SANTA FE COMMUNITY COLLEGE
Biofuel Center for Excellence

STUDENT MANUAL
Introduction to Algal Biofuel: Training & Methods

BIOFUEL CENTER FOR EXCELLENCE

Introduction to Algal Biofuel: Training & Methods

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Table of Contents

Class I:
Algal Biofuel Overview 1
Powerpoint Presentation Slides:..... 4

Class II:
Algal Biology – Diversity and Ecology; Microscopy..... 14
Powerpoint Presentation Slides:..... 24

Class III:
Algal Biology – Physiology, Culturing, and Measuring the Environment..... 30
Powerpoint Presentation Slides:..... 38

Class IV:
Algal Biology – Experimentation..... 45
Powerpoint Presentation Slides:..... 48

Class V:
Large Scale Algal Biomass Production..... 51
Powerpoint Presentation Slides:..... 52

Class VI:
Data Analysis – Presentation of Findings – Course Conclusions 57

References:..... 59

Class 1

Algal Biofuel Overview

Introduction

Algae have been one of the most important organisms on the planet for millions of years. Blue-Green algae are one of the most ancient organisms and are responsible for creating Earth's present atmosphere. The petroleum we use today is the result of planktonic algae having been buried and subjected to intense heat and pressures for millions of years. Despite their small size, algae can have huge impacts. For more than 30 years algae have been considered as a prime source for renewable biofuel that can replace our dependence on a limited petroleum supply. Currently, research is being carried out which has as its objective the large-scale production of algal biomass to be used to create a variety of biofuels. This course is designed to provide students with a broad understanding of algal biomass production and common methods used.

Terms: Photosynthesis, Biofuel, lipid, waste water, Biomass, GMO, Capitol cost, Operation cost, Revenue

Lab Procedure I

Techno-Economic Analysis

Introduction:

In order for the algae biofuel industry to be successful it must be economically viable. One of its major challenges is developing affordable technology that can successfully cultivate and process algae. The technology of growing algae consists of all of the research and development that goes into selecting and optimizing strains, designing and developing the growing, harvesting and extraction systems. This technology will result in establishing reliable growing protocols for algae strains and commercial growing systems. The costs associated with starting an algae farming business are called capital costs. The costs associated with operating an algae farm are the operating costs. Revenue is the amount earned from the algae products produced.

So, the revenue produced must be greater than or equal to the sum of capital and operational costs.

Revenue = R
Operational Cost = O_c
Capital Cost = C_c

$$R \geq O_c + C_c$$

Exercise 1

In the space provided, list factors that you think will affect R, O_c and C_c.

R:

O_c:

C_c:

Accurate economic models for algal biomass production are difficult to create. For instance, it is difficult put an accurate number on the value for services like wastewater treatment, labor and product processing since there is not a directly comparable industry. Still, estimates can be made to help indicate where costs must be cut or changed to make projects successful. Many algae business have and will fail due to improper or inefficient allocation of funds.

Exercise 2

From your list made above for R, O_c and C_c choose important factors and list how your can either maximize revenue or reduce cost for each variable.

R:

O_c:

C_c:

Powerpoint Presentation Slides:

Algal Biofuel Overview

What are Algae?

- Plant-like organisms
- Photosynthesis
- Ancient precursors to plants
- Very important in global environment



What is Biofuel?

- Fuel derived from biological carbon fixation
- Fossil fuels
- Corn
- Vegetable oil
- Food
- …..



Why Algae for Biofuel?

- Fast growing
- High lipid content
- Grow on waste water
- Grow on agricultural waste



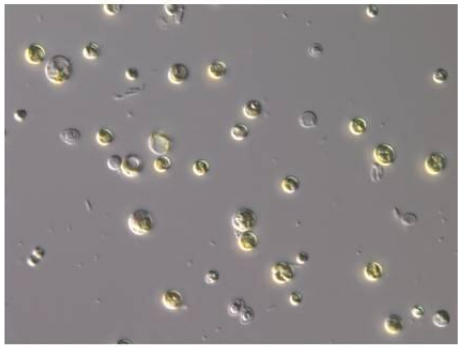
Why Algae for Biofuel?

- Co-products
- CO_2 neutral (?)
- Not competing with agriculture
- Replacement for fuels already in use



Types of Biofuel from Algae

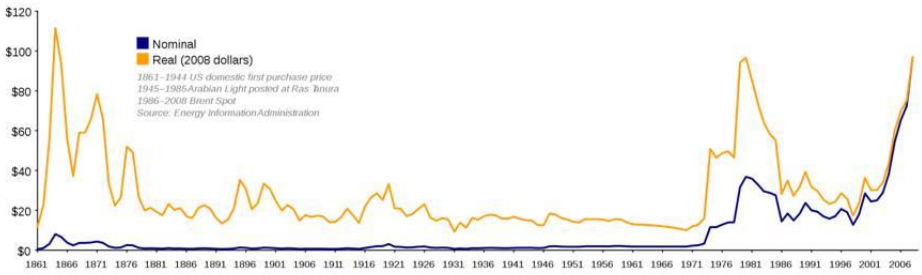
- Diesel
- Gasoline
- Jet fuel
- Ethanol
- Hydrogen
- Veggie Oil
- …..



