Mentoring Undergraduate Students in Neuroscience Research: A Model System at Baldwin-Wallace College

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As neuroscience research and discovery undergoes phenomenal growth worldwide, undergraduate students are seeking complete laboratory experiences that go beyond the classic classroom curriculum and provide mentoring in all aspects of science. Stock, in-class, laboratory experiences with known outcomes are less desirable than discovery-based projects in which students become full partners with faculty in the design, conduct and documentation of experiments that find their way into the peer-reviewed literature. The challenges of providing such experiences in the context of a primarily undergraduate institution (PUI) can be daunting. Faculty teaching loads are high, and student time is spread over a variety of courses and co-curricular activities. In this context, undergraduates are often reluctant, or ill equipped, to take individual initiative to generate and perform empirical studies. They are more likely to become involved in a sustained, faculty-initiated research program. This paper describes such a program at Baldwin-Wallace College. Students frequently start their laboratory activities in the freshman or sophomore year and enter into a system of faculty and peer mentoring that leads them to experience all aspects of the research enterprise. Students begin with learning basic laboratory tasks and may eventually achieve the status of "Senior Laboratory Associate" (SLA). SLAs become involved in laboratory management, training of less-experienced students, manuscript preparation, and grant proposal writing. The system described here provides a structured, but encouraging, community in which talented undergraduates can develop and mature as they are mentored in the context of a modern neuroscience laboratory. Retention is very good - as most students continue their work in the laboratory for 2-3 years. Student self-reports regarding their growth and satisfaction with the experiences in the laboratory have been excellent and our neuroscience students' acceptance rate in graduate, medical and veterinary schools has been well above the College average. The system also fosters faculty productivity and satisfaction in the context of the typical challenges of conducting research at a PUI.

Key words: Neuroscience pedagogy; Neuroscience education; Interdisciplinary studies; Baldwin-Wallace College

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Meaningful and realistic laboratory experiences are essential to the development of undergraduate students of neuroscience. Of course, laboratory skills are traditionally part of most science curricula. However, in our experience, more and more undergraduates are going beyond the classroom and are seeking to affiliate with a faculty member who has an ongoing program of research. Faculty members who welcome the building of these kinds of mentoring relationships are aware of the personal rewards they can bring. Simultaneously, when students work in a productive neuroscience laboratory, it enables them to experience first-hand the full range of joys and frustrations of science, it often facilitates their career decisions, and it helps the student build marketable laboratory skills and credentials.

There are many challenges to sustaining a research program that facilitates student mentoring at a primarily undergraduate institution (PUI). Institutional resources may not be adequate to maintain an ongoing program of student-faculty research and competition for extramural support may be difficult to obtain if scholarly productivity cannot be demonstrated. This "Catch 22" is exacerbated by the fact that research activities are not typically part of a faculty member's workload at most PUIs. It is frequently difficult to manage research around substantial teaching responsibilities. Research space frequently coexists with teaching space and competition for equipment may discourage a research program not directly affiliated with a particular course. A variety of co-curricular activities compete for each undergraduate's time. Even undergraduate students who are focused on science are gathering information about several career paths and may sample several different laboratory experiences. Therefore, lab Associates may work with an individual faculty member for only a brief time each semester and may not sustain this interest over multiple semesters.

Of course, many of these challenges are an inherent part of the PUI setting. Those of us who have been drawn to this environment enjoy the variety of students and the diversity of interests they bring to their studies. But how, in the context of a PUI, do we provide our students with a realistic neuroscience laboratory experience that offers them the depth and full range of the scientific enterprise? This paper describes the Neuroscience Laboratory at Baldwin-Wallace College (Appendix 1) and identifies a system that has been successful in attracting and mentoring undergraduate neuroscientists and providing meaningful laboratory experiences in the context of a sustained research program. It has been our observation that most undergraduates are reticent to initiate their own research project. They are more comfortable affiliating with a faculty

member who has an established research program. Only after a significant amount of skill and confidence building will a student take the initiative to design and execute their own study. Therefore, the Baldwin-Wallace program is designed to present an attractive enticement to beginning undergraduate scientists and provide a forum in which they may grow into skilled investigators even before receiving their bachelor's degree.

