Natural History Education for Students

Heading into the Century of Biology

TERRENCE P. MCGLYNN

Natural History & Evolution as Common Themes in Biology

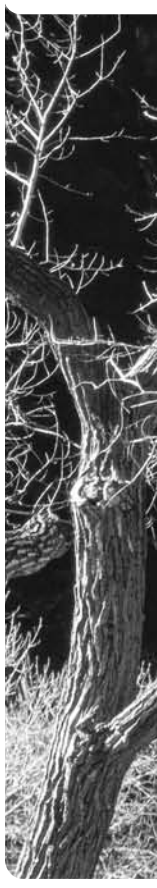
A colleague teaching at a liberal arts college was recently dispirited by the following question from a senior biology major: "Is a spider a vertebrate or an invertebrate?" After examining our curriculum, we should be reluctant to lay blame on the student. This student learned the evolutionary processes that generated the spider, how to sequence its DNA, and measure its rate of respiration. Nowhere in the curriculum was she expected to learn what a spider is. Decades of emphatic promotion of experimental ecology, at the cost of natural history education, has robbed young biologists of exposure to organisms in their natural environment. E.O. Wilson (1985, 2000) has long argued that the unpopularity of natural history is leading to an educational and research crisis in our country.

In the new "Century of Biology," educators are charged with preparing biologists who can conceptually unify information from apparently disparate fields (e.g., Kafatos & Eisner, 2004). As no individual can receive professional training in every single aspect of biology, curricula should be developed to provide students with the basic content knowledge and problem-solving abilities to address new challenges as they arise (Honts, 2003). However, it is not necessarily clear which sets of knowledge and skills are best for preparing the next generation of biologists. The *Bio 2010* report proffers many recommendations (National Research Council, 2002); at the root is the need to inspire undergraduate interest in biological sciences and provide the means to think across disciplinary boundaries. Some authors have argued that the conceptual unification of biology may be best accomplished by a consistent emphasis on natural history in biology education (e.g., Greene, 2005). Natural history education can effectively bridge gaps among disparate fields and is bound to elevate student interest.

Over the past two decades, organismal and field biologists have reported a decline in natural history in undergraduate education (Bartholomew, 1986; Trombulak, 1994; Noss, 1996; Krupa, 2000; Willson & Armesto, 2006). Some of the most effective appeals for emphasizing natural history in undergraduate coursework arrived as published plenary speeches by senior scholars receiving honors from scientific societies (Futuyma, 1998; Grant, 2000; Schmidly, 2005; but also see Arnold, 2003). The thesis of these pleas for natural history education is that we are training biologists strong in theory but weak in the ability to apply these theories to organisms and the natural world.

Fundamental to the training of biologists is a functional understanding of the causes and consequences of evolution. To most students, natural selection is an abstract concept. If educators do their job, students conceptually understand that the biotic and abiotic environment limits reproductive success of organisms. However, most graduating biology majors have little idea of the agents of selection that may operate on any given organism. A reading of *The Beak of the Finch* (Weiner, 1994) can get students closer to this goal, but this is more effectively achieved by spending time with organisms. Get your students to watch an animal trying to find food, build a nest, attract a mate, or avoid a predator. Examine microhabitats where organisms occur and find out why, in a common species, some plants have more flowers (or, in winter, withering infructescences) than others. Turn over rocks and find bugs. These are teachable moments for evolution that you can't get in a lab, and this is why natural history education is central to training biologists who can unify ideas in this new century.

While some contemporary scientists will disregard natural history as mere bookkeeping, a familiarity with organisms in their own environments is prerequisite for an integrative understanding of biology required for solving our most pressing research problems (Wilson, 1985, 2000). Natural history education is not just for field-oriented biologists. Some of the greatest advances in cellular and molecular biology have come from insights that could only be gleaned from a naturalist's broad take on the world. For instance, the conception of the polymerase chain reaction (PCR), which enabled the molecular biology revolution, occurred only because broadly-trained biochemists knew about ancient prokaryotes that existed within broad and



TERRENCE P. MCGLYNN is Assistant Professor, Department of Biology, California State University-Dominguez Hills, Carson, CA 90747; e-mail: terry.mcglynn@gmail.com.

elevated temperature ranges (Rabinow, 1996). Likewise, Sydney Brenner selected the nematode worm *C. elegans* as a model system for genetics and developmental biology on the basis of its natural history (Brenner, 1974). Brenner dedicated his Nobel Laureate lecture to the virtues of this worm, attributing research successes principally to the judicious selection of the model system.

Many educators are sympathetic with the need to conduct natural history education, but concrete steps to address this situation are rarely addressed. As biology departments around the country are seeking ways to introduce inquiry-based learning into their introductory curricula, this may be an opportune time to reintroduce natural history into the classroom, and outside the classroom. Below I provide a number of suggestions that may increase, to some extent, the role of natural history in teaching or help students make connections between the classroom and organisms in the environments where they evolve.

