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EDITORIAL

Conducting Impactful Research at Primarily Undergraduate Institutions

Elizabeth A. Addis[*,1], Carolyn M. Bauer[†], Rachelle M. Belanger[‡], Michael W. Butler[§], David C. Collar[¶], Findley Finseth[‖], Megan D. Gall[#], Eric J. Gangloff[**], Michele A. Johnson[††], Sharon E. Lynn[‡‡], Jenna A. Monroy[‖], E. Misty Paig-Tran[§§], Gregory M. Pask[¶¶], Tessa K. Solomon-Lane[‖], Zachary R. Stahlschmidt[‖‖], Nancy L. Staub[*], Joseph T. Thompson[##] and Jerry F. Husak[***]

[*]Biology Department, Gonzaga University , Spokane, WA 99258 USA; [†]Biology Department, Swarthmore College , Swarthmore, PA 19081 USA; [‡]Biology Department, University of Detroit, Mercy , Detroit, MI 48221, USA; [§]Biology Department, Lafayette College, Easton, PA 18042, USA; [¶]Department of Organismal and Environmental Biology, Christopher Newport University, Newport News, VA 23606, USA; [‖]Department of Natural Sciences, Pitzer and Scripps Colleges, Claremont, CA 91711, USA; [#]Biology Department, Vassar College , Poughkeepsie, NY 12604, USA; [**]Department of Biological Sciences, Ohio Wesleyan University , Delaware, OH 43015, USA; [††]Biology Department, Trinity University, San Antonio, TX 78212, USA; [‡‡]Department of Biology, College of Wooster , Wooster, OH 44691, USA; [§§]Department of Biology, CSU—Fullerton, Fullerton, CA 92831, USA; [¶¶]Biology Department, Middlebury College, Middlebury, VT 05753, USA; [‖‖]Department of Biological Sciences, University of the Pacific, Stockton, CA 95211, USA; [##]Biology Department, Franklin and Marshall College, Lancaster, PA 17603, USA; [***]Department of Biology, University of St. Thomas, St. Paul, Minnesota, 55105, USA

[1]E-mail: addis@gonzaga.edu

Synopsis Primarily undergraduate institutions (PUIs) are significant academic employers of Ph.D. recipients. Even though the focus of PUIs is undergraduate education, many Ph.D. faculty who teach at these institutions are research-active and conduct impactful work. Unfortunately, it has been our experience that many at funding agencies and research-intensive institutions hold the view that this is not the case. In this piece, 16 faculty members share their experiences and approaches to conducting research at PUIs.

Introduction

Roughly 30% of colleges and universities in the United States are 4-year primarily undergraduate institutions (PUIs), while only 8% of institutions are research-intensive [Research 1(R1) and Research 2 (R2) by the Carnegie classification; American Council on Education 2025]. As a result, more Ph.D. recipients teach at PUIs than research-intensive schools. As the term implies, work at a PUI is undergraduate focused, with the general expectation that more of a faculty member's time will be devoted to teaching compared to a research-intensive university (Slocum and Scholl 2013; Eisenhower 2019; though this is highly variable, see Table 1 for a sample range). However, even with a greater percentage of time teaching, PUI faculty can still engage in high-caliber, meaningful research. Teaching and research require similar skill sets and intellectual tools (Macfarlane and Hughes 2009; Eisenhower 2019)! In fact, of Society of Integrative and Comparative Biology (SICB) membership, most faculty at PUIs dedicate time to conduct research (Fig. 1). At the 2023–2025 SICB conferences, on average 26% of all presentations were given by PUI-affiliated individuals, with about 64% of those presentations given by students at PUIs (~17% of total presentations). Unfortunately, in our experience, the perspective that meaningful research is

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Table 1: Editorial participants, their institutions, and their work experiences

Contributor	Position	Time mentoring undergraduates	Department	School	Carnegie classificataion	Contact hours/week
Carolyn Bauer	Assistant Professor	7 years	Biology	Swarthmore College	Research colleges and universities	10
Rachel Belanger	Professor	15 years	Biology	University of Detroit, Mercy	Research colleges and universities	9
Mike Butler	Professor	13 years	Biology	Lafayette College	No research designation	8–10
David Collar	Associate Professor	9 years	Organismal and environmental biology	Christopher Newport University	Research colleges and universities	7–9
Megan Gall	Associate Professor, Director of Neuroscience and Behavior	12 years	Biology	Vassar College	Research colleges and universities	10
Findley Finseth	Associate Professor	20 years	Biology	Pitzer and Scripps Colleges	No research designation	10
Eric Gangloff	Associate Professor	6 years	Biological Sciences	Ohio Wesleyan University	No research designation	11
Michele Johnson	Professor	15 years	Biology	Trinity University	Research colleges and universities	12–18
Sharon Lynn	Professor	23 years	Biology	College of Wooster	No research designation	9
Jenna Monroy	Associate Professor	25 years	Biology and neuroscience	Pitzer and Scripps Colleges	No research designation	10
Misty Paig-Train	Associate Professor	13 years	Biological sciences	California State University—Fullerton	Research 2	11
Greg Pask	Associate Professor	10 years	Biology	Middlebury College	Research colleges and universities	9
Tessa Solomon-Lane	Assistant Professor	15 years	Neuroscience	Pitzer and Scripps Colleges	No research designation	10
Zach Stahlschmidt	Associate Professor	11 years	Biological sciences	University of the Pacific	No research designation	8
Nancy Staub	Professor	33 years	Biology	Gonzaga University	No research designation	9
Joe Thompson	Professor	20 years	Biology	Franklin and Marshall Colleges	Research colleges and universities	9

Note that the values in the "contact hours/week" are estimates of time spent teaching as most institutions included do not track teaching load by contact hours.

conducted at PUIs is often dismissed by our colleagues at research-intensive universities and funding agencies. This commentary aims to highlight the research activities of a sample of established research-active PUI faculty.

