PLANT GROWTH AND GAS EXCHANGE

STUDENT ACTIVITY PAGES

Culturally relevant ecology, learning progressions and environmental literacy

Environmental Literacy Project
http://edr1.educ.msu.edu/EnvironmentalLit/index.htm

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Contents

Name: _____ Period: _____ Date: _____

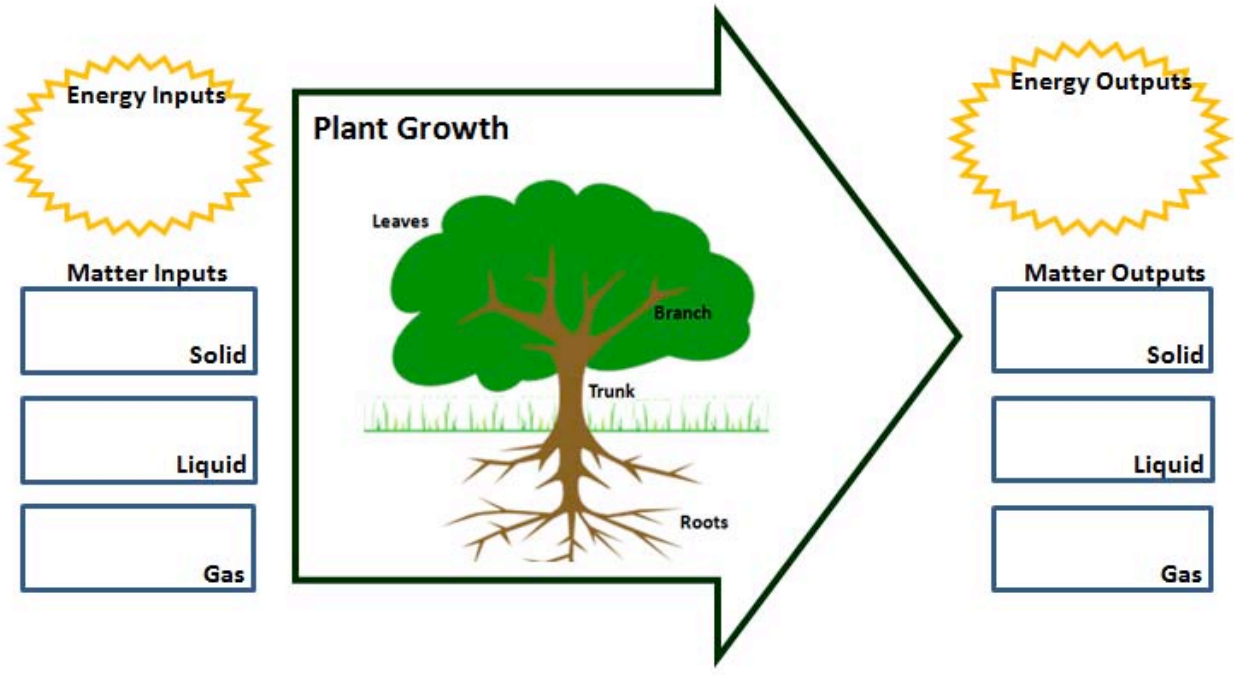
Activity 1: How Do Plants Grow?

Large trees can grow from small seeds. What do you think plants need to grow?

What evidence can you use from your own experiences that plants need these things?

How do you think plants use these things they need to grow?

Use the matter and energy process tool below to illustrate your thoughts about what plants need to grow:



Introduction

Today you will set up an experiment to test some of your ideas about what plants need to grow. Your group will grow plants from seeds and measure their growth. You will set up the experiment today and monitor the growth of your seeds over the next two to three weeks.

** KEEP THIS HANDOUT TO RECORD YOUR DATA! **

We will be setting up two types of plants to grow.

1. We will grow lettuce or radishes in soil (actually vermiculite, a mineral used in potting mixtures)
2. We will grow beans or peas in soil (again, vermiculite)

Methods

Lettuce or Radishes

1. **Make a 1-cm long cut** in the bottom of your growing cup with scissors, then **feed a small piece of wicking cloth** (strip of re-usable, industrial-strength paper towel folded length-wise approximately 7 by 12cm depending on height of grow cup) through the cut, with about half the length in and half out the bottom of the dish.
2. **Label** your cup with your group name and/or class period.
3. **Weigh** your empty cup and **record** its mass in row A of the table below.
4. **Fill** the cup ¾ full with vermiculite.
5. Use the table below to record the following measurements for the lettuce or radish seeds:

Lettuce/Radish: Cup Number _____			
	Mass of:	**Before growing** (Lesson 1)	**After growing and drying** (Lesson 9)
A	cup		
B	cup + soil		
C	soil (subtract B - A)		
D	seeds		
E	cup + soil + seeds		
	number of seeds		

6. Plant your seeds in the soil after you have weighed them – do not put all the seeds in the same spot
7. Answer the following questions:

   - Your prediction: What will happen to the mass of your plants as they grow?

