Keeping Up with the Revolution

Stuart L. Schreiber hopes his groundbreaking research in chemical genetics, which identifies the chemicals that modulate cellular processes, will one day be so obvious that high school students will shrug, "Of course, how could it be any other way?" Eric S. Lander, a leader in genomics, the identification of the genes that program those processes, agrees. "The goal of this extraordinary scientific revolution," he says, "is to be taken for granted as quickly as possible."

Schreiber, an HHMI investigator at Harvard University, and Lander, director of the Whitehead Institute/MIT Center for Genome Research, collaborated on the 2002 HHMI Holiday Lectures on December 5 and 6, called "Scanning Life's Matrix: Genes, Proteins and Small Molecules." They pointed to the power of Internet databanks of genetic sequences, such as GenBank, and of chemical interactions, called ChemBank, as tools for research and medicine.

Lander uses a car analogy. Studying traditional biology, he says, is like being a car mechanic who cannot look under the hood. The mechanic can listen to the engine or examine pieces that fall off to hypothesize how it works. Still, he has no way to know how many parts there are or what they do. Then somebody pops the hood. At first, the engine looks complicated, but eventually the mechanic can list the parts and determine how they function as a system.

Genomics and chemical genetics are "popping the hood" for biology, providing a comprehensive, yet finite, parts list and instruction set that eliminates the unpredictability of studying life systems, Lander says. GenBank is already indispensable for working biologists and will become important for students, too. Although students cannot sequence a genome or knock out a gene to study its effects, they can access GenBank to conduct "virtual" experiments.

For example, they could study evolution by downloading and comparing genes for cell division, reproduction and sensory receptors from human, mouse, fly and bacterium genomes, Lander says. They might find that genes for cell division have changed little over millions of years, while those for reproduction changed very differently from species to species as these organisms evolved. For smell-receptor genes, they would find a proliferation in mice, while many of the human versions have become nonfunctional. This would indicate that mice rely on smell more than humans do and that unneeded genes deteriorate.

ChemBank, though still a prototype, will provide similar power by cross-referencing proteins, small molecules and experimental observations, says Schreiber. Students could, for example, demonstrate how a drug interacts with cellular signals in a way that causes unwanted side effects.

Schreiber describes these databases as "hypothesis-generating engines" that are great equalizers. High school students can have the same access as scientists. "The only limit," Lander says, "is your imagination in thinking up questions" and in the computer's ability to recognize patterns in the data.

To realize such creativity,

Report Urges Changes in College Biology

Undergraduate biology education is not keeping pace with the rapidly changing arena of biological research, concludes a new report from the National Research Council of the National Academies. *BIO2010: Transforming Undergraduate Education for Future Research Biologists* is the culmination of an 18-month examination of how best to prepare the next generation of life-sciences researchers. The study was sponsored by HHMI and the National Institutes of Health (NIH).

"Biology has changed," says Joan A. Steitz, an HHMI investigator at Yale University and a member of the committee that wrote the report. "The frontiers are now on the interface with more quantitative sciences, such as structure determination and bioinformatics. Therefore, biology students need stronger backgrounds in mathematics, engineering, physics and computational science in order to succeed in future research."

The committee, which was asked by HHMI and NIH to make recommendations on undergraduate biology-curriculum reform, proposed that biology majors should receive much broader exposure to the methods of the physical sciences and mathematics. At the same time, the committee recognized that students should receive a broad liberal education as well.

After studying several approaches, the group recommended the incorporation of physical and information-science content into existing biology courses. In addition, they suggested that laboratory courses become as interdisciplinary as possible and provide exposure to real-world laboratories that routinely use techniques from both the biological and physical sciences.

In effect, the committee urged college and university faculty to retool their courses to include the new integrative biology. And to give some assurance and inspiration, the report highlights case studies of innovative teaching methods that have been successful both at large universities and small colleges; the report also lists links to Internet-based resources.

The just-implemented HHMI Professors program essentially affirms the report's conclusions and puts some of its recommendations into action. In announcing the new program's first 20 appointees, Institute President Thomas R. Cech noted that "we wish to empower scientists at research universities to become more involved in science education and come up with innovative ideas that break the mold and take a fresh look."

