

Rising to the Challenge:

Merging Research and Innovation for Undergraduate Science Education

By Dan Gordon

Two renowned molecular biologists in the College inject top-flight research into the undergraduate classroom experience in a landmark program funded by the Howard Hughes Medical Institute.

Cristy Cross admits that she was “afraid” of science. But last year, as a sophomore majoring in international development studies with aspirations for law school, Cross found herself conducting original research in plant genomics alongside a dozen of her undergraduate peers, using some of the most sophisticated instruments and techniques known to science.

Albert Cespedes was a freshman when he got his initial glimpse inside a major science lab—the same week he and 30 classmates began conducting experiments to characterize the genes responsible for cell-division defects in the eye development of *Drosophila*, the fruit fly.

“We got a crash course in the instrumentation, and then we just jumped in and began working with the organisms that very first week, before we understood all of the complicated molecular biology behind it,” Cespedes said. “As you do more research and ask questions, you gain an understanding that’s much deeper than if you had just looked at some diagram in a textbook.”

Cross and Cespedes are two among scores of UCLA undergraduates who are benefiting from the two \$1 million grants awarded by the Howard Hughes Medical Institute (HHMI) to a pair of renowned scientists in the Department of Molecular, Cell and Developmental Biology. As two of 20 HHMI Professors nationwide, Utpal Banerjee and Robert B. Goldberg are receiving the awards over four years to creatively improve undergraduate science teaching.

The Howard Hughes Medical Institute, a private philanthropic organization dedicated to biomedical research and science education, invited 84 research universities to nominate faculty members, then had a panel of scientists and educators review 150 proposals and select 20 HHMI Professors, challenging them to “show the same ingenuity in undergraduate teaching” as they do in scientific research.

UCLA is the only university in the United States to have more than one professor selected for the honor.

“The goal for Utpal and Bob was to create new educational settings that introduce undergraduates into research and let them experience the interest, excitement and joy that come with discovery and with finding solutions to research questions,” said Emil Reisler, acting dean of life sciences. “Both of them have achieved this goal with great success.”



Molecular Biologist Robert B. Goldberg (right) with senior Chris Santore.

Goldberg has used the grant to greatly enhance his efforts to teach undergraduates about the excitement of discovery, the process by which science is conducted, and how advances in biology and gene technology are rapidly transforming society. His course, “Genetic Engineering in Medicine, Agriculture and Law,” is geared toward entering life-science students and non-science majors.

“In an exciting teaching environment, many entering students may choose to become the scientists of tomorrow,” said Goldberg.

Others, such as Cross, are likely to be touched significantly by science in both their personal lives and their careers, Goldberg noted, and might well play a role in future science-related policy decisions.

In the classroom, Goldberg’s uniquely interactive, multimedia teaching style uses the provocative subject matter as a vehicle to teach undergraduates to think critically about science and its societal implications. Students are called on to summarize the previous lectures, taken out to dinner in small groups where they are engaged in debates, asked to write plays related to the material, and argue in moot courts.

“It was very challenging,” said Cross. “You had to come to class having done all of the reading, knowing that you’d get grilled on the material. As a result, it sank in.”

But just as unusual as Goldberg’s teaching style is the experience available to students who enroll in the follow-up laboratory course, designed to give them hands-on research experience with the genetic engineering technologies they’ve read about and discussed. Working in groups under the tutelage of advanced undergraduate students and postdoctoral fellows in Goldberg’s lab, the undergraduates chart new territory in a hunt for mutant genes critical to seed development. The HHMI funding provides students with expensive state-of-the-art tools for DNA sequencing and genetic engineering experiments.

“You can’t really convey what science is like in a classroom setting,” said Goldberg, a pioneer in the field of plant molecular biology. “Students have no idea about the frustrations along with the rewards that come out of it. We’re giving them an experience that is hands-on discovery.

“Our challenge is to take students who have never held a pipette or even been in a lab, and get them to be able to work independently using the most sophisticated genomics equipment, procedures and approaches,” Goldberg said. “It sounds overwhelming, but it works. The research that they’re doing now,



Utpal Banerjee with undergraduate Kirsten Regalia.

scientists couldn’t even have done it five years ago, that’s how cutting edge it is.”

