

Analyzing van Helmont's Willow Experiment

Jean Baptista van Helmont (1577-1644) performed one of the classic experiments in plant physiology. His research was published posthumously in *Ortus Medicinae* (in 1648) and is one of the first examples of the use of the "scientific method". Interestingly, this work was not truly original (it was mentioned by the Greeks and Da Vinci did a similar unpublished experiment with pumpkins).

In the following paragraph, van Helmont describes his experiment. Read the paragraph and then analyze the experiment by answering the questions that follow.

I took an earthen pot and in it placed 200 pounds of earth which had been dried out in an oven. This I moistened with rain water, and in it planted a shoot of willow which weighed five pounds. When five years had passed the tree which grew from it weighed 169 pounds and about three ounces. The earthen pot was wetted whenever it was necessary with rain or distilled water only. It was very large, and was sunk in the ground, and had a tin plated iron lid with many holes punched in it, which covered the edge of the pot to keep air-borne dust from mixing with the earth. I did not keep track of the weight of the leaves which fell in each of the four autumns. Finally, I dried out the earth in the pot once more, and found the same 200 pounds, less about 2 ounces. Thus, 164 pounds of wood, bark, and roots had arisen from water alone." (Howe 1965)

According to Hershey (2003) Van Helmont's experiments were almost certainly inspired by Nicolaus of Cusa's 1450 book *De Staticis Experimentis* in which he stated:

"If a man should put an hundred weight of earth into a great earthen pot, and then should take some Herbs, and Seeds, and weigh them, and then plant or sow them in the pot, and then should let them grow there so long, untill hee had successively by little and little, gotten an hundred weight of them, hee would finde the earth but very little diminished, when hecame to weigh it againe: by which he might gather, that all the aforesaid herbs, had their weight from the water."

Questions/Analysis: Now, considering these experiments, let's analyze the van Helmont experiment.

1. What was van Helmont's reason for conducting the experiment? In other words, what question did he set out to answer?
2. What was van Helmont's hypothesis?
3. Briefly restate in your own words the experiment performed by van Helmont.
4. List at least five variables that might affect this experiment. Which variable(s) is(are) controlled? Which is the experimental variable(s)?
5. Identify the experimental group and control group in this experiment.
6. If van Helmont had tested his hypothesis correctly, his experiment would have failed miserably (i.e., the plants would not grow). What experiment could he have done?

(Hint: rain water lacks essential minerals for growth)

7. van Helmont did not describe his methods in sufficient detail. For example, how did he actually remove the soil from the roots without destroying or losing too many? Can you think of any other methods that need to be clarified?
8. Calculate how much weight the soil should have lost during the growth of the willow. To do this you will need to make some assumptions: 20% of the fresh (or wet) weight of the plant is dry matter, and 5% of the dry matter is minerals (that the plant extracts from the soil).
9. Scientific papers should always include the identity, source and method of the preparation of any living materials used. What information are we missing?
10. The plant van Helmont selected was an excellent choice. Why?
11. How big was the pot that van Helmont used in his experiment? Was it the size of a gallon ice cream pail, a five gallon bucket, a 20 gallon garbage can or a 30 gallon garbage can? Calculate the size of the pot using the following assumptions: 1 pound of soil weighs about 0.5 kg; there is one kg of soil per liter.
12. Why did van Helmont sink the pot in the ground?
13. The accuracy of commercial balances can vary greatly. For example, a good quality 1000 pound capacity balance has an accuracy of +/- 0.5 pounds. Let's assume you use this balance to weigh a pumpkin and you get a reading of 120 pounds (a hefty pumpkin!). Thus the true weight of the pumpkin falls somewhere in the range from _____ to _____. How much weight did the soil lose by the end of the experiment (____ oz)? Convert this value to pounds (____ lbs). Is the soil weight loss within the accuracy limits of a decent quality, contemporary balance? Explain.

Reference:

This exercise is adapted from D Hershey, "Misconceptions about van Helmont's Willow Experiment;" *Plant Science Bulletin* 49: 78 (2003) at the following URL:
<http://www.botany.org/bsa/psb/2003/psb49-3.html#Misconceptions>