The availability of time and resources for research is highly variable among PUIs, often depending upon the expected teaching load, service expectations, and financial circumstances of the school. Based upon the experience of the authors of this piece, some PUIs allow faculty to use grant money to buy out of teaching, while others do not. Anecdotally, this is a more common practice at research-focused institutions than PUIs. Among us, teaching load varies from 7 to 18 contact hours per week (Table 1). Expected service contributions of faculty at PUIs also tends to be higher than at research-focused institutions, particularly at the Associate and Full Professor levels (Shields and Feller 2020). Generally, faculty at PUIs with more resources (e.g., support, equipment, internal funding) tend to have more time to devote to research and higher funding success rates from the National Science Foundation (NSF; Eisenhower 2019). Recently, some PUIs have even been classified as "Research Colleges and Universities" per the 2025 Carnegie Classifications (American Council on Education 2025). The American Council on Education defines research colleges and universities as institutions that spend at least $2.5 million on research and associated development. Note that besides having a lower minimum dollar amount spent on research, this classification excludes R1 and R2 schools, which are defined by both the dollar amount spent on research and the number of awarded research doctorates (American Council on Education 2025).

The disparities between PUIs and R1 and R2 schools likely results in different rates of publication, but re-

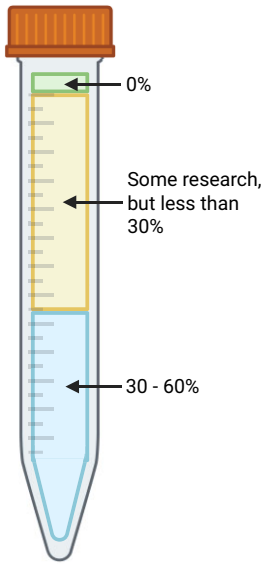

Fig. 1: Survey of SICB membership on working at PUIs. Data from the question asking, "If currently at a PUI, what percentage of your effort is dedicated to research?" The survey was advertised in the SICB newsletter, and there were 60 respondents. There was an additional option, >60%, but no respondents selected it. About 2% of respondents spend 0% of their time on research, 56% spend some time on research, but less than 30% of their time, and 42% of the respondents spend 30–60% of their time on research. This figure was made with bioRender (bioRender 2025).

search from PUI labs can still be, and often is, of high impact. The crux of the misperception that faculty at PUIs make less valuable research contributions is likely how one defines impact. In academia, impact is often quantified by number of publications, citation and impact factors, etc., most of which misconstrue the value of research contributions (e.g., Cagan 2013; Eyre-Walker and Stoletzki 2013; Hicks et al. 2015; Zhang et al. 2017). Funding success is also often used when considering research impact. Historically, NSF funding rates for PUIs and non-PUIs were not different, but grants awarded to PUIs were about two-thirds the size of those to non-PUIs (Slocum and Scholl 2013). However, impact also extends beyond publishing and funding, though these types of contributions are less frequently considered and only sometimes valued (Bornmann 2012; Ravenscroft et al. 2017; Oxley and Gulbrandsen 2024). For example, inclusion of undergraduates in research, a strength of research programs at PUIs, expands the scope of impact even further by teaching students the process of science and providing early training for future researchers (Linn et al. 2015; Rodenbusch et al. 2016; Hernandez et al. 2018). Science departments at PUIs tend to be smaller than at R1 and R2 institutions. These smaller department sizes at PUIs can result in more cross-disciplinary collaborations (Dehn 2010) and cross-institutional collaborations, which can increase creativity (Shields and Feller 2020; Dahlburg et al. 2021). So, while the approach to and scale of research between PUIs and research-intensive institutions can differ, it is fallacious to assume the quality of output does.

In this commentary, 16 faculty (Table 1) from 14 institutions share their experience of how they have succeeded in conducting impactful research at a PUI. The institutions vary in expectations of research, teaching load, and resources available for research; each contributor shares how *they* succeed at *their* institution.

When does your research happen—summer, academic year, summer and academic year?

C. Bauer. Because my experiments involve intense, time-sensitive periods of data collection, I often do the bulk of my research during the summer. However, my students and I do a fair amount of work over the academic year as well, and this tends to be centered on data analysis, writing, and small validation studies. It's difficult to do intensive data collection during the academic year, as teaching takes up a lot of my time, and also my students have very busy schedules with their coursework and extracurriculars.

R. Belanger. Research takes place in my laboratory year-round; however, my lab performs treatments and collects tissue samples during the summer and processes and analyzes them during the academic year. It has traditionally been very difficult to perform full research experiments during the academic year due to time constraints, unless I am on sabbatical.

M. Butler. Most of my field work is in the summer, and most of our sample analysis is in the academic year. This time allocation bleeds over from one to the other, of course. But that's how MOST of it occurs.

D. Collar. Research happens year-round, but most data collection and experiments involve teams of undergraduate research assistants during the academic year. Every other year, I also supervise an advanced student in a research project as part of CNU's Summer Scholars program (an 8-week full-time research internship). The project typically aligns with my main research goals but has room for students to make choices about particular aspects of the study.

M. Gall. Most of my research with students happens during the academic year, although I do sometimes have groups of summer students (about once every 3 years). I often reserve a month or so of my summer for research with collaborators. I often visit their labs during the field season to conduct small projects and collect data (and talk to other colleagues about ideas!).