History of Algae Biofuel in USA

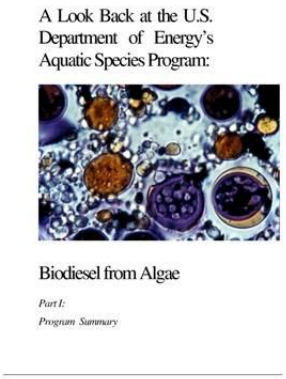
- 1973 – US Oil Embargo
- Organization of Arab Petroleum Exporting Countries (OAPEC)
- Sharp oil price increase

Oil Prices



Aquatic Species Program (ASP)

- 1978-1996
- Jimmy Carter
- Funded by Department of Energy
- Develop renewable transportation fuel

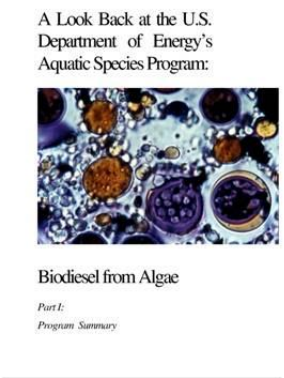

A Look Back at the U.S. Department of Energy's Aquatic Species Program:

Biodiesel from Algae

Part I:
Program Summary

Aquatic Species Program

- Initial focus – Hydrogen
- Focus shift – Biodiesel
- Culture Collection
  - High lipid
  - High production
  - 3,000 isolates
- Final Report 1998

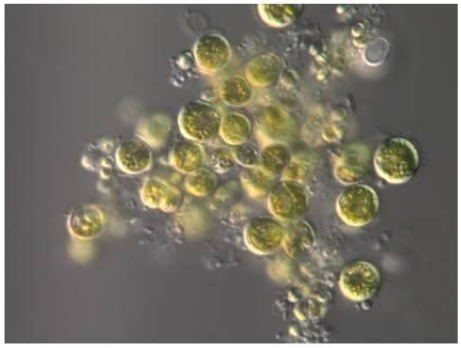

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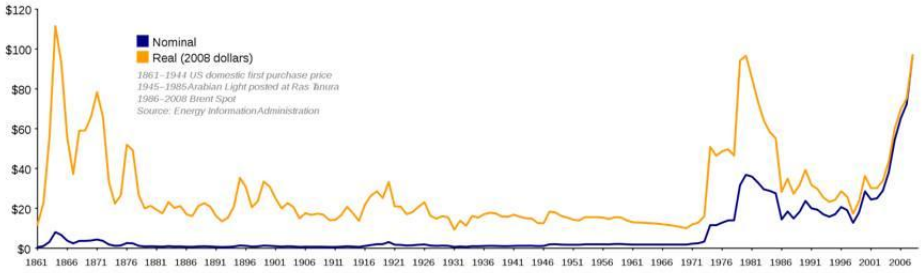
Part I:
Program Summary

ASP: Roswell New Mexico

- Biomass production: Open Ponds - CO_2 Utilization
- 50 $g/m^2/d$
- Projected cost of biodiesel 2x cost of diesel ($1.12) in 1998
- Showed potential of algae as renewable energy



Oil Prices



Recent Policy Towards Biofuel

- Energy Independence and Security Act 2007
  - Renewable Fuel Standard
    - 36 billion gallons of renewable biofuel by 2022
- American Recovery and Renewal Act
  - $800M
  - DOE – Biomass program

National Algal Biofuels Technology Roadmap

- Lower greenhouse gas emissions
- Reduce dependence on foreign oil
- Affordable, reliable energy
- Many technology paths



National Algal Biofuels Technology Roadmap

- "Developing the next generation of biofuel is key to our effort to end our dependence on foreign oil and address the climate crisis – while creating millions of new jobs that can't be outsourced." – Steven Chu – Secretary of Energy 2009

Challenges to Biofuel production from Algae

- Technological
- Regulations and Standards
- Public – Private Partnerships
- Economic



Technological Challenges

- Biomass Production
  - Growing System
  - System optimization – Algal Biology
  - Harvesting – Extraction
- Conversion or Harvest of Products - Market
  - Biomass to fuel
  - Co-products
  - Infrastructure

Regulation and Standards

- None exist
- GMO?
- Product quality
- Fuel Standards
- USDA
- EPA

Public – Private Partnership Industry – Academia

- Partnership challenging
- Differing goals
- Intellectual property vs education
- Both benefitial to progress of industry



Economics of Biofuel Production from Algae

- Cost of Production
  - Operational Costs
    - Utilities
    - Labor
    - Nutrients
    - Transportation
    - etc
  - Capital Costs
    - Land
    - Growing System
    - etc
- Revenue
  - Value of Products
  - Carbon sequestration
  - Bioremediation
  - Water treatment

Class 2

Algal Biology – Diversity and Ecology; Microscopy

Algae live in almost every type of habitat: lakes, rivers, oceans, soil, rock, deserts, hot springs and salt flats. As a result, there are thousands of species of unique algae, each with its special way of carrying out life. Today we will explore some of the biological diversity of algae. We will use the microscope to observe and count living algal cells. Also, we will learn how to determine the mass of algae in a sample. Today's class will help to give you an understanding of why algae are such good candidates for producing renewable biofuels.

