The Journal of Undergraduate Neuroscience Education (JUNE), Spring 2018, 16(2):A159-A167

ARTICLE
Partnerships in Neuroscience Research Between Small Colleges and Large Institutions: A Case Study

John G. McCoy[1,2], Heather J. Yu[1], Margaret Niznikiewicz[3], James T. McKenna[2], & Robert E. Strecker[2]

[1]Department of Psychology, Stonehill College, North Easton, MA 02357; [2]VA Boston Healthcare System and Harvard Medical School, Laboratory of Neuroscience (Basic Research Division), West Roxbury, MA 02132; [3]VA Boston Healthcare System and Harvard Medical School, Laboratory of Neuroscience (Clinical Research Division), Brockton, MA 02301.

There are advantages and limitations associated with a science, technology, engineering and math (STEM) education at small, liberal arts colleges relative to larger universities. While there may be increased opportunity for personal attention and access to faculty, students at liberal arts colleges may not always have the opportunity to gain experience with state-of-the-art equipment and technology. Herein, we describe a case study of an inter-institutional partnership between Stonehill College and two neuroscience research laboratories which are part of the Veterans Affairs Boston Healthcare System (VABHS). Both laboratories are affiliated with Harvard Medical School (HMS). We discuss the benefits as well as the challenges associated with the development and maintenance of this partnership. The experience with the use of sophisticated instrumentation and technology available in these laboratories may give students a competitive edge when applying to graduate school programs. However, we contend that the most important advantage of this research experience is the development of a sense of self-esteem and professional competence that will allow students to meet the many challenges that lie ahead in graduate school and beyond.

Key words: Neuroscience Education; Undergraduate Research; STEM; Inter-institutional Partnerships; Research Internship

BACKGROUND

This manuscript describes the formation and maintenance of a partnership between Stonehill College, a small liberal arts college, and two neuroscience laboratories affiliated with the VA Boston Healthcare System (VABHS) and Harvard Medical School (HMS). This partnership has provided research internships for numerous (>30) undergraduates who matriculated at Stonehill College. We discuss the perceived advantages and disadvantages associated with an education at a small, liberal arts college. This provides a context for understanding the importance of inter-institutional partnerships with large research institutions.

An attempt at a definition of the term liberal arts college may be a good starting point. While there is no single accepted formal definition, liberal arts colleges are mostly or entirely four-year baccalaureate-granting institutions (Clemmer, 1997). The undergraduate curriculum is typically generalist in nature, and often has wide ranging requirements (i.e., arts, humanities, natural and social sciences), as opposed to a highly specialized curriculum. Liberal arts colleges are often defined as those institutions in which at least half of the bachelor's degrees awarded are in liberal arts fields of study (Thelin, 2004). Additionally, liberal arts colleges are usually but not necessarily private, and class sizes are generally smaller in comparison to those at research or regional universities (Clemmer, 1997). For example, Stonehill College is a Catholic institution of higher learning with a student: faculty ratio of 12:1. The "Cornerstone Program" at Stonehill is a curriculum grounded in the liberal arts with one course required in each of four different humanities: History, Literature, Philosophy and Religion, one course required in each of three different scientific / mathematical modes of thought: Natural Scientific Inquiry, Social Scientific Inquiry, and Statistical Reasoning. Additionally, there is a two-part series of writing-intensive courses: a First Year Seminar, and an Advanced Writing-in-the-Disciplines course. Stonehill is therefore classified as a National Liberal Arts College. However, the distinguishing characteristics of liberal arts colleges are not absolute. For example, a few liberal arts colleges offer degree programs in engineering, while many research universities maintain aspects of the liberal arts tradition (Thelin, 2004).

Why do we feel that partnerships with larger institutions are important for students at liberal arts colleges, particularly those majoring in neuroscience? To answer this question, some preliminary information concerning growth in interest in the field is useful. Growth in the popularity of neuroscience among undergraduates is reflected in the continued increase in the number of schools, both large and small, that offer neuroscience as a major (Ramos et al., 2016). Moreover, in many of these institutions, the number of students graduating with degrees in neuroscience constitutes a substantial percentage of all life science graduates (Ramos et al., 2016). Ironically, the growth in undergraduate neuroscience programs in the past two decades has occurred mainly in smaller (enrollment < 4000) private, nonprofit colleges (Ramos et al., 2011) where the range of courses and research experiences are limited.

The interdisciplinary nature of neuroscience requires that students develop competence in several traditional fields of study, including physics, mathematics, computer science, chemistry, biology and psychology, in addition to developing competence in specialized neuroscience topics. Likewise, the variety of techniques that may be employed to address specific neuroscience research questions also naturally draw from these diverse fields that support the study and understanding of neuroscience. A major drawback, then, is that some techniques may be available at the home college while many others may not be. In a survey distributed to directors of graduate programs in neuroscience, research experience (not grades, GRE scores, nor letters of reference) was ranked as the single most important factor in evaluating applicants for graduate programs in neuroscience (Boitano and Seyal, 2001). Partnerships with larger research-oriented institutions can allow undergraduates at smaller schools to gain access to a wider range of courses and research experiences, which is particularly important in an interdisciplinary field like neuroscience.

