Brendan Connolly
Lucas Peilert
Matt Kreps
AP Biology
21 November 2012

Energy Lab Report

I. Introduction

The purpose of this lab was to measure the biomass of food as it passed through various trophic levels. Biomass is the mass of living biological organisms in a given area or ecosystem at a given time. Terrestrial biomass generally decreases markedly at each higher trophic level. The food in this lab can be considered terrestrial biomass because it acts as the "plant" for the larvae. Trophic levels are the position an organism occupies in a food chain. The higher the trophic level, the higher the biomass. The experiment will be able to demonstrate this process in the lab. Changes in biomass can be easily measured using a common scale to assess mass, which is how the biomass will be tracked in this experiment.

The specific organism that will be looked at in this experiment is the larval painted butterfly and the common hollyhock. In this model, the hollyhock serves as the example of a primary producer. Primary producers are able to support themselves without depending on other organisms. The hollyhock will be monitored for changes in biomass under the controlled lab conditions. The painted butterfly serves as a primary consumer in this ecological model: it will fuel much of its growth from the hollyhock biomass. The hollyhock has been chosen for this experiment because of its ability to grow quickly and support the butterfly species. The painted butterfly has been chosen because of its rapid life cycle; often making it from egg to larvae in three days and twenty seven days for the complete transformation from egg to butterfly.

The hollyhock uses a technique referred to as photosynthesis to synthesize its energy. It uses sunlight as well as nutrients from the soil to chemically synthesize ATP for energy. The process of photosynthesis in the hollyhock is not 100% efficient, however. Not all light is absorbed by the plant, and some energy is transferred as heat, which cannot be synthesized into ATP by photosynthesis.

The total of the primary productivity in an ecosystem is called the ecosystem's gross primary productivity, also known as GPP. This is the amount of light energy that is converted to chemical energy by photosynthesis in a unit of time. Not all of this production is stored as organic biomass in the primary producers because they use some of the energy for their own cellular respiration. Net primary productivity or NPP, is equal to the gross primary production minus the energy used for respiration. In most ecosystems, NPP ends up at about half of GPP. NPP is the more important measurement to ecologists because it represents the available food in the primary producers.

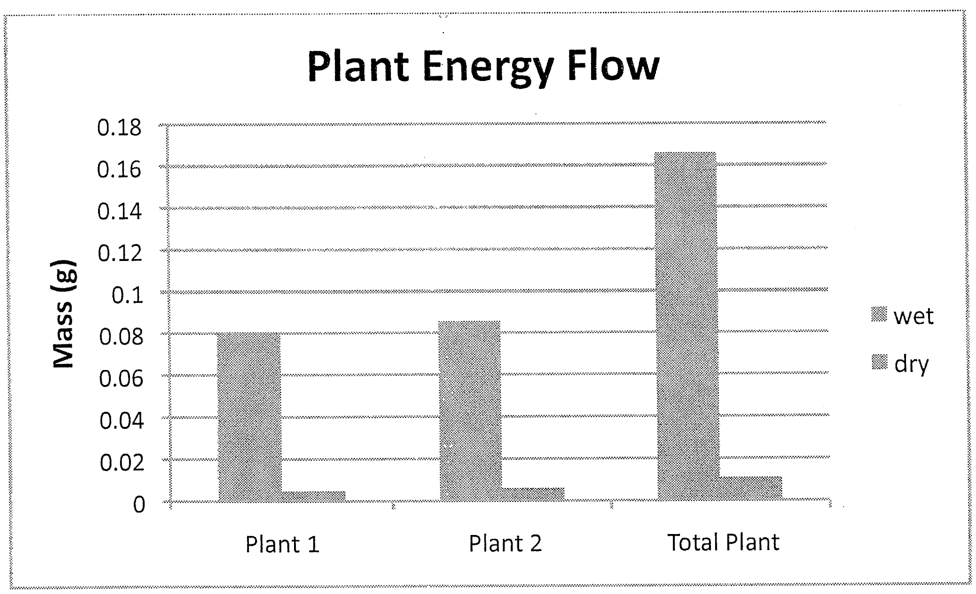
It is commonly believed that only 10% of energy in one trophic level is available for use in the next trophic level. This experiment will test this hypothesis.

II. Materials and Methods (*Refer to lab sheet)*

III. Results

Plant Data

Age of plant (days)	Wet weight (g)	Dry weight (g)	Percent of wet weight that represents biomass	Energy represented in biomass (4.35 kcal/g)	Net primary productivity/ day
0 days old, 11 seeds	N/A	0.1122	N/A	0.4881 kcal starting fuel	N/A
Average wt/seed	N/A	0.010	N/A	0.0431 kcal starting fuel	N/A
Plant #1 7 days old:	0.0804	0.0048	6%	0.021	0.003 kcal/g/day
Plant #2 7 days old:	0.0856	0.0060	7%	0.026	0.004 kcal/g/day
Plant Totals	0.166	0.0108	6.5%	0.047	0.007 kcal/g/day
Average per plant	0.083	0.0108	6.5%	0.0235	0.0035 kcal/g/day



