CLASSROOM FOCUS AND OBJECTIVES

As an integrative biologist who focuses on vertebrate anatomy and physiology, a career goal of mine is to teach courses that focus on the same topics. Because I am also a systematic biologist, I teach these topics under the unifying concepts of evolutionary history and phylogeny. As my research program expands, I hope to teach other courses that cover advanced topics in functional morphology and physiology and molecular evolution. I enjoy teaching in a variety of settings, including small field courses and laboratory sections as well as large lecture classes with over a hundred students.

In teaching comparative biology, I have two specific goals. The first is to have students actively explore the biological diversity of vertebrates through the unifying concepts of evolutionary history and phylogeny. The second goal is to have students develop an understanding of the scientific process. I want students to ask questions (i.e., propose hypotheses) that they can evaluate through their own observations.

INSTRUCTIONAL TECHNIQUES

In teaching courses in comparative biology, I engage students in a unit-based learning cycle that starts with exploration of themes and concepts in the laboratory and lecture. Initially, lab exercises and lecture presentations introduce students to vertebrate biodiversity through vivid slides, hands-on examination of specimens, and short discussions. Students then explore the subject of the unit, undertaking learning tasks that focus on skills and concepts central to the topic. These tasks often involve simple experiments in functional physiology and morphology. Next, the students, teaching assistants, and I engage in an explanation of what was uncovered in the exploration and experimentation. Students are asked to consider what the broader implications of their findings. In the last phase before evaluation, the students are asked to elaborate on and expand the learning focus by applying newly acquired skills and conceptual knowledge to related or similar models in vertebrate biology. Lastly, students are evaluated with a variety of assessment methods.
A simple example of this type of learning cycle follows, one that focuses on the locomotor behavior, physiology, and morphology in fishes. First, students are led through a discussion in lecture and about the association of body shape, caudal-fin morphology, and muscle composition with swimming type and speed. In the corresponding laboratory exercise, the TAs and I ask them to pick one of a dozen species, taken fresh from the market, and develop an hypothesis based on external body morphology as to the relative composition of red and white muscle. Dissections are made and red and white muscle weighed. The data are summarized for each species and then each hypothesis is evaluated in a class-led discussion. Students are asked to consider red-white muscle composition in the fishes and food animals they eat regularly and make inferences about the type of locomotor behavior food species display. Learning assessment of the students follow with specimen-based questions in a laboratory practical and short-answer questions on a lecture midterm.
LECTURES

Keeping students engaged and learning effectively is difficult in the lecture hall, especially for courses with large enrollments. Student engagement and successful learning is best ensured by the use of active-learning strategies that are part of an inquiry-based learning cycle like the one outlined above. The delivery and content of the lecture is perhaps just as important. My lectures are relaxed with a conversational tone so that students can engage with me and others in the class to better absorb the major themes, facts, and concepts we explore. To facilitate this atmosphere, lecture notes are provided online beforehand in PDF format so that the students are listening and asking questions rather than frantically taking down notes. Readings typically include short book chapters and a selection of peer-reviewed papers, often reviews that summarize key concepts or the history of problems in vertebrate biology.

An example of an evogram used in teaching vertebrate evolutionary biology (by B. Swartz and J. Frankel, from K. Padian, 2008. Integr. Comp. Biol.:48(2): 175-188). This figure simultaneously represents multiple lines of corroborating phylogenetic evidence and the evolutionary history of taxa and character complexes.
The slides that I show in my lectures are rich with multimedia and diagrammatic representation of the material. I am particularly fond of video clips that document in-situ behaviors and demonstrate the important interplay between morphology, physiology, and performance. Evograms, figures that represent major evolutionary events within a lineage, are also featured components of my lectures. Because they combine phylogeny with character complexes and simultaneously represent an evolutionary hypothesis, evograms are both complex talking points that stimulate in-depth discussions and efficient organizational tools that integrate important topics within the course.

Assessing Student Learning
Student assessment takes on many forms in my courses. Having taught classes with enrollments exceeding 120 students, I understand that there is diversity of learning styles and, because of this, I use a diverse suite of assessment modalities. For students that engage intellectually and find it most expressive to write about what they have learned, I give short answer exams. For those that thrive at exploring topics independently, I require a short paper that synthesizes what is known about a taxon, including morphology, taxonomic history, and interrelationships. Laboratory practicals and a graded lab notebook cater to students that respond best to hands-on experiences. For those that can best express what they have learned by word of mouth, a short oral presentation is given on the student’s paper topic. No single assessment method is dominant in the calculation of a student’s grade. Thus, students that may lack confidence in one aspect of this assessment scheme may utilize a number of other means to demonstrate what they have learned. In addition, from my experience as a student, teaching assistant, and instructor, I know relying on a narrowly focused suite of assessment tools can turn students off no matter how curious the student or interesting the subject matter.

Because the guiding purpose of assessment is not to assign a grade for the course, but rather to improve student learning, I use these assessment methods to identify how I can improve the effectiveness of the course. Feedback in the form of exam scores, drafts of papers, and answers to lab handouts are used to refine the course, not only from year to year, but also day to day. In addition to the feedback from assessment material, I use feedback from the students themselves, often in the form of a midterm class interview performed by a third party on campus, to fine tune an ongoing course. Just as I expect learning style to vary from student to student, I
explore the possibility that each class may respond to the course differently from year to year or term to term.

**Teaching Outside the Classroom**

If universities are to properly prepare undergraduates for positions in research, students should experience research early in their careers. As an undergraduate, the advice, guidance, and research opportunities I received were invaluable and are the foundation on which I perform research to this day. Realizing this, each year I invite one or two undergraduates to work with me on problems in deep-sea biology that focus on taxonomy, systematics, and anatomy. Together, we find modest funding opportunities and develop hypotheses and answer them using data collected by hands-on investigations taken on by the student. The experience students gain in this setting is unlike any they receive in the classroom. These one-on-one interactions and independent investigations are essential to the development of future scientists.