Connect Laboratories to Organisms in Natural Environments on Campus

Most biology majors never work outdoors to interact with organisms in the wild before they graduate. Field-based labs can happen in urban, suburban, and rural environments, regardless of season. Activities centered on laboratory work may include, at times, a modest but integral outdoor component, such as the collection of specimens to be assayed in the laboratory. For example, an introductory laboratory on the biology of unicellular eukaryotes could be improved by a short trip to the closest puddle of stagnant water on campus, which is sure to contain algae. An introduction to plants should not forsake campus landscaping.

Use Living Organisms Whenever Possible

Many laboratory activities use prepared materials and preserved specimens, even though the use of living organisms is feasible, more informative, and not necessarily more costly in terms of time or expense. Prepared slides, kits, and specimens often provide consistent results, but contribute to a "cookbook" effect in which students follow steps to complete an activity without conceptualization or contextualization (Luckie et al., 2004). Students will learn more in an investigative activity based on live organisms, even if it is less likely that they will observe the phenomena included in the objectives of the activity.

Regularly Incorporate Images of Organisms into Lecture

Everything in biology involves organisms. We far too often discuss biology in abstract terms, when we can often root lessons with the organisms we study. Lectures frequently include accounts of experiments, discoveries, and methodologies, based on real living creatures. With the advent of online image searches, publisher-provided image databases, and computer projectors, students can be shown pictures of these organisms, with only a few seconds of extra effort by instructors. For example, every student should know what model organisms look like and where they live, such as *Aspergillus* (yeast), *Arabidopsis* (plant), *C. elegans* (nematode), *Dictyostelium* (cellular slime mold), *Drosophila* (arthropod), *E. coli* (bacterium), and *Mus musculus* (vertebrate). These pictures may appear in the textbook, but if the role of lecture is to breathe life into textbook material, then imagery is key central to the unification of concept and real-world organisms.

Show Nature Videos in Class

Students have much to gain from observing organisms in contexts that they are unlikely to experience personally. Examples include watching tiny insects over their lifespans, the step-by-step conversion of an ecosystem by beavers, or exposure to distant biomes. Though the use of nature footage is often considered a poor substitute for faculty instruction, educational programs may introduce students to material substantially and with great effect when in concert with a comprehensive curriculum (Chaney-Cullen & Duffy, 1999). While most people watch plenty of television, in my experiences the majority of students rarely, if ever, watch nature programming, regardless of its quality.

Provide Informal Education Opportunities

Universities underutilize the rich resources available at natural history museums, zoological parks, and other informal science education institutions. In addition to exhibits, behind-the-scenes collections and personnel are often available to educational groups at no cost. Curators and researchers are often willing to engage substantially with university courses as such educational endeavors are a part of their institutional missions. Instructors can develop investigative activities for individuals or groups of students that make use of preserved or living collections. Many institutions will allow educational visits for free with some advance notice, including the "world-famous" San Diego Zoo. There, students may conduct instructor-led investigations involving comparative anatomy, biogeography, animal behavior and conservation biology. For example, students may select animals for observation to develop and test questions about the evolutionary history and biogeography of handedness in primates (e.g., Papademetriou et al., 2005).

Create Access to Service Learning & Internship Opportunities for Undergraduates

Many universities actively promote service learning opportunities. The service learning movement emphasizes the nexus between the academic aspect of learning and interactions with members of the community. If a department grants academic credit to majors for internships, then students will be more likely to volunteer with research, conservation, and education organizations involving work with organisms in their natural environments. Many of these interactions will provide students with the kind of interdisciplinary experiences that are difficult to introduce in a course with a single instructor. As such nonprofit groups often rely heavily upon volunteer effort, the establishment and maintenance of relationships with host organizations is rarely cumbersome.

Provide Resources To Facilitate Off-Campus Field Opportunities

Depending on institutional setting and resources, field experiences off campus may pose challenges in terms of transportation, liability, or scheduling. Modest changes might be able to ameliorate some of these barriers. On a campus where most students commute, laboratories may be scheduled to meet

at an off-campus field trip locality. Students often are able to carpool to field trip sites if university vehicles and drivers are not available. University risk management offices may be requested to provide waivers for field trips, as students driving on field trips may be eligible for secondary auto insurance. If such space is available, a "field room" for staging field trips reduces activation energy required by faculty to organize field activities on a regular basis.

Include Natural History Education as a "Broader Effect" in Federal Research Proposals

Federal agencies are actively petitioning for, if not requiring, significant educational components to be included within research proposals. Likewise, currently-funded proposals are often eligible for supplemental funding to meet curricular goals. Principal investigators can benefit from including requests for educational activities in support of organism-centered educational programs, as the inclusion of these activities is thought to increase attractiveness of the proposal to funding organizations.

