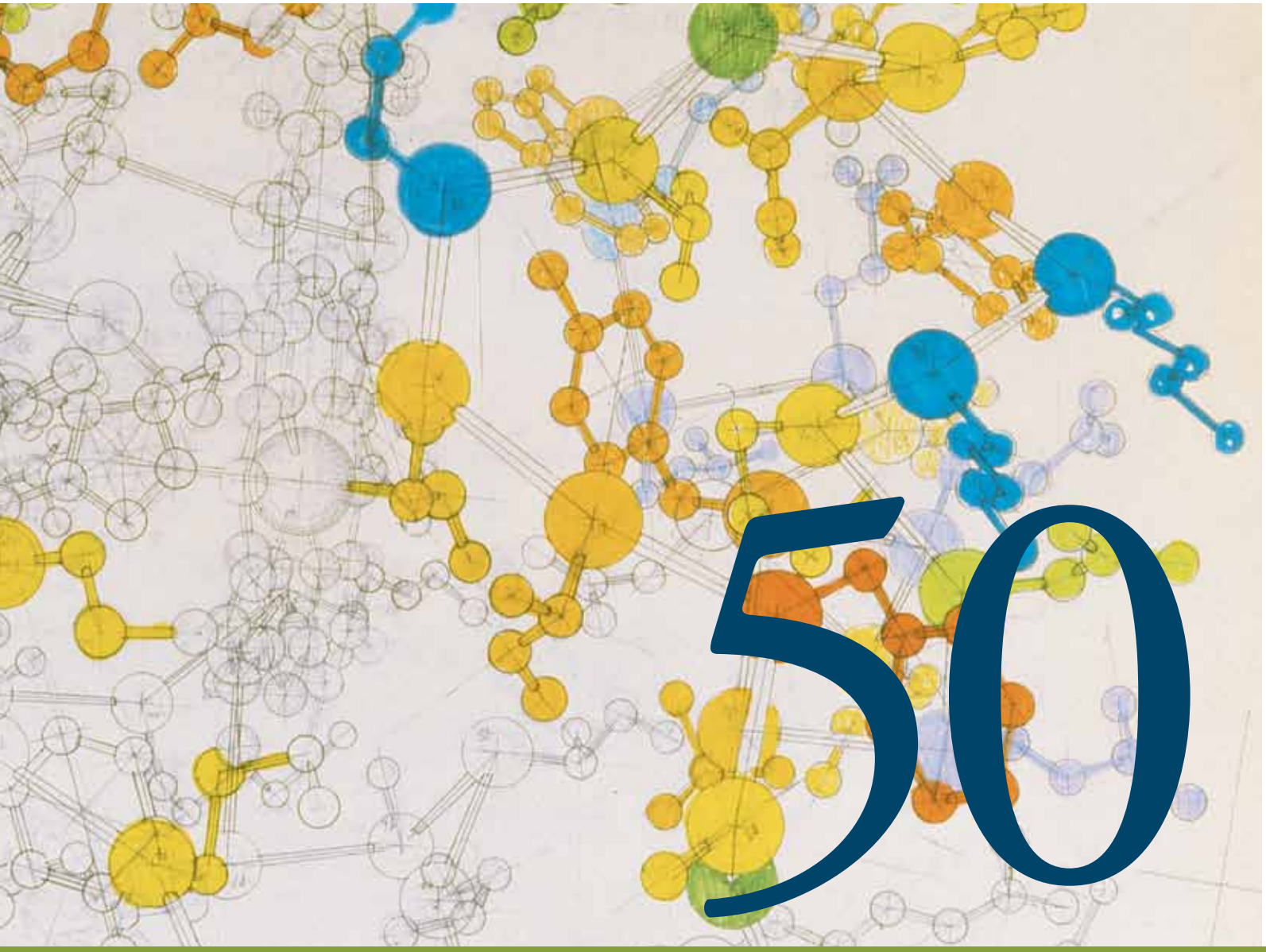


New HHMI Awards for Science Education to Research Universities

2010 Competition

HHMI
HOWARD HUGHES MEDICAL INSTITUTE

"HHMI is committed to funding education programs that excite students' interest in science. We hope that these programs will shape the way students look at the world—whether those students ultimately choose to pursue a career in science or not."

ROBERT TJIAN, PH.D. – PRESIDENT, HOWARD HUGHES MEDICAL INSTITUTE

New HHMI Awards for Science Education to Research Universities

2010 Competition

On May 20, 2010, HHMI announced new grants for science education to research universities and HHMI professors. This booklet focuses on the awards to research universities.

HHMI Awards $79 Million for Science Education to Research Universities, Top Scientists

May 20, 2010

The Howard Hughes Medical Institute (HHMI) today announced new grants totaling $79 million that will help universities strengthen undergraduate and precollege science education nationwide. The resources will let faculty at research universities pursue some of their most creative ideas by developing new ways to teach and inspire students about science and research.

HHMI is making the awards through its Precollege and Undergraduate Science Education Program and the HHMI Professors Program—two complementary initiatives that are transforming science education in the United States.

Fifty research universities in 30 states and the District of Columbia will be awarded a total of $70 million through the undergraduate program. The schools will use the grants, which range from $800,000 to $2 million over four years, to develop creative, research-based courses and curricula; to give more students vital experience working in the lab; and to improve science teaching from elementary school through college.

The HHMI Professors Program supports a small group of leading research scientists who are committed to making science more engaging to undergraduates. Thirteen HHMI professors will receive a total of $9 million over four years to focus on solving important problems facing science education, such as how best to bring research into the classroom, teach large introductory science courses, and encourage students from diverse backgrounds to become scientists.

"HHMI is committed to funding education programs that excite students' interest in science," says HHMI President Robert Tjian. "We hope that these programs will shape the way students look at the world—whether those students ultimately choose to pursue a career in science or not."

HHMI, the nation's largest private funder of science education, has spent $1.6 billion since 1985 to reform life sciences education from elementary through graduate school. At the undergraduate level, HHMI's strategy leverages the advantages of working both with institutions and individual professors, explains Peter J. Bruns, HHMI's vice president for grants and special programs.

The grants allow large research universities to tackle projects that affect hundreds or even thousands of students, both inside the university and at local K-12 schools, Bruns says. Individual scientists in the professors program can develop innovative ideas for the classroom using the same creativity and adaptability as they do in the research laboratory.

"By funding both initiatives, we are assured that both research universities and individual professors will make important contributions to science education," Bruns says. "We want to inspire scientists to think as hard about improving science education as they do about their research."

RESEARCH UNIVERSITY GRANTS

HHMI invited 197 research-focused universities to apply for grants to improve science education at the undergraduate and K-12 levels; 165 schools submitted applications last year. A panel of distinguished scientists and science educators reviewed the proposals, and HHMI selected 50 institutions. HHMI held a separate competition in 2008 to award science education grants to 48 liberal arts colleges and other primarily undergraduate-serving institutions.

"By selecting these 50 grantees, we highlight areas and approaches that we think are particularly powerful," says David Asai, director of HHMI's precollege and undergraduate programs. "We hope that universities across the country—even those that are not HHMI grantees—will turn to these programs when they think about improving science education."

Of the newly selected universities, five are getting an award for the first time—Florida International University, Northwestern University, the University of North Texas, Virginia Polytechnic Institute and State University, and Western Michigan University. Another 13 of the 50 universities are receiving funding after a hiatus.

The universities submitted proposals that outlined how they would tackle a range of problems facing science students and scientist educators on their campuses and in their local communities. For some, the proposed solutions involve making long-needed changes to dated curriculum or trying out innovative approaches that could change how undergraduates view science. For others, it means starting or continuing programs for science teachers and students in cash-strapped local school districts. A few themes emerged from the applications:

Community colleges: Community college is quickly becoming an important stepping stone for students as they transition to a four-year university. Recognizing that many students take their first university-level science classes at community colleges, Georgetown University and the University of California, Davis, are among several schools working to offer research opportunities to community college students and improve introductory courses there.

Training future teachers: Western Michigan University, Pennsylvania State University, and several other institutions will use part of their funds to provide a better scientific foundation for future K-12 science teachers. Some of these newly funded programs focus on providing research experiences to students who plan to become teachers so that they can understand how science is done and convey that knowledge to students later.

Student research: Some large universities, such as the University of California, Los Angeles, and Northwestern University, will use part of their grant to make research experiences available to more students and those from a more diverse array of backgrounds. Several will also attempt to get the students involved in research early in their college career, sometimes even as freshmen.

Diversity: Several grantees, including the University of Maryland, Baltimore County, and Montana State University, will focus on increasing diversity in the sciences. The proposed programs range from outreach for middle and high school students to extensive mentoring and expanded research experiences for undergraduates.

HHMI PROFESSORS

The HHMI Professors Program, created in 2002, assists top research scientists in putting their innovative ideas for science education into practice. The program reflects the Institute's long-time commitment to finding and funding talented scientists, then giving them the freedom to follow their instincts. HHMI held two previous competitions in 2002 and 2006, and awarded grants to a total of 40 HHMI professors. "The higher education community typically doesn't apply either the resources or rewards for creative thinking about teaching the way it does for research," Bruns says. "We are trying to change that."

Last year, the HHMI professors were invited to apply for four years of additional funding; 30 submitted applications. After a review by top scientists, 13 HHMI professors with successful science education programs were awarded a total of $9 million over the next four years. The individual grants range from $600,000 to $800,000. The professors will be working on a wide variety of projects that fall into several broad categories:

Research in the classroom: Several HHMI professors have transformed their own research interests into classes or projects that can be used in the classroom. For example, Baldomero Olivera at the University of Utah has developed projects to teach third and fourth graders about chemistry and biodiversity. And Sarah Elgin at Washington University in St. Louis has developed a nationwide research network that is getting undergraduate students involved in genomics research.

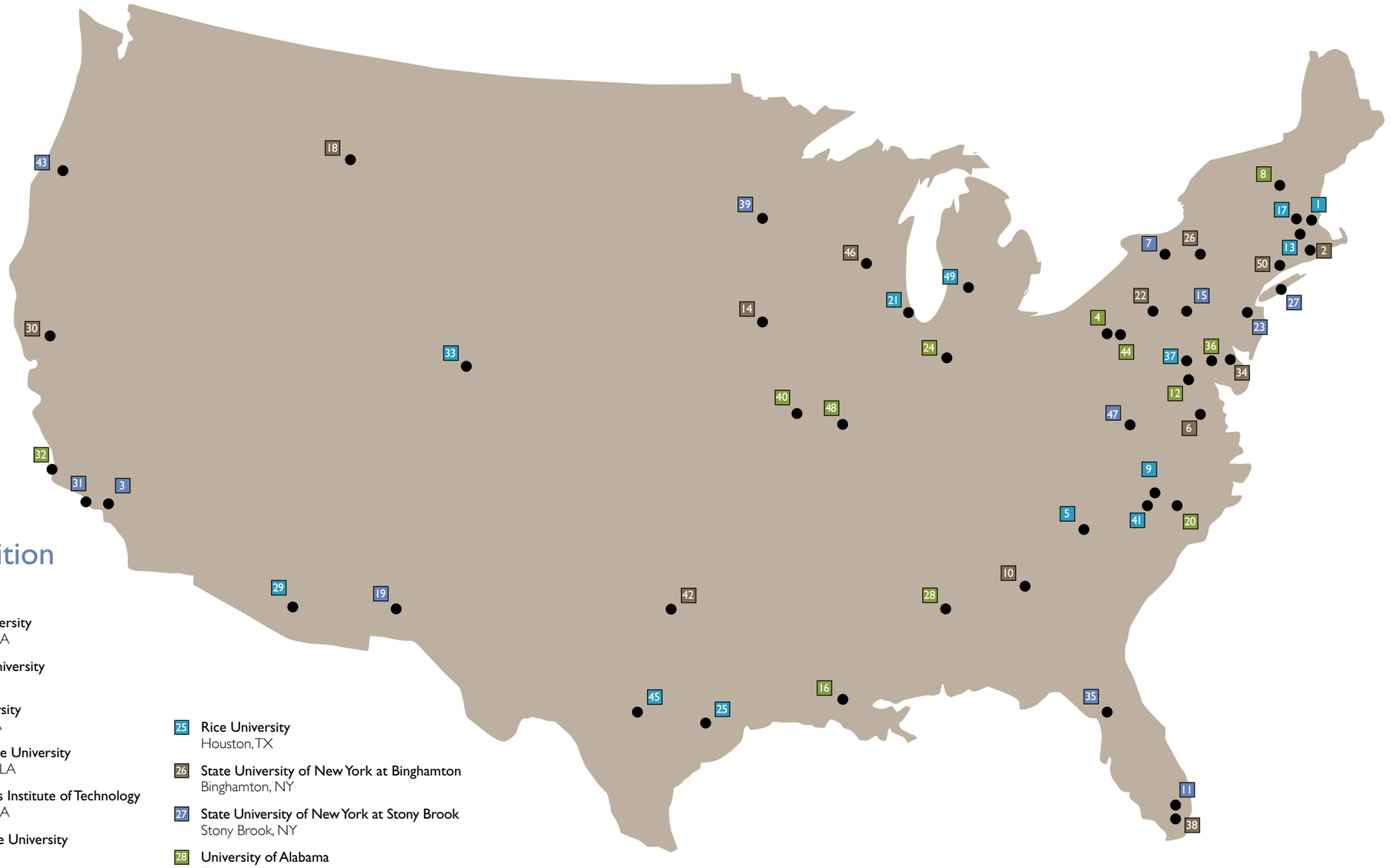
Student mentoring: Many of the professors' projects focus on improving student mentoring, in hopes of increasing the number of interested students who stay in science. Many of those projects, such as the one proposed by Isiah Warner at Louisiana State University, nurture students from groups traditionally underrepresented in the science. Warner has developed a "mentoring ladder" to support minority students as they enter different stages of their scientific career.

