

TEAM CLASSROOM IMPLEMENTATION PLAN REPORT

Project #2: Making Biodiesel for Research and Education

***“The Making of Biodiesel
From Plants to Power Plants”***

Submitted To

The RET Site

For

**“Sustainable Engineering for Urban Needs:
Research Experiences for Middle and High School Teachers”**

Sponsored By

The National Science Foundation

Grant ID No.: EEC-0808696

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Reporting Period: June 21 – July 30, 2010

ABSTRACT

Many high school students realize there are problems with pollution and with running out of natural resources that sustain our ways of life, but they are not sure what steps they can take to prevent it. Vertically integrating new technologies and methods into four year long science courses not only provides students with knowledge of alternative energy sources, but also provides a bridge of knowledge that links different science classes together. Biodiesel can be used as an alternative energy tool to teach students differing concepts in physical science, biology, chemistry, and physics, while building their knowledge and using scaffolding methods of learning and applying their knowledge of biodiesel. Developing activities that align biodiesel with curriculum standards in the four different science courses can help students construct their own knowledge through meaningful learning. In this paper, two teachers developed biodiesel related lesson plans that align with the Ohio Standards of Education. The two classes of interest are biology and chemistry, section i. describes the chemistry lesson plans whereas section ii. describes the biology lesson plans.

KEY WORDS: Biodiesel, Free fatty acids, Titration, Transesterification, Stoichiometry, Algae, Molarity, Concentration

1. INTRODUCTION

The National Science Foundation (NSF) funded Research Experiences for Teachers (RET) summer program is a program designed to provide teachers with an engineering research experience. Teachers use their research experience to design lesson plans based on “inquiry, experimental design, the nature of science, process skills, and communication” (Grove, 2009, p. 1). At a large Midwestern research university nine in-service teachers and three pre-service teachers were chosen to work on six different research project that all focus on energy and environmental conservation. Grove (2009) suggests that once teachers “acquire the belief that they are able to perform with their mentor [engineer], they can transfer this experience to their own students” (p. 1). *The Making Biodiesel for Research and Education* project had two participants: a high school chemistry teacher and a pre-service high school biology teacher.

The teachers developed a theme of biodiesel that would be aligned with the Ohio State Standards and taught throughout a four year period in four different science classes. These lessons provide “foundational ideas in science with activities and language that would build upon [prior knowledge] and develop cognitive structure that could facilitate the learning of all science in later years” (Novak, 2003, p.124). The program begins in 9th grade physical science class where students are introduced to different fuel sources; students will be able to look at the negative effects of coal mining and the use of natural resources and upcoming possible replacements for these resources. In 10th grade biology students examine different sources of

biodiesel and how these processes could be improved on. In 11th grade chemistry students discover the reaction of biodiesel and make their own batch of biodiesel. Finally, in 12th grade physics students test the efficiency of biodiesel and look at heat and energy transfer of biodiesel through an engine. During the four year process students discover different career options involved in each of the lessons, building their repertoire of real world application. The main focus of the two teachers was the development of the biology and chemistry lessons of the program (Fig. 1). The 10th grade Biology lesson, *From Plants to Power Plants*, focuses on the photosynthetic processes of algae and how algae are used to produce biodiesel. The chemistry lesson, *The Making of Biodiesel*, focuses on the chemical reactions, stoichiometry, and making of biodiesel from waste cooking oil.

2. LESSON OVERVIEW

In 2007, America was using 20.6 million barrels of oil per day; this number has been estimated to be on a 2% increase every year to sustain our ways of life. The United States is also estimated to produce one-fourth of the world's carbon emissions. With the increased need of oil, need to import foreign oil, and amount of pollution emitted from the burning of oil, the United States has realized the many societal and economic problems associated with the continued dependence on oil. Many alternative energy sources to petroleum derived diesel have become of interest to help lower the dependence of oil, biodiesel has become of special interest due to the fact that many automobiles and machines do not have to be replaced at expensive cost to use biodiesel as a replacement of oil. The burning of biodiesel also reduces the amount of particulate matter, CO₂, and sulfur oxides emitted into the air, which can be a clean burning alternative for oil. There are many sources that can produce biodiesel that are renewable such as waste cooking oil, soybeans, corn, and algae.

- i. Biodiesel and biodiesel production is a great concept for teaching a wide variety of chemistry concept including stoichiometry, titrations, chemical reactions, diffusion, acid/bases, etc. Many chemistry curriculums require that students have an understanding of all of these concepts and students try to learn it but never know why they learn it.

French Fries to Powering Cars is a lab design for 11th grade chemistry that will be taught after the introduction of stoichiometry and chemical reaction. The activity will allow students to understand that chemistry concepts are all around them and even if they are not a chemical engineer that the concepts are important to items they use every day.

- ii. "Microalgae are sunlight-driven cell factories that convert carbon dioxide to potential biofuels, foods, feeds, and high value bioactives" (Chisti, 2007, p. 295). Algae can be a

great renewable source of biodiesel as well as an important teaching tool in biology. Many curriculums in biology include standards in cell structure, function, and respiration, it also includes photosynthesis processes. Developing an algae lab that incorporates both photosynthetic processes and biodiesel research provides students the ability to build knowledge off prior knowledge from the physical science biodiesel introduction and use a real world experience to relate to and develop knowledge about photosynthesis. Students will be able to bridge the knowledge of photosynthesis and biodiesel together, creating a web of interconnected information.

From Plants to Power Plants is a lab lesson design for 10th grade Biology classes that is to be taught after students have basic knowledge of the process of photosynthesis; they should know and understand that plants use photosynthesis to convert carbon dioxide, water, and light into energy and oxygen is given off as a bi-product. In this lab students will be experimenting with different forms of algae to discover under what conditions do the algae favor most, focusing on temperature and light intensity. The first section of the lesson should be taught in a five day period, over a class time of 50 minutes.