A variety of other programs have been proposed to facilitate undergraduate scientific research (Eddins et al., 1997; Eddins and Williams, 1997; Monte, 2001). More recently, Jones et al. (2002) have focused on neuroscience research in particular. These programs share several common features with our own (e.g., active learning, a structured mentoring environment, and peer training). However, our model is especially well suited to a PUI where teaching is the primary mission and integration between research, the curriculum and co-curricular activities is prominent.

THE NEUROSCIENCE LABORATORY AT BALDWIN-WALLACE COLLEGE

The Neuroscience Laboratory at Baldwin-Wallace College has grown considerably since its institution only ten years ago. The laboratory began in the basement of the campus observatory within a small space (~200 square feet) and involved only one or two students/year. Our current research facility, located in the same building as the Biology and Chemistry Departments, is a multi-room lab space of approximately 1,000 square feet. The space was renovated in 1995 to meet our specific needs. Acquiring the new space and attracting the institutional funding required to renovate it could only have been possible in the context of a shared vision of a Neuroscience program at Baldwin-Wallace College. It took the support of the academic departments involved (Psychology, Biology, Chemistry) working with the Academic Deans to find the resources required.

The size and layout of our facility is important as it shapes the number of experiments as well as the type of experiments we are able to conduct simultaneously. We have found that our current facility comfortably accommodates 10-15 students in a given semester working on five or six different research projects. One of the things that make our program so desirable to students is that each of these projects has a number of different components including behavioral measures, imaging techniques, physiological measures, histological procedures, molecular techniques, data collection, and statistical analyses. Students working in the lab are invited to become involved in any number of these skills, thus allowing students to customize their experience. Ideally, interested students begin working in our lab during their sophomore year. We have found that most sophomores have at least completed their introductory science courses and may even have some research experience. Beginning as a sophomore seems to provide students with enough time to experience each component of the lab and then to become specialized in those components that are most interesting to them. On average, most of our students have worked in our lab for a sustained period of two to three years by the time they graduate.

Establishing a productive undergraduate research laboratory at Baldwin-Wallace College, required a fair level of support. As suggested above, from the beginning our research has been encouraged by the college itself. As our program began to grow and we became involved in more costly research projects, we looked outside of the college for much of our funding. For instance, we initially received an Instrumentation (ILI) grant through the National Science Foundation (NSF), which we used for start-up costs and to purchase much of our laboratory equipment. We have since been awarded research grants from both the National Institutes of Mental Health (via the R15, *Academic Research Enhancement Award* mechanism), and the National Science Foundation (via the *Research for Undergraduate Institutions* grant mechanism). Even with these research grants, we continue to be supported by the College in a number of ways. In addition to supporting our research directly, Baldwin-Wallace College has recently created a program that offers travel funding to our students who are planning to present research at national and international conferences. Similar grants (e.g., summer-research grants and travel grants) are provided to productive faculty. Baldwin-Wallace College has also offered matching support (along with extramural granting institutions) to allow the employment of a full-time Neuroscience Laboratory Director. The Laboratory Director helps the principal investigator / head of the program supervise the undergraduate students and the daily research projects. This position was designed to benefit the Laboratory Director as well as the students in the lab. Most of our previous Laboratory Directors have been recent college graduates who were planning to continue their professional education after taking a year's hiatus. The position normally lasts for one-year in which the Laboratory Director is trained in all of the essential laboratory activities, helps to plan and oversee the ongoing research program and participates as a colleague in the writing of peer reviewed articles and grant proposals.

The Neuroscience Laboratory space is a shared facility. A small-animal vivarium adjacent to the laboratory supports traditional laboratory courses as well as both student and faculty research in the departments of Psychology and Biology. The Neuroscience Laboratory itself is managed by the Director of Neuroscience Studies at Baldwin-Wallace College (currently GAM). The Director uses the space for his own research program, allocates space for student projects (e.g., Neuroscience Senior Theses, Independent Studies), and provides space for collaborative studies with other faculty members (who may also have space within their own departments). Thus, the facility is open to students and faculty in a variety of disciplines related to the brain sciences.

