



Connecting a Liberal Arts and Sciences Institution with a Research University

Neuroscience Collaborations between the College of Charleston and the Medical University of South Carolina

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The development of the Neuroscience program at the College of Charleston began in the fall of 2004. In the summer of 2005, the initial group of neuroscience faculty from the Biology and Psychology Departments attended a Project Kaleidoscope / Faculty for Undergraduate Neuroscience (PKAL/FUN) summer workshop, entitled "Undergraduate Neuroscience Education," allowing the program organizers to meet with undergraduate neuroscience faculty from across the country. The conversations at the PKAL/FUN workshop led to a formal proposal for a new Neuroscience program, which was brought to the Departments of Biology and Psychology in the fall of 2005. The first classes in the program were offered in the fall of 2006.

The Medical University of South Carolina (MUSC) is located a few blocks from the College of Charleston and has a successful

graduate program in Neuroscience. One of our faculty members had been collaborating with MUSC and had some familiarity with their Department of Neurosciences. As we were designing our program, we immediately envisioned a need to engage the MUSC faculty in order to provide the best possible experience for our undergraduate.

During these early stages of program development, we contacted the Chair of the Neurosciences Program at MUSC to gauge the level of support at their institution. The idea was well-received, and we were invited to several faculty meetings at MUSC to discuss our ideas for the program. The faculty seemed excited about the idea of having neuroscience undergraduates training in their labs and a potential source of well qualified students for their graduate program. Our goal was to garner enough support from MUSC faculty so that our students would be welcome in their

labs in order to gain valuable research experience, which is a requirement of the Neuroscience Minor degree. The program was immediately viewed as a mutually beneficial endeavor.

Thus, from the program initiation, the College of Charleston and MUSC have forged a strong partnership that has benefitted undergraduates studying neuroscience and faculty doing neuroscience research at both institutions. The programs maintain close ties in a variety of ways that facilitate communication between labs at both institutions and help undergraduates identify research experiences that can further their academic and career goals. The following sections highlight how our programs have forged these connections and the benefits of doing so for both institutions.

How are undergraduates from College of Charleston selected and matched with mentors at MUSC? How do the MUSC faculty benefit?

We have created several different venues to allow students to find and connect with MUSC faculty who are doing research that may interest them. College of Charleston's program website provides a list of faculty at MUSC who have either expressed interest in having undergraduates or have hosted undergraduates in their labs previously. This serves as a good starting point for students beginning to explore MUSC's research programs. As the program has grown and become more recognized at MUSC, faculty have begun to email the College of Charleston program directors and faculty directly with requests for undergraduates to fill lab openings. We disseminate that information through a student email list and by posting to our program's Facebook group. In some cases, MUSC faculty have joined our Facebook group and will post openings directly to the page. We strive to ensure that most neuroscience students are members of the page to create a community where this type of information can be shared.

For younger students who are just curious about what kind of research they might want to do in the future, we hold a joint meeting

called Neuropalooza that has a poster session where students can explore the work of different labs at MUSC. Once a student has identified a lab or labs they are interested in, it is up to them to make the connection and arrange for their research experience. This system has worked amazingly well, and up to 70% of our students in any given year do their final research project in a lab at MUSC.

With these open avenues of communication, once a student and MUSC mentor contact one another, their research partnerships can take many forms. The most direct, formal mechanism the Neuroscience program utilizes is the Bachelor's Essay. This two-semester, six credit-hour research experience is required for the completion of the minor and is typically completed during a student's senior year. Of course, this requirement can be filled through research experiences with College of Charleston faculty as well. Whether a student chooses to fulfill this requirement at the College or MUSC, he or she receives the same course credit.

Students who perform their Bachelor's Essay at MUSC are sponsored by a faculty member at the College of Charleston through our course number BIOL/PSYC 488 and directly supervised by a faculty mentor at MUSC. Essentially, this allows students to work for a mentor at MUSC without the necessity for that mentor to have a faculty or adjunct faculty appointment at the College of Charleston. The College sponsor meets periodically with the student throughout the year-long project to assist with, help edit, and grade the final written manuscript, the product of the research experience. Input and grade recommendations are also solicited from the MUSC mentor when determining the final grade for the course.