E. Gangloff. We have an intensive Summer Science Research Program, which funds students to be full-time

researchers for 10 weeks. Most of our fieldwork happens during this time, both because the weather is favorable for lizard activity and we can arrange to take trips for 3–4 days to our study sites in Cincinnati, which is about a 2-h drive from our University. During the academic year, we conduct lab-based experiments, perform wet lab assays, analyze data, and prepare our presentations. We're doing something pretty much all the time.

M. Johnson. Most of my field data collection happens during the summer (when students in my research group are often working full time), although data collection continues in the lab during the academic year (when students are generally working about 4 h per week in the lab). Most of my writing happens during the academic year.

S. Lynn. My research mainly focuses on hormone–behavior relationships in breeding birds. In terms of workflow, because I most often work with free-living, seasonally breeding birds, data collection is most often limited to the summers, with the academic year being reserved for analysis of samples, data analysis, and writing. However, the structure of Wooster's Independent Study program necessitates mentoring of student research (on a broad array of often unrelated projects) throughout the academic year as well.

J. Monroy, *F. Finseth*, *T. Solomon-Lane*. Research happens throughout the year, but uninterrupted data collection takes place in the summer. All our students have to write a senior thesis, which if planned well can contribute to our research.

In the summer, research is 100% effort with a lab full of students and experimental projects, data analysis, and writing. During the year, I write and do data analysis, but I struggle to get in the lab. My students, however, keep projects moving forward because they are often in the lab a couple of afternoons a week during the academic year.

A lot of preparation takes place in the semesters before the summer, including IACUC protocol submissions, experimental design, and background reading. Our students do a lot of work in the spring if they are going to collect meaningful data in the summer. There is no time to waste.

M. Paig-Tran. My research is ongoing throughout the year. I get small spurts throughout the semester, more when I don't have new course preps. But, while we are a PUI, I do have Master's students who do research as well and I am very lucky to also employ a post-doctoral researcher to help keep things on track. The big writing pushes tend to happen less over summer for me. It is not unusual for me to dedicate a month where all writing is dedicated to pushing out a paper or a grant application. In winter, we (my lab and I) spend time preparing our data to present at our home scientific conference—SICB.

G. Pask. Research in my lab occurs year-round, but there's certainly a predictable rhythm throughout the academic year. The summer months are highly active with the training of new students, field seasons, and developing student independence. This independence carries forward into the school year where students are largely working independently while I balance my teaching and mentorship duties. We also have a 4-week winter term during the month of January that can also serve as a highly active research time, like an extra month of summer, if I'm not teaching a course.

Z. Stahlschmidt. Experiments are happening year-round, but most of my writing happens in the summer.

N. Staub. Summer and academic year.

J. Thompson. It happens mainly during the summer, at least in terms of the number of successful experiments that we can carry out, but I work with several students in my lab during each semester of the academic year. Much of the academic year work usually is more for the students' benefit (e.g., developing skills, writing, critical reading, etc.) but more advanced undergraduates have the potential to contribute a few experiments toward a body of work. I also use the academic year work to pilot new experiments or techniques as a way to help decide if they're worth pursuing during the summer months.

Do you publish with students only or a mix of with and without students?

C. Bauer. I publish with students for almost all of my projects. The only exceptions are studies led by collaborators outside my university, but I usually play a minor role in those projects.

R. Belanger. I publish with a mixture of undergraduate students as well as collaborators (e.g., graduate students I collaborate with from other academic institutions). I have also published review papers and chapters with colleagues from other research institutions.

M. Butler. At this point in my career, nearly all of my publications have students. This pattern was a bit less pronounced when I began my faculty position, because for the first few years I was transitioning away from graduate school projects. Now though—I publish almost exclusively with students, unless I'm collaborating with someone outside of my institution on a different project.

D. Collar. I publish with and without students. Publications that do not involve undergraduate authors are typically collaborative with researchers from other institutions. Projects carried out at CNU (Christopher Newport University) typically have one or two student

co-authors. These students have held leadership roles in data collection, engaged in all aspects of the project, and presented on the work in some way—a poster or talk at a student research symposium or scientific meetings.

M. Gall. I publish papers with my undergraduates and also publish papers with collaborators at other institutions. Just over half of my papers are in collaboration with undergraduate researchers.

E. Gangloff. All of my empirical research is done with our team of undergraduate researchers. I am also fortunate to have a number of additional collaborators at other institutions, with whom I'm working on some exciting review and opinion papers. I think this provides a great balance of mentoring students through the writing process but also the opportunity to do some of my own exploring and thinking through writing.

M. Johnson. I publish both with students, and without. Students are generally coauthors on the research that comes out of our lab, but there are not always students involved in the collaborations I maintain with colleagues at other universities.

S. Lynn. I was provided with a generous opportunity to publish as an undergraduate, and therefore I have always valued including students in the publication process in meaningful ways when it is warranted. This can certainly slow progress with writing (which for me can occur during the academic year or when classes are not in session), but it fits beautifully within the goals of fostering personal and intellectual growth, and is, in my experience, quite worth the time invested.

J. Monroy, *F. Finseth*, *T. Solomon-Lane*. Each of us has published work with students and collaborators. Thesis students often collect and analyze data that contribute to a larger project. Other publications are with collaborators at larger institutions.

M. Paig-Tran. I would say I am a mix of with and without students. I try to publish with students whenever possible—my own students and also with students from other institutions.

G. Pask. Most of my publication goals (which also aligns with my departmental expectations) involve undergraduates as co-authors. This is a rich experience as it's a great way to train students in the final step of most scientific research—the dissemination of new information.