MAKING THE LABORATORY EXPERIENCE KNOWN AND ATTRACTIVE

The Baldwin-Wallace College Neuroscience Laboratory would not be successful without the ability to attract exceptional undergraduate students who conduct the research, help manage the laboratory and perpetuate the lab traditions. What makes this laboratory experience attractive to our students? What makes our students want to stay affiliated with the laboratory for extended periods of time (often years)? Informed selection of students is an important factor (see below). But there are also curricular and co-curricular activities that make students aware and interested in the Neuroscience Laboratory.

The Role of Feeder Courses. Many Lab Associates are recruited from the Neuroscience feeder courses: *PSY/BIO 250: Principles of Neuroscience* and *PSY/BIO 303: Physiological Psychology*. The *Principles of Neuroscience* course is a team-taught, cross-listed, sophomore-level course that introduces students to the study of the brain and behavior. This course meets core curriculum requirements in either social or natural sciences allowing curious students to explore the field. This course is ideal for recruitment since students typically take the course during either their freshman or sophomore year.

The *Physiological Psychology* course (also cross-listed between Psychology and Biology) provides students with an overview of the physiological bases for behavior, cognition, motivation, emotion, learning and memory. This course allows more advanced students to conduct research in the Neuroscience Lab by completing a course project. After working in the lab in this capacity, some students seek additional research experience.

While the feeder courses provide a fresh group of students from which to recruit, it is important to point out that the success of the laboratory also played a role in establishing the Neuroscience major and minor at Baldwin-Wallace College. With the rise in popularity of the Neuroscience Laboratory and encouragement of students to enroll in the neuroscience-based courses, it provided justification for formalized degree programs.

The Role of Peer and Faculty Advising. Many students are drawn to the Neuroscience Laboratory because it provides the opportunity for individualized attention from faculty, staff, and other students. While conducting, at times what seems like endless hours of research procedures, Lab Associates have the opportunity to talk with faculty, paraprofessionals and each other about best practices in classes and life experiences. Most of all, it provides an educational experience disguised by social interaction.

In the Neuroscience Lab, a significant amount of information regarding the policies, procedures, and research techniques is passed on from student to student. Veteran Lab Associates develop their leadership and mentoring skills by training newer Lab Associates. Members of the lab tend to study together for classes, share helpful college survival information, and socialize outside of the lab and beyond the college. In fact, two former students of the Neuroscience Lab, who did not participate at the same time, met at a “Lab Alumni” social at the Society for Neuroscience meeting and were married a little over two years later.

On many occasions, the constant interactions in the laboratory have provided the perfect opportunity for faculty and paraprofessionals to advise students on career paths, prepare them for professional/graduate school interviews, or simply give them that crucial reality check. In the Neuroscience Lab, faculty members work with Lab Associates closely, follow their progress, and in turn, write more knowledgeable and passionate letters of recommendation on their behalf. In addition, students who make contributions to the science and exert extra initiative in the lab are acknowledged, or identified as authors, on poster presentations and journal publications (see below) providing stronger professional/graduate school applications.

The Role of Co-Curricular Student-Run Organizations. In 1998, a group of students in the Neuroscience Laboratory set their sights on developing a College-recognized student organization for students interested in the field of neuroscience. To some extent this organizational initiative was motivated by the need to obtain funding for activities and travel to professional conferences. From this student-driven movement, the Interdisciplinary Neuroscience Society (INS) was established. Since that time, INS and its student members have provided the backbone for many of the educational, professional development, and community-building activities of the lab that go beyond the research.

With funding from the Student Senate, INS has been able to sponsor a number of attractive events that have raised the profile of the Neuroscience Lab and field of study in general. In addition to hosting social gatherings and funding for conference travel, INS primarily hosts the Brain Awareness Week activities for the College. During the “Decade of the Brain” (1990’s), Brain Awareness Week was established as a national movement to educate the public about the importance of brain research and fields related to neuroscience. INS and the greater neuroscience community continue to celebrate Brain Awareness Week and provide a variety of outreach and educational experiences. Each year, INS members travel to local elementary schools to present programs about the brain and behavior to eager future researchers. On campus, they host presentations from nationally-known neuroscience researchers and sponsor a Neuroscience Laboratory Open House. Here, INS members demonstrate many of the pieces of equipment used in behavioral neuroscience research and talk about the Baldwin-Wallace Neuroscience Program to interested peers.