While small liberal arts colleges may be limited in course offerings and the availability of scientific instrumentation compared with large research universities, there is evidence to suggest that a disproportionately large number of eventual Ph.D.'s in science received their undergraduate training in liberal arts colleges. Approximately twice as many eventual science Ph.D.'s attended a liberal arts college as an undergraduate compared with other four-year baccalaureate institutions (Cech, 1999) suggesting there is a tangible benefit to earning a degree from a liberal arts college. The possible reasons for this have been explored in depth by Cech (1999). To summarize, small classes provide for greater interaction with faculty. A wider array of pedagogies can be utilized with smaller classes, presumably allowing for greater engagement of students in the learning process. Inquiry-based laboratories can be incorporated far more easily when enrollment in lab classes is limited. Finally, it is simply more feasible for faculty to supervise undergraduate research projects and provide training when there are fewer students.

The advantages associated with an education at a liberal arts college are offset by certain limitations. For one, the time devoted to research is limited as teaching loads are generally higher for faculty at liberal arts colleges. Secondly, the type of experiments that faculty at small liberal arts colleges can pursue with undergraduates are often limited by equipment, time, and funds that are available (Sandquist et al., 2013). An unintended consequence of this is that if the available equipment and resources at a premiere research institution are beyond the scope of what is feasible at a liberal arts college, these students may feel intimidated in a "cutting-edge" research environment such as a graduate school program at a large university. This may be particularly true if their lab peers from larger institutions are familiar with the latest technology. Lastly, it may be less likely that a research project conducted on the campus of a small liberal arts institution will lead to a seminal discovery that redefines a field; and the resultant sense of excitement that accompanies that discovery published in a prestigious scientific journal. How can liberal arts institutions, with modest resources and where faculty research must compete for time with other responsibilities (e.g., advising, teaching, service), address some of these limitations? We propose that one effective solution is to partner with large, well-funded research institutions, and to form an internship program with them. This solution utilizes the best that each institution in the partnership has to offer. For example, interns benefit from the vast network and resources at the large research institution all while gaining critical research experience. Furthermore, the interns benefit from the close mentorship and guidance from the faculty liaison at the home college.

In recent years, there has been a trend towards small liberal arts colleges forging connections with larger, well-resourced institutions (Kaplan, 2011). Some of the benefits to the student should be obvious: the experience broadens and deepens their intellectual background. Development of competency in laboratory techniques provides them with a competitive advantage in graduate school and in post-college employment opportunities. Perhaps even more important is the confidence that students develop as they persevere to become proficient in laboratory techniques. The experience can also confirm if the student's career choice seems right for them. Russell et al. (2007) conducted a nationwide survey of students participating in undergraduate research opportunities (UROs). Similar to our internship program, they found that students participating in UROs were mostly juniors and seniors and had relatively high GPAs. Not surprisingly, these investigators also found that many of the URO participants expected to obtain an advanced degree in the future. After participating in the URO, almost 30% of those students surveyed in this study stated that they had a newfound desire to pursue a Ph.D. In another survey study of participants who completed an URO, Lopatto (2007) reported that about 40% of respondents planned to enter a Ph.D. program after undergraduate study. Another third of respondents in that same study said they planned to enter either an M.D. or M.D./Ph.D. program. While we do not see as high a rate of interest in Ph.D. programs compared with Lopatto (2007), many of our internship students initially have a goal of pursuing a Ph.D. program upon graduation. Despite the final lower rates of interest in Ph.D. programs, many of our participants in this internship program do continue to doctoral-awarding programs (see Figure 2). We presume that many of these students are undaunted by the competitive research atmosphere. We also acknowledge that others have changed their career goals entirely as a result of their experience in the laboratory. Several are now in M.S. programs, and intend to seek a position in industry upon graduation. We believe that both groups of students have been well-served by this internship experience.

SELECTION OF STUDENTS AND INNER WORKINGS OF THE INTERNSHIP PROGRAM

Our program provides select students at Stonehill College an internship in neuroscience in one of two participating research groups through the VA Boston Healthcare System. The two research groups are the Basic Research and Clinical Research divisions of the Laboratory of Neuroscience in the Department of Psychiatry, at Harvard Medical School (HMS). From 2012 to the present (during which time enrollment in the neuroscience program had reached a plateau), the percentage of neuroscience students participating in the VA internship program ranged from 21% - 31%. To date, 37 students have completed the VA internship program since 2006-2007.

Students chosen for the internship enroll in a Directed Studies course (NEU 490) and earn 3 credits per semester working in one of the two participating laboratories (see below). Students are expected to be able to work 8-12 hours per week during the academic year. We typically select only sophomore or junior neuroscience majors for the internship. While occasionally we may consider an advanced freshman, our experience informs us that the best practice is for freshmen at Stonehill College to focus on a successful academic and social transition to college life during their first year. On the other hand, starting this internship program in the senior year is also not ideal. The candidate we seek is a student who discovers that he or she enjoys the work, and hence continues working in the lab for an extended period such as full time in the summer between school years (though the maximum credit a student can earn is capped at 9 credits). Hence, participating in these internship programs has advantages for sophomores and juniors relative to freshmen or seniors. An intern would then work 8-12 h / week during the school year, but then increase their workload to full time for 10 weeks (35 h / week) during the summer typically through the Stonehill Undergraduate Research Experience (SURE) program (described below), or occasionally through funding from the laboratory principal investigator. The internship is structured in such a way that a student who works in the laboratory for 8-12 h / week during the semester can master requisite research techniques and is then able to “hit the ground running” on their research project during the summer, presuming their SURE Fellowship application is funded.

