Creative Discovery Museum Lesson Plan
Biofuels Outreach Lesson
“Farming for Fuel”

Time Needed for set-up (45 min. to 1 hr.)
Class time - 1 hour

This series of activities is designed to be presented as an inquiry-based lesson introducing the concepts connected with creating biofuels and the need to change to alternative energy sources for transportation. Each activity could be taught individually if the intent is to cover the concepts in depth instead of as an introduction to the topic. This lesson is designed to consist of a 15 minute introduction including the carbon demonstration and experiment followed by 5 student activity centers through which the students rotate for approximately 5 minutes each. That is then followed by a 5 to 10 minute wrap up of the concepts introduced. Possible recording sheets can be found at the end of this plan.

Target Age/ Audience: Grades 4 – 8
Main Concept:
Alternative energy sources, with an emphasis on biofuels made from non-food plants, are appropriate for transportation. Using alternative energy sources does not add as much CO₂ into the atmosphere as using fossil fuels does, and the carbon cycle can remain more balanced. A non-food product for fuel is important since food shortages often occur around the world.

Objectives of the Lesson:
(These objectives can be written on cards and placed at each center to encourage greater comprehension by students.)

- Fuel production from the fossil fuel sources, which are quickly being depleted, currently in use are more harmful to the environment because carbon dioxide they release a greater amount of CO₂ into the atmosphere. (Intro & Demonstration)
- Our current engines use liquid fuels, which are being depleted, for their power source. Biofuels, renewable sources of energy, can replace current fuels. (Center 1)
- Plants must be processed in order to release the energy stored in them. Some biofuel sources are not good choices since they are also food crops. (Center 2)
- Sugar is the energy source we use for our bodies and will be the energy source for new biofuels. (Center 3)
- Thick cell walls of plants must be broken down to release the sugar that is wrapped in lignin and cellulose. (Center 4)
- Current vehicles that use other alternative types of energy such as solar, wind, electricity for all their power are impractical for current engine technology.(Center 5)
Introduction

Answering the main problem:
Why do we need to stop using gasoline in our vehicles and factories?
Answer: Because it is putting too much carbon dioxide into the air.

CARBON DEMO:
Show students a large piece of coal and a cup of raw oil. These natural resources are formed from carbon deposits captured in the earth and compressed over millions of years.

Questions:
- Does anyone know how the carbon got in the earth? (It comes from decaying plants and animals.)

Background Information: Coal mines permanently alter the landscape. We do not know how long will it take for the environment to recover after the coal has been mined. This does not consider the CO₂ added to our pollution caused by the burning of this coal.

- What do we do with the carbon when we consume it? (We use the carbon as the oil and gas in cars, and in factories as oil or coal for heating. Burning coal is also the main source for generating electricity in the United States.) U.S. gets 49% of its power from coal. However, transportation uses predominantly oil. A barrel of oil contains 42 gallons. After refining, it makes about 19.5 gallons of gasoline in addition to numerous other products such as heating oil.

- What problem does this present to the earth? (The use of fossil fuels is one of the main causes of pollution. When that carbon is released into the air through burning – by using it to power vehicles or to heat factories – then it mixes with oxygen and becomes carbon dioxide. This is heavier than the other gases in our atmosphere and does not allow the warm rays of the sun to escape the atmosphere at night.)

Bring up 6 students up to hold the Carbon Cycle Cards. The cards include pictures on the front taken from the carbon cycle picture above. (source: http://eo.ucar.edu/kids/green/cycles6.htm) Students can also make their own symbol to portray their part.

- Sunlight - provides energy to plants to make food we call sugar. Plants use the sun’s energy to take CO₂ from the air and hydrogen from water to make a complex sugar using carbon, hydrogen, and oxygen. (C₁₂H₂₂O₁₁). This happens in the chloroplast of the cell.
- Photosynthesis – the process through which plants make food while giving off oxygen and using carbon dioxide from the air.
Decaying plants and animals – When plants and animals die, their carbon goes into the ground and is found in fossils and oil.

Plant and animal respiration - When plants and animals breathe, they give off carbon dioxide and oxygen into the atmosphere.

Auto and Factory Emissions - The Carbon cycle is in balance in nature, but when humans add CO\textsuperscript{2} from cars and factories the cycle gets out of balance.

CO\textsuperscript{2} Cycle – Carbon Dioxide collects in the atmosphere and is heavier than the other gases. It does not let the heat get away from the Earth at night so the atmosphere gets warmer causing global warming.