Furthermore, for the last five years, INS has sponsored the Northeast Ohio Brain Bee Competition. This is a venue for area high school students to demonstrate

their knowledge about topics related to the central nervous system and compete for prizes. The winner of the Northeast Ohio Brain Bee has the opportunity to represent Baldwin-Wallace College and Northeast Ohio at the National Brain Bee Competition held in Baltimore, MD. Local high-school students continue to look forward to the competition and in the process learn about the central nervous system and (not coincidentally) the Neuroscience Program at Baldwin-Wallace College. Overall, the activities sponsored by INS educate our College students/faculty and greater community in an enjoyable, yet informative, manner and thereby attract student researchers to the lab as well as the field of neuroscience.

STUDENT SELECTION CRITERIA

Although we would like to be able to provide a research experience to every student interested in working in our Neuroscience laboratory, we are fairly selective about the students we accept. Our selection process has two aims: it allows us to limit the number of students in the lab to an optimally sized group as well as to maintain a quality research environment. Currently, our students are selected to join the Baldwin-Wallace College Neuroscience lab based on four main factors: (1) competency and preparation, (2) recommendations from their peers, (3) student interest in the program, and (4) the amount of time the student can devote to the experience.

Competency is typically assessed by classroom performance and interviews. Students who have done well in the Neuroscience curriculum usually perform well in the more intensive and detailed work available in our Laboratory. Personal interviews with the Faculty PI and the Laboratory Director help make sure that the candidate has an accurate view of what is required of our laboratory associates and allows for assessment of the candidate's goals and expectations. The personal interview is also a time to screen students in regards to their feelings about working with experimental animals. We have found that peer recommendations, particularly from students already associated with the lab, have also proven to be very helpful in selecting quality students. It seems that as students become invested in the activities of the lab, they tend to recommend peers who also have qualities consistent with the makings of good, devoted laboratory colleagues. Although peer recommendations are a helpful selection criterion, an interested student does not need to know anyone affiliated with the lab in order to be selected. In fact, a student's interest in the program is itself an essential criterion for selection. Students who are genuinely interested in the current research projects are more likely to devote more of their time and energy into the research. Thus, these students are the ones who are more likely to return each semester and do quality work. While competency evaluations, peer recommendations and a student's interest are valuable to our selection process, the amount of time a student can devote to participating in lab activities may be the most critical factor. Students who have too many time commitments outside of the lab do not seem to benefit from the experience as much as other students. Even if a student comes highly recommended and is interested in the current research, if they don't have enough time to devote to learning in the lab, the quality of their work can diminish and they may not view their experience as worthwhile.

ORIENTATION TO THE LABORATORY

As they affiliate with the Neuroscience Laboratory, each student meets with the faculty member and/or the Laboratory Director and receives basic information about operations of the lab. Perhaps most important is the student's introduction to the culture of the lab and what will be expected of them. At the end of this orientation, students new to the Baldwin-Wallace College Neuroscience Laboratory read and sign a statement (see Appendix 2) verifying their understanding of information provided and a series of expectations.

As part of their initial orientation students are shown where supplies and equipment are stored, trained in animal handling, care and use, and are instructed how to make entries in the Lab Books. They, and the person doing the training, sign a statement as verification of the training. Within a day or two the student must pass a written quiz on the material covered during the orientation.

During this orientation, the student is given a Lab Associate's Checklist and Handbook. The Handbook contains the list of expectations (Appendix 2), sheets used to keep track of time in the lab (sign-in; sign-out), information about achieving Senior Associate status (see below), information about how paper authorship decisions are made and an extensive check list that students may use to keep a record of their training and performance of key lab tasks (Note: more details are available upon request).

Of course, orientation to the laboratory continues over several months. One of the ways we have facilitated this extended training is through the use of peer trainers or "Lab Buddies" - as we call them. Lab Buddies are seasoned lab Associates who are assigned to the new students based on their class schedule (so that there is a good chance they will be working in the lab at the same times) and their expertise. Lab Buddies work with the new student for at least a semester and sometimes longer.

