Plant-a-Plant Review Investigation Plant - Light

Investigation: Examine light as a limiting factor to plant growth.

Testable Research Question: Does the lack of light prevent plant growth?

Review Investigation Plan (Pre-lab)

1. Individually, begin by ***answering the pre-lab questions on the Student Laboratory Questions sheet.***
2. As a group, **read the *Plant-a-Plant – LIGHT Laboratory guide.***
   a. **Identify variables.** Within the lab guide, asterisk the independent variable, circle all dependent variables, and underline all constants.
   b. **Determine which lab questions can be answered** as a result of the experiment. Use the *Student Laboratory Questions* sheet to assist you.
3. Briefly **examine the *Plant-a-Plant Laboratory Data Sheet*** to see what kind of data you will collect during the lab and what kinds of calculations you will make. (This should help inform your hypothesis.)
4. **Develop and record an experimental hypothesis.**

HYPOTHESIS:

1. Based on your discussions and lab procedures, **determine a location for your experiment.**

2. On a separate sheet of paper **create a group schedule** for plant cultivation, daily watering responsibilities, making and recording observations, etc.

Conduct Investigation

Prepare and perform the experiment using the *Laboratory Guide, Laboratory Data Sheet* and *Data Summary and Analysis Sheet* provided.

Plant-a-Plant Student Laboratory Questions: Answer the questions and identify the sources for your ideas (D,B,S).

	Pre-Lab: Existing Knowledge	Can this question be answered by this experiment? (Y/N)	Post-Lab: Knowledge Gained	To what extent was the question answered? (All, In part, Not at all)
How does light affect plant growth?				
Is light a limiting factor to growth?				
Are plants able to grow without light?				
Do plants need sunlight specifically?				
How is light related to energy in plants?				

Identifying Sources for Ideas (adapted from GLOBE Earth Systems - LC1)

For each laboratory question identify what kind of source you used for the idea. Record the designation by writing the letter next to your idea and circling it for distinction.

D – Your answer is based on **data**. Use "D" to designate an idea for which you have collected or seen supporting data. Data could have been collected by your class, another GLOBE school, or others.

B – Your source is **background information**. Use "B" to designate an idea that you have recalled from a previous reading or experience in another course, at home, or elsewhere, and that you could actually find and bring to class. There may be data somewhere to substantiate this information, but you have either not seen it or do not have access to it.

S – Your source is **speculation**. Use "S" to designate an idea based on scientifically informed speculation. This is your opinion founded on what you have learned over time, but you can not point to a particular source of data or other information to support it. (Creative speculation – when based on authoritative background information and data – is one of the keys to excellent scientific work.)

Plant-A-Plant Light Laboratory guide

Task

This experiment examines **light** as a limiting factor to plant growth. To test how plants respond to light you will set up a control flowerpot placed in an area of natural light (the LIGHT treatment); and a DARK treatment, which will be a flowerpot of seedlings grown in the absence of light. You will observe height and leaf color throughout the growth period and then calculate differences in biomass, root:shoot ratio and carbon fixed during photosynthesis.

Prepare and Perform Experiment

All directions in this lab are written for one experimental replicate. This means there is one flowerpot of seedlings grown in natural light and one flowerpot of seedlings grown in darkness. Note that at least three replicates are recommended for this experiment.

Materials

- ❑ 12 maize seedlings
- ❑ 2 flowerpots (approx. 0.75 liter volume)
- ❑ Growing medium: gardening perlite or sand (2 liters)
- ❑ Fertilizer containing basic nutritients (for example, Kristalon Start or Miracle Gro)
- ❑ Distilled water (2 liters)
- ❑ Measuring cylinder
- ❑ Laboratory scale (accuracy of 0.01 g)
- ❑ 1 beaker or glass jar (volume 100 ml)
- ❑ 1 bottle (volume 1 liter) for fertilizer solution
- ❑ Pencil, permanent marker
- ❑ Scotchtape(cellotape) for labeling
- ❑ Large cardboard box (depth approx. 30 cm)
- ❑ Aluminium foil
- ❑ 4 spacers to support the carboard box (10-15cm height e.g. yogurt cups)
- ❑ Black paper (50 x 50 cm)
- ❑ *Laboratory Data Sheet – Light*
- ❑ *Student Laboratory Questions Sheet*

