Biofuels:
"Grow" Your Own Fuel

- Biofuels Scavenger Hunt
- Source of Biofuels – Photosynthesis
- Source of Biofuels – Chemical and Physical Properties of Vegetable Oils: Viscosity and Temperature
- Make Your Own Biodiesel: Dr. Pepper Style (Pat. Pending)

Rural Science Education Program
A partnership between Oregon State University
and rural K-12 schools

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Rural Science Education Program
The Rural Science Education Program is a partnership between Oregon State University and local rural K-12 schools for enrichment of the science curriculum with hands-on science activities that encourage critical thinking in K-12 students about the impacts of agriculture on the environment and the implications of advanced scientific research on human lives.

For More Information
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Source of biofuels – Scavenger Hunt

Description

The Biofuels Scavenger Hunt will prepare students upcoming lessons on the Source of Biofuels. Using the Scavenger Hunt worksheet, students will research information about alternative fuel sources, how biofuels are made, the relationship between plants and biofuels, and identify economic, environmental, and social reasons for using biofuels.

Student Outcomes/Objectives

- Students will investigate alternative sources of fuel
- Students will explore different sources for biofuels
- Students will investigate the relationship between alternative energy sources and plants.
- Students will identify reasons for using alternative energy sources

Standards

Time Estimate

- One 50-minute class period
- Students might need additional time outside of class to complete research

Materials

- Books
- Computers
- Internet
- Trade magazines

Worksheets

- Biofuels Scavenger Hunt

Vocabulary

Background Information

The students will research background information themselves using the Biofuels Scavenger Hunt.

Lesson Plan

- Day 1 – Introduction to Biofuels Scavenger Hunt

Extensions/Resources

Journey to Forever Online Biofuels Library
www.journeytoforever.org/biofuel_library.html

Biofuels.org – Using Biofuels in the Classroom
www.teachbiofuels.org/index.html

Biodiesel – The Official Site of the National Biodiesel Board
www.biodiesel.org/resources/biodiesel_basics/

Greening Schools – A project by the Illinois EPA and Waste Management and Research Center (WMRC)
www.greeningschools.org/resources

Lesson Plan
Source of biofuels – Scavenger Hunt

Note: Italicized words are potential script for the teacher.

Introduction

Biofuels are an important part of today's culture. Using biofuel as an alternative to petroleum-based fuel has numerous environmental, economic, and social benefits. Today, you will participate in a Biofuels Scavenger Hunt to research different aspects of biofuels in preparation for upcoming lessons on the Source of Biofuels .You need to use a combination of resources, including the internet, books, and various trade magazines to collect information about biofuels. Using the information you collect during the scavenger hunt, you will write a one to three page report discussing alternative fuel sources, how biofuels are made, the relationship between plants and biofuels, and reasons for using alternative fuels. Your report needs to be in standard APA style formatting with proper citations. You also need to include a bibliography page in addition to your one to three pages of content.

Procedure

- Pass out Biofuels Scavenger Hunt.
- Remind students they need to use a COMBINATION of resources to collect their data, not just the internet.

Report Guidelines

- Go over standard APA formatting
- Include basic methods for in-text citations and bibliographies
- Go over grading rubric

Source of biofuels – Scavenger Hunt

Name:	___________________	Male or Female (circle one)	
School:	___________________	Grade:	_______________
Teacher:	___________________		
Date:	___________________		

1. What is biofuel made from?

   A. Coal
   B. Vegetable oil
   C. Petroleum
   D. Old tires

2. What is a saturated fatty acid?

   A. A compound with no double bonds
   B. A compound with one double bond
   C. A compound with more than one double bond
   D. None of the above

How are fatty acids used in the chemical process of making biofuels?

3. Why do plants produce vegetable oil:

A. For human consumption
B. For energy for seed germination
C. To provide insects with food
D. As a waste product

How do we use plant oils to produce biofuels?

4. The primary energy source for plants is:

A. Water
B. Fertilizer
C. Sunlight
D. Nutrients in the soil

5. True or False

A. _______ Plants store energy that can be used as biofuel

B. _______ Petroleum and biofuels come from the same source

C. _______ Sunflower oil from the grocery store cannot produce biofuel

D. _______ Some seeds contain oil

E. _______ The carbon in fossil fuels comes from the soil

6. Which of the following is not a fossil fuel

A. Petroleum
B. Biofuel
C. Natural gas
D. Coal

Please discuss some environmental and economic advantages to using biofuels versus fossil fuels.

7. Canola is:

A. A source of biofuel
B. A can of oil
C. A plant from Canada
D. Some of the above

8. Ethanol is:

A. Made from wood
B. Made from corn
C. A source of biofuel
D. All of the above

9. Biofuels can be obtained from:

A. Soybean
B. Safflower
C. Flax seed
D. All of the above
E. None of the above

Based on the last three questions, please discuss reasons/benefits for using different plants to make biofuels.