Improving science teaching: Several HHMI professors are developing programs to improve teaching of undergraduates, especially in large introductory classes. For example, Diane O'Dowd has created "garage demos" that can bring to life complicated chemistry topics. And Jo Handelsman has created training programs for current faculty members and graduate students to help them understand the best ways to teach so students are actively engaged in learning.

The 13 professors will use part of their new funding to share their knowledge with the wider science community. "We would like the HHMI professors to become a national resource for science education," Asai says. "We want them to disseminate what they've learned. That will send a strong message to scientists nationwide that there are ways of approaching science education more creatively. Here are top research scientists who are doing it." To learn more about the 2010 HHMI professors, visit www.hhmi.org/news/prof_list20100520.html.

The Howard Hughes Medical Institute plays a powerful role in advancing scientific research and education in the United States. Its scientists, located across the country and around the world, have made important discoveries that advance both human health and our fundamental understanding of biology. The Institute also aims to transform science education into a creative, interdisciplinary endeavor that reflects the excitement of real research. For more information, visit www.hhmi.org.

Undergraduate Institutions Selected in the 2010 Competition



1 **Boston University**
Boston, MA

2 **Brown University**
Providence, RI

3 **California Institute of Technology**
Pasadena, CA

4 **Carnegie Mellon University**
Pittsburgh, PA

5 **Clemson University**
Clemson, SC

6 **College of William and Mary**
Williamsburg, VA

7 **Cornell University**
Ithaca, NY

8 **Dartmouth College**
Hanover, NH

9 **Duke University**
Durham, NC

10 **Emory University**
Atlanta, GA

11 **Florida International University**
Miami, FL

12 **Georgetown University**
Washington, DC

13 **Harvard University**
Cambridge, MA

14 **Iowa State University**
Ames, IA

15 **Lehigh University**
Bethlehem, PA

16 **Louisiana State University**
Baton Rouge, LA

17 **Massachusetts Institute of Technology**
Cambridge, MA

18 **Montana State University**
Bozeman, MT

19 **New Mexico State University**
Las Cruces, NM

20 **North Carolina State University**
Raleigh, NC

21 **Northwestern University**
Evanston, IL

22 **Pennsylvania State University**
University Park, PA

23 **Princeton University**
Princeton, NJ

24 **Purdue University**
West Lafayette, IN

25 **Rice University**
Houston, TX

26 **State University of New York at Binghamton**
Binghamton, NY

27 **State University of New York at Stony Brook**
Stony Brook, NY

28 **University of Alabama**
Tuscaloosa, AL

29 **University of Arizona**
Tucson, AZ

30 **University of California, Davis**
Davis, CA

31 **University of California, Los Angeles**
Los Angeles, CA

32 **University of California, Santa Barbara**
Santa Barbara, CA

33 **University of Colorado at Boulder**
Boulder, CO

34 **University of Delaware**
Newark, DE

35 **University of Florida**
Gainesville, FL

36 **University of Maryland, Baltimore County**
Baltimore, MD

37 **University of Maryland, College Park**
College Park, MD

38 **University of Miami**
Coral Gables, FL

39 **University of Minnesota, Twin Cities**
Minneapolis, MN

40 **University of Missouri, Columbia**
Columbia, MO

41 **University of North Carolina at Chapel Hill**
Chapel Hill, NC

42 **University of North Texas**
Denton, TX

43 **University of Oregon**
Eugene, OR

44 **University of Pittsburgh**
Pittsburgh, PA

45 **University of Texas at Austin**
Austin, TX

46 **University of Wisconsin-Madison**
Madison, WI

47 **Virginia Polytechnic Institute and State University**
Blacksburg, VA

48 **Washington University in St. Louis**
St. Louis, MO

49 **Western Michigan University**
Kalamazoo, MI

50 **Yale University**
New Haven, CT

BOSTON UNIVERSITY

Neuroscience Comes Alive in the Lab

Neuroscience at Boston University is booming. Introduced as an undergraduate major just a year and a half ago, it will be the second most popular science major in the College of Arts and Sciences by this fall. Still, only 4 of the 17 neuroscience majors graduating this year conducted enough original research to complete a senior honors thesis. "We need to get a larger percentage of our students into laboratories," says Paul Lipton, who will lead the new HHMI-funded program designed to do just that.

The central goal of the program, which is part of a broader science education initiative funded by an HHMI grant, is to bring students in the lab earlier in their undergraduate years. Most science majors at BU and elsewhere don't undertake research until they are juniors and seniors, says Lipton, director of BU's undergraduate program in neuroscience. That's not early enough if research experiences are meant to have a lasting impact on the students' career paths, he says.

The new program will revamp the lecture-based introductory neuroscience course into a hands-on, research-based experience. Rather than repeating cookbook lab exercises, students will work together in small teams to tackle real research problems under the guidance of faculty who are active researchers and respected teachers. Some students, for example, will explore the molecular and cellular mechanisms of memory formation. Others will devise experiments to image brain activity in people, or be trained to implant tiny electrodes in the brains of rodents to study how neurons communicate with one another. As they experience scientific discovery firsthand, the students will gain practical research skills through BU's electron microscopy facility and magnetic resonance imaging center.

Lipton's hope is that giving first-year students a kickstart in research will allow them to fully engage in the lab over the course of two or three years, rather than one or two semesters. The culmination of the experience, he says, will be a senior thesis that the students will be encouraged to submit for publication to a peer-reviewed scientific journal.

Previous science education grants from HHMI have helped BU establish its summer research program and bring new life sciences faculty to campus. As Lipton sees it, what better way to build on that program than by helping young minds flourish in a field that has clearly already caught their attention?

AWARD: $1.5 MILLION

BROWN UNIVERSITY

Learning Communities Bring Students, Faculty Together

When Michael McKeown worked in a laboratory for the first time as an undergraduate, he quickly felt part of the team. "I had a grad student mentor, but I didn't just tag along behind him," he remembers. "I had a project to work on. I went to the department journal clubs. And if the lab members had a party, I was there."

McKeown considers himself lucky to have had that experience. Now a geneticist at Brown University, he wants to give science majors the same sense of community. Through its new HHMI grant, Brown will bring together four diverse, eight-person research teams each summer. Together this "learning community" will go through one week of training to boost their computer and lab skills. They will then spend two months working on a research problem, under the supervision of a Brown faculty member and two graduate students. The teams will work with their faculty supervisors to design and carry out interdisciplinary projects that pique their interest and fit within broad themes, such as Disease Hunters, NanoInvestigators, and BioBuilders.

McKeown and his colleagues patterned the program after Brown's International Genetically Engineered Machine (iGEM) teams, clubs that compete to create microorganisms that can do useful things, such as sense toxins or clean up oil spills. "Students and faculty really do form tight bonds within those iGEM teams, and they work hard and get very excited about what they're doing," McKeown says.

Throughout the summer, the learning communities will come together to discuss results, report their progress, and brainstorm for new ideas. At the end of the summer, members of the learning communities will present their work to fellow students and the campus community at an interactive poster session. McKeown thinks the project, one part of a larger science education grant, has the potential to change how undergraduate students and faculty carry out science research. "I think it can serve as a model for learning communities at other institutions."

AWARD: $1 MILLION

CALIFORNIA INSTITUTE OF TECHNOLOGY

Putting the Tech in Caltech Classrooms

The California Institute of Technology has never been a by-the-book kind of school. Its students thrive on big challenges, such as investigative research projects that they help design. So it's not surprising that the university, a long-time HHMI grant recipient, will use part of a new $1.6 million grant to further empower its students in the classroom and the lab.

Caltech believes that its students can benefit by learning from—and teaching—their peers, says David Tirrell, professor of chemistry and chemical engineering. So part of its new HHMI funding will expand a program that allows undergraduates to teach, a rare opportunity at a top research university. The program places undergraduate teaching assistants (TAs) in several chemistry labs, and students, TAs, and faculty all call the project a success. Undergraduate TAs bring recent experience with the challenges faced by their students, unlike instructors and graduate student TAs, who learned the material years or decades ago.

"Undergrads at Caltech are so strong academically that, once they've been through a course and learned a subject, they're usually very good at teaching their younger colleagues how to think about science and how to work in the lab," Tirrell says.

Caltech students will also get the opportunity to do advanced research that is out of the reach of many undergraduates. In a biomolecular engineering course, student teams design their own experiments—for instance, building a strain of bacteria that can be prompted to wipe itself out after performing some useful task. With its new grant, Caltech will provide the class a fluorescence-activated cell sorter, which isolates those cells that demonstrate a specific, desirable feature. This expensive piece of equipment is often unavailable to scientists until they're pursuing a Ph.D., but the new one will be located in a teaching lab and dedicated primarily to undergraduate use.

Tirrell believes that with a machine like this at their disposal, students will be prompted to think more deeply about the science involved and carry out research that answers questions they pose themselves. "Our undergraduates will develop a sense of self-confidence that comes from knowing that they're using the same tools and approaches that are used in the best research laboratories around the world."

AWARD: $1.6 MILLION

CARNEGIE MELLON UNIVERSITY

Summer Research Sparks Passion

Science majors at Carnegie Mellon University (CMU) are a dedicated and curious lot. More than 85 percent of biology majors participate in mentored research during their undergraduate careers. "When students choose Carnegie Mellon, they come here with the expectation that they will have a research experience," says biology professor Aaron Mitchell.

In the past decade, nearly 700 CMU students have participated in the university's Summer Undergraduate Research Program. To fit the goals and experiences of its diverse student body, the school offers a variety of avenues for participating in research. Some students need an immersive summer experience to get a taste of their chosen future career. Others want to gain interdisciplinary perspective to supplement a degree in another field but need to leave time for other activities, so a part-time research position is more appropriate. A new $1 million grant from HHMI will allow CMU to continue several student research programs it has created to meet these needs.

The newest of them, the Summer Research Institute, takes an interdisciplinary, team-based approach to science. Since 2003, each summer the program has offered 12 students a chance to immerse themselves in full-time, discovery-based research. Forming themselves into three-member teams, these early scientists use genetics, biochemistry, and computational analysis to tackle projects ranging from designing biosensors to piecing together the process of ribosome assembly in yeast.

Many more students, mostly those about to begin their junior and senior years, work in more traditional mentored laboratory environments through the HHMI Summer Scholars and HHMI Summer Researchers programs. The two programs are structured differently to offer some flexibility to accommodate students' schedules and other needs; both supplement time spent in the lab with opportunities to learn how to communicate about science and discuss career choices with mentors and peers.

"We have a very gifted population of students here at Carnegie Mellon and we can move them much further ahead with the support from these programs. [Our goal is to give them] a deeper understanding of what research is. That has proven to be very effective," Mitchell says.

AWARD: $1 MILLION

CLEMSON UNIVERSITY

Science Programs Point South Carolina Students Toward College

Many of South Carolina's middle and high school students need support to interest them in college and prepare them for the high-level work required there. "Clemson [University] is up in the northwest corner of the state, far away from some of the neediest schoolchildren," who live in the southern part of the state, says biology professor and HHMI program director Barbara Speziale.

But Clemson wants those students to think about going to college—and about majoring in science when they get there. With its new HHMI grant, the university will continue its multipronged approach, which includes training for teachers in grades K–12, campus visits for middle and high schoolers, and research experiences for talented high school students, to make sure the message reaches as many students as possible. "We want to give the kids something to aspire to and show them a pathway to get there."

Clemson targets middle and high school students from low-income, rural schools, including several with large numbers of students from groups traditionally underrepresented in the sciences. With part of its grant, the university brings 200 students to campus each year for two-day visits during which they take lessons in molecular biology in up-to-date research labs and learn about the many science disciplines. They may also be experiencing a university campus and meeting professors for the first time. Since 1998, 1,746 middle and high school students have participated in this program, and more than 330 students have gone on to college. Speziale hopes to continue to encourage more students to pursue higher education.

Clemson will also continue a popular program that brings high school teachers to the university to take graduate-level science classes taught by active researchers. "Teachers can get education courses pretty easily once they're teaching, but it's been hard for them to get biology and other science courses," Speziale says.

Since the program started in 1998, 816 teachers and 70 teachers in training have participated in 103 graduate courses, ranging from forensic science to histology to the natural history of South Carolina. Science is constantly changing, Speziale points out, and high school teachers need training to keep them and their students up to date.