Terms: Microscope, wet mount, hemocytometer, dry weight, ecology, biology, physiology, algal bloom, nutrients

Lab Procedure II

Lab Etiquette and Safety

- Keep your workspace clean.
- No eating or drinking in laboratory space.
- Keep aisles clear of chairs, equipment and personal items.
- Always leave workspace and equipment clean and stored properly for the next persons use.
- Do not put chemicals or trash down the sinks.
- Follow instructions and procedures when using equipment.
- Do not interfere with other's work or experiments.
- Take your time when working.
- Follow safety standards for fire safety, chemical safety and equipment safety.
- Place broken glass or sharp wastes in designated waste container.
- Know where safety equipment is located and how to use it.

Observe these guidelines to help ensure that the lab is a safe and enjoyable environment to work in.

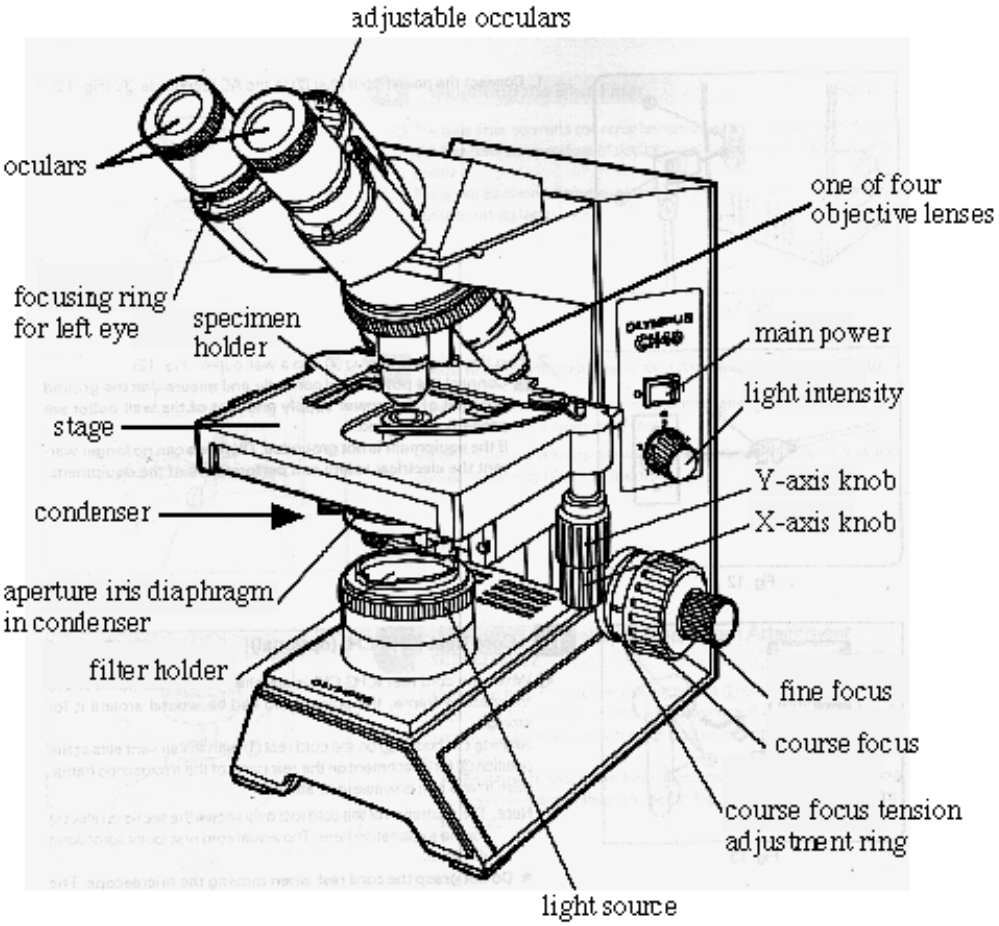
Lab Procedure III
Microscopy

Introduction

We will be using the microscope to view algae that are invisible to the unaided eye. The microscope is a tool that will help us to assess the health of algae cultures, identify species present and determine the density of algae in a sample. We will start by learning the parts of a microscope and how to operate its parts. We will then learn how to make a wet mount of an algae sample and view it on the microscope, making drawing of what we see.

Exercise 1

Parts of a Microscope



Adjustable Oculars – can be adjusted to fit distance between eyes. Move closer together or further apart until both oculars create single image.

Oculars – eyepieces through which you will view a specimen.

Focusing ring for left eye – to adjust, close left eye and bring specimen into focus using the fine focus knob. Then close right eye and adjust focusing ring for the left eye. This compensates for any differences in vision between eyes.

Stage – Platform for placing microscope slide.

Specimen holder – Holds microscope slide on stage and moves slide.

Y-axis knob – moves slide in the y-axis on the stage. From top of stage to bottom.

