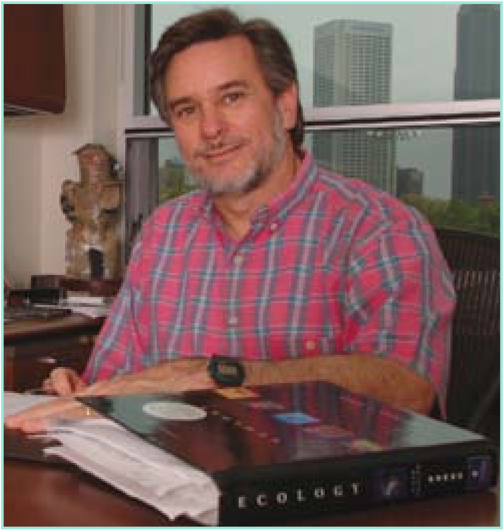
Georgia Institute of Technology

School of

BIOLOGY

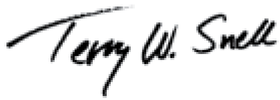
Spring 2011



The two primary responsibilities of professors are to generate new knowledge through research and to educate students. Professors are constantly trying to balance these two activities, especially in Research I universities like Georgia Tech where research is emphasized. Thankfully, there is a growing recognition that teaching and research are not mutually exclusive, but interact synergistically to enhance the effectiveness of both (Anderson et al. 2011). Our Biology curriculum is based on a belief that science education should provide broad content knowledge and strong analytical thinking skills. Course work and research experiences also should inspire curiosity about nature, excitement about discovery, and prepare students for a lifetime of learning about science. To accomplish this, a growing body of research shows that the curriculum needs to incorporate active learning, inquiry-based approaches, and participation in discovery through research. A challenge that we are engaging is how to transform Tech so that teaching of science is more effective, engaging, and mutually reinforcing with research. One of the great strengths of Georgia Tech is its ½ billion dollar a year research enterprise. This research activity provides big advantages for teaching Biology, and opportunities for undergraduates to participate in well-funded research labs doing cutting edge research.

A primary mission of the School of Biology is motivating and equipping the next generation of scientists so that they can help solve some of humanity's most pressing problems. In this newsletter, you will read about some of the programs that we are implementing to engage students in doing science and improve science teaching. We are fortunate to have Biology faculty who are passionate about improving student learning and achieving excellence in teaching. They are continuing to experiment with curriculum and delivery, and are developing best practices for teaching Biology in the 21st century. For more news about the School of Biology, please visit our website at www.biology.gatech.edu.

Best wishes,



Professor Terry Snell
Interim Chair
School of Biology

Anderson, WA, et al. 2011. Changing the culture of science education at research universities. Science 331:152-153.

Innovations in Teaching

The Georgia Tech School of Biology strives to create an effective learning environment for all of its students. Here, we highlight several new courses, co-curricular programs and course revisions that are giving students authentic research and problem-solving experience while learning the fundamentals of biology.

Inquiry in Introductory Biology Labs

Dr. Cara Gormally

The introductory biology laboratories for Biology 1510 and Biology 1520 have been redesigned as an inquiry-based curriculum. In an inquiry-based lab, students do science in a way that more closely approximates how practicing scientists do science—students are asked to think through designing and conducting experiments. The major difference between inquiry-based and traditional "cookbook" labs is that in inquiry-based labs students are not given explicit directions about procedures to test a particular hypothesis or objective, nor do they receive information about results that they might expect to find. Instead, the instructor poses an initial problem and uses questioning to guide students in selecting variables, planning procedures, and identifying potential flaws. Students work in groups to develop an experiment to address a particular question or objective, and collect and analyze their data, with guidance from their TAs. Lab modules are structured to be two to three week-long experiments, building on topics presented in the 1510 and 1520 lectures, linked together by major biological themes. One major change is the explicit emphasis on developing science process skills necessary for doing science that transfer across disciplines, e.g., developing hypotheses; experimental design; quantitative skills including data analysis using basic statistics; and scientific writing. The pedagogical design of these inquiry-based labs facilitates the development of these skills since students must practice each of these skills during each lab activity.

In tandem to support the implementation of the newly designed labs, advanced undergraduate biology majors and graduate students are trained to teach these labs. Many TAs teaching introductory labs have no prior experience teaching. Consequently, it's my hope that this initial experience helps to prepare them to be successful in subsequent teaching experiences and fosters an enthusiasm for teaching. Supporting TAs as they learn to teach inquiry-based labs is essential—one of the biggest challenges TAs face is to develop the ability to be proactive in asking their students questions in order to reveal student thinking about why they're doing what they're doing. Additionally, since students write lab reports to demonstrate their learning, TAs learn to respond to student writing, using a standardized rubric to grade and providing feedback on common issues in scientific writing.

