Curriculum Units by Fellows of the National Initiative
2011 Volume V: Chemistry of Everyday Things

Survival Chemistry: Using Everyday Things to Create Energy and Drinking Water

Curriculum Unit 11.05.05, published September 2011
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Introduction

Sustainability is defined by the EPA as "the policies and strategies that meet society's present needs without compromising the ability of future generations to meet their own needs" (1). President Obama has addressed sustainability, noting that in the next 100 years, Energy, Clean Drinking Water, and Food Production are going to be critical priorities for the success of our nation. The president further noted that to improve the quality of life for all Americans, we need to renew our commitment to science, technology, and innovation (2). With this in mind, the question for us as educators becomes, 'how can we create future critical thinkers and problem solvers that will understand the necessity of sustainability and yet still be prepared to tackle the upcoming energy and water crises of our planet?'

Teachers agree that there should be more hands-on activities. However, in a recent staff development of Science teachers, I conducted a survey and was shocked to find that only 14% of the teachers surveyed conducted **any** laboratory experiments (labs) or demonstrations (demos) in their classrooms. Surprisingly, the reason most often cited for this was not the lack of equipment. Rather, most teachers surveyed felt that students did not have enough of "the lab basics", were not emotionally ready, or were not "mature enough" to participate in labs. Teachers usually justified their statements with an addendum that expressed that, because of these deficiencies in skills, students would not be able to "get anything out of the lab anyway". I thought about what an unfortunate predicament this was for our students. Because students did not have any experience in labs, they would not be allowed to participate in labs. The second reason for not conducting labs or demos was that the labs were "too complicated to setup and breakdown". Upon further questioning, I determined that teachers looked at the issue from this perspective: if one lab or demo was performed per week, then there would be 38 labs or demos to prep for and clean up after. Further, the space requirement and organization of chemicals and equipment could become daunting. The third reason cited for not conducting labs and demos was that the labs held no relevance to the students and did not help to further their transference of learning (and scoring) on state exams. Transference of learning is a major issue in urban school environments, since our students do not necessarily have the same opportunities to explore and experience the world as other students in neighboring rural districts. Also, teachers felt that labs were "not useful because following directions and going through a lab [did not] help students understand the science or how to answer the question right on the [state end of course test]". This viewpoint seemed inherently illogical to me, as the whole purpose of hands on experimentation is to learn how to transfer information from one context to another. Transference is essential since our students are entering a global society in which original content stays the same but the framework that distributes that content is ever evolving. My unit will address these three issues to overcome the 'roadblocks' that are dissuading/preventing teachers from implementing labs and demos in the classroom.

This unit is designed for High School Chemistry students, which usually includes 10 th , 11 th , and 12 th graders. It is designed to extrapolate an entire year's worth of engaging, hands-on activities from the three foundational experiments in this unit, with the students becoming 'master high school chemists' by year's end. By using the repetition of materials and procedures from experiments, there will be an added benefit to the teacher of minimal preparation time, as well as minimal cleanup time, since the students will gradually take on more responsibility for this part of the process. By focusing on everyday life products such as diesel, soap, gasoline, and clean water that are all created from 'everyday items', students will be able to relate the value of Chemistry in 'Everyday Things'.

Background and Rationale

I teach in an Urban High School that has a demographic population of 98% African-American, 1% Hispanic, and 1% Caucasian students. My typical student is a 10 th to 12 th grader, enrolled in Algebra II, and has difficulty transferring Science and Math solutions to real world problems. Most of my students dread Math, and view Science as irrelevant to their lives. I intend to change this paradigm for my students by allowing them to master useful science skills that they can visualize to have a positive impact on their lives for years to come.

As a fourth year teacher, I realize that what motivates my students is my passion for a topic combined with them discovering, through inquiry based learning, aspects of the world around them that had gone unnoticed before. Supporting them in becoming masters of their own environment transforms their perspective on life, and overcomes barriers of racial issues, low self-esteem issues, and not understanding how to cope with their world. I want to have students experience everyday Chemistry in such a way that they can visualize the way the world works. Since Energy and Clean Water will be 'hot topics' for the next hundred years, I look forward to seeing my students become active participants in our global society.

Constructivist theory, scaffolding, and spiraling are three pedagogical approaches that will be intertwined throughout the unit. The constructivist theory is that "children learn best when given the opportunity to construct knowledge from their own experiences" (3). Thus, having students conduct 30 experiments that the students merely follow a set of directions will not have as much value as having my students conduct the same 3 experiments ten times, each time analyzing and thinking about a different facet of the experiment and each time gathering new lab skills. This latter aspect is referred to as spiraling, the pedagogical approach that has students revisiting a topic, but looking at it from a different viewpoint. Scaffolding is a pedagogical approach that uses consecutive skill sets to teach something. The skill sets are taught in an order such that skill 3 needs skill 2, and skill 2 needs skill 1. Thus, if you wanted to teach someone how to balance their checkbook, you would first teach them how to identify and count money, then how to add and subtract money, and finally how to balance their checkbook. In combining these three pedagogical approaches with three complex experiments and topics that could very well impact our nation's future, I hope that students will become comfortable taking risks, analyzing their manipulations of a topic, and adjusting their process moving forward (4).

Biodiesel – The Science and The Process

Biodiesel is a diesel fuel that can be used in any unmodified diesel engine. It is an excellent lubricant, and an excellent organic solvent. Although biodiesel is nontoxic and biodegradable, it can cause degradation in certain types of hose and gasket materials (5). Biodiesel is extremely efficient, and can also reduce global warming and tailpipe emissions, although it may increase nitrogen oxide emissions (6). Biodiesel is usually combined in the commercial market with regular diesel as a substitute lubricant for sulfur. In fact, the U.S. Government has recently mandated that by 2012, all of the diesel fuel sold at gas stations be combined with biodiesel instead of sulfur (7).