Z. Stahlschmidt. More than 90% of my papers as a faculty member include students as coauthors.

N. Staub. A mix with and without students.

J. Thompson. Definitely a mix of with and without. My graduate advisor had a philosophical approach to co-authorship that still resonates with me. I only co-author with students who have made a significant intellectual contribution to the body of work. That said, nearly all of the undergrads who have worked in my lab have made important contributions to research progress, even if those contributions don't end in co-authorship.

How do you structure your time?

C. Bauer. I'm not sure how I structure my time. . . things just "happen." I suppose I would say that during the academic year, my teaching always takes first priority. But that during the summer, research reigns supreme.

R. Belanger. I work 3 days per week in the lab during the summer (or more If necessary). I spend the other 2 days planning and writing. During the academic year, I have asked that I only teach classes on Mondays, Wednesdays, and Fridays so that I can spend Tuesdays and Thursdays scheduling meetings and working in the lab with my research students. With an understanding chair, this can work well. Otherwise, I have had to fit research in when I have large blocks of time. I also try to have only one to two projects occurring in my lab at one time, so that they will be completed. This ensures everyone is familiar with the project, learns the bench skills necessary to complete the project, and is an integral part of the team

M. Butler. During the academic year, my teaching schedule and required meetings drive the rhythm of my day. After that, I use my calendar to block out times to meet with the students in my lab, prep courses, and grade. Then it's managing my service load, which has become a pretty substantial component of my job. Honestly, I have to rely on my students to do the bulk of the data collection during the academic year, and I get very little writing done. Once summer rolls around, though—90% of time is in the field/lab or working on manuscripts.

D. Collar. During the semester, I prioritize teaching, of course, and my days begin with some mix of course prep, in-class time, and office hours depending on my teaching schedule. I try save afternoons for research and writing, but there are other faculty responsibilities, like committee work and responding to emails, that also compete for this time. I schedule weekly meetings to check in student research teams, and I hold separate meetings with students in leadership roles to discuss project progress and plans.

M. Gall. I try to have my classes concentrated on 2–3 days per week, to give me longer stretches of time for research. I have found it very important to block out research time on my calendar, as this can easily get diverted to other tasks or meetings. We teach the equivalent of five course a year, so I may scale back research in semesters where I have more teaching responsibilities

and scale up during semester with less teaching. Some colleagues like an equal split of teaching across the year, but I prefer to have a heavy and light semester, as I am not very good at multitasking!

E. Gangloff. Personally, I like to have a very specific plan for how to approach each day and what's going to get done when, which can lead to strife when unexpected things pop up (which they do, pretty much every day). So, the plan is seldom followed verbatim but this does help me to prioritize the important tasks on a given day. What I really try to do is have a long view and carve out a little time each day for things that are not immediately pressing or have a strict deadline—for example, a manuscript or grant proposal. If I don't hold time for those kinds of long-term projects, then all my time gets eaten up by the immediate demands of a day. Most of the time I've been able to do this, and I've learned to let go on the days I can't.

J. Monroy, *F. Finseth*, *T. Solomon-Lane*. I try to teach lectures and labs early in the week so that I have time for research or students later in the week. I consider myself lucky if I have one day in the week without teaching and only a few meetings.

J. Monroy, *F. Finseth*, *T. Solomon-Lane*. I try to develop a task list at the beginning of each week, though I rarely check off all of my tasks. I categorize tasks according to research, teaching, and service. It helps me prioritize. During the academic year, I try to get my service and/or teaching tasks done during a typical 9–5 weekday (though it doesn't always happen). Since the research is more like fun, I often work on that in the evenings, mornings, or on the weekends.

M. Paig-Tran. I try to structure my time as 40% teaching and teaching prep, 40% research (grant writing, writing manuscripts, data collections, etc.), and 20% service though this shifts from year to year depending on committee needs, number of students, new preps, etc.

G. Pask. Though it's highly variable depending on the semester, I often try to have one day per week without a class meeting, or at least a couple half days throughout the week with large chunks of time to engage in scholarship. I also try to have my classes as early in the day as possible, because I find I'll often be tinkering lectures slides and such up until class no matter when I teach. So, limiting that situation with early morning classes is helpful!

N. Staub. My time is pretty much structured for me by classes and labs I teach. Outside of that I try to have one day each week devoted to working with students or writing or research. But much of that time ends up being taken up by grading and class prep.

When do you write?

C. Bauer. I write pretty consistently throughout the year. During the academic year I take part in a weekly faculty writing group, that has always been quite helpful. Once students have completed a project, I like them to write it up as part of their academic research credit—I find that this also helps me stay committed to writing up and publishing projects, as I'm constantly editing their writing throughout the semester.

R. Belanger. I really only have time to write during the summer or during school breaks. I teach several writing intensive courses, so my academic year is often busy grading reports and papers.

M. Butler. This is the million-dollar question! Pretenure, I'd set aside time three or four times a week; even just 30 min a day was critical toward finishing manuscripts. Post-tenure (and with the commensurate MUCH higher service load), it's been a lot harder. Honestly, 80–90% of my writing takes place during school breaks (winter/spring/summer).

D. Collar. Most of my writing happens during the breaks in the academic calendar, largely in the summer. I do try to write during the academic year, but it is difficult to find the blocks of time I need to make real progress on writing. I make writing a priority during breaks, and that is when I get the most done.

M. Gall. I write during the academic year, during research trips and on sabbaticals. I like to encourage students to write sections of papers (ranging from part of the methods for newer students to whole manuscripts for senior students that are considering graduate school). I give extensive feedback on their work, and we go through many drafts. I often end up writing much of the paper, but the process is an excellent learning opportunity for students. This process often takes longer than it would take me to simply write the paper. However, I feel accountable to my students, so this often helps me accomplish writing tasks during the academic year that might otherwise get deprioritized.