X-axis knob – moves slide in the x-axis on the stage. From left to right.

Fine focus – moves the stage up and down in very small increments in order to focus the specimen. Use at high power objectives.

Coarse focus – moves the stage up and down in large increments in order to focus the specimen. Use at low power magnification. **DO NOT USE at 100x OBJECTIVE.**

Main power – provides power to the light source.

Light intensity – changes voltage supply to light source, dims or brightens light.

Condenser – focuses light into the objectives from the light source. Proper adjustment increases resolution of specimen.

Iris diaphragm – adjusts the amount of light and size of light cone sent to the objective.

Objective lens – lenses that magnify the specimen. Usually 4x, 10x, 40x, and 100x.

Exercise 2

Preparing a wet mount

1. Place one or two drops of sample containing living algae onto the center of a microscope slide
2. For quick viewing, angle a single coverslip at a 45° toward the drops of sample. Move the bottom of the coverslip along the slide until it makes contact with the sample. Ease the coverslip onto slide.
3. For longer viewing, place a small bead of Vaseline around the bottom edges of the coverslip. Gently lower the coverslip over sample. Press to seal Vaseline to slide.

Exercise 3

Viewing a wet mount

1. Make sure microscope is set to the lowest power objective and that the stage is at its lowest position.
2. Place slide with prepared wetmount onto the stage of the microscope and secure in the specimen holder.
3. Using the X-Y- axis knobs, move the specimen directly under the low power objective.
4. Turn on the main power.
5. Adjust oculars to fit eye distance.
6. Looking through the oculars, begin raising the stage using the course focus knob.
7. When specimen comes into view, begin to use the fine focus knob to bring into focus.
8. Change to the next power objective, up to 40x for viewing live algae. Do not use the 100x objective at this point.

Exercise 4

Illustrate living algae

Make several drawings of algae that you see. Use texts to tentatively identify the species found.

Drawings

Lab Procedure IV
Cell Counts using a Neubauer Hemocytometer

Introduction

Algal cell density is a useful measure to determine biomass. Cell density can be correlated with other measures of biomass such as optical density and dry weight in order to better understand biomass production rates. This procedure describes how to perform algal cell counts using a **hemocytometer**. A hemocytometer is a thick glass slide with a depression that creates a chamber of fixed volume. When filled with a cell suspension cells will settle onto a grid of known area. An equation is provided for the hemocytometer that will calculate the concentration of cells in the original suspension.

Procedure

1. Sample algae from a well mixed system so that it accurately represents cell density of the entire volume of the system.
2. Always carefully handle the hemocytometer. Use lens paper to clean the counting surfaces and thick coverslip with lab grade water. Make sure you are using the coverslip provided with the hemocytometer.
3. Place the coverslip over the counting chambers.
4. Mix algae sample by vortexing or shaking.
5. Load both counting chambers by placing the algae suspension at the edge of the coverslip with a pipette. Capillary action will fill the void of the counting chamber.
6. Let hemocytometer settle for 10 minutes.
7. Start at the low power magnification and bring specimen into focus. Move up to 40x for counting.
8. Count all algae cells within the inner grid for both counting chambers. Move the slide carefully so not to disturb the settled cells.
9. Use formula provided with hemocytometer to calculate cell density per milliliter from counts.

Lab Procedure V
Algal Dry Weight Determination

Equipment and Supplies

- Whatman GFF filters
- Filter apparatus and holder
- Filter flask
- Vacuum tubing
- Vacuum
- 10-20 ml pipette
- Aluminum Trays to hold filters
- Dessicator
- Drying oven
- Balance capable of 0.000 g precision
- DI water in squirt bottle
- Vortex
- Algae Sample

Procedure

1. Extract algae from a well mixed sample so that it accurately represents dry weight of the entire volume of the sample.
2. Number aluminum trays by marking tab. Prepare enough trays to process the number of samples you have with three replicates. Record tray number in datasheet. Avoid touching aluminum with bare hands.
3. Using forceps, place a single filter smooth side down in each tray. Record weight of each tray + filter in datasheet.
4. Assemble filter apparatus and connect to vacuum with hose.
5. Turn on vacuum and rinse several times with DI water.
6. Using forceps, place filter in filter apparatus.
7. Rinse filter with DI water.
8. Mix algae sample well by vortexing and shaking.

9. Depending on the density of the algae sample add known volume of mixed sample to the filter apparatus. Dense cultures may require 5-10 ml. Less dense samples can have volumes up to 50 ml.
10. If the algae sample is grown in seawater, rinse three times with 5-10 ml DI water.
11. Wait until all visible moisture is removed from the surface of the filter.
12. Disassemble filter apparatus and carefully remove filter with forceps. Place filter in its numbered aluminum tray.
13. Process three replicates for each sample and place all samples on metal tray.
14. Place tray of samples in drying oven at 100°C for at least 8 hours.
15. Weigh samples. Record weight in datasheet.
16. Place samples back in drying oven at 100°C. Weigh again and record weight.
17. Repeat drying and weighting until you have the same weight three times in a row in order to determine sufficient drying time.
18. Samples can be stored in desiccator after complete drying in oven.
19. Calculate dry weight: subtract the dried weight in grams of the algae+filter+tray, from the initial weight in grams of the filter+tray. Divide this by the number of ml filtered through the filter.
    a. DW=(dry algae+filter+tray in grams– filter+tray in grams) / ml sample filtered