Biodiesel is considered a renewable resource because it can be produced from plants and waste vegetable oil, and can be put directly into any unmodified diesel engine. Feedstock is the material that is gathered to produce biodiesel, the most common of which is waste vegetable oil (WVO). The feedstock used is an important consideration when determining the viability of biodiesel since obviously, by producing more crops for biodiesel, we are competing for the same resources used to produce food, inherently increasing the cost of our own food supply. Studies have shown that if we planted every available acre in the United States, we could not actually produce enough biodiesel to meet our demand for supply (8). However, if biodiesel is produced from WVO gathered locally (from restaurants, schools, and hospitals) and produced in small quantities, referred to as microproduction, then biodiesel can become a very viable option that adds to the sustainability of a community (9).

Whatever the feedstock used, it is combined with an alcohol and a catalyst to produce biodiesel fuel (a methyl ester compound). This process is called transesterification. During transesterification, when the fatty acids in the vegetable oil are separated, glycerol is produced as the byproduct (See Appendix A, Biodiesel Production Process). Glycerol can be further utilized to make many products including detergents, soaps, lotions, and fertilizers (10). The table below explains the process using a skeleton reaction:

Table 1: Transesterification Process	
Skeleton Reaction:	Triglyceride + Alcohol $\xrightarrow{\text{Catalyst}}$ Biodiesel + Glycerol
Commonly Used:	WVO + Methanol $\xrightarrow{\text{Potassium Hydroxide or Sodium Hydroxide}}$ Biodiesel + Glycerol

The conceptual process for producing biodiesel from WVO in a classroom environment is simple. Essentially, WVO is collected, allowed to settle, and filtered. For larger quantities, a sample of the WVO is then combined with a solvent mixture (50% isopropyl alcohol, 50% toluene) and titrated with a 0.1% sodium hydroxide solution. The amount of solution needed to complete the titration determines the amount of potassium hydroxide that needs to be added as a catalyst. For beginning Chemistry classes creating microscale amounts of biodiesel, a simple chart can determine the amount of catalyst needed.

The WVO is heated, and the methanol is added (in a 5:1 ratio) along with the catalyst (usually potassium hydroxide or sodium hydroxide). The mixture is stirred and then allowed to settle for the next step. After the mixture is settled, there will be two insoluble layers (biodiesel and glycerol) which need to be separated; since the glycerol is heavier, it will settle and separate below the biodiesel. The glycerol can be drained so that the biodiesel (top layer) is ready to 'wash'. Washing is a term used to describe the final portion of the process that removes any remaining contaminants in the biodiesel. The most common method of washing the biodiesel is called water washing, where water is mixed with the biodiesel and allowed to separate. When this portion is complete, the water (now the bottom layer) is drained, and the biodiesel's pH is tested to ensure that it falls within the tolerable range (5). The washing process is repeated until the desired pH is attained (See Appendix A), at which time the biodiesel is ready for use.

Water Purification, Filtration, and Distillation – The Science and The Process

The topic of clean water (or lack thereof) is a well researched issue that is critical for our survival. Although the social issues caused by lack of clean drinking water are beyond the scope of this unit, the overarching problem must be addressed with students who are most likely unaware that a problem even exists. As one panel with the National Science Foundation put it,

> "One of the most pervasive problems afflicting people throughout the world is inadequate access to clean water and sanitation… 1.2 billion people lack access to safe drinking water, 2.6 billion have little or no sanitation, millions of people die annually – 3,900 children a day – from diseases transmitted through unsafe water… Problems with water are expected to grow worse in the coming decades, with water scarcity occurring globally, even in regions currently considered water rich. Addressing these problems calls out for a tremendous amount of research to be conducted to identify robust new methods of purifying water at lower cost and with less energy, while at the same time minimizing the… impact on the environment." (11)

Even with this urgency, most students are not aware of the differences of water purification, filtration, and distillation. If put in the context of a natural disaster, most citizens are helpless to acquire the basic necessity of life – clean drinking water.

Clean drinking water is usually understood to mean water that is free of pathogens, particulates, waterborne bacteria, enteric viruses, and is generally clear and transparent (4). However, just because water is clear (free from particulates) does not mean that it is safe. Water purification is generally accepted as the multi-step process to remove contaminants from surface or groundwater so that humans can consume it without getting sick. Water filtration is usually understood to mean the process that separates the solids (particulates) from the water. Water distillation is the process of purification of water through vaporization, condensation, and collection of pure water distillate. In a natural disaster, all three processes should be used in conjunction to ensure that water is drinkable (11).

Water purification processes have evolved as technology has progressed. India used the Ultra-Violet (UV) rays from the sun 2000 years ago to purify the water, while today we use UV Lamps to simulate the same effect (12). UV light has been proven effective in the removal of many bacterial pathogens. The germs proven effective to kill with UV light include: bacteria - Escherichia coli, vibrio cholera, salmonella, shigella flexneri, campylobacter jejuni, yersinia enterocolitica, virus – rotavirus, and parasites – giardia, and cryptosporidium (13). Even though UV light can kill these germs, it is important to note that UV light is ineffective at killing viral pathogens. There is, however, currently promising research in using photons combined with engineered nanostructures to catalyze materials that inactivate viruses (13). In analyzing the processes of the past while looking to the processes of the future, better decisions can be made as to water systems that are viable to implement.

