Writing a RUI Proposal

Strategies for Success

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Writing any grant proposal can be a daunting task, and writing for NSF, where the success rate can be in the 15–20% range, can be downright scary, particularly for new faculty members at PUIs. However, I believe that NSF's RUI (Research at Undergraduate Institutions) program provides a beacon of hope for PUI investigators, and given a solid effort, it allows them to put their best foot forward through the promotion and implementation of undergraduate research.

I have been fortunate to be PI on two RUI grants over the past five years, and I am utterly grateful to the NSF for support of the research being conducted at Murray State University, Hancock Biological Station, and the Rocky Mountain Biological Laboratory. One project is aimed at understanding the biogeochemistry and ecology of reservoir ecosystems in western Kentucky, and involves a team of nine faculty members and up to 10 undergraduate collaborators per year. The other project concerns the observational and experimental evaluation of the mechanisms producing population fluctuations in salamanders from Colorado, and is a collaborative effort among Scott Wissinger (Allegheny College), four to five undergraduate students (per year) and myself.

The funding success of each project has been a team effort: each proposal was written with collaborators that were accomplished grant writers. Many of the Co-PIs contributed directly by writing sections of the proposal, while others provided advice, encouragement, and much-needed editing. Thus, new faculty members should consider collaborating on their first grant with colleagues with known grant track records, who can provide the assistance and support they need to write their first successful RUI proposal.

Reviewing successful proposals from other PIs is also a useful way of learning what works and what does not. The

Above: Catherine Aubee, an undergraduate at Murray State, completes the sutures on an anesthetized tiger salamander. Catherine implanted a radio transmitter into the animal as part of her independent research project on the behavior of this species.

Left: Amanda Crook (left) , MSU undergraduate, and Howard Whiteman collect salamanders the fun way in the mountains of Colorado.

Title: Biogeochemical and Ecological Processes Within a Reservoir Littoral Zone
NSF RUI Award: $789,764

Title: Collaborative Research on Mechanisms Underlying Salamander Population Fluctuations
NSF RUI Award: $303,876

current director of URSA (Undergraduate Research and Scholarly Activity) at Murray State provided me with several successful C-RUI proposals from his colleagues through CUR, and we obtained another through one of the Co-PIs, which helped us tremendously in understanding what might or might not work. Based on this information, and my experience helping to construct and review proposals over the years, I describe some of what we have learned below.

The major theme for writing a successful RUI proposal, in my mind, is to infuse undergraduate research throughout — make it clear what the impacts will be on undergraduates in the summary, throughout the main body of the text (What is their role? How will their projects fit into the main study?), in the impact statement, in the budget justification (support money for undergraduate research, travel to local and national meetings, "etc."), and in your *curriculum vitae* (note undergraduate co-authors, other synergistic activities).

Intellectual Merit

The science of any proposal has to be sound and well supported to stand up to the "Intellectual Merit" criteria of NSF. The research should follow logically from previous work (whether your own or that available in the literature), and any preliminary data you have to help make your case should be clearly described in the proposal, perhaps most effectively using easily understood figures. In both proposals described above, our hypotheses were based on years of data that both set up our research questions as well as showed the reviewers that we knew what we were doing. If there are complex techniques that need to be completed beforehand, you must show you can do them... not just say you can, but **show** you have. For example, I once had a proposal denied because we had not worked out the molecular markers (but felt we could); this was not good enough for NSF, and we should have included a figure showing the markers that were already developed, as they were critical to the rest of the research.

To get such preliminary data, consider writing an NSF Research Opportunity Award, where you pair with a PI that already has an NSF grant and that is working on a similar system. In my experience, the ROA is an underutilized avenue to get a year of support for you and one or more undergraduates (up to $20,000 for one year in my experience). The proposals are short (five pages), and a successful proposal can provide you with the opportunity to get the data you need using NSF funds, which NSF would likely appreciate seeing in the full proposal (i.e., their ROA funds have seeded the new and larger grant efforts).

Broader Impact

RUI proposals are likely judged to a greater degree by the "Broader Impact" criteria than non-RUI proposals. Each reviewer uses their own weighting system, but it seems that such broader impacts would be elevated for RUI proposals. Broader impacts can include the long-term benefits of the research to basic science, potential applied aspects of the research, and benefits to science education and society as a whole. Although the intellectual merit of the proposal typically takes up the majority of the main text, I suggest setting aside a separate section to clearly define the broader impacts. This is not to say that many of the broader impacts might also be mixed throughout the main text; this is a very effective strategy as well. But, having a stand-alone section helps the reviewer evaluate what for some people is a nebulous criterion, particularly for those reviewers that are not at PUIs. In addition, both intellectual merit and broader impacts must be clearly defined in the project summary; often subheadings can help make the distinctions clear. I suggest about one page of the main text, and one to two paragraphs of the summary, be set aside to describe the broader impacts of the proposal.