Preparation

1. If directed by your teacher, calculate the amount of materials needed for more than 1 replicate.

2. Mix 1 liter of fertilizer solution with a concentration of 0.5g/l for watering during the experiment. Weigh 0.5 g of fertilizer and dissolve into one liter of distilled water. Pour fertilizer solution into a labeled bottle and store in a cool, dark place.

3. Set up the LIGHT treatment by choosing a well illuminated place (such as a window sill) in the classroom or laboratory.

4. Set up the DARK treatment.

    a. Plants in the dark treatment will not have access to light energy essential for pho-

tosynthesis, but they should have all other conditions for growth – sufficient input of both water and mineral nutrients, availability of carbon dioxide and oxygen and ideal temperature.

b. Cover the surface of a large cardboard box with foil – it will reflect light and therefore avoid overheating of the inner space of the box. This will also prevent any light from entering the sides of the box.

c. Lay black papers on the window sill in the area next to the LIGHT treatment. (To prevent reflection of light upwards toward the plants).

d. Place the spacers (yogurt cups) on the corners of the black paper and rest the carboard box on the spacers. Boxes shouldn´t stand directly on the black surface since it may prevent air from getting to the plants inside.

5. Prepare 2 flowerpots by filling them with gardening perlite or sand (to about 2 cm below the edge). When using sand rather than perlite, it is necessary to wash it with tap water very carefully and dry it a little before putting it into the flowerpots.

6. Label each flowerpot to identify the experimental treatments.

Plant and Observe Seedlings

1. Transplant 5-6 young seedlings from the germination tray into each flowerpot.

2. Place the light pot in the designated area and dark pot under the cardboard box.

3. Choose a watering container. The watering quantity will always be 100 ml. Water the plants in each pot every other day with 100 ml of the 0.5 g/l fertilizer solution. The first day of watering will be when you transplant the seedlings.

4. Grow plants at room temperature for **11 days**. During this time observe and record differences in plant height and leaf color between the natural light and the dark treatment (Table 1 of the Laboratory Data Sheet). Begin observations on day of transplant.

Harvest Plants and Make Calculations

Materials and tools (*per replicate*)

- ❑ Sink / washbasin with tap water
- ❑ Plastic trays (it is possible to re-use the germination trays)
- ❑ Scissors (ideally fine surgical ones or nail scissors) or razor blade
- ❑ Aluminium foil
- ❑ Permanent marker
- ❑ Pencil
- ❑ Laboratory scale (accuracy of 0.01 gram)
- ❑ Absorbent paper (paper towels, filter paper, etc)
- ❑ *Laboratory Data Sheet- Light*
- ❑ *Data Summary and Analysis Sheet -Light*

**Note: kiln or drying oven is also necessary

Harvest Procedure

All plants from each flowerpot will be harvested together as a set.

1. Before harvesting prepare 3 squares of aluminium foil (approx. 15 x 15 cm) for each flowerpot: one for roots, shoots and seeds. Label them with a marker – write the treatment information, such as ***roots, LIGHT*** and the number of replicate.
2. Remove plants from the substrate being careful not to break the roots and place them in a plastic tray filled with tap water. Wash roots completely, do not leave grains of substrate on them (especially important if using sand as substrate). Place plants on absorbent paper (paper towels, filter paper, etc) to dry roots.
3. Use scissors to divide plant into its parts: shoot, roots and seed residues. Group like parts from the same flower pot together.
4. Place each plant part group into its own labeled foil packet– KEEP THE LABEL VISIBLE.
5. Puncture the foil envelopes/packets several times using the small point of the scissors, a pin or a paperclip to allow evaporating water to escape.
6. Weight all packets and record the fresh weight in Table 2 of the Laboratory Data Sheet.
7. Place the packets into kiln or oven at 90°C and dry them for 8 to 12 hours. It is also possible dry them at lower temperatures but for a longer time (e.g. 60°C for 2 to 3 days).