With a rapidly growing minor, faculty laboratories and associated research experiences at the College of Charleston quickly reach capacity. The collaboration with MUSC faculty is vital in this sense. Furthermore, the opportunities at MUSC offer our students something unique. Specifically, the Neuroscience Department at MUSC has a particular focus on addiction and related neural mechanisms. Their faculty are

successful in obtaining external funding, providing substantial infrastructure to support large dynamic labs. Conversely, the mentors at MUSC benefit from the added research productivity in their labs supplied by the undergraduates. The Neuroscience program has been fortunate in attracting dedicated and motivated students who typically perform well in the labs. So, even with requisite training time, these students ultimately contribute significantly to laboratory projects, present posters at conferences, and in many cases earn co-authorship (and in exceptional cases first authorship) on peer-reviewed publications.

These experiences at MUSC have been very positive for both students and faculty. It gives students the opportunity to be part of the dynamic in a large research lab stocked with graduate and post-doctoral students, in addition to developing a wealth of research skills. In many cases, the relationships that these students develop extend into their post-undergraduate careers. Often these students are prime candidates for any paid laboratory technician positions that may open up. This is particularly helpful for those students who are not applying to graduate school during their senior year and are seeking more experience before applying, to help their decision process and to strengthen their vitae.

How is undergraduate research at MUSC typically funded? Are MUSC mentors compensated? If yes, how?

Funding of undergraduate student research at MUSC varies depending on the context in which the student works in the lab. The most common way in which this work is funded is by integrating undergraduate researchers into an already-existing project funded through traditional grant mechanisms. This is the case for students who work in the lab for Bachelor's Essay credit, for example, and accounts for support of most volunteers. In some cases, such as for the Summer Undergraduate Research Program (SURP), there are MUSC departmental or university funds set aside to assist the mentor in supporting undergraduate research. Currently,

in this case, the mentor pays a fraction of the SURP student's summer salary, the department pays a fraction, and the university pays a fraction.

Mentors are rarely financially compensated for supporting undergraduate research. For the SURP program, the university allots a small sum of money to cover lab expenses (reagents, consumables, etc.) so that the SURP student does not present much additional cost to the host laboratory. In a small number of cases, there are grants specifically designed to fund undergraduate-related research and teaching. These usually come in the form of fellowships for graduate students or postdoctoral fellows who are interested in incorporating undergraduate-related teaching and mentoring into their career training. An example of such a fellowship, the PACD grant, is discussed in detail below.

There is typically no expectation of reimbursement for MUSC mentors. Both mentors and students predominantly believe that students are given an opportunity to conduct research in a lab related to their interests, while mentors are given training in mentoring undergraduate students and are provided with a motivated, intelligent young person to assist in experimental design and execution at no additional cost (as would be incurred with hiring additional staff, for example). These benefits are discussed in more detail below. This exchange is appreciated by MUSC faculty, postdoctoral fellows, and students and typically results in a positive outcome for both parties.

What benefits do the research associates, graduate students, and postdocs from MUSC derive from the collaboration between institutions?

Teacher Training Program

In the absence of an undergraduate program at MUSC, graduate students do not have the opportunity to develop and strengthen their teaching skills as would be common in other graduate programs. This puts these students at a disadvantage when they are applying for faculty positions and limits their scope of future opportunities. As a

means to provide opportunities for pedagogical development at the graduate level, a Teacher Training Fellow (TTF) Program was initiated in 2008 through funding by the Howard Hughes Medical Institute Undergraduate Education Award granted to the College of Charleston. This program is meant to provide an opportunity for graduate students to continue their laboratory research while they are involved in the classroom, similar to what would be required of Teaching Assistants in other graduate programs. The program is not restricted to students of a particular discipline, but the majority of TTFs have been from the MUSC Department of Neurosciences. Graduate students are formally recruited for the TTF program through a direct call for applicants from College of Charleston faculty, although most students learn about the opportunity from previous TTFs in their lab or department.

