

# Time, Money, Mentors:

OVERCOMING THE BARRIERS TO UNDERGRADUATE RESEARCH

By Kathryn Brown

**H**ow do you find FSH receptors on dog-fish gonad cells? That question, unlikely as it seems, sparked Zed Mason's love of science. To fulfill an undergraduate honors program at the University of North Wales, Mason undertook his first research project on those receptors. "It was the most daunting—and exciting—thing I'd ever done," Mason says. He was hooked.

Today, Mason is a marine biologist at California State University, Long Beach. A believer in passing the torch, Mason participates in a new HHMI-funded program to give undergraduates their own shot at lab life. "At least a quarter of my students could probably be better scientists than I—you just have to generate that spark," Mason says. And he's not the only one hoping to light a fire or two. At colleges and universities across the country, researchers are looking for new ways to nudge promising researchers into the lab.

But first some barriers must be overcome. With the pressure of submitting



MELISSA GOODLETT/TTU

*Katie Kennedy carries out research on ovarian development with mentor Vaughan Lee at Texas Tech University.*



*Marc Orbach (left) guides University of Arizona student Michael Bolaris in gathering soil samples for a research study.*

grant proposals, writing papers and teaching courses, who has time to mentor? With little pay—or prestige—offered by most schools for spending hours with a curious kid, who can justify the extra effort? And, although they often learn quickly and make important contributions to a research project, undergraduates don't always make the easiest protégés. Here this year and gone the next, they have little time to master techniques or see a project through to the end. Even when mentor and protégé are willing, everyday logistics—lack of lab space, for instance—can come between them.

“Undergraduates tend to get lost,” says Tory Hagen, a biochemist at Oregon State University in Corvallis. The good news is that some schools have decided to tackle the problems that commonly discourage undergraduate research. In the process, they have demanded more—from themselves and their students.

### STRETCHED STUDENTS

Long before most undergraduates even consider the lab, their calendars are crammed. “The kids in our summer

HHMI program tend to be pretty talented, and they often overcommit,” says Carol Bender, director of the undergraduate biology research program at the University of Arizona. Whether playing in the university orchestra, volunteering at local hospitals or serving in student government, these undergraduates have plenty to do, and packing in weekly blocks of time in the lab can be hard.

The University of Vermont has been creative in meeting this challenge. Rather than schedule a hefty lab project smack in the middle of the semester, the university serves up a measured dose of research-related experience year-round, with preparation for intensive research built into the process. In the spring of their junior or senior year, students choose mentors and write grant applications to compete for summer research internships. Their proposals include a research hypothesis, a description of experimental methods, a timetable and a budget. What's more, the students must pitch their proposals to an academic panel, which selects the scholars each year. “Our students aren't just in a lab with an adviser telling them what to

do,” says Vermont biologist Judith Van Houten. “They really have to think through their projects and make them work.” With more expected of them, and a little help managing the schedule, students typically rise to the challenge.

Over the summer, the research scholars at Vermont conduct their projects with faculty mentors, earning about \$3,500 for their efforts. In August, after the last beaker has been washed and shelved, the students present their study results to their peers and mentors. Finally, they meet periodically through the next year to hear guest speakers and stay in touch. “The students asked us to help them stay together, to network and make this experience stretch year-round,” Van Houten says. Real work, mentors and peers are the spark as these University of Vermont students experience the culture of science at an early age.

And the earlier the better. To provide for plenty of mentoring and hours at the lab bench, Kansas State University actively recruits second-semester sophomores for biology research. “By getting them earlier, we give students a better chance at

undergraduate biology success,” says KSU biologist Brian Spooner. At the start of their senior year, some biology undergraduates at KSU have a full two years of experience, and some see the results of their research submitted for publication.

### PRESSURE AT THE PODIUM

Sometimes it’s not the lack of time or opportunity but overbooked faculty that dampens the enthusiasm of science students. At the University of Michigan in Ann Arbor, biology majors can earn research course credit in schools ranging from public health to dentistry. Occasionally, students have complained that they were just an extra pair of hands for

For faculty swamped with competing commitments, a major issue is support. Prospective mentors on the tenure track often face a dilemma: If researchers need five publications to win tenure, can they afford the time—or earn professional recognition—for taking on students? “At Cornell University, the majority of professors do take undergraduates into their labs,” says Michael Goldberg, a biologist at the university. “But it’s a fair investment of time. It’s hard to choose a good project for an undergraduate, for instance, since they often won’t be in the lab long enough to master that many techniques.”

Schools that emphasize faculty involvement in teaching are naturally more like-

courses, when going up for promotion or tenure, Hagen says. “We are thoroughly encouraged, in both attitude and deed, to help undergraduates undertake research projects in our labs.”

Good mentoring flourishes less often in schools that don’t reward it. “There needs to be some sort of calculation in the system so researchers get credit for mentoring,” says Mason. The time spent with an undergraduate has definite value, often motivating the first step to a science career. When a school or funding agency evaluates a researcher’s teaching efforts, mentoring should always count, Mason says. “What will the students who benefit bring to the rest of their careers?” he asks. “It’s substantial.” Mason’s students have gone on to graduate degrees in genetics, neuroscience and other fields at universities across the United States.

Even for eager students and motivated mentors, sharing a spot on the lab bench requires the right logistics. Despite outside funding, there are limits on lab space. At Vermont, for instance, less than half the hopeful students win a coveted HHMI summer research slot. Van Houten and others at Vermont have begun to seek extra funds to expand the opportunities, asking university departments or funding agencies to match their outside grants—and they have had some success. In other cases, would-be mentors find room in their own research budgets to hire summer applicants who otherwise wouldn’t see time in a lab.