10. Give 3 reasons why we need alternative sources of energy.

11. Discuss the potential environmental, economic, and social benefits of using biofuels?

12. Are there drawbacks to using biofuels? For example, are there any counter arguments to using biofuels or byproducts associated with making biofuel?



Source of biofuels – Photosynthesis

Designed by Tom Chastain

Description

This unit will cover conversion of the sun's energy in plants through photosynthesis, the carbon cycle, and energy transformations; students will conduct their own experiments; students will calculate the leaf area index, crop growth rate and net assimilation rate for diverse plant species used in their experiments; students will participate in discussions on current and future energy needs and alternative energy sources.

Student Outcomes/Objectives

- Students will practice asking research questions.
- Students will design and implement an experiment.
- Students will demonstrate their understanding of the relationship between alternative energy sources and plants.
- Students will describe photosynthesis as a chemical process and part of the carbon cycle.

Standards

Benchmark 3

- Based on observations and scientific concepts, ask questions or form hypotheses that can be answered or tested through scientific investigations.
- Design a scientific investigation that provides sufficient data to answer a question or test a hypothesis.
- Collect, organize, and display sufficient data to support analysis.
- Summarize and analyze data including possible sources of error. Explain results and offer reasonable and accurate interpretations and implications.

Time Estimate

Four 50-minute class periods

Materials

Day 1

- Seeds: canola, radish, sunflower, soybean, etc.
- 18 - 1 gallon pots per group of 2-4 students
- Potting soil
- Microscope
- Lab balance

Day 2/3 (Once germination has occurred and 1st set of true leaves have developed)

- Scissors
- Lab oven
- Lab balance

Day 14

- Graph paper
- Lab balance
- Lab oven

Day 15

- Lab balance

Worksheets

Day 1

- Data sheet

Day 2/3

- Dry weight data sheet

Day 14

-Leaf Area Index data sheet

Day 15

-Net Assimilation Rate data sheet
- Experiment follow-up
-General report guidelines

Vocabulary

Photosynthesis: The process by which green plants make carbohydrates such as sugar, using water, carbon dioxide, and sunlight.
Carbon cycle: The steps by which carbon (in the form of carbon dioxide) is extracted from the atmosphere by living organisms and ultimately returned to the atmosphere.
Leaf Area Index (LAI): An estimate of the size of the plant's photosynthetic system or in other words, the plant's light collector. This is similar to a solar panel on a building.
Net assimilation rate (NAR): The increase in carbon after losses due to growth and maintenance respiration are accounted for in the plant.

Background Information

Basic background knowledge in biochemical reactions and biological processes in living systems is required.

- Students should be familiar with the process of photosynthesis and respiration.
- Students should be familiar with the carbon cycle.
- Students should be familiar with using lab equipment such as a lab balance to determine weight.

Lesson Plan

Day 1 – Setting up the experiment
Day 2/3 – Determining dry weight
Day 14 – Calculating Leaf Area Index (LAI)
Day 15 – Calculating Net Assimilation Rate (NAR)

Extensions/Resources

Biofuels for Transport – International Energy Agency
http://www.iea.org/Textbase/publications/free_new_Desc.asp?PUBS_ID=1262

Oregon State University Feedstock Research
http://cropandsoil.oregonstate.edu/bioenergy/index.html

Energy Efficiency and Renewable Energy – US Department of Energy
http://www.eere.energy.gov/

Biodiesel Education Program – University of Idaho
http://www.uidaho.edu/bioenergy/

OSU Biodiesel Initiative
http://biodiesel.oregonstate.edu/index.php

Lesson Plan

Source of biofuels - Photosynthesis
Day 1
Setting up the experiment

Note: Italicized words are potential script for the teacher.

Introduction

Students need an introductory lecture on photosynthesis and respiration prior to this lesson. This lesson includes a PowerPoint presentation that you can adapt to your class. Students should have some background knowledge about the carbon cycle.

Biodiesel Outreach 1.ppt

The price of fuel is increasing due to the shortage of petroleum. Worldwide countries are seeking alternative sources of fuels. One alternative source is biofuel, which is derived from the sun via green plants. Green plants capture solar energy and collect CO_2 from the atmosphere and convert this energy into a stable chemical form. Instead of using solar panels to capture solar energy, plants use a canopy of leaves and stems to collect the sun's energy. The conversion of solar energy to chemical energy by plants is known as photosynthesis.

During photosynthesis carbon from atmospheric CO_2 is reduced to carbohydrates. Carbohydrates are transported from the leaf, most commonly in the form of sucrose (table sugar), to the developing seed. In the seed, the sucrose is converted to oil. Oil is stored in the seed to provide energy for the growing seedling during the seed germination process. But this seed-based oil may also be collected and used by humans as vegetable oil, or it can be converted to biofuel.

Plants differ in how they capture solar energy and convert it to oil. To pick the plant that is most efficient, we need to compare photosynthesis in different plants. Remember, photosynthesis is affected by temperature, light, and water. You will grow three different species of plants to test and compare.