E. Gangloff. When I'm at my best, I carve out a small chunk of time to write each day. I think it is much more effective to write regularly in small intervals than it is to wait until a bigger chunk of "writing time" comes along—which it seldom does! I will close down my e-mail, throw my phone out the window, and set a timer for 45 min. If I can do that five to six times a week, then I find I can generally stay on top of writing projects and keep myself happy. It's amazing how much you can do in this amount of time if it is focused!

M. Johnson. I block off a few hours each week for writing, aiming for two morning writing sessions a week. I also currently have a weekly afternoon writing session with four other colleagues, all from different depart-

ments. We sit in a conference room together wearing headphones, and we commit to all working on writing tasks while we're together.

S. Lynn. In the early stages of a writing project, I normally write most efficiently when I have a block of time with no interruptions. So, I most commonly save that kind of work for when classes are not in session. However, as I get further along in a given project, and the work becomes easier to do in smaller chunks, I can often make decent progress on writing during the semester as well.

J. Monroy, *F. Finseth*, *T. Solomon-Lane*. Writing generally happens in the summer or when on sabbatical. During the academic year, writing often takes place in early mornings or evenings, generally in bursts with periods of intense writing and other periods when writing is not happening. It is often difficult to find enough time to get a substantial amount of work done before having to do something else. Writing retreats at the start of the summer have been helpful.

M. Paig-Tran. I try to engage in writing every week—grants, manuscripts, whatever. In general, I allocate at least an hour or two daily to concentrated writing, though some days (or weeks) there are too many interruptions or unforeseen events to allow this to be totally consistent from day to day. And when that happens, I try to arrange my schedule in the following days to allow a little extra writing time (if possible).

G. Pask. I've found that I find more time to write manuscripts and grants during the academic year than during the summer. It might be due to how much I'm thinking about my students' writing for class, inspiring me to do my own writing in the midst of the semester. Because I'm also writing with students, we often have weekly meetings (with tea!) where we check in on the writing process and revision drafts of manuscripts, usually divided by sections. Outside of that, I also find nice writing time at home next to the wood stove before the kids wake up.

Z. Stahlschmidt. The bulk of it happens during breaks (summer, winter, and holidays), but I've also gotten more productive during the academic year

N. Staub. If I'm in the middle of writing something, then I can write a few sentences or paragraphs here and there throughout the week. Otherwise, I need larger blocks of time to get my brain wrapped around the manuscript again.

Do you seek out external funding and, if so, what types (e.g., federal, charitable, state, NGO)?

C. Bauer. I do seek out external funding from a variety of sources. My latest grant was an NSF International Research Experience for Students (IRES) award, and this was great for funding students to do field work in Chile with my study system.

R. Belanger. Yes. I have written three NSF Improving Undergraduate STEM Education (iUSE) grants for funding for research intensive labs and a Major Research Instrumentation (MRI) grant. These were not funded. I have also received an NIH pilot award for laboratory course development. I am also currently a co-investigator on an NIH Undergraduate Research Training Initiative for Student Enhancement (U-RISE) grant. I am also currently writing an NSF Neurobiology in Changing Ecosystems (NICE) grant and have considered writing an EPA grant. Further, I have also submitted a grant to a foundation. In the future, I am also interested in submitted and Research in Undergraduate Institutions (RUI) supplement.

M. Butler. I try to! I haven't been successful yet, but I've mostly applied to NSF using the RUI designation, I've also submitted a few letters of intent to a few statewide foundations.

D. Collar. I do seek external funding, but honestly, I have found it difficult to apply for grants. I currently have a grant proposal under review at NSF, which is a collaborative project with a researcher from an R1 institution. I previously applied for grants through NSF with colleagues from my department, but they were unfunded. I have made do with smaller sources of funding, though. I received a small project grant from the Virginia Academy of Science a few years ago. I am also fortunate that my institution provides funds—through competitive application processes—for faculty and student research, and I have used these to cover costs of some past projects.

M. Gall. I have not sought external funding as the primary PI, although I have written many letters of collaboration for the grant proposals of colleagues or been co-PI on the collaborator's grants.

E. Gangloff. I am fortunate that our current research on introduced wall lizard populations is funded through the NSF's Building Research Capacity of New Faculty in Biology (BRC-BIO) program. This provides funding for fieldwork, equipment, hiring a post-doc, paying undergraduate students for research, and attending meetings—all essential to keep our work moving forward. Additionally, we have a full-time postbaccalaureate researcher working on our salamander projects, funded through NSF's Research and Mentoring for Post baccalaureates in Biological Sciences (RaMP) program, as part of the Salamander Population & Adaptation Research Collaboration Network. I'm currently working on an NSF core program proposal with collaborators, which will hopefully provide the same support for future projects.

M. Johnson. I regularly apply for funding from NSF. I've primarily had funding from NSF's RUI program and the HHMI Inclusive Excellence Program (although that program has recently been cancelled).

S. Lynn. Over my career, I have sought and received some external (mainly federal) funding. I have also been supported by smaller funds available through my institution. Availability of funding has absolutely shaped what kinds of work my students and I can do, but scarcity can also be a strong promoter of growth and creativity.

J. Monroy, *F. Finseth*, *T. Solomon-Lane*. All of us have received NSF funding. We look for mostly federal grants (RUI, R15, etc.) that are geared toward smaller institutions and undergraduate research experiences.