Carbon Dioxide experiment:
1\textsuperscript{st} Option: Have a student come up and pour carbon dioxide from a beaker with dry ice in the bottom over a candle flame. Be sure to have gloves when placing the dry ice in the beaker. The carbon dioxide is heavier than the air and smothers the flame when no oxygen can get to it. (Fire must have oxygen to burn.) Question: How does this relate to a car engine’s function? (The burning of fuel requires oxygen taken into the engine.)

2\textsuperscript{nd} Option: Carbon dioxide is the product given off when yeast is working to digest sugar in a solution. This experiment shows the carbon dioxide that is produced as it pushed the other gases into the balloon.

Directions:
1. Using the funnel, add 3 teaspoons of baking soda to each balloon.
2. Fill each bottle 1/3 full with vinegar.
3. Without dropping in the baking soda, fit the balloon over the bottle opening.
4. Hold up the balloon and let the baking soda fall into the vinegar.
5. Watch as the baking soda mixes with the vinegar to make carbon dioxide gas and blow up the balloon.

What's Going On?
The vinegar mixes with the baking soda to create a chemical reaction that produces carbon dioxide gas. The gas then blows up the balloon.

Source: [http://www.familieswithpurpose.com/funwithgas.html](http://www.familieswithpurpose.com/funwithgas.html)
Introduction to Activity Centers:

What can we do to solve the problem of too much carbon dioxide in the atmosphere? Take all answers. Refer back to the information given in the carbon demonstration explanation.

Is there any other liquid that we could use to power our vehicles now? Take all answers. Students may be aware of ethanol made from corn that is mixed with gasoline or have heard about experiments using cooking oil or other products to create a liquid fuel.

Tell the students that today we are going to be learning about a variety of ways to power our vehicles that will decrease the amount of carbon we are putting into the atmosphere and use renewable sources instead of fossil fuels. Then introduce the activity stations.

Activity Centers: (Walk around to each station as it is introduced.)

- **Center 1** – Current engines use liquid fuels, which are being depleted, for their power source. Biofuels, renewable sources of energy, can replace current fuels in current engines.
  - **Center set-up:** Try to have several models of a gasoline engine with labels so students can learn the parts of what powers the current cars. If you have a shop automotive class that can cut off the outside casing to show the parts, students will be excited to explore how it works. (See materials for small model of piston engine) Students will have a picture to label with the parts of the engine.

- **Introduction:** Show a model of an engine and explain that this is part of the engine that powers your car at home. **Explanation:** By using biofuels from no-food sources that are perennials, we can cut down on the CO\(_2\) added to the atmosphere. When the gasoline is mixed with air and sprayed into the sparkplug area, it explodes, causing the piston to move.

- **Question:** Do you think you could use a biofuel in this engine? Why or why not? (Yes, because it is also a liquid fuel that burns like gasoline. Explain that changing to a biofuel is better than other alternatives that would require development of different engines than an internal combustion engine.)

- **What parts of an engine can you name?** (Show and explain parts of engine referring to the model.)

- **Activity:** Students will label the parts of an engine and read what each part does as they find it.
Center 2 – Plants must be processed in order to release the energy stored in them. Some biofuel sources are not good choices since they are also food crops.

- **Station set-up:** There will be 3 mortars and pestles in which students can grind soybeans and corn (cracked and whole). A mechanical grinder can be used to demonstrate later technology and ease of grinding. A bio-refinery activity which consists of grass, a small mortar and pestle, pretreatment container, container with “enzymes” and container with “microbes,” and a delivery truck.

**Introduction:** Show a mortar and pestle and grinder and demonstrate how they are used to create edible food from plants. **Explanation:** Corn is an annual crop which requires tractors, fertilizing, and more vehicle time.

The harvesting of annual food crops puts more CO$_2$ into the atmosphere than harvesting switchgrass, which is a perennial and requires very little fertilizing.

**Question:** What foods do you eat that contain corn? (Include cornbread, corn flakes, ketchup, some noodles)

- **What makes the price of these foods increase?** (A limited supply of corn, especially if corn is being used for non-food purposes.)
- **What plants that are not food sources could we use to make fuel?** (switchgrass, tree bark, algae – these are plants that scientists are currently working with to create biofuels.)