   - Reason for your prediction:

8. Water the growing containers carefully, according to your teacher's directions.
9. Place your cup in the light near a window, if possible.

Beans or Peas

10. Follow the same steps for bean/pea seeds as for lettuce/radish seeds. Use the table below to record data about your bean seeds.

Beans: Cup Number _____			
	Mass of:	**Before growing** (Lesson 1)	**After growing and drying** (Do later: Lesson 9)
A	cup		
B	cup + soil		
C	soil (subtract B - A)		
D	seeds		
E	cup + soil + seeds		
	number of seeds		

11. Water the seeds as you did for the lettuce and place the cup in the growing area.

Track the progress of your seeds

You will need to monitor your plants to track their progress and add water as necessary. You should check your plants every day and fill out the following data table about every 2-3 days. Note the general health and growth patterns of the plants: Have all survived? Are all producing healthy green leaves? and so forth. Be complete and accurate in your notes.

Date							
Lettuce/Radish: number of shoots							
Lettuce/Radish Observations							
Beans: number of shoots							
Additional Observations:							

Name: _____ Period: _____ Date: _____

Activity 2: Zooming In and Out

When thinking about different scales, we can generally group systems and parts of systems into one of four groups:
1) atomic-molecular (things we cannot see even with a microscope),
2) microscopic/cellular (we cannot see with our eyes, but can use a microscope to see),
3) macroscopic (things we can see with our eyes), and
4) large scale (things that are too large to see with our eyes as a whole).

The following is a list of systems included in the Powers of Ten video. Try to sort these systems into one of the four categories described above.

Universe	Man or Woman	Cell Nucleus	United States
Hand	Earth	Lake Michigan	DNA molecule
Skin	Carbon Atom	Picnic Blanket	Galaxy
Capillaries	Skin Cell	Quarks	Chicago
City Park	White Blood Cell	Solar System	

1. What systems would you see at the atomic/molecular level?

2. What systems would you see at the microscopic or cellular level?

3. What systems would you see at the macroscopic level?

4. What systems would you see at the large-scale level?

5. Are there any systems that you are unsure about?

You may watch the Powers of Ten video again. However, this time your teacher will pause the video at each scale, and you will need to think about what appears and disappears when you zoom in or out. Complete the table below.

What You See When You Zoom In	Starting Point: What You See	What You See When You Zoom Out
	City Park	
	Chicago	
	United States	
	Solar System	
	Galaxy	
	Hand	
	Skin	
	Capillaries	
	DNA molecule	
	Carbon Atom	

After watching the video again, is there anything you would change from your groups on the first page?

Activity 4: *Molecules of Air, Plants and Soil* Graphic Organizer

Material	Atomic-Molecular Scale	Microscopic Scale	Macroscopic Scale	Key Facts / Questions
Air				
Plants				
Soil				

Name: _____ Period: _____ Date: _____

Activity 4: Molecules Quiz

1. Fill in the table below about the kinds of atoms and molecules in air, plants, and soil.

Material	***What kinds of atoms are in this material?***	***What kinds of molecules or ions are in this material?***	***Do these molecules have stored chemical energy (in C-C or C-H bonds?***
Air			
Plants			
Soil ***(include only water and minerals that plants can absorb through their roots)***			

2. Where do the molecules in plants come from?

3. Based on your answers in the last column above, if you answered “yes” to any of the materials storing energy; identify the material and explain where the stored energy comes from.

Name: _____Period: _____ Date: _____

Activity 5: Investigating Mass Gain and Mass Loss

First Questions about Gaining and Losing Mass

We all know that people can eat food and gain weight, and that plants can grow and gain weight. But what does it REALLY mean to gain mass? Try filling out the table below.

When you add water to a sponge, does it gain mass?	Yes No	Explain your answer
When you drink a cup of water, do you gain mass?	Yes No	Explain your answer
When a plant grows in the sunlight, does it gain mass?	Yes No	Explain your answer
What measurements do you need to make to determine if a plant has gained mass?		