Because of the RUI Impact Statement (see below), PIs only need to summarize what the impact statement will expand upon…that undergraduates will be incorporated into every aspect of the proposed research. In a sense one could write a summary of the impact statement, and refer the reviewer to it for more detailed explanation. From this perspective, RUI proposals have an advantage in terms of broader impacts relative to regular NSF grants, as they include a separate section dedicated to justifying undergraduate education.

PIs should make it clear in the Broader Impacts section that they will actively recruit students from underrepresented groups in science as undergraduate researchers. They should detail how such recruitment activities will be conducted, for example, through a research seminar, through contacts with other faculty members in the department, through mass emails to all majors, and/or through informative flyers. It might also be important to detail the selection process: will there be an application form, what will the requirements be, and who will make the decisions?

Additionally, PIs should strongly consider some form of outreach as part of the current proposal. Murray State has institutionalized a program by which faculty members enter regional school systems and present their research to local students. This typically occurs at the high school level, and clearly aids in recruitment to the university, but it also provides a unique service to the surrounding community. Whether your university does this or not, taking your science into the classroom can be an effective broader impact. Such presentations can also be made to local clubs and organizations. Additionally, some researchers have utilized high school students in their laboratories, broadening their effect on society even more.

One could argue whether faculty members from PUIs, often with high teaching loads and little free research time, should be spending any time in such outreach activity. I believe we should, and feel that it is the duty of all scientists to engage in educating the public about our work. I also believe that the NSF is well justified in asking us, via the Broader Impacts section, to consider the consequences of our research on society and new ways in which positive benefits might stem from it. No matter what your opinion on the matter, having an effective Broader Impacts section is critical to the success of your proposal.

RUI Impact Statement

The RUI Impact Statement is an extremely important component of any RUI proposal. PIs should use the impact statement to clearly show how the proposal will affect the success and careers of undergraduates that are involved. First and foremost, PIs should state how they will guide their undergraduates through their research. From my review of other RUI proposals, I have always felt that it is a so-called "red flag" when PIs are clearly using their students as RAs, or when they say they will "encourage" their students to participate in an independent research project. I believe that part of our grant success at Murray State was that we proposed (and have since implemented) that each student would be provided with the time and funds to complete an independent project as part of their research experience. In our Kentucky work, this is exactly what the students are doing, while in my Colorado research, students assist in the classic RA fashion, but also conduct an extensive independent research project at the same time, providing them (and me) with the best of both worlds.

To this end, PIs should make it clear how undergraduates will play a critical role in the research, by providing examples of potential research projects (better described here than in the main text, perhaps, to save space for the latter), while allowing students to have a say in how the projects develop and what specific research avenues they might be most interested in. In my experience, students do a much better job with their research, are more excited about it, and really take it on as their own when they have had a say in what they are doing and how the research is conducted. Of course, there must be limits in place to maintain the integrity of the main research effort, but within certain bounds students can often have quite a bit of flexibility in their research interests.

PIs should also document if students will be required to produce a proposal of the research for review and a final paper of their research, which should have the potential for publication, either on its own or as part of a larger paper. PIs should make it clear that students will present their research (not be encouraged to, but **will**, assuming the research is suitable and good enough) at local, regional, and, for the best students, national meetings of relevant societies. Such meetings might include attendance at undergraduate research conferences, such as NCUR and CUR's Posters on the Hill.

Another important point to consider for the RUI Impact Statement is documenting the degree to which undergraduate research is a part of the college or university (Is it institutionalized? Are there opportunities for presentations? What percent of undergraduates conduct research?). If the university has institutionalized undergraduate research to one degree or another, play off this strength. If it has not, show how the proposal will provide the seed to get such an effort going on campus (and consider, carefully, how your grant might do exactly that). For example, as part of one of our grants we proposed and implemented the first Undergraduate Research Day within the College of Science, Engineering, and Technology (CSET). We did all of the groundwork as part of the grant, including reserving the rooms, arranging for refreshments, organizing the schedule, and publishing an abstract booklet. This single day was quickly expanded with funds from the Howard Hughes Medical Institute and the creation of our URSA office to become Scholar's Week, evolving from a few dozen students to hundreds of participants throughout the campus. Our

Jason Albritton, a student in the NSF C-RUI program at Murray State, samples the sediment of Kentucky Lake as part of his independent research experience.

early efforts thus laid the groundwork for a campus-wide celebration of undergraduate research and scholarly activity that encompasses all academic disciplines. However, even if Scholar's Week had not been created, the Undergraduate Research Day within the CSET would still have been a valuable contribution to the campus community. If you don't already have something of this sort on your campus, propose starting it, even on a small scale, and make it clear how you will do so in your impact statement.