Report Results

1. Remove the foil packets from the kiln or oven (carefully as they will be hot) and weigh individually on the scale. Record your packet dry weight value on your worksheet.
2. Follow the instructions on the student worksheet to calculate:
   a. Increase in biomass (in grams of dry weight) (Table 4)
   b. The root-shoot ratio using plant dry weights (Table 5)

Analyze Data

1. Compare experimental treatments (*Data Summary and Analysis* Table 6) by determining the replicate average.
2. Follow instructions on the student worksheet to graph interesting and/or important results, create a summary table, and record initial observations.

Discussion and Conclusions

1. Fill out the Post-Lab section of the *Student Laboratory Questions* sheet.
2. Follow instructions on the student worksheet to evaluate your hypothesis, answer further questions and describe potential sources of error.

Share Findings and Conclusions

1. All scientists, once they have completed their investigation, share their findings with peers in their community. Follow the instructions provided by your teacher to share your work.

Plant-A-Plant Student Worksheet – Light

Lab Group: _____ Replicate no. _____

OBSERVATIONS AND CALCULATIONS (per replicate)

Record data observations and calculations in tables one through five. Shaded cells indicate a calculation is necessary (required equations included below). Tables are designed for a single replicate. Photocopy these tables (pages 8-10) in order to record data for all of your replicates (e.g., pots per treatment).

Plant and Observe Seedlings

During cultivation you may notice differences between experimental treatments. Plant height or changes in shoot leaf color may be some of the notable differences observed. Use a ruler to estimate average seedling height for each flowerpot. Record your observations in Table 1.

TABLE 1: Observations of Plant Characteristics (dependent variables)					
Day of cultivation	Height Comparison		Shoot Color Changes		Additional observations or questions (use backside of data sheet if necessary)
	Light Treatment	Dark Treatment	Light Treatment	Dark Treatment	
1					
2					
3					
4					
5					
6					
Journal Question: What differences have you noticed after 6 days of cultivation? Do your observations agree with your original hypothesis? Explain.					
Day of cultivation	Height Comparison		Shoot Color Changes		Additional observations or questions (use backside of data sheet if necessary)
	Light Treatment	Dark Treatment	Light Treatment	Dark Treatment	
7					
8					
9					
10					
11					

Harvest Plants and Make Calculations

All plants from each flowerpot should be treated as a set and harvested together (as a replicate).

Whole Plant = shoot + root + seed residue.

Mark the foil with replicate number and treatment type.

Table 2: Fresh weight of whole plants and parts				
Treatment (independent variables)	Fresh weight of plant parts in the foil (g)			
	Shoots	Roots	Seed Residue	Whole Plant
Light				
Dark				

Table 3: Dry weight of whole plants and parts (dependent variable)				
Treatment (independent variables)	Dry weight of plant parts in the foil (g)			
	Shoots	Roots	Seed Residue	Whole Plant
Light				
Dark				

Don't weight it - calculate it!

Calculations

Dry weight whole plant = Dry weight shoot + Dry weight root + Dry weight seed residue

Table 4: Increase in biomass (dependent variable)					
Treatment (independent variables)	Average fresh weight of seed (g) **	Dry weight of seed (g)	Dry weight of seed group (g)	Dry weight of whole plants	Increase in biomass (dry matter in g)
Light					
Dark					

Important notes for calculating increase in plant biomass.

Plants consist mainly of water. Water content in leaves is about 60-90%. In contrast, seeds contain only 12% water.

When calculating the increase in maize biomass, you need to know the initial dry weight of the seedlings you have used for planting. However, because it is impossible to measure the dry weight of a seed without damaging it and preventing its ability to grow, we must use the assumption above that seeds contain 12% water. Therefore 88% of the seed's mass is its dry weight.