- *This experiment will take 15 days to complete.*
- *Today you will decide what your question is, generate a hypothesis, and develop your procedures.*
- *Day 2/3: You will determine the dry weight of your plants*
- *Day 14: You will calculate Leaf Area Index (LAI).*

- *Day 15: You will calculate Net Assimilation Rate (NAR).*

Scientific inquiry review

- Review scientific inquiry and have students write the steps in their notebooks.
  - Question (Ask)
  - Investigate (Do)
  - Create (Learn)
  - Discuss (Write and share)
  - Reflect (Think and plan again)

Divide class into groups of two to four students

Brainstorm questions related to photosynthesis and the carbon cycle.
Go over the following questions as a class to help students generate their hypothesis.

- *What factors are critical for determining which plants should be used for biofuel production?*
- *Does the architecture of a plant affect how efficient a plant is at converting solar energy to chemical energy?*
- *What are some different plant architectures?*
- *While growing different plants what data should be collected?*

Setting up the experiment

- Develop a hypothesis, predictions, and procedures for conducting your experiment.
- Select 3 different plants to use in this experiment.
- Examine the seeds under the microscope.
- Draw the seeds to scale, record size and any other observations you make.
- Calculate and record the average weight of the seeds for each plant.
- For each plant species, plant 10-15 seeds per pot in 6 pots. Once seedlings have germinated you will thin seedlings to 5 per pot.
- Place pots in warm, well-lighted environment. Water and fertilize as needed to support plant growth. As plants grow make observations and ask questions about what you see.

Data Sheet – Day 1

Select 3 different plants for your experiment (canola, radish, sunflower, soybean, etc).

Examine each seed under the microscope.

Draw the seeds to scale.

Seed #1 Seed #2 Seed #3

Observations:

Hypothesis:

Predictions:

Procedures:

* Record seed species, size, and weight in the data table:

Date/Time	Seed species	Seed Size	Seed Weight

Lesson Plan

Source of biofuels - Photosynthesis

Day 2/3

Determining Dry Weight

Note: Italicized words are potential script for the teacher.

Introduction

- *Today is day 2 of your experiment.*
- *You will collect leaf samples from your plants to determine the dry weight for each plant. You will use this data later to determine which plants are good candidates for biofuels.*
- *First, collect the leaf samples. Once you have your samples, you will dry them in an oven until they reach a constant weight, referred to as the plants dry weight.*
- *The dry weight is used to measure plant growth. This is the most reliable test because plants have a high composition of water, and the level of water in a plant will vary based on how much water is available in the environment.*
- *Drying the plants will take about 24 hours. You will collect and dry your samples today, and record your data tomorrow.*

Collecting dry weights

- Each group needs 3 pots for each plant species. Students should select pots with plants that that have their 1^{st} true leaves. True leaves are the first leaves that develop after the cotyledons, and look like the regular plant leaves.
- Students should have a total of nine pots.
- Students need to clip the plants at the soil surface.
- Place leaves in an oven overnight at 60º C (100º F). It will take plants approximately 24 hours to reach their dry weight.
- Remove plants from the oven and allow them to cool in a dry environment (a Ziploc bag will work). A humid environment will cause the plants to absorb moisture.
- Once the plants have cooled, weigh them.
- Record the dry weight. This information will be used in the next step of the experiment.

Cleanup

- *Collect plant material and dispose of it in the designated area.*

Dry Weight Data Sheet

Select 3 pots for each species. You should have 9 pots total.

Follow the directions for measuring dry weight and record the weight fore each species in the data table.

Date/Time	Seed species	Dry Weight Day 3

-Observations:

-Questions for further thought:

Examine each of your plant species. Do you notice any difference in the plants architecture? How do you think different architectures affect a plants ability to capture solar energy?

How do you think temperature, light and moisture affect photosynthesis?

Lesson Plan

Source of biofuels - Photosynthesis
Day 14
Calculating Leaf Area Index

Note: Italicized words are potential script for the teacher.

Introduction

- *Today is Day 14 of your experiment.*
- *You will calculate the leaf area index (LAI) today to help you determine which plants are the most efficient at capturing solar energy from the sun and converting it to oil. Answering this question will help you determine which plants are good candidates for biofuel production.*
- *You will collect a sample of 5 leaves from each pot to calculate the average LAI for each plant species.*
- *When you collect your samples you need to make sure you are following proper sampling procedures. Something things to keep in mind include:*
    - *Determine the size of leaves you are going to pick before you start. They can be small, medium, or large, but you need to be consistent.*
    - *Your samples should be free of diseased, yellow, or otherwise unhealthy leaves.*
    - *Your sample should be representative of all the plants in that pot. Don't just pick the leaves from the biggest or smallest plant.*
    - *Each sample will represent one pot.*

Calculating Leaf Area Index

- Each group should have several sheets of graph paper.
- Students need to measure the area of one of the squares in square centimeters on the graph paper. Next, have them cut out one of the squares and weigh it. Using the area and the weight of the square, have students determine the area per weight ratio. **Don't forget units.**
- Students need to take a sample by picking 5 leaves from one pot.
- Trace the leaf blades on the graph paper. Carefully cut out the tracing of the leaf blade and weigh the leaf facsimile.
- Calculate the area for each leaf by multiplying the weight of the facsimile by the area/weight ratio of the square from the graph paper.