I think the change to inquiry-based labs positively impacts both undergraduate students and TAs. Undergraduates are given the opportunity to develop and apply science process skills that are relevant for future coursework as well as in their lives. TAs have an opportunity to learn to teach in more innovative ways—experiences that will help them later on as they develop their own courses—and may improve their own critical thinking skills as a result of the process of helping their students to think through the design of an experiment. The emphasis on writing may help TAs not only to improve their ability to critique others' writing but also their own scientific writing.

The following are examples of student comments from an end-of-semester curriculum survey:

"It allowed me to really think outside the box and even though it was sometimes difficult, I think this process will help me in future classes."

"I feel as if I learn better by doing. Instead of blindly following procedures and steps in the lab manual, it was required that you think through every step. As a result of this, more thought and insight was placed into the labs."

"I learned how to collaborate with a group and work well together, while listening to other opinions. I learned to challenge myself when designing experiments and voicing my opinions."

"Collaborating with a group to design an experiment is definitely something that I will take away from this class. It taught me a lot about ensuring that the whole group was on board with the experiment, which often meant we had to stop and explain to each other what we were thinking before we just jumped into action."

"I learned how to write a very good report and this in turn helped my writing in general. Also, I learned how to write about only the important things and not every single detail."

"It helped me improve on the way I think by encouraging me to think on my own a bit rather than simply regurgitating information all the time."

Ask the Audience: Trolling (Polling) for Misconceptions
Dr. Jung Choi

Do you remember the large lectures in freshman biology (or freshman chemistry, calculus or physics), where the instructor would ask a question, and no one would raise a hand? Or the same students sitting in the front row answered all the questions? Maybe you knew the answer, or maybe you didn't, but neither you nor the instructor could know how many of the students sitting in the lecture hall were "getting it."

Starting in the fall of 2007, the School of Biology began using personal responses systems (clickers) in the large introductory biology lectures, Biol 1510 and 1520. These are small remote-control size units that students purchase at the bookstore, and can use for all their classes that require clickers. Instructors now ask a question during class, either a multiple-choice question or a question with a numeric solution, and students enter their responses. In real time, a histogram of the collected student responses are projected on the lecture hall screen. Each and every student has to engage and answer the question, and the instructor knows right away, how well the students are learning.

Some questions probe common and deeply held misconceptions, or particularly difficult questions. In these cases the class is almost equally divided among two answer choices. The class erupts in laughter, and the instructor says, "Turn to your neighbors, and convince them that your answer is correct." For the next minute or two, the lecture fills with animated discussion. The instructor asks the same question, and the students re-vote. Will the students converge on the right answer? Just how stubbornly held is that misconception? If you want a sample: Q—the dry mass in a two-by-four piece of lumber comes primarily from: A) water; B) minerals in the soil; C) air. Of course, you knew the correct answer was C)!

The clickers have brought significant change to the large lecture. It has improved attendance, increased student engagement, and made classes more lively and interesting, for both students and instructors.

Effective Study Habits
Dr. Linda Green

I designed an online Effective Study Habits Poll for students in Biology 1520 for my 2009–2010 CETL Teaching Scholars Project. I was interested in addressing the problem that students often have false impressions of what study techniques are effective in introductory biology courses, often with inefficient study sessions and ineffective habits. The online quiz allows students to self-assess their study habits and receive feedback on how their behaviors compare to other students' habits and performance. Following the first exam, students voluntarily take an online survey that asks about study habits. After their response to each question, feedback is provided comparing their answer to the average scores of students with similar habits, as well as what A students are doing. Examples: "6 hours is more than the average A student…" "1 hour is close to the C average…" "Excellent! Most A students are spending…" "According to your peers, this is not enough to do well…"

By comparing their efforts to their peers, students gain an appreciation for the effort required to succeed in class.

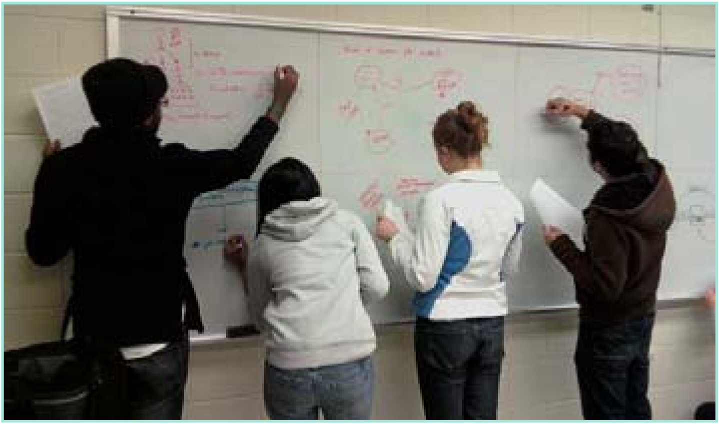
Problem-Based Learning in Honors Ecology

Dr. Marc Weissburg

One of the great challenges in teaching is to help students learn to think and problem-solve, along with learning the particular facts that comprise the body of knowledge in a discipline. In fact, many might argue that education should be more geared to producing thinkers, not simply those who can memorize a whole list of facts. A well educated Chinese citizen in the Tang dynasty memorized thousands of lines of poetry, philosophy and regulations, but we certainly don't look upon that as a valuable educational model .