Remember, you are working with an entire set of plants from a watering system tray; therefore you must multiply the average weight with the appropriate number of plants.

Example: Initial average weight of a seed was 0.420 g, dry matter is 88%.
Average dry weight of seed= 0.88 x 0.420 g = 0.370 g.
You have 10 seeds in one experimental system, thus:
The average dry weight of the seeds = 10 x 0.370 g = 3.7 g.
Increase in biomass = Dry weight of harvested plants - 3.7 g.

Calculations:

** = from germination datasheet

Dry weight of seed = Average fresh weight of seed** x 0.88

Dry weight of seed group = Dry weight of 1 seed x Number of plants in the treatment (tray)

Increase in biomass = Dry weight of whole plants – Dry weight of seed group

Table 5: Weight Ratio- root:shoot (dependent variable)			
Treatment (independent variables)	Dry weight of roots (g)	Dry weight of shoots (g)	Ratio root:shoot
Light			
Dark			

Calculations:

Root:shoot ratio = Dry weight of roots / Dry weight of shoot

The root:shoot ratio is one measure to help you assess the overall health of plants. The root:shoot ratio measures the allocation of carbon in the form of photosynthate to the roots (below ground tissue) and shoots (above ground tissue). Environmental stimuli (e.g., light, CO_2) may influence carbon.

Summarize and Analyze Light Data

Compare Experimental Treatments (summary of all replicates)

For evaluation of experimental treatments and making general conclusions about the influence of light availability on maize growth, calculate average values of plant parameters (dependent variables) from all the replicates. Use the data recorded on your *Laboratory Data Sheet* and Share your replicated data with other lab groups.

Table 6: Average Across Experimental Replicates

	Dry Weight of Whole Plant (g)		Increase of Biomass (dry matter in (g)		Root: Shoot Ratio	
	Light Treatment	Dark Treatment	Light Treatment	Dark Treatment	Light Treatment	Dark Treatment
Replicate 1						
Replicate 2						
Replicate 3						
Replicate 4						
Replicate 5						
Sum						
Total # Replicates (3-5)						
Average						

Average = sum of all replicate values/total # of replicates

Table 6: Average Across Experimental Replicates Con't				
	Carbon in the Dry Biomass (gC)		Carbon Fixed During the Experiment (gC)	
	Light Treatment	Dark Treatment	Light Treatment	Dark Treatment
Replicate 1				
Replicate 2				
Replicate 3				
Replicate 4				
Replicate 5				
Sum				
Total # Replicates (3-5)				
Average				