Currently, a patented water purifying unit (14) developed by Rolf Engelhard offers a viable purification system that takes weaknesses of other systems into account. This unit will have students recreating the model using everyday parts, and testing the model before placing it in the distillation unit. Essentially, there is a cylindrical column in which water that needs to be cleaned passes through. As the water enters the cylinder, the water is exposed to UV light as the water is forced into a swirling pattern. This allows for germs to be killed before entering the filtering portion of the column. The water then goes through an activated charcoal filtration system that is mounted 'about' the UV light. (14) The inventor noted in his patent that other systems release the water after the charcoal filter, assuming that the water is clean. However, if there are accumulated particulates which themselves had grown bacteria on the exit portion of the activated charcoal, then the system would be rendered useless. Thus, to prevent accumulated germs from recontaminating the water, the water is exposed (for the second time) to a UV light before exiting the purification filter to be prepped for the distillation unit. Once the water is in the distillation system, it can be distilled until the end result is clean, purified, filtered, distilled water.

Bioethanol – The Science and The Process

Ethanol is an alcohol that consists of two single bonded carbon atoms that have a hydroxyl group at the end of the chain. Bioethanol simply refers to ethanol that was produced from a renewable feedstock, and thus for the purposes of this unit, the terms will be used interchangeably. Ethanol is produced when the feedstock is fermented with yeast in an oxygen deprived environment. The fermentation process converts the sugars (usually glucose) from the feedstock into ethanol. The byproduct of this fermentation process is carbon dioxide (15). Thus, the formula looks like this:

Table 2: Ethanol Chemical Process	
Skeleton Reaction:	Feedstock Sugars $\xrightarrow{Catalyst}$ Ethanol + Carbon Dioxide
Commonly Used:	Glucose from Fermented Feedstock $\xrightarrow{Yeast}$ Ethanol + CO_2

Bioethanol is a biodegradable, clear, colorless, extremely flammable liquid that can be produced from corn, sugar cane, and even grapes (16). Due to cost, bioethanol in the U.S. is most commonly produced from corn, while Brazil uses mostly sugar cane. Unfortunately, the entire corn plant cannot be easily fermented, and thus only the corn kernels are used to produce bioethanol. Cellulosic bioethanol is ethanol produced from plant stocks, trees, grass, and other biomass. As opposed to sugar cane and corn whose sugars ferment into glucose, cellulosic biomasses need to have their cell wall components broken down so that the cellulose is exposed. Only then can the enzymes break the cellulose further down into glucose or some other form of sugar so that they can ferment into cellulosic ethanol. Also, cellulosic ethanol needs to be distilled since other biofuels can sometimes form as byproducts (17). Even with all of these drawbacks, however, cellulosic bioethanol deserves further study, since using corn is competing with the nation's food supply. In fact, as with biodiesel, if every available acre of land in the United States planted corn, we could not produce enough ethanol to meet our demand for supply (6). Further, cellulosic feedstock is much more available and can be grown using less water and pesticides than is necessary for growing corn. Waste product cellulosic feedstock that can also be used to produce ethanol include grasses, forest excess growth, city waste, and even some forms of fast growing trees (18).

Bioethanol is already in gas stations across the country, since gasoline now commonly includes ethanol in the mix. Although this works well to increase the octane rating and efficiency in unmodified gasoline engines, ethanol does not have the same energy output as gasoline (10). Although bioethanol produces CO_2 as a byproduct, the net effect is negligible since the CO_2 that ethanol forms when burned was absorbed by the plant as it was maturing. Thus, it is said that ethanol is CO_2 neutral (18).

The process of making bioethanol is complex for larger quantities, but relatively simple for a classroom laboratory. In a sterilized container that can be covered with a flexible top, place water, corn meal, sugar, and yeast into it, and then cover. The cover should be flexible like a balloon or finger portion of a latex glove (allowing one glove to cover 5 containers). Allow the mixture to sit in a warm location for several days, or until the flexible cover stops reacting. If the top comes off, you must start over, as the feedstock needs to ferment in an oxygen deprived container. Decant the solution above the precipitate matter into a container suitable for distillation. Distill the liquid using a condensation column, making sure that you have a thermometer in the boiling flask, being careful to not use open flames as the solution is very flammable. The distillate that condenses at a boiling temperature of 78 C (173 F) is ethanol ready for use as fuel (19).

Objectives

The Unit will be taught over a 6 week period at the beginning of the year. Prior to the unit, the following items will have already been covered:

I. The 12 principles of Green Chemistry – What are they, and what do they mean?

II. The Periodic Table – How to read and interpret atoms, protons, electrons, neutrons, charges, reactions, reactants, and products.

III. The Scientific Method and Design – A brief overview of the steps and concepts, as well as a review of the graphical components of gathering data (X&Y-axes, labeling graphs, isolating one variable at a time, the importance of repeated trials)

IV. Significant Figures and Calculations – A brief overview of how to determine the number of significant figures and apply to operations (multiply, divide, add, and subtract).

The Unit will teach the following objectives:

Organic Molecules	Reaction Types	Electronegativity
Ionization Energies	Reaction Rates	Equations/Formulas
Ionic Compounds	Molar Calculations	Catalysts
Covalent Compounds	Equilibrium	Activation Energy
Dimensional Analysis	Acid/Base Theory	Stoichiometry
Kinetic Theory	Solutions/Dilutions	Gas Laws
Phase Changes	Molarity	Titrations
Heat Capacity	Molar Heat	Enthalpy
Dimensional Analysis		Entropy

Strategies & Activities

The three foundational experiments (biodiesel, bioethanol, and water purification/filtration/distillation) will be performed first by the teacher. The first time that the lab is presented, students will observe the teacher properly building the setup, performing the experiment, disassembling the setup, cleaning the setup, and finally putting the equipment back in the correct location. The students will then create cartoons describing the setup, the experiment, and the disassembly, making sure to specifically label all of the equipment as well as identifying which (in their opinion) is the most important step. The second repeat of the experiment will have the students conducting the experiment on their own, guided by the teacher, with the focus on proper technique and lab safety measures. Students will do their first official 'lab write-up' with this experiment. The third and further repeats of the experiment will have the students manipulating variables and focusing on different learning objectives. The concept is simple: if the students do these labs repeatedly, they will feel comfortable enough to begin thinking critically and learning the objectives at a higher level, while gaining their hands-on lab skills. Further, once this confidence is present, then students will begin deciding which variables they would like to manipulate (if approved by the teacher for safety conditions) so that they can truly begin their own self-initiated inquiry lab experiments.

