

## Successfully Combining Start-up Faculty Research with Undergraduate Research

A unique postdoctoral position allowed me to successfully establish my own research program and simultaneously to initiate a vigorous program of mentoring undergraduate researchers—an experience that benefited both me and my students considerably and one that I believe can be instructive for other early-career faculty members.

I arrived at Juniata College, a small, four-year liberal arts college in rural central Pennsylvania, in fall 2006 to begin a unique teaching postdoctoral position (formally, I was the William J. von Liebig Scholar in Biology) that allowed me to establish my own microbial-genetics research laboratory as a principal investigator, while also gaining experience teaching at a primarily undergraduate institution. Three years later I have gained experience teaching eight different courses and mentoring 17 undergraduate research students and 16 undergraduate teaching assistants. My students are winning national and regional awards for their research and moving on to competitive graduate and medical-professions programs. And I recently was promoted to assistant professor and am moving forward with a successfully established research program in pursuit of a tenure-track position. I'd like to describe what is possible as a new investigator and share some of the key features of my research program.

### Establishing a New Laboratory: Easier, More Fun with Assistance

As I began my position at Juniata College, I read many anecdotal articles written by researchers that helped me develop a strategic plan for what I wanted to accomplish in the early stages of my career. A common strategy of new faculty members is to begin their research slowly and on a very small scale. However, establishing an undergraduate research program is now listed as an essential requirement for most faculty positions at primarily undergraduate institutions and factors into promotion and tenure decisions. Setting up your own laboratory is an arduous task even with a 50 percent teaching-50 percent research appointment like I had when I arrived at Juniata. Yet it can be made into an exciting experience for new faculty members and their students.

I began by recruiting research students in my sophomore cell-biology lecture course at the beginning of my first semester. I announced that I was looking for highly motivated students to participate in microbiology research that incorporated microscopy, genetics, and cell biology and was excited to find four students who were very interested. After interviewing the four, I accepted all of them into my new research program, and they enrolled for research credits. In addition to the four sophomores, two seniors and one junior contacted me because they had heard about the opportunity from other professors. Because of their interest I did not hesitate to accept them into my laboratory as well. The seven students helped me set up my new laboratory much more quickly than I could have on my own, and it was certainly much more fun than I would have had by myself. I ordered the necessary equipment and materials, and they unpacked boxes and organized the laboratory. As the equipment and supplies arrived, I began showing the students how to make media and culture bacteria. Then they enthusiastically began conducting independent research.

I decided to start with a larger research group partly because I knew that I had loved being in a large lab as a graduate student (and partly because I did not know any better). In hindsight, this worked especially well for me because I was able to immediately begin a strong, sustainable research program. Each student was conducting research in my area of interest and even though all students were participating in independent projects, they were learning many of the same research techniques in groups. Furthermore, the initial mixture of students at different academic stages and the fact that all four sophomores decided to stay in my laboratory throughout their college careers, maintained consistency in my research program for subsequent years. More-experienced students have always been willing and able to assist me in training new laboratory students, making my job much easier and more gratifying, while providing the students with important peer-mentoring skills that will help them throughout their careers.

When establishing a research program, it is important to understand that it is of significant interest to administrators how much undergraduate research will cost and what the return on their investment will be. Many institutions are cutting back faculty members' start-up funds in response to the current eco-

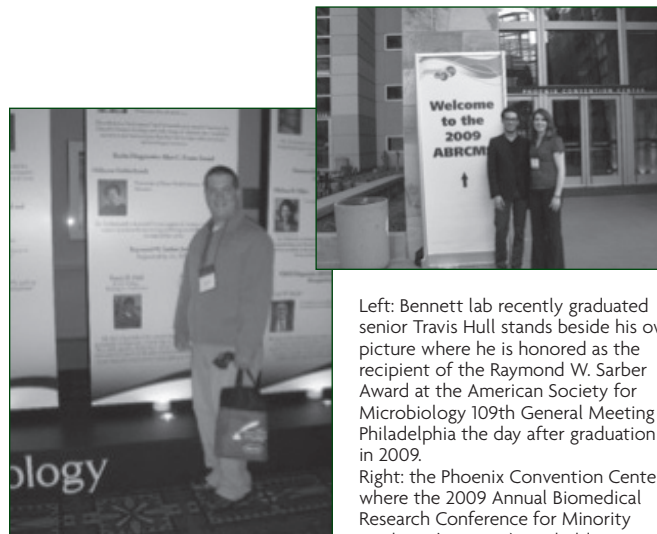
conomic climate. Furthermore, many colleges are just beginning to place an emphasis on undergraduate research so not much money has yet been allocated for such programs. Therefore, new faculty members will need to understand how to sell their new undergraduate research program to their administration and, most likely, to explain how the research can be conducted with only a modest budget. Since I arrived at Juniata, I have gained external funding to support these collaborations with my students in the form of student stipends, small supply grants, and travel awards. The modest sums of money awarded to me have been enough to build a successful undergraduate research program and to leverage institutional support for our travel to meetings and additional summer student stipends.

