanted to create a timeline of the earth from 4.5 billion years ago to the present, how long would your adding machine tape have to be?

Did You Know?

- There are three major kinds of fossil fuels: petroleum (oil), coal, and natural gas. Petroleum is used to make many kinds of fuels, such as gasoline and diesel.
- Fossil fuels are useful because they contain a lot of energy in a small space.
- Fossil fuels create problems because they can cause air pollution when they are burned, and water pollution if they are spilled in the ocean.
- Using fossil fuels releases carbon dioxide into the air, which is a cause of global warming.
- Fossil fuels were formed under the earth millions of years ago. We are using them up fast, and they are becoming harder and harder to find.

Journaling

On a separate piece of paper, write or draw answers to one or both of these questions:

1. If you could add more items to your timeline, what would you like to add?
2. If you could live at some other time in the past, what time would you choose? What would it be like to live then? What kinds of energy sources could you use?

Lesson 4
Renewable Energy

What Do You Know About Renewable Energy?

Without turning the page, discuss what you know about renewable energy. Then, turn to page 14, look at the Renewable Energy Facts, and see how these compare to your answers.

Renewable Fuel Model

You will make a circular model of biodiesel production. Biodiesel is a renewable fuel. You will be creating a model of biodiesel made from canola oil.

You will need:

- stiff paper
- colored pencils or pens
- scissors
- large compass (capable of drawing a circle 8" in diameter), or a round lid or container (to trace around)

Instructions:

1. Draw a large circle (about 8" in diameter) on your stiff paper. You can draw this freehand, you can trace around a lid or round container, or you can use a compass.
2. Cut out the circle.
3. Divide your circle into four sections.
4. Label the sections Spring, Summer, Fall, and Winter.
5. Using the information on the Biodiesel Timeline table, add information about the seasons and process to your circle.
6. You can also draw pictures if you like.

7. Draw arrows from one season to the next so you go all the way around the circle, starting and ending with planting canola seeds.

Biodiesel Timeline

Season	Process
Spring	Canola seeds are planted
Summer	Canola plants grow
Fall	Canola seeds are harvested
Winter (or any time if seeds are stored for later use)	Oil is extracted from the seeds and made into biodiesel
Spring	Biodiesel is used in tractor that helps plant canola seeds

Compare Models

Compare the biodiesel model to the fossil fuels timeline.

Why is the biodiesel model circular?

What are some similarities and differences between the two models?

Since fossil fuels are not renewable, and since we will eventually run out, what can we do to reduce our use of fossil fuels?

Journaling

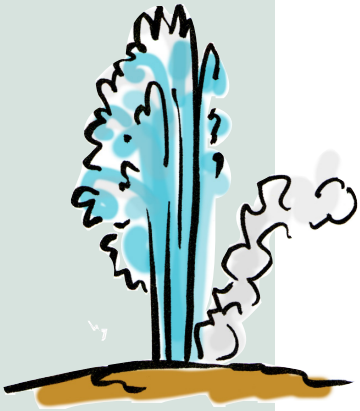
Suppose the President of the USA asked you for advice about whether the country should use fossil fuels or renewable fuels. What advice would you give to the President? Write a letter to the President telling him about your advice.

Did You Know?

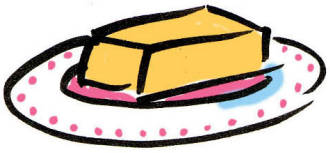
For every pound of fossil diesel or biodiesel burned, 3 pounds of carbon dioxide (CO_2) are released into the air. Carbon dioxide is a "greenhouse gas"—scientists believe it is a cause of global warming. So does that mean biodiesel causes global warming?

No, because the plants from which we make biodiesel absorb 3 pounds of carbon dioxide from the air in order to produce 1 pound of oil (which makes 1 pound of biodiesel). Biodiesel made from animal fat also helps to absorb CO_2 from the air, because the animals had to eat a lot of plant material to produce that fat.