Banerjee’s HHMI program is centered on the “Undergraduate Research Consortium in Functional Genomics,” a lower-division course heavily focused on the research experience, with the opportunity for a select group of students to move on to an upper-division series that offers three additional quarters of more intensive research.

In the lecture setting, some 30 students each quarter are prepared to work in a research laboratory specifically designed for undergraduates, and are taught about careers in science and the importance of research. For their midterm exam, students write a mock grant proposal for National Institutes of Health funding. For the final, they write a paper describing the results of their research.

“No one knows the answer to the questions these students are asking,” said Banerjee, a nationally recognized investigator who studies the nature of cell-cell communications in *Drosophila*—considered a premier genetic system for studying many cellular and developmental processes. “We teach students the mechanics of the experiments, but in terms of who will find the prize mutation and who will not, that’s largely up to chance, just like real research is.”

Banerjee’s undergraduates create mutant fruit flies, removing one gene at a time in the developing

eye or the blood. By doing this for a large number of genes, students collectively uncover clues to the function of *Drosophila*'s genes—not all of which are known—with implications for human gene function and disorder. The students' work is being pooled together in preparation for submission to a major peer-reviewed journal.

"We don't start at the bottom, washing glassware; we jump right in to doing real research, where there is no 'right' answer and we're trusted to set up the experiments and collect the data," said Joy Wu, one of about 15 undergraduates who have gone beyond the lower-division course and are now performing more advanced research in which they're studying the functions of specific *Drosophila* genes identified by the group.

Wu, a junior majoring in neuroscience, said enrolling in the program was "the best decision of my life." She intends to pursue a Ph.D. in neuroscience and eventually do human brain research.

Thanks to the generous funding, Banerjee has been able to recruit three faculty-level scientists interested in teaching students in the research setting, including one whose main responsibility is to assist the undergraduates in getting published. Goldberg has been able to call on assistance from expert members of the Seed Institute, a consortium of university laboratories (co-directed by Goldberg) dedicated to identifying the genes necessary to make a seed from scratch. This year, Goldberg added a new dimension to his course by having his lectures simulcast to 30 students enrolled in Japan.

Nationally, the 20 HHMI Professors are using their funds in different ways, all with the same goal of making science more engaging for undergraduates. HHMI isn't the only organization to see such a need. The National Academy of Sciences and the National Science Foundation, among others, have studied the matter and made similar recommendations.


"Research is advancing at a breathtaking pace, but many university students are still learning science the same old way, by listening to lectures, memorizing facts and doing lab experiments that thousands have done before," said HHMI President Thomas R. Cech, a biochemist who continued teaching undergraduates at the University of Colorado at Boulder after he won

a Nobel Prize. "We want to empower scientists at research universities to become more involved in breaking the mold and bringing the excitement of research to science education."

In Goldberg and Banerjee, HHMI funded two top scholars who have long demonstrated their commitment to engaging undergraduates in the excitement of the discovery process. Both are winners of UCLA's Harriet and Charles Luckman Distinguished Teaching Award, and the Gold Shield Award for Excellence in Teaching and Research—and both are pleased with students' response to the opportunities made possible by the grants.

"Three-fourths of the undergraduates in my lecture class, made up of mostly non-science majors, were pounding on my door for the chance to spend the next quarter in my lab doing the things they had learned about in the classroom," said Goldberg. "That's unbelievable."

Both of UCLA's HHMI Professors see value in exposing as many undergraduates as possible to the research experience at the start of their time on campus. For those who are considering careers in science, they note, knowing early on about the nature of life as an investigator—something that tends to be mysterious to those on the outside—will help them reach more informed decisions about the path they wish to take. And, Banerjee adds, even for those with no intention of pursuing science as a profession, the experience is invaluable.

"I have complete conviction that involving students in research early in their careers will make better scientists, better doctors, better lawyers, and better politicians out of them," Banerjee said. "Instead of reading from a book and doing an assigned problem set, they're learning to make their own connections, to follow their own logic. When they start to do that, it's amazing how turned on they become." 

Bob Goldberg

Home Page:

www.mcdb.ucla.edu/Research/Goldberg

HHMI class Web site:

www.mcdb.ucla.edu/Research/Goldberg/hhmi-index.htm

Utpal Banerjee

Home Page: www.mcdb.ucla.edu/Research/Banerjee

HHMI class Web site:

www.lscore.ucla.edu/research/index.html

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