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Cultivation of an Interdisciplinary, Research-Based Neuroscience Minor at Hope College

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Hope College is an undergraduate liberal arts college with an enrollment of approximately 3,000 students. In the spring of 2005, we began to offer an interdisciplinary neuroscience minor program that is open to all students. The objective of this program is to introduce students to the field of neuroscience, and to do so in such a way as to broaden students' disciplinary perspectives, enhance communication and quantitative skills, and increase higher-level reasoning skills by encouraging collaboration among students who have different disciplinary backgrounds. This is a research-based program that culminates in a one-year capstone research course. Here we present the story of the program development at Hope College, including a description of our newly developed curriculum, our initial assessment data, and the lessons we have learned in developing this program.

Key words: neuroscience minor; undergraduate curriculum; curriculum development, interdisciplinary; liberal arts college, Crawdad

The Soil – Institutional Setting

Hope College is an undergraduate liberal arts college located in Holland, Michigan, founded in 1862, and affiliated with the Reformed Church in America. Hope currently enrolls 3,070 students who major in programs offered by the divisions of Arts, Humanities, Social Sciences, and Natural Sciences. All students at Hope College take ten credit hours of science and mathematics as part of the college's general education program. The Natural Science Division at Hope is known for its research-based curriculum, which includes investigative laboratories in most science courses and significant opportunities for undergraduates to participate in scientific and mathematical research. The Natural Sciences Departments are located in two adjacent buildings, one of which also houses the Department of Psychology, part of the Social Science Division. This building also houses an animal suite with rooms for housing, testing, and surgical procedures.

Planting the Seed – Neuroscience at Hope (1959-1998)

Just as nervous systems arise from neurons and glia, a new neuroscience program arises from component parts. At Hope College, those components have been slowly developed over the past 50 years. The first faculty member at Hope College with an interest in neuroscience was hired as a member of the Department of Psychology in 1959 and began teaching a course on perception soon thereafter. This course continued until 1993, when it was replaced by a course in *Cognitive Psychology*. *Physiological Psychology* and *Animal Behavior* courses began in 1970 following the hiring of a physiological psychologist. Another early course offering related to neuroscience was *Fundamentals of the Human Nervous System* which was taught by a biologist at Hope from 1974 to 1984. By 1986, there were six faculty members at Hope with an interest in neuroscience who included neuroscience content in their courses and did neuroscience related research. Outside of the Psychology Department, the courses included *Vertebrate Physiology* and *Animal Behavior* taught in the Biology Department and *Philosophy of the Mind* taught in the Philosophy Department. Through the courses taught by these faculty and through their research programs, students at Hope College were learning many of the components of neuroscience, albeit in an unfocused way.

Nurturing the Seed – Support from HHMI for Interdisciplinary Programs

Moving from faculty members with interests in neuroscience to a program in neuroscience required planting the idea and allowing time for wide ranging discussions. The first formal proposal for a neuroscience program came in 1990, when Hope was invited by the Howard Hughes Medical Institute (HHMI) to apply for an Undergraduate Science Education Program Award. At that time we considered both neuroscience and biochemistry/ molecular biology as themes. In part because the Department of Psychology was not yet sure of its interest in a neuroscience program, we focused on the biochemistry/molecular biology theme in our proposal, which was funded in 1991. A hallmark of the HHMI supported program was the hiring of a faculty member in biochemistry and molecular biology, who was appointed as a member of both the biology and chemistry departments. With this appointment, we began our commitment to working more deliberately across departmental boundaries, a necessity if one is to develop a neuroscience program.

By the time we were invited to apply for another HHMI award in 1995, the Division of Natural Sciences at Hope had seen the benefits of cross-departmental programs and was further aware of the importance of neuroscience at the undergraduate level. Thus, we decided that the proposal to HHMI would build on our previous HHMI-supported program while moving in the direction of neuroscience. We

requested funding from HHMI to support the start-up costs of another faculty member who would hold a joint appointment in biology and chemistry, but this time in the area of neurochemistry. This individual would teach a course in neuroscience and would be charged with developing a neuroscience program at Hope. This neuroscience hire was possible because the Department of Psychology had, by that time, expressed strong interest in being involved in a neuroscience program and indicated that a future hire would be made in that area. This was critical to our success as we had decided that no minor in neuroscience was possible at Hope without the full involvement of the Psychology Department.