- Calculate the area of the pot by tracing the pot on a piece of graph paper. Cut out the circle and measure the radius. Use the calculation for the area of a circle to calculate the pot area.
- Area of a circle = $\pi * r^2$
- Calculate the leaf area index.

Calculations for Leaf Area Index

Leaf area index (LAI) = an estimate of the size of the plant's photosynthetic system. This is the plant's light collector.

LAI = leaf area day 4/pot area

Leaf area = cm^2

Pot area = cm^2

- Follow Day 2 procedures to determine the dry weight of the samples.

Leaf Area Index Data Sheet

Leaf area index (LAI) = an estimate of the size of the plant's photosynthetic system. This is the plant's light collector.

Collect a sample of 5 leaves from each pot to calculate the average Leaf Area Index (LAI) for each plant species.

Sampling methods:

-Each sample will represent one pot.

-Determine the size of leaves you are going to pick before you start. They can be small, medium, or large, but you need to be consistent.

-Your samples should be free of diseased, yellow, or otherwise unhealthy leaves.

-Your sample should be representative of all the plants in that pot. Don't just pick the leaves from the biggest or smallest plant.

*Graph paper area/weight ratio data table

Date/Time	Area (cm^2)	Weight	Area/weight ratio

*Leaf Facsimile area/weight ratio

Date/Time	Weight	Area

*Calculate the area for each leaf by multiplying the weight of the facsimile by the area/weight ratio of the square from the graph paper.

*Pot Area

Date/Time	Radius	Area

Calculate the area of the pot by tracing the pot on a piece of graph paper. Cut out the circle and measure the radius.

Use the area of a circle to determine pot area.

Area of a circle = $\pi * r^2$

Calculations for Leaf Area Index

LAI = leaf area day 4/pot area
Leaf area = cm^2
Pot area = cm^2

*Leaf Area Index

Date/Time	Species	Average Leaf Area Index

Dry Weight Day 14

Date/Time	Seed species	Average Dry Weight Day 14

Observations:

Questions:

What factors are critical for determining which plants should be used for biofuel production?

Lesson Plan

Source of biofuels - Photosynthesis
Day 15
Calculating Net Assimilation Rate

Note: Italicized words are potential script for the teacher.

Introduction

- *Today you will collect your samples from the oven and determine the LAI.*
- *Using the LAI values from today and those from Day 3 you will calculate the Crop Growth Rate (CGR). The CGR is the change in a crops weight over time. This measurement is taken when the plant initially starts to grow and then again after a period of time. For your experiment this is a 14-day period.*
- *You will use that information to determine the Net Assimilation Rate (NAR) for the plants. The NAR is the increase in carbon after losses due to growth and maintenance respiration are accounted for in a plant.*

Calculating Crop Growth Rate

- Remove the leaves from the oven and allow leaves to cool in a dry environment (you can reuse your Ziploc bags from Day 3).
- When the leaves are cool, weigh them.
- Using these values and the values from Day 3 determine Crop Growth Rate (CGR).

Calculations for Crop Growth Rate (CGR)
Crop Growth Rate = dW/dt,
dW = change in plant dry weight
dt = change in time
(plant weight Day 15 – plant weight Day 3)/number of days in interval (14)

- Use the LAI and CGR values to determine the Net Assimilation Rate for each plant species selected for the experiment.

Calculations for Net Assimilation Rate (NAR)
NAR = CGR/LAI

- **Record your data**

Record your observations and conclusions about your hypothesis and experiment

Cleanup

- *Collect plant material and dispose of it in the designated area.*

Go Over Report Guidelines

- Hand out report guidelines.
- Briefly explain.

Crop Growth Rate and Net Assimilation Rate Data Sheet

Crop Growth Rate (CGR) is the change in a crops weight over time. This measurement is taken when the plant initially starts to grow and then again after a period of time. For your experiment this is a 14-day period.

Calculations for Crop Growth Rate (CGR)

Crop Growth Rate = dW/dt,
dW = change in plant dry weight
dt = change in time
(Plant weight Day 15 – plant weight Day 3)/number of days in interval (14)

Date/Time	Seed species	Crop Growth Rate

The Net Assimilation Rate (NAR) is the increase in carbon after losses due to growth and maintenance respiration are accounted for in a plant.

Calculations for Net Assimilation Rate (NAR)
NAR = CGR/LAI

Date/Time	Seed species	CGR	LAI	NAR

Graph your results on a separate sheet of paper. You will use your graphs in your final report.