Building a solid undergraduate research program has enormous potential to generate a new faculty member's main scholarship for future promotion and tenure decisions. I have met many professors who firmly believe that undergraduate researchers do not have the ability to conduct quality work and are a burden to their research program. They feel that it is their duty to work with these students but think that they could have the research completed much faster if they performed it themselves. From my experience this is just not the case. It would not be easier for me to conduct the research myself, and further, I find that the students become very motivated and start to think like graduate students well before they have their undergraduate degrees, if given challenging, open-ended projects and rewarded with career-enhancing opportunities.

### Introducing Research to the Classroom

Teaching is the primary role for faculty members at undergraduate institutions, and I have been asked on several occasions how much time I devote to teaching versus research. This question always fascinates me because every minute spent on research I also consider as a minute spent on teaching. In addition to performing research as a method for discovery, I think of research as a powerful hands-on approach for student learning, as well as an opportunity for professional development that transfers to better teaching in the classroom. With a little planning, I have found that introducing research activities into the classroom also has the power to significantly advance a research program.

Following are three examples of how the introduction of research into my courses has dramatically transformed my own research program:



Left: Bennett lab recently graduated senior Travis Hull stands beside his own picture where he is honored as the recipient of the Raymond W. Sarber Award at the American Society for Microbiology 109th General Meeting in Philadelphia the day after graduation in 2009.  
Right: the Phoenix Convention Center where the 2009 Annual Biomedical Research Conference for Minority Students (ABRCMS) was held, outstanding undergraduate speaker Nicholas Sepúlveda and ABRCMS judge Dr. Jennifer Bennett pause for a photograph.

1. My laboratory has identified mutants with potentially interesting developmental phenotypes using primary visual screens. In the freshman microscopy module that I teach, students participated in an early independent research project by conducting the secondary phase-contrast microscopy screen to verify the presence of developmental defects for these mutants. The students were provided with a high-impact learning experience, while determining whether 160 mutants were worthy of further experimentation in my laboratory.
2. By introducing my research into the microscopy module, a natural extension of this project became readily apparent in the form of a project involving, as Ernest Boyer labeled it, the scholarship of teaching and learning. In collaboration with the professor who created the original microscopy module, we are currently working on a manuscript that describes the impact of early research exposure on the freshmen students.
3. Introducing research topics into courses, even when not directly related to my own program, has allowed me to come up with many new ideas for experiments. In one of my upper-level courses, I assigned an article that actually transformed the entire focus of my research program. Through experiments designed to identify new developmental genes, my students and I had recently discovered a novel gene involved in spore formation, but did not realize the significance. As we read an article assigned to students in the Microbial Genetics course I designed, we realized that we had identified a novel func-

tion for a group of genes that controls motility and virulence in many disease-causing bacteria. Through this knowledge we were able to find eight additional genes belonging to the same family and create mutants for these genes. We are ready to submit our first manuscript describing five of the mutants my students have constructed and have two additional manuscripts almost completed.

### Communicating Research is Essential

From the beginning, I have had students present their projects and related research from the primary literature in the informal setting of our weekly laboratory meetings, which are open to questions and discussion. In addition to providing valuable practice communicating their research, it allows them to learn from their peers about other projects in the lab and about techniques they may not be using themselves. Students frequently have brought up interesting perspectives and new ideas during laboratory meetings that have helped our research program. The lab meetings are also essential to our success because they allow me and my students to get to know one another, thus creating an environment in which the students want to work and spend more time because they have friends there. Lab meetings keep me motivated to read more scientific literature, and keep my thoughts on new ideas for the student projects. The meetings also keep my research ordered and allow me to communicate “lab business” just once, rather than individually for each student.