SURE is a signature summer research program at Stonehill for select students who are matched with faculty mentors, based on similar research interests. Summer housing and a modest stipend are provided, such that students are given the opportunity to work on a research project full-time (35 h / week for 10 weeks) under the supervision of a faculty mentor. Application for the SURE Fellowship is accomplished jointly by student and faculty mentor. The SURE Fellowship is competitive and introduces the student to the concept of competitive grant funding. The NEU 490 course is overseen by the Director of the Neuroscience Program (McCoy) who is a tenured faculty member at Stonehill, and who is also a Research Health Scientist at VA Boston Healthcare System. The Director also serves as the Stonehill faculty mentor and concurrently as the faculty liaison between Stonehill College and the VA.

Below we describe how students are selected for the research internship and subsequent SURE summer program. By the end of the freshmen year, students have taken two semesters of chemistry and two semesters of biology, and possibly calculus. Selection of students for the internship is based on the following criteria:

1) GPA (most students have GPA 3.5 to 4.0) and relevant science coursework.
2) Recommendations, either written or verbal, from the student’s professors and instructors.
3) Level of interest as assessed by the investigators through informal feedback. Following the lab tour, students are asked to comment and rank order available research projects in terms of interest.
4) Match between each student’s specific interests and availability of an appropriately matching position with an ongoing lab project. In the Laboratory of Neuroscience, Basic Research division, there are multiple projects. Some projects involve molecular / cell biology, others focus primarily on neuroanatomy, physiology, or behavioral analysis. In the Clinical Research division, students learn primarily neuropsychological assessments and / or EEG recording techniques in persons diagnosed with schizophrenia and their matched control individuals. Consistent with views expressed at other liberal arts colleges, we agree that it is very important to consider each student’s prior knowledge and lab skills and to match students with projects that challenge and stretch capacities, but which do not go beyond their reach (Hunter et al., 2007). More details on the matching process are found in the next section.
5) Feasibility: on the student’s course schedule, the student typically works in the lab two or three times per week for blocks of 3-4 hours at a time. Thus, some degree of flexibility is required and the investigators understand that these are full time college students. For example, we recommend that students “front load” work schedules, putting in as many as 16-20 h / week early in the semester. This is to compensate for the fact that students typically work reduced hours prior to midterms and final exams. Occasionally, students are able to work in the labs between the fall and spring semesters to get started on their research and the hour requirement.
6) Motivational Level: Each student intern must complete an extensive paperwork process, obtain medical clearance, pass a background check, and complete on-line tutorial courses on regulations governing chemical hygiene and safety, security, issues related to the proper care and use of laboratory animals, etc. If a student plans to work in the clinical setting, they are required to complete appropriate training on the principles of ethical research with human participants. The paperwork process takes 2 to 3 months to complete on average and students need to be highly motivated to complete the regulatory compliance in a timely manner. Thus, this process can serve as a screening tool (i.e., less motivated students take longer to complete the process). Careful student selection for the internship program is critical. Highly motivated students are preferred since students are encouraged

to work in the lab for more than one semester. Indeed, some have found their niche in laboratory research, and have continued in the laboratory for a year or more. In our case, the liaison is in the best position to select students as he has already taught them and has a sense of each student's motivation and abilities.

MATCHING OF STUDENTS TO LABORATORIES / PROJECTS

As mentioned previously, the Laboratory of Neuroscience includes two research groups: The Basic Research and Clinical Research divisions. The research techniques available in these two labs are listed in Table 1. Examples of projects in the Basic Research group include investigations of the role of neural systems mediating sleep loss-induced cognitive deficits, using transgenic mice as a model system for neuroanatomical investigation of brain systems regulating sleep and wakefulness, and the use of optogenetic technology to evaluate the role of sleep spindles in memory consolidation. The Clinical Research group examines abnormalities in perceptual and cognitive processes associated with schizophrenia spectrum disorder that include symptoms of thought disorder, language impairment, social cognition impairment, and perceptual abnormalities. Students are trained in traditional neuropsychological measures, together with event related potential (ERP) measures.

Molecular/Pharmacology:	*Real time PCR*
	RNAi
	qRT-PCR
Neuroanatomy:	*Immunohistochemistry*
	Tract tracing
Surgical:	*Stereotaxic surgery*
	Transcardial perfusion
Behavioral:	*Operant conditioning*
	Water maze
	Electroencephalography *Rotorod assay of cerebellar function*
Neuropsychological Assessment	
Imaging:	*Neurolucida*
	fluorescence microscopy
Computational/Statistical:	*SigmaStat*
	SPSS

Table 1. Laboratory Skills used by student interns.

The number of students selected for the internship program varies from one semester to the next and depends on how many investigators have a need for a student in any given semester. There are more full time Ph.D. investigators in the Basic Research group than in the Clinical group, and the distribution of interns reflects this. While only 1-2 students may be assigned to the Clinical group under the supervision of Dr. Margaret Niznikiewicz in a given semester or year, the number assigned to the Basic Research group is larger and varies to a larger degree (2-6 students per semester with an average ~4). Dr. Robert E. Strecker, Director of the Behavioral Neuroscience Section of the Basic Research group, serves as Co-Director of the internship program along with Prof. John McCoy, the liaison from the home college.

The liaison between the College and the VA Labs, who is a full time Stonehill faculty member, takes into account the interests and preferences of the students. We find that our neuroscience students often have a preference that predisposes them to be a part of one laboratory over the other. Some of our students are natural reductionists, comfortable with subjects such as physiology, cell and molecular biology, and therefore may be a natural fit for the Basic Research group. Other students find that they understand the "bigger picture" rather than the molecular analysis and so go on to find their niche at the molar level of analysis, understanding cognitive processes and other psychological constructs. We find that this latter group is often a better fit for the Clinical Research group.