M. Paig-Tran. Yes. My lab has had successful funding from the NSF, State funds, and some intramural funding.

G. Pask. Yes, I've sought and attained external funding through the NSF, specifically through the Research at Undergraduate Institutions (RUI) mechanism. I've also had success applying to a private foundation supporting new investigators in interdisciplinary science.

Z. Stahlschmidt. Yes, but only when I have particularly compelling "big" ideas that I think are worth funding. For these, I apply to IOS at NSF.

N. Staub. Federal, private, regional, and university funding have all been helpful!

J. Thompson. Yes, I regularly apply for external funding, mainly through the NSF (IOS in particular). All of the NSF grants I've been awarded have been collaborative with colleagues at several different R1 institutions.

What is one piece of advice you would give to a new PI at a PUI to be successful?

C. Bauer. I would advise new PUI researchers to be realistic. If you came from a high-powered R1 institution with a lot of resources, then you're going to need to change how you do your science, because you're going to have to take on a lot of duties now that you didn't need to before, such as ordering your own supplies, writing your own institutional protocols, etc. Also, undergraduates are wonderful, but they are very limited in their time during the school year, and it also takes a significant amount of time for them to become competent on certain skills, so just remember that you're going to need to put in a lot of time training students or collecting difficult data on your own. Most PUIs also have modest amounts of money available to support research, so you might need to also adjust your research so you're not relying on expensive techniques, equipment, etc.

R. Belanger. I was given this piece of advice from a person I think of as a mentor, and it has served me well over the years. The advice is to stagger your lab. This means have students at different stages of their academic career working in your lab. Try to take in first or second year students and train them well. They can then become lab mentors for the next cohort of students and so on and so forth. They can help train other students, which saves times and helps them build confidence and interpersonal skills.

M. Butler. Keep the long view in mind; this is a marathon and not a sprint. Set yourself up for success over the next 6 years, not the next 6 months. And this advice applies to everything—teaching, research—all of it. You don't need the perfect course the first time you teach it. Be okay with doing a good job, but not necessarily a great job. Then, the next time you teach that course, improve it. After your third or fourth time teaching something, you WILL have a great course. Similarly, lean on your strengths from your graduate school or postdoc experiences when developing your research program. Balance a few projects that are likely to be successful with a few that are higher risk, higher reward. Know where you need to be by the time you submit your tenure packet, and work backward from there.

D. Collar. My advice is to complete a project early. Identify a straightforward, low-risk study that can yield a complete data set within the first year. The project should be in line with your main research goals, so that it can help guide decisions about lab equipment and materials purchasing. I also recommend recruiting undergraduate research assistants to help, though I would keep the number small. Aim students who are mature enough to know what they are interested in but still have another year or two to contribute to the lab. Then, once the data set is complete, prioritize analysis and writing. Publishing the first paper based on data collected at your institution is an important threshold, and crossing it early gives you freedom to pursue other longer-term, more complex, or riskier projects.

M. Gall. I have found collaborations, both internal and external, to be tremendously valuable for my work. Staying connected to research at larger institutions helps me stay up to date, which is valuable for both my research and teaching. Internal collaborations can also be very valuable for finding new avenues of inquiry. Collaborations are also a great way to maintain accountability and can help prioritize research-related work. I have also found it valuable to ask research questions that have no wrong answers. Or, put another way, not hang the success of a research project on a hypothesis being correct. In my lab, we often ask questions about the impact of the environment on the auditory processing of birds and frogs. The data we collect allow us

to test hypotheses, but they also provide descriptions of the auditory processing capabilities of these species. If none of our hypotheses are supported, we can still publish descriptions of the auditory processing properties of these species. These observations can provide a valuable baseline for other researchers that might investigate the mechanisms, function, or phylogeny of these patterns. Set up a server and require students to keep their data on it. This is vitally important for keeping track of data as students go abroad, leave the lab, or graduate.

E. Gangloff. Read read read! It's easy to get too busy to keep up on the literature, but it is so essential to keep your brain working like a scientist (and not someone whose sole job is to respond to e-mails). For me, I get up early (very early) every morning and will read a paper sitting on the porch with my morning coffee. Once I open my computer and get sucked into the black hole of e-mails, there's no turning back to get myself settled into the mindset to meaningfully think about research. It's not always easy, but I've been mostly successful in keeping up this habit. And I love it—no sense hiding that it brings me great joy to nerd out and read about lizard thermoregulation first thing each day.

M. Johnson. Find "your people" at your institution. These may be in your department, or they may come from all corners of the campus. It's the relationships you build that will make your work meaningful.

S. Lynn. Ultimately, my primary piece of advice for a new PI at a PUI would be to remember what drew you to this career in the first place and use that as your guide in mentoring your students. For me, it was intellectual curiosity. In academia, the stakes will always feel high with regards to research productivity. But, in giving myself permission to evaluate where my true potential for impact lies as a PI, I have realized that helping young people build their confidence and intellectual curiosity is far more important to me than any amount of personal productivity. And, with that approach, the productivity followed anyway.

J. Monroy, *F. Finseth*, *T. Solomon-Lane*. Collaborate! Cultivate and maintain strong internal and external collaborations. Collaborations are fun, intellectually stimulating, improve the quality of the research, and establish instant accountability. Many of our publications represent collaborations with external colleagues and with newly forged collaborations with faculty at our institution. Collaborations were therefore instrumental in obtaining tenure, in addition to being among the most rewarding parts of the job.

J. Monroy, *F. Finseth*, *T. Solomon-Lane*. A second piece of advice is to integrate your research program into the classroom. Use course-based research experiences as pilot experiments and a chance to test out new ideas with lower risk. Students also get excited about working on novel discoveries where the outcome is unknown.

