Reassessing Van Helmont, Reassessing History

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History is not a stranger to the biology classroom: many if not most textbooks present evolution through a history of Darwin's voyage on the Beagle and his visit to the Galapagos; we rarely separate a discussion of inheritance from Mendel and his pea plants, or present the structure of DNA without some anecdote from James Watson's The Double Helix. History serves as an occasion to organize the serial development of concepts, to reconstruct reasoning, to celebrate scientific discovery, and to bring humor into a lecture: in each case, episodes from the past can extraordinarily enrich our teaching. Yet teachers can also abuse history just as researchers can abuse data: by asking it to speak for a specific theory or perspective it does not "represent." Here, then, I would like to highlight some potential dangers to avoid in applying history in teaching biology.

In particular, I would like to give an award for the "Most Outlandish Use of History in Biology Education." And I would like to nominate a textbook, *Biology* (by Nason and Goldstein 1965), that included the following two accounts of work by Jean Baptiste van Helmont, a Dutch physician from the early 16th century.

The pair of examples is even more striking, however, because they grossly misrepresent van Helmont, the conclusions he drew, and what we might want to convey about the nature of science historically.

In the first example, the authors describe an "experiment" devised by van Helmont to demonstrate the spontaneous generation of mice. The procedure was to throw some grains of barley or wheat in an old rumpled shirt in a damp cellar: one should return several weeks later to find that the cereal grains have been transformed into baby mice. The lesson, of course, is clear, even to the unsophisticated science student: van Helmont is one of those ignorant, short-sighted scientists of history who failed to understand the "obvious" origins of living matter and the virtues of a controlled experiment. We know better now. Science progresses.

In the second example, we learn about van Helmont's now renowned "willow tree" experiment, sometimes hailed as the origin of experimental plant physiology. As many well know, van Helmont weighed a willow sapling along with a 200-lb. potful of soil, planted the tree, and 5 years later weighed the two again: the tree had grown a substantial 164 pounds, while virtually all the soil remained. Students are to see how elegantly van Helmont had shown how the matter of the tree had not come from the soil, but instead from a gas, a term which van Helmont himself had coined. Here, van Helmont is not the fool, but the hero. And from his example, we can draw the deeper lesson: construct a test, quantify, measure—and be prepared in some cases to be very patient for the data. Contemporary students are sometimes even guided to repeat this lesson for themselves, albeit on a smaller scale, using radish plants whose weight change can be observed in weeks rather than years. Follow the correct procedure and the right answer will inevitably follow.

The example is outlandish, of course, because van Helmont is praised and ridiculed as a scientist in the same text: he is portrayed as both hero and fool (see also Gould 1974). Now, one might take this as a lesson about the nature of science—that scientists are textured individuals, rarely having all the right answers: even Darwin, we know, made gross errors with inheritance, and his explanation that the "parallel roads of Glen Roy" represented receding coastlines was ultimately ill-founded. But the message about the richly complex human dimension of science was clearly not the intent. Rather, the context was a more simplistic, moralistic one: the right answers of today come from the right methods, the wrong answers from the wrong methods. Scientific method is algorithmic and thereby triumphs with the truth.

The pair of examples is even more striking, however, because they grossly misrepresent van Helmont, the conclusions he drew, and what we might want to convey about the nature of science historically. In the willow tree case, for example, van Helmont concluded that the bulk of the mass of the tree had come—not from carbon dioxide, a substance wholly outside his conception—but from from the water that had been added to the pot. Van Helmont had a rather elaborate world view which included the notion that there was only one primal element—water—from which all other forms of matter were derived. In this, he challenged the existing Aristotelean doctrines that there were four elements: water, earth, fire and air; and an alternative view that the basic elements were "principles" of salt, mercury and sulfur. The tree experiment was essentially designed to show, then, that the belief that the tree was earth mixed with some fire, say (according to the antecedent system of thought), was misconceived. Van Helmont provided an alternative explanation more consistent with observations: namely, our "common sense" notion (formalized through experiment) that plants need water to grow. In its intended role, the experiment was dramatically successful—especially in provoking others to think about the problem and in some cases to repeat the experiment.

One need not always get the "right" answer to see an experiment as valuable or appropriately assembled. How much more would a student learn about the nature of reliability and fallibility in science by seeing how we can construct "wrong" answers using the "right" methods?