Hope obtained a second Undergraduate Science Program Award from HHMI in 1996 that allowed us to move forward with our plan to hire a neuroscientist. In 2000, Hope hired Dr. Leah Chase, a neurochemist whose research area is in the area of hippocampal electrophysiology and neurochemistry. She brought to Hope College a background in neuroscience and enthusiasm for developing a neuroscience program. The first course in neuroscience at Hope, offered in 2001, was a lecture course entitled *Introduction to Neuroscience* that was cross-listed as both a biology and a chemistry course. The course reached its maximum enrollment on the first day of registration, confirming our expectation that there was significant student interest in neuroscience among Hope students.

In the spring of 2004, Hope College was awarded a third Undergraduate Science Program Award from HHMI to, in part, increase interdisciplinary studies in the sciences. The development of a neuroscience minor is a component of the current HHMI program at Hope. The minor is seen as an excellent complement to divisional and departmental efforts to enhance interdisciplinary science training at Hope College (other areas include Mathematical Biology, Environmental Science, and Bioinformatics) and is serving as a model for the development of additional interdisciplinary programs, such as Computational Sciences and Modeling, in the Natural Science Division.

Germination – Development of a Neuroscience Lab Course

The guiding philosophy of science education at Hope College is that students learn science best by doing science. Thus it was important to us that the initial neuroscience course have a laboratory component. Although the neurochemist's research laboratory was well equipped thanks to the HHMI award, we did not have enough equipment for a teaching laboratory. We, therefore, submitted a proposal entitled *Development of Project-Oriented Neuroscience Laboratory at Hope College* to the National Science Foundation Course, Curriculum, and Laboratory Improvement (CCLI) program. This proposal was informed by studies (Fortenberry, 1998; McNeal et al., 1998; Svinicki, 1998; Crowther, 1999; McConnaughay et al., 1999; Leonard, 2000; Wycoff, 2000; Zoller, 2002) on the educational benefits of small group and research intensive approaches to learning science, which provide students with experiences that increase critical thinking while training students to do, rather than just learn, science. We, thus, decided that the laboratory component of the neuroscience course would be based on investigative laboratories, wherein students are first trained in a scientific technique and then use that technique to answer a question which they have posed. This approach was well established as an effective active learning technique (Woodhull-McNeal, 1992; Zamer, 1993; Sundberg and Moncada, 1994; McNeal et al., 1998; Sundberg et al., 2000;). Further, we decided that we would use the project lab approach, in which students spend several weeks on a single project of their own design (McLean, 1999; Henderson and Buising, 2000; Sundberg et al., 2000; Switzer and Shriner, 2000). The student-designed projects would build on techniques the students learned doing structured lab exercises, with each exercise ending in a simple student-designed experiment to test a hypothesis that closely followed the structured lab. During the last five weeks of the course, students would carry out a major project based on their own hypothesis and experimental design.

The CCLI proposal was funded by NSF and we put the plan into action. With funds from that grant and additional funds (beyond the required matching funds) from Hope College, we purchased equipment for six extracellular and intracellular electrophysiology stations which interface with our previously owned computerized data acquisition systems. We also purchased equipment for behavioral analyses. Most of the laboratory exercises using the electrophysiology stations were adapted from the *Crawdad: A CD-ROM Lab Manual for Neurophysiology* created by Wyttenbach et al. (1999). In addition, we incorporated the *MetaNeuron* program (Newman, 2002) into the course.

Participation in the *combined* neuroscience lecture and laboratory course significantly increased the students' abilities to formulate hypotheses, design experiments, and evaluate data (in textual, chart, and graphic form) as demonstrated in the ability of students to answer experimental questions on course exams. We found that students in the 2002 neuroscience course, without a laboratory, scored an average of 80.2 ± 9.1% (mean ± S.E.) on their final exam with an average of 67.9 ± 12.3% on applied and experimental questions. The students in the 2004 course, with the laboratory, scored an average of 84.5 ± 9.5% on their final exam with an average of 81.1 ± 8.6% on applied and experimental questions. Using a t-test, there was no significant difference in the average performance on the final exams; however, there was a significant difference on the performance on the experimental section of the exams ($p<0.01$). In addition, there were no differences in the distribution of the students from biology, chemistry, and psychology in the courses. The two courses were taught by the same professor using the same outline and syllabus. The final exam questions were similar, but not exactly the same. These data suggest that the implementation of the lab component of the course had a significant effect on the ability of the students to formulate hypotheses, design experiments, and evaluate data.