To date, six TTFs have finished the program, serving in classes in the neuroscience curriculum, including Principles of Neurobiology, Biophysical Modeling of Excitable Cells, Techniques in Neuroscience. As the TTF, the graduate students attend lectures, hold weekly recitations, prepare and present lecture material, and contribute to student assessment. MUSC mentors were compensated for the time their graduate students were not involved in their research. This is accomplished by having the TTF Program pay for part of their salary while they participate in teaching, thus freeing up some of their salary funds in their home lab for other uses. All the TTFs reported their desire to participate in the program regardless of this compensation. In fact, several of the graduate students have sought out additional, uncompensated teaching opportunities. For example, one graduate student who was a TTF in our neuroscience lab course, Techniques in Neuroscience, volunteered to participate in a lecture-based neuroscience course in order to gain additional experience. In order to assess the TTF program, we surveyed the fellows at the end of their training semester, and our survey results indicate that the opportunity has increased the interest in teaching-related careers and made participants more

competitive for jobs. Additionally, the TTF program has not impacted graduate student research productivity. Since they have served as TTFs, cumulatively, they have published 16 peer-reviewed research papers. In a recent grant renewal, we have expanded the TTF program in order to increase teaching opportunities for MUSC students.

Mentoring and Research Experience

Outside of formal mentoring programs and grants, graduate students, postdoctoral fellows, and junior faculty at MUSC benefit from the experience of mentoring undergraduates. Student mentoring is a skill that must be learned, and, besides the examples mentioned above, there are few formal mechanisms or courses by which graduate students or postdocs can learn this skill. Frequently, when an undergraduate conducts volunteer research in a laboratory, they are paired with a graduate student or postdoc who will oversee their work on a regular basis. The experience of training a new student, teaching material to someone with less experience, maintaining organized schedules for a research team, and encouraging an inexperienced scientist-to-be through difficult times (e.g., data dry-spells) is absolutely invaluable for graduate students and postdocs who have aspirations of becoming training faculty at universities or colleges. The skillsets that mentors can develop and refine through training undergraduate students are of invaluable aid in running their own future laboratory. The sooner that graduate students have access to this opportunity, the better.

Research Assistance and Research Assistants

Having engaged and motivated undergraduates has the potential to be of significant value to MUSC investigators beyond the mentoring experience. Undergraduates bring enthusiasm and new perspectives to a research laboratory, and their presence allows for a constant influx of new ideas. Because undergraduate students are usually integrated into ongoing projects, their contributions can be substantial. Students engaged in relatively long-term laboratory commitments, such as those conducting Bachelor's Essay-related research, are frequently given a specific project that they are trained on and are responsible for pushing forward. This project is often a sub-goal of a grant-funded research investigation. For example, this could involve conducting behavioral tests on a cohort of animals and testing one of multiple (e.g., pharmacological) manipulations related to a behavior of interest. Another common example is the analysis of previously-collected brain tissue for particular protein- or gene-expression. Research projects like these are frequently of value to the MUSC investigators as a way of making progress towards a larger research goal and provide the students with hands-on research experience for which they can assume a measure of responsibility.

Of course there is not necessarily any expectation that the student must see this project through to completion before graduation, but having students engaged in a specific project of their own frequently results in some amount of useable data. Because undergraduates are typically committed to a shorter time-frame than are graduate students or postdocs and have other commitments such as coursework, the complexity of the experiments must be tailored to their capabilities. However, most labs have small projects that are amenable to a limited degree of commitment.



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There are, in addition, examples of students who become deeply ingrained in a particular laboratory, beginning their research during their freshman or sophomore year and continuing to participate in research throughout college. These students often take on more and more responsibility, providing further benefits to the host lab, most often in the amount of data they are actually able to contribute to the lab's main research goal. In the other extreme are students who want more of a taste of laboratory experience with smaller time-commitments. These students are often given projects that, while allowing participation in lab research, are somewhat more routine and less autonomous. For example, students have been involved in the scoring of previously-collected behavioral data or preparing sections of previously-collected brains for future analysis. As above, having students perform these tasks is of significant value to the host laboratory and can be very beneficial for the student who gets a taste of lab life. In some cases the work that these students perform for the lab is of sufficient value and scope that they are included in publications resulting from the research, as was the case with a 2012 report from the laboratory of Dr. Ron See.

