YALE NATIONAL INITIATIVE
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Curriculum Units by Fellows of the National Initiative
2012 Volume VI: Asking Questions in Biology: Discovery versus Knowledge

Introduction

by Paul E. Turner, Professor of Ecology and Evolutionary Biology

Many teachers observe a trend in their classrooms where students are increasingly reluctant to ask questions. Apparently, students fear that asking questions would reveal their limited knowledge, or would cause them to appear less intelligent than their peers. This trend is especially troubling when biology and other sciences are taught in the classroom, because it signals that students are stifling their inherent curiosity about the natural world. This seminar examined why it is important to encourage students to ask questions in the classroom, particularly in biology. It emphasized that asking questions is crucial for making scientific discoveries, which are essentially questions (hypotheses) that are either supported or refuted through direct tests. We learned that, over time, this iterative process of discovery-making translates directly into the collection of facts that we call "scientific knowledge." We discussed why biologists and other scientists generally consider their careers rewarding, even though their discoveries are often overturned, or proven incorrect. In addition, we learned that many famous scientific discoveries occurred through sheer accident, which emphasizes that science is mainly about asking questions and pursuing unknowns, and less about posing ideas that are absolutely correct. We examined the biological underpinnings of question-asking, and learned that our strong curiosity prompts humans to ask questions, whereas our close primate relatives such as chimpanzees do not. We considered how philosophical approaches to asking questions have changed through history, but that certain approaches such as Socrates' Scientific Method have remained influential and persisted over time. We discussed scientific ethics and the public perception of science, to better understand why some scientists act irrationally in the name of career advancement, and how their actions can violate public trust of science and medicine. Throughout the seminar we related discussions of these topics to the fundamental human fear of being perceived as "wrong," and how this creates a reluctance to ask questions in the classroom. Importantly, we worked together to discuss and design curriculum units which may be used to address this problem, especially by convincing students that discovery and knowledge in biology can only occur through willingness to ask questions. The seminar included discussions of reading assignments on asking questions, some hands-on laboratory experiments, and a tour of the collections at the Yale Peabody Museum of Natural History to learn how these holdings are used to test hypotheses in biology research. The seminar was intended for teachers of biology at all grade levels.

The resulting units were diverse, reflecting the varied interests and backgrounds of the Fellows. Benjamin Barnett-Perry develops a unit for special-education students that allows them to intensely examine the strengths and weaknesses of their particular disabilities, and those of their peers, drawing analogies to the unique and diverse traits other species; this unit helps to empower special-education students, so that they become increasingly independent and willing to self-advocate. Emily Dentel's unit looks at the great variety of reproductive life cycles seen in nature, and brings examples into the classroom to help early elementary school students to pose questions about life cycles, thus prompting them to think like scientists. Rebekah

Edwards focuses on evolutionary biology and the ability for organisms to become better adapted to their environments, but uses instruction on insect evolution to emphasize that useful traits often evolve as a compromise, where existing characteristics are modified for new purposes. Jane Gerughty's unit for high school students emphasizes that science can only advance through bold hypothesis-testing, and describes how many famous scientists were very persistent – but also sometimes very lucky – when striving through obstacles to make their most key discoveries. Kathleen Gormley's unit introduces third-graders to scientific insight, where they are prompted to ask questions about biological observations, such as comparing the skeletons of closely and distantly related creatures; these activities stimulate their curiosity but also empower them to think like scientists. Georgia Karns's unit is on the biology of Chesapeake Bay, to teach middle school students about healthy ecosystems and proper stewardship of their local environments; the unit emphasizes inquiry and scientific investigation, along with cooperative learning skills. Megan McLaughlin's unit engages elementary school students to think about the adaptations which allow animals to better thrive in their environments; by posing questions about species similarities and differences the students will gain an understanding of biodiversity and will think critically about why organisms differ in appearance in behavior.

Paul E. Turner