If lab meetings and experiments are the practices, research conferences are the big invitationals. Students who complete the circle of research by communicating their results are better trained for their current positions in the undergraduate research lab and for their future positions beyond graduation. I have yet to attend a conference that has not been valuable for my students, my research program, and my professional growth as an educator. Professional conferences allow both students and mentors to learn about new research and exchange ideas with others while building a professional network. Tentative students gain confidence, overcoming the anxiety of speaking in public and presenting alongside graduate students and undergraduates from large universities.

Conferences also provide a wonderful assessment tool for how well I have taught and mentored my students, based on my own observations of student performance, comments made

by others, and, in many cases, competitive awards my students receive. The impact of all the preparation they undergo is readily apparent when my students present their research. This, in turn, has helped me to gain recognition in the job market, resulting in a few invitations to apply for upcoming tenure-track positions. At my institution, my track record of student success has been rewarded with additional research funding for students, supplies, and conferences.

### Quality Research Gets Attention

Quality research done by undergraduates is noticed by graduate and health-professions schools. It also translates into relevant mentoring experience for faculty when they are searching for jobs and seeking promotion and tenure. Seven of my students have won a total of 16 national or international awards for the research that they have conducted in my laboratory, including a Goldwater Scholarship (and an honorable mention), two Sigma Xi Grants-in-Aid of Research administered by the National Academy of Sciences, and two Raymond W. Sarber Awards (2009 and 2010), given by the American Society for Microbiology annually to one undergraduate in the country for research excellence and potential. In addition, one of my students recently received an Outstanding Presentation award for his talk at the Annual Biomedical Research Conference for Minority Students (ABRCMS), held in Arizona. Research awards are a tremendous boost to student applications and faculty research programs.

Because of my success in mentoring undergraduate researchers, I have received many forms of recognition. In addition to being invited by CURQ editors to write this article, I have been an invited speaker for the 108th and 109th General Meetings of the American Society for Microbiology (ASM). I have received early-career travel awards to attend the ASM Conference for Undergraduate Educators and to serve as a judge at the minority-student biomedical conference. I was also selected to attend a Teagle Foundation Undergraduate Research Conference at Furman University following my first year at Juniata to provide input for the assessment of undergraduate research at the institutional level. I recently was appointed to the advisory board of a new technician-training program at a local community college and elected as councilor for the ASM Allegheny branch.



Left: Bennett research students Courtney Sturey, Travis Hull, Aubrey Cyphert and Ryan Johnson enjoy historic sites in downtown Philadelphia, including this Darwin 200th anniversary display, in between presenting at the American Society for Microbiology 109th General Meeting in May 2009.

Right: Dr. Bennett and her senior research students spend time on their projects in the Juniata College Microscopy Laboratory. From left to right Laura Rupprecht, Dr. Jennifer Bennett, Katherine Manupipatpong, Nicholas Sepúlveda, Courtney Sturey, Ryan Johnson and Lindsey Draper.

## Conclusion

To many students, undergraduate research has been “nothing short of life changing and career altering” (to quote one of my recently graduated seniors). Four of my students have shifted their goals of becoming MDs to the pursuit of MD/PhDs (two students) or a PhD in microbiology or molecular biology/biochemistry (two students). One of my students is finishing the first year of his MD/PhD and is thrilled with his new path. Whether students change or solidify their career choices, it is readily apparent that substantial undergraduate research has changed the way that they think. These students now understand the connection between medicine and research and have become more effective communicators, teachers, and critical thinkers.

Mentoring undergraduate research is the most rewarding part of my job. I have had several students thank me for the impact that I have had on their lives, but what is not as readily apparent to them is the tremendous impact they have had on mine. Their efforts have furthered my research program, my career, and, on a much more personal level, have shaped my life in many new ways. Does maintaining a strong undergraduate research program take a great deal of effort? Undeniably, yes. Are the benefits worth the time and effort invested? Yes, again.

Nothing is more satisfying than seeing your students succeed and knowing that they are going to repay the investment made in them many times over in the coming decades. Quite simply, their successes are also my successes.

## Acknowledgements

My teaching postdoctoral position, research funds, and four undergraduate summer stipends were provided by the William J. von Liebig Foundation. My research program also received support from the American Society for Microbiology in the form of four Undergraduate Research Fellowships, three national Corporate Activities Student Travel Grants, two early-career faculty travel grants, and three travel grants from the society’s Allegheny branch. Two Sigma Xi Grants-in-Aid of Research to my student researchers were administered by the National Academy of Sciences. I would also like to thank my many mentors and colleagues for all their support.

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