Does water make materials gain mass?

Materials:

1 plastic cup
1 dry sponge or small amount of dried vermiculite
Tap or distilled water
1 small digital balance (300-g capacity)

What to do:

This will be a two-day experiment:

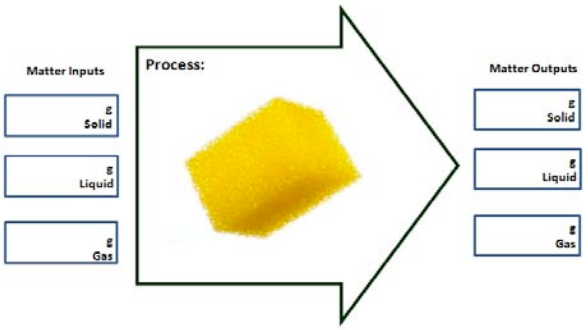
- On the first day, you will **predict and measure the mass of the sponge or vermiculite** before and after you add water. This means you will:
  - **Weigh** the dry sponge or vermiculite.
  - **Weigh** a cup, then add some water and weigh the cup filled with water.
  - Figure out the **mass of just the water**. How can you do that?
  - **Predict the mass** of moist material after it soaks up the water.
  - **Weigh** the moist material to see how well you predicted.
- Your teacher will dry out the material overnight
- On the second day, you will **predict and measure the mass of the dried material**.

You can use the table below to record your predictions and measurements.

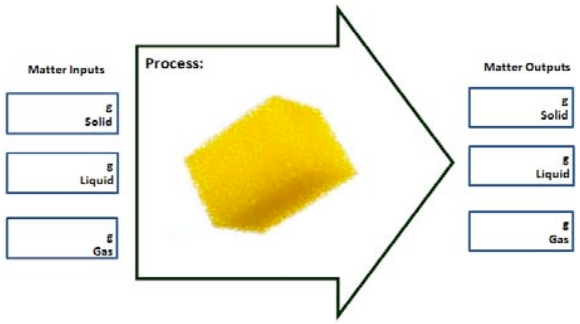
Day 1: Weighing Wet and Dry Material (Sponge or Vermiculite)		***Day 2: Weighing Material that Has Been Dried Overnight***	
Mass of dry material:			
Mass of empty cup:			
Mass of cup with water:			
Mass of just the water:			
Your hypothesis: What will the mass be when the water is added to the material?		*Your hypothesis: What will the mass be when the material is dried overnight?*	
Reason for your hypothesis:		*Reason for your hypothesis:*	
Actual mass of wet material:		Actual mass of dry material:	

When we added water, did the material gain mass? Explain your reasoning.

Use the mass tracing process tools to trace the masses for the wet and dry material.



Wetting material: Fill in the masses that you measured. Is mass conserved?



Drying material: Fill in the masses you measured. What happened to the mass of the water?

Do Plants Gain Mass When You Water Them?

Materials

1 small digital balance (300-g capacity)
Your plant
Small plastic cup
Water

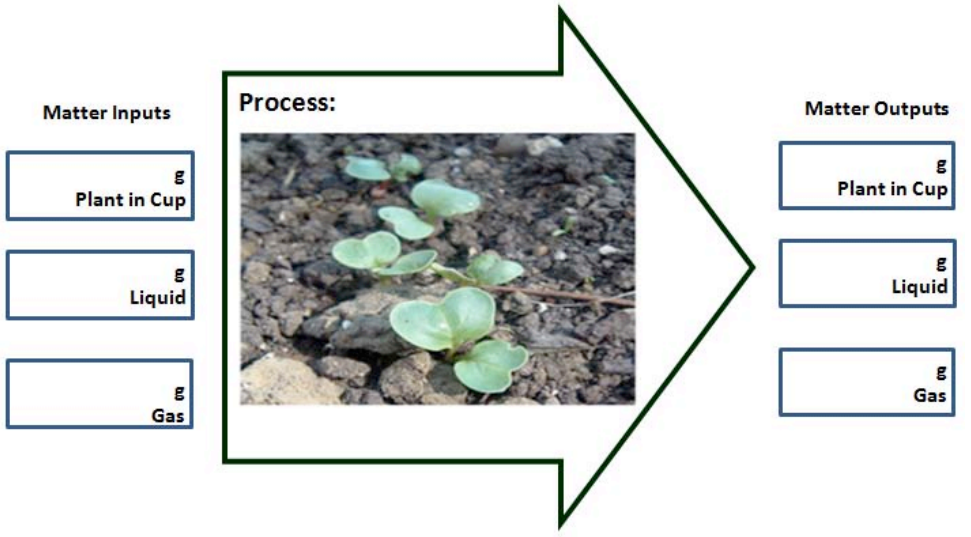
What to do:

- **Weigh** your plant in its cup on the digital balance.
- **Weigh** the cup, then add some water and **weigh** the cup with water.
- **Figure out the weight** of just the water. How can you do that?
- **Predict the weight** of your plant after you have watered it.
- **Weigh** your plant to see how well you predicted.

Use the table below to record your measurements and predictions:

Mass of your plant in its cup:	
Mass of empty cup:	
Mass of cup with water:	
Mass of just the water:	
Your hypothesis: What will your plant weigh after it is watered?	
Reason for your hypothesis:	
Actual mass of your watered plant:	

Use the mass tracing process tools to trace the masses for the student and your plant.



Watering Plants: Fill in the masses that you measured. Did the plant gain weight when you watered it?

1. What do you think might happen to the mass of your plant in its cup overnight? Why?

2. Do you think your plant REALLY gained mass when you watered it? Explain your reasoning.

One final question: You can see that the measured mass of something—soil, plants, or animals—can vary a lot depending on how much water is in the system, even though the water does not affect the underlying dry mass of the thing. How could we tell whether plants are gaining dry biomass?

Name: _____Period: _____ Date: _____

Activity 6: Does CO_2 Have Mass?

Do gases (like air, oxygen or carbon dioxide) weigh anything? In this activity, we will investigate whether the bubbles in a bottle of soda have weight (mass). We will weigh a cup filled with soda immediately after pouring. After some time has passed and bubbles have escaped out of the cup, we will weigh the cup again, still with the soda but without the bubbles.

Warm-Up Questions:

Do you think the air around you has mass?	Yes No	Explain your answer
After we pour the soda and let gas escape will the mass of the cup + soda **increase, decrease or stay the same**?	Explain your answer	

Does the gas in soda have mass?
Materials:

Approx. 50 ml of carbonated soda beverage
Small cup
200-g scale

What to do:

- Your teacher will pour about 50mL of the soda into your cup.
- Read the mass on the scale *immediately* after the soda is poured, and record it in the table below.
- Record the mass of the cup and soda at two other times during the class period and once at the very end.

Fill in the table below over the rest of the period:

Time	Minutes since start	Weight of soda + cup	Weight of gas lost since start
At Pouring	0		
After pouring			

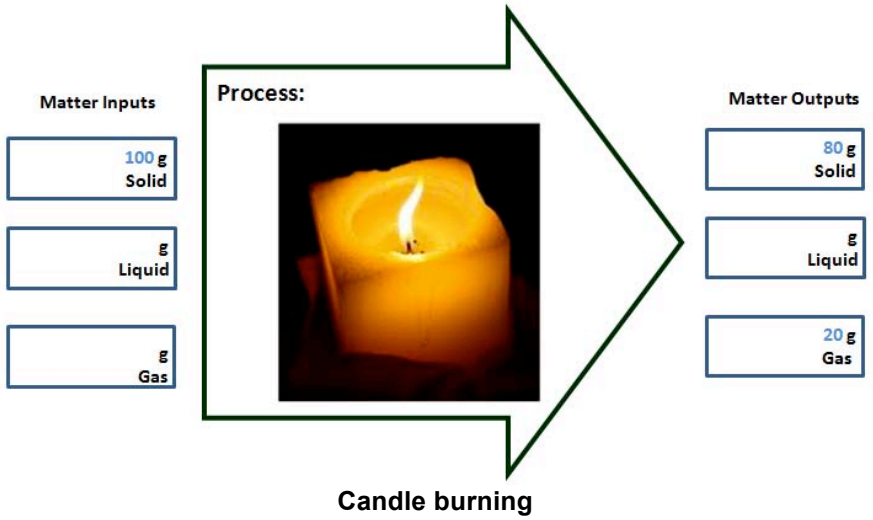
The next three experiments will be done as classroom demonstrations.

As your teacher prepares each of the three demonstrations:

- Observe the concentration of CO_2 in the chamber and the mass before the demo. Record your observations in the table below in the appropriate column.
- Observe what happens to the levels of CO_2 and mass, and record a final concentration and mass.