Finally, particularly motivated or dedicated students are often extremely valuable to their host lab as future employees. Undergraduates wishing to go to graduate or medical school frequently take a year or two off between college and graduate school. In many cases, these students are able to take a position as a paid research assistant in their previous host laboratory. This outcome is useful to the lab for a number of reasons. First, the assistant is pre-vetted, so the lab knows that they are hiring someone they can trust. Second, the assistant has been trained by previously volunteering in the lab, decreasing the amount of initial investment that other lab members have to make in getting them up to speed. In some cases, undergraduate volunteers sometimes join MUSC as graduate

or medical students, again providing a service to the university, department, or host lab (depending on where they end up performing their graduate research) by including a student of known ability in the community.

Postdoctoral Academic Career Development

Overlapping research interests between the College of Charleston and MUSC faculty have also provided fruitful outcomes for student development. For example, Dr. Parrish Waters (Postdoctoral Research Associate, MUSC) and Dr. Michael Ruscio (Associate Professor, CofC) conducted a collaborative year-long research and mentoring program. This collaboration began with Dr. Waters submitting a Postdoctoral Academic Career Development (PACD) training grant through MUSC. The PACD program is aimed at engaging postdoctoral researchers in enhancing the research culture at predominately undergraduate institutions in South Carolina. A main goal of Dr. Waters' grant application was to conduct a series of experiments to further understand the role of the neuropeptides oxytocin and vasopressin, as they relate to addictive behavior and propensity to relapse. Another goal was for Dr. Waters to gain experience in mentoring and teaching undergraduates. With these goals in mind, the situation lent itself to a natural collaboration with Dr. Ruscio who had expertise regarding neuropeptidergic systems as they relate to social behavior and several years of experience teaching and mentoring undergraduate research.

Dr. Waters designed a series of experiments which were conducted in laboratories at MUSC. MUSC has an extensive and well-established infrastructure for performing addiction research using rodent models. It is important to note that although these experiments were designed to incorporate undergraduates they were by no means simple experiments. They were designed with the intention of creating publishable data and furthering a more extensive research program headed by Dr. Ron See at MUSC with whom Dr. Waters performed his post-doctoral studies. The program began with Dr. Waters presenting a

series of lectures in Neurobiology and Behavior, a required course in the Neuroscience minor at College of Charleston. These lectures helped identify student collaborators in the spring semester, with the intention of conducting research the following academic year, or in some cases beginning in the summer. Secondly, they allowed Dr. Waters to further develop his teaching skills in a venue where Dr. Ruscio and the students could provide feedback.

For the six undergraduate students who participated in this research opportunity, it dovetailed well with the requirements for the Neuroscience minor. They were able to receive academic credit for their year-long effort as part of their Bachelor's Essay requirements. Students were involved with data collection, analysis, and presentation of their results. Dr. Waters' extensive efforts with students in the lab, and Dr. Ruscio's knowledge of appropriate venues and presentation formats for undergraduate research, resulted in a total of six national poster presentations, 12 regional poster presentations, and two talks at regional meetings. Lastly, each student was also responsible for writing up their research in a form designed to represent a professional manuscript assisted by both Dr. Waters and Dr. Ruscio. Further analysis of the data will determine the possibility of publishing the results.

In sum, this collaboration was mutually beneficial for all. It was based on an overlapping research interest regarding the roles of oxytocin and vasopressin in social behaviors. It allowed Dr. Ruscio to expand his research interests into areas associated with addiction. It provided Dr. Waters with the ability to collect a wealth of data with undergraduate research collaborators and gain valuable mentoring experience. Finally, it gave six students the opportunity to take their first substantial foray into neuroscience research.

How are the two communities connected during the academic year? What benefits do faculty at the College of Charleston derive from the collaboration with MUSC during that time?

Scientific Meetings and Conferences

There are many different ways that the research communities at both schools stay connected during the academic year. The Cognitive Neuroscience Center at MUSC has monthly meetings that feature a seminar from one of the participating labs. College of Charleston faculty are invited to attend and participate in these meetings. This provides a larger community for Charleston faculty whose research interests are in this area. In addition to this monthly meeting, the Neuroscience Institute at MUSC hosts a one-day, statewide Frontiers in Neuroscience symposium that features platform presentations and a poster session. College of Charleston faculty attend this meeting with their students to present their work. Charleston neuroscience students working in labs at MUSC will often present their research at this meeting as well.