Reinstate Organismal Courses

Restructuring a curriculum is not a small task. We can teach our students the way our academic antecedents learned, by trampling into the wild to work with creatures. Organismal biology courses can be taught without disregarding contemporary scientific practices. We can design our student experiments to test biological concepts while simultaneously learning about the organisms. Courses in Ornithology, Entomology, Botany, and Herpetology can incorporate inquiry-based learning, introduce major concepts in contemporary biology, and simultaneously introduce students to organisms in the natural world.

Include One Night Outdoors at Some Point in the Undergraduate Curriculum

Simply put, most biology undergraduates have never gone camping. Taking students out for one night out-of-doors does spiritual good, even though some may enter the experience grudgingly. When students weather the elements just as plants and animals do, they'll achieve a more tangible realization of the range of environmental conditions experienced by plants and animals. An experiential understanding of natural selection in the wild is more difficult to synthesize in a university teaching laboratory.

Summary

Natural history is more than just an historic root of contemporary biology. Organisms are the heart of biology education and research, and to prepare students as holistic thinkers we must show them how to see the organism for the cells as well as the forest for the trees. In each institutional setting, some avenues are easier and more practical than others. Infusing curiosity and knowledge about nature into undergraduates is best achieved with creative approaches that suit the pedagogical approach of each instructor (Noss, 1997).

Acknowledgments

This paper was written under support of the National Science Foundation (OISE- 0526561; EAR-0421178) and the College of Natural and Behavioral Sciences, California State University-Dominguez Hills.

References

Arnold, S.J. (2003). Too much natural history, or too little? *Animal Behaviour*, *65*, 1065-1068.

Bartholomew, G.A. (1986). The role of natural history in contemporary biology. *BioScience*, *36*, 324-329.

Brenner, S. (1974). The genetics of *Caenorhabditis elegans*. *Genetics*, *77*, 71-94.

Chaney-Cullen, T. & Duffy, T.M. (1999). Strategic teaching framework: Multimedia to support teacher change. *Journal of the Learning Sciences*, *8*, 1-40.

Futuyma, D.J. (1998). Wherefore and whither the naturalist? *American Naturalist*, *151*, 1–6.

Grant, P.R. (2000). What does it mean to be a naturalist at the end of the twentieth century? *American Naturalist*, *155*, 1-12.

Greene, H.W. (2005). Organisms in nature as a central focus for biology. *Trends in Ecology and Evolution*, *20*, 23-27.

Honts, J.E. (2003). Evolving strategies for the incorporation of bioinformatics within the undergraduate cell biology curriculum. *Cell Biology Education*, *2*, 233-247.

Kafatos, F.C. & Eisner, T. (2004). Unification in the century of biology. *Science*, *303*, 1257.

Krupa, J.J. (2000). The importance of naturalists as teachers and the use of natural history as a teaching tool. *The American Biology Teacher*, *62*(8), 553-558.

Luckie, D.B., Maleszewski, J.J., Loznak, S.D. & Krha, M. (2004). Infusion of collaborative inquiry throughout a biology curriculum increases student learning: A four-year study of "Teams and Streams." *Advances in Physiology Education*, *28*, 199-209.

National Research Council. (2002). *BIO 2010: Transforming Undergraduate Education for Future Research Biologists*. Washington, DC: National Academy Press.

Noss, R.F. (1996). The naturalists are dying off. *Conservation Biology*, *10*, 1-3.

Noss, R.F. (1997). The failure of universities to produce conservation biologists. *Conservation Biology*, *11*, 1267-1269.

Papademetriou, E., Sheu, C.F. & Michel, G F. (2005). A meta-analysis of primate hand preferences, particularly for reaching. *Journal of Comparative Psychology*, *119*, 33-48.

Rabinow, P. (1996). *Making PCR: A Story of Biotechnology*. Chicago: University of Chicago Press.

Schmidly, D.J. (2005). What it means to be a naturalist and the future of natural history at American universities. *Journal of Mammalogy*, *86*, 449-456.

Trombulak, S.C. (1994). Undergraduate education and the next generation of conservation biologists. *Conservation Biology*, *8*, 589-591.

Weiner, J. (1994). *The Beak of the Finch: A Story of Evolution in our Time*. New York: Vintage Press.

Willson, M.F. & Armesto, J.J. (2006). Is natural history really dead? Toward the rebirth of natural history. *Revista Chilena de Historia Natural*, *79*, 279-283.

Wilson, E.O. (1985). The biodiversity crisis: A challenge for science. *Issues in Science and Technology*, *2*, 20-29.

Wilson, E.O. (2000). On the future of conservation biology. *Conservation Biology*, *14*, 1-3.