3. GOALS AND OBJECTIVES

- i. The two overlying goals of the chemistry approach to biodiesel are: students can relate the production of biodiesel to real world applications and professions, and students can understand that science and chemistry are related to everything around them. The objectives corresponding to the first goal are students will be able to: balance a chemical equation, identify how changing the amount of chemicals in a reaction will change the results, and correctly calculate a stoichiometric problem. The objective corresponding to the second goal is students will be able to identify different types of chemical reactions (Table 1).
- ii. There are two main goals for this lab that students should walk away with; the first is students can relate the photosynthetic process with plant life in a real world scenario. To accomplish this goal, students must be able to: illustrate the photosynthetic cycle, describe under what conditions the algae optimal growth has, and explain the conditions and type of algae that produces the most oxygen. The second goal is that students can understand the importance of alternative energy resources. To accomplish this goal, students must be able to: list ways why algae are important as an alternative energy source, describe how this particular lab is useful for algae cultivation, and explain the process of biodiesel production from algae (Table 2).

4. MATERIALS

- i. For this activity students will need; waste cooking oil from the cafeteria, methanol, sodium hydroxide, indicator solution, hot plate and separation funnel. These items are necessary for the actual production and purification of the biodiesel. The teacher will need sulfuric acid, pipettes, biodiesel reactor, gas chromatograph (if possible) and a calorimeter.
- ii. Four different algae samples will be need to perform this lab: *Chlorella*, *Phormidium*, *Cryptomonas*, *Fremyella*. Each group of students will prepare two test tube samples of each type of algae; one to be placed a high light source with a warm temperature and the other to be placed in a lower light source with cooler temperature. These two very different climates provide students the ability to observe how temperature and light effect the growth of the algae. *Fremyella* displays the color of the light source; to further challenge students, place these test tubes under different colored light sources to let them observe and make prediction to why the test tubes are different colors, using the plastic colored light filters. To prepare the samples of algae, students need pipets to transfer the algae samples into test tubes and fill with room temperature water samples. These test tubes should be placed in a test tube holder and placed under a light source. There should be two different light sources used in this lab, a high intensity light source (such as a lamp) and a low intensity light source. The high intensity light source should be kept in a warm humid climate, whereas the low intensity light source should be kept in a cooler temperature with a less humid climate. A light microscope will be need so students can look at wet slides to observe algae structure and growth. A Pasco dissolved oxygen apparatus will be needed so students can record the amount of dissolved oxygen that is being produced by the algae in the test tube. All of these materials will be need to go along with the lab worksheets, which are attached in Appendix II.

5. INSTRUCTIONAL STRATEGY

- i. The teacher will provide mostly direct instruction due to the use of several hazardous chemicals. Toward the end of the activity the focus will switch to an inquiry discussion surrounding methods the students could use to produce more pure biodiesel products. Students will be working in a cooperative learning environment; one lab report will be due from each group with their conclusions on the lab.
- ii. The teacher will only provide direct instruction to describe lab instructions and safety precaution that students will need to follow to successfully complete the lab. This lab is mainly designed for students as an inquiry based lesson where they have to first make

predictions based on prior knowledge, collect data and observations, and work out relationships between their results and what they already know about photosynthesis. Through this lab, students undergo group discovery by finding which type of algae has the highest rate of photosynthesis and what environmental factors lead to optimal rate of photosynthesis. Each student will prepare a lab report to help them visualize and connect the information and research how algae can be made into biodiesel, keeping with the over theme of alternative energies. Students will use peer critiques with one another to provide valuable feedback on their rough drafts of the lab reports, a feedback sheet with certain criteria will be used to have consistent feedback.

6. TECHNOLOGY

- i. If possible a gas chromatograph will be used by the teacher to show and compare the composition of the samples to the students. If a GC is not available at the teachers school many labs can be contacted that will be will to run a GC analysis on the samples. If this can still not be done the teacher can just use a calorimeter to test the efficiency of each sample and compare them for the students.
- ii. A Pasco dissolved oxygen apparatus will be used to determine oxygen levels in each of their test tubes. This is an efficient and quick way to determine oxygen levels; it allows students the opportunity to see how oxygen levels increase or decrease daily. Students will also use microscopes to look closer at algae, how it interacts with each other and how light and environmental condition affects it on a microscopic level. Finally, computer will be used for research and lab report write ups. This helps students have higher college preparations where all lab reports must be typed and research may have to be conducted.

7. PRE/POST ASSESSMENT/ACTIVITY

- i. The pre-assessment questions for this activity will be basic knowledge about the lab as well as several stoichiometric calculation problems.
 1. Why is stoichiometry important to chemists and chemical engineers?
 2. Why is it important that all chemicals in a reaction are reacted and there is no excess?
 3. What could be a problem with excess chemicals in a sample of biodiesel that would be used in a automobile?
 4. Stoichiometry problems, TBD.

ii. Pre-Assessment Questions: Students will first answer some questions and make some hypotheses about what they think will happen in the lab.

1. Describe the process of photosynthesis.
2. Under what light conditions will the most algae be produced?
3. Under what temperate conditions will the most algae are produced?
4. How can the color of the light source affect the algae?
5. Will oxygen levels rise or decrease throughout the five days? Why?

Post Assessment: Students will write a lab report describing the five pre-assessment questions thoroughly and make conclusions to why their initial predictions were either correct or incorrect. Students will also need to connect this lab with biodiesel production from algae.

8. LEARNING PARTICIPATION/ACTIVITY

i. On day one students will observe a teacher demonstration and receive a background on biodiesel and the biodiesel industry. Day to students while working with their partners will make appropriate calculation to produce biodiesel from their waste cooking oil then carry out the reaction. The following days students will purify and wash their biodiesel. The teacher will take samples from each group and test the sampel for comparison by the students.