Finally, both programs hold a joint meeting called Neuropalooza that occurs in the weeks prior to or after the Society for Neuroscience meeting. The late afternoon symposium features a keynote speaker, four student talks, and a poster session. Faculty from both institutions attend along with undergraduates, graduate students, and postdocs. The four student talks are split between institutions to provide opportunities for students at both institutions to present their work. The 2011 meeting featured a keynote presentation by Dr. Larry Young (Emory) and student talks that ranged from computational neuroscience to mouse models of addiction.

Brain Awareness Week

While our partnership is strong, there has been limited neuroscience-related educational outreach into the local community. Brain Awareness Week is an international campaign dedicated to advancing public awareness about the progress and benefits of brain research. This has provided an opportunity for faculty and students from our two institutions to work together to stimulate neuroscience

awareness by increasing community involvement in neuroscience-related activities.

Sparked by a growing neuroscience student body at Charleston and a desire to integrate service-learning in the curriculum using HHMI funding, Charleston initiated efforts in developing a community outreach program in 2009. In 2010, we expanded the program by teaming with MUSC's program to educate local children about the nervous system through school visits. Prior to this, MUSC was engaged in outreach to a select number of local schools, but there was no partnership with Charleston. We have developed a successful outreach program that has brought graduate students and postdocs together with the neuroscience undergraduates as "teaching teams." Scheduling of the school visits and pairing up in the teaching teams has been a collaborative effort between a Charleston faculty member and an interested graduate student from MUSC. Over the past three years, these teaching teams have visited 20 local middle schools, 54 individual classrooms and impacted over 1,600 children. Moreover, 36 undergraduates have been paired with MUSC graduate students and postdocs to carry out these outreach efforts. This experience is mutually beneficial for both institutions as it provides an opportunity for the MUSC post-graduates to mentor the undergraduates in a pK-12 classroom setting.

As the program continues to grow, there has been an increase in interaction during Brain Awareness Week between our two institutions. In 2011, Dr. Linnea Freeman, a former TTF in the program, directed the outreach activities from MUSC. In addition to the school visits, Dr. Freeman expressed interest in participating in more extensive outreach activities, such as at the Children's Museum of the Lowcountry which has exposed over 2,000 children to neuroscience since 2009. Here, undergraduate neuroscience students plan and execute several days of hands-on activities for young children (pK-5) at the local museum. Dr. Freeman worked with the undergraduates to help design activities and participated in several days of outreach. These collaborative

efforts resulted in a poster presentation at the Society for Neuroscience in 2011.

Does the bridging of student and faculty research across institutions with different missions (undergraduate liberal arts vs. research and graduate medical education) present any unique problems or conflicts?

By and large there are few conflicts that arise from the joint MUSC-College of Charleston research training programs. This is possibly due to the fact that the interaction between schools, particularly at the level of undergraduate research volunteers at MUSC, is well-established and both parties have an understanding of the expectations of the nature of the enterprise. Problems can potentially arise when the nature of the training is not well-characterized in the beginning. For example, problems may arise if MUSC mentors are expecting time commitments akin to paid research assistants or have only a limited commitment to training the undergraduate mentee. From the undergraduate research perspective, it is often critical to set up expectations of responsibilities from the outset. In many cases, undergraduates play important roles in grant-funded research projects, and any misunderstandings about things such as reliability or punctuality can result in disruption of the project and potentially damaging setbacks.

Both of these examples are common to most training endeavors and are not unique to

liberal arts vs. research/graduate schools. However, because the schools are not completely integrated, it may be the case that parties on both sides are less aware of the needs and demands placed upon each other. Ultimately, these issues are rare and are usually obviated through open channels of communication on the part of both the undergraduate and the mentor.

In sum, the partnership between MUSC and the College of Charleston has been a fruitful one that continues to develop and evolve in a direction that promises to strengthen and expand this relationship. Faculty at MUSC have the benefit of bringing enthusiastic, dedicated and hard-working students into their lab. Conversely, the students gain invaluable experience in the development of their laboratory skills and professional development. Opportunities like the teacher training program allow post-doctoral researchers to gain experience in the classroom and mentoring undergraduates. Furthermore, overlapping research interests between faculty at both locations creates additional bridges and avenues for collaboration. As the Neuroscience program continues to grow at the College of Charleston, this working relationship with MUSC will remain an important cornerstone of the program.