NATIONAL CENTER FOR IMPROVING STUDENT LEARNING AND ACHIEVEMENT IN MATHEMATICS AND SCIENCE

NEWS RELEASE

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New Approach to Teaching Evolution Speaks to Debate

A new approach to teaching evolutionary biology may be one answer to the divisive debate about the teaching of evolution in high school.

The new 9-week course initiated at Wisconsin's Monona Grove High School shows how evolutionary biology can be taught as an investigative process, versus the traditional approach of dishing out definitions and theories for memorization. The course challenges juniors and seniors to grapple with three historical explanations for species' origins. It also gives them a chance to elaborate their own explanations based on rich data and Darwin's theory of natural selection. As they work together on research cases, the students become a research community and gradually learn that scientists are similar to detectives, piecing together evidence and theory.

A team of researchers and teachers at the National Center for Improving Student Learning in Mathematics and Science and the University of Wisconsin-Madison developed the course to give students a unique opportunity to learn evolution as inquiry.

"When students learn about evolution in traditional classrooms, they usually rely on a textbook that elaborates 20 pages of definitions and concepts," observes team researcher John Rudolph. "Imagine a 10th grader coming to grips with any of this content with real understanding in less than two weeks. This information tends to be thrown at students and taught in a very top-down way."

Most U.S. adults learned the textbook version of evolutionary biology, if they learned it at all. Few learned science as a *process* that allows them to inquire about their world, as recommended by the 1995 national science standards. The research team contends that learning by rote continues to substitute for scientific inquiry in many of today's classrooms, particularly with regard to evolutionary biology.

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“Typically, there are few, if any, opportunities for students to actually solve problems, as evolutionary biologists do,” states researcher Sam Donovan. “Students may get a question at the end of a book chapter, such as ‘What is natural selection?’ But students will get no sense that evolution is a problem-solving endeavor.”

Evolutionary biologists study patterns and interactions among organisms. For example, in the desert southwest, the yucca moth and the yucca cactus depend upon each other for survival. How did this interdependence develop and what functions does it serve?

Questions like these drive scientific inquiry, data collection, and explanation building. Students, however, rarely have an opportunity to experience this scientific process. As a result, they often leave school with a very foggy picture of what science is really about.

The research team led by Jim Stewart and collaborating teacher Sue Johnson has designed and evaluated the impacts of science-as-inquiry courses over 12 years. For the past four years, the team has been developing and pilot-testing the evolutionary biology course. Although it focuses on Darwin’s theory of natural selection, [see Box re: natural selection] the course also introduces students to other explanations for species diversity, including one that suggests a divine designer.

“Because one of our goals is to build a classroom research community that encourages student reasoning and discussion, we want to address up front the major views that students bring to the study of evolution,” states researcher and teacher Cindy Passmore.

At the beginning of the course, students read about William Paley’s model of intelligent (divine) design, Jean Baptiste Lamarck’s model of species adaptation, and Charles Darwin’s natural selection model. After they read abridged versions of each author’s original work, they discuss the authors’ different explanations for species diversity. Then they explore the very phenomena that inspired the authors’ scientific models. For example, they examine fossils as discussed by Lamarck; they dissect an eye to examine the structures that so fascinated Paley; and they view some of the pigeon breeds described by Darwin in *Origin of Species*.

“Given the assumptions informing these models, any of them can work,” states Donovan. “However, not all the assumptions are consistent with a scientific worldview.” By examining them the first few weeks of class, the students have a chance to compare the models and the assumptions on which they are based. They also clarify the distinct mechanisms propelling the natural selection model. From this foundation, the students analyze three cases of species adaptation, employing the natural selection model to define processes that may have led to changes or adaptations in the species over time.

Using the natural selection model actually forces students to confront the same scientific dilemmas that evolutionary biologists confront. “Because they are often unable to directly observe events, evolutionary biologists rely on historical data and probabilistic models, such as natural selection, to understand evolutionary change,” explains Passmore.

Various types of data, such as fossil records, similarities among organisms and molecular information, make up the indirect evidence evolutionary biologists use.

Students learn how difficult it is to sift indirect evidence as they evaluate data that range from the rich to the perplexing. Working together, the students begin to learn that science is as much about collaborative inquiry as drawing conclusions. They construct explanatory models about increasingly complex research cases and present these to their classmates for discussion, analysis, and debate. The course builds a scientific community, as the students learn to ask questions and critique one another's work.

"The course definitely challenges students to learn and understand the material at a deeper level than merely memorizing definitions or theories," states Johnson.

Passmore adds, "Students can't 'fudge' their answers in this class. They have to confront their own understanding and take responsibility for their learning. From the beginning, we set up classroom norms about how they can question, discuss, and present their ideas and models, similar to how scientists do in their work."