• Day 1 (TEACHER DEMO)

- Assign 4 person groups, 5 minutes
- Have each groups get the appropriate lab equipment, 5 minutes
- Students will be given a background on biodiesel, 15 minutes
- Set up as a demo the teacher will titrate a 1 mL sample of WCO with NaOH to determine the free fatty acid content of the sample, 10 minutes
- Using an equation for conversion of FFA students in their groups will calculate how much NaOH must be added to a 500 mL reactor to convert the FFA of the sample to under 1%, 15 minutes
- Teacher will collect the paper at the end of the day

• Day 2

- Each group will receive 50 mL of waste cooking oil from the cafeteria(provided by the teacher), 10 minutes
- Students will use the equation and method of preparing biodiesel. 40 minutes

- Day 3

- Students will wash the biodiesel according to the methods instructed by the teacher, 55 minutes

- Day 4 (TEACHER DEMO)

- The teacher, using the students samples will test the biodiesel using a calorimeter to figure out who was able to make the most efficient biodiesel, 55 minutes

ii. Students will begin this lab by completing the pre-assessment worksheet. The instructor will then provide a review of photosynthesis and provide an introduction of the lab which includes background information, lab safety, and starting directions. The students will then separate into groups and perform the beginning set-up of algae tubes and place under the corresponding environmental conditions. A small amount of time will be designated at the end of the class period to clean up. The following four days will be designated to collecting data for roughly 10-20 minutes of the class period. During this time students will collect oxygen level readings, write their observations, and look at the algae growth through the microscope. Day 6 is the final day of collecting data, after data is collected students will dispose of the algae properly and begin their lab reports. Students will perform a peer critique of their lab report and make corrections on Day 7. This day will be the final day for lab reports to be collected. A schedule of daily class period time usage can be seen below:

Procedure:

Day 1

- Pre-assessment worksheet (10 min)
- Review of photosynthesis and introduction to lab with safety and instruction (10 min)
- Preparation of algae test tubes, place in correct light source (20 min)
- Recording of initial information (5 min)
- Lab clean up (5 min)

Day 2-5

- Take daily recording of observed data, Pasco measured data, and wet slide of sample under the microscope every other day (10~20min)

Day 6

- Final lab day recording (20 min)
- Lab clean up (5 min)
- Begin Lab reports (25 min)

Day 7

- Peer review of lab reports (20 min)
- Lab report edits (20 min)

Lab report print outs and turn in (10 min)

9. ESSENTIAL QUESTIONS AND REVIEW

i. The major focus of the lab is the application concepts learned in the chemistry classroom. These questions will be discussed before the lab activity begins and answered again by each group on their lab report.

1. Why is stoichiometry and balancing equations important to chemists and chemical engineers?
2. Why is stoichiometry important to this lab, be specific?
3. What types of chemical reactions happen in the activity? Be specific and tell when each reaction is happening.
4. Why is it important for researchers to be exploring new ways of producing biofuels?

ii. There are five essential questions that students must be able to answer after this lab is complete, they should be answered in detail in their lab reports. A review can also be given in a form of a worksheet after the lab is completed. The essential questions are as followed:

1. Identify the different features in a plant cell.
2. Diagram the process of photosynthesis and the bi-products.
3. Justify whether or not you think algae can become a sustainable fuel source.
4. Propose a plan for a machine that has conditions to produce the most algae, justify your answer.
5. Explain how photosynthesis and algae growth are connected.

There are also post test questions that could be asked to fully assess whether students understand photosynthesis processes and the products and bi-products of photosynthesis:

1. Which element is needed for the plant to make chlorophyll although is not part of the chlorophyll molecule?
2. What happens to energy as a result of photosynthesis?
3. Chlorophyll absorbs most energy from what color regions of the light spectrum?
4. When a plant makes a glucose molecule by photosynthesis, from what source does the hydrogen molecule come from?
5. What products are made during photosynthesis?

10. POSSIBLE CHALLENGES

- i. This lab is designed for help students understand the applications of concepts like stoichiometry and titrations, two concepts that they really do not know why they are learning them. However it does require that they know HOW to solve a stoichiometry problem and know how to titrate a sample.
- ii. Some possible challenges that may occur during this lab are students may not fully understand the connection between photosynthetic rates of the algae and why that may be important to biodiesel production. Another problem that may occur during the lab might be that the algae may not grow under any of the conditions which could be a big problem for students to encounter.

11. ACKNOWLEDGEMENTS

We would like to thank Dr. Mingming Lu and our graduate assistant Qingshi Tu for allowing us the opportunity to assist them in the lab and for all the help they provided us during our six week period to help design our lesson plans. We would also like to thank Andrea Burrows and Dr. Anant Kukreti for their assistance with our papers, problems, and concerns through this process. Finally, we would like to thank the Research Experiences for Teachers Site for "Civil Infrastructure Renewal and Rehabilitation" Grant (EEC-0808696) for allowing us this summer opportunity to work with such a great team of professors, engineers, and teachers throughout the six week period.

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13. APPENDIX I. LESSON PLAN TEMPLATE

i. Chemistry implementation lesson plan template:

(See lesson plan template attached document)

ii. Biology implementation lesson plan template:

(See lesson plan template attached document)

14. APPENDIX II. WORKSHEETS, POWERPOINT, ECT

i. Chemistry Worksheets:

French Fries to Powering Cars

Name: _____

Bell: _____

Date: _____

Background: As the threat of supply of petroleum is always unknown; how much is left, wars, etc scientist and researchers are exploring new methods of providing fuel. One source that has become increasingly used is biodiesel. Biodiesel is the production of fuel that can be used in traditional biodiesel from plant oils. Biodiesel can also be produced from waste cooking oil in our very own cafeteria, which we will be doing.

Waste cooking oil from the cafeteria has a free fatty acid content above 1% which is the cut off for acceptable biodiesel. Waste cooking oil(WCO) is the broken down triglycerides(fat) after they are reacted with the water given of by foods. Day one of this lab will focus on the acid pretreatment of WCO. Once the FFA content is determined the biodiesel will be produced and washed on day 2 and 3.

Purity is important in biodiesel, harmful chemicals in the biodiesel can harm an engine, on the last day the purity and efficiency of the biodiesel will be observed.

Day 1 –FFA Pretreatment:

Teacher will demonstrate a titration of 1mL of WCO to determine the FFA content. Then a large batch, 500 mL of WCO will be treated.

What was the FFA content of the WCO before the reaction? _____%

What was the FFA content of the WCO after the reaction? _____%

What was the percentage of FFA that was converted? _____%

Day 2- Making Biodiesel (Transesterfication):

The amount of NaOH to be used per 1 mL of WCO, determined from the acid pretreatment? _____

Methanol ration is 5:1 oil to methanol, measure your sample, determine how much methanol to use? _____

Heat the oil to 130 degrees F. Dissolve the NaOH in the methanol and mix the two. Cover the reaction flask and store under the fume hood until tomorrow.