Renewable Energy Facts



- Renewable energy is any kind of energy source that we won't run out of, because the raw materials are not going to get used up, or because we can grow new raw materials.
- Common sources of renewable energy include: sunlight, wind, water, geothermal energy (heat from within the earth), and biomass (which includes wood that can be burned; sugar and starch from plants that can be turned into ethanol; and oil from plants that can be turned into biodiesel).
- A biofuel is an energy source produced from biological material (plants or animals). Two common biofuels are ethanol and biodiesel.
- Biodiesel is a liquid fuel that can be used in trucks, tractors, or cars with diesel engines.
- Biodiesel is made from vegetable oil or animal fat.



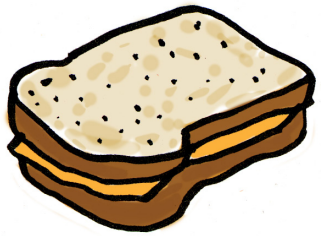
Lesson 5

Vegetable Oil and Animal Fat as Sources of Energy

Opening Experiment

1. Your leader will provide you with a number of different food substances, such as nut butters, skim milk, cream, honey, oil, applesauce, water, butter, jam, and/or vinegar.
2. Pour or place a little of each substance into separate small containers.
3. Dip your finger into the first substance and dab a tiny amount onto a clean sheet of white paper. Label this smear with the name of the item.
4. Clean your finger on a paper towel!
5. Dip your clean finger into the next substance, dab it onto another spot on the white paper, and label this.
6. Continue to clean your finger, dip, dab, and label until you've done this with all your substances.
7. MAKE SURE YOU ARE ONLY DABBING A SMALL AMOUNT. These smears need to dry by the time your meeting is finished.
8. You are going to wait until everything dries, and then see what it looks like on the paper.
9. Set this aside until the end of your meeting.

What Do You Know About Oil and Fat?



- What is oil? What is fat?
- How do seeds get the energy to sprout?
- What is an oilseed?
- If we eat more food than we need, what does our body do with that extra food?
- How do people and animals store energy?

How Many Calories?

In this experiment, you will guess how many calories are in 10 grams of oil, and 10 grams of sugar.

You will need:

- oil
- sugar
- two small bowls
- A scale that measures grams

Instructions:

1. You will work in pairs or small groups.
2. Place a small bowl on the scale. Write down the weight of the bowl.
3. Weigh out 10 grams of oil (a little less than a tablespoon) into the bowl. Remember, when weighing, be sure to add the weight of the bowl. For example, if the bowl weighs 25 grams, then your scale should read 35 grams when you're done weighing the bowl plus the oil.
4. Set that bowl aside.
5. Place another small bowl onto the scale. Write down the weight of this bowl.

6. Weigh 10 grams of sugar (about a tablespoon) into the bowl. Again, be sure to add the weight of the bowl.
7. Set this bowl next to the oil bowl.
8. Can you guess how many calories are in 10 grams of oil? Can you guess how many calories are in 10 grams of sugar?
9. Write down your answers.
10. Compare your answers with the answers of other groups.
11. Ask your leader for the correct answers. How do your answers compare?

How Many Calories?

Six slices cucumber = 5 calories

One orange = 60 calories

Mozzarella cheese stick = 70 calories

One small apple = 80 calories

One tablespoon peanut butter = 95 calories

½ cup ice cream = 125 calories

12 ounces (one can) of soda = 160 calories

Cheeseburger = 300 calories

Journaling

Create a picture, comic strip, skit, or story about the energy in seeds which allow the seed to sprout and grow into a new plant.

Experiment Results

Look at the paper that you smeared with various substances at the beginning of the meeting. Hold the paper up to light. What do you notice?

Fill in the following table.

Substance	Appearance on paper	Reasons

Lesson 6

How is Biodiesel Made and Used?

Watch How Biodiesel is Made

You will watch your leader make a small batch of biodiesel.

Opening Discussion

Do you remember what biodiesel is? What is biodiesel made from? What kinds of engines use biodiesel?

What did you notice when you watched biodiesel being made? What chemicals and substances did the leader mix together?

The mixture will begin to separate as you proceed with this lesson. Later in the lesson, you will discuss what products were created by this chemical reaction.

What is a Chemical Reaction?

A "chemical reaction" changes one type of substance into another type of substance.

Chemical reactions don't just occur in the laboratory—they occur all the time in everyday life. For example, your body converts food into energy using chemical reactions. Iron reacts with water and oxygen to form rust.