Senior Associates are student peer experts that, in many ways, form the core of the training and quality control functions of the Neuroscience Laboratory. They also work with the faculty member and the Laboratory Director to do planning and make the major decisions for the lab (e.g., What will be the next experiment? What will be the topic of the next grant proposal? Who will be working in the lab this summer?). Senior Associates are the peers that less-experienced students turn to for information and advice. As such, the Senior Associates are a critical part of the lab management team.

The designation of Senior Associate was also born out of the dilemma of awarding paper authorship. Only Senior Associates may be authors or co-authors on papers that come out of the Baldwin-Wallace College Neuroscience Laboratory. Many undergraduates are looking for a brief experience in the Neuroscience Laboratory to try their hand at the conduct of science and to see if this is a career path they wish to pursue. As a PUI, it is our obligation (and joy) to provide a place for this type of exploration to occur. However, with students who are naïve about the effort that goes into producing a publishable piece of work, they may be confused about what sort of dedication and consistency of effort typically characterizes paper authorship. Student authors from the Neuroscience Lab need to demonstrate that they know the theory behind the studies we do, have facility with the techniques, contribute to the conduct and documentation of the study, and explain the data in an articulate manner.

In addition to the benefit of authorship, Senior Associates: (a) become members of the Lab Management Team (where we discuss and develop ideas for current research), (b) are given priority to work (for pay) in the lab over extended breaks, (c) may be selected/supported to attend the annual Society for Neuroscience meeting or other such professional gatherings, (d) typically receive excellent recommendations for graduate school, medical school or employment, and (e) have the opportunity to train other students.

A student becomes a Senior Associate after he/she has taken specified coursework, become expert in the work performed in the lab, performed and documented an Independent Senior Associate "Focus" Project and passed an oral quiz about the ongoing work of the lab.

All students receive a Lab Associate's Checklist and Handbook when they begin their work in the lab (see above). One component of the Handbook is a list of skills and techniques that a student may acquire. Examples include: mixing drugs and making solutions, conducting heath checks on our animals, mounting/staining brain slices, running animals in a water maze and performing immunohistochemistry assays. Students first observe the particular task they wish to learn. Once they have watched this skill for the first time, they have the faculty member, the Lab Director or a Senior Associate verify this by signing on the 'observation' line of the checklist. Additional training is available and each time this is performed, the faculty member, Lab Director or a Senior Associate signs the 'training' line under that skill. When the student feels comfortable with his/her skill level in that area, they schedule a time with one of the lab managers to be tested on their proficiency in the task. We insist that the training-test interval be at least one week to ensure that the student can retain the skill over time. Again, a written record of the test result is made. Once this process of observation, training and successful testing is complete, the student is qualified to perform this particular task on their own. We have found that this method of initial observation, training and testing has been instrumental in maintaining quality control in the laboratory.

The Focus Project that is required for Senior Associate status is typically a pilot study or a small project that helps the lab develop a technique or solve a problem. Examples of recent Focus Projects include developing techniques to record heart rate from neonatal rats, performing a systematic test of the accuracy of our pipetters and setting up an apparatus to measure ultrasonic vocalizations in neonatal rats. Students propose a particular project, have it approved by the faculty supervisor, perform the project and document the results.

The oral quiz is the last step in the Senior Associate process. The quiz is an informal discussion with the faculty supervisor where the student is asked questions such as: Why are we doing the experiments we are doing? What do we hope to accomplish? How do the studies relate to the literature? What is a possible next logical study? After successful completion of this quiz the student is awarded (with some "hoopla") the Senior Associate status.

TEAM BUILDING

Developing a sense of community among a diverse group of students who are constantly coming and going throughout the day can be very challenging. Lab meetings are an important weekly event for faculty, staff, and Lab Associates. Not only is the lab meeting an opportunity to discuss general lab business, provide training, and schedule procedures, but it's also an opportunity for the students to spend time with each other as a research group. In addition, problems or decisions about the research are presented to the group for brainstorming to encourage critical thinking and student input into our collaboration. We have found that frequently, when given the chance, the Lab Associates can offer a fresh, creative point of view that faculty and staff too close to the project may lose.