Day 3 – Washing the biodiesel:

In your flask there will be two layers, biodiesel on top, glycerin on the bottom. If you want the glycerin can be made into soap, we can walk around smelling like French flies if we used it to make soap!!!! Decant the biodiesel of the top, be sure to remove as much biodiesel as you can while leaving the glycerin behind.

In the beaker with the biodiesel carefully pour an equal amount of water down the side of the beaker to wash the biodiesel. Do not stir, you could form soap. After two minutes decant the oil into a fresh beaker and wash again. After 3 washes place your biodiesel under the fume hood, be sure they are labeled. The teacher will draw a sample to test for purity.

Day 4 – GC analysis and calorimeter test.

Question:

- 1) Why is stoichiometry and balancing equations important to chemists and chemical engineers?
- 2) Why is stoichiometry important to this activity?

- 3) What types of chemical reactions are used in this activity? Be specific and tell when each reaction is happening.
- 4) Why is it important for researches to be exploring new ways of producing biofuels?

ii. Biology Worksheets:

Name: _____

Date: _____

Bell: _____

From Plants to Power Plants:

Algae Growth and Oxygen Monitoring Lab

Background:

In 2007, America was using 20.6 million barrels of oil per day; this number has been estimated to be on a 2% increase every year to sustain our ways of life. The United States is also estimated to produce one-fourth of the world's carbon emissions. With the increased need of oil, need to import foreign oil, and amount of pollution emitted from the burning of oil, the United States has realized the many societal and economic problems associated with the continued dependence on oil. Many alternative energy sources to petroleum derived diesel have become of interest to help lower the dependence of oil, biodiesel has become of special interest due to the fact that many automobiles and machines do not have to be replaced at expensive cost to use biodiesel as a replacement of oil. The burning of biodiesel also reduces the amount of particulate matter, CO₂, and sulfur oxides emitted into the air, which can be a clean burning alternative for oil. There are many sources that can produce biodiesel that are renewable such as waste cooking oil, soybeans, corn, and algae.

Today we will be looking at algae as a source of energy. Many scientists and engineers are finding ways to optimally grow algae to produce biodiesel. Four different algae samples will be needed to perform this lab: *Chlorella*, *Phormidium*, *Cryptomonas*, *Fremyella*. Each group of students will prepare two test tube samples

of each type of algae; one to be placed a high light source with a warm temperature and the other to be placed in a lower light source with cooler temperature. We will also be monitoring oxygen level in the test tube to find which source of algae has the highest rate of photosynthesis.

By the end of this lab you should be able to:

- a. Illustrate the photosynthetic cycle
- b. Describe under what conditions the algae has optimal growth
- c. Explain the conditions and algae that produces the most oxygen
- d. List ways why algae is important as an alternative energy
- e. Describe how the lab is useful for algae cultivation
- f. Explain the process of biodiesel production from algae

Pre-lab Questions:

1. Describe the process of photosynthesis.
2. Under what light conditions will the most algae be produced?
3. Under what temperate conditions will the most algae are produced?
4. How can the color of the light source affect the algae?
5. Will oxygen levels rise or decrease throughout the five days? Why?

Materials:

- Algae samples: *Chlorella*, *Phormidium*, *Cryptomonas*, *Fremyella*
- Test tubes, test tube holder
- Water
- Pipets
- Light sources
- Plastic colored light filters
- Microscope (Light)
- Pasco dissolved oxygen apparatus
- Wet slides

Procedures:

Day 1:

1. Separate into your groups; send one person to collect materials needed.
2. Label all 8 of the test tubes: include team name, type of algae, and H or L for high intensity light or low intensity light.

3. Use a pipet to pipet 1 type of algae into the 2 test tube, dispose of the pipet (algae samples cannot be mixed in the same test tube). Repeat for the other 3 samples.
4. Fill the test tubes with the room temperature water from the large beaker in front of the class.
5. Using the Pasco apparatus, take an initial oxygen reading from each of the test tubes.
6. Place the test tubes the test tube holder and place the holders under the correct light source.
7. Record all initial information.

Day 2:

1. Collect all group test tubes and record observations.
2. Using the Pasco apparatus, take oxygen readings from each of the test tubes.
3. Record all information collected.

Day 3:

1. Collect all group test tubes and record observations.
2. Using the Pasco apparatus, take oxygen readings from each of the test tubes.
3. Record all information collected.
4. Prepare a wet slide from each test tube, write observations, and draw algae

Day 4:

1. Collect all group test tubes and record observations.
2. Using the Pasco apparatus, take oxygen readings from each of the test tubes.
3. Record all information collected.

Day 5:

1. Collect all group test tubes and record observations.
2. Using the Pasco apparatus, take oxygen readings from each of the test tubes.
3. Record all information collected.

4. Prepare a wet slide from each test tube, write observations, and draw algae

Day 6:

1. Collect all group test tubes and record observations.
2. Using the Pasco apparatus, take oxygen readings from each of the test tubes.
3. Record all information collected.
4. Dispose of algae and clean up lab.
5. Start on lab report

Data collection:

Oxygen Levels

	Tube 1	Tube 2	Tube 3	Tube 4	Tube 5	Tube 6	Tube 7	Tube 8
Day 1								
Day 2								
Day 3								
Day 4								
Day 5								
Day 6								

Microscope slides: observations

	Tube 1	Tube 2	Tube 3	Tube 4	Tube 5	Tube 6	Tube 7	Tube 8
Day 3								
Day 5								

Lab Report Format:

Title Page: Include a title sentence describing the lab, your name, group partners, date, and bell period

Introduction: Background information on photosynthesis, biodiesel, and algae, question of interest

Hypothesis: Include all questions from the pre-lab in paragraph format

Materials and Procedure: Describe what was used and what was done

Results: Include tables from the worksheets; create graphs show growth of algae and another showing oxygen rate

Conclusion: What does this mean? Describe in detail which environment, light source, and algae did the best, which had the most oxygen, do they relate to each other. Also describe how biodiesel can be made from algae, why this experiment might be important for biodiesel research, and possible impacts of biodiesel. Also include possible future work and possible problem that could have occurred while doing the lab (at least 3).