**Demonstrate how the grass goes through the process at the refinery to become a biofuel.

**Activity:** Students will use the grinder and mortars and pestles to grind corn and soybeans. They will cut a small portion of grass and take it through the process of refining it into fuel.

The picture on the left is a model of the biofuel processing plant on the right. Each bottle is labeled with the description and explanation of the contents: Students can do the following as they read and discuss the labels:

1. **Cut a little of the grass grown or picked from outside (grass in this picture is wheat grass)** (LABEL on Board: Biomass is harvested and delivered to the biorefinery.)
2. **Put a little bit of the grass in the mortar and pestle to try to grind it up.**
3. **Remove the lid of the first bottle with the label.** (LABEL on bottle 1: Biomass is cut into shreds and pretreated with heat and chemicals to make cellulose accessible to enzymes.)
4. **Through the pour spout, pour liquid from bottle 1 to bottle 2 which has very small glass beads to represent Enzymes.** (LABEL on bottle 2: Enzymes - a bio-molecule that catalyze (i.e., increase the rates of) chemical reactions. Any complex chemical produced by
living cells that is a biochemical catalyst. Stain removers like Shout have enzymes that can breakdown grass stains.)
5. Through the pour spout, pour liquid from bottle 2 to bottle 3 which has slightly larger elongated beads to represent microbes. (LABEL on bottle 3: Microbes – microscopic one cell organisms. Microbes are used in fermentation to produce ethanol and in biogas reactors to produce methane. Scientists are researching the use of switchgrass to produce liquid fuels.)
6. Fuel Tanker delivers fuel to station. Through the pour spout, pour liquid from bottle 3 into small cups in a toy truck to be delivered to the fuel station which can be represented by a cup with the picture of a gas station on it.

- **Center 3** – Sugar is the energy source we use for our bodies and will be the energy source we use for our cars.
- **Set-up:** Set up cups containing juice, soda, cow’s milk, soy milk, and grass tea. Each one will have a corresponding dropper with which students can take samples and measure sugar content on the refractometer. (listed in materials)
- **Directions:** Put several drops of a liquid on the screen of the refractometer. If LLL shows up – put some more liquid on and try again to get a reading. Be sure to wipe off screen after each test.
- **Question:** What do our bodies get from food that gives us energy? (Sugar)
- **Do you know which one of these has the most sugar in it?** We are going to perform a test to find out.
- **Introduction:** Demonstrate how to use the refractometer. Explain how to fill in the graph to show the sugar content of each liquid. (Tell the students if they get an LLL, that their sample is not large enough.)
- **Explanation:** Compare the fact that our bodies use sugar for energy, that plants use sugar created by photosynthesis to grow, and that cars can use ethanol made from sugar for power.
- **Activity:** Students will test the sugar content of each liquid and fill out the graph to indicate how much sugar each contained.
Center 4 - Thick cell walls of plants must be broken down to release the sugar that is wrapped in lignin and cellulose.

Set –up: There will be specimens of blades of grass and tree leaves to examine under a Dinoscope (small microscope connected to a laptop) so that students can compare the tree leaf with a grass blade to see the thicker cell wall on the blade of grass. The Dinoscope, that is connected to a laptop, will be available for students to look at the leaves and grass blades as well as slides of other plant cells. There will also be several cell models to provide answers to discussion questions about the parts of the cell.

Introduction: Explain to the students that when we want to look at something very small, we have to use a microscope. This Dinoscope is connected to the computer to allow them to see a large picture of something very small. They will be looking at a variety of leaves and grass to see if they can find the cells. Students can also examine their own skin and compare their cells to those of plants.

Explanation: Look at the difference between the cells of the grass and that of the leaves of annual plants that do not stand up like grass. Slides give a closer view of the actual cells. When looking at skin, you are looking at the top tissue layer, not the individual cells.

Question: Do you think you will see a difference between the types of leaves? (Grass leaves will have a thicker cell wall because there is lignin in their cell wall. The cell wall contains the sugar used to make ethanol. Lignin is what makes grass and trees stand up straight.)

What part of the cell would scientists need to change to make a thinner cell wall? (DNA found in the nucleus. Scientists are working on changing the DNA to lessen the thickness of the cell wall so they can get the sugar out of the cell more easily.

Activity: Students will examine the leaves and slides samples under the Dinoscope and answer the questions on their recording sheet.
• **Center 5** – Alternative vehicles, that employ alternative types of energy, such as solar, wind, electricity for power are not widely available due to cost. Existing internal combustion engines can use biofuels with only minor adjustments to their internal seals.