AWARD: $1 MILLION

A high school teacher climbs a tree looking for red-cockaded woodpeckers as part of a course called Natural History of the South Carolina Coastal Plain offered by Clemson. The teachers are looking for newly hatched birds as part of conservation and monitoring of endangered species.
Photo: Greg Yarrow

COLLEGE OF WILLIAM AND MARY

Research Courses Send Students into the Woods

For the past two years, a handful of freshman biology students at the College of William and Mary have jumped directly from high school into hands-on research on dirt-dwelling, bacteria-infecting viruses called phage.

Many of the students enrolled in the year-long course, part of HHMI's Science Education Alliance, come to William and Mary without a strong high school science background but find themselves inspired by science by the end of the experience, says HHMI program director Margaret Saha. "It's authentic research," she explains. "They know that what they are doing has never been done before and that it will be used by other scientists." As a result, more participants remain science majors and go on to conduct research with faculty than do students in the traditional introductory biology labs.

William and Mary will use part of its new $1.2 million grant to spread the enthusiasm to more students. The school is designing several new courses modeled on the phage research but incorporating the scientific pursuits of their own faculty members. That means interested students can continue their research at William and Mary after the course. "After a year they don't want to drop it," Saha explains. "They could do this for four years and publish their findings."

In one course, students will venture deep into a mature forest called College Woods, where they will sample and analyze the bacterial communities that live in the soil. The students will also compare the College Woods bacterial community with another forest's to identify the differences in the soil. Another course will focus on the effects of mercury on the environment—the subject of research by an interdisciplinary group of William and Mary faculty. Students will test samples from a contaminated site for the presence of mercury and then examine how exposure to mercury alters gene activity in laboratory animals.

The college will also partner with nearby Thomas Nelson Community College to adapt the new courses to the community college curriculum. Thomas Nelson faculty will participate in the research in William and Mary labs before returning to their campus to introduce the courses to their students.

AWARD: $1.2 MILLION

CORNELL UNIVERSITY

Summer Workshops Kick Off Ongoing Support for Science Teachers

Each summer dozens of teachers descend on the small, lakeside city of Ithaca, New York. Settling into Cornell University's dorms for up to two weeks, they spend their days attending lectures by leading researchers, sharpening their laboratory skills, and exploring the natural gorges, fossil sites, and bogs in the area.

Nearly 1,000 teachers have participated in these wildly popular summer workshops, which HHMI has supported since the program's creation in 1989. Originally designed for high school teachers, the workshops have since expanded to welcome middle and elementary school teachers, as well. At the workshops, high school teachers learn about advances in basic biology and applications of molecular biology. Elementary and middle school teachers focus on using inquiry-based science to help students develop better reading, writing, and math skills and meet state science standards.

But far more than a summer getaway, the workshops serve as the gateway to the Cornell Institute for Biology Teachers (CIBT)—an innovative and sustained program that supports teachers long after the summer workshops have concluded.

"The strength of this program is that it's not just a one-time event. Once teachers participate, they become CIBT alumni and our support and interaction continue," says Jeff Doyle, professor of plant biology. "We have alumni return to campus events, and we have off-campus outreach events."

At the end of the workshops, teachers can check out equipment such as DNA and protein gel electrophoresis rigs, PCR machines, and microscopes from a CIBT lending library. That library is linked to an extensive catalog of laboratory exercises that is supported by Cornell staff available for phone and e-mail consultation, Doyle says. Many alumni teachers also participate in a listserv to share their ideas.

"One of the most gratifying aspects of the program is the inspiration the teachers get from being on a research campus with their peers," says Doyle. "Those in rural counties can be isolated from other biology teachers. This gives them important support."

These aspects of the program will continue with Cornell's new grant from HHMI. The school also intends to strengthen its year-round support with new partnerships between CIBT classrooms and Cornell undergraduates. The undergraduate students will serve as mentors for K–12 students, as well as make school visits and teach CIBT activities.

AWARD: $800,000

DARTMOUTH COLLEGE

Reinventing Introductory Science Courses

Chem 5 is a tough rite of passage for chemistry and biology majors at Dartmouth College. With a reputation as one of the most challenging courses on campus, its focus on quantitative thinking, numerical problem solving, and abstract concepts in chemistry has driven many students to switch majors.

Faculty from both departments realized they were losing potential science majors at an alarming rate due, in part, to students' bad experiences in Chem 5, an introductory chemistry course, and in introductory biology courses. Much of the new $800,000 grant will help faculty redesign an introductory course in each department that hopefully will better prepare students for upper-level courses and improve retention.

Chemistry and biology majors, for instance, will soon have an alternative to Chem 5. Dartmouth faculty Roger Sloboda and John Kull envision a course that integrates the quantitative and mathematical aspects of chemistry into the study of biological processes, such as those that would be presented in an introductory cell biology course.

"We'll try to explain chemistry principles by using real-life cell biology applications that students can understand from their own cell physiology," says Sloboda, the Ira Allen Eastman Professor of Biological Sciences and the HHMI program director. Sloboda plans to teach acid/base chemistry by instructing students about the stomach's acidic environment, which helps to break down and digest foods. He will also discuss stomach epithelial cells and the 2005 Nobel Prize–winning research on *Helicobacter pylori*, a bacterium that infects the stomach and plays a causative role in ulcers and gastritis.

Sloboda and Kull, an associate professor of chemistry, are offering their curriculum as a single course covering two trimesters—instead of teaching chemistry one trimester and biology the next. Students will be required to watch lectures via podcast before class. Time in class will be for interaction—problem sets, small group discussions, and review. They hope the revamped course will ignite students' passion for science, rather than scaring students away.

But Chem 5 won't go away for at least three years. It will be offered for students who prefer the "old school" approach to learning chemistry, giving faculty the opportunity to monitor grade and drop-out data for both classes to see if the new approach improves retention of potential biology and chemistry majors.

AWARD: $800,000

DUKE UNIVERSITY

Students Tackle Science Across Many Scales

To many scientists, there is no wilder place than the human brain. Understanding it fully takes cross-disciplinary, collaborative work spanning fields such as genetics, evolutionary biology, and psychology. With support from HHMI, Duke University is giving undergraduates a taste of that collaborative world with the new theme of its undergraduate research program, "Inquiry Across Scale: From Genes to Cognition." The idea is to get students involved in research and to get them thinking about scientific questions on a variety of scales, from the workings of molecules in cells to the behaviors that arise from millions of neurons firing in concert.

HHMI has funded Duke's Hughes research fellows program since 1990. In this program, 20 undergraduates dedicate eight weeks of the summer after their freshman year to an independent project in a faculty member's lab. They come together twice a week for talks related to the grant theme—for the last three summers, it has been systems biology, a way of thinking holistically about an organism or system. With the new inquiry across scale theme, scientists will talk about how the brain makes decisions and how humans evolved the ability to solve problems. The students also blog about their progress—hiccups as well as successes—throughout the summer.

"It's been a fabulous program for us because it engages students early in their academic career, and they tend to stay in their labs and really get hooked on research," says Lee Willard, Duke's associate vice provost for academic planning. Many of the students continue doing research throughout their college careers. "We're trying to develop a culture of research," says Willard. More than three-quarters of science students at Duke do some research with a faculty member.

A second HHMI-funded program introduces upperl level students to research on interdisciplinary teams. During the summer after their sophomore and junior years, students spend 10 weeks working on a team of two undergraduates, two graduate students, and two professors. "We're trying to create a new generation of problem solvers that can adapt their scientific knowledge and skills across disciplines," says Willard. "They can use those skills to really think outside of the box about important issues."

AWARD: $1 MILLION

EMORY UNIVERSITY

Student Research Changes Faculty Attitudes at Emory

When Emory University set up its first, modest HHMI-sponsored undergraduate research program in the late 1980s, skeptics wondered whether Emory faculty would be willing to have undergrads in their labs, Pat Marsteller recalls. "Nowadays we have several hundred faculty—from the medical school, the school of public health, and all the science departments—wanting to be involved," says Marsteller, a biology professor and HHMI's program director. And if they're left out, she hears about it: "'How come I didn't get my undergraduate student this year?'"

A new HHMI grant will help Emory meet the rising demand through two programs that get students into the lab—and do it earlier. Research Partners, which began as a pilot in 2005, places 30 students in the university's research labs during the school year, where they are mentored by graduate students and faculty. With the new HHMI grant, the popular program will expand to 40 per year and will target freshmen and sophomores. The second program, the long-running Summer Undergraduate Research Experience, which has placed more than 1,100 students in research labs, will start focusing on first- and second-year students too. "We know that when we get students interested during their first year, they're much more likely to stay in a science major and go on to a research career," Marsteller says.

To add a taste of science for beginning students, introductory science courses and seminars will incorporate research modules in which students analyze papers written by Emory faculty, graduate students, and postdoctoral fellows. A 2006 pilot test of this approach in an introductory biology lab course showed that students who took that class and reviewed papers from an Emory zebrafish biology lab were more likely than those who took a more traditional course to do undergraduate research and to remain science majors. "In these modules the students will be reading papers, deconstructing them, and figuring out what's exciting about the research questions being investigated," Marsteller says, emphasizing that the school will try to integrate research into courses at all levels. During the coming fall semester, students will study Emory papers on polymers produced by living organisms, drug design, and coevolution.

AWARD: $1.8 MILLION

FLORIDA INTERNATIONAL UNIVERSITY

A New Model for Teaching Science in Miami

With 40,000 undergraduates and a high percentage of students drawn from groups traditionally underrepresented in the sciences, Florida International University (FIU) generates more science and engineering graduates who are members of minority groups than any other school in the nation. For that reason, FIU feels a strong responsibility to forge an engaging, effective science curriculum, says physics professor Laird Kramer. "We need to find ways to remove barriers to learning—like the traditional large lecture environment—that tend to undermine underrepresented minorities."

With its new HHMI science education grant, the school's first, FIU will create a more hands-on, active learning environment in introductory science courses. Its redesigned program will draw heavily from the successful modeling instruction technique, in which students design and test their own models of scientific phenomena.

Kramer and his colleagues first tried out model-centered instruction in 2003 with an introductory physics course. "As a scientist I go through cycles of building and testing and extending models of the physical world, and we do that too in the modeling class," he says.

Instead of lecturing, the instructors teach problem-solving techniques and methods of inquiry to small groups of students. The students put these skills to use in developing and testing their models of real-world physics phenomena, such as acceleration or force. "We're trying to replicate what we do in a research environment in as many ways as possible," Kramer says. After the physics modeling initiative was established at FIU, the number of physics majors at the school increased almost threefold, and students' grades and attitudes about physics improved as well. The program also won an award from the Physics Teacher Education Coalition.

With its HHMI grant, FIU will extend modeling and other group-based teaching strategies to many other science and math courses. "We know that we can scale up this kind of thing and apply it comprehensively to physics, biology, and chemistry introductory courses at FIU," Kramer says. "It's largely the financial challenges that have limited us, but HHMI's grant will now help us to overcome those."

AWARD: $1 MILLION

Florida International University students will now have science classes that build their knowledge through a coordinated sequence of labs and engaging activities designed to replicate a scientist's process—a teaching method called modeling instruction. Here, students learn about magnetic induction through a lab activity and by talking with professor Laird Kramer.
Photo: FIU Instructional Photography and Graphics

GEORGETOWN UNIVERSITY

Lighting the Path to a Life in Science

A career in scientific research might seem like a long shot for students at Montgomery College, a community college in the Maryland suburbs of Washington, D.C. Many are the first in their families to attend college and they may never have even met a scientist. But a new HHMI-funded program at Georgetown University is designed to show these students that a scientific life is not only attainable, but appealing. The goal of the program, which will include coursework and research, is to motivate students to pursue further study in science by continuing on to a four-year institution once they complete the two-year program at Montgomery College.

Georgetown has received HHMI funding since 1994 for its own undergraduate research program, which continues to grow. The university is no stranger to the wider community, having used the same grants to develop mentoring programs for at-risk students in D.C.'s urban middle and high schools. But the relationship with Montgomery College is new. "We have a mission to figure out a way of reaching populations of people who are not well integrated into the scientific community," says Georgetown's Maria Donoghue, and so Montgomery College seemed a natural partner. Its 35,000 students represent 170 countries, and many are squeezing classes into busy schedules that include full-time jobs.

Starting this fall, a few dozen students at the college's campus in Germantown, Maryland, will be introduced to the program in a seminar in which they'll discuss hot scientific issues framed by newspaper and magazine articles written for popular audiences. "What you want to do with these students is give them the sense that they're capable, not a sense that, 'oh, this is too complicated for me,'" says Donoghue.

The following summer, eight students from the seminar will spend 11 weeks on the Georgetown campus. There, they will share apartments with Georgetown's HHMI-funded undergraduate research scholars, work in research labs, and discuss science at evening salons. "It's about modeling an intellectual life," says Donoghue. The program will also offer mentorship and technical assistance to students applying to four-year colleges, in hopes that they'll go on to graduate programs and careers in research.

AWARD: $1.6 MILLION

HARVARD UNIVERSITY

Preparing for Boundary-Free Science

Many research centers bring together scientists from different fields so they can apply their diverse perspectives to common problems. Harvard University wants future scientists to approach every problem with an interdisciplinary perspective of their own.