Also include answering the following questions:

1. Identify the different features in a plant cell.
2. Diagram the process of photosynthesis and the bi-products.
3. Justify whether or not you think algae can become a sustainable fuel source.
4. Propose a plan for a machine that has conditions to produce the most algae, justify your answer.
5. Explain how photosynthesis and algae growth are connected.

Peer Review Critique:

Rate your partner's report and provide feedback on how they can improve on their report.

1 is a low score that does not meet the required elements, 5 means it is perfect and nothing needs to be changed.

1. Title: Do they have all of the required elements, is their title in sentence format?

1 2 3 4 5

Comments:

2. Introduction: Are the required element met:

- a. Photosynthesis Background: 1 2 3 4 5
- b. Biodiesel Background: 1 2 3 4 5
- c. Algae Background: 1 2 3 4 5
- d. Question of Interest: 1 2 3 4 5

Comments or Improvement Areas:

3. Hypotheses: are all questions from the pre-lab answered in complete sentences?

1 2 3 4 5

Comments:

4. Materials and Procedures:

- a. Are all materials used in lab listed: 1 2 3 4 5
- b. Are procedures in complete sentences and numbered in steps: 1 2 3 4 5

Comments:

5. Results:

- a. Are the two tables from the data recording included: 1 2 3 4 5
- b. Graph of algae growth: 1 2 3 4 5
- c. Graph oxygen levels: 1 2 3 4 5

Comments:

6. Conclusion:

- a. Details on best environment: 1 2 3 4 5
- b. Details on best light source: 1 2 3 4 5
- c. Details on algae that produced the most oxygen: 1 2 3 4 5
- d. Details on if light, environment, and type of algae relate to each other and what may be the cause: 1 2 3 4 5

e. Experiment in relation to biodiesel research: 1 2 3 4 5

f. Impacts of Biodiesel: 1 2 3 4 5

g. Future work described: 1 2 3 4 5

h. 3 Problems of experiment: 1 2 3 4 5

Comments:

15. APPENDIX III. LESSON PLAN DEVELOPMENT SCHEDULE

Schedule 1: Time schedule for chemistry implementation of biodiesel

Day 1	Free Fatty Acid Pretreatment of a sample of waste cooking oil from the cafeteria. Demonstration carried out by the teacher.
Day 2	Biodiesel production in student teams.
Day 3	Purifying and washing of biodiesel by the students teams.
Day 4	GC comparison and calorimeter observation, demonstration carried out by the teacher, follow up questions answered by the students.

Schedule 2: Time schedule for biology implementation of biodiesel

Day 1	Review of Photosynthesis processes Introduction to lab: safety, directions, and introduction Lab set-up: perform beginning stages of lab, algae preparation and lighting placement
Day 2-5	Data Recording: students record algae observations and check oxygen levels in their algae test tubes, looking at samples through microscope
Day 6	Lab wrap-up: get final data recordings and perform lab clean-up Begin lab reports: begin lab reports, processing collecting data
Day 7	Lab report: Finish lab reports and turn-in

16. APPENDIX IV. TABLES

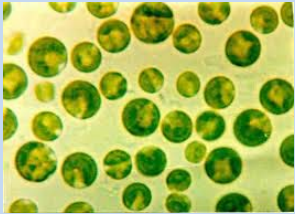


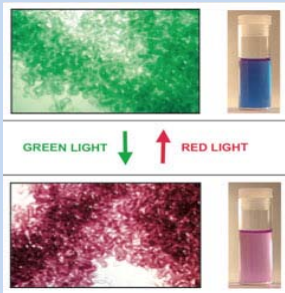
Table 1: Goals and Objectives for chemistry implementation of biodiesel

Goals:	Objectives:
1. Students can relate the production of biodiesel to real world applications and professions	Students will be able to: <ul style="list-style-type: none">a. Balance a chemical equationb. Indentify how changing the amount of chemicals in a reaction will change the resultsc. Correctly calculate a stoichiometric problem
2. Students can understand that science and chemistry are related to everything around them.	Students will be able to: <ul style="list-style-type: none">a. Identify different types of chemical reactions

Table 2: Goals and Objectives for biology implementation of biodiesel

Goals:	Objectives:
1. Students can relate the photosynthetic process with plant life in a real world scenario	Students will be able to: <ul style="list-style-type: none">a. Illustrate the photosynthetic cycleb. Describe under what conditions the algae has optimal growthc. Explain the conditions and algae that produces the most oxygen
2. Students can understand the importance of alternative energy resources	Students will be able to: <ul style="list-style-type: none">a. List ways why algae is important as an alternative energyb. Describe how the lab is useful for algae cultivationc. Explain the process of biodiesel production from algae

Table 3: Material list of the different forms of algae to be used during the *From Plants to Power Plants* lab

Algae:	Picture:
<i>Chlorella</i>	
<i>Phormidium</i>	
<i>Cryptomonas</i>	
<i>Fremyella</i>	