M. Paig-Tran. Time management is key. It is easy to get sucked into course prep and trying to make everything absolutely perfect the first time around—but that rarely happens. Also remember to be willing to pivot—sometimes that really great pedagogical idea bombs, sometimes the research all fails, or there is a global pandemic. But there is always some low hanging fruit of something that you can do to push your research further. If you just keep working at it in small doses, you'll end up with big payoffs.

G. Pask. I think the best thing is to find a yearly rhythm as early as possible. Thinking about when you have the most available time to train undergraduates, conduct research, write proposals and manuscripts, and do scientific outreach, all while teaching your course load, is crucial. There also may be opportunities to incorporate some of your research into your courses as a pilot project to generate preliminary data!

Z. Stahlschmidt. Only one?! Okay, I'll cheat and say: Carefully manage your time while allowing students' ideas to move your research in new directions. Some of the major themes of our research group started as, er, less-than-fully-formed thoughts from undergraduates. Brainstorming how to experimentally address these ideas has gotten students involved in the entire scientific process and has created a strong sense of project ownership by students.

N. Staub. Collaborate. My work was so specialized that at the beginning of my career I hadn't figured out how to collaborate with others. Once I did that, not only was research more productive, but it was also rewarding to interact regularly with colleagues across the country and beyond. Another bit of advice—keep going to meetings and be active in your professional societies (like SICB!). This not only feeds your intellectual curiosity and keeps you aware of all the cool research going on, but it also provides connections with colleagues/friends that to me have been very important. Plus, conferences often lead to collaborative projects.

J. Thompson. In terms of developing and maintaining a productive research program that involves undergraduates, subdivide your research objectives into different sized chunks: (1) small ones that can be managed by novice researchers in the context of a semester in which they're spending only 10–12 h per week in the lab, (2) bigger ones that can be managed by more experienced undergrads who have greater mastery over the techniques, and (3) more ambitious objectives that you can tackle with your undergrads during the summer.

Is there a paper you have published with undergraduate students for which you are particularly proud?

C. Bauer (Arusha et al. 2024). I'm proud of this paper as all of my coauthurs were undergraduates in my lab at the time. This was my first big project as a faculty member at Swarthmore.

R. Belanger (Abdulelah et al. 2020). This research article represents a significant scientific accomplishment achieved through collaboration with undergraduate students. It not only advances knowledge in its field but also showcases the dedication, curiosity, and intellectual growth of the students involved, serving as a testament to the many hours of hard work, perseverance, and commitment required to conduct rigorous research and overcome challenges.

M. Butler (Armour et al. 2020; Butler et al. 2021). I have several, actually! But there are two related ones that examined how dosage of a commonly used immunostimulant affected oxidative damage. We first used captive animals to test our ideas, and by "we" I mean "my thesis student, myself, and another Lafayette student, and faculty member." For her thesis work, Ellen found that ecoimmunologists may by typically using dosages that are far higher than necessary (Armour et al. 2020). Several other students and I (and collaborators) then followed up on this finding by testing free-living animals in the field, and found the same pattern (Butler et al. 2021)! It was pretty neat, actually, and highlighted the importance of checking our assumptions as scientists. (Does this dosage model what I think it models?)

D. Collar (Collar et al. 2021). I am particularly proud of this work because it was one of the first projects I completed entirely at CNU and because it achieved two of my major aims in research. First, it showed a novel pattern in morphological evolution, which earned its publication in a top tier journal in my field. And second, it provided meaningful research experience for two students who worked on every phase of the project.

M. Gall (de Koning et al. 2020). Two truly excellent undergraduates, Megan de Koning and Julia Beatini, are authors on this paper in which we investigated the directional auditory sensitivity of Northern saw-whet owls. These little owls rely heavily on hearing for hunting and have amazingly asymmetrical skulls. We found the owls are most sensitive to sounds in front of and above their heads, which we suspect helps them keep areas of high auditory sensitivity trained on prey during flight. These two students were involved in the project every step of the way—from experimental design to manuscript writing—and I think they learned a tremendous amount about the process of doing science!

E. Gangloff (Vaughn et al. 2023). This paper is a great example of the smart and creative ideas that undergraduate students bring to research. Basically, Princeton Vaughn, the lead author, said, "Can we do this cool thing?" to which I replied, "I have no idea how to do that but sure." And from there we built an interdisciplinary and collaborative project that included six undergraduate students and one of my colleagues at OWU.

M. Johnson (Taylor et al. 2022). This is a paper I'm especially proud of because of the teamwork (from all five undergraduate co-authors on this paper) and student leadership (particularly from first author Laura Taylor) that occurred in this study. This work contributes to our growing understanding of the complex ways artificial light affects wild animals, and it was a collaborative effort that contributes to a growing literature on light pollution.

S. Lynn (Lynn et al. 2023). The reason I've chosen this paper is that I think it is a nice example of the kind of creativity and insight that can arise from letting students take the reins in study design and research focus. Much of the work described in this paper arose from initially asking the two student coauthors what sorts of questions they were interested in, and where they might take the overall research question. These two students did not actually meet during the planning or research process (based on their graduation years), but their research questions and methods blended together beautifully, and their collective work helped me to think differently about questions I had been asking for years.

J. Monry (Hurley et al. 2022). This paper is a culmination of quality work done by undergraduate students. I am so proud of the dedication and determination the students put into this project.

T. Solomon-Lane (Harmon et al. 2024). I'm so proud of this paper because of how it reflects all phases of the scientific process: a question that follows up on a previous finding of mine, a clever experiment designed collaboratively by students, future rounds of students who joined to analyze the integrative data, and the first publication from work carried out solely in my lab.

