Student Dan Schuster discusses research on echocardiograph images with Dr. Kofo Ogunyankin. Photo by Andrew Campbell.
When undergrads are in the lab, everybody benefits

If you had to pick a word to describe Dan Schuster, it would be “motivated.”

Consider this image: Riding the University shuttle down to his research gig on the Chicago campus, Schuster dons a suit, clicks away on his iPhone, and shuffles through homework. The student next to him sleeps.

It’s this motivation that got Schuster (biomedical engineering ’11) a research position in the lab of Kofo Ogunyankin, assistant professor of cardiology at Northwestern’s Feinberg School of Medicine, and it’s this motivation that earned him a spot as a coauthor on published papers and as a speaker at an international cardiology conference.

“I realized quickly that research was what I wanted to do,” Schuster says. “I wanted to go beyond the schoolwork and apply the knowledge I was learning.”

Schuster is not alone in his pursuit of undergraduate research experience. Since 2005 the number of undergraduate researchers at McCormick has tripled. In the first four months of 2010 alone, 20 undergraduate researchers published papers. Over the past decade, McCormick undergraduates have coauthored more than 150 articles in more than 40 different journals and have participated in more than 65 academic conferences.

“At Northwestern we provide many activities for students outside the classroom: design opportunities, student government, sports,” says Julio M. Ottino, dean of the McCormick School as well as a professor of chemical and biological engineering and mechanical engineering. “Those who choose to perform research have the opportunity to use both sides of their brain — to be both analytical and creative — and the results have been fantastic. Our undergraduate research program has grown exponentially in recent years, and everybody has benefited from it.”

Undergraduates pursue research opportunities through work-study positions, for class credit, or even as volunteers. Some professors tape flyers around campus or post listings to the McCormick Undergraduate Research Society website; others snag students from their courses.

For Schuster, finding a position required persistence. During his first year at Northwestern, when most students were taking classes in search of a major, Schuster was already planning his postgraduate life. He knew he wanted to go to medical school (a hospital stay at age 10 to have his appendix removed convinced him he wanted to practice medicine), and he already had an interest in becoming an orthopedic surgeon. Despite having no research experience, he began sending e-mails to professors at Feinberg, looking for leads and asking if they needed any help in their labs. He pitched himself as a motivated freshman who, once trained, could provide them with four years of research work.

Ogunyankin answered the call. In his lab Schuster analyzes echocardiographic images — which are essentially sonograms of the heart — to help build a database for researchers to use in considering questions related to the function of heart ventricles. Schuster uses software to “speckle track” the echocardiographic images, analyzing the pixels to determine how the heart muscle is functioning. Since Northwestern Memorial Hospital’s heart transplant program is considered one of the best in the world, many of the echocardiographs that Schuster analyzes are those of transplant patients.

“I’ve definitely been exposed to the reality of the medical field, like the taxing hours,” Schuster says. “But I’ve developed my research skills, and that’s something you just can’t get in a classroom.”

Schuster even got a chance to present his work at an American Society of Echocardiography conference in June 2009, the week before finals. “I was introduced as Dr. Schuster,” he says. “I had to correct them. I didn’t want to get thrown any tough questions! I felt a lot of pressure to prove myself, but it went well.”

Schuster’s experience has changed what he thought were concrete career plans. Now he wants to be a cardiothoracic surgeon who does both research and clinical work — a model he found in Ogunyankin. “I’d like to find a balance like Dr. Ogunyankin has,” Schuster says. “Medicine is hard work, and it’s a lot of time away from your family. But the exposure I’ve gotten has helped me decide that it’s what I want to do.”

Learning how research works

The research interests of Marissa Krotter (mechanical engineering ’12) led her right to the top: the labs of Dean Ottino and Richard Lueptow, senior associate dean for operations and research and professor of mechanical engineering. As a scholar in the Murphy Institute (a program
that invites select McCormick undergraduates to engage in self-directed activities), Krotter had funding for a long-term research project, and she approached Ottino and Lueptow about working for them.

“I’m interested in fluid mechanics,” she says. “I’ve always been interested in how things move based on different forces. So I looked around on professors’ websites, and I liked what Deans Lueptow and Ottino were doing.”

Krotter started out with easy tasks — like helping to organize items in the lab and updating chemical lists — that act as both a litmus test and a way to introduce students to lab life, Lueptow says. “These undergraduates are extremely talented, and their help extends what we can do in the lab. It’s fun because they are so energetic and bright and are willing to ask naïve questions and do the routine work that needs to get done — and they do it better than we would!”

Krotter now spends 5 to 10 hours a week on her laptop, running programs that simulate a new kind of mixing called the cut-and-shuffle method, which mixes a material similarly to how cards are shuffled. Ottino’s and Lueptow’s experimental and theoretical research projects involve examining how fluids and granular materials mix, yielding applications for the geophysical sciences, medicine, microfluidics, materials processing, and nonlinear dynamics.