17. APPENDIX V. FIGURES

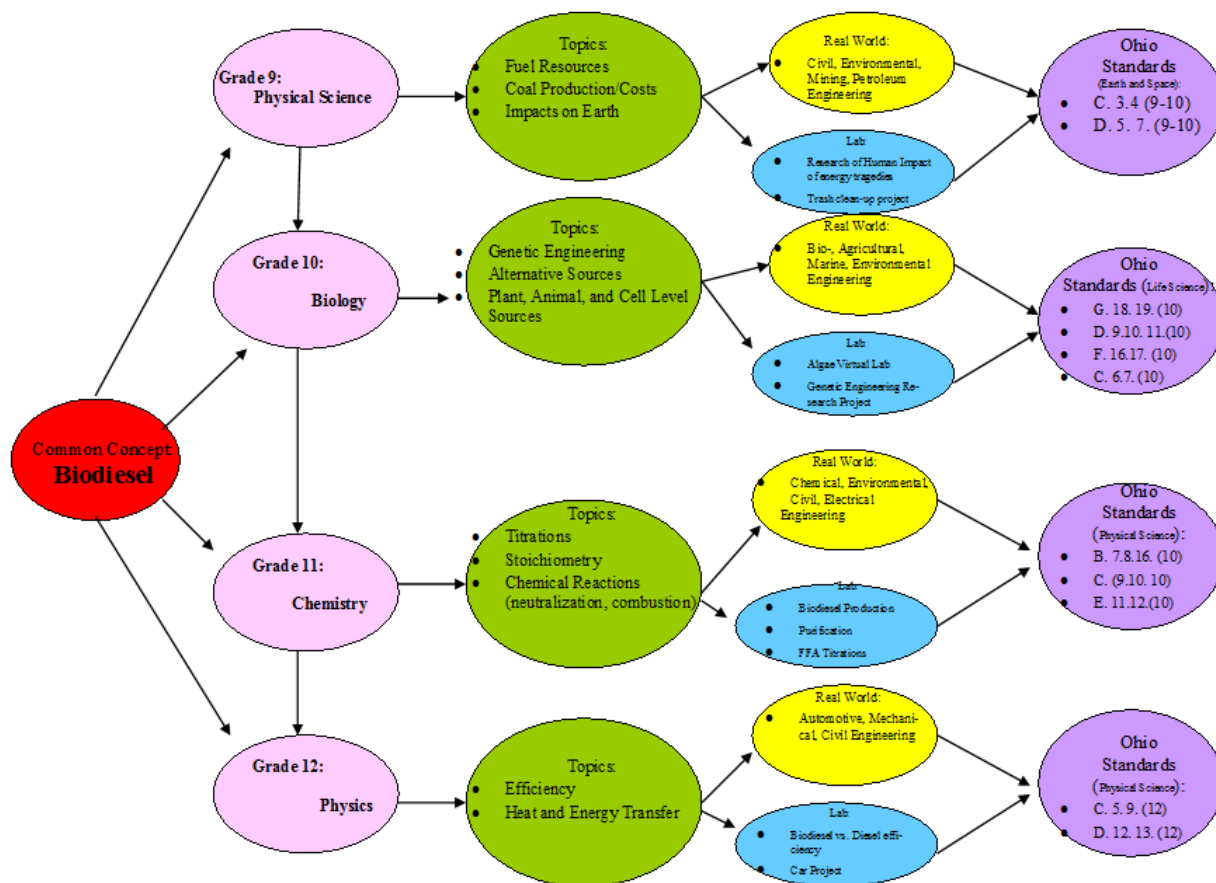


Figure 1: Concept Map illustrating biodiesel as a main goal of the curriculum fitting into four subjects of science

Lesson Name: From Plants to Power Plants Fellow Name: Jennifer Keiner
Subject: Biology Grade Level: 10 Duration: 7 days

Analyze Learners:

Overview & Purpose (Energy theme)

- What will be learned and why it is useful.
- **A** – Engineering application
- **C** – Engineering career connections
- **S** – Societal impact

Application:

Engineers have to design a way for biodiesel to be produced on a large scale; also find a way to get the largest amount of oil produced from the algae to produce greater quantities of biodiesel.

Career Connection:

Bioengineers, Agricultural Engineers, Marine Engineers, Environmental Engineer

Societal Impact:

Biodiesel can reduce harmful emission, lessen air pollution, and lower respiratory problems. It also reduces our need of natural resources and lowers our dependence on foreign oil.

Education Standards Addressed

Ohio Standards:

G. Describe how human activities can impact the status of natural systems.

1. Describe ways that human activities can deliberately or inadvertently alter the equilibrium in ecosystems. Explain how changes in technology/biotechnology can cause significant changes, either positive or negative, in environmental quality and carrying capacity.
2. Illustrate how uses of resources at local, state, regional, national, and global levels have affected the quality of life (e.g., energy production and sustainable vs. unsustainable agriculture).

D. Explain the flow of energy and the cycling of matter through biological and ecological systems (cellular, organismal and ecological).

1. Describe how matter cycles and energy flows through different levels of organization in living systems and between living systems and the physical environment. Explain how some energy is stored and much is dissipated into the environment as thermal energy (e.g., food webs and energy pyramids).
2. Describe how cells and organisms acquire and release energy (photosynthesis, chemosynthesis, cellular respiration and fermentation).
3. Explain that living organisms use matter and energy to synthesize a variety of organic molecules (e.g., proteins, carbohydrates, lipids and nucleic acids) and to drive life processes (e.g., growth, reacting to the environment, reproduction and movement).

F. Explain the structure and function of ecosystems and relate how ecosystems change over time.

1. Relate how distribution and abundance of organisms and populations in ecosystems are limited by the ability of the ecosystem to recycle materials and the availability of matter, space and energy.
2. Conclude that ecosystems tend to have cyclic fluctuations around a state of approximate equilibrium that can change when climate changes, when one or more new species appear as a result of immigration or when one or more species disappear.

B. Explain the characteristics of life as indicated by cellular processes and describe the process of cell division and development.

1. Compare the structure, function and interrelatedness of cell organelles in eukaryotic cells (e.g., nucleus, chromosome, mitochondria, cell membrane, cell wall, chloroplast, cilia, flagella) and prokaryotic cells.

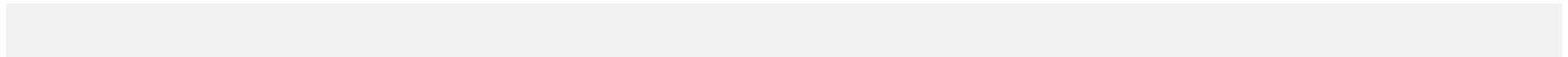
C. Explain the genetic mechanisms and molecular basis of inheritance.

1. Explain that a unit of hereditary information is called a gene, and genes may occur in different forms called alleles (e.g., gene for pea plant height has two alleles, tall and short).
2. Describe that spontaneous changes in DNA are mutations, which are a source of genetic variation. When mutations occur in sex cells, they may be passed on to future generations; mutations that occur in body cells may affect the functioning of that cell or the organism in which that cell is found.
3. Use the concepts of Mendelian and non-Mendelian genetics (e.g., segregation, independent assortment, dominant and recessive traits, sex-linked traits and jumping genes) to explain inheritance.