According to the researchers, the students become very involved and animated as they work together on scientific questions, even if at first they are uncomfortable with the new learning environment. The different course structure, Johnson points out, might also be challenging to teachers, because it is so student centered. She states, "While the teacher is a contributor, he or she is not center-stage."

Johnson's comment raises an important question facing the research team: How can this education strategy be implemented by other teachers in other schools? Although this course is in line with the science standards, it still differs from typical science instruction. The group is aware of the difficulty of transferring the innovative strategy adopted at Monona Grove High School to other schools, where teachers might rely on traditional textbooks for curriculum coverage.

Donovan notes, "Dropping this type of instruction into a normal, year-long science class would be a challenge. It requires teachers to establish new classroom norms to guide student interactions. It also means that teachers will need to learn how to assess student mastery of those norms."

Rudolph adds, "In some ways, the top-down strategy that most teachers use makes for easier classroom management — especially where teachers feel challenged to cover the textbook." For example, new high-stakes tests in some states exert pressure on teachers to "teach to the test." To assure that their students pass these tests, teachers might try to cover a lot of material, but not in great depth because of time constraints. As a result, students miss the opportunity to engage in in-depth inquiry.

Lead researcher Jim Stewart respects teachers' skills, as well as the predicaments they face. "A lot of very accomplished teachers have the same intent we do — to challenge students to work hard, inquire, and more deeply understand science. But it's difficult for them to do this on their own in their classrooms."

The teachers may work in schools where curricular changes take a long time to happen. They also might be challenged in the same ways their students are, having themselves been taught at universities and schools that science involves memorizing a lot of definitions, rather than inquiring into ideas or theories. "If you really think about it," Stewart adds, "the challenge of teacher education reaches into both university science and education classrooms."

Changing science instruction, including the way evolutionary biology is taught, requires a re-assessment by the education community of its goals for science education. Teachers also need support to try new strategies, such as those initiated at Monona Grove High School.

With the pilot study behind them, the research team plans to refine and conduct the new evolutionary biology class again this fall. They will gather a second round of data to further assess gains in student learning. Pilot study evidence, according to the researchers, indicates that students developed a sophisticated understanding of the natural selection model. Two students, Megan Pfeiffer and Matt Kebbekus, displayed their understanding at a poster session of the National Society for the Study of Evolution meeting, held this summer in Madison, Wisconsin. According to Johnson and Stewart, the two students were representative of their entire class. They knew their material and could hold their own in conversations with adults.

Kebbekus says he enjoyed his experience at the national meeting. Now a freshman at UW-Madison, he states "We put together posters based on our class work, and our posters were very articulate and clear." The posters described the students' theory about why male ring-necked pheasants are brightly colored as compared to the dull-colored females. The posters also outlined an experiment the students devised to test their theory.

Remembering his science-teaching days, Stewart says, "I couldn't imagine taking any of the students I taught — as bright as they were — and bringing them to a national meeting and having them interact with evolutionary biologists the way these students did. They understood the evolutionary biology. And any of the students in the class could have done just as well."

After the meeting, Kebbekus' father approached Sue Johnson to thank her for the class and his son's experience. "He thanked me," Johnson said, "because his son became thoroughly engaged in this class. He was coming home at night and talking about the cases we were working on. He was excited, he said, because what students were thinking was important, and he wasn't expected to just parrot back something the teacher had said."

Matt Kebbekus concurs, “I liked being able to think for myself and apply creativity to science. After finishing the class and participating in the conference, I feel confident discussing evolution with anyone.”

The Natural Selection Model

Proposed by Charles Darwin, the theory of natural selection posits that

1. organisms produce more offspring than are able to survive in nature.
2. because of limited resources, members of a species struggle among themselves for survival.
3. variation naturally exists among individuals of the same species.
4. some variations increase the likelihood that certain individuals will survive to produce offspring.
5. because variations are inherited, the offspring of that individual will likely possess the advantageous variation as well.

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About The NCISLA

The National Center for Improving Student Learning & Achievement (NCISLA) in Mathematics & Science is a university-based research center focusing on K–12 mathematics and science education. Center researchers collaborate with schools and teachers to create and study instructional approaches that support and improve student understanding of mathematics and science. Through research and development, the Center seeks to identify new professional development models and ways that schools can support teacher professional development and student learning. The Center's work is funded in part by the U.S. Department of Education, Office of Educational Research and Improvement (PR/Award Number R305A600007), the Wisconsin Center for Education Research at the University of Wisconsin-Madison, and other institutions. More information about NCISLA is available at www.wcer.wisc.edu/ncisla.