This article reprinted from:

Gray, M. E., N. K. Marioni, and C. J. Howard. 2005. Modeling scientific thinking through controversy: An example using plant chemical warfare (allelopathy). Pages 373-374, *in* Tested Studies for Laboratory Teaching, Volume 26 (M.A. O'Donnell, Editor). Proceedings of the 26th Workshop/Conference of the Association for Biology Laboratory Education (ABLE), 452 pages.

ISBN 1-890444-08-1

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Modeling Scientific Thinking through Controversy: An example using plant chemical warfare (allelopathy)

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One of the most important and difficult goals in our general biology laboratory course at the University of Nevada, Reno is to introduce freshman and sophomore Biology majors to the process of science. One method we have found quite effective for introducing students to scientific thinking is to have students conduct a simple laboratory experiment in plant-plant allelopathic interactions and then have the students find out later that their "research" was not as straightforward as they had originally intended. When explored deeper, students find that their oversimplified conclusions are similar to the conclusions drawn by many experts in this field and that incorrect inferences can occur from experimental design flaws and overstated conclusions. This forces the students to rethink their research and gives them the broader perspective necessary to critique their work and the work of others.

This guided investigative laboratory is divided into three modules. The first module allows students to conduct an allelopathic experiment, much like the one published by Muller *et al.* (1964), that investigates plant-plant allelopathy in a laboratory setting. Students are also introduced to Muller's general hypothesis (model) where he claims that stands of *Artemisia tridentata,* California sage, can inhibit the growth of adjacent grasslands by emitting volatile, allelopathic compounds. In doing so, the sage stands are thought to create a bare zone (60 cm region of bare soil) and a zone of inhibition (6 meter region of stunted grasses) that surrounds the sage and prevent annual grasses from competing for water and essential nutrients. Students try to replicate Muller's research conducted in a laboratory setting by growing *Brassica rapa*, Wisconsin Fast Plants, in closed containers with allelopathic plant tissues from sagebrush or rabbitbrush (Figure 1). As expected, the growth of Wisconsin Fast Plants is stunted in the presence of these allelopathic tissues, relative to the control.

The second module involves students writing a scientific paper for their allelopathy experiment conducted in module one. This is an effective strategy for getting students acquainted with the scientific literature and having them begin to express their understanding of allelopathy in writing.

The third module focuses on critical thinking using allelopathy as the theme for this investigation. The students are given a general introduction to critical thinking and then are presented with two papers to read and evaluate. The first paper by Muller *et al.* (1964) heavily supports the idea of plant-plant allelopathic interactions through laboratory experiments that help Muller explain the bare zones seen in the environment. The second paper is by Bartholomew (1970) and it supports the idea that the contribution of allelopathy to the bare zone is minimal. Bartholomew uses field studies to support his hypothesis that the bare zone and zone of inhibition are caused primarily by small animal activity, including foraging behavior.

The follow-up with the students includes discussions of these two papers and a critique paper, written by the students, to evaluate one or more of the experiments conducted by the papers' authors. By having students critique some of the controversial issues surrounding allelopathy, students can begin to grasp that science is process of constant re-evaluation that can sometimes lead to paradigm shifts in how we perceive the world around us. This adjustment in thinking helps students to place their own research in a historical context and to evaluate the merits of their research, and the research of others, as "junior scientists" working in their area of expertise.

For more information on the allelopathy series conducted at the University of Nevada, Reno, please see the website http://unr.edu/homepage/cjhoward/teach/index.htm.

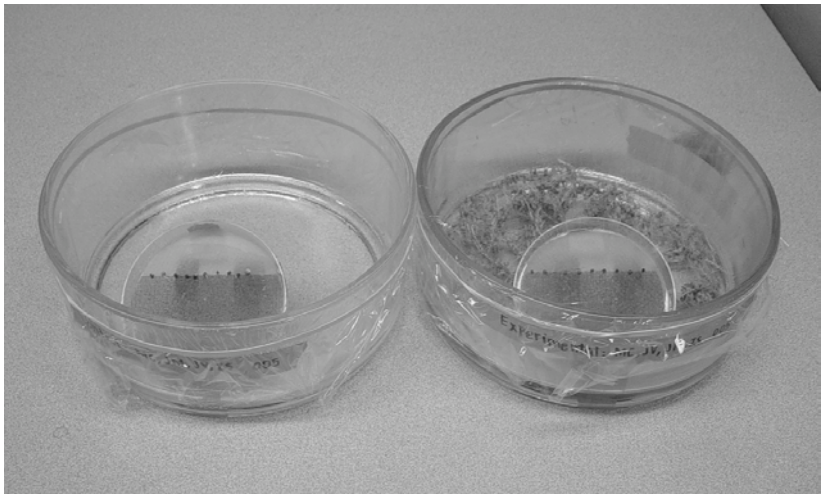

Figure 1. Experimental set-up for allelopathy lab. Dish on the left contains Wisconsin Fast Plants only (control). The right dish contains Fast Plants grown in presences of sagebrush leaves, stems and flowers (experimental).

Literature Cited

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