Select Goals & Objectives	Teacher Guide	Student Guide	
<p>Goals (learn/understand)</p> <p>Objectives (measurable) (Specify skills/information that will be learned.)</p>	<p>Goals</p> <ol style="list-style-type: none"> Students can relate the photosynthetic process with plant life in a real world scenario Students can understand the importance of alternative energy resources <p>Objectives</p> <p>Students will be able to:</p> <ol style="list-style-type: none"> Illustrate the photosynthetic cycle Describe under what conditions the algae has optimal growth Explain the conditions and algae that produces the most oxygen List ways why algae is important as an alternative energy Describe how the lab is useful for algae cultivation Explain the process of biodiesel production from algae 	<p>Misconceptions about this topic:</p> <ol style="list-style-type: none"> Students believe energy only flows from the top of the food chain down, with those at the top having the most energy and increasing in number at the expense of those below Students believe organisms in a population are important only to those other organisms on which it preys for food sources. Students believe populations will increase indefinitely because the resources are unlimited. Students believe the greenhouse effect is caused when gases in the atmosphere behave as a blanket and trap radiation, which is then re-radiated to the Earth. Students are taught global warming is a myth. Diagrams of energy pyramids that indicate decreases in energy (without indicating that the energy is given off as heat) can reinforce students' misconception that energy is not conserved. Students believe energy can be recycled through an ecosystem many times. 	<p>Materials Needed</p> <ul style="list-style-type: none"> Algae samples: <i>Chlorella</i>, <i>Phormidium</i>, <i>Cryptomonas</i>, <i>Fremyella</i> Test tubes, test tube holder Water Pipets Light sources Plastic colored light filters Microscope (Light) Pasco dissolved oxygen apparatus Wet slides Worksheets
<p>Select Instructional Strategies – (Give and/or demonstrate necessary information)</p>	<ul style="list-style-type: none"> Direct instruction Inquiry lesson Lab 	<ul style="list-style-type: none"> Group discovery Peer critique Student lab reports 	
<p>Utilize Technology</p>	<ul style="list-style-type: none"> Computer Microscope Pasco dissolved oxygen apparatus 	<ul style="list-style-type: none"> Computer Microscope Pasco dissolved oxygen apparatus 	<p>Other Resources Worksheets, textbook Internet resources</p>

<p>Require Learner Participation</p> <p>Activity (Describe the procedure and/or independent activity to reinforce this lesson)</p>	<p>Procedure:</p> <p>Day 1</p> <ul style="list-style-type: none"> • Pre-assessment worksheet (10 min) • Review of photosynthesis and introduction to lab with safety and instruction (10 min) • Preparation of algae test tubes, place in correct light source (20 min) • Recording of initial information (5 min) • Lab clean up (5 min) <p>Day 2-5</p> <ul style="list-style-type: none"> • Take daily recording of observed data, Pasco measured data, and wet slide of sample under the microscope every other day (10~20min) <p>Day 6</p> <ul style="list-style-type: none"> • Final lab day recording (20 min) • Lab clean up (5 min) • Begin Lab reports (25 min) <p>Day 7</p> <ul style="list-style-type: none"> • Peer review of lab reports (20 min) • Lab report edits (20 min) • Lab report print outs and turn in (10 min) 	<p>Procedure:</p> <p>Day 1</p> <ul style="list-style-type: none"> • Pre-assessment worksheet (10 min) • Review of photosynthesis and introduction to lab with safety and instruction (10 min) • Preparation of algae test tubes, place in correct light source (20 min) • Recording of initial information (5 min) • Lab clean up (5 min) <p>Day 2-5</p> <ul style="list-style-type: none"> • Take daily recording of observed data, Pasco measured data, and wet slide of sample under the microscope every other day (10~20min) <p>Day 6</p> <ul style="list-style-type: none"> • Final lab day recording (20 min) • Lab clean up (5 min) • Begin Lab reports (25 min) <p>Day 7</p> <ul style="list-style-type: none"> • Peer review of lab reports (20 min) • Lab report edits (20 min) • Lab report print outs and turn in (10 min) 	
<p>Evaluate (Assessment)</p> <p>(Steps to check for student understanding; Evaluate goals and Assess objectives)</p>	<p>Essential/Review questions are outlined (at least 5 from different levels of Bloom's taxonomy)</p> <ol style="list-style-type: none"> 1. Identify the different features in a plant cell. 2. Diagram the process of photosynthesis and the bi-products. 3. Justify whether or not you think algae can become a sustainable fuel source. 4. Propose a plan for a machine that has conditions to produce the most algae, justify your answer. 5. Explain how photosynthesis and algae growth are connected. 	<p>Pre and Post assessment is explained</p> <p>Pre-Assessment</p> <ul style="list-style-type: none"> • Students will first answer some questions and make some hypotheses about what they think will happen in the lab: <ol style="list-style-type: none"> 1. Describe the process of photosynthesis. 2. Under what light conditions will the most algae be produced? 3. Under what temperate conditions will the most algae are produced? 4. How can the color of the light source affect the algae? 5. Will oxygen levels rise or decrease throughout the five days? Why? <p>Post Assessment</p> <ul style="list-style-type: none"> • Students will write a lab report describing the five questions thoroughly from the pre-assessment making conclusions to why they were either correct or incorrect. 	<p>Pre/Post Test Questions:</p> <p>Pre Test Questions:</p> <ol style="list-style-type: none"> 1. Describe the process of photosynthesis. 2. Under what light conditions will the most algae be produced? 3. Under what temperate conditions will the most algae are produced? 4. How can the color of the light source affect the algae? 5. Will oxygen levels rise or decrease throughout the five days? Why? <p>Post Test Questions:</p> <ol style="list-style-type: none"> 6. Which element is needed for the plant to make chlorophyll although is not part of the chlorophyll molecule? 7. What happens to energy as a result of photosynthesis? 8. Chlorophyll absorbs most energy from what color regions of the light spectrum? 9. When a plant makes a glucose molecule by photosynthesis, from what source does the hydrogen molecule come from? 10. What products are made during photosynthesis?