Observations:

Questions:

Conclusions:

Experiment Follow-up

1. Answer your research question.

2. Was your hypothesis right? Provide data to support your answer.

3. What was one thing about your experiment you didn’t expect to happen?

4. If you were to repeat this experiment, what is one thing you would do differently?

5. Is there any part of your experiment you feel you could do better? What? How?

Final Report Guidelines

Your biofuels photosynthesis report needs to have the following sections. Use your data, observations, and questions to help you write your report. Be creative and include as much information as possible. You need to include graphs in your report, this will help the reader understand and interpret your data.

1. Cover page/title
   - Separate page
   - Title (should tell reader something about your experiment)
   - Names of your group members
   - Teacher's name
   - Class

2. Table of contents
   - List each section of your report and the page

3. Materials and supplies

4. Research question section
   - Write the heading
   - Write the question you were trying to answer with your experiment.

5. Hypothesis section
   - Write the heading
   - Write your hypothesis

6. Prediction section
   - Write the heading
   - Write down your predictions

7. Procedures section
   - Write the heading
   - Write the procedures, numbering each step

8. Results section
   - Write the heading
   - Discuss your results

9. Conclusion section
    - Write the heading.
    - Address the following questions
        - Did your results support or falsify your hypothesis?
        - Were there any errors in your experiment?
        - How would you change this experiment if you did it again?
        - If this experiment continued, what would be your next research question?

Source of Biofuels – Chemical and Physical Properties of Vegetable Oils: Viscosity and Temperature

Designed by …………….

Description

This unit will cover various oilseed crops as sources of biofuels; students will discuss the effect of the chemical and physical properties of vegetable oils on their use as biofuels; students will conduct their own experiments; students will participate in discussions on current and future energy needs and alternative energy sources.

Student Outcomes/Objectives

- Students will practice asking research questions.
- Students will design and implement an experiment.
- Students will demonstrate their understanding of the relationship between oilseeds from different crop sources and the chemical and physical properties of those oils.

Standards

Benchmark 3

- Based on observations and scientific concepts, ask questions or form hypotheses that can be answered or tested through scientific investigations.
- Design a scientific investigation that provides sufficient data to answer a question or test a hypothesis.
- Collect, organize, and display sufficient data to support analysis.
- Summarize and analyze data including possible sources of error. Explain results and offer reasonable and accurate interpretations and implications.

Time Estimate

Two 50-minute class periods.

Materials

Day 1

- Vegetable oils (you will need at least 3 times the volume of the test bottles for each type of oil for each group of students)
- Tall smooth sided plastic containers (graduated cylinders will work)
- Glass marbles small enough to fit through the mouth of the bottles
- Tape or adhesive labels for labeling the bottles
- Markers
- Lab balance
- Refrigerator with freezer compartment
- Thermometer
- Paper towels
- Safety glasses

Day 2

- Stop watch accurate to 0.1 seconds
- Paper towels
- Safety glasses

Worksheets

Day 1
-Density data sheet

Day 2
-Temperature and viscosity data sheet
-Experiment follow-up
-General report guidelines

Vocabulary

Fatty Acids: molecules made of the elements carbon (**C**), hydrogen (**H**) and oxygen (**O**) arranged as a carbon chain skeleton with a carboxyl group (**-COOH**) at one end.
Carbon Chain Length: the number of carbon atoms in a fatty acid chain.
Double Bond: a covalent chemical bond where two pairs of electrons are shared between atoms.
Viscosity: The measure of a liquids resistance to flow. For example, water is "thin", so it has a low viscosity, but vegetable oil is "thick", giving it a higher viscosity.

Background Information

Limited background knowledge of chemistry is required.

Lesson Plan

Day 1 – Setting up the experiment
Day 2 – Measuring Oil Viscosity

Extensions/Resources

Biodiesel America – Biodiesel resources, information, community, & news
http://biodieselamerica.org/what_is_biodiesel

Lesson Plan

Source of biofuels – chemical and physical properties of vegetable oils: viscosity and temperature

Day 1
Setting up the Experiment

Note: Italicized words are potential script for the teacher.

Introduction
Give students the Powerpoint lecture on Oilseed Crops as Sources of Vegetable Oil.

Biodiesel From Locally Grown Oilseed Crops.ppt

Vegetable oils consist mostly of triacylglycerol molecules that have three (tri) fatty acids (acyl chemical groups) connected to a glycerol backbone. Fatty acids are chains of carbon atoms. Fatty acids can vary widely in the number of carbon atoms in the chain, the number of double bonds in the chain, and the functional groups attached to the carbon chain. Each oilseed crop produces a different proportion of these fatty acids. The characteristics of the fatty acids largely determine the physical properties of a particular vegetable oil. As a result, vegetable oils from different crops differ in their suitability for use as sources of biofuels.