So—when I was offered the chance to develop Ecology (my favorite subject) as an honors course, I took this as a chance to depart from the standard "teacher-speaks-students-listen" mode in favor of a model of problem-based-learning. As the saying goes—lecturing is a process where the information passes from the professor's mouth onto the students notes without passing through the brain of either. We made a commitment to virtually abandon the canned lecture in favor of a process whereby, with our help, the students learn in the context of active problem solving. We merged the lecture into the lab, since thinking and doing are related, and structured the course around 5 problem modules that allow the students to explore the important ecological concepts. It's quite a shock to the students, when on day 1, we dispense with the usual blather about the syllabus and tests and grades, and present them a one paragraph description about an endangered species, and tell them they need to develop a population management plan, in three weeks. In this time, we work intensively with each student group to teach them how to identify the essential knowledge, acquire it, formulate critical tests, and communicate their findings to others. They work in both the lab, and the field, often on issues of local relevance, such as the determinants of communities in endangered rocky outcrops such as Arabia Mountain, or stream water quality of Cochran's Mill. Once the students get over the fact that we generally won't answer their questions directly ("have you discussed this as a group"—is our standard answer), but will only point them to the ways of thinking that will help them solve the problem ("what are the assumptions here, how certain are you of this fact, is there a gap in this body of knowledge" are common themes and phrases), they become active participants in their own learning. They learn how to think about their own thinking process, and how to improve it.

The results are impressive, and frequently surprising to the students. At the end of the course, we commonly get reports and presentations that any first year graduate student would be proud of. By our own assessments, as well as the student's comments, we know that participants in this class learn critical thinking, hypothesis testing, research and team skills that benefit them for the rest of their careers. Many students continue research, and report their experience in Honors Ecology was a great benefit. More than a few tell us, that while they worked as hard as they ever have, they wished there were more opportunities to take courses like this at Tech. There's nothing better for a teacher to hear than the students have worked hard, gladly, and would do so again. As a result of this experience, I have begun to apply the techniques and approaches from this small honors course into my much larger lecture heavy classes. I am proud of the fact that SOB allows me to offer a course different from the standard model, and is willing to invest the necessary resources to develop cutting edge pedagogical methods.



PEER LED INSTRUCTION

Dr. Mirjana Brockett

I have identified typical problems in large Biology classes, such as engagement of students, format of tests and exams, involvement of teaching assistants and above all creation of a dynamic, interactive learning environment.

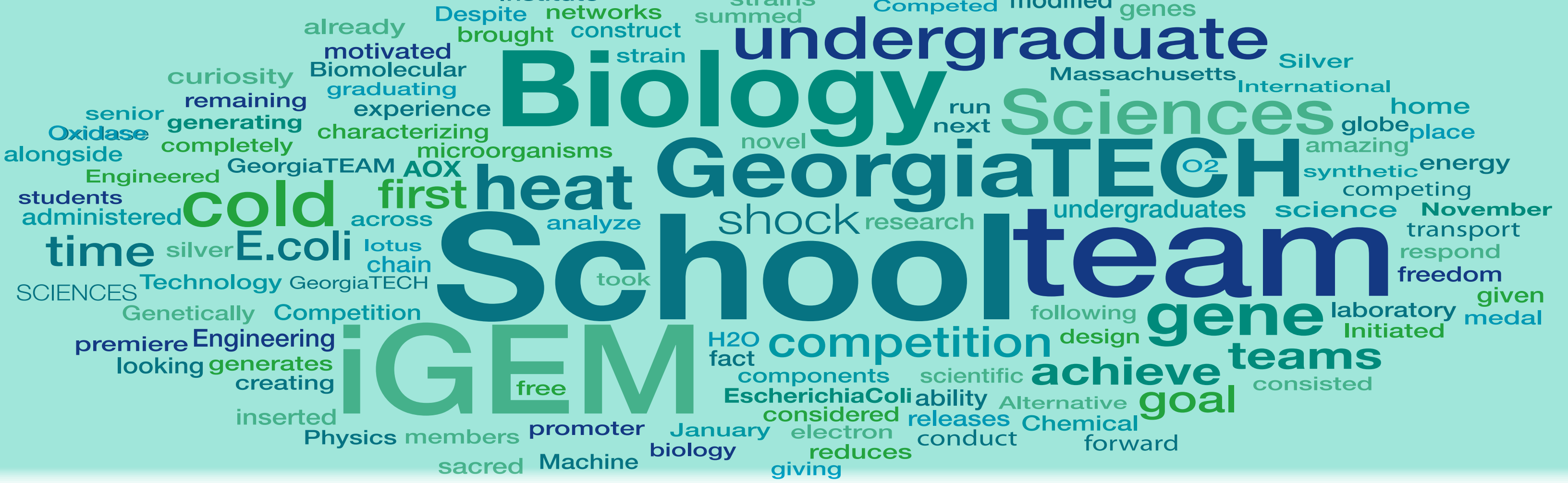
In my study with Georgia Tech's Center for the Enhancement of Teaching and Learning's (CETL) Class of 1969 Teaching Scholars program, I evaluated the effectiveness of using Peer- Assisted Learning (PLUS) model, funded by the Office of Student Success Programs in my evolution class. I also developed simple conceptual tools to reinforce understanding of mathematical principles in Population genetics and, in my view, deepen understanding of evolutionary theories. I worked with a student peer leader to develop activities and workshops for two recitation sessions each week.