Lesson 1: Biodiesel

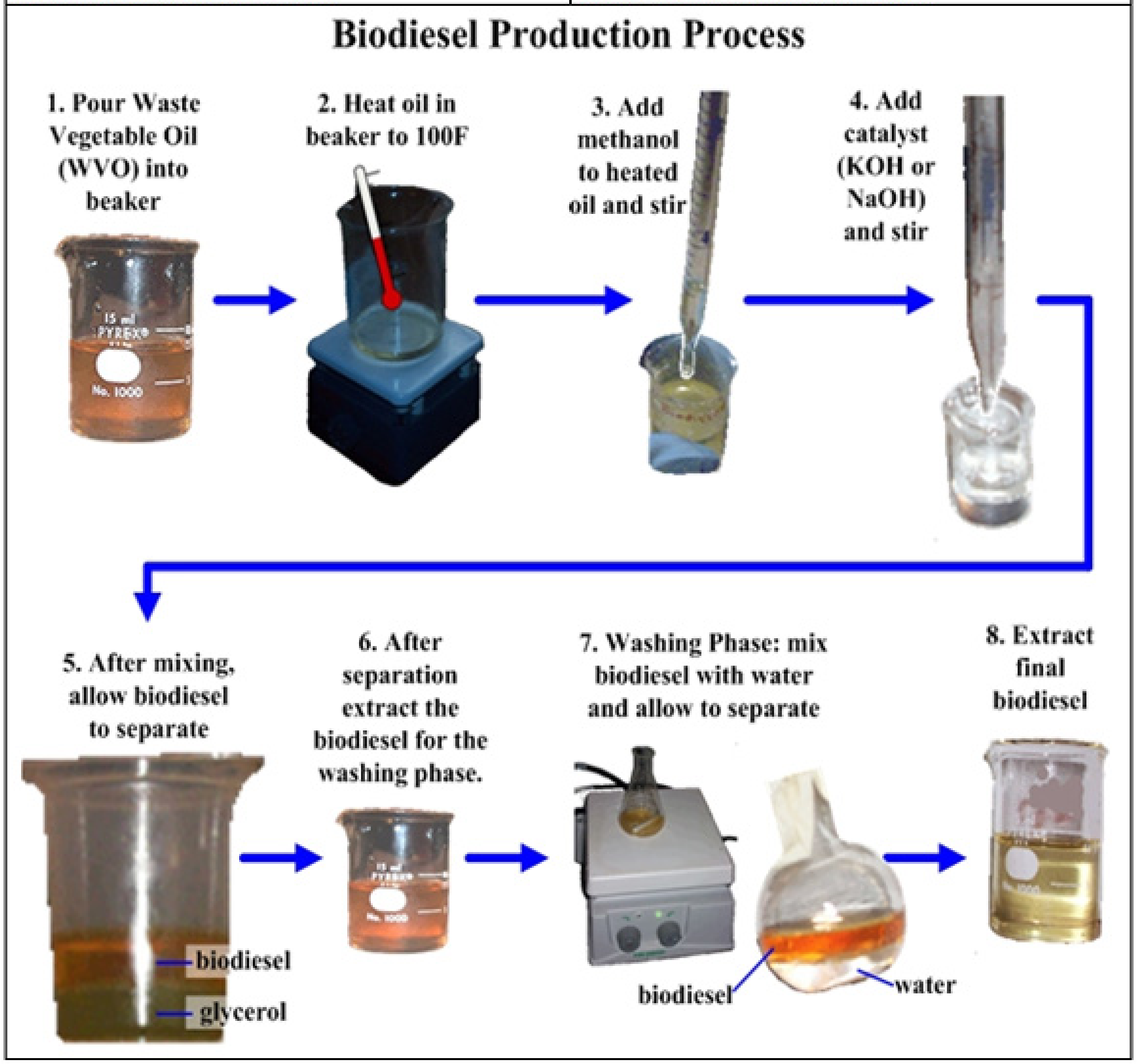
Biodiesel will be created from Waste Vegetable Oil. Pre-demonstration discussions will include a feasibility study (20) that has students exploring not only the uses for biodiesel and its byproducts, but the feasibility for use to replace diesel fuel (20).

For the initial lesson the teacher will demonstrate, over a timeframe of three days, how to make biodiesel. During all aspects of the biodiesel synthesis, the students will be observing and taking notes (See Table 3: Biodiesel Production Activity). The objective of this activity will be for the students to create a cartoon to demonstrate their knowledge of lab safety, process, procedures, and the equipment (See Table 4: Biodiesel Activity Assessment).

The following topics can be spiraled with this activity through the course of the year: Law of Conservation of Mass, Byproducts, Chemical vs. Physical Properties, Separation Techniques, Catalysts, Transesterification, Organic Molecules, Multiple Step Reactions, Compound Synthesis, Acids/Bases, Indicators, Titrations, and Stoichiometric Dimensional Analysis.