Different liquids have different properties. One of these properties is ***viscosity****, the liquid's resistance to flowing. Water, milk, and fruit juice are comparatively thin and flow more easily than thicker, more viscous liquids such as honey, corn syrup, shampoo, or liquid soap. One way to test the viscosity of a liquid is to see how much time an object takes to move through it. Viscosity of most liquids is affected by temperature. Since biofuels may be used over a wide temperature range (summer and winter or northern and southern states), knowing the effect of temperature on viscosity may be quite important when deciding which oil to use in making biofuels.*

You will work in groups and conduct an experiment to determine which oils might perform best as biofuels under low temperature condition.

Divide class into groups of two to four students

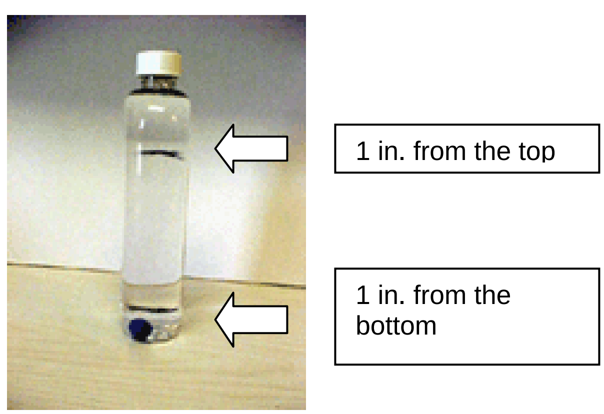
- Give each group the following supplies
  - 3 plastic containers
  - 3 marbles
  - Tape or adhesive labels for labeling the plastic containers
  - Markers for labeling the containers

Brainstorm questions related to the properties of vegetable oils
Go over the following questions as a class to help students generate their hypothesis.

- *What chemical characteristics of vegetable oils might determine their chemical and physical properties?*
- *Over what temperature range could biofuels be used?*
- *Why would this be important?*
- *What data could be collected to help determine which oil would be the best for biofuel production?*

Setting up the experiment

- Develop a hypothesis, predictions, and procedures for conducting your experiment.
- Each group needs to select three types of vegetable oil for testing (canola, soybean, flax, peanut, sesame, coconut, palm, sunflower, or safflower).
- Examine each type of oil. Use the worksheet to describe the color, taste, and smell of each oil.
- Weigh 100 ml of each oil sample and record the mass.
- Calculate the density (kg/m^3 and pounds/gallon) of each oil sample.
- Insert a marble into each of the clear plastic containers, fill each bottle to the top with oil, and close the cap tightly.
- Use the tape to label each bottle with the type of oil in the bottle so they can be identified later.
- Label one bottle "Room Temperature", one bottle "Refrigerator", and one bottle "Freezer".
- Measure 1 inch up from the bottom of each container and draw a horizontal line. Measure 1 inch down from the top of each bottle and draw another horizontal line. When you finish your bottles should look something like the picture shown below.
- Place one bottle at room temperature, one bottle in the refrigerator, and one bottle in the freezer.



Calculations for Liquid Density:

Density = mass/volume

Convert initial measurements (grams/milliliter) to kg/m^3 and pounds/gallon

Cleanup

- Cleanup any oil that spilled and dispose of paper towels in the designated area.
- Return supplies to the supply table.

Data Sheet
Oil Density

Hypothesis:

Predictions:

Procedures:

-Weigh 100 ml of each oil sample and record the mass
-Calculate the density of each oil sample

Calculations for Liquid Density:

Density = mass/volume

-Convert initial measurements (grams/milliliter) to kg/m^3 and pounds/gallon

***Oil Density**

Oil	Mass	Density (grams/milliliter)	Density (kg/m^3)	Density (pounds/gallon)

Helpful conversions:

1 kilogram=1000grams
1 m^3=1,000,000 milliliters
1 lb=.453592 kg
1gallon=.003785 m^3

Oil	**Room temperature, refrigerator, or freezer**

Observations:

Questions:

What chemical characteristics of vegetable oils might determine their chemical and physical properties?

What data could be collected to help determine which oil would be the best for biofuel production?

Lesson Plan

Source of biofuels – chemical and physical properties of vegetable oils: viscosity and temperature

Day 2
Measuring oil viscosity

Note: Italicized words are potential script for the teacher.

Introduction

- Have students form the same groups as before.
- *Today is Day 2 of your experiment.*
- *Each group needs to collect their bottles of oil and bring them to your table.*
- *You will make observations about the oil in the bottles.*
- *Did temperature change any of the oils?*
- *You will conduct a series of tests to determine the viscosity of each oil.*
- ***Between each observation return chilled bottles to the refrigerator or freezer*.**

Procedures

- Collect all 3 of the bottles and place them side-by-side.
- Observe each bottle and record any changes in the appearance of the oil (Did temperature change any of the oils?).
- Measure and record the temperature of the oil in each bottle.

- Invert the bottle and observe the marble dropping through the liquid.
- With the stopwatch, try to measure the time it takes for the marble to drop from one line on the bottle to the other when you invert it. (This may be hard to do because the marble drops so quickly).