The Lab Associates contribute to the Neuroscience Lab in many ways other than providing an extra pair of hands. Students that complete summer internships give presentations on their research to the other lab members bringing valuable research ideas and techniques back to the laboratory. In the past 3 years we have had students report on their National-Science-Foundation sponsored REU (Research Experiences for Undergraduates) at Duke University, University of Pittsburgh, Carnegie-Mellon University, and Indiana University. We have found that these reports help convince other students that they might be successful in competing for these internships as well. Lab Associates also bring traditions, shared elsewhere, to the Baldwin-Wallace College Neuroscience Lab to enrich the culture of the group. For instance, the Neuroscience Lab celebrates "Mole Day". In essence, this is recognition of Avogadro's number (6.02×10^{23}) representing the amount of a chemical compound having a mass (in grams) equal to its molecular weight. So, on the 10^{th} month of the

year (October) on the 23rd day from 6:02 am to 6:02 pm Lab Associates decorate the lab in chemistry paraphernalia and we host a math/proportions skill review.

Encouraging the Lab Associates to spend social time together outside of the lab also encourages a sense of community. On a regular basis, the Lab Associates and available staff go out to eat. Field trips to the local Science Museum to watch the IMAX movie and snow tubing provide interesting stories for everyone. INS sponsors an annual picnic and encourages group activities with the Biology League such as joint picnics and football games. A little competition goes a long way to develop group identity.

Sadly, Lab Associates, who have become an important part of the lab community, eventually graduate and move on to the next step in their academic careers. Typically, a send-off includes a cake adorned with the school emblem of their new institution and small gifts that are appropriate for the student. For instance, a large pack of index cards was given to a student who made flash cards for every class he ever took at Baldwin-Wallace and post-it notes were awarded to a student who was famous for leaving them all over the lab. Most recently, a "fiesta" (including chips, salsa, piñatas, and sombreros) was thrown for a student who was leaving for a semester of study abroad in Spanish-speaking countries.

To maintain a close tie with alumni, Lab Associates, faculty, staff, and students attending national conferences, such as the Society for Neuroscience, are encouraged to get together to share old and new experiences. Alumni are also encouraged to check in regularly to the Baldwin-Wallace College Neuroscience Lab Alumni website (http://www.bw.edu/academics/nro/outcomes/) to update their profiles and email faculty. Once a member of the lab, always a member of the lab!

LAB MANAGEMENT

Management of the laboratory is a joint effort shared by the faculty supervisor, the Laboratory Director and the Senior Associates. A weekly meeting of this group precedes the regular lab meeting and allows the members to plan the agenda for the upcoming general lab meeting, discuss and schedule the experiments for the weeks ahead, solve lab problems, plan for training opportunities and work on papers and/or grant applications.

This team approach to lab management is an important part in the student's development as young scientists. It allows the participants to have a real sense of the decisions that need to be made to keep the laboratory productive. Moreover, as they see the implications of the group's decisions, they gain a better understanding of the best uses of the lab's time and other resources.

PROGRAM EVALUATION

We have done a systematic assessment of our undergraduate's experiences in the Neuroscience laboratory at Baldwin-Wallace College. This assessment consists of exit interviews, transcript reviews, and an analysis of responses to an annual survey (completed anonymously). This survey documents the kinds of skills the student acquires while in the lab, the student's professional career plans and the student's perceptions of his/her experience. Many of the items are scored on a 7-point Likert-type scale (1 = disagree; 4 = undecided; 7 = agree). For example, the following statements (derived from survey responses of 32 student Laboratory Associates during the 2001-2003 academic years) received an average rating of >6.8: *"My experience in the Neuroscience Laboratory has given me a more-positive view of science"*; *"I have learned many things and grown significantly by working in the neuroscience laboratory"; "My knowledge of Neuroscience has increased through my experience in the Neuroscience Laboratory"; "Overall I rate my experience in the Neuroscience Laboratory as excellent".* Thus, the survey indicates strong appreciation for the skills that students obtain and the experiences they have in the lab:

About 35% of Baldwin-Wallace College's Psychology, Biology, and Chemistry majors go on to Medical, Veterinary or Graduate Schools. However, over 90% of the students who have worked in the Neuroscience Laboratory have gone on for such post-undergraduate training and/or have started a career in science. Of course, the extent to which Neuroscience students are admitted to graduate-level training in numbers greater than the rest of the College population may be a reflection of both the laboratory selection criteria in addition to the laboratory experiences themselves.