Table 3: Biodiesel Production Activity

Materials and Equipment	Materials and Equipment (cont'd)
10 mL WVO	(1) Pair of Beaker Tongs
0.1 mL 9 M Potassium Hydroxide	(2) Glass Stirring Rods
1.5 mL Methanol	(3) 4 mL Beral Pipettes
(1) 50 mL Beaker	(1) Hot Plate
(1) 15 mL Beaker	
(1) 10 mL Graduated Cylinder	**Safety Precautions**
(1) Thermometer	(1) Pair of Safety Goggles
1 mL Distilled Water	(1) Protective Apron
(1) Pair of Crucible Tongs	(1) Pair of Protective Gloves



Procedures 1. Pour 10 mL Waste Vegetable Oil (WVO) into 50 mL beaker 2. Place beaker with WVO onto hot plate, and insert thermometer 3. Heat WVO to 100 ^{0}F, then turn off hot plate 4. Using beaker tongs, pour WVO into 15 mL beaker 5. Measure 1.5 mL of methanol using a 4 mL beral pipette 6. Add methanol into WVO beaker, stirring slowly 7. Measure 0.1 mL of 9 M sodium hydroxide with a 4 mL beral pipette 8. Slowly add sodium hydroxide into 15 mL beaker 9. Stir the mixture for 7 minutes with a glass stirring rod 10. Let mixture sit and separate (24 hours) until there are 2 clearly visible layers 11. The top layer is biodiesel 12. Extract biodiesel with a 10 mL beral pipette 13. Place biodiesel in 50 mL beaker and mix with distilled water 14. Let mixture separate and extract water layer 15. The container now has washed biodiesel

Table 4: Biodiesel Activity Assessment	
Create a cartoon with illustrations and captions explaining the biodiesel production process. There are 6 windows which you can use to break the process down. Make sure to include safety precautions, specific quantities of reactants, and to label all lab equipment.	
Panel 1 – Students should draw the initial equipment and materials used.	Panel 2 – Students should draw the filtering and heating of the WVO.
Panel 3 – Students should draw the addition of methanol and catalyst, and depict the mixing (and time to settle)	Panel 4 – Students should draw the process of extracting the biodiesel from the glycerin.
Panel 5 – Students should draw the biodiesel being mixed with water to "wash" the biodiesel.	Panel 6 – Students should draw the testing of the biodiesel and the final product.

Lesson 2: Water Purification, Filtration, and Distillation

A water purification system will be created based on the patent model discussed. River and rain water will be collected, filtered, purified, and distilled using the purification and filtration model and a standard distillation setup. Students will become proficient in creating their own heating curves (with multiple chemicals overlaid), determining the boiling points of a liquid, empirically determining what the liquid is, creating their own batches of distilled water from tap water for other experiments, and efficiently setting up, performing, and taking down purification and distillation setups. Discussions about where distillation processes are used in life (water, sodas, coffees, fuels) will be infused through the repeated experiments. The following topics will be spiraled through the repetition of the experiment: Prediction of Outcomes, Writing a Hypothesis, Lab Safety, Identification of Equipment, Measurements, Significant Figures, Percent Yield, Percent Error, Concentration (Molarity), Molar Mass, Solubility, Polarity, Boiling Points, Melting Points, Phase Changes, Distillation, Chemical vs. Physical Properties, Condensation, Evaporation, Separation Techniques, and Elements vs. Compounds vs. Homogeneous Mixtures vs. Heterogeneous Mixtures.

This lesson will be demonstrated with two experiments, the first being a water purification and filtration setup, and the second being a standard distillation setup. The water should be purified with UV light before and after filtration (see Table 5: Water Purification and Filtration Activity: setup diagram). Once purified and filtered, the water should be transferred to a standard distillation setup, and distilled (see Table 6: Water Distillation Activity: setup diagram) The objective of this activity will be for the students to create a schematic of the water purification and filtration process as well as for a standard distillation setup. The schematic should demonstrate students' knowledge of lab safety, process, procedures, and the equipment (See Table 7: "Water Purification and Filtration Activity Assessment" and Table 8: "Water Distillation Activity Assessment").

Table 5: Water Purification and Filtration Activity

SETUP DIAGRAM

Materials		
Filter Paper	Funnel	Erlenmeyer Flask/Large Knorr's Jar
Burette/Burette Clamp	Ring Stand/Clamps	3 ft. fluorescent UV light
Gravel Rocks (1-2 cm)	Sand	Activated Charcoal
Aluminum Foil	Tall Cardboard Containment	

Alternative Equipment - Any clean container can be used for the receiving container. For your cardboard containment, a science fair presentation board can be folded in the center, creating a four-sided semi-enclosed container.

Procedures

1. Place the filter paper in a funnel. Add layers (approximately 2 cm each) of gravel, sand, activated charcoal, and sand, respectively. This is the "Filter" of your experiment.
2. Secure the Filter over a Knorr's jar or Erlenmeyer flask. This is your "Receiving Container".
3. Pour water into a burette placed above the Filter laying on top of the Receiving Container.
4. Using the Ring Stand and Clamps, secure, vertically, the UV Light as near as possible to the burette and Receiving Container.
5. The Burette, Filter, Receiving Container, and UV Light is your "System".
6. Glue aluminum foil to the cardboard, and surround the System on four sides with the cardboard walls (aluminum foil facing the inside).
7. Allow the water to be purified and filtered through the burette while the UV light is on, and collect the water in your receiving container.
8. Allow the UV light to continue to purify the water in the Receiving Container for 1-2 hours, after which you can place the water in the distillation system.

Table 6: Water Distillation Activity

Materials		
Bunsen Burner	Erlenmeyer Flask	Distillation Flask
Corks	Thermometer	Condenser
Condenser Tubing	Water Source	Ring Stands and Clamps
Ceramic Fiber Square	Receiving Flask	

Procedures

1. Place Bunsen Burner on ring stand base.
2. Install ring clamp and ceramic fiber square above Bunsen burner.
3. Place distillation flask above ceramic fiber square and attach clamp to hold neck.
4. Insert cork with thermometer on top cylindrical neck, and attach cylindrical sidearm to the condenser using a cork to ensure a tight seal.
5. Connect one condenser tube to water input, and one to water output, leaving the output tube in a location that will allow for drainage.
6. Place the opening of the Erlenmeyer flask, known as the Receiving Flask, underneath the spout of the condenser.
7. Pour liquid that you desire to distill into distilling flask.
8. Heat liquid to desired temperature, which will cause the liquid to go into the gas phase, and then cool via the condenser, pouring into receiving flask.