- Let's try another technique.
- Place the bottle on its side with the cap resting on a film canister or other small object. This makes a gentle ramp for the marble to roll down. If the ramp is not

very steep, the marble will roll through the liquid slowly enough for you to time it.

- Raise the end of the bottle so that the marble rolls to the cap end. Place the end of the bottle down quickly but gently.
- Use the stopwatch to measure the time it takes for the marble to roll from one line on the bottle to the other.
- Record the time in the data table.
- Repeat four more times and calculate the average time for the each oil sample.
- Repeat steps #7 through #10 to obtain the results for each oil sample at each temperature.
- Graph the relationship between temperature and viscosity for each oil sample.

Cleanup

- *When finished collecting your data, return the bottles to the designated area.*
- *Return any additional supplies used during your experiment.*

Go over report guidelines

- Hand out report guidelines
- Briefly go over report guidelines

Data Sheet
Oil temperature &Viscosity

Observations:

Did temperature change any of the oils?

***Between observations return bottles to the refrigerator or freezer so they stay cold.**

Oil	Temperature	Time	Average time for each oil
		Trial #1: Trial #2: Trial #3 Trial #4:	
		Trial #1: Trial #2: Trial #3 Trial #4:	
		Trial #1: Trial #2: Trial #3 Trial #4:	

Graph the relationship between temperature and viscosity for each oil on a separate sheet of paper.

Questions:

Over what temperature range could biofuels be used?

Why would this be important?

Experiment Follow-up
Source of biofuels - Temperature &Viscosity

1. Answer your research question.

2. Was your hypothesis right? Provide data to support your answer.

3. What was one thing about your experiment you didn't expect to happen?

4. If you were to repeat this experiment, what is one thing you would do differently?

5. Is there any part of your experiment you feel you could do better? What? How?

Final Report Guidelines

Your biofuels viscosity and temperature report needs to have the following sections. Use your data, observations, and questions to help you write your report. Be creative and include as much information as possible. You need to include graphs in your report, this will help the reader understand and interpret your data.

1. Cover page/title
   - Separate page
   - Title (should tell reader something about your experiment)
   - Names of your group members
   - Teacher's name
   - Class

2. Table of contents
   - List each section of your report and the page

3. Materials and supplies

4. Research question section
   - Write the heading
   - Write the question you were trying to answer with your experiment.

5. Hypothesis section
   - Write the heading
   - Write your hypothesis

6. Prediction section
   - Write the heading
   - Write down your predictions

7. Procedures section
   - Write the heading
   - Write the procedures, numbering each step

8. Results section
   - Write the heading
   - Discuss your results

9. Conclusion section
    - Write the heading.
    - Address the following questions
        - Did your results support or falsify your hypothesis?
        - Were there any errors in your experiment?
        - How would you change this experiment if you did it again?
        - If this experiment continued, what would be your next research question?

Source of Biofuels

Making Biodiesel – Dr. Pepper Style (Pat. Pending)

Description

This activity was developed using Tilly's World Famous Dr. Pepper Technique available on the Collaborative Biodiesel Tutorial website. This activity demonstrates how biodiesel is made using a chemical process called transesterification; students will identify byproducts of biodiesel; and students will participate in discussions on current and future needs for alternative and sustainable fuel sources.

Cautionary Notes:

- Strict supervision is required during this experiment.
- Demonstrate and practice proper lab techniques.
- ALWAYS have running water available.
- NEVER inhale ANY vapors.
- Chemical proof gloves, aprons, and eye protection are REQUIRED during this experiment.
- Long-sleeve shirts, full shoes, and pants are REQUIRED in lab area.
- NO shorts or sandals are allowed in the lab area.
- Chemicals are dangerous/poisonous when improperly handled.
- Methanol is poisonous if absorbed through the skin, inhaled, or consumed.
- Methanol can cause blindness and death if handled improperly.
- Sodium hydroxide in caustic soda, NaOH, and lye can cause severe burns and death if handled improperly.

Student Outcomes

- Students will learn the chemical process of making biodiesel.
- Students will practice using safe lab techniques for conducting a chemical experiment.
- Students will investigate the environmental and economic benefits of biodiesel.
- Students will demonstrate an understanding of the chemical process and reactions in biodiesel production.

Standards

Time Estimates

- One 50-minute class period.