<p>Reflection on Lesson:</p> <p>(Note – Supporting documents, Poster, and video Tutorial are available on this lesson as well.)</p>	<p>After the lesson is taught:</p> <ul style="list-style-type: none"> • What happened? • What did you learn? • How would you change your lesson next time? 	<p>Is this a MIDDLE SCHOOL lesson? No</p> <p>If not, please explain how it could be: During the ecosystem interdependence section of 8th grade science students can learn about algae as a source of food and life in many different ecosystems. They can grow their own algae and look how light affects algae growth, they could also go through basic microscope use and look at different algae slides through the microscope.</p>	<p>Is this a HIGH SCHOOL lesson? Yes</p> <p>If not, please explain how it could be:</p>
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Lesson Name: Biodiesel Lab Activity Fellow Name: Chris Behm
 Subject: Chemistry Grade Level: 11-12 Duration: 4X55 min

Analyze Learners: Overview & Purpose (Energy theme) <ul style="list-style-type: none"> What will be learned and why it is useful. A – Engineering is all about find ways to make an item as good as the original but with less materials and a lower cost, this is a chemical application of that. C – Students will compete to make the most efficient biodiesel with the least amount of waste, a similar responsibility of a chemical engineer. S – Students will understand diesel emission effects on people and how biodiesel helps reduce emissions 	Education Standards Addressed Physical Science 10, F.16 Illustrate that chemical reactions are either endothermic or exothermic (e.g., cold packs, hot packs and the burning of fossil fuels). Life Science 11, F.11 Investigate issues of environmental quality at local, regional, national and global levels such as population growth, resource use, population distribution, over-consumption, the capacity of technology to solve problems, poverty, the role of economics, politics and different ways humans view the earth. Physical Science 12, D, Apply principles of forces and motion to mathematically analyze, describe and predict the net effects on objects or systems.
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Select Goals & Objectives	Teacher Guide	Student Guide	
Goals – For students to understand the process of making biodiesel, benefits or biodiesel and possible downfalls of biodiesel. Objectives - For students be able to balance chemical equation, carry out a stoichiometry problem, and carry out a titration.	Goals I want to understand what students views on emerging technology is and where they are getting most of their information. Objectives I want to identify problems with knowledge gaps by students to improve the lab in the future.	Misconceptions about this topic: <ul style="list-style-type: none"> Students think that chemical reactions are a change to the initial substance and not an interaction between atoms. 	Materials Needed <ul style="list-style-type: none"> Waste Cooking Oil Methanol Sulfuric Acid Sodium Hydroxide Indicator Solution Hot Plate Pipettes Biodiesel Reactors Beakers Graduated Cylinder
Select Instructional Strategies – (Give and/or demonstrate necessary information)	: <ul style="list-style-type: none"> Direct instruction Inquiry lesson Hands on lesson Activity 	<ul style="list-style-type: none"> Cooperative Learning 	
Utilize Technology	<ul style="list-style-type: none"> Gas chromatograph 	<ul style="list-style-type: none"> Gas chromatograph 	Other Resources

<p>Require Learner Participation</p> <p>Activity Students must have been introduced to stoichiometry, titration methods and have an understanding on the use of lab equipment</p>	<p>Day 1 (TEACHER DEMO)</p> <ul style="list-style-type: none"> Assign 4 person groups Have each groups get the appropriate lab equipment Students will be given a background on biodiesel Set up as a demo the teacher will titrate a 1 mL sample of WCO with NaOH to determine the free fatty acid content of the sample Using an equation for conversion of FFA students in their groups will calculate how much NaOH must be added to a 500 mL reactor to convert the FFA of the sample to under 1% <p>Day 2</p> <ul style="list-style-type: none"> Teacher will collect the paper at the end of the day Each group will receive 50 mL of waste cooking oil from the cafeteria(provided by the teacher) Students will use the equation and method of preparing biodiesel <p>Day 3</p> <ul style="list-style-type: none"> Students will wash the biodiesel according to the methods instructed by the teacher <p>Day 4 (TEACHER DEMO)</p> <ul style="list-style-type: none"> The teacher, using the students samples will test the biodiesel using a calorimeter to figure out who was able to make the most efficient biodiesel 	<p>Day 1</p> <ul style="list-style-type: none"> Assign 4 person groups Have each groups get the appropriate lab equipment Students will be given a background on biodiesel Set up as a demo the teacher will titrate a 1 mL sample of WCO with NaOH to determine the free fatty acid content of the sample Using an equation for conversion of FFA students in their groups will calculate how much NaOH must be added to a 500 mL reactor to convert the FFA of the sample to under 1% <p>Day 2 (STUDENT ACTIVITY)</p> <ul style="list-style-type: none"> Teacher will collect the paper at the end of the day Each group will receive 50 mL of waste cooking oil from the cafeteria(provided by the teacher) Students will use the equation and method of preparing biodiesel <p>Day 3 (STUDENT ACTIVITY)</p> <ul style="list-style-type: none"> Students will wash the biodiesel according to the methods instructed by the teacher <p>Day 4</p> <ul style="list-style-type: none"> The teacher, using the students samples will test the biodiesel using a calorimeter to figure out who was able to make the most efficient biodieselare highlighted here 	
<p>Evaluate (Assessment)</p>	<p>Essential/Review questions are</p> <ul style="list-style-type: none"> Why is stoichiometry and balancing equations important to chemists and chemical engineers? Why is stoichiometry important to this activity? What types of chemical reactions are used in this activity? Be specific and tell when each reaction is happening. 	<p>Pre and Post assessment is explained</p> <ul style="list-style-type: none"> Why is it important for researches to be exploring new ways of producing biofuels? 	<p>Pre/Post Test Questions:</p> <ul style="list-style-type: none"> Is there anything that could be done differently in the acid pretreatment, biodiesel production and washing that could be done differently to get better results? All groups used the same methods, why did some groups prepare a better sample than others?
<p>Reflection on Lesson:</p> <p>(Note – Supporting documents, Poster, and video Tutorial are available on this lesson as well.)</p>	<p>After the lesson is taught:</p> <ul style="list-style-type: none"> What happened? What did you learn? How would you change your lesson next time? 	<p>Is this a MIDDLE SCHOOL lesson? _____</p> <p>If not, please explain how it could be:</p>	<p>Is this a HIGH SCHOOL lesson? _____</p> <p>If not, please explain how it could be:</p>