The Basic Research group is divided into Molecular and Biochemical, *in vitro* Electrophysiology, Neuroanatomy, and Physiology & Behavior sections. Each section is directed by a faculty member at the Associate or Assistant Professor level at HMS. These faculty work closely with additional scientists (~4 total) at the faculty level of Instructor. Finally, there are typically 2 to 4 Postdoctoral Fellows and visiting scientists in the laboratory at any given time. In the Basic Research group, students who are selected for the internship are then matched with individual mentors, typically on a 1-to-1 basis, though faculty mentors with extensive experience may take more than one intern. The "match-making" process is based on student research interest, perceived readiness of the student for a given project, and faculty need. While each student intern is assigned a primary faculty mentor, there is much collaboration among faculty and across sections. Effort is made to expose each student to different techniques that approach scientific problems at different levels of analysis (i.e., molecular, cellular, systems, behavioral). For example, one student may gravitate toward neuroanatomy while another may be more intrigued with *in vivo* physiology and behavior. When possible, each student is assigned to a project and a faculty mentor appropriate to his / her primary interest. Nonetheless, an intern focusing on neuroanatomy will also gain some exposure to other techniques outside of that section. Breadth of experience attained seems tied tightly to 1) time in the lab and 2) motivation level of the student.

With regard to formal mechanisms by which faculty mentor student interns in our program, there are a few noteworthy items to mention. First, we offered a Friday afternoon seminar for college credit organized by Dr. Strecker, and later by Dr. McKenna for a number of years. All of the co-authors of this manuscript and a number of other Harvard / VA faculty members contributed as well. During this period, all research interns were required to take the weekly seminar along with working 8-12 hr / week. The seminar course typically involved one or two introductory lectures on the neuroscience of sleep and/or schizophrenia. After that, faculty would present either on their own ongoing research projects or on a recently published paper pertinent to the research. Toward the end of the semester, students would then give presentations either on their own projects, or related published work. Students, thus, were able to model their presentation skills directly from experienced faculty, and receive coaching and feedback from faculty. This formal course had to be discontinued as increasing regulatory paperwork made it impossible to take on enough interns to enroll a paid course.

However, this same process of "coaching" and feedback continues today in a less formal way, with individual mentors meeting and working with students on a daily basis and Drs. Strecker and McCoy meeting with students somewhat less frequently to discuss everything from current challenges in their experimental work, to career directions. Both the Basic and the Clinical Neuroscience Laboratories used to be housed at the Brockton VA Hospital, but the Basic Neuroscience Laboratory was relocated to the West Roxbury VA Hospital in 2015. As a result, it has now become more difficult for Prof. McCoy to meet with all interns at one time. To address this problem, Prof. McCoy began sending a weekly summer career email to all interns in 2015. Each would focus on a particular science-based career. Each email would present some factual information with sources, followed by a frank discussion of perceived advantages and disadvantages associated with each career choice. It is emphasized that the discussion material is partly opinion, and that students should seek multiple opinions. This weekly email has become quite popular, as it often leads to individual conversations between Prof. McCoy and individual students when time permits.

As it relates to mentoring and providing career choice guidance, we surveyed former interns and asked them to pick which goals best matched their career plans at the time of the internship. Figure 1 illustrates the intended post-graduate career goals of interns who responded to our survey (25 respondents out of 35 interns contacted).

Career goals and outcomes do not always match, even for highly motivated interns. Figure 2 depicts the current known outcomes of the 37 alumni from this internship program. Comparing these data to those of Figure 1 (surveyed goals) versus actual outcomes (Figure 2), the number of students interested in and matriculating into doctoral programs stayed mostly consistent. In contrast, the number of interns that actually entered research careers after graduation was much higher than the number of students who responded to the survey saying they had the initial goal to do research after graduation.

Furthermore, we expect that some students may change their career goals after this internship experience. Indeed, in our survey approximately 50% of respondents stated that their career goals had changed as result of this specific experience, while the other approximately 50% stated that their career goals did not change as a result of this experience (data not shown).

Lastly, it is noteworthy that 21 graduates of the Stonehill neuroscience program went on to doctoral programs, and 13 of these graduates (62%) are alumni of the VA internship. This is significant in that participation rates in the internship program ranged from 21-31% since 2012. Interestingly, eight neuroscience program graduates who did not participate in the VA internship also entered doctoral programs. While these students are not part of this study, this will be of significant interest for a future

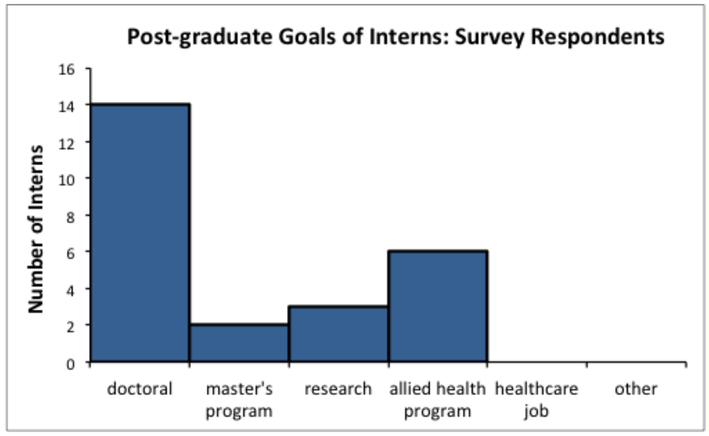

Figure 1. Survey data of Post-graduate goals of VA student interns at the time of their internship. Doctoral program includes Ph.D. M.D., D.O., D.P.T., PharmD. Master's Program includes M.S., M.A., M.P.H. Research includes research assistant, research associate, research technician. Allied Health Program includes R.N. N.P., O.T., P.A. Health Care job includes clinical coordinator, nursing assistant. Other includes public service and counseling. Note these survey data were collected from 25 out of 35 former interns, reflecting a 71% response rate. (Two interns were unable to be reached due to a lack of updated contact information.)