With the help of a previous HHMI grant, Harvard revamped its introductory science curriculum to expose students to a set of interdisciplinary foundation courses. Rather than the traditional, separate courses in biology and chemistry, students take a first course synthesizing chemistry, molecular biology, and cell biology and a second covering topics in genetics, genomics, and evolutionary biology. Forty percent of all first-year students take these courses. One of the principles behind the reform, which was launched in 2005, is to make students more comfortable applying perspectives drawn from the different sciences.

It should be clear from the beginning of students' college careers that everything is interrelated, says Robert Lue, the university's director of life sciences education and HHMI program director. "The new curriculum has been extremely successful. It has increased the number of students enrolled in life sciences courses and who subsequently major in the life sciences," he says.

With its new HHMI grant, Harvard will develop an interdisciplinary summer fellowship for students who have completed their introductory coursework and are ready to apply their knowledge to a research project. The program will involve three new centers at Harvard that embrace interdisciplinary collaboration: the Center for Brain Science, the Faculty of Arts and Sciences Center for Systems Biology, and the Microbial Sciences Initiative. Students will work with pairs of faculty on projects that bridge the work of laboratories in separate fields.

"This is a great opportunity to leverage what the centers are doing to create a summer research project with students that is explicitly interdisciplinary," says Lue. The hope is that students will employ boundary-free thinking as they participate in research teams. The program's broader aim is to cultivate a generation of scientists who are equally strong researchers, educators, and citizens.

AWARD: $800,000

IOWA STATE UNIVERSITY

New Labs, Course to Capitalize on Growing Interest in the Environment

Going green excites students—especially those who can use science to explore ways to keep the planet healthy.

With the help of a new $1.6 million grant from HHMI, Craig Ogilvie, a physics professor at Iowa State University (ISU), hopes to ignite students' passion for science by giving them a chance to apply their skills to today's scientific challenges and environmental problems. ISU will revamp its introductory lab courses and develop a new interdisciplinary class on science and sustainability so that sophomores can experience firsthand how science can help solve complex and socially important problems.

"Many of our science students feel like they have to go through three or four years of courses before they can practice being a scientist and experience the joy of asking a question and using scientific methods to find an answer," says Ogilvie. "If you give students a choice to generate their own questions and the tools to answer them, they grow and do an outstanding job."

All introductory science labs on campus will be transformed: rather than focusing on traditional cookbook exercises, students will design their own experiments, even in labs with 200–300 students enrolled each semester. Armed with new skills, students can move on to a course in which they will form project teams to design and conduct experiments related to environmental sustainability. For example, they may study the chemistry of turning organic matter into biofuels, determine the energy efficiency of recycling technologies or wind energy, or look at the impact of a warming climate on water resources in Iowa.

By giving students a chance to test their own ideas and experience how various disciplines—including chemistry, economics, and agriculture—can be used to address environmental concerns, Ogilvie and colleagues intend to excite the imagination of a new generation of problem solvers.

AWARD: $1.6 MILLION

LEHIGH UNIVERSITY

Driving a Cultural Change in Undergraduate Research

Lehigh University wants to keep pace with a changing scientific culture that is placing new demands on researchers. Today's students must be prepared to work and think across disciplines, and it takes a culture shift on campus to make that happen.

Armed with an HHMI science education grant awarded in 2006, Lehigh launched the Biosystems Dynamics Summer Institute (BDSI)—a 10-week summer program that places undergraduates, graduate students, and faculty members on interdisciplinary teams to tackle projects such as looking for drugs to treat stress disorders and developing reliable methods to separate cells in the blood for detection of HIV.

Behavioral neuroscience professor Neal Simon says the BDSI has already advanced the university's broader efforts to establish a more integrated, interdisciplinary approach to science, both in and out of the classroom. Some of the collaborative teams created during the summer institute have continued to work together during the school year, and faculty members have sought out new collaborations with colleagues in other departments. The boundaries between teaching and research have diminished, and Lehigh's department of biological sciences has the feel of a research institute, says Simon, who codirects the program with molecular biology professor Vassie Ware.

A partnership with Lincoln University and Cheyney University—two historically black universities—allows students and faculty from those schools to participate in BDSI as well. "The cohort of students attracted to BDSI has been exceptionally well qualified and very diverse across gender, ethnicity, and academic interests," says Simon, pointing out that the partnership with Lincoln and Cheyney is supported by both Lehigh and the state.

"The exciting thing about the Biosystems Dynamics Summer Institute is that it is a mechanism for building an enduring cultural change in how science is practiced at the institution," he says. "That in turn impacts how our students learn to think about science."

Simon and Ware are pleased that the school will be able to continue to offer at least 16 spots in the popular program to new students as part of its new HHMI grant. With the grant, Lehigh will also begin to incorporate interdisciplinary approaches into more science courses. "We hope that moving coursework in this direction, combined with the overall cultural change, will benefit all Lehigh students," he says.

AWARD: $1.5 MILLION

LOUISIANA STATE UNIVERSITY

Students Learn Science Crosses Borders

Participating in undergraduate research can open entire scientific vistas that students never knew existed. At Louisiana State University (LSU), undergraduate researchers will also have the opportunity see the world.

As part of a $1.4 million HHMI science education grant, and in a new collaboration with HHMI professor Isiah Warner, 5 to 10 LSU undergraduates will travel to the labs of infectious disease researchers in Europe, Africa, South America, and Asia. In addition to expanding students' options for research experience, the university hopes to broaden their perspective and introduce them to new ways of thinking about science.

"Too often U.S. students have an insular view of research," says Randy Duran, a chemistry professor and the HHMI program director at LSU. Many U.S. researchers assume that the way science is done in this country is the best way, without seeking out opportunities to experience how researchers in another culture might approach a problem differently, he says. "By sending talented young students to world-class research labs abroad, we hope that they will be more open to discovering distinctive elements that make top scientists outside the U.S. successful and innovative."

The international research opportunity is a natural follow-on to LSU's existing student research program, which also has HHMI support. Students from LSU and across the country participate in a 12-week summer research program. LSU students can continue their research throughout the year. Those who excel at home get the opportunity to work in laboratories of HHMI investigators around the country who have links to LSU scientists.

Now students who have worked successfully in LSU labs will also be able to spend a summer and fall semester working with an international research group. The focus on infectious disease is expected to help students see the immediate relevance of their laboratory work as it is applied to societal needs, Duran says.

AWARD: $1.4 MILLION

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Science Education Outreach Goes Viral

For the past 20 years, HHMI funding has helped strengthen education outreach and the undergraduate biology curriculum at the Massachusetts Institute of Technology (MIT).

When it comes to education outreach, MIT's OpenCourseWare (OCW) program is the school's killer app. Simply put, OCW makes lecture notes, exams, and videos from MIT faculty freely available over the internet. When first unveiled in 2002, OCW offered 32 courses. It has since grown to more than 1,900 courses, featuring materials from more than 75 percent of MIT's faculty. More than 50 million unique visitors have already discovered the OCW website, which currently features more than 70 biology courses.

MIT will use part of its $1.8 million HHMI grant to share its online science educational tools with a larger worldwide audience through OCW. Graham Walker, an HHMI professor and biologist at MIT, and his colleagues have made two popular educational tools from his group's STARBiology software suite available as part of this effort. STAR is an acronym that stands for software tools for academics and researchers.

One component of the StarBiology suite, StarBiochem, is a protein viewer that helps students see how proteins are folded and how they work inside cells. Walker developed StarBiochem in 2006 to improve the teaching of large introductory biology lectures. At the time he was building the application, most protein-viewer programs were considered too sophisticated for beginners. But Walker felt that "playing with a protein" was exactly what new students needed to grasp how molecular biology works. StarBiochem has been used by more than 3,000 undergraduates and high school students and has been accessed online more than 15,000 times by students and teachers from 71 countries.

StarBiochem's success stimulated the development of StarGenetics, an educational software tool that allows students to perform virtual genetic experiments. Students can use the program to simulate mating experiments between organisms that are genetically different across a range of traits to analyze the nature of those traits. Both software programs are available through MIT's STAR website, the biology department's educational resources site, and HHMI's Cool Science for Educators. "Both programs are being widely used nationally and internationally, and we hope that usage will continue to increase," said Walker.

AWARD: $1.8 MILLION

Biology teachers Nicole Digenis from Lincoln-Sudbury Regional High School and Ann Dannenberg from Newton North High School proudly display their dissected sheep brain during a 2009 HHMI teachers workshop.
Photo: Mandana Sassanfar

MONTANA STATE UNIVERSITY

Using Science to Reach Native American Students

Montana State University (MSU) wants more Native American students to get into college—and science. "We have 12 Native American tribes and seven reservations in this state," says Gwen Jacobs, an MSU neuroscientist and the HHMI program director. "But it's a big state." Getting from one of these far-flung reservations to MSU's campus in Bozeman can take a day-long bus journey—which significantly limits the numbers of students MSU can attract to its on-campus outreach conferences. With a new HHMI grant, MSU will modify a popular half-day outreach program for middle school girls, Science Saturdays, to attract more Native American students. In addition to holding events in Bozeman, MSU will send undergraduates to those distant tribal communities to introduce students there to the excitement of scientific discovery.

The outreach initiative is part of MSU's larger push to recruit tribal high schoolers into its Montana Apprenticeship Program (MAP), which brings 20 Native American students to MSU for a six-week summer research experience. "Half of the day they spend building their math, science, and writing skills, and the other half they spend working in a research lab," Jacobs explains. The students are mentored in part by undergraduates doing research through another HHMI-funded program—often in the same lab. The older students help the high schoolers feel comfortable on campus, learn about working in a lab, formulate their research question, and prepare presentations.

MAP has run for about two decades and has received funding from HHMI since 2002. Of the 60 most recent MAP students, 66 percent have gone on to a four-year college, far more than the approximately 20 percent of high school students on Montana's reservations who attend college after graduation. With the new HHMI grant, MSU will expand the number of spaces in the MAP program to 25.

Jacobs hopes that Science Saturdays and other reservation outreach projects still in development will further enhance the "pipeline to get students from the tribal high schools into MAP and hopefully then to MSU as undergrads."

AWARD: $1.2 MILLION

NEW MEXICO STATE UNIVERSITY

High School Students Get a Taste of Discovery

When high school students touch their tongues to paper strips infused with the organic compound PTC, some wrinkle their noses at the bitter taste. Others don't understand the fuss, because they can't detect a thing. But this isn't a taste test, it's a genetic experiment. In the past four years, more than 2,000 high school students across New Mexico have conducted basic genetics experiments with the help of New Mexico State University scientists and a mobile lab that travels to a different high school each week. Among other things, students study the gene that controls their ability to taste PTC. In the process, they learn the distinction between genotypes and phenotypes. The lessons are hands-on, personalized, and arguably more memorable than textbook-based instruction.

The program, created with the help of an HHMI grant in 2006, has been a success—but the school's HHMI program director, Ralph Preszler, knew it was only a beginning. "The lab was so popular that we couldn't respond to all the requests from high schools," he says.

Thanks to a new grant from HHMI, NMSU won't have to say no; instead, the school will expand its offerings. The grant will support new programs that equip high school teachers with the tools and information they need to develop classroom modules similar to those offered through the mobile lab. The teachers will be able to borrow specialized lab supplies—which schools on tight budgets often can't afford— for isolating genes and genetic markers. They will also take ownership of the process, adjusting the lessons over time to better suit the needs of their students and schools. In later stages, the program's veteran teachers will pair with outreach scientists to develop entirely new lessons and experiments.

In the end, Preszler hopes these modules will give high school students a new perspective on science. "We want them to understand that biology is exciting and interesting," he says. "And we hope that it inspires them to continue their studies in college."

AWARD: $1.8 MILLION

New Mexico State student Victoria Carpenter isolates a mosquito to study a gene associated with the mosquitoes' ability to obtain a blood meal, as part of a Research Methods in Molecular Biology course.
Photo: Tonia Lane

NORTH CAROLINA STATE UNIVERSITY

Taking Notes from Nature's Classroom

Here's one way to get high school students excited about biology: let them loose in a marsh. "They get to go out in canoes, get their hands and feet wet and muddy, and have a good time while they're exploring a hypothesis that they test as a scientist would," says Damian Shea, who heads North Carolina State University's biology department. The students he describes are part of an outreach program that HHMI has funded since 2002, in which the university partners with an environmental learning center in a poor, rural area in the northeastern part of the state.

The students start with an intensive week-long program at the center, then work on a year-long research project in a team of two juniors, two seniors, and a teacher. Most juniors continue for a second year. Over the years, the students have been more likely to take advanced science classes in high school, and major in science in college, than other students at their schools who didn't take part in the program.

A portion of the university's latest grant will be used to expand the program beyond the original marsh location to other sites throughout the state. Students at a mountain site will study the ecology of a mountain stream. Others will learn about terrestrial ecology in the hilly Piedmont region, examining how insects and plants interact. Near NCSU's campus in Raleigh, one group will study a pond ecosystem. The goal is to get the students excited about doing biological research and eager to continue their studies in science. It's a cost-effective approach—environmental experiments in ponds and streams normally don't require the expensive equipment and reagents that often accompany biomedical lab research.

At the same time, the program will train local high school teachers to take these techniques back to their own schools. "Some have easy access to the sites, and they're welcome to use those," says Shea. "Some of them will not, but they have either a terrestrial site or an aquatic site near the school where they can apply the same methodology."