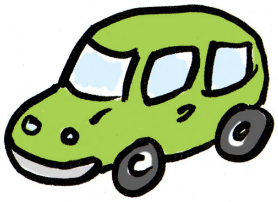
Optional Activity

- Your leader will provide each group with some caps (the little things that are used in a cap gun), a large rock, a candle, and a match.
- Take the caps and rock outdoors, and hit the caps with the rock. This is how one type of engine works.
- Indoors, light your candle with the match. This is how the other type of engine works.

Two Different Kinds of Engines

This activity will help you understand the two different kinds of engines that are widely used in cars, trucks, and tractors today. One of the engines runs on gasoline (and/or ethanol), and the other runs on diesel fuel (and/or biodiesel).

1. You will look at the two different kinds of engines—either actual engines, or videos and simulations online.
2. How are these engines similar to each other?
3. How are these engines different from each other?
4. If you did the cap and candle activity, which engine is similar to the cap and rock?
5. Which engine is similar to the candle?
6. Which kind of engine can use biodiesel as a fuel?

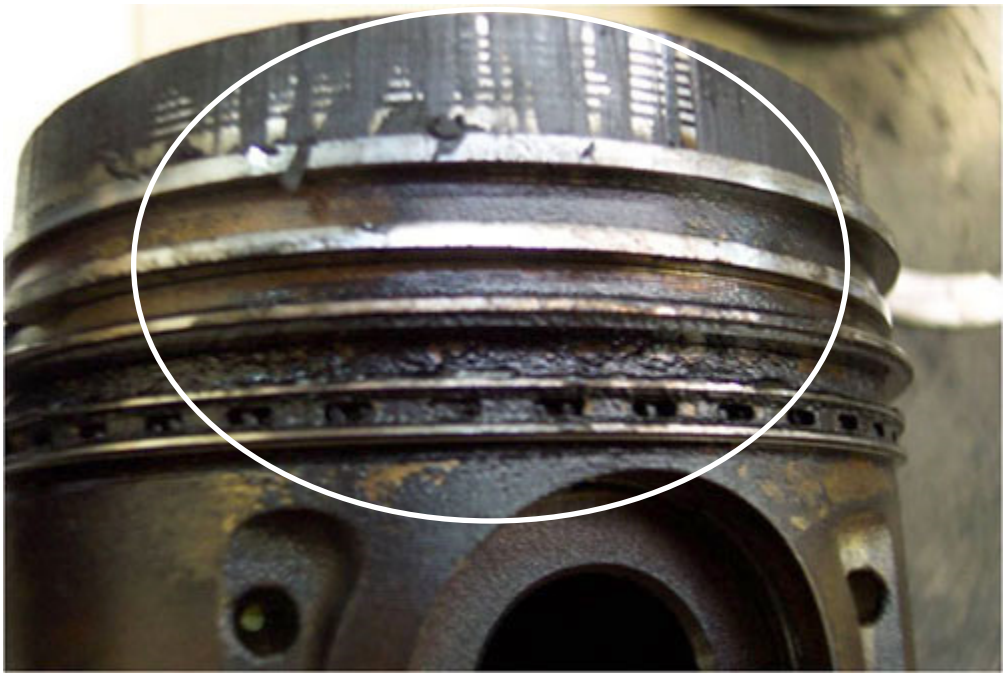


Biodiesel Discussion (2nd part)

Take a look at the chemical mixture that your leader made. What do you notice? What are the two different liquids in the container? What happened to the oil?

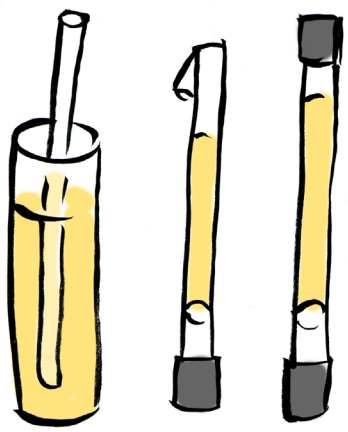
Can you describe the chemical reaction that happened?

Question:
If oil is a liquid fuel, why can't it be used to run a normal diesel engine? Why does it have to be transformed into biodiesel? The viscosity wands activity should help you answer this question.



This picture shows damaging deposits on an engine's "piston ring." These deposits were formed by using raw vegetable oil in the engine.