	Concentration of CO_2 before activity	Concentration of CO_2 after activity	Mass before the activity	Mass after the activity
Exhalation				
Candle Burning				
Baking Powder + Water				

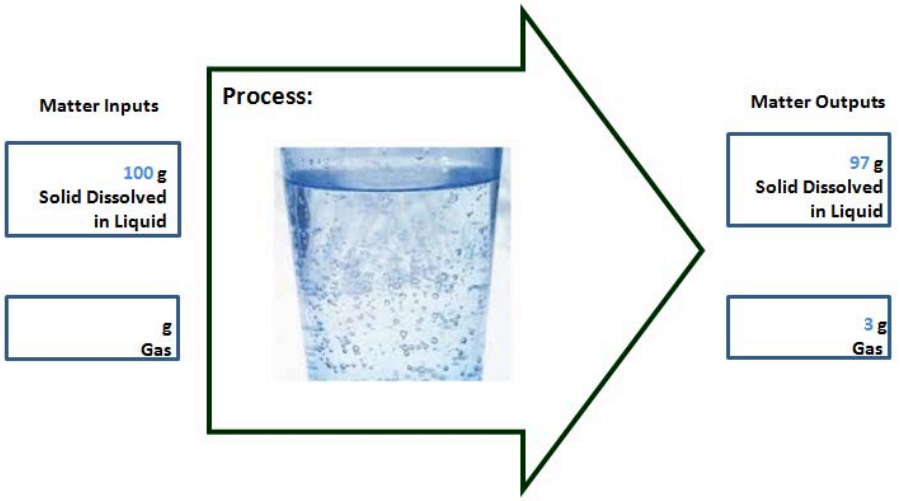
Use the mass tracing process tools to trace the masses for the candle and baking powder in water.



Candle burning

What did you observe happening to the mass and CO_2 concentration as the candle was burning?

Explain what you think happened to the mass of the candle as it burned?



Baking powder in water

What did you observe happening to the mass and CO_2 concentration as the baking powder and water fizzed?

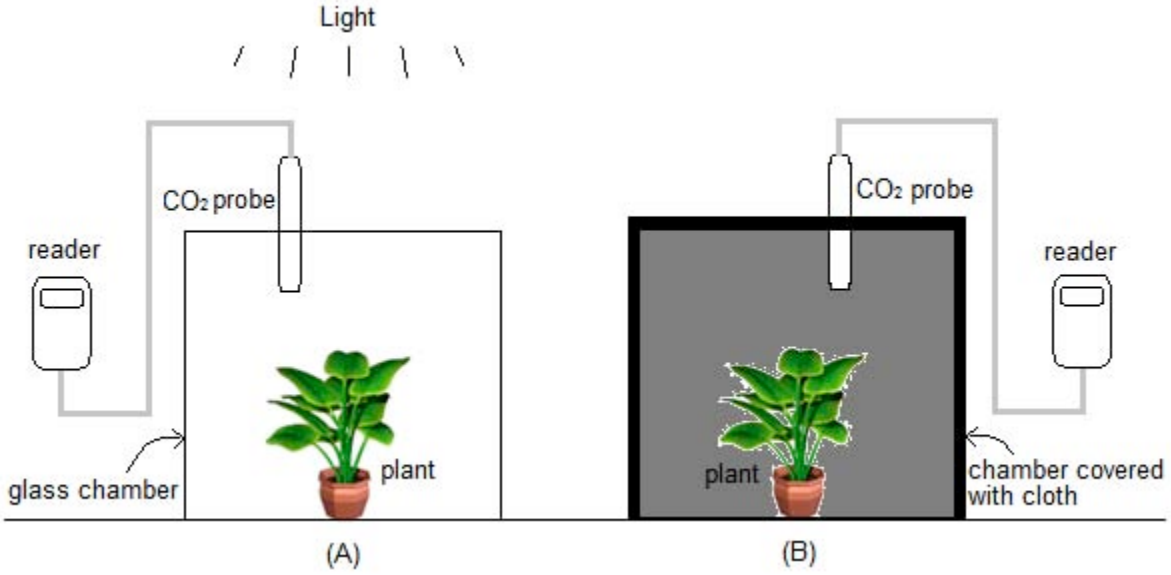
Explain what you think happened to the mass of the baking powder and water mixture when it fizzed?