Lab Procedure VI
Measuring Optical Density using a Spectrophotometer

Equipment and Supplies

- Kimwipes
- Thermo Genesis 20 Spectrophotometer
- Cuvettes
- DI (deionized) water
- Algae Sample
- Pipettes
- Datasheets

Procedure

1. Power on **spectrophotometer** by turning on power switch on the back of the machine. Let the lamp warm up for 10 minutes.
2. Select the wavelength 680nm by pushing the wavelength arrows up or down.
3. Run a blank of DI water by placing a clean cuvette in the cuvette holder, closing the door and pressing the blank key.
4. Measure all samples for this wavelength. Mix samples well in cuvette using a pipette before reading. Make sure the cuvette is clean and that there are no air bubbles or debris in the sample.
5. Record data in datasheet.
6. Verify that the machine is not drifting by running the DI water as a sample.
7. If the DI water does not read + or - 0.001, re-blank the machine.
8. After all samples have been run for 680nm, change the wavelength to 750nm and start at step 3 again. Be sure to re-blank the machine when changing wavelengths.

Powerpoint Presentation Slides:

Class II: Algal Biology – Diversity & Ecology; Microscopy

Introduction to Algal Biofuel

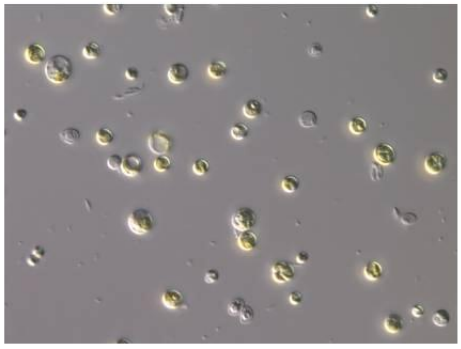
Class Outline

- Lecture
  - Algae Diversity
- Lab Exercises
  - Lab Etiquette and Safety
  - Microscopy
  - Cell Counts using a Hemocytometer
  - Algal Dry Weight Determination
  - Optical Density Measurements
  - Algal isolation

Algae Diversity

- Plant-like organisms

Unicellular (Microalgae)



Multicellular (Macroalgae)



Algae Diversity



- Diverse Habitats
  - Deserts
  - Oceans
  - Lakes
  - Rivers
  - Hypersaline

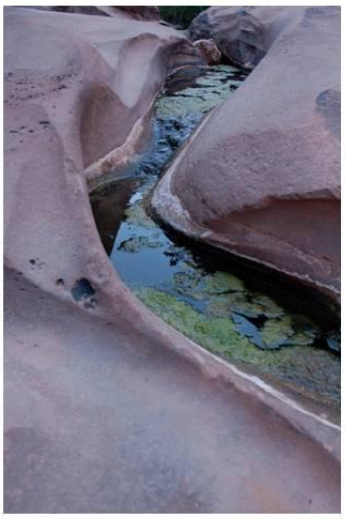
Algae Diversity



- Diverse Physiologies
  - Light
  - Nutrients
  - Temperature
  - pH
  - Storage Products

Algae in the Environment

- Typically not abundant
  - Factors limit success of single species
    - Lack of Nutrients – Natural levels
  - Many species co-occur
    - Share resources
  - Competition
  - Herbivory



kkkk

Isolating Algae in the Environment





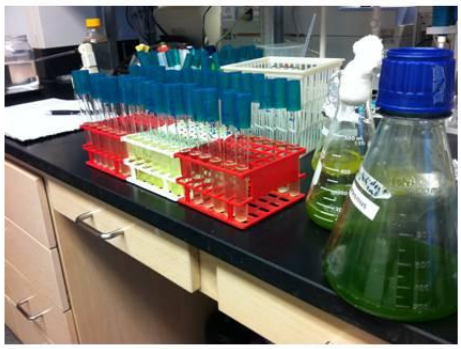
Economic Uses of Algae

- Food
- Fertilizer
- Agar
- Bioremediation
- Fuel
- Plastics



Lab Exercises

- Lab Etiquette
- Keeping the lab clean
- Workspace



Lab Exercises

- Performing cell counts using Hemocytometer



Lab Exercises

- Optical Density Mearurements
  - Spectrophotometer
    - A680nm
    - A750nm



Class

3

Algal Biology – Physiology, Culturing, and Measuring the Environment

We are continuing to explore the diversity of algae, but this class will focus on algal physiology. Algal physiology entails the study of how algal cells carry out their biological functions. These functions can be anything from how an alga deals with temperature to what concentration of nutrients is preferable for growth or how much lipid is produced by a cell. The many different species of algae have developed countless ways of dealing with the environment. In order to understand how algae responds to changing environmental conditions we must be able to measure variables important to algal growth. In this class we will cover topics of algal physiology as well as measuring the environmental conditions by using sensors. Also, we will learn methods for culturing algae. We will be using methods we learned in previous classes to measure algal growth.