The modeling that Krotter does requires her to write code in MATLAB, a high-level technical computing language and interactive environment for algorithm development. Her computational experiments quickly reached a level that allowed her to collaborate with a doctoral student in the Department of Engineering Sciences and Applied Mathematics, and her data could provide the basis for a mathematical theory that lies behind the mixing. “I have learned so much about the research process,” she says. “I’ve never been involved with anything like this before. It has been a great opportunity to learn about what you actually do when you do research.”

“Of the fun things about working with undergraduates,” says Lueptow, “is that they really don’t understand how research works yet. In high school they are trained in the scientific method, which isn’t the way research is done. Instead it builds on previous research, and it’s more curiosity driven than hypothesis driven. It didn’t take Marissa long to understand that idea.”

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JULIO M. OTTINO

and plans to give a talk at a regional conference this fall. In the meantime, she continues to meet weekly with Lueptow, who considers the meetings “one of the highlights of my week.”

“Marissa has been great,” he says. “We know that our students are some of the best there are. Conducting research really provides them with benefits in the long run, no matter what career they choose.”

Giving graduate students a chance to mentor

On any given day Mitra Hartmann, associate professor of biomedical and mechanical engineering, could have half a dozen graduate students and up to a dozen undergraduates working away in her lab. Hartmann’s laboratory uses the rat whisker system as a model to study how the brain integrates tactile information with movement. The research requires students to learn a tremendous variety of skills, from numerical modeling to training rats to perform tactile discrimination tasks.

Because of the large number of students involved in research and the diversity of skills required, Hartmann and her graduate students have developed a mentoring system as efficient as the experiments themselves: as each graduate student progresses through the PhD program, he or she gradually assumes more responsibility for mentoring undergraduates. This helps ensure increased help for graduate students as their thesis projects become more complex and gives undergraduates high-quality research experiences.

“There is a significant time and resource investment in training undergraduate students,” Hartmann says. “At least initially, it requires almost daily one-on-one interaction. Graduate students can provide that, and it gives them a chance to gain mentoring experience. In return, help from qualified undergraduates enables graduate students to expand the scope of their thesis projects. Undergraduates also allow the lab to explore higher-risk research avenues that we would not otherwise have the resources to explore.”

For graduate student Brian Quist and postdoc Blythe Towal, working with undergraduates provides both assistance with their work and a chance to practice their managerial skills. Towal has supervised undergraduates in the construction of laser light sheets she designed to detect whisker movements as well as on developing MATLAB code to process images from slow-motion videos of rats. Quist has managed...
undergraduate students in a project he designed to quantify whisker mechanical properties. “It’s neat to be working with people to whom you can give concepts and ideas and have them follow through,” Quist says. “The opportunity to manage these smart people is great.”

One of those smart people is Samuel Protas (mechanical engineering ’11), who has worked in Hartmann’s lab with both Towal and Quist for a year. In his first six months Protas helped develop an algorithm to automatically track the movements of rat whiskers in video footage of rats performing behavioral experiments. In his second six months he designed a method to characterize the material properties of rat whiskers.

“By pursuing an undergraduate research experience I was able to get a kind of ’sneak preview’ of a career in research,” he says. “Whether it was image processing or programming from my first project, or the design and machining skills from my second, everything I did was practice for something I could end up doing with my life. It allowed me to become somewhat of an expert on these subjects, which is very satisfying. There’s a feeling of accomplishment at the end that I just don’t get from finishing a class project.”

While the opportunities for undergraduate research at McCormick are plentiful, not everyone is cut out for it. Sometimes students’ skills aren’t suited to the work. Some students can only commit to work in the lab for a quarter — which, in the world of research, isn’t enough time to accomplish much.

For those who do commit, however, the lessons are as much about tenacity as the project at hand. “It teaches undergraduates about what I like to call the ‘time constant’ of research,” Hartmann says. “Undergraduate courses have deadlines or exams every few weeks. Research operates on a very different time scale. Ten weeks might be barely enough to get your first piece of data. Then, when you analyze the data, you might realize that you need to go back and do the experiment over.”

“Things don’t always work,” Towal says. “Undergraduates can be uncomfortable with that. It’s totally alien for them not to find an answer to the question they are trying to solve. It’s good for them to have this experience.”

Learning to take the skills they’ve gained in courses and combine them with creativity to solve a problem will help students immensely in their careers, Hartmann says. “If an undergraduate student is driven by genuine curiosity, research is an unmatched opportunity to pursue a question in detail,” she says. “When experiments work and analysis shows a clear result, the feeling of accomplishment and moment of insight is brilliant.”