F. Finseth (Budischak et al. 2023). I am proud of this paper because (1) it represents an internal collaboration with an undergraduate co-author that is a product of a course-based undergraduate research experience and (2) the origin, execution, and completion of the paper occurred during virtual-only days of the pandemic primarily by two working mom co-authors with kids home full-time…it was a real lemonade out of lemons experience.

M. Paig-Tran (Vandenberg et al. 2023). The lead author was an undergrad and the anchor author was my post-doc. The second author was a graduate student. I am particularly proud of this collaboration because it

really highlights a method where I gave my post-docs leverage to learn how to mentor (leading the effort for publishing), while working closely with the undergrad. The undergraduate took ownership of the work and, in fact, created all of the beautiful images throughout the study. My post-doc helped direct the grad student, and the grad student helped lead the undergrad. I was the funding source and, mentoring at all levels here with the design, implementation, and writing of this work, also was mentoring at all levels—working directly with the undergrad, and helping the grad student and the post doc to develop their mentorship. To me, this was the final reward from committing to mentoring at varying stages of the academic pipeline. As a result, the undergrad decided to enter a grad program, the grad student is now the post-doc, and my post-doc now has a tenure track position and is successfully leading her own team.

G. Pask (Gellert et al. 2022). Absolutely! We had a paper with three undergraduates and a science support staff member that used scanning electron microscopy (SEM) to explore the antennal sensory structures of several ant species. This was a technique I had never used before, but my students took the lead and produced amazing images and a beautiful publication!

Z. Stahlschmidt (Stahlschmidt and Vo 2022). Most of our papers include teams of undergraduate coauthors, but some of my favorites are those with a single dedicated student. Cindy Vo was a first-generation prepharmacy student that worked through the pandemic, including a summer research fellowship, on a study examining the effects of temperature and Roundup® on embryos and egg-laying decisions. Cindy is now a successful pharmacist.

N. Staub (Black et al. 2024; Gunelson et al. 2024). This is like trying to choose a favorite child! But the paper by Gunelson et al. comes to mind because Anna Gunelson and Minh Anh Tuong worked during the covid outbreak on this project, which made a challenging project even more challenging. But they persevered and have this paper to show for all their hard work. The second one I've listed in another recent one that involves two undergraduates (Cecilia Black and Katherine Van Gunst). Katherine worked in my lab 20 years ago and then Cecilia finished the project off relatively recently. Proud of their work and nice to get old but valuable work published.

J. Thompson (Smith et al. 2020). I taught Scott LaValva and Matt Loiacono, two undergrads who worked in my lab in the summer of 2014, how to do surgical implantations of EMG (electromyography) electrodes and sonomicrometry transducers in anesthetized squid, a technique that I'd been doing for a decade at that point. To make it easier to suture one of the transducers far back in the mantle cavity, I quickly detached the nuchal joint (i.e., a gliding joint that allows the head to move toward and away from the mantle cavity) and gently moved the squid's head to one side. After suturing was done, I moved the head back into place and the nuchal joint "snapped" right back into position. Noticing that the joint could be detached and reattached multiple times with no loss of function, Scott asked how the joint worked. The take-home message from this story (and one that I tell undergrads who are new to the lab) is that I had no answer to Scott's question because up until that point, I had been so focused on one thing (suturing transducers) that the unusual behavior of the joint completely escaped me. It was a reminder of the value of asking seemingly simple questions.

Conclusions

Several themes emerge from the experiences and approaches these 16 faculty share. First, being strategic and intentional about time management facilitates productivity. The scale of time management can range from to the day all the way to across multiple years. Because of the higher teaching and service expectations of PUI faculty (Slocum and Scholl 2013; Eisenhower 2019; Shields and Feller 2020), time in much of an academic calendar is the most limiting reagent of research at PUIs. Another theme presented is the value of collaborating with others within institutions and beyond (often R1s). PUIs often have fewer resources available for research, particularly in the case of expensive equipment (Dahlberg et al. 2021, Slocum and Scholl 2013; Eisenhower 2019). Further, and perhaps more importantly, collaborations can provide intellectual stimulation, keep one connected with others in the field, and provide accountability in a position that has endless time pulls. Third, federal funding agencies, such as NSF and the National Institute of Health, have (or had) grant programs geared specifically for PUIs and undergraduate students. As previously mentioned, historically NSF's funding rates for grants submitted by PUIs were the same as research intensive institutions (Slocum and Scholl 2013). In some areas of the country there are private agencies geared toward specifically supporting PUIs (e.g., Murdock Charitable Trust in the Northwest). Needing to support few or limited graduate students can substantially decrease the costs of research. As in any research endeavor at any scale, there are projects that do not come to fruition for innumerable reasons. A multitude of studies has documented that the experience of participating in a project in a research lab is in itself impactful for undergraduate students (e.g., Linn et al. 2015; Rodenbusch et al. 2016; ; Haeger et al. 2024). So, even if a project ends up not being publishable for various reasons, the experience the

student had while participating in it is valuable. Lastly, while there are common themes amongst faculty experiences, perhaps the clearest theme is the lack of one: that each individual faculty found research success by a path that works for them (see also Hoang et al. 2024). The common and unique approaches reflect individual personalities and the variation among PUIs in their expectations of teaching, research, and service and available resources.

In summary, even with high teaching expectations, faculty at PUIs have found strategies that enable them to have productive research labs, be funded by various entities, including NSF, and provide research experiences for undergraduates that can influence their lives far beyond academia. Impactful research is conducted at PUIs.

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