Terms: physiology, sensor, environmental variable, biomass, salinity, pH, dissolved oxygen, environmental variable

Lab Procedure VII

Algal Biomass and Environmental Monitoring

Introduction

Today we will practice the methods of measuring biomass learned in the previous class. Several samples of algae at varying concentrations and varying environmental conditions will be provided for this exercise. You will be performing cell counts, dry weights and optical density measures in order to determine algal biomass. In order to become familiar with collecting environmental data you will also use sensors to measure salinity, pH and dissolved oxygen on the same samples. Allow plenty of time to focus on gaining an understanding of these procedures.

Exercise 1: Algal biomass Measurements

You will be provided with three samples of varying cell densities and environmental conditions. Measure three replicates for each sample for each method. Using the methods in this manual, collect the following data:

Cell Count

	Rep. 1	Rep. 2	Rep. 3
Sample 1	_____	_____	_____
Sample 2	_____	_____	_____
Sample 3	_____	_____	_____

Optical Density 680 nm

	Rep. 1	Rep. 2	Rep. 3
Sample 1	_____	_____	_____
Sample 2	_____	_____	_____
Sample 3	_____	_____	_____

Optical Density 750 nm

	Rep. 1	Rep. 2	Rep. 3
Sample 1	_____	_____	_____
Sample 2	_____	_____	_____
Sample 3	_____	_____	_____

Dry Weight

	Rep. 1	Rep. 2	Rep. 3
Sample 1	_____	_____	_____
Sample 2	_____	_____	_____
Sample 3	_____	_____	_____

Exercise 2 Environmental Monitoring

Use the Vernier sensors to gather the following data:

Salinity

	Rep. 1	Rep. 2	Rep. 3
Sample 1	_____	_____	_____
Sample 2	_____	_____	_____
Sample 3	_____	_____	_____

pH

	Rep. 1	Rep. 2	Rep. 3
Sample 1	_____	_____	_____
Sample 2	_____	_____	_____
Sample 3	_____	_____	_____

Dissolved Oxygen

	Rep. 1	Rep. 2	Rep. 3
Sample 1	_____	_____	_____
Sample 2	_____	_____	_____
Sample 3	_____	_____	_____

Compare your data with that of your classmates. The instructor will compile all student data and demonstrate how to view using graphs.

Lab Procedure VIII
Algal Culturing

Introduction

Successfully growing algae in the laboratory is a key step in mass cultivation of algae. In order for algae to grow, they must be presented with conditions that are similar to their natural environment. Key variables in growing algae include light level, temperature and important elements of water chemistry. Optimizing these variables for each strain of algae will help it to grow as fast as possible. In this procedure we will learn how to make media to successfully cutivate algae in the lab. There are many algae media recipes available, but we will focus on two commonly used. The first recipe will be for f/2, a medium used to simulate high nutrient seawater. Second we will look at Bolds Basal Medium (BBM) a medium that grows many species of freshwater algae.

Procedures

The following tables shows the solutions used to make 1 liter of f/2 and BBM media. For f/2, solution 3 is only used if growing diatoms, otherwise it is omitted.

Mixing 1 liter of f/2

		Volume Used
Solution 1	$NaNO_3$	1 ml
Solution 2	NaH_2PO_4	1 ml
Solution 3	$Na_2SiO_3 * 9H_2O$	1 ml
Solution 4	Trace metals	1 ml
Solution 5	Vitamins	0.5 ml

Equipment and supplies

- Autoclave
- f/2 stock solutions
- 1 ml pipette
- 1 liter volumetric flask
- 1 liter media bottle
- Instant Ocean seawater
- Autoclave tape
- Labeling tape

Procedure

1. Using a 1 liter volumetric flask add around 500 ml of instant ocean seawater.
2. Add the specified volumes of the f/2 stock solutions.
3. Bring the volume up to 1 liter using instant ocean seawater
4. Mix well. Make sure there is no precipitate.
5. Transfer f/2 to 1 liter media bottle. Label bottle and apply autoclave tape. Keep cap loose.
6. Autoclave.
7. After autoclaving allow f/2 to cool for 24 hrs before use.

Mixing 1 liter of BBM

Used		Volume
Solution 1	$NaNO_3$	10 ml
Solution 2	$CaCl_2*2H_2O$	10 ml
Solution 3	$MgSO_4*7H_2O$	10 ml
Solution 4	K_2HPO_4	10 ml
Solution 5	KH_2PO_4	10 ml
Solution 6	NaCl	10 ml
Solution 7	Alkaline EDTA	1 ml
Solution 8	Acidified Iron Solution	1 ml
Solution 9	Boron Solution	1 ml
Solution 10	Trace Metals Solution	1 ml

Equipment and supplies

- Autoclave
- BBM stock solutions
- 1 ml pipette
- 1 liter volumetric flask
- 1 liter media bottle
- DI water
- Autoclave tape
- Labeling tape

Procedure

1. Using a 1 liter volumetric flask add around 500 ml of DI water.
2. Add the specified volumes of the BBM stock solutions.
3. Bring the volume up to 1 liter using DI water
4. Mix well. Make sure there is no precipitate.