Students regularly attending our plus sessions made up 58% of the lecture class (with 106 total visits). Average visit per student was 4.6. Average exam score for all students was 73, while the average plus exam score was 75. This indicates a small, yet statistically significant improvement in learning gains.

However, average PLUS attendee exam score (with 3 or more visits) was even higher, 77. As a contrast, average NON-PLUS exam score was 71.

The preliminary results show that with a consistent use of active learning models and Plus Program sessions, students could achieve a significantly better understanding of important concepts in evolution.

Evolutionary biology is in some ways a "metacognitive" discipline and understanding of these significant concepts might contribute to deeper appreciation of science and human knowledge, as well as promote critical thinking. The variety of practical applications of these concepts is evident (from medicine to environmental biology) and I firmly believe that work on better education in this field is very important.



iGEM

Drs. Eric Gaucher and Joshua Weitz

For the first time, Georgia Tech competed alongside 130 other teams from across the globe in the International Genetically Engineered Machine Competition (iGEM) which took place at the Massachusetts Institute of Technology November 6–8, 2010. Initiated in January 2003, iGEM is considered the premiere undergraduate synthetic biology competition, in which undergraduate teams design, construct and analyze microorganisms whose components (like genes and gene networks) have been modified to achieve an engineering goal.

Georgia Tech's iGEM team consisted of 13 undergraduates, advised by Eric Gaucher, Associate Professor in the School of Biology, Joshua Weitz, Assistant Professor in the School of Biology, Mark Styczynski, Assistant Professor in the School of Chemical and Biomolecular Engineering, Megan Cole, postdoctoral fellow in the School of Biology, Richard Joh, Ph.D. candidate in the School of Physics and Ryan Randall, research technician in the School of Biology.

Despite competing for the first time, the Georgia Tech team brought home a silver medal for creating and characterizing a completely novel strain of Escherichia coli (E. coli) which generates heat when a cold shock is administered. To achieve this goal, the team isolated the Alternative Oxidase gene (AOX) from sacred lotus, which reduces O_2 to H_2O and releases the remaining free energy as heat in the electron transport chain. The team inserted this heat generating gene next to a cold shock promoter, hence giving E. coli strains the ability to respond to cold with heat.

Margo Clark, a graduating senior in the School of Biology, summed up the experience with the following, amazing fact: "A team of undergraduate students were given the freedom to run a laboratory and conduct research motivated by their own scientific curiosity." The Georgia Tech iGEM team members are already looking forward to the 2011 competition.

bio bash
Celebrating 50 Years of BIOLOGY at Georgia Tech

BioBash
Dr. Jennifer Leavey

Last October's BioBash homecoming event and 50th anniversary celebration raised over $5000 for the newly formed *Biology Student and Faculty Programs Fund* (BSFPF). A committee of students and faculty was formed to evaluate project proposals. This spring, the committee awarded money to support research by Biology undergraduates at the Mars Desert Research Station in Utah in February. This April, BSFPF is sponsoring the Georgia Tech Earth Day Celebration, including a eutrophication demonstration run by Biology students. BSFPF is also sponsoring biology demonstrations at Kids@Kollege on April 10th, a program that brings inner-city youth to campus to interact with students and faculty with the goal of inspiring these kids to attend college. Finally, BSFPF is sponsoring a series of Biology student-faculty lunches designed to foster professional relationships and mentoring between undergraduates and faculty members.