SETUP DIAGRAM

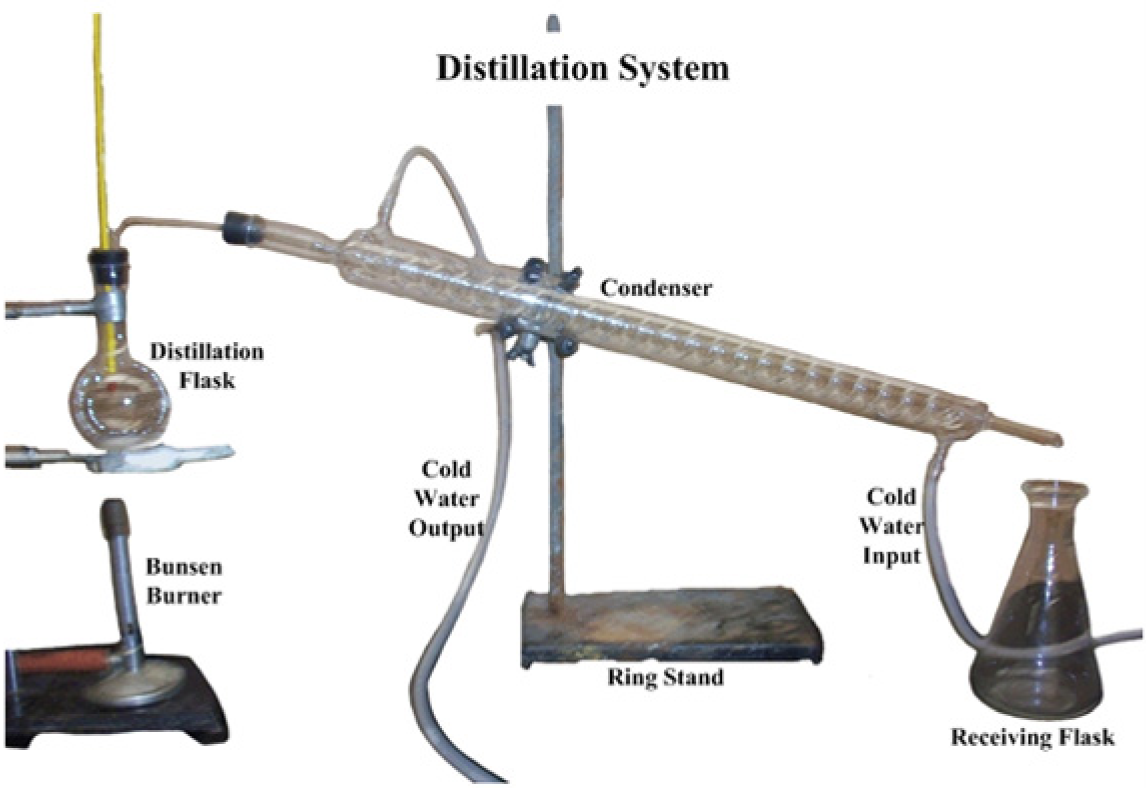


Table 7: Water Purification and Filtration Activity Assessment
Create a schematic with illustrations and captions explaining the water purification and filtration process. There are 2 windows which you can use to create your schematic. Make sure to include safety precautions, specific quantities of reactants, and to label all lab equipment.
Panel 1 – Students should draw a diagram of the overall unit with all parts labeled.
Panel 2 – Students should draw a 'zoomed in' view of the filter with the layer details.

Table 8: Water Distillation Activity Assessment
Create a schematic with illustrations and captions explaining the distillation process. Your schematic should make the distillation process clear, making sure to include safety precautions, specific quantities of reactants, and labeling of all lab equipment.
Panel 1 – Students should draw the standard distillation setup in detail.

Lesson 3: Bioethanol

Bioethanol will be created from raw materials (Corn Meal). Pre-demonstration discussions will include a discussion regarding the use of feedstock that competes with food production and how ethanol is currently being used (21).

For the initial lesson on bioethanol the teacher will demonstrate, over a timeframe of two weeks, how to make bioethanol. During all aspects of the bioethanol synthesis, the students will be observing and taking notes, with special attention also being paid to the fermentation process (See Table 9: Bioethanol Production Activity). The objective of this activity will be for the students to create a cartoon to demonstrate their knowledge of lab safety, process, procedures, and the equipment (See Table 10: Bioethanol Activity Assessment).

The spiral topics described in the biodiesel lesson can also be reviewed during this lesson. A new topic that can be introduced is fractional distillation. Differences between gasoline and diesel engines as well as their purposes will also be discussed.

Table 9: Bioethanol Production Activity

Materials

50 mL Florence Flask	100 mL Erlenmeyer Flask	Scale
Hot Plate	Distillation Setup	25.0 mL of Water
0.5 g Yeast	4.0 g Corn Meal	6.0 g Sugar

Safety Precautions

Materials are extremely flammable
Use caution around open flames

Procedures

1. In a 50 mL Florence flask, pour 25 mL of warm water (80 □F) and add 0.5 g of yeast.
2. Swirl mixture and add 4.0 g of corn meal, and 6.0 g of sugar, continuing to swirl.
3. Cover Florence flask with a flexible top (suggestion: cut off a finger from a latex glove and place over the neck)
4. Allow the mixture to sit for 6 days, or until the flexible cover deflates after the fermentation process is complete. If the top comes off, you must start over, as the feedstock needs to ferment in an oxygen deprived container.
5. Decant the solution above the precipitate matter into a 50 mL Distillation flask attached to a distillation setup.
6. Distill the liquid using a condensation column, making sure that you have a thermometer in the boiling Erlenmeyer flask.