5. Transfer BBM to 1 liter media bottle. Label bottle and apply autoclave tape. Keep cap loose.
6. Autoclave.
7. After autoclaving allow BBM to cool for 24 hrs before use.

Transferring Algal Cultures

Equipment and supplies

- Stock algae culture
- Sterile culture flasks with 50 ml growth medium and cotton plugs
- Labels
- Laminar flow hood or sterile environment
- Alcohol lamp
- Sterile pipettes
- Spray bottle with alcohol

Procedure

1. Spray working space with 70% alcohol and wipe clean.
2. Place equipment and supplies in working area and spray lightly with alcohol.
3. Light alcohol lamp and place near working area.
4. Remove cotton plug from sterile culture flask, holding by the top, keep it between two fingers.
5. With a sterile pipette transfer around 2 ml from a healthy culture to the fresh sterile medium.
6. Replace cotton plug.
7. Place new culture on growing rack.

Powerpoint Presentation Slides:

Class III: Algal Biology – Physiology, Culturing, and Measuring the Environment

Introduction to Algal Biofuel

Class Outline

- Lecture
  - Algal physiology, culturing method, and environmental monitoring
- Lab Exercises
  - Algal Biomass Monitoring
  - Algal culturing
  - Environmental Monitoring

Algal Physiology

- How do algal cells carry out the biological functions that keep them alive?



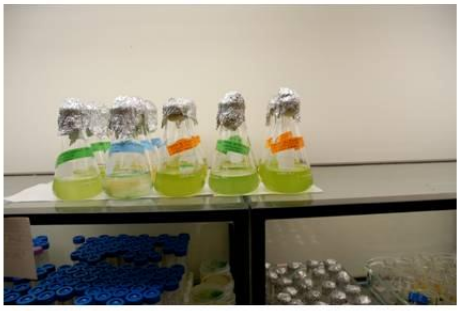
Algal Physiology



- Algae have diverse biological functions
  - Salinity
  - Temperature
  - pH
  - Nutrient conditions
  - Light
  - Lipid Production
  - Toxin Production
  - Growth Rate

Algal Physiology

- Measuring Algal Growth
  - Growth response to measured variable
  - Cell count
  - Optical density
  - Dry weight
  - Fluorescence
  - Chlorophyll content



Culturing Algae

Types of Media:

Defined

- Known components + pure water
- Can determine growth response to specific changes
- Many recipes formulated for specific algae species

Undefined

- Custom media
- Unknown components + pure water
- Wastewater, soil extract, groundwater – can change
- Grows "picky" species

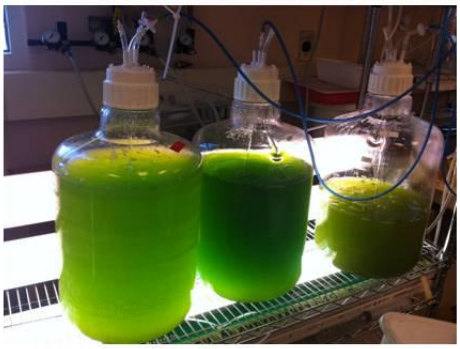
Culturing Algae

- Mixing Media from Stock Solutions
  - Calculating concentrations and volumes



Measuring the Environment

- Variable Environment
  - In nature, leads to diversity
  - Don't want growing systems to vary from optimized conditions
    - pH shifts
    - CO_2 gradients
    - O_2 gradients
    - Nutrient depletion
    - Contamination of non-target species



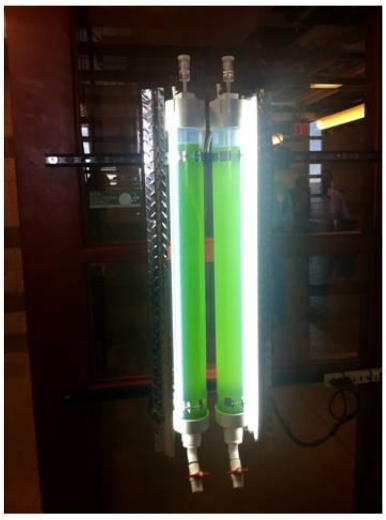
Measuring the Environment

- Monitoring and Control in Growing Systems
  - Monitor variables important to growth
  - Control variables within range



Measuring the Environment

- Controlling environment
  - Easier in Bioreactors
  - Hard in Open Ponds



Measuring the Environment

Optimal Growth

- Provide optimal growing condition
  - pH
  - Salinity
  - Nutrients
  - temperature

Compound Production

- Stressful condition
  - Limited nutrient
  - High salt
  - Etc

Lab Exercises

- Using a Spectrophotometer
  - Measuring optical density

Lab Exercises



- Algae Culturing
  - Sterile/Unialgal conditions
  - Making media
  - Transferring cultures

Class 4

Algal Biology – Experimentation

In order to better understand algal biology we can perform experiments that address specific questions. For example: two strains of algae can be compared to see which grows fastest under a set of conditions. Experiments can help us discover the growth preferences of algal strains we are interested in growing so that we can produce the as much biomass as possible. In today's class we will design and set up an experiment to answer specific questions. We will monitor our experiments, collect data and analyze the results in the next class period. In the last class, we will continue data analysis and report to the class our findings.

