

Making Fuel From Algae: Design Your Own Algae Biofuel Company

Students will learn how massive quantities of algae are grown and how they could be used to make biofuels. They will learn about the challenges and costs involved in growing algae to make these products. Then, students will role-play and become managers of their own "algae farms" with the goal of making a profit from this renewable energy source. Using data and figures, they will make informed decisions about which algae species to grow, the location of their facility, which growth systems to use, and which water resources to use to maximize the amount of algae they grow. The uncertainties and challenges they will face while managing their algae are the same problems that researchers are currently trying to solve.

Learning Objectives

1. List ideal characteristics of an energy resource and identify which of those characteristics algal biofuels have.
2. Describe the growth requirements of algae.
3. Decide how to grow algae at an algal biofuel facility by evaluating data and information.

Standards covered:

NC Essential Science

8.P.2 Explain the environmental implications associated with the various methods of obtaining, managing, and using energy resources.

8.L.2 Understand how biotechnology is used to affect living organisms.

8.L.3 Understand how organisms interact with and respond to the biotic and abiotic components of their environment.

Next Generation Science

MS-ETS-1 Engineering Design

Approximate time for lesson plan: 1 hr + homework reading prior to lesson

Appropriate for grades: 8 - 12

Class size: Any class size, students work in groups of 3-4

Resources needed: Printed homework readings, worksheets, and scientific evidence packets. *Teacher Background Information packet provided.*

Lesson plan developer: Sarah Loftus, PhD Student at the Duke University Marine Lab. Please contact sarah.loftus@duke.edu with any questions or comments about this lesson plan.

Homework

Reading packet including:

- 'Eukaryotic Microorganisms' description from Brock's Biology 11th edition (pg 35)
- EPA "What are biofuels?" paragraph
- Algae: The scum solution (2-page Nature article)
- Department of Energy's Algal Biofuels fact sheet (2-pages)

Instruct students: While reading, consider the advantages of using algae as a renewable fuel source. What are the requirements needed for algae to grow? What are some ways to grow algae?

In Class

Materials needed:

- Printed worksheets (black and white) and scientific evidence packets (in color) for each student. Teams can share scientific evidence packets if color printing is limited.

1. Teacher creates groups of 3-4 students. Students sit with each other for entire lesson (2 min)

2. **Engage students in the topic of algal biofuels** (7 min)

Teacher asks students questions. Students raise hands to answer questions. If students struggle or do not answer fully, clarifying answers are provided below the questions for the teacher to announce to the class.

Optional: while discussing, show relevant photos found online on a display in front of the class via powerpoint (e.g., photos of fossil fuels and renewable energy sources).

What are fossil fuels?

Fossil fuels include coal, oil, and natural gas that were produced over millions of years from plants buried underground that experienced intense heat, pressure, and a lack of oxygen. These fuels are nonrenewable because we use them at a much faster rate than they can be replenished by natural processes.

What are some environmental impacts that fossil fuels have on the planet?

The extraction of fossil fuels by mining and drilling can disrupt ecosystems; fossil fuels emit greenhouse gases when burned that lead to global climate change; an increase in carbon dioxide concentrations in the atmosphere can lead to ocean acidification. See what other answers the students come up with.

What does it mean for energy to be renewable? Why would we want to use renewable energy instead of fossil fuels?

Renewable energy can be produced over and over again because it depends on factors such as sunlight, water movement, and plant growth. Renewable energy does not emit as many greenhouse gases as fossil fuels and can have less of a harmful impact on ecosystems than fossil fuels do.

One kind of renewable energy is biofuels. What are biofuels?

Biofuels are fuels such as ethanol and biodiesel that are derived from plants and other organic matter (matter that contains the element carbon). Corn, sugar cane, grasses, and soybeans are typical bioenergy crops.

Transition: Teacher says that algae are another potential bioenergy crop that can be used to make fuels.

3. Activity: Students use scientific evidence to role-play as managers of an algae biofuel company and decide how to grow their algae (30 min)

While passing out worksheet and packet of scientific evidence, teacher explains that students will now be managers of their own algal biofuel companies. First they should name their company (get creative!). Using the information they learned from their homework reading and from the scientific evidence provided, they will make decisions about how to grow their algae. The goal is to consider different scenarios that might help and harm their algae, and consider all parts of the problem together. They will use the worksheet provided to guide their thinking process and decisions. In 30 minutes, students should have all decisions made and will present their company's plan to the class, backing up their decisions.

While students are discussing, teacher walks around to help when students are struggling or if they have clarifying questions. Teacher should be familiar with answer key and background information to help students.

4. Presentation to class of each company's executive plan for algae cultivation and explanation for their decisions. (~20 min, depending on class size)

While students are presenting, teacher can ask questions to make sure students have thoroughly thought through their decisions. For example, a teacher can ask "what happens if there is a drought and you run out of freshwater?", "what if there are harmful bacteria that get into your open pond and kill all of your algae?". There are no "correct" answers to the decisions about how to grow algae, but the students' answers should be appropriate (e.g., do not choose a marine algae species and a freshwater source of water).

Optional: Create a point system and tally up costs and profits based on the decisions of each team. Give each group a scenario and see if their plan will make a profit (positive number of points) under the given scenario. For assigning points, consider the relative costs and benefits of each decision (i.e., open ponds should cost less points than closed systems).

Explain to students that uncertainty is why researchers build models and start experiments on a small scale before testing their decisions on a large scale, so that they can predict the outcomes without using so much time, materials, and money. Researchers are currently working to solve the problems that the students tried to solve today by deciding how to grow their algae with the information they had available.