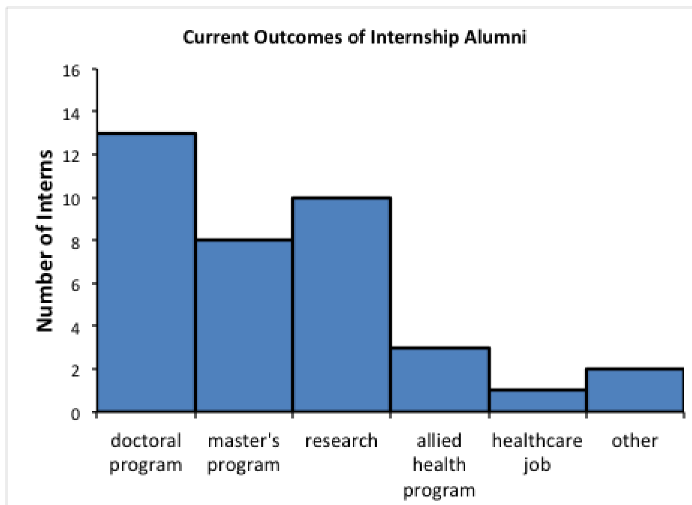

Figure 2. Current outcomes of VA student interns. Doctoral program includes Ph.D. M.D., D.O., D.P.T., PharmD. Master's Program includes M.S., M.A., M.P.H. Research includes research assistant, research associate, research technician. Allied Health Program includes R.N. N.P., O.T., P.A. Health Care job includes clinical coordinator, nursing assistant. Other includes public service and counseling. The majority of these outcomes (34 out of 37) were Neuroscience majors. The other three interns were Biology majors who worked closely with the Neuroscience Program.

study that analyzes these students' academic and career trajectories.

RECIPROCAL BENEFITS OF THE INTERNSHIP PROGRAM

We have previously alluded to the multiple student benefits accrued from associations with large research institutions such as the VA system: development of competency in laboratory techniques, broadening of intellectual development, enhancement of self-efficacy, and competitive advantage for graduate school applications. Additionally, the research internship facilitates awareness of what type of career would be the best fit for the student's strengths and interests.

In addition to providing an enriching experience to the interns at the home institution, there are also benefits to the host research institution. The most obvious is that this relationship provides an investigator with needed assistance in carrying out his/her research. Student participation increases lab productivity. For faculty at other small colleges interested in forming similar ties to research institutions, this is a "hook" that can be used effectively to attract the host research institution to participate in the internship program. Due to the remote location of the VA labs, Drs. Strecker, McKenna, and Niznikiewicz do not have practical access to undergraduate/graduate students through their parent academic affiliations (HMS) despite their enjoyment of working with students.

There may be additional benefits that are less obvious. For example, postdoctoral fellows and investigators in the laboratory can gain useful teaching and mentoring experience by working with undergraduates, a fact that they can include on the teaching/mentoring portion of their HMS CV. Even at research-intensive institutions, some teaching experience is expected and the liberal arts college can provide opportunities to teach that may boost one's chances for tenure and promotion (Kaplan, 2011). The experience of teaching and mentoring undergraduates may also help the postdoctoral fellows and junior faculty to refine their career goals. In some cases, they may find the mentoring to be extremely rewarding while others may realize that they do not have the patience for teaching and mentoring undergraduates. (This latter group would then tailor their job applications to more research-focused institutions.)

FORMER VA INTERNS RATE THEIR EXPERIENCE

The perceived benefit of undergraduate research formed the basis for a study by Hunter et al. (2007). From their study of four liberal arts colleges, they found that the students' perception of the benefit of internships differed from faculty perceptions of the benefit. Both groups (faculty and undergraduates) described student gains within the general realm of "becoming a scientist." Students' responses referred mainly to their personal and intellectual development, while faculty described these gains as a component of professional socialization as scientists and an introduction to professional practice.

Our experience suggests that interns gain (and are aware that they gain) core competencies in scientific thought and practice since they cite skills and accomplishments on their resumes. Interns also demonstrate increasing levels of independence and self-direction over the course of the program. Although interns appear to realize the hard skills that they have gained as a result of this experience, they may be less aware of gains in their professional competence (Hunter et al., 2007). Included in interns' development is the understanding that scientific research is slow, requiring refinement and repetition, is often tedious, and can be fraught with regulations.

Part of our survey that was sent to former interns was based on the survey designed and conducted by Lopatto in 2007. In our survey we asked former interns to rate twenty-two potential benefits of this internship program (Table 2). Consistent with other studies, we found that our alumni rated the ability to work independently and the acquisition of specific laboratory skills higher than other competencies such as developing scientific writing skills and understanding the grant-writing process. Gaining self-confidence and clarifying career goals were rated in the middle.