Terms: experiment, hypothesis, scientific method, experimental design, replication

Lab Procedure IX

Design and Setup of Experiment and Data Collection

Introduction

Today's lab exercise will deal with designing and setting up your own experiment using algae. So far we have covered factors that affect algal growth and how we can quantify both growth and the environmental factors that may be controlling it. Below are some examples of how you might conduct your experiment. You should keep detailed records in your lab notebook about your ideas, how you are carrying out your experiment, how to operate equipment and other important details of your work. If you have time you can set up more than one experiment. After designing your experiment, set it up and begin collecting data. Your instructor will work with you.

Procedures

Potential factors for experimentation

Light

We know that most algae require light to survive. Some algae may be adapted to high light and some to low light. Design an experiment that tests an algae's growth response to varied light conditions.

pH

pH may well be one of the most important environmental factors affecting algal growth. pH can affect many components of water chemistry including the availability of nutrients to algal cells. Design an experiment that shows how algae respond to changes in pH.

Temperature

Many algae exhibit a seasonal preference. While some of this response may be attributed to day length, temperature can have a significant effect. Temperature can increase metabolism and hence growth. However temperatures that are too high or too low can be inhibitory. Design an experiment that demonstrates a response to temperature by a strain of algae.

Nutrients

In natural environments, key nutrients are often limiting for algae. In particular, Nitrogen (N) and Phosphorus (P). In areas that are polluted, algal blooms often occur in response to increased nutrients. However, different species will respond to changes in nutrient levels in specific ways. Increasing nutrients is not always good for growth. Design an experiment that shows how changes in nutrient levels can affect the growth of a strain of algae.

Powerpoint Presentation Slides:

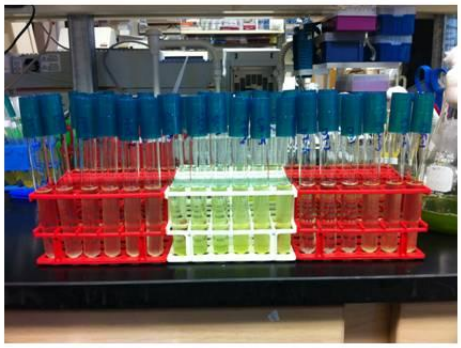
Class IV: Algal Biology – Experimentation

Introduction to Algal Biofuel

Class Outline

- Lecture
  - Experimentation
  - Scientific Method
  - Testing a Hypothesis
- Lab Exercises
  - Experimental Design
  - Experimental Implementation

Experimentation



- What is an experiment?
  - Method of testing a hypothesis
  - Compare the effects of treatments
  - Repeatable

Experimentation



- Scientific Method
  - Make Observations
  - Form Hypothesis
  - Test Hypothesis – Experiments
  - Expand Idea
  - More Experiments
  - Interpret Results
  - Conclusions

Experimentation

- Testing a Hypothesis
  - Statistical significance
  - Replication of treatments



Lab Exercises

- Experimental Design
- Experimental Implementation



Class 5

Large Scale Algal Biomass Production

We have covered topics of algal biology that allow us to understand how algae grow in response to important environmental variables. We have also designed and are carrying out experiments that will help us understand what conditions favor algal growth. Today we will look at large scale production systems of algal biomass, bioreactors and open ponds. We will also continue monitoring our experiments and begin analyzing our data.

Powerpoint Presentation Slides:

Class IV: Large-Scale Algal Biomass Production

Introduction to Algal Biofuel

Class Outline

- Lecture
  - Mass production of algae
  - Production Systems
- Lab Exercises
  - Demonstration of NSE Bioreactor
  - Biomass Harvest Demonstration
  - Continued Experimentation

Algae Production

- Mass Production
  - Comparable Systems
    - Spirulina farming
    - Agriculture
    - None identical



Algae Production

- Production Systems
  - Closed
    - Advantages
      - High production
      - Little Water/CO_2 loss
      - Less contamination
      - More controlled conditions
    - Disadvantages
      - Less gas exchange
      - Biofilms
      - Cost



Algae Production

- Production Systems
  - Open
    - Advantages
      - Cost
      - Simple/easy to operate
    - Disadvantages
      - Varying conditions
      - Contamination
      - Water loss
      - Light limitation

Lab Exercises

- Demonstration of NSE Bioreactor
  - describe



Lab Exercises



- Biomass Harvest Demonstration
  - centrifugation

Lab Exercises

- Continued Experimentation
  - Collect Data
  - Analyze Data

Class

6

Data Analysis – Presentation of Findings – Course Conclusions

Student presentations need to consist of the following elements:

- Description of experiment
    - Goals
    - Design
    - Data Collection
- Presentation of findings
    - Graphs
    - Tables
    - Interpretations
    - Recommendations

Class time will also be needed for cleaning up experiments and putting away equipment.

End the class with a summary of the course and discussion with the students about things they enjoyed and how they might like the class to change.

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