AWARD: $1.5 MILLION

NORTHWESTERN UNIVERSITY

Northwestern Will Hook Students Early

The trick to keeping undergraduates in science, says biochemistry professor Linda Hicke, is to start early. In her experience, students who join her lab as freshmen and sophomores are the ones who are most interested in going on to graduate school and are most successful in their postgraduate careers. "It is more fulfilling for the student and more fulfilling for me than when they are just there for a summer. You can see them getting hooked," she says.

With its first HHMI grant, Northwestern University (NU) will create a formal program to encourage this addiction to scientific inquiry. As part of its $2 million grant, the NU plans to establish a summer BioEXCEL program for 20 entering freshmen interested in medicine or bioscience who come from groups traditionally underrepresented in the sciences. To prepare them for the rigors of college life, the students will take four intensive courses: calculus, chemistry, a survey of the "greatest hits" of recent biomedical research, and a project designed to build study skills and teach teamwork. "It's a jump-start program for students from schools that didn't have the resources to provide intensive, high-level classes in science," Hicke says.

Students in the BioEXCEL program who show a strong interest in research will have the opportunity to move seamlessly into another new, HHMI-funded program: the NU Bioscientists. A freshman seminar will help prepare 30 students—teaching them basic laboratory skills, as well as poster presentation and proposal writing—and guide them toward a faculty laboratory doing research that attracts their interest. The students will then receive funding to work with a Northwestern faculty mentor doing research the summer after their freshman year.

Students who flourish in this environment will be able to spend up to three years working in their chosen laboratory—an important commitment, because Hicke says it can take a long time to learn the necessary experimental techniques to solve a problem and even longer for a student to develop the ability to think creatively about actually solving it. "But three years will allow the students to experience all the typical ups and downs of scientific research and give them enough time to generate data and be part of a publication," she says.

AWARD: $2 MILLION

PENNSYLVANIA STATE UNIVERSITY

"Go Teach" Aims to Turn Science Students into Science Teachers

Scientists know that sometimes their best insights begin with a simple observation. That's certainly true at Pennsylvania State University, where the biology faculty began noticing that a growing number of their students were asking about obtaining their high school teaching certification.

Around the same time, faculty at Penn State's College of Education saw an increase in students inquiring about teaching opportunities—such as being a peer mentor or a teaching assistant—in the biology department. "The science faculty and the education faculty sat down and started talking over lunch," says Richard Cyr, professor of biology and assistant head for undergraduate affairs. "How could we put our two programs together in a way that would benefit students and faculty alike?"

Those brainstorming sessions led to a proposal to develop a combined degree program called Go Teach: Penn State. The program is designed to improve the quality of tomorrow's K–12 science teachers by recruiting prospective teachers from the ranks of undergraduate science students.

Students in the new five-year Go Teach program—which is being developed with a new grant from HHMI—earn a bachelor's of science in biology and a master's of education, and become credentialed to teach science at the high school level in Pennsylvania. "We realized we could fit some of these education courses into the curriculum under the general education requirements for the biology major," Cyr says. Normally, completing both degrees, one after another, would take six years.

The new program will ground students in the most up-to-date techniques for teaching science, including the latest thinking on science curriculum development at the secondary school level. "We hope that the students that we send out are really at the cutting edge of science pedagogy. They know their stuff, and they're teaching it in the best way possible, using the most modern tools," Cyr says.

With a bachelor's degree in science and a master's of education, these newly minted teachers should have ample job opportunities. And the students in their classrooms will benefit from teachers who have a deep knowledge of their subject.

AWARD: $1 MILLION

PRINCETON UNIVERSITY

Science Teachers Head for Summer School

Whether fighting for funds for supplies and equipment or trying to find time to learn about scientific advances, high school science teachers face numerous challenges as they struggle to make science compelling and exciting for their students.

For the past 20 years, Princeton University—with support from HHMI— has offered science teachers a lifeline in the form of two-week summer workshops that help them keep current on the latest science and polish their teaching techniques. The more than 500 teachers who have participated in the workshops since the program's inception have shared their experiences with thousands of students. The program's current emphasis is on training teachers to show their students how to do scientific research.

"Everybody gets more excited about science when they actually do science," says Fred Hughson, program director for Princeton's HHMI grant. "Our goal is to give students and high school teachers direct experience with scientific research and discovery. That's the best way to hook 'em."

The new $1.5 million grant from HHMI enables Princeton to extend its outreach efforts, which include on-campus talks that workshop alumni and their students attend, a science expo for middle school teachers and their classes, and creation of satellite learning centers in underserved urban and rural communities.

The grant also will enable Princeton to develop new lab modules for the teachers to use in their high school classrooms. This summer, the teachers will become scientists, as they experiment with different lab modules to determine which is the best fit for their classroom. One module under development involves experimenting with DNA plasmids showing off a rainbow of fluorescent proteins, a technique developed by HHMI investigator and Nobel laureate Roger Tsien and used in research labs worldwide to visualize proteins in action.

To bring these techniques into the classroom, teachers need supplies and equipment. To that end, the grant will enable Princeton to loan specialized equipment—such as PCR thermocyclers and gel electrophoresis kits—and reagents that teachers can use when they return to their classrooms, reinvigorated and inspired.

AWARD: $1.5 MILLION

PURDUE UNIVERSITY

Biology by the Numbers at Purdue

College students who study biology are awash in a sea of complex data. But when it comes to the tools required to analyze and interpret that data, most undergraduates don't equip themselves early enough, says Purdue's HHMI program director Dennis Minchella. "Students will put off statistics courses until they're seniors," he says, despite the fact that quantitative skills can enrich even introductory science coursework. With that thought in mind, Purdue will draw on a new HHMI grant to integrate statistical reasoning and data evaluation into the biology curriculum.

A team of about a dozen scientists and educators will develop "plug and play" modules that instructors can integrate into existing biology courses to introduce statistical techniques. "It's not about reinventing the wheel," Minchella emphasizes. "But it is about reinventing how the wheel is measured, evaluated, and interpreted by students. We can put something together that faculty members can easily incorporate into their lectures." The work will deepen the school's existing strategies for integrating mathematics and life sciences, developed with an HHMI grant in 2002.

The new curriculum will show students that statistics and biology naturally intermingle. By the time they've reached upper-level courses, where more complex statistical models may be used, they'll have no trouble jumping in, says Minchella. Even if the students don't go on to conduct research, they will be able to use statistical evidence to analyze information that is relevant to them, such as news stories containing percentages and probabilities.

Of course, giving students the tools to understand statistical concepts is not the only goal. The deeper objective is to prepare them for careers that require facility with statistical and mathematical data. "[Those skills] are necessary in almost any biological position that a student will take," Minchella says. "We believe this approach is an effective way to train our future leaders in biology."

AWARD: $1.5 MILLION

RICE UNIVERSITY

Rice Challenges Students to Solve Global Health Problems

A low-cost fluorescence microscope that makes malaria and tuberculosis diagnosis easier. A backpack full of diagnostic tools—including a microscope, centrifuge, and rapid tests—that nurses in the developing world can use to accurately determine what is making a patient sick. A tiny clip that pharmacists can attach to a syringe to prevent patients from overdosing. These are some of the practical solutions to real-world problems that students in Rice University's Beyond Traditional Borders (BTB) program have developed.

"Our program aims to open students' eyes to the challenges of global health, and help them use the tools of science and engineering to design solutions that are affordable, effective, and culturally appropriate," says Rebecca Richards-Kortum, a bioengineering professor. After coursework on the health challenges of poor communities, students put their knowledge to work. In the first BTB class, students get an introduction to biomedical engineering and design a simple solution to a real-world global health problem. Those who join the BTB minor—which includes four additional BTB classes and two related electives—tackle progressively more difficult design problems. Engineering solutions for global health has captured the imagination of Rice's students: since 2006, more than 10 percent of all Rice undergraduates have taken one or more of the classes, with participants from science, engineering, humanities, and social science majors. Some have even traveled to developing nations to test their designs in local clinics.

With part of a new $1.2 million grant, Rice will expand to a national scale. An annual outreach workshop on bioengineering and world health for high school teachers will recruit the best science and engineering teachers from across the country to start up similar programs. Rice will also invite undergraduates from other universities and local high schoolers whose teachers were trained in the outreach workshop to participate in an international health technologies design competition, which they hope will become a forum for students to share their designs and experiences and find mentors for future career guidance.

"I'm excited about the opportunity for students nationwide to be a vital part of the process of designing a new technology and seeing the impact that it has," Richards-Kortum says. "I think we're creating a generation of students who can design solutions to important global health problems."

AWARD: $1.2 MILLION

Rice student Catherine Slater demonstrates a diagnostic Lab-in-a-Backpack to doctors at a hospital outside Kigali, Rwanda. The pack, designed by students in Rice's Beyond Traditional Borders initiative, contains tools to allow healthcare providers to perform basic diagnostic exams in remote settings in the developing world.
Photo: Rebecca Richards-Kortum

STATE UNIVERSITY OF NEW YORK AT BINGHAMTON

Jumpstarting Collaboration

For more than 60 years, undergraduate students at the State University of New York (SUNY) at Binghamton have been involved in biology research. Historically, they have worked within a single department, a practice that mirrored the way science used to be done—with experts from a single discipline teaming up to do experiments. Science has become more collaborative and multidisciplinary in the last decade, and SUNY at Binghamton has embraced that, too.

"Biology is incorporating more mathematics, engineering, physics, and computer science," says Anna Tan-Wilson, SUNY distinguished teaching professor of biological sciences and HHMI program director. "In the real world, those boundaries are blurring."

With the help of an HHMI grant, undergraduates at SUNY Binghamton will now have more opportunities to cross those disciplinary boundaries. The HHMI grant will jumpstart a new effort to pair majors in the life sciences with students in the physical sciences, mathematics, computer science, and engineering as they begin collaborative, interdisciplinary research projects focused on biological questions. The teams will begin in the summer and continue working together for the following academic year, along the way getting training in how to work effectively across disciplines. Graduate students will also be trained as mentors. "We want to work with them also because these Ph.D. students will be faculty members someday," says Tan-Wilson.

To make sure that there are plenty of labs to welcome students, Tan-Wilson and her colleagues will host workshops where faculty can meet to propose collaborative projects that undergraduates can carry out.

Tan-Wilson says the university is also interested in understanding how students develop and progress. Krishnaswami Srihari, distinguished professor of systems science and industrial engineering at SUNY, will observe the students as they work and use data to model the social interactions of the interdisciplinary teams. They will use what they learn to determine what factors help interdisciplinary students grow into independent scholars and better match students to faculty mentors. "What are the conditions that make for success?" says Tan-Wilson. "Or if the students get disgruntled and frustrated, what are the conditions that lead to that?"

AWARD: $1.4 MILLION

STATE UNIVERSITY OF NEW YORK AT STONY BROOK

Attracting the Brightest Community College Students to Science

Faculty at the State University of New York at Stony Brook know that tomorrow's top scientists could come from any college in the country. But unless those future scientists get a chance to tinker with the tools of science in research projects of their own, they may never know how exhilarating—and attainable—such a career path can be.

In 2007, the university expanded its HHMI-funded summer Research Fellows Program to include not just Stony Brook undergraduates but students throughout the nation. The outreach focused on students from economically disadvantaged backgrounds or from groups that are traditionally underrepresented in the sciences. "Many don't come from a family background where their parents have gone to college, so they don't have that embedded in their daily lives. It's not part of their vision," says David Bynum, a professor of biochemistry and cell biology. "We see that change because we bring them on campus. Our goal is to enlarge their vision of what's possible with their life."

With a portion of its new $1.5 million grant, the university will expand the program to another underserved group: students enrolled in New York's community colleges. The university will recruit 15 academically talented community college students as research fellows each summer. Statistically, students who attend community colleges are more likely to leave school than similarly qualified students who attend more selective institutions. Stony Brook wants to challenge these students before that happens, Bynum says. He hopes the research exposure will help encourage them to enroll in a university and eventually pursue postgraduate studies in science.

"There is a ton of talent out there that chooses to get educated [at community colleges] because of financial, family, or logistical reasons, who are skilled enough to do top-level work at the university," Bynum says. "There are students out there who are passionately interested in science and don't quite have the opportunity. That's the kind of talent we would like to attract."

AWARD: $1.5 MILLION

UNIVERSITY OF ALABAMA

One Collaboration, Three Schools, Diverse Possibilities

University of Alabama (UA) biology professor Martha Powell feels a special call to help students from minority groups get into science, because of the legacy of segregation in the state and the persistent barriers that remain in Alabama and nationwide. She wants to make it easier for students to leap those barriers.

Powell is encouraging students of all backgrounds to be engaged in—and serious about—scientific research. The university is collaborating with two other Tuscaloosa institutions, Stillman College, a historically black liberal arts school, and Shelton State Community College, to bring diverse groups of students together to do bioscience research in a supportive environment. "A lot of people have gone over or around the barriers, and if they've gone over, it's because someone has helped them," she says. "We want to offer that help."