Taking Root – Development of the Neuroscience Minor

Concurrently with the development of the laboratory component of the neuroscience course, Dr. Chase was awarded a Towsley Research Scholar Grant from Hope College that provided her with support to begin to develop a neuroscience program at Hope College. The Towsley Research Scholar Program is a competitive program open to all tenure-track faculty in their third year at Hope College. The program provides the recipient with a one-semester third year sabbatical and partial summer support for four years to assist the faculty member in building her/his research program and reaching her/his professional goals. In addition, during this time, the Department of Psychology began its search for a faculty member with expertise in neuroscience who would serve as a key contributor to the neuroscience program. In 2003, Dr. Charles Behensky, who works in the areas of neural substrates of language processing and computational models of categorization, was hired to fill this position. The third core faculty member for the neuroscience program, Dr. Gregory Fraley, was hired by the Department of Biology in 2004. Dr. Fraley works in the area of central regulation of energy balance and reproduction using rats as experimental models. We want to stress that 1) the release time provided by the Towsley Research scholar program and 2) the commitments of the Biology and Psychology Departments to the neuroscience program through these hires were essential to the success of the program.

A neuroscience program task force was assembled in 2003 to develop the framework for the neuroscience program. Deliberate efforts were made to invite participation of faculty from many departments in multiple divisions so that the neuroscience program would be interdisciplinary and inclusive to all students. Thus, the final task force included faculty from eight departments, including Philosophy, Mathematics, Biology, Chemistry, Physics, Psychology, Nursing, and Education.

In its first meetings, the committee decided to develop a minor program rather than a major program in neuroscience. This decision was based on the success of previously developed interdisciplinary minor programs in Environmental Studies and Women's Studies at Hope College. In addition, the committee decided the purpose of the neuroscience program was not to prepare students for a graduate career in neuroscience. *Instead, the purpose of the program would be to introduce students to the field of neuroscience, and to do so in such a way as to broaden students' disciplinary perspectives, enhance communication and quantitative skills, and increase higher-level reasoning skills by encouraging collaboration among students who have different disciplinary backgrounds*. The interdisciplinary nature of the program was of significant importance to the committee as there was broad interest in the program from faculty across departments, and it was important to the faculty that all students could participate in the program. In addition, the discussions commenced just as *BIO2010: Undergraduate Education to Prepare Biomedical Research* (Council NR, 2002), a report commissioned by the National Research Council, was released. This report calls for reevaluation of the current status of the undergraduate biology curriculum. In the report, particular emphasis is made on building a more interdisciplinary and quantitative-based science curriculum that would better serve future scientists. Specifically, the report states, "Connections between biology and the other scientific disciplines need to be developed and reinforced so that interdisciplinary thinking and work become second nature." The neuroscience committee considered other reports that stress the importance of an interdisciplinary science education, including a report from the American Cancer Society, which stated, "In the post-genomic era of research, multidisciplinary and interdisciplinary research will command center stage, requiring team approaches and the collaboration of many individuals from vastly different fields, ranging from computational mathematics to clinical science" (American Cancer Society and Howard Hughes Medical Institute, 2000; Council, NR, 2002). Hence, the committee agreed that the neuroscience minor program would be an excellent forum to introduce students to the process of collaborative, interdisciplinary study.

Taking these ideas into account, the task force developed five objectives for the neuroscience minor at Hope College.

1. Students will obtain an understanding of the fundamental principles of neuroscience.
2. Students will obtain an appreciation/understanding of the multidisciplinary aspect of neuroscience.
3. Students will be able to develop hypotheses, design experiments, carry out these experiments, and interpret data for a question related to a neuroscience problem.
4. Students will discuss ethical issues related to scientific research.
5. Students will be able to access, read, and gain insight from reading the primary neuroscience literature.

The task force then set to work developing a curriculum that would fulfill the aforementioned objectives. The other interdisciplinary minor programs at Hope College served as excellent models. In addition, the committee reviewed several notable undergraduate neuroscience programs at liberal arts colleges, including Oberlin, Davidson, Macalester, Haverford, and Pomona Colleges. Dr. Chase also visited Professor Dennison Smith at Oberlin College and discussed the development of their very successful neuroscience program.

The committee deliberately decided that no prerequisites would be specified for the neuroscience program so that it would be accessible to any student from any discipline. However, those students with majors outside of psychology are strongly encouraged to take *Introduction to Psychology* to fulfill their Social Science General Education Requirement, and majors outside of biology are strongly encouraged to take *Human Physiology* as a flagged course prior to taking the *Introduction to Neuroscience*.

