The hard road to education reform

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Frontiers in Ecology and the Environment is taking the lead in promoting educational reform with a new education series, beginning in this issue (see page 323). This is, in part, a response to recent articles in *Science* (Wood and Gentile 2003; **302**: 1510; Handlesman *et al.* 2004; **304**: 521) that called for education reform and challenged professional societies to be at the forefront of advocacy and action for that reform. The ESA is to be applauded for its proactive stance and actions.

Undergraduate science education in biology faces a number of hurdles. Reform efforts have generally been "more like rearranging the deck chairs than steering a ship. They end up being minor rearrangements of credits or sequences without any substantial change in direction" (Pollack RVH 1989; *Intervet* **24**: 8). The problem is too many fact-jammed lectures, too many subdisciplines of biology, each requiring undivided attention, the lack of concordance on the key elements that all biologists should know, and an over-reliance on colleagues from related disciplines to teach "all that stuff" (eg chemistry, physics, mathematics, computer science) biologists need to know, without then including it into biology courses so as to promote integrated learning.

If this does not sound familiar, then your institution has either found the golden egg approach to reform and should patent it, or has not gone into the depths of curriculum reform in biology in recent history. The primary goal for undergraduate education in biology must be to move from a curriculum that provides a compendium of details that comprise a grab sample of information to one that promotes student learning through an interdisciplinary effort to understand complex systems. The curriculum should underscore the connectedness of mathematics and the physical and biological science. This will help bring the interdisciplinary research that now sits center stage within the research community into the education of undergraduate students. A report by the American Cancer Society (*Am Cancer Soc*, Burroughs Welcome Fund, and Howard Hughes Medical Institute 2000) notes: "interdisciplinary research…requires the approaches and the collaboration of many individuals from different fields". The report further states: "The changing paradigm of research calls for innovations and changes in the education of scientists along the spectrum of K-12, undergraduate, and graduate education". This has been echoed in numerous reports in the past several years, and is as critically important to the ecological community as it is to the biomedical community. Such an interdisciplinary curriculum in the life sciences is not just about teaching biology students more math, physics students more biology, or everyone more computer skills; it is about helping students to develop the intellectual capacity to deal with real, complex problems, the confidence and willingness to approach problems from multiple perspectives, the flexibility to communicate with scientists from other disciplines, and the ability to make decisions in the face of uncertainty.

The challenge for the educational and research communities in all the biological sciences will be to work together to bring students up to speed, so that they can take fuller advantage of the evolving knowledge base and tools that now define science. This includes: (1) building a strong interdisciplinary curriculum that integrates physical science, computational modeling, and mathematics into the biological sciences in a more profound and direct manner; (2) bringing the subdisciplines of biology together in conversation which will result in a holistic view of what it means to be a life scientist; (3) seriously reducing through thoughtful triage the number of "factoids" that are currently offered to students in standard courses; (4) working collaboratively with colleagues in related disciplines to evolve ways in which the physical science and mathematics courses can teach life science concepts and, importantly, make biology courses more effective at integrating the physical sciences and mathematics into the curriculum; (5) focusing on the new challenges found in understanding of complex systems in the life sciences; (6) creating more opportunities for undergraduate students to engage in meaningful research; (7) designing research-focused, theme-centered laboratory experiences for all students; (8) promoting and rewarding teaching excellence at all institutions; and (9) finding ways to overcome the barriers that keep excellent research scientists from becoming equally excellent teachers.

It is imperative that faculty and institutions articulate with certainty and clarity the content and pedagogies of educational reform and that research about student learning and the impact of pedagogical change on learning be part of the package. Teaching is not intended to merely box something into a discreet package and disseminate it, but rather it must promote meaningful exchanges and ways to grow and expand the knowledge base and its application for students and educators alike.