With two prior HHMI grants, the university created the Hughes Undergraduate Researcher Program, which brings freshmen and sophomores from all three schools to UA to do hands-on research for two years. Of the 141 students who participated during the last 10 years, 98 percent chose careers related to science and technology, including 28 percent who went to medical school, 18 percent who entered doctoral programs, and 12 percent who became teachers.

The new grant will create a semester-long introductory seminar to the research program that will rotate among the three campuses, a feature that is critical to the program's success, Powell says. Shelton students, many the first in their family to go to college, will get to know Stillman and UA students and professors and may consider pursuing a Ph.D. When white UA students walk onto the Stillman campus, they will experience—possibly for the first time—what it feels like to be a minority.

The seminar itself will prepare students by helping them think broadly about science, Powell says. Students will learn about important research discoveries: the scientists behind them, what barriers they faced, and the work's societal impact. Participants will also visit campus major research centers where work such as microscopy and genome sequencing takes place. "Students are very aware of the end products of research but aren't thinking about the process it took to get to that point. . . . We're emphasizing how science builds upon itself and that there's an enormous degree of serendipity and creativity in discovery."

AWARD: $1.5 MILLION

University of Alabama professor and mentor Margaret Johnson discusses test results with undergraduate researcher Taneka Head. The pair discovered a new form of an enzyme that makes the essential nutrient inositol, which cells use to communicate with each other. Abnormal levels of inositol may be the cause of several brain disorders.
Photo: Tysondria Pritchett

UNIVERSITY OF ARIZONA

Making Biology About the Numbers

Over the past four years, advanced math students at the University of Arizona have been wrestling with biology in their calculus and statistics courses: calculating drug accumulation rates and analyzing child development trends, while also grappling concepts traditionally in their math courses. Over the next four years, some introductory biology students are going to find far more math mixed in with their biology too.

It's part of a multiyear effort to make biology teaching more quantitative and problem based and to help math students see how their problem-solving and quantitative skills can be applied to complex biological questions. Arizona's BioMath program—an effort to revise coursework and support research at the interface of biology and math—is driven by the increasing complexity of biology itself.

Recent technological advances have increased the amount of data that labs are producing. Genomics and proteomics research, for example, are particularly data intensive. Interpreting that information requires the skills that BioMath is striving to teach its students, says Roy Parker, an HHMI investigator and the HHMI program director. "The combination of large data sets and very complex problems requires that you know how to conduct sophisticated quantitative analysis," he says. "That skill will only become more critical in the future."

With a portion of its the new HHMI grant, the university will add to its BioMath course offerings and provide support to undergraduates doing summer research at the interface of biology and math, working through a successful undergraduate biology research program directed by Carol Bender. But students have already begun doing exactly what BioMath's developers hope: applying what they learn in the classroom to actual research problems. "Six students who took the [biology-based] statistics course went back to their labs and used what they had learned in class," says mathematics professor Joe Watkins, who heads the university's BioMath committee. When those students share their knowledge with their labmates, the culture shift that unites the two disciplines spreads beyond the number of students that BioMath can reach directly. "If you are an 18-year-old biology major, you aren't that far from your last math class, Watkins says. "They truly understand the importance of math to biology."

AWARD: $1.8 MILLION

Students in the Undergraduate Biology Research Program, funded in part by HHMI, dressed up as the organisms they study and marched in the 2008 Fourth of July Parade in the hamlet of Summerhaven, Arizona. As they marched they sang a song about PCR and tossed candies bearing the line "Science is cool!"
Photo: Carol Bender

UNIVERSITY OF CALIFORNIA, DAVIS

Students on the Research FASTRAC

With the economic recession forcing more students to attend community college, the transition to a four-year university can be particularly tough for those who are interested in engaging in undergraduate research.

"For the most part, they don't make it into a lab until their senior year, so it pretty much guarantees that they'll graduate with one year or less of laboratory research experience," says Kenneth Burtis, dean of the college of biological sciences at the University of California, Davis (UC Davis).

But now, transfer students at UC Davis will have the opportunity to get the full benefit of doing undergraduate research, through multiple research projects or one long-term effort. With the help of an HHMI grant, the biology faculty is designing a program called FASTRAC—FAcilitating STudent Research ACcess—that will identify up to 20 community college students each year who are interested in working in a research lab after they transfer to UC Davis. During winter break of their last year in community college, the students will spend two weeks at UC Davis to meet faculty and other students, receive mentoring, and get an intensive lab experience.

About half the students from FASTRAC will be selected to work in biology labs for 10 weeks in the summer and participate in the institution's Biology Undergraduate Scholars Program, which provides activities with peers who are also doing research. Burtis is optimistic they will continue working in those labs until they graduate. "By the time the summer comes to an end, and they begin their coursework, they'll be fully embedded in their labs and hopefully will carry forward with a successful research experience," he says.

Burtis thinks the project could have a big impact on community college transfer students who aspire to do scientific research. Students who do research for a full two years have more opportunities to coauthor papers, present their work at scientific conferences, and get strong letters of recommendation for applying to graduate school—all steps on the path to becoming a working scientist.

AWARD: $1.2 MILLION

UNIVERSITY OF CALIFORNIA, LOS ANGELES

UCLA Tears Down Departmental Walls

The University of California, Los Angeles—one of the country's top 10 feeder schools for science and engineering Ph.D. programs—has a solid track record of engaging students in science. But many of the school's 3,000 biology undergraduates don't get to experience the excitement of discovery in the lab, in part because they only have time to take required classes.

The university will use part of a new $1.2 million HHMI grant to break down artificial boundaries imposed by traditional major requirements to allow students to experience the thrill of the scientific chase. "We're finding that the kind of structure we used for setting up departments isn't really right for 21st-century science, which involves being able to take information from genomics, genetics, developmental biology, microbiology, biochemistry, and putting it all together," says HHMI program director Frederick Eiserling.

Under the new program, students will still take the lecture courses associated with their major. But for their laboratory experience, they'll choose among three interdisciplinary research tracks. The first track allows students in lab-based classes to jump into experiments related to a professor's research, such as hunting down novel bacterial viruses in soil or taking a close look at plants and their associated microbes. The second gives students a hands-on research experience working with faculty mentors from a wide variety of life science and medical departments for at least two back-to-back quarters. The third track, part of a larger biomedical research minor, provides a similar lab-based research experience but matches students specifically with biomedical researchers, with whom they will work for more than a year. Students working in individual scientists' labs will also enroll in a seminar that will help them learn about the hows and whys underlying lab research. In all three tracks, students will be assisted in finding a faculty mentor or research-based class outside of their traditional major.

UCLA will test this approach for the approximately 900 students in two majors. If the tracks provide students an authentic research experience, UCLA will expand the program to all life science majors. The hope, Eiserling says, "is for our students to view science as a more integrated exercise in intellectual activity, rather than being forced to jump through a set of hoops without quite understanding why."

AWARD: $1.2 MILLION

UNIVERSITY OF CALIFORNIA, SANTA BARBARA

Using Worms to Lure Students into Research

At the University of California, Santa Barbara (UCSB), hundreds of sophomores take the introductory biology course each year. Soon, each one will get a taste of doing original research on the roundworm *Caenorhabditis elegans*, a widely used genetic model.

The inspiration for the new curriculum came from biology professor Joel Rothman's experience as director of a summer embryology course at the Marine Biological Laboratory (MBL) in Woods Hole, Massachusetts. In the MBL course, graduate students and postdocs would spend three days conducting original experiments on C. elegans. Despite the time limitations, students were able to make interesting discoveries and came away with an appreciation for this area of research. Back at UCSB, Rothman and fellow professors Kathy Foltz and Rolf Christoffersen began thinking about whether such
an approach could be adapted to undergraduate lab activities that might kick-start college students' interest in research.

"If advanced students could make original discoveries in only three days," Rothman says, "we wondered, might it be possible—over several quarters—to do this for six to eight hundred Intro Bio students who are just starting their training?"

As part of the new effort, called the Large-scale Undergraduate Research Experience (LURE), each introductory biology student will use RNA interference to knock down one of the worm's 20,000 genes in an effort to identify genes important for specific aspects of development or physiology. *C. elegans* is easy to grow, and the techniques are standard, making it ideal for such a large-scale undergraduate project, Rothman says. It will be true research, as the outcome of each experiment will not be known beforehand. In fact, some students may not find anything. That will be an important lesson, too, Rothman says. "Failure is a perennial part of the research experience," he notes.

The university plans to share the students' results with the worldwide C. elegans research community by publishing their data on the web. Those results could stimulate new directions for researchers around the world. "There are elements in science in which 600 pairs of eyes and hands are very valuable," Rothman says.

AWARD: $1 MILLION

UNIVERSITY OF COLORADO AT BOULDER

Python Project Grabs Students, Refuses to Let Go

Snakes are a source of fascination—or disgust—for many people, but they hold a special place in the hearts of some researchers and students at the University of Colorado at Boulder (UCB). Pythons fast for long periods of time and then eat a huge meal that can be equivalent to half their body mass. To do this, pythons quickly ramp up their metabolism and double the size of their organs. But not much is known at the genetic level about how the snakes accomplish this feat.

For the past three years, undergraduate students at UCB have been studying the python genome in order to answer some of these questions. They are doing this research as part of an undergraduate laboratory class called the "Python Project," which was developed three years ago with HHMI support. "The thing that makes it different from the standard laboratory class is that it's real research," says Leslie Leinwand, an HHMI professor who developed the course. "It's not cookbook, with outcomes already known."

The course is just one way undergraduates actively engage in research at UCB. Through the university's Biological Sciences Initiative (BSI), with HHMI support, more than 60 students do research in faculty labs each year, and more than 250 K–12 teachers engage in workshops that include cutting-edge research coupled with lab activities they can learn and take back to their classrooms. "The common denominator of the university's BSI programs is providing access to the tremendously exciting scientific enterprise here at UCB," Leinwand says.

A new HHMI grant will allow the university's BSI programs to continue to build on this success. With the python course as a springboard, new interdisciplinary research courses will be offered, ranging in topics from microbiomes in health and disease to vaccine development. Each will ask students to tackle a research project that draws from collaborative work already being done in labs at the university — from tissue engineering to molecular biology. "The idea is to make these research classes representative of translational interdisciplinary research," Leinwand says. "It is quite representative of where the field of biomedical research is moving."

AWARD: $1.8 MILLION

High school and middle school science teachers investigate stream ecology and aquatic insect diversity through a Biological Sciences Initiative teacher workshop taught by in a University of Colorado at Boulder scientists, including Cesar Nufio.
Photo: Norma Sánchez

UNIVERSITY OF DELAWARE

Bringing Math Home to Bio Majors

To analyze data, biologists use statistics. The tools of calculus help them arrive at the rates of diffusion across cell membranes, the weights of proteins, and animal population models. But these aren't the kinds of examples likely to land on the chalkboard in a typical college math course. "Many of the examples used in calculus are based on physics or engineering," says Hal White, a biochemist at the University of Delaware and the university's HHMI program director. As a result, undergraduate biology students often struggle to see how math relates to their field at a time when biological research is increasingly quantitative, White says.

With support from HHMI, Delaware has set up a section of the required core calculus course. It covers the same material as the other sections but is punctuated by examples that are relevant to what the students are learning in their biology courses. The university has also established a quantitative biology major in the mathematics department for students who are equally interested in biology and math. They take classes in both departments and tackle cross-disciplinary problems, such as how an egg—with an impressive degree of mathematical precision—blocks multiple sperm from entering at the same time.

The other part of the equation is integrating more math into biology classes. "One of the difficulties that we have is, oftentimes, the TAs or faculty teaching these courses don't feel comfortable with the math, so it's often a self-perpetuating problem," says White. The university will bring in students with a math background to help biology students analyze their data in advanced laboratory classes. These labs have no predetermined outcome, so students must draw on mathematical concepts and statistical techniques to interpret the results of their experiments. "I think if biology students become more aware of how mathematics are used in biology and graduate with a sense that they're not afraid of mathematics, that would be a great success," says White.

White and his colleagues will share these resources through an annual quantitative biology summer institute run by Delaware, Emory University, the University of Arizona, and a consortium of other institutions.

AWARD: $1.2 MILLION

UNIVERSITY OF FLORIDA

Dual Mentoring Program Broadens Student Perspectives

Many students enter the University of Florida eager to dive into scientific research. They have completed advanced placement classes in high school and arrive on campus well versed in the basics of science and ready for some hands-on experience.

Since 2006, funding from HHMI has helped the university bring meaningful research experiences and valuable mentor relationships to students early in their college careers. Across the sprawling, 50,000-student campus, eight colleges and 50 departments are participating in the UF/HHMI Science for Life program. To date, 215 undergraduates have worked on faculty research projects, and students in the program have become coauthors on 57 research papers. As a result, more students and faculty want to be involved, says Ben Dunn, a distinguished professor of biochemistry and molecular biology and the HHMI program director.

Part of a new $1.2 million HHMI grant will give students the chance to participate in a new dual-mentorship program. They will learn from two faculty collaborators from different disciplines—most often a basic scientist and a translational scientist—how to apply scientific understanding to a practical problem in human health. For example, a student could work with a professor of chemistry who is creating a new compound to fight infection and then observe the compound being tested in a mouse model or in patient studies. Another student might join a team that brings together a mechanical engineering professor who studies movement of artificial joints with a surgeon who replaces knee joints. The students will learn about the different philosophies and approaches used in the two complementary laboratories.