In a recent critique of how we use the van Helmont experiment in the classroom, Hershey (1991) also challenges the easy historical interpretations of van Helmont's achievement. Yet at the same time, he views the experiment almost exclusively retrospectively, and in terms of what students can learn about experimental design, execution and analysis based on what we know today. He claims, for instance, that students can understand how van Helmont performed the "wrong" experiment. To assess his hypothesis about the role of water, he should have grown the willow hydroponically—that is, by water alone. And he should have used distilled water, so as to exclude the role of minerals in the water. If he had done this, Hershey notes, van Helmont would have observed that, to paraphrase a more familiar notion, "willows do not live by water alone." Here, the motivation is to go back and "correct" the history and make it come out "right." The effort is to restore truth following the rule, "right method, right answer."

But Hershey does not fully respect the context of Helmont's work. Concerns about distilled water in the context of an experiment done centuries before anyone understood the concept seem slightly misplaced. More deeply, van Helmont was probably well aware that plants do not grow outside soil. He even buried the pot in the earth, as if the location was a significant parameter not to disturb. That is, in our framework, he included it among the "controlled" conditions. There was certainly no existing evidence to suggest that the substrate of the soil was not relevant in some respect. Indeed, the lack of substantial soil loss even though the soil was present, was integral to showing that it was not the decisive factor in the weight gain of the tree. One may instead interpret van Helmont as rather clever in devising a technique for isolating the relevant soil system within the boundaries of a pot.

Hershey also notes that van Helmont failed to replicate his findings. Again, one may ask whether one ought to assess the original experiment by importing standards of experimental design developed only later. More significantly, Hershey neglects the role of demonstration as an effective form of experiment, one that gives initial warrant to a particular hypothesis before one applies additional resources, time, etc., to explore it in more detail. Not all experiments follow the model of the controlled experiment. In the view which Hershey merely epitomizes, one assesses Van Helmont's experiment or other historical scientific work for its flaws. In a more sensitive historical view, however, van Helmont's work exemplifies an experiment designed and interpreted appropriately in context, yielding a clear result, but which nonetheless was later construed as "wrong." One need not always get the "right" answer to see an experiment as valuable or appropriately assembled. How much more would a student learn about the nature of reliability and fallibility in science by seeing how we can construct "wrong" answers using the "right" methods?

In the same way, we must view the "experiment" on the mice in its historical context. In a more sympathetic, contextualized interpretation, it is difficult to conclude that van Helmont would interpret this case as an example of what we would call (and ridicule) today as "spontaneous generation." Nor would such an idea of transforming matter have been that ill-conceived in van Helmont's late Renaissance setting. Van Helmont was fascinated by the problem of transformation. He wanted to understand and explain digestion—the magical transformation of food into flesh. Like others at the time, he saw it as similar to the fermentation of grapes on the vine and off, akin to the transformation of bread rising with yeast. Van Helmont conceived form as generated not from chaos—that would be absurd—but from a form-giving element—what he called at times a ferment, a seed, a leaven, an archeus or miniature workman embodied in matter and which could be recaptured in the gas given off when things burn. Disease, in van Helmont's view was similarly due to external causative or form-changing agents that occupied specific organs in the body—what we may recognize as a rudimentary correlate of the germ theory of disease. As a physician, then, Helmont sought to remove the cause of the illness, not merely treat its symptoms; remedies were thus to be disease-specific: a revolutionary idea for the time. For van Helmont then, the transformation of wheat or barley into a mouse was not literal but it was very real nonetheless: today, we would interpret his concerns in terms of metabolism and enzymes. Once again, an idea that seems patently "wrong" on the surface, gains a substantially different meaning in its proper historical context. And an effort to draw a lesson merely from our current scientific understanding seems misguided.

In an effort to reveal the process of science, this text I have nominated as "Most Outlandish" actually obscures an honest or genuine view of that process. The intent is admirable—and surely we can benefit from more excursions into history while teaching biology. But one can be misled by the impulse to judge and "fix" the past ("scientifically"), rather than to listen to it (historically). To the extent that we borrow from history to teach about the nature of science as a process and as a social and human endeavor, to give a broader sense of institutions, instruments and ideologies, as well as ideas, we must be sensitive to the history, else we risk betraying the very subject we hope to portray.

Literature Cited

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