Note: Use a hot plate away from open flames as the solution is very flammable. The distillate that condenses at a boiling temperature of 78 □C (173 □F) is ethanol. If the distillate was to be distilled multiple times, it would be ready for use as a fuel.

SETUP DIAGRAM

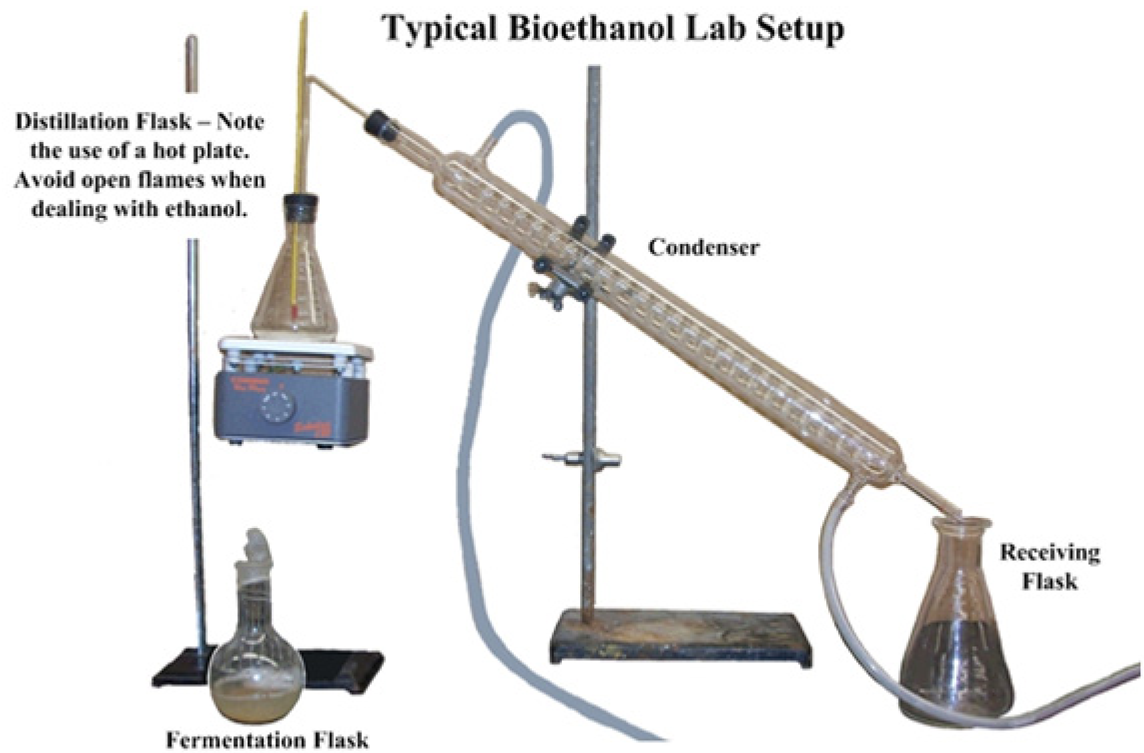


Table 10: Bioethanol Activity Assessment
Create a cartoon with illustrations and captions explaining the bioethanol production process. There are 2 windows which you can use to break the process down. Make sure to include safety precautions, specific quantities of reactants, and to label all lab equipment.
Panel 1 – Fermentation – Students should draw the fermentation setup in detail.
Panel 2 – Distillation – Students should draw the distillation setup in detail.

Lesson 4: Biodiesel

Biodiesel will be created from Waste Vegetable Oil, but this time by the student and under close supervision from the teacher. Evaluation will be based on the students' abilities to follow the process, as well as on the lab write up submitted by the students.

Lesson 5: Water Purification, Filtration, and Distillation

A water purification, filtration, and distillation system will be created, but this time by the students and under close supervision from the teacher. Evaluation will be based on the students' abilities to follow the process, as well as determine what other methods and materials could be used to clean water.

Lesson 6: Bioethanol

Bioethanol will be created from corn meal feedstock, but this time by the students and under close supervision from the teacher. Evaluation will be based on the students' abilities to follow the process, as well as on the lab write up submitted by the students.

Conclusion Lesson of the Unit: Survival Using Everyday Chemistry

Our community has just been hit with a major hurricane. Support services are limited and you and your team (class) have been commissioned to assist in the recovery of vital services. Using materials that you find within your neighborhood, the classroom, construct a biodiesel processing unit, a bioethanol processing unit, and a water purification, filtration, and distillation system. You will be given valuable raw materials (1 knorr's jar of waste vegetable oil, 1 knorr's jar of river or rain water, 2 ounces of yeast, 2.25 kg of sugar, and 2.25 kg of corn meal). Besides building the processing units, you must create 1 clean knorr's jar worth of distilled, purified, and filtered drinking water, 1 jar of biodiesel, and 1 jar of bioethanol). The timeframe to complete the project is 2 weeks. Good Luck. Our survival depends on this.