Learning to work independently	*4.76*
Understand and perform laboratory techniques	*4.58*
Understanding of the research process	*4.48*
Learning ethical conduct	*4.44*
Tolerance for obstacles	*4.36*
Understanding science	*4.36*
Readiness for more demanding research	*4.33*
Ability to integrate theory and practice	*4.32*
Understanding the design of experiments	*4.32*
Understanding how scientists think	*4.28*
Understand how scientists work on problems	*4.24*
Self-confidence	*4.24*
Assertions require supporting evidence	*4.21*
Becoming part of the learning community	*4.12*
Clarification of a career path	*4.08*
Understanding of how knowledge is constructed	*4.04*
Understanding the importance of attending conferences	*3.95*
Skill in interpretation of results	*3.88*
Understanding primary literature	*3.88*
Skill in oral presentation	*3.88*
Ability to analyze data	*3.64*
Skill in science writing	*3.61*
Understanding the grant-writing process	*3.14*

Table 2. Alumni ratings of twenty-two potential benefits of the VA internship. Former interns were asked to rate from 1 to 5 (5 being the highest) their perceived gains in each of the above categories. The list is sorted from highest rated to lowest rated and gives a weighted average from a Likert scale. These survey data reflect a 71% survey response rate.

Communication skills in science and research are also critical. In this case study, we have described the mentoring process throughout the internship program between the scientists, the interns, and the liaison. In addition to these one-on-one or small group interactions, interns also benefit from presenting their research at local and national conferences [e.g., NorthEast Under/graduate Research Organization on Neuroscience (NEURON), Society for Neuroscience (SfN), Associated Professional Sleep Societies (APSS)]. The annual NEURON conference is a good venue for students to make their first scientific presentation (e.g., Trausch et al., 2015), as it is not as large and potentially intimidating as SfN or APSS. The conference exposure gives students a chance to see and understand where their work fits into the larger scientific community. Furthermore, these opportunities allow students to have conversations and engage with other researchers and begin to understand the collegiality and connections that can easily be made. In a sense, the playing field seems more level and accessible after these experiences. Numerous interns have also been coauthors on presentations and / or published abstracts at national and international conferences (e.g., Brown et al., 2016). Some interns have earned co-authorship on a manuscript because they have played an integral role that extended beyond data collection (e.g., McCoy et al., 2010; McKenna et al., 2013). All coauthors invested and contributed significantly to the science that drives the experiments, not just to the technical aspects of work. This policy is in accordance with Harvard Medical School's authorship guidelines which emphasizes intellectual contributions as follows: "Everyone who is listed as an author should have made a substantial, direct, intellectual contribution to the work." Link to HMS guidelines: https://hms.harvard.edu/sites/default/files/assets/Sites/Ombuds/files/AUTHORSHIP%20GUIDELINES.pdf.

In addition to addressing gains in tangible research skills, our survey also asked former interns to rate the effectiveness of different types of communication activities for their career development and goals (Table 3).

Discussions with the faculty liaison (Prof. McCoy)	*4.67*
Presentation of a poster on campus	*4.44*
Discussions with the scientists at the VA	*4.40*
Presentation of a poster at a conference or professional meeting	*4.33*
Discussions with internship peers	*4.00*

Table 3. Alumni ratings of five communication activities during the VA internship. Former interns were asked to rate from 1 to 5 (5 being the highest) the effectiveness of the listed communication activities. The list is sorted from highest rated to lowest rated and gives a weighted average from a Likert scale. These data reflect a 71% survey response rate.

Lastly, the survey that we conducted also solicited anonymous open responses from former interns. Each intern that completed the survey offered some thoughts and feedback about their experience. We found that all responses were positive in some way. For instance, most alumni expressed that this internship was a valuable experience. Some said this experience got them excited about research and as a result wanted to pursue it as a career. Other responses reflected that this experience, although a positive one, helped clarify that research was not for them. A few responses indicated that as a result of this experience they were able to gain employment after graduation. Below are a few examples of the responses we received.

"My experience at the VA Hospital was the driving force behind my decision to pursue research after receiving my bachelor's degree. I developed the skills necessary to troubleshoot errors in a methodology or research protocol, and learned to look at both the positive and negative results in any experiment."

"My internship at the VA was a valuable experience for me. While I found it very interesting and enjoyed learning the science behind the experiments, it also taught me that working in a lab was not for me. As a result, I pursued a physician assistant degree and have worked as a hospitalist PA for the last several years."

"The VA allowed me to work more hands on than I thought I would be allowed in research. I was helping to perform surgeries, running experiments on my own, analyzing data and discussing research with top scientists. Everyone at the lab was incredibly helpful and would help me to fully understand all my tasks. The amount of trust they had in me to help with research greatly increased my self-confidence."

Feedback from former interns cite the hard skills and techniques they learned in this internship program (as in Hunter et al., 2007). Interestingly, we have received additional feedback (independent of our survey) from former interns who are currently working as scientific researchers. Their reflections on this internship experience suggest that not only did they learn techniques and confidence, but that they gained more nuanced skills and a deeper understanding of what being a scientist entails:

"I was presented with an amazing opportunity during my time at Stonehill College to work with a talented group of Harvard Medical School- affiliated researchers at the VA hospital. During this internship, I gained valuable hands-on experience performing various research techniques including stereotaxic surgeries and fluorescent microscopy analysis. Throughout my experience I was able to contribute significantly to several research projects, and was given the opportunity to present the work at regional and national conferences. The VA internship was something that I believe greatly contributed to my acceptance to multiple Master's programs across the country at great universities, and ultimately to the Graduate School at Brown University where I am continuing my education."