"A student can make connections by doing time in each lab," says Dunn. "Everybody who goes into an applied area needs a strong grounding in the basics. This is a way to enrich that and give basic science students an understanding of how their research may be used."

AWARD: $1.2 MILLION

UNIVERSITY OF MARYLAND, BALTIMORE COUNTY

High Expectations Mean High Achievement for Students

To Michael Summers, boosting diversity in the science community requires creating the right conditions: assembling a group of high-achieving students, insisting they set high goals for themselves, and giving them early research experience and mentoring. "It's about taking students who we think have the best chances of becoming tomorrow's leaders, and making sure that they're not lost in the process," says Summers, an HHMI investigator and director of the HHMI Scholars Program at the University of Maryland, Baltimore County (UMBC).

The Scholars program, which began in 2002, was modeled on UMBC's successful Meyerhoff Scholars Program, which has supported hundreds of students from groups traditionally underrepresented in the sciences and is cited as a model for boosting minority participation in science and engineering graduate programs. Undergraduates are matched with research labs and provided the support that creates an expectation of achievement. As Summers—a longtime mentor in the Meyerhoff program—likes to point out, Meyerhoff Scholars are five times more likely to enter graduate school and twice as likely to have science careers as those who were offered the scholarships but declined.

The HHMI Scholars Program nurtures students during their vulnerable first and second years and explains science careers to the students' families. It also requires the students to do research outside of UMBC in the labs of HHMI scientists, with some students participating in HHMI's Exceptional Research Opportunities Program (EXROP). And the results have matched those high expectations: 33 of the 35 students who have graduated so far have enrolled in a biomedical graduate or professional program.

With the new HHMI grant, UMBC will increase the number of HHMI Scholars from seven to nine per year. Summers expects to spend even more of his time helping other universities establish similar programs. Many schools have high-achieving students from underrepresented minority groups who want to become scientists but don't know how to make it happen. "A lot of people are interested in setting up a culture in which students know that excellence is expected of them."

AWARD: $1.5 MILLION

UNIVERSITY OF MARYLAND, COLLEGE PARK

Murky Waters Make Science Real

The Chesapeake Bay, the largest estuary in the United States, supports a rich diversity of plant and animal life. But pollution and poor water quality threaten those ecosystems and have a significant impact on the 17 million people who live in the Chesapeake watershed. The University of Maryland is betting that bringing the waterways and beaches of the Chesapeake Bay directly to students will produce citizens who understand how scientific research can help them take better care of their environment.

The long-time HHMI grantee will use a portion of its new $1.5 million grant to partner with the nonprofit MDBio Foundation to bring its mobile laboratory to high schools throughout the state for one-week visits. When the 18-wheeled biotechnology lab rolls up to the schools, it will bring with it equipment to test water samples for microorganisms that indicate fecal contamination. Students will isolate and quantify bacterial strains from samples collected from their own neighborhoods and from the bay and its associated waterways. Undergraduates at Maryland will then apply recombinant DNA and bioinformatics methods to identify the specific bacterial strains. This research will allow them to use the laboratory and data analysis methods they have learned in their courses for a real-world purpose. A project website will let students compare their findings with those of other students and gain a broader view of water quality in Maryland.

Through the results of their work in the mobile laboratory and related classroom lessons on watershed ecology, students will learn about the effects of the bay's health on its surrounding communities and how their own behavior influences the health of the bay. "The take-home message," says Norma Allewell, dean of the college of chemical and life sciences, "is that human activities often affect the environment in ways that impact human health."

Testing local waters with the same techniques used by official monitoring agencies lets students see firsthand the practical applications of science, Allewell says. When students discover for themselves what lurks in the waters that their families depend on for food, work, and play, their perceptions of the environment may be transformed. "We hope to energize students to save the planet," she concludes.

AWARD: $1.5 MILLION

UNIVERSITY OF MIAMI

Attracting Students to Science by Focusing on Family

One challenge facing many schools is how best to attract first-generation college students and those from groups traditionally underrepresented in the sciences to pursue careers in science. Since 1994, the University of Miami (UM) has used support from HHMI and the National Institute of General Medical Sciences to build a highly successful bridge program that helps students from nearby Miami Dade College (MDC) transfer to four-year institutions, including highly selective colleges and universities. Most of those students complete bachelor's degrees in the sciences.

The bridge program supports about 15 new Bridge Scholars per year. More than a quarter enroll in Ph.D. programs, says HHMI program director Michael Gaines, and about 30 percent go to medical school. MDC is the largest community college in the country, graduating more minority students than any other two-year college in the U.S. Since 1998, 275 HHMI-supported MDC and UM undergraduates have received B.S. degrees in a science, technology, engineering, or math field.

Despite Miami's impressive history in preparing undergraduate students from underrepresented backgrounds to succeed in science, the school sees an opportunity to do more to support those students pursuing graduate science degrees. To that end, UM is using a portion of its new $1.4 million HHMI grant to spearhead an approach that focuses on those students' families.

"We felt it was really important to bring families in," says Gaines, a professor of biology. "We know our Bridge Scholars are more likely to choose careers in research if their parents support that choice."

As part of the MDC bridge program, families of MDC students will be invited to campus for "Family Science Sundays," where they will conduct a one-day research project and interact with faculty members. Projects will include using DNA fingerprinting to solve a mock crime and looking at the effects of pollutants on sea urchin development.

The parents love it, Gaines says. "They gain a better understanding of what it means to be a research scientist and have fun, to boot," he notes. Over the next four years, Gaines and his team will develop new Science Sunday research projects, involve more faculty, and assess the effectiveness of the new approach.

AWARD: $1.4 MILLION

UNIVERSITY OF MINNESOTA, TWIN CITIES

From Lab Head to Head of the Class

For postdoctoral researchers, teaching can be as big a challenge—and as rewarding an endeavor—as unraveling the knottiest of problems in their fields. But too often, postdocs find themselves at the head of the class with only minimal training, an experience that can be frustrating for student and instructor. The University of Minnesota wants to change that teaching trajectory. With the help of an HHMI grant that will support a range of initiatives, the university will be able to offer more thorough and meaningful training for science postdocs.

Historically, postdocs have learned to teach primarily through an isolated and haphazard process of trial and error, says Robin Wright, the university's HHMI program director. "We need to make our classrooms as open and available for analysis and critique as we make our research," she says. "It's not the culture now, and we need a culture change."

The grant will ultimately support eight postdoctoral HHMI teaching fellows, who will select mentors from a faculty group with expertise in educational research and curriculum development. In a weeklong conference on science education, the fellows and supporting faculty will discuss effective teaching methods, as well as design and revise educational materials.

With the support of faculty mentors, the fellows also will be charged with developing courses for new curriculum initiatives in math and science at the university. By linking faculty development with course development, both the university and participants will reap rewards. The university will benefit from the postdocs' teaching innovations, while the postdocs will be able to do work that can influence courses and programs for years to come. "The creativity and energy of these postdocs will help us move forward," says Wright.

Teaching science may seem much different from doing science, but Wright believes that with the right mindset and training, the similarities become obvious. "We want postdocs to understand that there is a science that underlies effective teaching, and they can apply that science in a way that will make them more effective teachers," she says.

AWARD: $1.5 MILLION

UNIVERSITY OF MISSOURI, COLUMBIA

Preparing Young Scientists to Communicate

Whose job is it to convey scientific discoveries to the public? Many scientists would say, "Not me." But, traditional newspapers and other media outlets have been hit hard by the economic downturn, which offers scientists an unprecedented opportunity to communicate directly with the public. And the University of Missouri, Columbia, plans to help them do it.

"Communicating in understandable ways has not been part of the normal training of scientists," says Jack Schultz, professor of plant sciences and the HHMI program director. "We're going to try to change that."

The university will use part of its $1.5 million HHMI grant to create an interdisciplinary program with the renowned University of Missouri School of Journalism to prepare up-and-coming scientists to communicate with—even educate—the public.

"We want people to understand the value of what we're doing," Schultz says.

A select group of sophomores, juniors, and seniors will receive support to do full-time summer research plus spend two part-time semesters in a research lab. These HHMI undergraduate research fellows will meet weekly with graduate student mentors to read and discuss popular media reports of topics related to their research area and understand how the lay media reports scientific information.

Undergraduate journalism students will be embedded in research labs with the fellows and will collaborate to create and contribute to the Online Media Lab, a new science media portal that will carry traditional print stories as well as videos, podcasts, and blogs produced by the students. The students will also use emerging social media tools, such as Facebook, Twitter, YouTube, and Flickr. The National Newspaper Association will make the students' stories available to more than 2,400 U.S. newspapers, and a media tracking service will determine which of their stories are picked up by the press or viewed online.

The journalism students will be exposed to how science is done and the scientists-in-training will learn to communicate in a way that engages the public. Schultz hopes the journalists will frequently ask the HHMI fellows, "So what? Why would my readers care about this?"

"The presence of journalism students will encourage the science students to pay attention to the broader meaning of their work," he says.

AWARD: $1.5 MILLION

UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL

Exceptional Opportunities for Exceptional Students

Among the most vexing challenges facing scientists today is devising effective strategies to significantly increase diversity in the research community. The University of North Carolina at Chapel Hill has taken a first step toward that goal with its Carolina Covenant Scholars Program, which attracts gifted students from low-income families to the university. Now, an extension of that program will encourage some of those students to pursue biomedical research.

The HHMI Undergraduate Research for Future Scientists and Clinicians Program will help 12 Carolina Covenant Scholars undertake original research in biology or chemistry each year, as part of a broader science education initiative supported by HHMI.

Most summer undergraduate research opportunities last for a single season, but participants in the UNC program will continue their work the following summer. Project director Patricia Pukkila says extending research beyond a single summer heightens students' dedication and performance. "What students produce in that second summer is mind-boggling," she says. "They're presenting at prestigious meetings, they're winning scholarships, and they're coauthoring publications in top journals." The result is improved confidence and, often, a commitment to a career in science, she says.

Students will work alongside faculty and graduate-student mentors, who provide research support and career guidance. In their second year of the program, students will be expected to help and advise first-year students. The goal is to build a support system that will ensure students have every opportunity to succeed. "When we can provide empowerment, information, and the means to pursue science, students can begin to imagine themselves in science careers," says Pukkila. "They realize the benefits. And that is incredibly invigorating."

Giving skilled students from underrepresented communities the tools and support they need to develop careers in science requires concerted efforts—but the payoff will be a more diverse community of scientists bringing new approaches to modern research problems and questions.

AWARD: $1.3 MILLION

UNIVERSITY OF NORTH TEXAS

Meeting Students Where They Are

The University of North Texas (UNT) knows its unique student population. It has the largest number of transfer students in Texas, and half of its students qualify for federal financial aid. That means many students are forced to fill their "free" time with paying jobs instead of laboratory research.

With those students in mind, UNT will use a portion of its first $1.3 million HHMI grant to encourage a successful transition for students from community colleges to the four-year school and expand research opportunities to more students.

The HHMI Transitions Summer Workshop will bring first-year community college students to UNT each summer for a five-week program teaching academic success skills and introducing research methods. Part two of the program, the HHMI Transitions Summer Research Experience, will provide second-year community college students with faculty-mentored summer research experiences.

UNT also intends to create the Classroom Research Laboratory (CRL) to offer classes modeled on HHMI's National Genomics Research Initiative, in which students are engaged in authentic research experiences under the close supervision of teaching faculty. The CRL will enable the addition of four new research laboratory courses. It will also enable expansion of the freshman-level mycobacteriophage genomics laboratory course UNT began offering this year as a member of HHMI's Science Education Alliance. With this new space, up to 72 additional students per semester will have a research experience.

"It's real research; we don't know what the answers will be," says Lee H. Hughes, assistant professor of biology and UNT's HHMI program director. "Providing this class means we can get students excited and maybe they'll go on to do more research in another faculty member's lab," he adds.

The HHMI Undergraduate Researchers Program will provide financial support for UNT juniors and seniors for one year in a biology or biochemistry lab. For example, UNT students might address the question of how bacteria respond to stress. Researchers have identified genes that are involved in stress responses but not what role they play.

"Exposure to research is invaluable," says Hughes. "Students can take those experiences and it will jumpstart their future graduate careers or whatever path they take with biology."

AWARD: $1.3 MILLION

UNIVERSITY OF OREGON

Improving Science Teaching for the Next Generation of Students

Students taking the typical college science course know the drill: the professor lectures, writes on the board, and asks a few questions. Students take notes and read textbooks. In a large introductory science class, any in-depth discussion waits for a recitation section or tutorial led by a teaching assistant later in the week. Many courses are run this way simply because that's how it's always been done, says Judith Eisen, professor of biology at the University of Oregon.

"People who teach science at the college level don't typically receive a lot of training in pedagogy, so they teach as their professors taught," says Eisen. "A lot of it—especially the lecture part—was not very interactive, and it's sort of a passive learning experience."

