



## Putting on Mass: Just how do Trees grow?

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Used <http://education.leeds.ac.uk/research/scienceed/PlantNutrScheme.pdf> as inspiration.

<b>Time :</b>	2 periods
<b>Preparation Time :</b>	
<b>Materials :</b>	Seeds, young plant, and chunk of wood per group Student worksheet on van Helmont's experiment Questioning photosynthesis reaction overhead Putting on Mass – Student Homework sheet: Can you help van Helmont?

### Abstract

The connection between photosynthesis and plant nutrition for growth is often not made by students. This lesson serves as an introduction to a mini-unit on photosynthesis by challenging students to think about how a plant might gain mass. Students are introduced to van Helmont's experiment as a thought exercise. This is an opportunity for the teacher to identify existing conceptions students have about photosynthesis and for the student to assess what they understand.

### Objectives

Students will be able to:

1. articulate an explanation of photosynthesis
2. identify problems they have with understanding how a plant gains mass
3. describe a historical experiment

### National Science Education Standards

*The energy for life primarily derives from the sun. Plants capture energy by absorbing light and using it to form strong (covalent) chemical bonds between the atoms of carbon-containing (organic) molecules. These molecules can be used to assemble larger molecules with biological activity (including proteins, DNA, sugars, and fats). In addition, the energy stored in bonds between the atoms (chemical energy) can be used as sources of energy for life processes.*

### Teacher Background

<http://www.nsta.org/Energy/find/luminaries/>  
<http://helmont1.tripod.com/HelmontABT91.htm>

### Related URLs

<http://www.nsta.org/Energy/find/luminaries/>  
<http://www.timelinescience.org/resource/students/photosyn/photosyn.htm>

### Activity

Remind students to check on their cotton seeds. The plants may not need watering, but daily checking gets students in the practice of taking care of their plants.

1. Before class place a seed, a young plant and a chunk of wood on each group's table. On the board pose this question, "How does a seed gain the mass necessary to develop into a sapling and then into a tree?" "How does this compare to how people grow taller and larger?" Students write their individual responses in their notebooks before discussing them as a group. Students often don't recognize photosynthesis as the method by which plants obtain their food to grow. Discuss this as a class, writing on the board student's ideas. Examples might be, 'the plant



obtains food from the soil." At this time all responses are accepted, the class will return to their ideas again at the end of class. Photosynthesis is not introduced at this time.

*Jan Baptista van Helmont exercise*

2. After students have proposed their own ideas about how a plant grows and gains food, challenge them by recounting Jan Baptista van Helmont's experiment.

"Van Helmont was a 17<sup>th</sup> century scientist who attempted to answer the same question posed to you. He planted a tree weighing 5lb, in 200lbs of soil. Over five years he added only rain water. After five years he weighed the tree, including its roots and the soil. These were the results: the tree and roots weighed 169 lbs, the soil weighed 199lbs 14oz. How would you explain how the tree gained 164 lbs in mass? What made up that mass? Be prepared as a group to defend your answer. Write your answers down in your notebook. How does this change your answer to the first question? Discuss and write up possible ways you might test your group's ideas." After 10 minutes encourage students to share some of their ideas about where the tree's mass came from after reviewing van Helmont's experiment? This might also be a good time to add van Helmont's experiment to your science time line if you maintain one.

3. Ask students to identify some common themes in their responses explaining van Helmont's experiment then come up with a general class explanation. Ask students to identify what might seem scientifically implausible in their explanation of van Helmont's experiment. This is an opportunity for you to really question students' models, to address issues that the students have with the larger idea of photosynthesis although not directly identified as such at this time, unless addressed by the students. At this time share with the students that scientists have indeed come up with an explanation of how plants get the food they need to grow from a small seed or as in van Helmont's experiment from a sapling to a tree. Share with them that the plant uses carbon dioxide from the air plus water to produce sugar and as a by-product, oxygen. If they identified some part of this already, recognize that. However, van Helmont identified water as the sole source of nutrition for the tree. Explain to the students that at the time he was performing his experiments, the composition of the air was unknown and van Helmont didn't know about carbon dioxide in the air.

4. While students may have heard that carbon dioxide and water produce sugar and oxygen before and may have accepted it, does it make sense to them? Using overhead 2, have the students working in groups, review the statements and agree or disagree and list 3 reasons justifying their decision. You may want to add statements that the students have proposed or use their explanations as additional statements. Have each group share their reasons as to agreeing or disagreeing with at least one statement. You may use this time as an opportunity to note a group's conceptions about the growth of a plant. At the end of the class discussion let students know that they will be addressing these issues over the next two days.

**Embedded Assessment**

Throughout the lesson there are multiple opportunities for teacher assessment of students' ideas. The initial activity, where the students write an individual explanation of how a tree gains mass, provides a great opportunity for pre-assessment. The goal of this lesson is for students to evaluate what they understand and identify the topics which they have difficulty with. Students' notebooks will provide a written history of their developing ideas about photosynthesis. Over the next few lessons students will piece together an argument for photosynthesis as the source of a plant's nourishment. The homework demonstrates the students' ability to critically review experimental technique.



### **Homework**

Students analyze van Helmont's experimental technique. How would they change the procedure? Provide the homework sheet for this exercise. Are they able to identify lack of control of variables? What are the independent and dependent variables? How repeatable are the results?

### **Preparation notes**

Today partially cover up leaves on several geranium plants using black construction paper or aluminum foil and paper clips. Strips of paper or foil three by five centimeters typically work well. Fold the strips over the geranium leaves so that they cover approximately half the leaf. Slide a paper clip over each piece of foil or black construction paper to secure to leaf. Both the top and underside of one half of the leaf should be covered. Make sure the plants are in bright light. You will use these leaves on day 3.



## Putting on Mass – van Helmont’s Experiment

*“I took an earthen vessel, in which I put 200 pounds of earth that had dried in a furnace, which I moistened with rainwater, and I implanted therein the trunk or stem of a willow tree, weighing five pounds. And at length, five years being finished, the tree spring from thence did weigh 169 pounds and about three ounces. ... Lest the dust that flew about should be mingled with the earth, I covered the lip or mouth of the vessel with an iron plate covered with tin and easily passable with many holes. ... I again dried the earth up in the vessel, and there was found the same 200 pounds, wanting about two ounces.”*

How would you explain how the tree gained 164lbs in mass?

What made up that mass?

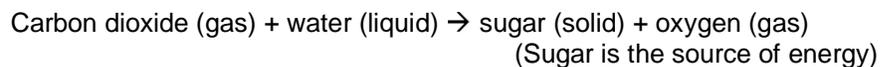
Be prepared as a group to defend your answer. Write your answers down in your notebook.

How does this change your answer to the first question?

Discuss and write up possible ways you might test your group’s ideas



## Putting on Mass – Overhead 2



What do you think? This chemical reaction is the way that scientists say plants get their food (sugar.) Read the following sentences and as a group, decide whether you agree or disagree with each sentence. Be prepared to explain your reasoning.

1. Hogwash! If there was a chemical reaction going on inside the plant you would see something happening.
2. How can a liquid, water, and a gas, carbon dioxide, make a solid? That just doesn't seem right.
3. If van Helmont's tree was just placed in a bucket of water it wouldn't have survived. That shows soil provides food for trees.



## Putting on Mass Homework

### Could you help van Helmont?

The experiment that van Helmont performed in the 16<sup>th</sup> century was revolutionary and led to a greater understanding of plants and the world around us. However, while dispelling one misunderstanding about plant nutrition, van Helmont's experiment and his conclusions were flawed! Review his account of the experiment.

"I took an earthen vessel, in which I put 200 pounds of earth that had dried in a furnace, which I moistened with rainwater, and I implanted therein the trunk or stem of a willow tree, weighing five pounds. And at length, five years being finished, the tree spring from thence did weigh 169 pounds and about three ounces. ... Lest the dust that flew about should be mingled with the earth, I covered the lip or mouth of the vessel with an iron plate covered with tin and easily passable with many holes. ... I again dried the earth up in the vessel, and there was found the same 200 pounds, wanting about two ounces. Therefore, 164 pounds of wood, bark, and roots, arose out of water only."

Identify his hypothesis:

Independent variables

Dependent variables

Identify his conclusion

Does his conclusion address his hypothesis?

What would you say based upon these results as a conclusion?

How reliable is his experiment?

How would you change the experimental procedure?