"I began as a research intern at the VA Boston Healthcare System the second semester of my sophomore year. It is here that I learned not only what it is like to be a researcher in the basic sciences of a Harvard affiliated lab, but also directly experience it first hand and work alongside researchers at the cutting-edge of neuroscience. I was provided with great mentors who fostered my development in the field of sleep research. They helped hone my lab skills and fed my curiosity through an accepting intellectual environment. I became an integral member of the team progressively learning more advanced

procedures over time. This included fluorescent microscopy, immunohistochemistry and even stereotaxic surgery. All of these I never fathomed learning, but today I cannot imagine being a research assistant without them. My work as an intern became part of grants, posters, and manuscripts while I simultaneously began to understand what each entailed. I even taught many of the lab skills to others once I was proficient. I presented my research at several conferences both local and out of state with audiences ranging from fellow undergraduates to postdocs and other researchers in the field. This internship provided me an exceptional opportunity to learn beyond the classroom while enriching it at the same time. Looking back, I realize it provided me the foundational knowledge and expertise to not only be competitive applying to graduate school, but genuinely succeed and grow within the field of neuroscience."

Though most interns may be initially less aware of these more nuanced benefits cited above, the development of professional competence is likely to be very important to employers and graduate selection committees. For example, tenure-track faculty must also engage in activities that demonstrate professional competence. Rates of tenure and promotion are higher for those faculty with a larger network of colleagues and coauthors (Warner et al., 2016). We suggest that these early experiences allow students to better understand and prepare for the nature of conducting professional scientific research. One should not, however, assume that the viewpoint of the typical undergraduate student is remotely close to the viewpoint of faculty, who have the benefit of years of experience. For example, Sanders and Landrum (2012) surveyed undergraduate students in psychology on the importance of various factors in the graduate school application process. While GPA, letters of recommendation, and research experience were considered to be of high importance to students, publications and conference presentations were naïvely ranked as less important by these students.

The benefit that students gain working in an active research laboratory extends far beyond the procedural training. As cited in the two interns' quotes above, these students specifically state that the formation of a professional network and the opportunity to participate in the grant-writing process are also integral to their current success in neuroscience research. Students gain implicit knowledge by observing the gamesmanship of science, and the critical role of networking, grant writing, publications, and conference presentations in establishing one's professional reputation. Prior to the internship, the students' conception of a professor's job was based solely on their experience at the liberal arts college. From the internship, they learn that faculty in science occupy very different kinds of positions with different job requirements and certainly different priorities. Having this knowledge, in turn, should facilitate decision making concerning one's career path. One cannot "play to one's strengths" without an understanding of the different kinds of academic positions that are available.

In summary, there are numerous benefits that can accrue from partnerships of liberal arts colleges with large research institutions, ranging from those benefits that are explicit (e.g., training and experience with technology not available on the smaller campus) to those that are implicit (e.g., knowledge of science as a profession, and development of confidence). Thus, these internships help prepare students to enter the world of science as practiced in the real world. For example, the competitive research environment is very different than the sheltered environment on a typical liberal arts campus. Students often cite the desire for individual attention from faculty as a critical factor in choosing a smaller college. It may be argued that the receipt of personal attention from individual faculty is a double-edged sword. We recognize that not all students would flourish in a large university setting, but we acknowledge that there may be a tendency for some students to become overly dependent, and less willing to try to solve problems independently. In contrast, while student interns in our program are initially given a great deal of attention and instruction from mentors, they are gradually encouraged to become more self-reliant, though help is always available. In the final analysis, the development of perseverance and independent problem-solving skills are some of the most important benefits the student can accrue from this internship.

FUTURE DIRECTIONS

Our outcome measures did not track the effect of business cycles and the impact of recession on graduate student enrollment trends (Johnson, 2013). Our data were collected from 2006 (when the Neuroscience Program at Stonehill College was established) to 2017, a timeframe which notably includes the recession that began in 2007. (While some Stonehill students worked in the laboratories prior to 2006, we began collecting data in 2006, with the inception of the Neuroscience Program). More data are needed to assess the impact of economics (and policy) on the creation of research partnerships such as this one, on matriculation rates into graduate programs in science, and on general level of interest in the participation of internships from both students and researchers.

Yates and Stavnezer (2014) have successfully utilized a regional network of colleges and universities to provide UROs, professional development opportunities, and a broader network for both faculty and students. Surveys report that students valued the relationships that were forged and 90% of participants (faculty and students) made a connection that helped with one's own research. Students may interpret these relationships as having short-term (aiding in the completion of a project) or medium-term benefit (knowing someone who can provide a recommendation letter for a graduate program). It is less clear whether students' have a concrete understanding of the importance of this benefit in the long-term (becoming a professional scientist). In the future, we plan to track these views by asking interns to complete surveys immediately after their internship experience, and by following up with them one to two years after graduation. Finally, a fair number of Stonehill neuroscience alumni who did not participate in the VA internship program (8 out of 21 total) eventually go into doctoral programs. A deeper exploration of the factors that mediate these students' progression and decision-making process would be worthy of investigation as well.