PIs should also clearly document in the proposal that they can successfully mentor undergraduate researchers, and show the fate of each student beyond the university. We have created a table containing information about the success of the PI and each Co-PI, showing the number of students mentored, number of projects, number of publications and presentations by students (or with student coauthors), and the number of students in professional or graduate school. In one proposal we listed all of our undergraduates who had conducted independent projects and their success. Most of our former students have presented their research at local, regional and/or national meetings, and many of them have authored or are co-authors on publications stemming from their work. A surprising number now have Ph.D.s of their own, which is a success story NSF should appreciate. Such success may or may not be due to our initial work with our students, but it is likely that we planted the seeds of research in many of them via their undergraduate research (or at least watered those seeds), which tells the NSF committee that future research efforts are likely to have similar success. Irrespective of their current status, however, the observation that the PIs of a proposal are keeping track of their undergraduate research students reveals the deep commitment they have to undergraduate education.

In this regard, PIs should also document how they will track the results of their research on the education and future success of their students. Many of us follow students informally via email contact and if this is true it should be documented. My department has a senior exit exam and senior survey, the latter of which asks about their involvement in undergraduate research, including one of the grants described above. Thus, we can compare the success of our students in the exit exam, as well as their attitudes toward the department, the university, and science, to those students who did not participate in our research program.

Budget and Justification

The budget and budget justification should clearly reflect a commitment to undergraduate research. If you are new to the undergraduate research game, discuss it with others who have the experience to give you advice on what you might need to guide your undergraduates successfully, or, once again, get successful proposals and study them. Pay your

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students well; many projects routinely pay undergraduate researchers that are doing independent projects in the range of $2500-4000 per summer, or even more if they are in an area with a high cost of living. Pay them in salary, and make it clear to them that it is such; that is, send the message to your undergraduates and to NSF that this is a research experience, not a job that you are paid hourly wages for, and thus they are expected to be more responsible for their work on a day to day basis than an hourly employee. Even if most of your work is in the summer, consider requesting funds to keep your students working in your lab during the academic year, even at 5–10 hours a week, to keep their research going. Summer field studies often require some lab work, or students can be working on data analysis, posters, talks, or manuscripts during this time, all of which will aid the main research effort.

Be sure to request funds for your time to work on the project, and justify your summer salary well. If you have multiple responsibilities during the summer (teaching, workshops, etc), show how the project fits into your schedule; document what proportion of time will be spent on the project, and only request funds for this time. Don't be afraid to ask for fractions of a month if it is well justified and makes sense given your time constraints. If you do have other summer responsibilities and the research will be ongoing all summer, justify how you will mentor your undergraduates effectively during this time.

If your research can be conducted throughout the academic year, consider requesting funds to hire an adjunct to provide more time during one or more semesters to work with undergraduates, and again justify this use of these funds. Make sure you carefully discuss this possibility with your chair before pursuing it with NSF, as adjuncts are not always available and their use in lieu of your teaching responsibilities could be looked upon negatively by your departmental or university colleagues. Personally, I have found this a very effective way of increasing the productivity of my research and enhancing the undergraduate research experience in my laboratory.

The budget and justification should also contain adequate funds for undergraduate supplies, travel to meetings, and publication costs. Make it clear in the budget justification that supplies for the research include those needed for undergraduate research projects. Document that students will have funds available to present their research at local, regional, and national meetings, including travel funds and funds for poster production, etc.

A Final Thought

Although I believe I have been extremely fortunate in my grant writing efforts, it has not been without hard work. The two proposals that have been funded were preceded by seven proposals that were not, including two postdoctoral fellowship proposals, four regular (non-RUI) grant proposals, and one RUI proposal. Persistence pays. If you don't succeed with your first proposal, evaluate why. If there are things that you can improve upon, make the improvements and resubmit as soon as possible. If, however, your research has some fatal error noted by the reviewers, or appears to be something that doesn't quite fit in any specific NSF directorate (i.e., an integrative or cross-cutting proposal spanning several disciplines), consider how you might better couch your work to fit the program, try to find funds elsewhere, or, as a last resort, change your research!

Howard Whiteman received his B.S. in biology and psychology from Allegheny College, where he conducted and published his senior project under the tutelage of Scott Wissinger. He has been hooked on undergraduate research ever since. He received his Ph.D. in Biology from Purdue University, conducted postdoctoral research at the University of Georgia's Savannah River Ecology Laboratory, and is currently an Associate Professor of Biological Sciences at Murray State University.

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