PROGRAM CHALLENGES

Ours is a behavioral neuroscience laboratory and, as such, provides a variety of opportunities for student involvement and skill building. Several of our procedures are readily learned (e.g., running rats in a water maze; setting up for surgical procedures) while others are much more challenging (e.g., performing spinal blocks on pregnant rats; developing new immunohistochemical assays). Thus, a strength of our program is the ability to offer students early successes as well as challenges that require significant commitment to master. The success of transitioning our model to other settings may depend, in part, on the complexity of the tasks at hand and the extent to which peer mentors can acquire the skills they need. Laboratories that do not use such a broad range of techniques (presenting a variety of skill difficulties) may not be able to rely extensively on peer mentors. Under these circumstances, one alternative is to hire a technician proficient in the more-difficult procedures to help train and supervise the students when faculty members are teaching or fulfilling their other duties. Fortunately, a recent increase in the maximum amount of the NIH's Academic Research Enhancement Awards (AREA or R15) from $100,000 to $150,000, have made this kind of solution possible. Of

course, key to the model we provide here, is that undergraduate students continue their work in the laboratory for two, or more, years. Thus, if they are retained, peer mentors may indeed have the time to acquire and pass on even the most-difficult laboratory skills.

Over the last 9 years our program has evolved into one that seems to work well in the context of Baldwin-Wallace College. However, many of the challenges presented in the opening paragraphs of this paper remain. For example, there exists a tension between providing undergraduate mentoring and maintaining research productivity. In many cases it would be more expedient for the Laboratory Director or faculty to perform the research work by themselves. In our laboratory, significant time is expended in training, mentoring and establishing systems that can ensure quality control. However, since our primary mission is quality teaching, we have made the conscious decision that mentoring of our undergraduates comes first. The research productivity that comes out of this approach is a welcome side-benefit of the enterprise. Our laboratory produces only 1 or 2 peer-reviewed publications/year but we also graduate 4-5 well-trained young neuroscientists each year. To us, this seems like a good balance.

Should the primary goal of the undergraduate Neuroscience Laboratory be training students or publication? In many ways, this debate presents a false dichotomy. Publication (or dissemination of data via other forms) is central to science and therefore must also be central to the training of young scientists. To deprive our undergraduates from participating in the publication process would communicate to them that this aspect of what a professional scientist does is not really necessary after all. Our goal has been to present our Neuroscience students with the full range of activities that represent the work of professionals in the field. Our students are engaged in the generation of research ideas, experimental design, running of the studies, documentation and dissemination of the results. The more-senior students author papers, help write grant proposals and defend their work at scientific meetings. Our view has been that doing all aspects of the scientific enterprise, including publication, is the very best training we can offer a young scientist.

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APPENDIX 1:

Baldwin-Wallace College is a private, selective, liberal arts school outside of Cleveland, OH. The college, founded in 1845, has been ranked (for quality of education) in the top twenty of all the colleges and universities in the Midwest region. We offer over 42 different majors. Based on strategic planning completed in 1991, the College decided to limit enrollment to between 4,700 and 5,000 excellent students. The Neuroscience Laboratory at Baldwin-Wallace College (http://www.bw.edu/academics/nro/) functions in the context of a recently implemented interdisciplinary Neuroscience curriculum that was developed with attention to available prototypes (See References: *Neuroscience, 1990; Interdisciplinary connections,* 1995; http://www.bw.edu/coursecatalog/degreerequire/nro/). Students may pursue a Minor or Major in Neuroscience and specialize (i.e., double-major) in Psychology, Biology or Chemistry. Currently we have approximately 15 students pursuing our 3-year-old Neuroscience Major and about 30 students are in the process of meeting the requirements for the Neuroscience Minor. Participation in the work of the Neuroscience Laboratory is by no means limited to students involved in the Neuroscience curriculum.

APPENDIX 2:

The following information (authored by one of us: GAM) is read and acknowledged (in writing) by each Associate as part of his/her Neuroscience Laboratory orientation.

