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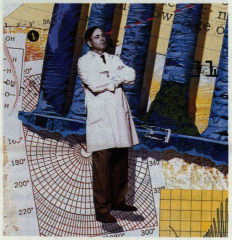
Of Mice and Mentors

A SEASONED SCIENTIST ADVISES A YOUNG RESEARCH APPRENTICE

I'M CROSSING HITT STREET IN FRONT OF MEMORIAL UNION EARLY ONE MORNING LAST SPRING AS A BIKER EMERGES FROM LOWRY MALL. MY MENTAL RECOGNITION ROUTINE KICKS IN—IT'S A SIGHT-AND-SOUND MIND-GAME I USE ALL THE TIME TO RAPIDLY IDENTIFY THOUSANDS OF PLANTS AND ANIMALS IN THE WILD: MOUNTAIN BIKE, TALL AND STEADY RIDER, MALE, MEDIUM LENGTH DARK HAIR, BENT OVER THE HANDLEBARS, SHORTS AND FIELD BOOTS, GREEN TOUR PACK.

Green tour pack! Bingo. Positive ID. It's Brett Ziercher from St. Charles, Mo., whooshing by me. Then I hear brakes squeal and his baritone voice, "Hi, Dr. Carrel. I've got to tell you what I'm doing this summer. You won't believe it." I turn and greet my advisee, now a senior majoring both in philosophy and in biology.

I first met Brett in the fall of 1994 when he was a sophomore entering my General Biology Honors class. Because I taught all of the biology labs and discussions, we had lots of chances to talk during and after class. He couldn't decide on a major—too many things interested him. But Brett had to declare his major soon, and he felt pressured to pick one subject. I told him that his dilemma was a good thing, that students should have myriad interests, that they should want to do several very different things with their lives, that they should see the University not as a trade school but as the vast repository of knowledge of humankind that it is. I suggested to Brett that he consider declaring



either a major in interdisciplinary studies, which includes courses in three departments, or a dual major, which is what he eventually chose.

One afternoon late in fall 1994, Brett told me that his frat house, Sigma Phi Epsilon, had bats by the dozen roosting uninvited in its attic. I mentioned that Professor Phil Jen, Mizzou's "Batman," might need animals for his studies on how bat brains process the high-speed echoes of their ultrasonic calls to pinpoint flying insects. So Brett and I headed for the Bat Lab. On the way, I suggested that Brett consider doing undergraduate research with Jen or another physiologist in our department.

This chance event proved productive. Sig Ep ridded itself of unwanted guests, Professor Jen collected bats for his project, and Brett started thinking seriously about research. Sure enough, early in February 1995, he strolled into my office to discuss research opportunities.

Brett's web of faculty acquaintances was growing into the realm of research, a one-on-one relationship in which students gain a great deal of skill in matters of science and research. They also observe and absorb the rigorous work habits of researchers as well as the less tangible but very hard-headed habits of thought that serve well in any profession. It's a rare thing in our country for undergraduates to work with first-rate scientists on origi-

BY PROFESSOR JAMES CARREL, 1997 FACULTY/ALUMNI AWARD WINNER
ILLUSTRATION BY R.J. SHAY

nal research—an opportunity that only a research university like MU can offer routinely. Departments across MU's campus have worked hard to make such opportunities available, especially in math, engineering and the hard sciences.

This work pays off every day for students, and it also paid off in generous grant funding during the 1990s from the Howard Hughes Medical Institute. Hughes funds totaling more than $2.3 million enhance these research programs. Other recognition has followed, but what such an award really means is that MU's students are living and learning in ways that few students in our country experience, ways that make the most of a research university's special faculty, facilities and mission, ways that prepare them well for life and work.

Apprenticed to a Researcher

As director of undergraduate research in the Division of Biological Sciences, I advise 40 to 50 students a semester about doing research. I ask about their scientific interests, career goals and workloads, and I outline the commitment required: perform 300 to 400 hours of lab work or other activities, write a project report and present the research in a forum, such as the Missouri Academy of Sciences annual meeting. Finally, I reassure students that their grade is based largely on the quality of their effort, not on the quantity of their data or the importance of their results. I think it's almost as valuable for students to work hard on an experiment and fail as it is to work on one that comes up with great results.

When Brett told me after the bat incident that he would stay in Columbia for the summer, I excitedly told him that he was well qualified for one of our prestigious Howard Hughes Medical Institute internships, which pay enough to replace summer-job savings. But the application deadline was just four days away, and he needed to hustle to find a faculty mentor and write a good research proposal. Two days later Brett returned, research proposal in hand. He was awarded an internship for summer 1995 on a study with important public health implications—the hormonal effects of trace amounts of the insecticide DDT in the diets of laboratory mice. This research, led by Professor Fred vom Saal, was part of an international effort to learn whether exposing women and their unborn babies to minute quantities of synthetic chemicals poses a significant health risk.