The University of Oregon is now embarking on a project it hopes will change the way faculty teach general science classes. The Science Literacy Program (SLP), funded by an HHMI grant, will help faculty from four departments—chemistry, physics, biology, and geological sciences—transform the classes they offer to non-science majors.

The SLP will train faculty in teaching strategies that are known to be effective and will encourage them to share that knowledge with their colleagues on campus. The school will also select a number of undergraduate and graduate science students as SLP fellows, who will learn the teaching methods and help professors plan and teach the courses. "That's very good training for scientists to learn how to speak to the broader public," says Michael Raymer, professor of physics. "Teaching science to non-majors is really perfect training for that kind of skill development."

New courses will span departments and incorporate more interactive, inquiry-based learning techniques. For example, faculty from physics, biology, and geological sciences will collaborate to teach a course called "Scientific Revolutions—Major Advances That Altered Our Understanding of the World." Through interdisciplinary courses, the SLP program aims to improve the scientific literacy of all students, giving them the tools to make decisions in their daily lives that involve science, health, and technology, Eisen says. And by training students as teaching fellows, the University of Oregon hopes to improve the quality of science teaching for the next generation.

AWARD: $1.5 MILLION

UNIVERSITY OF PITTSBURGH

Building Community into the Undergrad Research Experience

The standard model for undergraduate research has a lot going for it, says Graham Hatfull, chair of the biology department at the University of Pittsburgh (Pitt). Students spend a summer or two doing a research project, often get drawn in by the experience of first-hand discovery, and sometimes go on to graduate or medical school. "It's all positive," he says. But there is room for improvement at many institutions, he adds: "The concern that we have is that it lacks community."

With support from HHMI, Hatfull and his colleagues have been working to bring that crucial element into undergraduate research. Rather than placing students in labs and leaving them alone for the summer, the program is structured so students can continually learn from one another. A portion of the university's latest HHMI grant—which will also help improve how science is taught—will be used to expand students' opportunities for mentorship and peer-to-peer support.

Students start the summer with a two-week workshop, where they learn basic techniques in molecular biology. Then they split off to work in the research labs where they'll spend the summer. They have formal and informal opportunities to discuss their research with peers and get valuable feedback. In pairs, they go to regular mentoring sessions, where they talk about issues such as how to help someone learn a technique or how to resolve conflicts. Hatfull says it is part of developing successful members of the research community. "I think that with the opportunity to do a cutting-edge research project comes the responsibility to serve as an educator," he says, adding that becoming an educator often starts with becoming a mentor.

The fabric of community created in Pitt's summer program will now stretch into the academic year, where students will work under the mentorship of a postdoctoral researcher in a new facility dedicated to undergraduate research. The teams of students will work toward a common research goal—aligned with the research interests of the mentoring postdoc. The approach enables students to bring their interests and skills to an interdisciplinary setting, where they are encouraged to share ideas and solve problems together. Students benefit, and the postdoc gains experience teaching undergraduates and running a research team.

AWARD: $1.2 MILLION

Research fellows Devon Jackson and Margot Goldberg from Dr. Tia-Lynn Ashman's lab discuss pollination of Mimulus guttatus, the common monkey flower, in the biology department greenhouse. Goldberg researches sex chromosome evolution in plants while Jackson's work focuses on the effects of multiple pairs of chromosomes in plants, like strawberries.
Photo: Tom Harper

UNIVERSITY OF TEXAS AT AUSTIN

Front-Loading Research for Student Success

Plum undergraduate research assignments tend to go to students who have already run the gauntlet of introductory classes, labs, and major requirements. While this approach rewards dedication, it can also close doors for talented students who aren't quickly convinced they want to pursue a career in science. The University of Texas at Austin is finding ways to engage more students in research earlier, says Sarah Simmons, the school's HHMI program director. "Instead of just letting the most persistent, high-flying students get access to precious resources, we decided to expose as many students as we could to research early on," she says.

With the help of a 2006 HHMI grant, the university created year-long Research Streams for freshmen, a program that will grow with the school's most recent grant. Research streams allow students to tackle small parts of faculty members' research agendas. "When you allow students to get excited about science by trying it, it lays the foundation for all kinds of success later," says Simmons.

Some 500 students each year participate in research streams already. The new grant—the scope of which also includes faculty development and outreach to high school science programs—will make room for more students and include a focus on more cross-disciplinary research streams. It will capitalize on the spontaneous collaborations that have emerged between participating faculty in bioinformatics, biofuels, and biophysics. A new stream in algal genomics, for example, will marry molecular biology with bioinformatics, introducing students to a flourishing field of research with relevance to biofuel development. In another new stream, students will work in the lab and in the field to understand the evolutionary relationships between groups of organisms.

So far, the program's results suggest that early research experiences can catalyze further study in science—and improved performance in upper-level classes. The research streams have also improved the recruitment and retention of science students from diverse backgrounds. "We hope that the experience will either light a fire in them so that they become scientists, or if not, that they at least understand what scientists really do," she says. "We hope it's something that can inform what they do for the rest of their lives."

AWARD: $1.6 MILLION

UNIVERSITY OF WISCONSIN–MADISON

Bio Boot Camp Helps New Students Find Their Way

For many students, the first year of college can be both thrilling and terrifying. They must negotiate challenging schedules, learn new study habits, and find their place in a new social structure. Freshmen at the University of Wisconsin–Madison who are interested in the life sciences also face the risk of getting lost at sea: they must choose from more than 30 possible majors in 60 different departments. A new program supported by HHMI will help students navigate those options without floating adrift.

"Academic expectations [of new students] are huge, and it's also probably the first time they've lived on their own," says Teri Balser, an associate professor of soil science and director of the Institute for Cross-College Biology Education, who will lead the program. Her goals, in part, are to ease students' transitions from high school to college and usher those who are interested in research into the lab as quickly as possible, with a special focus on students from groups traditionally underrepresented in the sciences.

The program will begin with a week-long Mad Biology Boot Camp, bringing students together before classes start to give them a preview of college life and teach them to manage time and stress. As the semester begins, students will attend a seminar that introduces them to the scientific process and big-picture subjects such as evolution, energy, and stem cells. In conjunction with the seminars, the students will be mentored by more advanced students, who will share their own strategies for success.

To help these mentors, an existing course—Entering Mentoring—will also be expanded with the new grant. Developed by HHMI professor Jo Handelsman and her colleagues, the course trains graduate students and postdoctoral researchers to be better mentors in the lab, especially as they work with first-year students. The course will now be available to a wider population of students and faculty members.

AWARD: $1.4 MILLION

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Exploring the Nexus of Life Science and Engineering

The strict separation of basic and applied research has been showing cracks for decades, as scientists have been forced to find new approaches and develop new tools to confront increasingly complex challenges. Yet, at Virginia Polytechnic Institute and State University (Virginia Tech), few students are being trained to use the interdisciplinary strategies that are needed to confront many of today's most important scientific problems.

That is about to change, with the help of Virginia Tech's $1.4 million science education award from HHMI—the university's first. The weakening wall between engineering and the life sciences is about to be torn down.

To help undergraduates acquire the knowledge and skills they will need to address the scientific challenges of the future, the school is developing a "Scieneering" minor that will unite life sciences with engineering. Students who pursue the Scieneering minor will take courses in departments outside their major and participate in seminars exploring topics at the interface of science and engineering. "They will also be required to complete their capstone research project in a laboratory outside their major discipline," says Daniel Wubah, Virginia Tech's vice president and dean for undergraduate education. "That means a biology major will need to do their research in an engineering lab and an engineering major will go to a chemistry, biology, or physics lab."

The Scieneering program is Virginia Tech's first step toward developing an interdisciplinary undergraduate biomedical engineering program, building on a successful biomedical engineering graduate program already on campus.

"The idea is to do something innovative for the students to prepare them for the challenges they will face in their future careers," says Wubah. "It has been a goal of the administration to increase the number of students who get research experiences. That has been successful, but support of the Scieneering program will take us to the next level."

AWARD: $1.4 MILLION

WASHINGTON UNIVERSITY IN ST. LOUIS

Real Science Keeps Students Interested

Many undergrads learn about genomics from textbooks and lectures. At Washington University in St. Louis, freshmen in a special genomics course have learned by doing. Working in small teams, they isolated and sequenced the DNA of phages—bacteria-infecting viruses that look like something out of *War of the Worlds*, only in nanoscale. "It not only taught them about genomics and genomic analysis but also resulted in a real contribution to our knowledge base," says biology professor Kathryn Miller.

The course, part of HHMI's Science Education Alliance, is just one piece of a widespread effort to change how science is taught at Washington University. That experience will shape how the university utilizes part of its new HHMI grant, which is aimed at helping faculty members make changes throughout the curriculum so that teaching and learning about science better reflect the scientific process. "These curriculum projects allow faculty to collaborate across departments and cross-fertilize ideas of how to teach, what to teach, and how to support the students," Miller says. "They encourage faculty across the university to think creatively about their teaching and about how to engage students successfully."

One important goal is to bring authentic research experiences to more students. To do that, the university will incorporate a streamlined version of the phage research project into the standard introductory biology lab course. The phage course will also become an integral part of an introductory computer science lab. "Students in introductory computer science classes will be using biological examples for some of their programming projects," Miller says. "That's one of the projects that we're most excited about."

The faculty members are also excited about making changes to large classes—organic chemistry, immunology, and introductory biology—so the classes focus more on students' understanding of how scientists ask and answer questions, with students working in groups to solve scientific problems. And students like the changes too. After the recent introduction of real-world experiments to an undergraduate physical chemistry lab, Miller says, "It went from a course taken by a fraction of the chem majors to something that's very popular and bulging at the seams with students who seem very enthusiastic about what they're doing."

AWARD: $1.6 MILLION

Washington University undergraduates Andreas Mitchell and Kemi Aladesuyi practice their micropipetting technique in preparation for conducting research as part of a program for incoming freshmen.
Photo: Amy O'Brien

WESTERN MICHIGAN UNIVERSITY

Building Better Teachers Through Research

Students who hope to become middle or high school science teachers often have a hard time landing summer research opportunities, which are more likely to go to students planning research careers. Western Michigan University, which has one of the largest teacher-training programs in the nation, thinks this is cause for concern. And so, with the school's first HHMI grant, students pursuing science education will now have more opportunities to participate in cutting-edge research. "We want them to get the content knowledge that they need, but we also want to train them as practitioners, so that they see themselves as part of the science community," says Susan Stapleton, the school's HHMI program director.

Western Michigan will offer 15 research internships for education students the summer before their junior year in areas ranging from neurobiology to nuclear physics. Students will work closely with faculty mentors and get firsthand experience with the skills they'll eventually be teaching their students, from navigating primary literature to generating hypotheses and gathering data. "When teachers have enthusiasm not only for the knowledge of science but also for the practice of science, they'll be able to instill that in their students," says Stapleton.

The internships, which include weekly group seminars, will give the aspiring teachers a starting point for thinking about how to bring the excitement of research into classrooms. Over the long term, Stapleton hopes the students will maintain relationships with their research mentors and receive guidance on how to keep their lesson plans up to speed with the latest scientific ideas and methodologies.

Recognizing teachers as members of the scientific community starts by treating them as colleagues in the lab, says Stapleton. Taken back to the classroom, a research experience may lead to innovative teaching and inspired students, which she believes will be successful and measurable outcomes of their HHMI-supported initiative.

AWARD: $1 MILLION

YALE UNIVERSITY

Cross-Disciplinary Training for Future Physicians

Molecular biology, organic chemistry, and calculus are standard fare for students with medical school in their sights. But treating these courses as stand-alone subjects doesn't always prepare students to do the kind of cross-disciplinary thinking that will be required of them as medical students and physicians working in complex clinical settings. To better tailor the premed curriculum to the needs of future physicians, Yale University is developing a cluster of new interdisciplinary courses that devote special focus to the concepts most relevant to medicine.

Yale has garnered 21 years of continuous HHMI funding to improve undergraduate science education. The grants have allowed the university to create mentor networks for female students, to broaden opportunities for students from disadvantaged backgrounds, and to help both professors and postdocs learn how to teach more effectively.

In keeping with that tradition of innovation, the new premed curriculum draws on the recommendations of a 2009 report from HHMI and the Association of American Medical Colleges called the *Scientific Foundations for Future Physicians*, says program director Robert Wyman. Preparing for a career in medicine requires understanding traditional scientific concepts, the report's authors wrote, but it also calls for the ability to apply one field of knowledge to another. Premed courses, they advised, should be interactive and interdisciplinary.

Wyman agrees. In one of Yale's new courses, students will learn about quantitative approaches to biological problems. Another course will link evolutionary biology and medicine, tackling topics such as the evolution of disease-causing viruses and bacteria, the development of drug resistance, and the emergence of new diseases.

HHMI support will also extend an existing rainforest biochemistry course created by HHMI professor Scott Strobel. Currently, course participants travel to a South American rainforest to collect samples of microorganisms that live inside plants. They return to Strobel's Yale laboratory to analyze molecules made by the microorganisms, looking for natural products that could lead to future medicines. HHMI funding will now allow students to continue these projects in the labs of other Yale scientists.

As with previous efforts, outcomes of the premed curriculum changes will be monitored carefully, Wyman says. "Success is even more important to us than innovation."

AWARD: $1.6 MILLION

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