NEUROSCIENCE LABORATORY INFORMATION AND REQUIREMENTS

"Welcome to the Neuroscience Laboratory of Baldwin-Wallace College! I hope that you will have a good experience working in this laboratory. Some students work in this lab for a short period of time in order to get a "feel" for hands-on science. Other students work in the lab because they have very specific goals of advanced training in Neuroscience or a related field. If your performance is found acceptable, there may be an opportunity to work in the lab for several semesters. Students who have a more-permanent tie to the lab may be encouraged to perform an Independent Study here. They may also be included as authors on published papers or presentations at National or International Neuroscience meetings.

Whatever your personal goals are, I have certain expectations about your behavior in the lab:

1. I expect that you will attend weekly Lab Meetings and that you will be on time. Our meetings are designed to plan the following week's activities and to bring everyone up to date on lab activities. It is also a time to discuss data and recent articles in the literature. The time of weekly meetings will be set to (hopefully) accommodate everyone's schedule. We are all busy. Don't make things difficult for me and your fellow students by coming in late or missing a meeting.

2. I expect that you will volunteer to participate in a variety of lab activities (some fun, some not-so-fun). Some of the things we do in the lab are enjoyed by almost everyone (e.g., fetal/neonatal injections, neural imaging) while other tasks (e.g., lab cleaning) are not quite so popular. I expect that each of you will volunteer to do some of both types of tasks. If everyone volunteers to do the less-desirable tasks, each of us will have to do them less frequently. I have found that some students express a desire to work in the lab but then don't volunteer to do much at our weekly meetings. This is usually due to students over-committing themselves. If this occurs, we should discuss rescheduling your lab experience to some future semester when you have more time.

3. I expect that you will actually do what you volunteer to do. In other words, I expect that you will be reliable. If you commit yourself and then realize that you cannot follow through, I expect that YOU will make alternate plans to ensure the task is completed properly. While I might appreciate the information that you and another lab member have switched duties, I expect that you will make the arrangements for the switch yourself. You will be held accountable if a task that you volunteered to perform is not completed properly in your absence. I usually give students one mistake in this area - if it is accompanied by a reasonable excuse and many apologies. Otherwise, you can expect to be asked to leave the lab.

4. I expect that you will treat the animals with respect and care. Experiments on non-human animals have told us much of what we know about the brain. This knowledge benefits humans and other animals alike. We owe a lot to the animals we use in our studies. We must provide them with excellent care and other essentials (e.g., relief from pain). This lab follows all of the animal care and use Guidelines established by the National Research Council, National Institutes of Health and the American Psychological Association. You will receive training in this area. However, new tasks you encounter may necessitate reading of these Guidelines which are available in the lab. Mistreatment of the animals will not be tolerated and will result in immediate dismissal from the lab and prosecution under the Federal Animal Welfare Act.

5. I expect that all lab visitors will be cleared by Dr. Mickley or a member of the Psychology faculty/staff. The lab is not without it's hazards. Animals bite. We use harsh chemicals. We use sharp instruments. I will not allow visitors in the lab unless we are sure that they are protected against these safety hazards. Further, some people do not support the use of animals in experimentation and have desires to disrupt our studies through violent means. We need to be careful about who has access to the animals. Usually, I will accompany tours through the lab or arrange for another experienced lab person to do so. Do not take family or friends on unauthorized tours. Do not allow strangers in the lab.

6. I expect the lab to be clean and neat. A messy lab presents us with a variety of problems. It's aesthetically unappealing. It conveys the wrong image to the rest of the College community. Further, dirt may present hazards to the animals by attracting insects. Instruments and supplies have a particular place in the lab where they belong. They should be returned to this place after use. If need be, we may organize "Cleaning Parties" to deal with chronic untidiness. However, this can be avoided if everyone leaves work areas cleaner than when they found them.

7. I expect honesty. You will be trained to make entries in the lab book. You should enter anything of significance in the lab book, including mistakes. I rarely criticize someone for making a mistake in a laboratory procedure. I make mistakes. You will too. It's much easier to deal with a mistake we know about (animals can be removed from the study, data can be qualified, etc.). However, we cannot accommodate an unknown error. Tell me if you make a mistake - and write it in the lab book."

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