Letters

Amphibian Recommendations

The article "First-Grade Record Keepers" by T. Pinou, H.A. Flanigan, and M.S. Drucker (*S&C*, January 2009, pp. 31–35) prompted us—officers from the Society for the Study of Amphibians and Reptiles (SSAR) and Amphibian Ark *(www.amphibianark.org)*—to consider some recommendations regarding classroom activities involving live amphibians given the potentially negative effects on biodiversity. In general, we applaud the program presented in the article. However, the authors suggest using "…eggs of regional species of amphibians that can be released back into their native habitat once hatched—preventing the disruption of the natural biodiversity."

This suggestion is highly problematic because it risks transferring nonnative pathogens from captive animals into wild populations. Emerging infectious diseases are now acknowledged as a leading cause of amphibian declines and extinctions. Pathogens that are highly virulent to native frogs and salamanders can be spread by human activities, such as the translocation and release of species sold as bait, pets, and teaching specimens. Although we do not wish to simply squelch this exercise for reasons of risk avoidance, we believe that some traditional classroom uses of living amphibians are no longer acceptable given the devastating effects that diseases are having on amphibians globally.

The activity is a great approach to fostering "bioliteracy." Therefore, the question becomes, how can we encourage programs like this without adding to the problem of pathogens in the wild? We believe that this activity could proceed if teachers were to adhere to the following strict guidelines:

- Absolutely **no other live amphibians are also maintained in the classroom** (or, if they are, the amphibians are not allowed to come into contact with any other materials shared with other amphibians); and
- At the time any amphibians are brought into the classroom, **they should be maintained in isolation from all other aquatic organisms** and their potential pathogens. Setting up the specimens in new or sterilized enclosures will ensure this.

We hope our simple recommendations will allow innovative programs like the one described in the article to continue to bring the wonder of amphibians to the classroom without risking the very same amphibians we seek to admire. Please see our full response posted on the SSAR website: *www.ssarherps.org*.

Joseph R. Mendelson III (Zoo Atlanta), *Jennifer B. Pramuk* (Bronx Zoo/Wildlife Conservation Society), *Ron Gagliardo* (Amphibian Ark), *Allan Pessier* (San Diego Zoo Conservation Research), *Betsie B. Rothermel* (Archbold Biological Station), *Kevin C. Zippel* (Amphibian Ark), *Catherine Bevier* (Colby College), *Marion Preest* (The Claremont Colleges), and *Brian Crother* (Southeastern Louisiana University)

Author Response:

I first want to applaud my colleagues on their interest in supporting k–12 science education and bioliteracy. Teachers need mentors and specialists that can work with them collaboratively to ensure a safe and thoughtful learning environment for all. For this reason, the article "First Grade Record Keepers" strongly recommended teachers use the SSAR Herp Hotline to access professional herpetological mentors, resources, and advice and in no way meant to suggest that teachers release organisms randomly into the environment.

As an international leader in herpetological research and conservation, I am pleased with the actions taken by my academic brothers and sisters to shepherd teachers in need of implementing a tested learning activity. A close partnership between teachers and practitioners ensures that proper measures are in place for a successful and ethical learning experience while providing much needed logistical help to the classroom teacher to ensure that commercially purchased and diseased organisms aren't released.

Theodora Pinou

Hypotheses Here to Stay

As a biologist, I was alarmed to read Bill Robertson's assertion (*S&C*, Science 101, "How Does a Scientific Theory Become a Scientific Law?", January 2009, pp. 56–58) that the subject of hypotheses in science education was overemphasized and "maybe a bit overrated." Hypothesis testing is central to the scientific method, a logical process that allows us to ask critical questions and further our understanding of the world around us.

However, the scientific method does not begin with hypotheses, it begins with observations! We constantly make observations about our world, and these observations lead us to generate questions that we want to further investigate. Based on this process, we then state hypotheses about the patterns or processes that we expect to occur and the reasons for expecting those outcomes. By designing a test to find evidence that supports or rejects our hypothesis, we can begin to build our knowledge of what drives the phenomenon under investigation. Hypotheses take on additional meaning in a mathematical context; we can state and test them based on statistical analysis. Thus, while calling a hypothesis an "educated guess" may be a necessary oversimplification for our young students, it misses certain nuances. Similarly, we sometimes see the scientific method portrayed visually as a linear process. This is rarely the case in science; it's simply another oversimplification.

All of this is not to say that there aren't other methods available to advance science and that all scientists do or should employ this approach. However, it does not negate the value of this framework or make it "overrated." It's no surprise that hypothesis testing and the scientific method are pervasive in textbooks; they empower a new generation of scientists, our students, with a logical way to think critically about our world.

Following experience and careful observation, I predict that hypotheses are here to stay. Now, we just need to collect the evidence….

Gregory R. Goldsmith (University of California, Berkeley)

Author Response:

I appreciate the opportunity to clarify my position on hypotheses. I did not state that hypotheses are unimportant, but I do stand by my comment that they are overrated. And by this I do not mean that scientists overrate hypotheses. They certainly know the role of hypotheses in the advancement of science. Rather, I claim that hypotheses are overrated in their presentation in elementary and middle school curricula.

Mr. Goldsmith and I agree that the scientific method as presented in most schools does not reflect accurately on what scientists do—the scientific process is not nearly as linear as portrayed. I also believe that the "scientific method" overemphasizes the role of hypotheses. In some models of the scientific method, the first step is to formulate a hypothesis. In others, observation comes before hypotheses. But observation in science is much more than mere observation. It involves a great deal of relatively unstructured experimentation, so much so that one can spend months and months before attempting to formulate a hypothesis. Even then, the scientific method gives the impression that after observation, one cannot proceed without developing a formal hypothesis.


Science 101

Q: How does a scientific theory become a scientific law?

I can illustrate that this is not true with a simple example. Suppose a student wants to determine which brand of paper towel is the strongest. The scientific method would have this student formulate a hypothesis, such as "the most expensive towel will be the strongest because the manufacturers put more money into it." But the student's investigation, a scientific investigation, can proceed just fine without the hypothesis. The student can formulate a test of strength for paper towels and get a result without that hypothesis that he or she was forced to develop.

Bill Robertson