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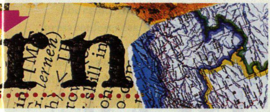
Brett understood the purpose of his research well enough. But he struggled to grasp the meaning of day-to-day events in the lab—new terms to learn, dozens of papers to read, examinations of thousands of mouse cells to conduct, and daily data records to keep. The tasks of a scientific investigator proved mind boggling—a typical reaction among novice research students. After 30 years, I still remember my struggle as a senior at Harvard, studying fire ant behavior to remember the "minutiae" while keeping the "big picture" in focus.

Even in this high-tech age of "big science," wherein lab groups often exceed a dozen people, students learn how to conduct original research by serving as an apprentice to one or a few team leaders. Learning one's way around a lab is time-consuming and intense. The same is true for ecological field research in which the flow of seasons often offers but one chance a year to do the test. One major slip-up and you have to wait a year to try again.

After Brett's summer internship, he continued on in the fall. But, as often happens, his interests shifted, and in winter 1996 he moved into the molecular neurophysiology lab of Professor Joel Maruniak. Here Brett expanded his skills into studies of enzymes in receptor cells lining the nose of the mouse—enzymes that break down toxic odors after they are inhaled. A year later he still worked with Maruniak, for a strong faculty-student bond had been forged between them.

What it's All About

A researcher's primary job is testing ideas in order to better understand the world. Collecting data and amassing facts are but means to this end. Most Americans don't comprehend modern science simply because they haven't ever done it. Or if they did, it was way back in the third grade when they tinkered with a broken bicycle. Tinkering works just fine in science, especially early on when you are just becoming acquainted with the object of your curiosity. But the best science usu-



ally requires that researchers formulate fairly exact questions. Such hypotheses result from careful reasoning and thoughtful design. That means we can teach the scientific process, and it's wise to do so. After all, research is the way that scientific knowledge advances in our increasingly technical society, and research is one of the engines that drives our national economy. In 1992, MU's biological sciences chair, John David, and I recognized that research also is a great capstone experience for our undergraduates. A novel element of MU's new General Education Program, the capstone experience is a way of asking students to crystallize ideas from many classes in their major.

Our goal is to teach about 30 percent of our 1,200 biology majors how original science is done by immersing them in it. We have 70 students a year doing research on such topics as depression in rheumatoid arthritis patients, diversity of birds in Costa Rican coffee plantations, genetic control of root development, and patterns of nerve regeneration in lampreys after spinal-cord damage. We do not wish to turn all or even most of our graduates into researchers, but we hope many talented and curious students will be inspired to pursue master's and doctoral degrees.

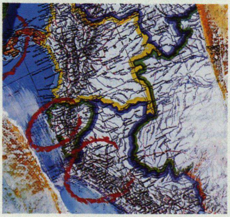
Research Comes to Class

Students often become interested in research because something in my general biology class piqued their curiosity. For instance, scientists are hotly debating the origin of birds from reptilian ancestors in the Triassic Period. Many believe that modern birds evolved from small, ground-dwelling dinosaurs called theropods, which had long hind legs for walking and short front legs for handling prey. But a few well-placed experts strongly argue that birds came from tiny, tree-dwelling lizards that had parachutes on their backs made from highly modified scales. Such competing models sharpen students' thinking about scientific problems because I ask them to devise a test that resolves the debate.

In 1994 I began to think about how to teach the art of scientific investigation in my general biology labs. In this case, individual apprenticeships weren't feasible. I wanted to structure the curriculum so that students could quickly become "para-experts," sufficiently knowledgeable about an organism that they could formulate a biological question and figure out a way to answer it. The real trick was to come up with an approach that would work for 20 lab sections a semester for less than $20 a student.

After two years of planning, I created a sequence of lab exercises in which students work with model organisms. These are plants, microbes or animals such as fruit flies and white mice, which work amazingly well in biological research from molecular biology to behavior and evolutionary ecology.

Just as I was formalizing my ideas for these new labs, the National Science Foundation (NSF) announced that it was going to grant major funding to just 10 institutions nationwide that demonstrate how to integrate research into undergraduate curriculum. My proposed biology labs were part of the campuswide grant



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proposal, which earned MU a $500,000 grant for three years from the NSF. Winning this grant shows how much faculty in science and engineering have improved teaching here. It also provides incentives to continue our innovations and lead the way into the next century.

Back to Brett on the Mall

That morning on Lowry Mall when Brett stopped his bike to talk, I expected his big news to be about lab work—some discovery about the mouse's nose. I was dead wrong. His excitement was about a once-in-a-lifetime adventure to Latin America. He was going on a three-country tour combining environmentalism, medicine and human values—in effect melding his biology-philosophy course work. After starting with a first-hand look at rural medicine and human nutrition in Costa Rican rain forests, Brett's group would proceed to Ecuador and climb from near sea level into snow atop one of the world's highest active volcanoes. Then they'd be off to Peru for a bike trip along ancient Incan footpaths in the Andes Mountains, ending at mysterious Macchu Pichu. I was ecstatic, for undoubtedly his life would be transformed by this experience. ❋

About the author: Biology Professor James Carrel is a 1993 winner of a William T. Kemper Fellowship for Teaching Excellence.