Viscosity Wands



You will need:

- biodiesel in a tall bottle or glass
- vegetable oil in a tall bottle or glass
- glycerin in a tall bottle or glass
- clear drinking straws
- an empty jar or tall glass
- sticky tape
- a permanent marker

Instructions:

1. You will work in small groups.
2. Take one drinking straw and place it in the glass with the biodiesel.
3. Fold over the top end of the straw and tape it down securely.
4. Have someone with clean, dry hands be in charge of the tape! If liquid gets on the tape, it won't stick.
5. Use a permanent marker to write "B" (for biodiesel) on the tape.
6. Remove the straw. Because you have closed one end, the liquid should stay inside. Turn it upside down, and place it into the empty jar or glass.
7. You will probably have to tap the straw gently on the bottom of the empty jar or glass to coax the liquid down to the bottom of the straw.
8. Wipe off the top of the straw with a paper towel. Fold over the open end of the straw and seal it with tape.
9. Follow steps 3 to 7 for the vegetable oil and the glycerin. Write the first letter of the liquid on the tape.
10. NOTE: Be sure to keep the cap on the glycerin as much as possible. Glycerin attracts moisture from the air. This moisture will cause the glycerin to become thinner eventually.

11. If you accidentally spill any liquid, clean it up with a paper towel.
12. Turn your wands upside down. Compare all your wands. How long does it take the air bubble to reach the top?
13. Compare your wands to the wands of other groups.

Viscosity Wands Discussion

Viscosity is a way to describe how sticky liquids are. Liquids that are highly "viscous," that have a high "viscosity," tend to flow more slowly than liquids that have low viscosity.

Which of your liquids is the most viscous?

Which is the least viscous?

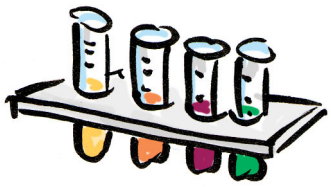
What would happen if you heat the liquids? Would they become more or less viscous? (Think about what happens when honey gets cold, and what happens when you warm the honey).

When your leader made biodiesel, the oil separated into biodiesel and glycerin. How does the viscosity of biodiesel compare with the viscosity of oil and glycerin?

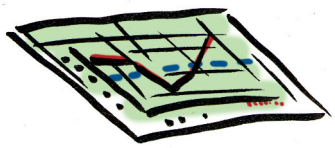
Why do you think oil is not a good fuel for diesel engines? Why do you think biodiesel is better?

Journaling 

Pretend you are a reporter for television, radio, newspaper, or a web site. Write a news article about biodiesel. Read your article to the rest of the group.



Lesson 7



Scientists and Engineers

The process to create biodiesel was invented by scientists and engineers.

What do you know about scientists? What do you know about engineers? How are they similar and different?

Your leader has arranged for a scientist and an engineer to visit your meeting. Find out their ideas about scientists and engineers. What do they think are the same about scientists and engineers? What do they think are different?

Together with your visitors, create a compare/contrast chart about scientists and engineers.

Profession	How are they similar?	How are they different?
Scientists		
Engineers		

What kinds of things have your visitors studied or invented?

Discuss with your visitors some environmentally friendly sources of energy that have been invented or created by scientists and engineers.

Did You Know?

Biodiesel was invented several times around the world during the 20th century. Whenever the price of fossil fuels went up, many people wanted to figure out how to transform vegetable oil or animal fat into a fuel that could be used in diesel engines.

- In 1937, a Belgian man named C. G. Chavanne figured out how to remove the glycerin from palm oil. He used an alcohol called "ethanol" instead of the methanol you used during lesson 6. The product was called an ethyl ester of palm oil (the word "biodiesel" had not yet been coined). Although this fuel was used in buses, after about 1945 the price of fossil fuel fell and the world forgot about C. G. Chavanne's experiment.
- In the 1970s, the price of fossil fuels again rose so high that people around the world began looking for another type of fuel. During this time, scientists and engineers in the United States, Germany, Austria, and South Africa re-invented the method to remove glycerin from vegetable oil and animal fat.
- The word "biodiesel" was probably first used in 1984. However, it was not until the 1990s that the word "biodiesel" became commonly used.