### IF YOU BUILD IT, THEY WILL COME

Mason and others at Cal State Long Beach are taking a different tack. To offer biology students more research experience, they’re building an honors curriculum. Instructors will teach a broad range of relevant subjects, from critical thinking to research design and scientific writing, and seniors in the program will earn a year’s paid position in a faculty lab. “One key strategy is to offer a stipend that outpays what they’d earn in casual employment, some place like McDonald’s,” Mason says.

Cornell has found a way to introduce students in early biology courses to the culture of science. Each semester, students in two introductory biology courses venture off in small groups for



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*Annette Fornos screens for mutants in the alga Chlamydomonas with Peter Luykx, her mentor at the University of Miami.*

a busy instructor, not real contributors to research. So the biology department launched what Julian Adams, who chairs the department, calls “quality control.” Each student-mentor team writes up a short description of its upcoming research project, including the student’s duties. This extra bit of clarification, Adams says, lets students and mentors alike know just what to expect from their shared time at the bench.

ly to promote undergraduate mentoring (see sidebar). At Oregon State University, for instance, Hagen says faculty attitudes make all the difference. “Research is clearly important, but teaching is a major part of why we’re here,” he explains. “I consider undergraduates a major, not peripheral, part of my lab.” That view gets hammered home at Oregon State, where faculty members list their mentoring duties, along with publications and

an afternoon's work with a faculty member in the lab or the field. "It's not meant to teach them the subject of what we do but how we do it," says Cornell geneticist Peter Bruns. "We want to connect students to the research culture—the creativity, discovery, self-reliance. We'd like to develop that vision."

In other classes, too, Cornell is sharing "the life of science" with students. One year, when lab-minded undergraduates outnumbered spaces at the bench, the genetics section created a hands-on course—students screened fruit fly mutants for an embryogenesis study. The one-time course was costly, says Goldberg, since it required a faculty member's close supervision and plenty of lab equipment. Still, he adds, the class gave students a chance to roll up their sleeves and try molecular biology firsthand.

Meanwhile, Cornell developmental

biologist Mariana Wolfner, working first with evolutionary biologist Amy McCune and then neurobiologist Ron Harris-Warrick, has created cross-disciplinary research seminars for students. Students read and present research papers and attend seminars given by visiting scientists. Afterward, the students get a chance to talk with the scientists about their research. "It's not a substitute for working in a lab," Wolfner says, "but it's far more cutting-edge than your standard science survey course can possibly be." The seminar series also soaks up time and money, so it's offered only sporadically. "Still, it's a very energizing experience for faculty and students alike," Wolfner says. People flock to the seminars, she adds, to hear how biologists nationwide are unraveling basic questions of, say, evolution or human development.

## THE TORCH IS PASSED

Exposure to real science pays off. Just ask Sathya Ravichandran, a senior at Oregon State who did a project last summer in Hagen's lab, exploring the role of excess iron in brain cells affected by Parkinson's disease. The low point was a three-week stint in which every new batch of cells came out contaminated. The high point was sifting through her data to draw research conclusions along with Hagen and his graduate students. As Ravichandran turns toward graduate school, she's grateful for the summer experience. "I know exactly what I'm looking for now," she says. "When I look at a school, I know I'm looking for a certain kind of project, a certain set of techniques, a certain number of researchers working together."

A future scientist—and mentor—Ravichandran is hooked.

## THE SMALL COLLEGE EXPERIENCE

When Haverford College biologist Philip Meneely needs to troubleshoot an experiment, he turns to his research colleagues: the undergraduates working in his lab. At Haverford and other small schools, professors and students work side by side, sharing disappointment and success alike. "There's a rare kind of closeness at a small school," Meneely says.

For research-minded students, small schools can offer an intensely satisfying lab life. Meheret Birru is a case in point. After considering several big and small schools, she settled on Kenyon College in Ohio. Now a junior, Birru has spent much of her time there in one lab, researching the expression of virulent *E. coli* genes. "The experience has been second to none," she says. "At big research universities, there can be a real disconnect between students and professors, with graduate students doing the teaching and mentoring. Here, that middleman doesn't exist, and we get so much attention from faculty."

But small schools also face unique challenges in providing undergraduates with rich research experience. Labs that rely heavily on transient undergraduates often feel a sharper loss when one student graduates and another rolls in. The constant flux of students means researchers are forever in transition, trying to design short-term projects and teach lab recruits the necessary techniques. Small schools also have fewer labs, leaving some students without a spot at the bench.

So at these schools, faculty members are learning to think out of the box—literally. At Earlham College in Indiana, for instance, biology

students have left campus for the past three summers to work in the labs of alumni at nearby drug giant Eli Lilly and Company. Another Earlham alumnus, immunologist Carter Van Waes, has welcomed interns into his lab at the National Institute on Deafness and Other Communication Disorders.

At Williams College in Massachusetts, even the youngest students can get involved. The school encourages all students to try research before they've settled on a major. For instance, Steven Zottoli, a biologist at Williams, brings freshmen and sophomores to the Marine Biological Laboratory in Woods Hole, Massachusetts, for programs that provide a hands-on introduction to science. Some students get on track for a science major early, possibly heading toward a science career, but others do not. "From my perspective, scientific research is truly in the liberal arts tradition," Zottoli says. "All students should try it." Even students who do not choose a science career, he adds, benefit from trying something new.

Perhaps the biggest payoff for undergraduates who study science at small schools is the chance to find out just what they are capable of accomplishing. At Haverford, Meneely says, some waltz in with confidence from day one—but others discover themselves along the way. "As a mentor, the real reward is knowing you've had an impact on a student who might not have prospered in a different environment," Meneely says. "Sure, some students go on to become well-known scientists. But some are simply satisfied with their short time in the lab. They've accomplished things they didn't dream they had in them."

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