CONCLUSION

There are multiple advantages associated with an education at a liberal arts college, most notably the increased personal attention and access to the faculty. However, these advantages are offset by certain limitations, such as the lack of access to state-of-the-art instrumentation. A successful collaborative internship program between a liberal arts college and a large research university permits the students from small colleges to gain experience with sophisticated equipment and technology, and to share in the excitement of working toward seminal discoveries at the forefront of the field. An education at a liberal arts college has much to offer, but it can also be an insular environment. Outside of the campus, some students may lack confidence and may privately wonder whether they can compete with students from other, better-known institutions. In our view, the single, most important advantage to our collaborative internship program is *not* the access to sophisticated instrumentation, nor is it the opportunity to interact with world class neuroscientists. Rather, the most important advantage is the confidence that the students acquire as they work hard to develop competencies in the laboratory. Over time, they become an integral part of the laboratory team and develop a sense that, "I can do this, I fit in here, and, hey I like doing this." While the research techniques they mastered likely increased their probability of acceptance into competitive graduate school programs, we believe it is the development of each student's self-esteem and professional competence that will allow them to meet the many challenges that lie ahead in graduate school and beyond.

REFERENCES

Boitano JJ, Seyal AA (2001) Neuroscience curricula for undergraduates: a survey. Neuroscientist 7:202-206.

Brown RE, Yang C, McKenna JT, McNally JM, Gamble M, Hulverson A, McCoy J, Anderson-Chernisof M, Winston S, Deisseroth S, Thankachan S, Basheer R, McCarley RW (2016) Basal forebrain glutamate neurons studied using vGluT2-tdTomato mice: intrinsic membrane properties, cholinergic sensitivity, calcium binding protein content and projections. Presented at the Annual Meeting of the Society for Neuroscience (SfN), San Diego, CA.

Cech TR (1999) Science at liberal arts colleges: a better education? Daedulus 128:195-216.

Clemmer J (1997) "The Liberal Arts College Library Director and the Collegiate Myth". In Dandraia, F. The Academic Library Director: Reflections on a Position iTransition. (2013 ebook ed.) Routledge.

Hunter A-B, Laursen SL, Seymour E (2007) Becoming a scientist: the role of undergraduate research in students' cognitive, personal, and professional development. Sci Educ 91:36-74.

Johnson MT (2013) The impact of business cycle fluctuations on graduate school enrollment. Econ Educ Rev 34:122-34.

Kaplan K (2011) Academia: small-school science. Nature 477:239-241.

Lopatto D (2007) Undergraduate research experiences support science career decisions and active learning. Life Sci Educ 6:297-306.

McCoy JG, McKenna JT, Connolly NP, Poeta DL, Ling L, McCarley RW, Strecker RE (2010) One week of exposure to intermittent hypoxia impairs attentional set-shifting in rats. Behav Brain Res 210:123-126.

McKenna JT, Yang C, Franciosi S, Winston S, Abarr KK, Rigby MS, Yanagawa Y, McCarley RW, Brown RE (2013) Distribution and intrinsic membrane properties of basal forebrain GABAergic and parvalbumin neurons in the mouse. J Comp Neurol 521:1225-1250.

Ramos RL, Esposito AW, O'Malley S, Smith PT, Grisham W (2016) Undergraduate neuroscience education in the U. S.: quantitative comparisons of programs and graduates in the broader context of undergraduate life sciences education. J Undergrad Neurosci Educ 15:A1-A4.

Ramos RL, Fokas GJ, Bhambri A, Smith PT, Hallas BH, Brumberg JC (2011) Undergraduate neuroscience education in the U. S.: an analysis using data from the National Center for Education Statistics. J Undergrad Neurosci Educ 9:A66-A70.

Russell SH, Hancock MP, McCullough J (2007) The pipeline. Benefits of undergraduate research experiences. Science 316:548-549.

Sanders CE, Landrum RE (2012) The graduate school application process: what our students report they know. Teach Psychol 39:128-132.

Sandquist J, Romberg L, Yancey P (2013) Life as a professor at a small liberal arts college. Mol Biol Cell 24:3285-3291.

Thelin JR (2004) A history of American higher education. Johns Hopkins University Press.

Trausch AG, McNally JM, Strecker RE, McCarley RW, McCoy JG (2015) Acute ketamine mimics schizophrenia-like gamma band abnormalities in *in vitro* and in *vivo* mouse models. Presented at the 26th Annual Conference of N.E.U.R.O.N. Quinnipiac University School of Medicine, New Haven, CT.

Warner ET, Carapinha R, Weber GM, Hill EV, Reede JY (2016) Faculty promotion and attrition: the importance of coauthor network reach at an academic medical center. J Gen Intern Med 31:60-67.

Yates JR, Stavnezer AJ (2014) Engaging undergraduate summer research students and faculty in a regional neuroscience network. J Undergrad Neurosci Educ 13:A45-A51.

Received October 13, 2018; revised April 05, 2018; accepted April 27, 2018.

The authors would like to thank the following investigators, past and present, who have graciously given their time to mentor Stonehill interns: Yunren Bolortuya, Stuart Winston, Fumi Katsuki, Mark Zielinski, Jay McNally, Grace Francis, Michael Christie, Chris Ward, Jamie Tartar, Richie Brown, Lichao Chen, Youngsoo Kim, Mahesh Thakkar, Stephen Thankachan, Marissa Anderson, and Josh Cordeira (who was both an intern and later, a mentor). Special thanks to Mike Tirrell at Stonehill, who worked with Bob Strecker to develop the internship program in the early years of this century. Last but not least, we would like to thank our former and current students who participated in the VA internship program for their enthusiasm, efforts, overall contributions to our research, and also for taking the time to answer our survey and provide valuable comments. They have, to a person, enhanced our research program, brightened our days, and kept us on our toes!

Address correspondence to: Dr. John G. McCoy, Psychology Department, 320 Washington Street North Easton, MA 02357. Email: jmccoy1@stonehill.edu