Investigation 10: Energy Dynamics

What factors govern energy capture, allocation, storage, and transfer between producers (algae) and consumers (brine shimp) in a marine environment?

Background

Ecosystems rely on a continuous flow of energy, starting with its capture by autotrophs and moving through various trophic levels to sustain life. In aquatic environments, microalgae such as *Nannochloropsis* serve as primary producers by converting sunlight into chemical energy through photosynthesis. This energy is then passed on to primary consumers, such as brine shrimp (*Artemia fransiscana*), which rely on the algae for nutrition.

This investigation focuses on quantifying the energy transfer between these two organisms in a controlled marine environment. By measuring the biomass of *Nannochloropsis* and *Artemia fransiscana*, students will explore how energy is captured by producers, stored as biomass, and eventually transferred to consumers. The lab will allow students to observe the phases of algal growth and the subsequent impact of grazing by brine shrimp, reflecting the energy dynamics of a simple aquatic food web.

Understanding these energy dynamics is essential for grasping broader ecological concepts, such as the efficiency of energy transfer between trophic levels, the stability of ecosystems, and the role of energy availability in shaping population and community structures. Through this hands-on experiment, students will gain practical insights into how energy flows within ecosystems and the importance of primary producers in sustaining life.

Learning Objectives

- ENE-1.M: Describe the strategies organisms use to acquire and use energy.
- ENE-1.N: Explain how changes in energy availability affect populations and ecosystems.
- ENE-1.O: Explain how the activities of autotrophs and heterotrophs enable the flow of energy within an ecosystem.
- SYI-3.A: Explain the connection between variation in number and types of molecules within cells to the ability of the organism to survive and/or reproduce in different environments.

General Safety

Follow general lab safety procedures: closed toe footwear, safety goggles, a laboratory coat, and gloves. Both *Nannochloropsis* and Brine Shrimp (*Artemia fransiscana)* are non-invasive, endemic across the United States, and can be disposed of down the drain in your lab.

Key Vocabulary

Autotroph: Organisms that can produce their own food from inorganic substances. Ex. Capturing energy from the sun through photosynthesis.

Heterotroph: Organisms that cannot synthesize their own food and must rely on other organisms for nutrition and energy.

Biomass: The total mass of living organisms in a given area or volume. In this experiment, we will be measuring biomass in dry weight to assess energy transfer.

Energy Dynamics: The study of how energy is captured, stored, and transferred among organisms within an ecosystem.

The Investigations

Procedure 1: Estimating Algae Biomass Using an Analytical Instrument

Guiding Questions:

How can we use an analytical instrument to measure the dry weight of algae biomass in the beaker bag?

Materials:

Algae Research and Supply's Brainy Briny in a Beaker Bag kit Includes: *Nannochloropsis* starter culture, salts, algae nutrients, brine shrimp cysts, Secchi stick, and 3mL pipette

Procedure:

1. Set up the Brainy Briny kit as per the instructions included. After blowing up the Beaker Bag, add salts and 450mL dechlorinated water (spring water, RO water, distilled water, student tears, etc.) Seal the Beaker Bag and shake to dissolve salts. Some will precipitate at the bottom and will dissolve later; this is perfectly fine.
2. Open back up the Beaker Bag and include the algae culture nutrients and culture, making sure to get all the biomass stuck at the bottom of the centrifuge tube. Reseal and shake to resuspend the algae.

At this point, you can decide whether to add the Brine Shrimp cysts or not. Not adding them on Day 0 will allow the algae to grow more densely. Adding them on Day 0 will allow you to watch the algae culture grow, then decrease as it is being grazed on.

3. Now you are ready to record your biomass measurements! Take your Secchi stick and fold along the dotted line, making the target perpendicular to the millimeter ruler. To measure the Secchi Stick Depth (SSD), slowly lower the target into your Beaker Bag. Once the target disappears, record where the water line passes the water line in the table below.

Figure 1: Secchi stick target disappearing in algae culture

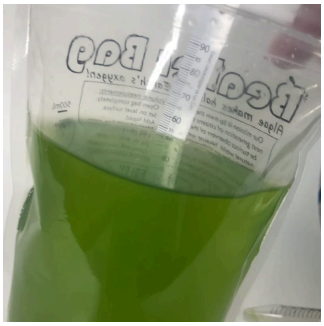
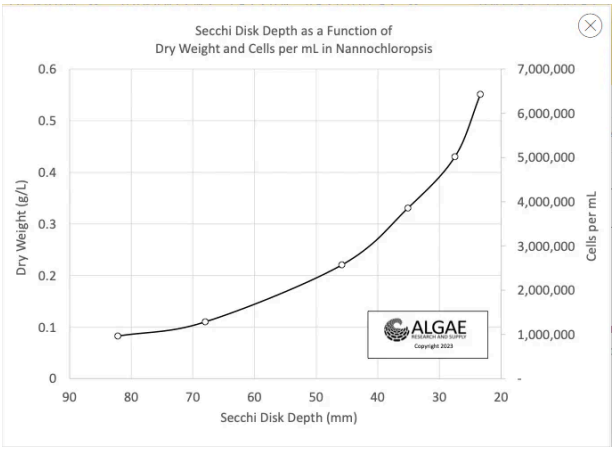


Figure 2: Water line crossing the ruler

4. Because SSD is not an SI unit, we must transform this measurement to the dry weight of algae. To do this, use the graph below (we did the hard part!)



5. Graph your results as experiment day number (putting together the kit will be Day 0) as a function of algae dry weight (y-axis).

Date/Time	Day # of experiment	SSD (mm)	Dry Weight (g/L)

Results:

Describe the shape that the graph made. Label the lag phase, exponential phase, and stationary phase on your graph.

Procedure 1: Estimating Energy Flow Between Algae (producers) and Brine Shrimp (Consumers)

Guiding Questions:

How can we measure the dry weight biomass of the brine shrimp? What does their relationship tell you about ecosystems?

Materials:

- Algae Research and Supply's Brainy Briny in a Beaker Bag kit (approximately 6 weeks after starting)
- Paper towel
- Analytical balance
- Aluminum foil
- Lighter (optional)

Procedure:

1. Approximately 6 weeks after beginning the beaker bag and adding the brine shrimp cysts (so they are full grown and sexually mature), we can start to measure the brine shrimp biomass. Begin by using your "brine shrimp extracting device" (pipette) to select one adult brine shrimp from your beaker bag to place on the paper towel.
2. Transfer the brine shrimp from the paper towel to a pre-weighed boat of aluminum foil. You might need approximately five brine shrimp to get an accurate read on your analytical balance. This is the **wet weight** of the brine shrimp.
3. To get to the dry weight of the brine shrimp (the same units we calculated for the algae), we must drive off the water from their bodies. To do this, there are two options.
    a. Less invasive: divide the wet weight by five to get the dry weight
    b. More invasive: take a lighter to the underside of the aluminum foil for a couple seconds before weighing again. What percentage of the brine shrimp mass was water weight?
4. Once you have the dry weight of one brine shrimp, you can count the individuals in your beaker bag to determine the standing crop of the ecosystem.

Results:

1. Were the brine shrimp you selected males or females? How can you tell? Draw brine shrimp below and label the defining features.

Female

Male

2. What was the largest mass of algae dry weight biomass did you have in your beaker bag?

3. What mass of brine shrimp dry weight biomass did you have in your beaker bag?

4. Do your findings match with what we expect of an ecosystem? (Hint: what percentage of algae biomass was the brine shrimp biomass?) If not, what could have gone wrong?