One last question: What do you think happens to your mass when you breathe out carbon dioxide?

Name: _____Period: _____ Date: _____

Activity 7: Gas Exchange in Plants

In this activity, we will use probes to study how plants affect levels of CO_2 in the air around them. We will test the plants under two different conditions: 1) When the plant is in the dark, and 2) when the plant is in the light.



What do you predict will happen to the concentration of CO_2 in each chamber?

	In the light	In the dark
The amount of CO_2 will…	☐ increase ☐ be the same ☐ decrease	☐ increase ☐ be the same ☐ decrease

Record Data in the table below:

	In the light		In the dark
Time (seconds)	Level of CO_2 in the chamber	Time (seconds)	Level of CO_2 in the chamber

1. Record your observations:
    a. What happened in the light?

    b. What happened in the dark?

2. Based on your other experiments with CO_2 (e.g. – candle, person breathing, etc), what do you think is happening to the biomass of plants in the dark?

3. What might be happening to the biomass of plants in the light?

4. Explain what you think is happening to produce these results.

Name: _____Period: _____ Date: _____

Activity 8: Photosynthesis and Respiration

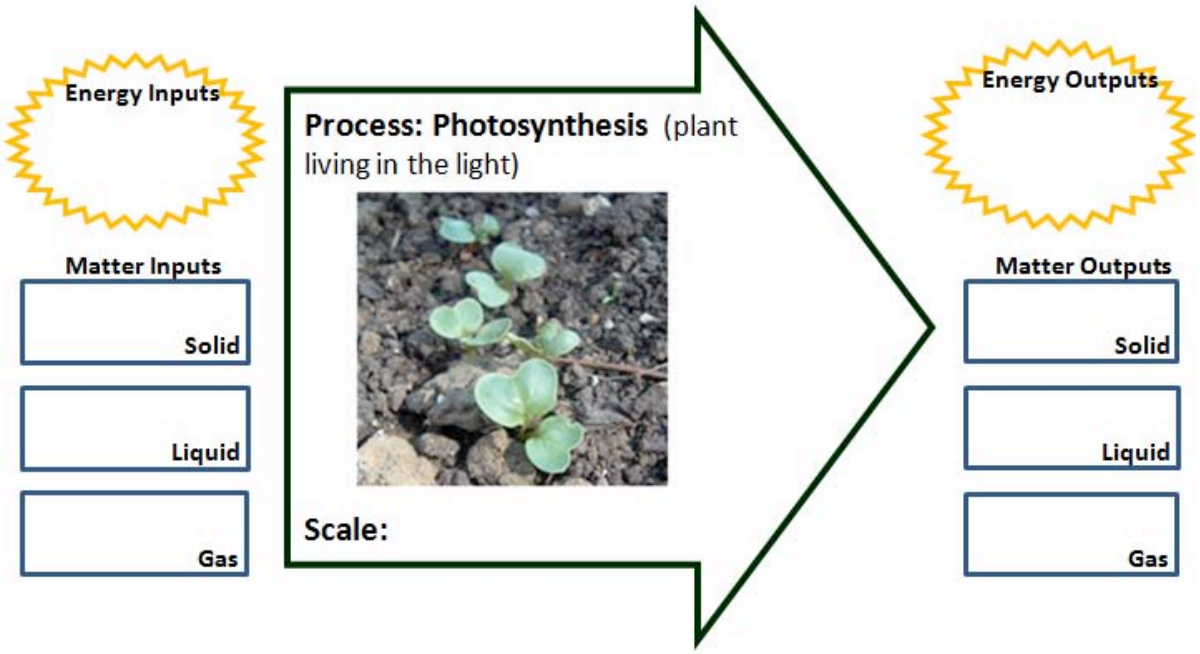
In the last activity you observed plants living in the light and the dark, and recorded the changes in concentration of carbon dioxide gas in the air around the plants over time.

1. What happened to carbon dioxide levels near the plant in the *dark*? What biological process was mainly responsible for that change?

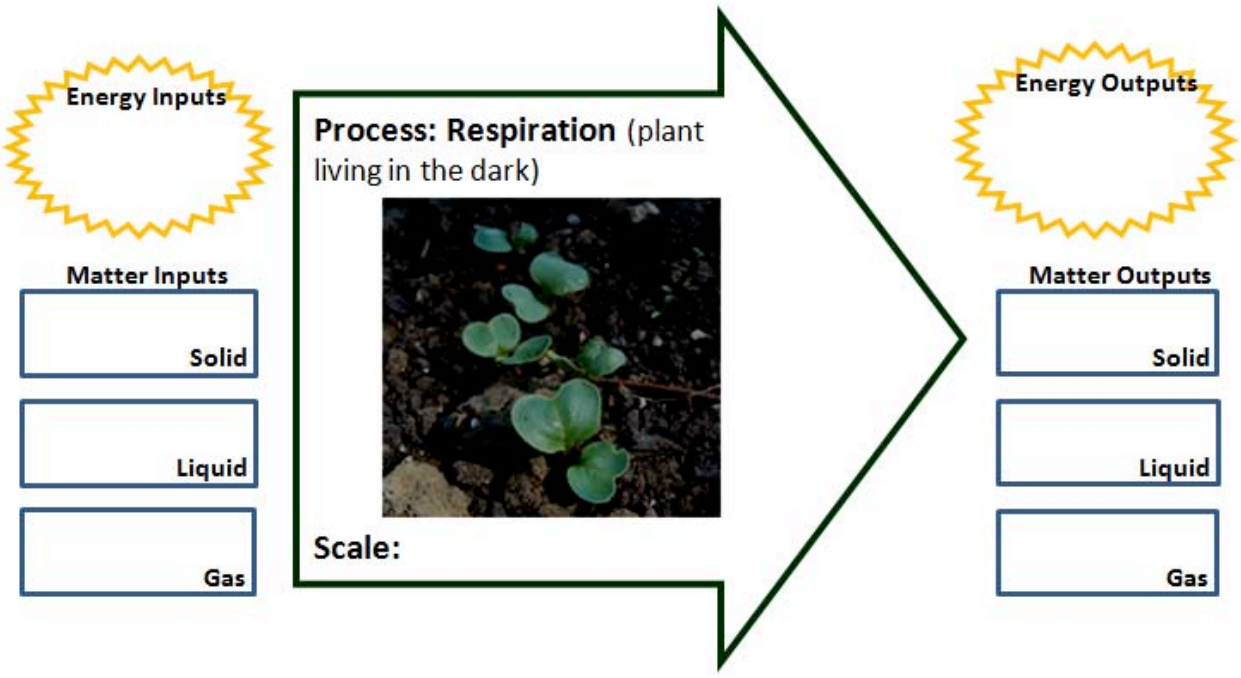
2. What happened to carbon dioxide levels near the plant in the *light*? What process was responsible for the change in CO_2 concentrations in this case?

Now let's consider those processes a little more fully. Working with your lab group, fill in the following process tools for photosynthesis and respiration as completely as you can. They will be more complicated than any of the others that you have completed so far, so check that you include all the inputs and outputs of both matter and energy.

Plant living in the light



Plant living in the dark



In the next activity you will measure the changes in biomass (the dry mass of the plants that is not water) in the radish/lettuce plants that you have been growing.

3. How do you predict your plant's biomass will have changed?

4. How do you think that this happened? How did the plants change their mass?

Name: _____Period: _____ Date: _____

Activity 9: Harvesting Plants

In the last several weeks, you set up an experiment to observe plant growth. Meanwhile, you have learned about the requirements plants have for growth and the role of gases, particularly carbon dioxide, in that growth. You've also discussed the differences between wet and dry mass.
Now you will harvest your plants and measure dry mass to see how things have changed.

1. Copy your measurements from the data table in lesson 1 into the "Before Growing" column in the table below.
2. Find the mass of your weigh boat and record in row F.
3. Gently remove the growing cup from your bag, weigh it, and record in row G.
4. Pour the remaining contents of your bag onto a paper or plastic sorting surface.
5. Using your fingers or tweezers, gently pick out all of the plant material (roots, shoots, potentially even seeds) from the soil and set them in the weigh boat.
6. Dump the soil into the cup, weigh it, and record in row H.
7. Subtract the mass of the cup to calculate the dry mass of the soil. Record in row I.
8. Weigh the plants in the weigh boat and record in row J.
9. Subtract the mass of the weigh boat to calculate the dry mass of the plants. Record in row K.
10. Calculate the change in mass over the experiment. Subtract the mass in Lesson 1 from the mass in Lesson 9 to find the difference.

Lettuce/Radish: Cup Number _____							
	Mass of:	**Before growing** (copy from Lesson 1)		**Mass of:**	**After growing and drying** (Lesson 9)		**Compare Before and After** (Lesson 9 – Lesson 1)
			F	weigh boat			
A	cup		G	cup			
B	cup + soil		H	cup + soil			
C	soil (B - A)		I	soil (H - G)		L	
			J	weigh boat + plants			
D	seeds		K	plants (J - F)		M	
E	cup + soil + seeds						
	number of seeds						

Summary questions

1. Let's compare!
    a. Did your soil mass change (see row L)? How? Can you explain why?

    b. Did your plant mass change (see row M)? How? Can you explain why?

2. What materials contribute to plant mass?

3. What does "dry mass" mean? Why is it important to measure when looking at plant growth?

4. Is a plant's source of energy related to its dry mass? Why?

5. Summarize the process observed during the experiment, from seed germination to the harvest. Include the factors that affect plant growth.

Discussion

Write the main ideas you can conclude from this activity. Remember the purpose of growing the plants was to examine the requirements of plants for growth...

Name: _____Period: _____ Date: _____

Activity 10: Von Helmont's Willow Tree Reading Guide

Where does a plant's mass come from? As you read, use the left column to record passages that help you answer this question. In the right column, write down what the passage tells you about the answer to the question.

Info from the text	What this tells you about the question
He waters the tree regularly, but does not add any more soil	*Von Helmont thought soil might not be food for plants and did an experiment to test the idea*
Von Helmont found that the soil lost a little weight while the willow tree gained a lot of weight	*The mass must have come from somewhere other than the soil*

Info from the text	What this tells you about the question

Name: _____Period: _____ Date: _____

Activity 10: Gaining, Transforming and Losing Plant Mass

Look at this young tree planted in a bucket of soil. As the tree grows it gains mass. Think about whether the soil is food for the plant.

1. Do you think the mass of this tree came mostly from materials the plant took from the soil?

   YES NO

2. Do you think the mass of the soil in the pot will "increase", "decrease", or stay the "same" as the plant grows:

WEIGHT CHANGE OF SOIL

*****Read the first part of this lesson's reading, *von Helmont's Willow Tree*, before proceeding.*****

3. Write down the changes in mass of the tree and the soil.

MASS CHANGE OF TREE	MASS CHANGE OF SOIL

4. How would you explain the results that von Helmont found? Where does the majority of a plant's mass come from if not the soil?

5. Why did the soil lose some mass? What components of the soil might now be somewhere else?

Although von Helmont was able to show that plants didn't simply take mass from the soil for all of their growth, he believed that instead the plant's material was somehow composed of water, the only thing that he had added to the bucket other than soil.

6. What process describing plant growth was unknown to him and other scientists of the time?

7.What is the main product of this process that contributes to plant mass?

As you consider any plant, though, it is obvious that although it has both water and this product, it is more complex than either of those things.

8. What are some other molecules that make up a plant's dry material, and where within the plant or its cells might those molecules be found? (for hints, look back over your reading from activity 4)

*****Return to the reading to complete the section *Plants: Even more complex than von Helmont knew!******

To summarize all that we've discussed, please complete the following table:

	Gaining Mass	Transforming Mass	Losing Mass
Which process is responsible?			
What happens to the amount of CO_2 around the plant?			
What is the main product(s) of the process?			

Name: _____Period: _____ Date: _____

Activity 11: What's the "Matter" with Carbon?

1. Using the diagram your teacher projected, identify objects that contain carbon (at least two for each of the benchmark scales).

Atomic Molecular	**Microscopic**	**Macroscopic**	**Landscape or Global**

2. Using the carbon cycle diagram your teacher projected, describe two possible routes that a carbon atom could take through the ecosystem:

1st Location	Process ⇨	2nd Location	Process ⇨	3rd Location

Atmosphere Box Model:

3. What is the net flux presented in the box model?

Stabilization Wedges:

4. What happened to the amount of carbon emissions between 1950 and 2000?

5. What does the vertical yellow dotted line represent?

6. How and why was the dashed line named current path=”ramp” created?

7. How and why was the orange line at 2010 created?

8. What effect will increasing concentrations of carbon dioxide have on the earth’s average temperature? How does CO_2 cause that effect?

Unit Assessment: Pick two or more of these questions and respond to them using everything you have learned about carbon.

What is carbon?
Why do we think carbon is so important?
Why do scientists and environmentalists talk about carbon?
What is the meaning of a “carbon footprint”?
What’s the big deal about carbon?
What’s the “matter” with carbon?