Table 11: Teacher notes for Culminating Activity

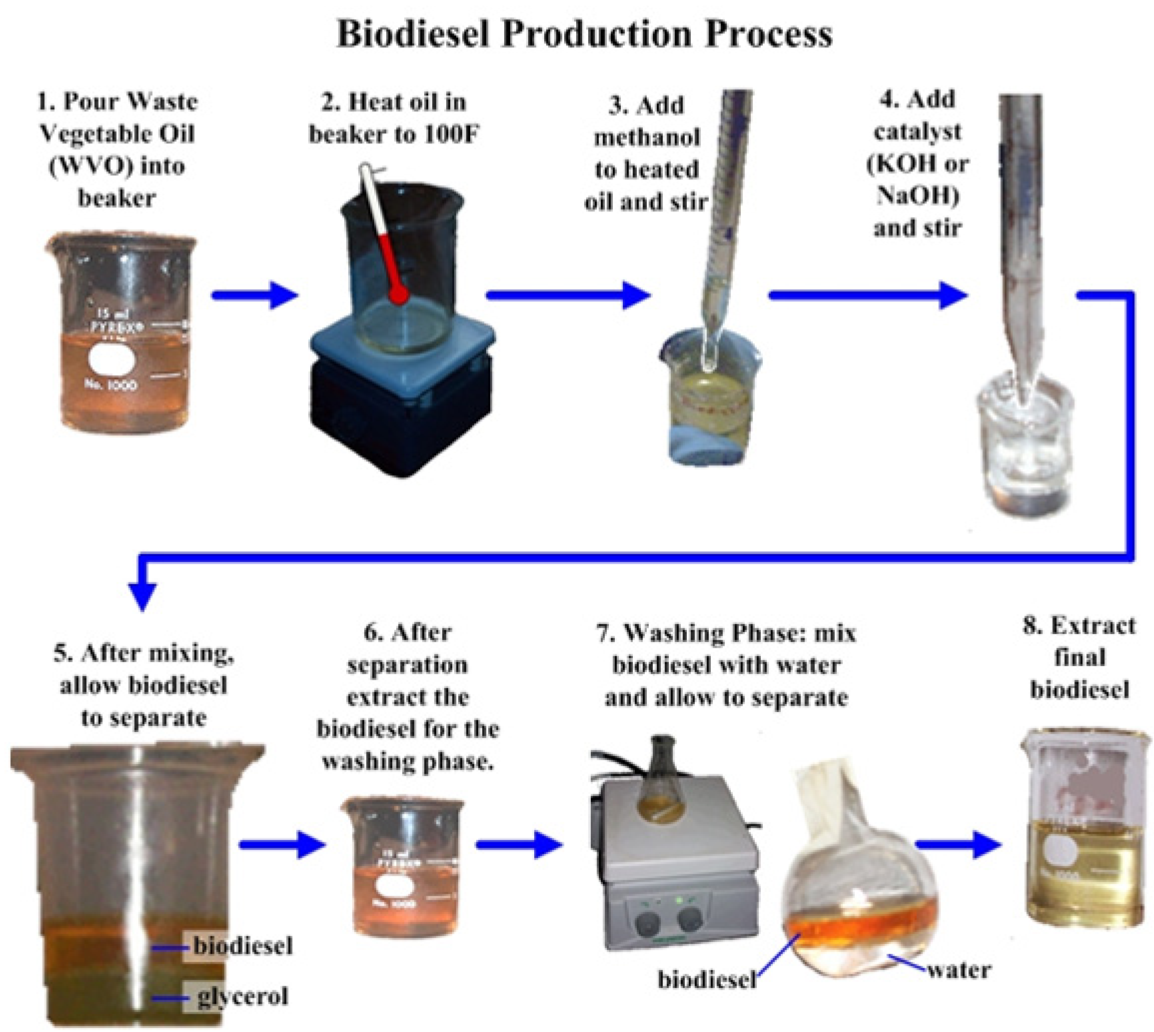
The key to making this activity interesting is removing lab equipment that students may feel is critical to the process. Also key is not telling the students which materials you have replaced so that students can construct their own theories, and test their own hypotheses. Some materials that should be added to the culminating activity include:

- New Duct Tape
- Gorilla Glue
- New Straws
- Various nylon tubings
- 20 ounce plastic bottles
- Cutting materials
- Various Copper Tubings
- Used Ice Chests
- Used Aquarium Pumps
- 2 Liter plastic bottles
- Empty wine bottles (wine and labels removed)

Some removal and replacement ideas are listed below:

Item to Remove	**Item(s) to Replace With**
Distillation Flask	Erlenmeyer Flasks and tubing or Metal containers with tops that can be sealed
Receiving Containers	Plastic Bottles
Fermentation Flask	Any small necked glass container (wine bottles)
Funnel and Burette	Inverted 2 Liter plastic bottle with bottom removed for easy access.
Biodiesel separatory funnel	Inverted 2 Liter bottle with tubing and clamp

Appendix A – Biodiesel Production Process



Endnotes

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Teacher Resources

"Green Chemistry | US EPA." U.S. Environmental Protection Agency. http://www.epa.gov/greenchemistry (accessed July 13, 2009). This is the EPA's website regarding Green Chemistry. It is a great resource for teachers with links to activities and literature regarding sustainability and green chemistry initiatives.

"Biomimicry Institute - K-12 Education." Biomimicry Institute - Home. http://www.biomimicryinstitute.org/education/k-12/k-12-education.html (accessed July 2, 2009). This website has curriculum activities and literature regarding biomimicry.

Ennis, Catherine, and Terri McCauley. "Creating urban classroom communities worthy of trust." *Journal of Curriculum Studies* 34, no. 2 (2002): 149-172. This journal article discusses how to create trust in an urban classroom setting, from which, once established, learning can take place.

Wiig, Diana. "Creating a Classroom Community of Young Scientists, Second Edition." *Science Scope* 31, no. 4 (2007): 82. This article describes how to invoke a love and passion for STEM in the classroom.

Student Resources

Criddle, Craig, and Larry Gonick. *The Cartoon Guide to Chemistry*. London: Collins, 2005. This illustrated book is a fantastic resource that simplifies Chemistry concepts while maintaining rich content.

Dingrando, Laurel. *Chemistry: matter and change*. New York, N.Y.: Glencoe/McGraw-Hill, 2005. This Chemistry textbook is available online and has activities that can be accessed by students.

Macaulay, David. *The New Way Things Work*. Austin: Houghton Mifflin/Walter Lorraine Books, 1998. This book has great illustrations on how many machines, gears, and systems work; it is ideal for a reference when the students are looking for ideas to complete the culminating activity.

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