• **Set-up:** This center will contain solar cars, hydrogen cars, and wind cars. Solar lights, fans, and power cords must be available. Students will also have graphs to complete or they can compete with each other. There can also be pictures of current vehicles using these technologies.

• **Introduction:** Explain to students that these types of experimental vehicles, that use alternative forms of energy, have already been developed. Show pictures and models of solar, hydrogen, and wind cars.

**Explanation:** Biofuels is a short term solution that puts less CO₂ into the atmosphere until the future technologies can become widely used.

- **Question:** With the solar and wind car, ask: What is the power source for this vehicle? (Sun, wind)
- **What are the elements in water and how could we use these elements to power a car?** (Water is made from hydrogen and oxygen. This car separates the hydrogen and oxygen with electricity and the hydrogen powers the car.)

- **Why are these alternative vehicles impractical for general use by the public?** (Wind cars – what do you do if there is no wind? Solar cars – It takes a huge amount of solar cells to power one vehicle. They won’t work well at night. Hydrogen cars -Water is very heavy, and it takes longer to power the car than it will run. Also, hydrogen is a very light gas and hard to contain efficiently.)

- **Activity:** Students will experiment with hydrogen fuel cells in model cars. They should record how long and/or how far the car runs on the power provided.
Wrap-up – (5 to 10 min.)

Did we find out the answers to our questions and problems??

- Walk around to each station and do a quick review emphasizing the main objective of each station:
  - **Center 1** – Ask the students which fuel they think will be the best choice by the time they are adults and why? Talk about short term solutions and long term solutions. (Short term solution– new biofuels; long term solution – create new types of engines, possibly hydrogen powered, that are now expensive to make individually and not prone to mass production.)

Have a student hold up the objective card from the station and read it: **Our current engines use liquid fuels, which are being depleted, for their power source. Biofuels, renewable sources of energy, can replace current fuels.**

- **Center 2** – What problems are there with using the corn or soybean-based biofuel that is presently being made and used in some vehicles? (Increase in cost because of supply and demand. CO2 released by vehicles necessary for planting the crops.)

Have a student hold up the objective card from the station and read it: **Plants must be processed in order to release the energy stored in them. Some biofuel sources are not good choices since they are also food crops.**

- **Center 3** – Where you get your energy for your body? (Sugar.)

Have a student hold up the objective card from the station and read it: **Sugar is the energy source we use for our bodies and will be the energy source for new biofuels.**

- **Center 4** – What is the difference between your skin cells and plant cells? (Your skin cells have only a thin membrane as a cell wall and plants have a thick cell wall containing sugar and lignin.)

Have a student hold up the objective card from the station and read it: **Thick cell walls of plants must be broken down to release the sugar that is wrapped in lignin and cellulose.**

- **Center 5** – Why are the alternative energy vehicles that you explored less practical than a biofuel would be? (Wind cars – what do you do if there is no wind? Solar cars – It takes a huge amount of solar cells to power one vehicle. They won’t work well at night. Hydrogen cars -Water is very heavy, and it takes longer to power the car than it will run.)

Have a student hold up the objective card from the station and read it: **Current vehicles that use other alternative types of energy such as solar, wind, electricity for power are impractical.**
Possible Student Recording Sheets for Activity Centers
(Feel free to create your own to help your student’s understanding.)

Name: _____________________

Compare your cars

<table>
<thead>
<tr>
<th>Car</th>
<th>Power Source</th>
<th>Time to Charge</th>
<th>Distance Traveled</th>
<th>Time Car Runs</th>
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</thead>
<tbody>
<tr>
<td>Sail Car</td>
<td>No charge necessary</td>
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<tr>
<td>Solar Car</td>
<td>15 min.</td>
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<td>Hydrogen Car w/ battery power</td>
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Sugar Quantities in Liquids- make a bar graph to show the percentage of sugar in the liquids below. It is the sugar we get from the plants that we will use to make biofuel. Round to the nearest percent.