A curriculum proposal containing an outline of the program and a description of the courses and associated

assessment plans was written in the fall of 2004 and submitted to the Hope College Curriculum Committee. This proposal was discussed at the December 2004 Curriculum Committee Meeting and was officially accepted in January of 2005. A brief description of this program is given below.

Early Growth – Neuroscience Minor Curriculum

The resulting curriculum directly follows the framework that was developed by the participants of the first joint Project Kaleidoscope/Faculty for Undergraduate Neuroscience workshop "Interdisciplinary Connections: Undergraduate Neuroscience Education" held at Davidson College in 1995 (Ramirez, 1997). Specifically, the minor program promotes the process of discovery and inquiry-based learning and is rooted in one of the greatest strengths of Hope College, its research program. The neuroscience minor program can be broken down into three educational levels, introductory, intermediate, and advanced, with each level having its own specific objectives. In addition, students are allowed to tailor their own specialized program to match their specific interests in neuroscience.

The Neuroscience minor consists of a total of 21 credit hours, including both core courses and flagged courses from several departments.

The core courses consist of:

1) NSCI 211 *Introduction to Neuroscience* sophomore-level introductory course and lab (4 credits)
2) NSCI 311 *Neuroscience Journal Club*: junior-level neuroscience journal club (1 credit; must be taken a total of two times)
3) NSCI 411 *Advanced Neuroscience Research I* senior-level capstone research course (2 credits)
4) NSCI 412 *Advanced Neuroscience Research II* senior-level post-capstone writing course (1 credit)

In addition to the core courses, students are required to take 12 credits of flagged courses, four of these credits must be taken outside the student's major department and cannot satisfy the requirements for the student's major. The students are encouraged to complete their flagged courses prior to taking the capstone.

NSCI 211 Introduction to Neuroscience

This course introduces students to the interdisciplinary field of neuroscience and serves as a foundation for the neuroscience minor. It is the only course in the minor in which the primary objective is to teach students the fundamental principles of neuroscience (Table 2). The course consists of two 90-minute lectures and one, three hour lab period each week. The course begins with an historical perspective on the origin of neuroscience that is followed by a one week unit on the philosophy of the mind taught by a member of the philosophy department. Students are subsequently introduced to the basics of cellular, molecular, and systems neuroscience and nervous system organization. Eventually, students explore more complex behavior and cognitive topics including motivation and reward, memory, learning, attention, and language. The textbook for this course is *Neuroscience: Exploring the Brain* by Bear et al. (2006), and the course is currently co-taught by a member of the Psychology Department and a member of the Chemistry or Biology Department.

Biology
- Human Physiology* (4)
- Advanced Topics in Cell Biology (4)
- Embryology (4)
- Animal Behavior (4)
- Neurochemistry and Disease† (4)
- Advanced Topics in Animal Physiology (4)
- Behavioral Neuroendocrinology (4)

Chemistry
- Neurochemistry and Disease† (4)

Math
- Mathematical Biology (4)

Philosophy
- Philosophy of Mind (4)

Psychology
- Practical Aspects of Memory (4)
- Physiological Psychology (4)
- Cognitive Psychology (4)
- Behavior Disorders (3)
- Learning and Learning Strategies (4)

Nursing
- Pathophysiology (4)
- Psychiatric Mental Health Theory and Practicum (3)

Table 1. Flagged Courses for Neuroscience Minor. Students must take 12 credits of flagged courses which are listed above. The department through which the course is offered is shown in bold. The number of credits for each course is given in parentheses. All of the flagged courses, with the exception of *Neurochemistry and Disease* and *Behavioral Neuroendocrinology,* were offered at Hope College at the time the program was developed. * indicates that the course is not open to biology majors. † indicates the course is cross-listed in biology and chemistry.

In the laboratory, students learn experimental techniques that are fundamental to the area of neuroscience. Lab exercises focus on electrophysiology (specifically the intracellular recording of resting membrane potential in the crayfish muscle, extracellular recording of action potentials in the crayfish motor neuron, and sensory neurons from the Crawdad Lab System), neuroanatomy, human senses and vision, language lateralization, and EEG recording. In addition, students complete a set of related labs that are interspersed throughout the semester that focus on the effects of gonadal steroids on brain structure and function. Early in the semester students perform ovariectomies on female rats and implant steroid capsules containing estradiol, testosterone, or vehicle. Several weeks later in three different lab periods, students compare 1) sexual behavior (as measured by expression of lordosis) and 2) spatial-learning behavior (as measured in the Morris Water Maze) in these same rats. Ultimately, students examine the effects of hormone treatment on 1)

expression of long term potential in the CA1 region of the hippocampal slice and 2) microstructure of the brain. In all of the labs, significant emphasis is placed on the scientific method, development of hypotheses, experimental technique, and data analysis in order to fulfill the third objective of the minor and prepare students for the capstone research course. The use of statistics and scientific writing is also emphasized.