—KARYN HEDE

» The full text of the *BIO2010* report is available at *www.nap.edu/catalog/10497.html*. Print copies may be obtained by calling (888) 624-8373 or (202) 334-3313.

student and scientist alike must cultivate an interdisciplinary mind-set, says Schreiber. "Life science is tackling complex problems that can only be solved through multidisciplinary approaches." He acknowledges, however, that this is easier said than done. Teachers should focus on underlying connecting principles that many fields have in common. To make that job easier, he encourages using familiar, simple and precise language, devoid of the jargon that isolates scientists from other fields of research. In addition, Schreiber urges teachers and students to "go to general science lectures, watch "NOVA," read *Scientific American*" to become familiar with work in many different fields.

To make true progress, however, multidisciplinary approaches must be integrated with information sciences, he says. "Our experiments generate staggering sheets of data that would run around the planet. We cannot easily make sense of that information unaided, but with the help of computers, amazing patterns emerge."

Thus it's no surprise, Schreiber and Lander note, that teachers need sophisticated tools for translating new discoveries into usable classroom exercises. Today, it takes a courageous teacher with advanced computer skills to incorporate these databases into classroom learning. One day, however, they predict that the necessary tools will become ubiquitous. No one will be able to conceive how people ever learned biology in the dark ages before genomics and chemical genetics, just as most scientists cannot imagine how anyone studied chemistry before the periodic table. **—CATHRYN M. DELUDE**

» For more information, see *www.hhmi.org/lectures/2002*

Young Scientists Learn the Management Ropes

Johannes Walter faced unfamiliar challenges as he started up a molecular biology lab at Harvard Medical School in 1999. At the University of California, San Diego, he had excelled as a postdoc, publishing papers on DNA replication in prestigious journals such as *Science* and *Molecular Cell*. But running a laboratory as principal investigator (PI), he soon realized, required more than scientific smarts.


PAUL FETTERS

Postdocs and new PIs attended a course to learn how to run a lab.

For one thing, assembling a top team of postdocs wasn't going to be easy. "You're a new PI, nobody knows who you are and you're competing with the best in your field," says Walter. He quickly learned the recruitment game—sending inquiries by e-mail to colleagues in the field, flying in candidates from near and far, even hosting some of them at his home in Boston—and the effort paid off. His Harvard lab now hosts a research group of eight, including postdocs, graduate students and a research assistant.

During years of graduate work and postdoctoral fellowships, young scientists focus on their research, with hopes that strong papers will help them garner first-rate faculty positions. When these same researchers land jobs as assistant professors, however, the tasks of coordinating staff, budgets and grants often pose a harsh reality—they weren't trained for this.

"Our energies are so focused on getting the job—then what?" asks E. Lynn Zechiedrich, a PI in molecular virology and microbiology at Baylor College of Medicine. Answering that often-overlooked question was the goal of the first annual Course in Scientific Management held at HHMI headquarters in Chevy Chase, Maryland, in July. Sponsored by the Burroughs Wellcome Fund and the Institute, the course included sessions on collaborations, writing National Institutes of Health (NIH) grant proposals and time management and mentoring skills. Postdocs and new faculty—127 in all—attended from the United States and abroad.

Karen M. Ottemann, a microbiologist in her third year as an assistant professor at the University of California, Santa Cruz, says the step from postdoc to PI requires not only a shift in thinking but a whole reconstruction of one's day: "You transition to being a PI, and you have all these new responsibilities. You have to mentor more students and less-senior researchers, you have to attend faculty meetings, write your grants—and balance it all."

Some find managing their money to be the big challenge. That might explain why attendees packed the session on applying for the coveted NIH RO1 grant—the gold standard in multiyear, federal grants. "The most surprising thing was cost," says Bernardo L. Sabatini, a second-year PI at Harvard Medical School, where he runs a five-person neurobiology lab. "I thought I was okay with three or four private foundation grants. But I'm running through money like you wouldn't believe." Average startup costs for new labs in the life sciences can run from $100,000 to $1 million, excluding salaries, according to the Burroughs Wellcome Fund.

Many saw the four-day course as an especially welcome opportunity to speak with others who were going through the same process, and those who had survived it. "It's reassuring," says Yashi Ahmed, a new PI at Dartmouth College, "that many people here have the same fears." **—ELI KINTISCH**