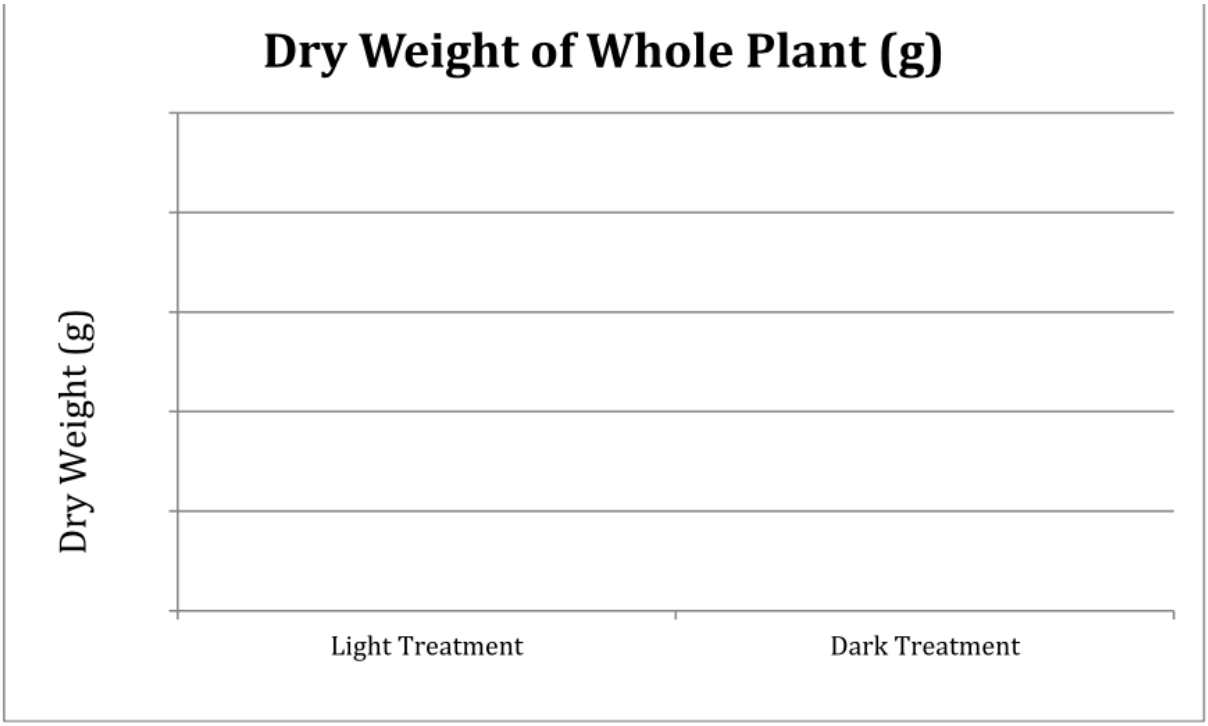
Calculation:
Carbon is approximately 50% of dry plant biomass.

Carbon in Dry Biomass (gC):
Whole plant dry biomass x 0.50 = total carbon stored in plant materials
Carbon in dry biomass includes the carbon that was 'fixed' by photosynthesis AND carbon available from the original seed.

Carbon Fixed During the Experiment (gC):
Increase in biomass of whole plant (table 4) x 0.50 = carbon fixed during the experiment
'Fixed' carbon refers to the carbon that was converted from carbon dioxide to glucose during photosynthesis.

Graph Results

One way to compare experimental treatments is to graph treatment results side by side. Below is a sample graph format that could be used to compare any of the variables listed in Table 6. Use a graphing program or graph paper and pencil to graph the results you find interesting and/or important.



Create Summary Table

Creating a succinct table that summarizes your data is a good way to compare experimental results and see patterns across your data. Fill in the table below using the information from Table 1 and Table 6, or create a table that is appropriate for your research question.

Table 7: Summary of Results		
Dependent Variable	Average of Replicates: Light	Average of Replicates: Dark
Overall Leaf Color Change		
Overall Height Comparison		
Dry Weight Whole Plant (g)		
Increase in Biomass (g)		
Root:Shoot Ratio		
Carbon Dry Biomass (g)		
Carbon Fixed (gC)		

Record Initial observations: looking at your data

1. Based on your existing knowledge, do the data seem reasonable? (*Are the numbers similar to numbers for classmate's replicates? Do the data seem consistent?) If not, what may have caused this? (Check calculations and units. Are there other outside factors that could have influenced results?*)

2. What patterns or trends do you see in your data? How did the plants differ between the light and dark treatments?

3. Record any other observations or questions that you have.

Discussion and Conclusions

1. Evaluate the validity of your hypotheses. Were they proved affirmed or rejected?
   a. **Describe** how the data support your claims.

2. For any post-lab questions you were unable to answer using the experimental results:
   a. **Choose one question that could be answered by performing an additional experiment.** Sketch and label a basic experimental procedure.
   b. **Perform literature research** (textbooks, scientific papers, reputable online sources) to answer remaining questions.

3. Did you encounter **any issues/difficulties** while performing the experiment? What were potential **sources of error** in the experiment? Are there ways the procedure could be improved?

4. **Record any remaining questions** about the experiment or its outcomes.