Animal Data

Age of larvae (days)	Weight of larvae (g) Note: there were two larvae	Wet weight of waste (fecal and molts)	Wet weight of remaining food	Esti mated rati o o' dry weight (biomass) to wet weight for each category	Energy represented in biomass for each category (Larvae=5.5 kcal/g, waste = 4.76 kcal/g, food=4.35 kcal/g)	Net primary producti vity/ day (kcal/g/day)
1	0.03g	0g	5.97g	larvae dry weight is assumed to 40% of wet weight	larvae= 0.066, food = 8.570	N/A
2	0.0689g	0.0264g	5.5375g	The food dry weight is assumed to be 33% of wet weight	larvae= 0.1519, waste=0.0478 food=7.9491	larvae= 0.1519, waste= 0.0478, food= 0.6209
5	0.2660g	0.6213g	3.0856g	Frass dry weight is assumed to be 38% of wet weight	larvae= 0.5852, waste= 1.1238, food= 4.4294	larvae=0.1951, waste= 0.3746, food= 1.1732
8	0.6558g	0.6266g	0.7775g		larvae= 1.4428, waste= 1.1334, food= 1.1161	larvae= 0.4809, waste= 0.3778, food=1.1044
Added 3g of food to cup						
10	1.1166g (one caterpillar was in a cocoon)	1.5016g	0.9793g		larvae= 2.4565, waste= 2.7161, food= 1.4058	larvae=1.2283, waste= 1.3581, food= 1.35515
13	1.240g (both caterpillars in cocoons)	0.1147g	0.4140g		larvae= 2.728, waste= 0.2075, food= 0.5943	larvae=0.9093, waste= 0.0692, food= 0.2705
Calculati ons		total energy in food consumed = 8.570 + (3g x .33 x 4.35kcal/g) =12.8765 kcal/g		total energy in larvae = 2.738	total energy in waste (all waste values from above column added together) = 5.4292	total energy in waste as percentage of food= 42%

V. Conclusion

In the hollyhock mass chart, a significant increase in mass was observed. The hollyhock took on most of its increase in biomass though the addition of water weight. This can be seen through the tiny gains that were made in the dry weight between the average plant and average seed weights. On the other hand, there was a large difference, almost tenfold, between the wet weights.

In regards to our hypothesis, our experiment yielded some interesting results. For the plant, our data suggested that the plant uses 6.5% of its wet weight for biomass. This roughly correlates to using 6.5% of the energy it gets from the sun, thought that quantity could not be measured. The larvae data, on the other hand, suggested that animals can use 32% of the energy they get in food for biomass. This is surprising since the commonly held belief is that each trophic level can only use 10% of the energy from the previous energy level. Of course, more experiments would be needed to support the results from this experiment.

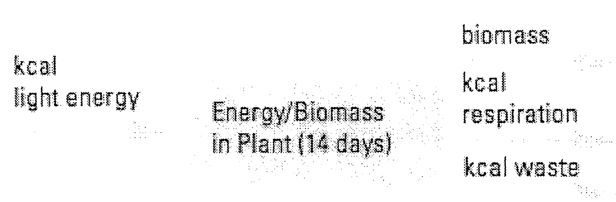
Some limitations in this experiment could be some of the plants not sprouting or one larva not coming out of its cocoons. Uncontrolled variables include the heat in the room and any disturbances caused by lab technique. This experiment could be improved by having better lab technique and precision when extracting the frass from the food, as this would have given an incorrect mass of the frass, as well as having better germination technique when germinating the seeds of the hollyhock. This could have caused some of the plants that did not sprout to sprout. This experiment could be extended by taking more measurements throughout the entirety of the life of both the butterfly and the hollyhock.

Part 2 Assessment Questions

1. Were you measuring that productivity or gross productivity and your plant experiment? Explain the difference.

Because gross productivity is simply a measure of how much energy was converted from light to chemical energy in the form of biomass, not all of the energy is stored as organic material in the primary producers, so the experiment actually measured net primary productivity. There was no accounting for the energy used by the plants as fuel for cellular respiration because that was a continually active process in the plants as measurements were taken. In the equation, NPP=GPP-R, we see this represented mathematically. We simply have no way of finding the R (respiration). Fortunately, the significant value for ecologists is the NPP. They mainly use NPP because it is the number that actually shows how much energy will be available to consumers in an ecosystem.

2. Drawing energy flow diagram representing the plants in your system to use as an accounting tool for the flow of energy into your system and the varied outputs. Include the amount of energy estimated to flow into each output based on your baseline data for Hollyhock.



Biomass is estimated 6.5%, but respiration and waste were not able to be calculated due to insufficient data in this lab, specifically not being able to measure waste/respiration of the plant.

3. What factors might limit the efficiency of energy transformation in your plants?

There are several factors that could limit energy transformation in plants. Since the energy transformation process in plants is based in photosynthesis, a large factor is the physical structure of the plant itself. Plants have evolved to have large surface areas to capture maximum sunlight. Without a large surface area, a plant might not be able to collect the requisite energy to support itself. The amount of available carbon dioxide, a requisite of photosynthesis, could also have an effect, and is another factor that is influenced by surface area. Since the plant does not live by photosynthesis alone, the nutrients it absorbs through the roots influence its ability to maintain homeostasis and continue to convert solar energy through the photosynthesis process. Efficiency also depends on the type of chlorophyll being used by the plant, since there is a range of wavelengths able to be absorbed by different kinds of chlorophyll. Finally, the respiration requirements of photosynthesis can affect the efficiency of energy conversion.

4. Draw an energy flow diagram representing your butterfly larvae, as you did for your plants. Include estimates of energy flowing into each output.

Input	Output
• food	• frass (estimated 42%) • respiration(estimated 36%) • biomass (estimated 32%)

5. What factors might limit the efficiency of energy in your larvae?

The larvae are constantly doing respiration in order to stay alive and they lose energy through this process. A lot of energy is also lost through heat escaping from the larvae. Energy is also lost through metabolism of food, as some energy is lost in the conversion of that food into a form the organism can use.

6. Draw an energy flow diagram including the flow between a producer and a primary consumer in a more natural setting and note limitations might be more significant in a more complex ecosystem