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<tr>
<th>Amount of Sugar</th>
<th>Grass Tea</th>
<th>Coke</th>
<th>Soy milk</th>
<th>Cow milk</th>
<th>Corn syrup</th>
<th>Fruit juice</th>
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Parts of a Cell Questions

1. The nucleus of the plant controls how the cell grows and develops. What part of the nucleus are scientists trying to change? __________ so the cell will have less lignin blocking the sugar. __

2. What part of the cell provides food through photosynthesis? This food is the sugar we use to make biofuel. ____________________________________________

The cell membrane controls what comes in and what goes out of the cell. If we can change the DNA to make it weaker, it will be easier to get the sugar out of the cellulose.

3. What do you think it lets in? ____________________

4. What do you think it lets out? __________________

Standard Cylinder Type Engine – Can you see how biofuel would work in current engines??
Please use these parts to label the blank parts of your engine picture.

The **Crankshaft** is at the bottom of the engine & turns the pistons up and down motion into a circular motion just like a crank on a jack-in-the-box does. This circular motion is then transferred to the wheels of the vehicle.

The **sump** surrounds the crankshaft and contains the gas explosion from the fuel. It contains some oil which collects in the bottom of the engine. The lubrication system is fed by the oil sump that forms the lower enclosure of the engine.

The **connecting rod** connects the piston to the crankshaft. It can rotate at both ends so that it’s angle can change as the piston moves and the crankshaft rotates. With this motion, it moves the crankshaft which moves the wheels.

The **piston** is in the middle of the engine cylinder and is a cylindrical piece of metal that moves up and down inside the cylinder, It must withstand the heat generated when the fuel explodes.

The **spark plug** supplies the spark that ignites the air-fuel mixture so that combustion can occur. If we change from gasoline to biofuel we will still use a sparkplug to ignite the fuel.

The **valves** open at the proper time to let in air and fuel and to let out the exhaust. The fuel can not burn without air. **Circle the 2 valves**

The **piston rings** provide a sliding seal between the outer edge of the piston and the inner edge of the cylinder. They prevent fuel from leaking into the pump.
Background information (attached)

http://videos.howstuffworks.com/howstuffworks/2-how-diesel-locomotives-work-video-video.htm


Vocabulary Words Addressed: renewable, energy, environment, solar, pollution, biofuel, emission, fossil fuel, carbon cycle, hydrogen, internal combustion engines, lignin, cellulose, ethanol

Materials List & Possible sources for purchasing materials:

For Demo and Carbon dioxide experiment - Carbon cycle cards
*CO2 demo – 1st option - Candle, Tongs, Hammer, Matches, Balloons & Test tube, Gloves
2nd option - Balloons; Small funnel or a small piece of paper rolled up in a funnel shape; Baking soda Vinegar; Clean, empty 8 or12 ounce plastic soda bottle.

Center 1 - Engine model -(www.sciencekit.com, $39.95/piece)

Center 2 - 1 large mortar and pestle, (www.importfood.com, $18.95/each)

1 mechanical grinder (Pleasant Hill Grain, Hampton NE, #402-725-3835, 119.95/piece)
catch container for grinder, 1 small mortar and pestle, (www.fantes.com, $9.99/piece) dried corn kernels, dry soybeans, print a copy of Carbon Cycle picture and small refinery picture (below),

Biofuels refinery materials - 3 bottles with pull tops, 1 small mortar/pestle, 1 toy tanker truck
Plastic cup with gas station picture, Food coloring (color the water in the first bottle yellow)Board base to attach bottles to with Velcro.

Center 3 - 2 refractometers
(Pulse Instruments, Van Nuys CA, #818-909-0800, $280.25/piece)
Wipes, Paper towels, 6 eye droppers, 6 paint cups
Materials for liquids testing: Corn syrup (mix with at least 25% water), 2 green tea bags, Coke, Cow’s milk (powder), Soy milk (powder), Juice

Center 4 - Laptop Computer, Cell model (www.sciencekit.com, 17.95/piece)
Microscope slides of corn kernels, plants, and animals.
Dinolite and stand (Educational Innovations, Inc., Norwalk CT, #203-229-0730, $225.00/piece)

Center 5 - Distilled water for hydrogen cars, Bottle for filling cars,
2 hydrogen cars, (Pitsco Education, Pittsburg KS, #(800)835-0686, $249.00/piece)
Air bottle (for drying hydrogen cars), Power strip, Extension cord
K’Nex kit for solar cars, (www.sciencekit.com, $195.00/piece)
2 90W spot lights, Station cards, Small Box Fan, Sail car (www.sciencekit.com, $19.95/piece)
Source: http://eo.ucar.edu/kids/green/cycles6.htm

High resolution available at: