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# Photosynthesis, the van Helmont Experiment,

# & Argumentation

**Introduction**

Up until the middle of the 1600s, scientists thought that all plants – trees, bushes, grass, flowers, all vegetation – grew through a process of sucking in soil through roots and essentially absorbing that soil and somehow converting it into vegetative substance. In 1638, late in his life, pioneering Flemish scientist Jan van Helmont began a five year experiment to test the hypothesis that plants grow through this process of absorbing soil through their roots.

The way he set up his experiment was to plant a willow sapling (a sapling is a baby tree) in a pot of soil, watering it regularly and keeping it outside, where it was exposed regularly to the often bright sunlight in the variable Dutch climate. The willow sapling began with a mass of 2 kilograms. The pot of dry soil began with a mass of 90 kilograms. Van Helmont watered the sapling regularly, distributing about 110 kilograms of water into the pot annually. The sapling grew into a nice-sized willow through the course of the five years. In 1643, as the experiment was coming to an end, van Helmont uprooted the willow to weight its mass: it came in at 77 kilograms. He also dried and weighed the soil: it had a mass between 89 and 90 kilograms.

Jan van Helmont drew to conclusions from his experiment. He said that the data set provided clear evidence to scientifically invalidate the view that plants grow by absorbing soil and converting it into the vegetative substance. He also argued that his experiment suggests that plants grow through a process of absorbing the mass of water.

The van Helmont experiment is generally credited with conducting the science that opened the door to the discovery of photosynthesis, as we understand it today. The significance of his landmark work in biology has led many scientists since the mid 17th century to work replicate his experiment, and even to go beyond his findings.

In this culminating assessment of your learning in our photosynthesis unit, you are being given a data set from a simulated version of experiment done to confirm and extend van Helmont’s experimental findings, and from that data set you will be asked to complete a short-form argumentative writing assignment. Your argumentative writing in biology will be assessed based on a discipline-specific argumentation rubric, which is being distributed separately.

Argumentation in science is like argumentation in all academic subject areas. Each argument you make will need to include a clear and focused claim, be supported by relevant and credible evidence from the data set, and incorporate a warrant explaining how it is that your selected data proves the claim. Rigorous argumentation always engages with and refutes counter-arguments, i.e., arguments that might be made by someone opposing or skeptical of your position; each of your short-form argumentative writing pieces should include and respond to one counter-argument. Argument is the means by which scientific knowledge is communicated and ultimately tested in an open and ongoing clash of ideas, fueled by continual process of inquiry and discovery.

**Data Set**

The following data set is from a simulated experiment that re-creates and expands on van Helmont’s work in the 17th century. This experiment includes the measurement of a few new variables. One of these new metrics measures the average intensity (or brightness) of light (i.e., sunlight) falling on the tree in any given season. This intensity can be measured in the number of photons (a constituent of light) falling on objects (like plants or trees) per square meter per second. The ‘Einstein’ symbol ‘uE’ represents about 6,000 photons per square meter per second.

In the course of making arguments, each student will be required to use, as part of their data/warrant (or evidence/reasoning) combinations, each of the following terms related to photosynthesis (at least once):

* Light-dependent reactions
* Light-independent reactions
* Rate of photosynthesis
* Mass conversion

**Simulated Repetition of the van Helmont Experiment (2009 – 2013)**

(W) stands for the winter measurement (Jan or Feb). (S) stands for the summer measurement (July or Aug). Tree mass, soil mass, and accumulated water mass is measured in kilograms. Oxygen levels are measured as they are changing (positively or negatively), in Oxygen molecules per meg. Sun brightness is measured in photons per square meter per second, using Einsteen units.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Photosynthesis**  **Metric** | **2009**  **(W)** | **2009**  **(S)** | **2010**  **(W)** | **2010**  **(S)** | **2011**  **(W)** | **2011**  **(S)** | **2012**  **(W)** | **2012**  **(S)** | **2013**  **(W)** | **2013**  **(S)** |
| **Tree Mass**  **(in Kgs)** | 2 | 17 | 18 | 31 | 31 | 47 | 48 | 63 | 63 | 77 |
| **Soil Mass**  **(in Kgs)** | 90 | 91 | 90 | 90 | 90 | 89 | 89 | 88 | 88 | 89 |
| **Water Mass**  **(in Kgs)** | 5 | 110 | 165 | 220 | 275 | 330 | 385 | 440 | 495 | 550 |
| **Light**  **Brightness** | 120 | 400 | 135 | 405 | 100 | 420 | 130 | 400 | 95 | 375 |

**Scientific Argument: Short-Form Writing Assignment**

1. Affirm the following scientific claim made by Jan van Helmont in 1643: **Plants do not grow by**

**absorbing soil through their roots.**

On separate paper make two developed arguments, with separate claims backed up by evidence in which warrants show how the data supports the claims. Draw on data from the data set above for your evidence. Use the following structure for your short-form argumentative report.

Paragraph 1: Introduction

-- Very brief background on the issue

-- Statement of your argumentative position – i.e., Jan van Helmont was right in concluding

that plants do not grow by absorbing soil through their roots.

Paragraph 2: First Argument Supporting Your Position

-- Claim: a reason that the scientific conclusion that plants do not grow by absorbing soil

through their roots is true

-- Evidence: citing data from the data set

-- Warrant: your explanation, using logical reasoning, that the data you chose as evidence

actually proves your claim

Paragraph 3: Second Argument Supporting Your Position

-- Claim: another, distinct (not the same as the first) reason that the scientific conclusion that

plants do not grow by absorbing soil through their roots is true

-- Evidence: citing data from the data set

-- Warrant: your explanation, using logical reasoning, that the data you chose as evidence

actually proves your claim

Paragraph 4: Refuting a Counter-Argument

-- Stating a counter-argument: the best reason someone else might have for disagreeing with

your argumentative position

-- Refute the counter-argument: make an argument with claim/data/warrant that the

counter-argument doesn’t disprove your argumentative position

Paragraph 5: Conclusion

-- Evaluate the evidence and reasoning and make a statement that shows that the weight of

the argument favors and supports your argumentative position.

2. Refute the following scientific claim made by Jan van Helmont in 1643: **Plants grow solely by absorbing water through their roots.**

On another separate piece of paper, make two developed arguments, with separate claims backed up by evidence in which warrants show how the data supports the claims. Draw on data from the data set above for your evidence.

Use the following structure for your short-form argumentative report.

Paragraph 1: Introduction

-- Very brief background on the issue

-- Statement of your argumentative position – i.e., Jan van Helmont was wrong in his view

that plants grow solely by absorbing water through their roots.

Paragraph 2: First Argument Supporting Your Position

-- Claim: a reason that the view that plants grow solely by absorbing water through their

roots is false

-- Evidence: citing data from the data set

-- Warrant: your explanation, using logical reasoning, that the data you chose as evidence

actually proves your claim

Paragraph 3: Second Argument Supporting Your Position

-- Claim: another, distinct (not the same as the first) reason that the view that plants grow

solely by absorbing water through their roots is false

-- Evidence: citing data from the data set

-- Warrant: your explanation, using logical reasoning, that the data you chose as evidence

actually proves your claim

Paragraph 4: Refuting a Counter-Argument

-- Stating a counter-argument: the best reason someone else might have for disagreeing with

your argumentative position (i.e., for supporting van Helmont’s view, in this case)

-- Refute the counter-argument: make an argument with claim/data/warrant that the

counter-argument is wrong

Paragraph 5: Conclusion

-- Evaluate the evidence and reasoning and make a statement that shows that the weight of

the argument favors and supports your argumentative position.