Objectives	*1*	*2*	*3*	*4*	*5*
Intro. Neuro.	X	X	X		
Journal Club		X		X	X
Adv. Nsci Res. I		X	X	X	X
Adv. Nsci. Res. II		X	X	X	X

Table 2. Neuroscience Minor Courses and Objectives. The neuroscience minor curriculum is designed such that each course contributes to at least three of the major programmatic objectives: objective 1) students will obtain an understanding of the fundamental principles of neuroscience; objective 2) students will obtain an appreciation/understanding of the multidisciplinary aspect of neuroscience; objective 3) students will be able to develop hypotheses, design experiments, carry out these experiments, and interpret data for a question related to a neuroscience problem; objective 4) students will discuss ethical issues related to scientific research; objective 5); students will be able to access, read, and gain insight from reading the primary neuroscience literature.

NSCI 311 Neuroscience Journal Club

The journal club was developed to fulfill several objectives of the minor program, most significantly teaching students how to read the primary neuroscience literature critically (Table 2). In addition, this course was designed to prepare students for the Advanced Neuroscience Research Courses by 1) exposing the students to current important questions in the neuroscience literature, 2) allowing them to gain a historical perspective of select, fundamental topics in neuroscience, 3) demonstrating the application of several experimental techniques to important scientific questions, and 4) giving them practice evaluating scientific data and drawing conclusions based on the data. To accomplish these objectives, significant student participation is required in the form of classroom discussion for one hour each week. While the topic changes with the instructor's interest, the papers are purposefully selected so that students are exposed to experimental techniques that are used by neuroscientists working at different levels, e.g. molecular, cellular, organismal, etc. In addition, students are required to consider carefully the experimental and statistical methods that are employed to address the scientific questions/hypotheses and ethical issues related to each experiment in a written review of each paper.

NSCI 411/412 Advanced Neuroscience Research I & II

These are a set of inquiry-based courses in which students with different academic majors work together in four-member teams to complete self-designed neuroscience research projects. The projects are directly related to a general neuroscience theme chosen by the instructor. Together, these courses serve as the capstone course in the neuroscience minor program. Students are expected to integrate and apply their knowledge and experimental expertise they obtained in all of their courses to the design of their research project. Students write project proposals during the first four weeks of the first course, and they complete their experimental work during the remainder of the first semester. In the second semester, students focus on writing a formal manuscript describing their research results. During the first semester, the students meet for one, three-hour lab session each week and one, one-hour group meeting each week. In the second semester, students meet for one hour each week to discuss scientific writing and for peer review.

We were pleased to discover that the program we developed would address all of the education objectives that were identified by Dr. Eric Wiertelak, past president of the Faculty for Undergraduate Neuroscience, as education goals for undergraduate neuroscience programs (Wiertelak, 2003). These goals include 1) awareness of critical natural science and psychological principles, 2) awareness of experimental methodology, 3) ethics, 4) awareness of historical trends and theoretical perspectives that inform the field of neuroscience, 5) advanced awareness of a particular area or areas of study within neuroscience, 6) critical thinking and independent thought, 7) and effective communication skills (Wiertelak, 2003). Although we did not explicitly list goals 4-7 as objectives of our program, they are emphasized throughout the curriculum we developed. Specifically, students are introduced to historical trends in NSCI 211 *Introduction to Neuroscience,* and advanced study is accomplished both in the upper level flagged courses as well as the capstone research experience. Critical thinking and communication skills are emphasized throughout the neuroscience curriculum and the general education curriculum of Hope College. Thus, the newly developed program should lead to student gains in each of these identified skill areas.

In Full Bloom – Current Status and Assessment of the Neuroscience Minor

In the spring of 2005, the first *Introduction to Neuroscience* course was offered. There were 21 students initially registered for the course, and 18 students completed the course. The students included one freshman, 14 sophomores, one junior, and one senior representing majors in psychology (6), chemistry (4), biology (2), nursing (1), religion (1), education (1), and physics (1). Fifteen of the students were eligible to continue in the minor program. Currently, ten of these students representing all the aforementioned majors (with the exception of the Education major) are still involved in the program, and are taking flagged courses in addition to the journal club courses this year. In the spring 2006 *Introduction to Neuroscience* class, 12 sophomore students, representing majors in biology, chemistry, and psychology, have enrolled in the course.