Materials

- 1 liter of Unused oil
- 6 grams of NaOH (lye/caustic soda)
  -NaOH is used as a drain cleaner and can be found next to Drano
- 250ml of methanol
  -HEET® Gas-Line Antifreeze in the yellow bottle is methanol and is available in auto supply stores
- 1- 2 liter Dr. Pepper bottle in sound condition with the top and dry inside
- 1- measuring cup to measure 250ml methanol
- 1- lab scale to measure 6g Na OH
- 1- teaspoon
- 1- glass sealable container to mix methanol and NaOH
- 1- funnel
- Pan to heat the oil
- Stove for heating oil
- Thermometer
- Lab gloves
- Lab aprons
- Safety goggles

Vocabulary

Biodiesel: A fuel comprised of mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats. It is a clean burning alternative fuel, produced from domestic, renewable resources.
Glycerin: A byproduct of biodiesel.
Methanol: A chemical compound with chemical formula CH_3OH. It is used to make biodiesel.
Methoxide: An organic salt with the chemical formula CH_3O^-. It is a conjugate base of methanol.
Transesterification: The chemical process used to make biodiesel whereby glycerin is separated from fat or vegetable oil. The process leaves behind two products -- methyl esters (the chemical name for biodiesel) and glycerin (a valuable byproduct usually sold to be used in soaps and other products).

Background Information

Background knowledge in organic chemistry and chemical reactions is required.

Lesson Plan

Day 1 – Making Biodiesel

Extensions/Resources

Biodiesel – The Official Site of the National Biodiesel Board
www.biodiesel.org/resources/biodiesel_basics/

Greening Schools – A project by the Illinois EPA and Waste Management and Research Center (WMRC)
www.greeningschools.org/resources

Biofuels.org – Using Biofuels in the Classroom
www.teachbiofuels.org/index.html

Collaborative Biodiesel Tutorial – Tilly's World Famous Dr. Pepper Technique
www.biodieselcommunity.org/makingasmallbatch

Lesson Plan
Making Biodiesel

Source of Biofuels
Making Biodiesel - Dr. Pepper Style
(Pat. Pending)

Teacher Preparation
Prior to class, make an announcement about the upcoming activity. Inform students they need to wear long-sleeved shirts, pants, and complete shoes on the day of the lesson. For safety reasons, students who fail to wear appropriate lab attire will not be able to actively participate. Prepare lab stations with all required materials and safety equipment. Make sure safety equipment is readily available and in good condition in the event of an emergency.

Note: Italicized words are potential script for the teacher.

Introduction
With efforts to reduce our dependence on foreign oil and decrease global warming, biodiesel is gaining popularity as a clean burning alternative fuel. The emissions from biodiesel have been rigorously tested, and have been proven to have significantly fewer environmental and human health effects than petroleum diesel. Since biodiesel is produced from domestic, renewable resources, it not only supports our national economy, but it is more sustainable than petroleum diesel. City transit systems, national parks, government agencies, schools, and many farmers across the country are fueling their buses, trucks, and tractors with biodiesel.

Today, we will make a small batch of biodiesel using Tilly's World Famous Dr. Pepper Technique. The chemicals used to make biodiesel are available in most large shopping centers; however, they are still very dangerous and need to be handled with EXTREME caution. Before we begin we need to go over a complete list of proper lab techniques and procedures.

Go over proper lab procedures and safe handling techniques for mixing chemicals

Oil Preparation

- Add the oil to the pan and heat until it reaches 55°c.

METHOXIDE IS A POISON!! DO NOT BREATHE THE VAPORS. WASH OFF ANY SPLASHES IMMEDIATELY. DO NOT MIX THE

METHOXIDE IN A PLASTIC SOFT DRINK BOTTLE AS THE NaOH ATTACKS THE PLASTIC AND YOU WILL QUICKLY BE SHAKING A BOTTLE FULL OF HOLES WITH METHOXIDE GOING EVERYWHERE.

Making the Methoxide

- Measure 250ml of methanol
- Measure 4 grams of NaOH
- Mix the methanol and NaOH in the sealable glass container at your table to form the methoxide.
- Tightly seal the glass container once.
- Begin gently shaking and swirling the mixture.
- While the solution is being mixed the temperature will increase begin to increase, this is normal.
- NaOH and methanol do not readily mix, so this step will take a little time and patience – 10 minutes.
- When all the NaOH is dissolved the solution is fully mixed.
- Evaporation may occur during the mixing process. If this happens top the methanol up to 250ml using fresh methanol.

Making the Biodiesel

- Measure the oil temperature – it needs to be ~55°c.
- Using the funnel, pour the liter of oil into a DRY Dr. Pepper bottle
- Using the same funnel, pour the methoxide (mixture of methanol/NaOH) on top of the oil in the Dr. Pepper bottle.
- Remove the funnel and set aside.
- TIGHTLY screw down the lid of the Dr. Pepper bottle.
- Shake vigorously for 10 seconds (40 good shakes).
- Do not be concerned, no appreciable pressure is generated during this time.
- Place the bottle on the table.
- Within 10 minutes the by-product of biodiesel (glycerin) begins to separate and form an increasing layer on the bottom of the bottle. The amount of glycerin will be equal to the amount of methanol that was originally added to the biodiesel.
- Allow the bottle to rest for an hour to allow all the glycerin to separate to the bottom.
- The bottle now contains a layer of lighter colored biodiesel on top of a layer of glycerin.
- The biodiesel will be cloudy, so allow it to sit for one or two days to clear.