In the spring 2005 *Introduction to Neuroscience* course, a student survey was given at the beginning and the end of the semester to probe students' self-assessment

of their disciplinary and interdisciplinary skills in science. Students were asked to assess their confidence in 23 different areas, giving themselves a score of 1 (not confident) to 5 (extremely confident) for each category. While we observed gains in all 23 areas, significant ($p<0.05$) gains were observed in (A) "Learn about complex science problems that require insight from more than one discipline," (B) "Communicate my research results to student in my major(s)," (C) "Understand how scientific research is carried out in my major(s)," (D) "Communicate my research results to students not in my major(s)," (E) "Pose questions in one discipline that can be addressed by collecting and evaluating scientific evidence," and (F) Write reports using scientific data as evidence (Figure 1). Students reported the smallest gains in "Extracting main points from a scientific article and developing a coherent summary" and "Finding scientific journal articles in one discipline (for example, in your major) using the library/internet." These data suggest we are successfully modeling for students how to work at the interface of the disciplines, one of the main programmatic objectives of the neuroscience program. In addition, the skills they were least confident in are emphasized in the subsequent journal club courses.

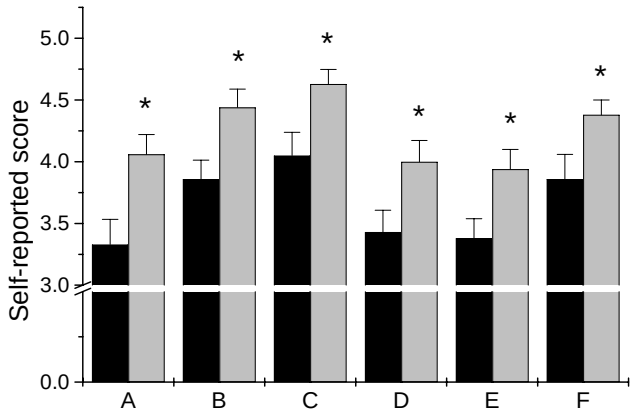

Figure 1. Self-Assessment of Learning Gains for the Introduction to Neuroscience Course. Areas in which students reported significant gains are shown above. Black bars indicate mean self-reported score on pre-test and gray bars indicate mean self-reported score on post-test (n=18). * indicates statistical significant difference between pre- (black columns) and post-survey (gray bars) as tested by ANOVA, $p<0.05$. Statements corresponding to *A-F* were: *A)* "Learn about complex science problems that require insight from more than one discipline," *B)* "Communicate my research results to student in my major(s)," *C)* "Understand how scientific research is carried out in my major(s)," *D)* "Communicate my research results to students not in my major(s)," *E)* "Pose questions in one discipline that can be addressed by collecting and evaluating scientific evidence," and *F)* Write reports using scientific data as evidence.

Bearing Fruit – Lessons Learned

In the process of developing this minor program, we have learned some valuable lessons that we feel are important for anyone considering developing any new program at their institution.

1. Find an advocate

One of the most important steps in the development of any program is finding someone who is passionate and who will enthusiastically embrace the challenges that will certainly emerge. Not only should this person have a background in neuroscience, she/he should also have good interpersonal skills to facilitate conversations with administrators and faculty from numerous departments. If this individual is a junior faculty member, it is important that the individual seek and rely on helpful advice from more senior colleagues about navigating the college offices. In addition, serving on the college curriculum committee would be useful to learn about the structure of academic programs at the institution and about writing successful curriculum proposals.

2. Gain administrative support

The program leader needs to be given time and resources to build the program. This is important not only for the success of the program, but also to minimize the negative impact on the leader's own scholarly work. This cannot happen without administrative and departmental support. Dr. Chase was fortunate in that she already had excellent support from her department chairs and the Dean for Natural Sciences when she arrived at Hope. She used the Towsley Research Scholar Program proposal as an opportunity to build further interest in the program at the administrative level. After receiving the Towsley award, Dr. Chase used the one-semester sabbatical to assemble the neuroscience task force and to build her research program. Thus, the sabbatical was critical in providing Dr. Chase time to build connections with faculty members and develop the framework for the minor program. The ongoing support of the program from the HHMI award has also been critically important. However, we are still in the process of working with the administration to establish a budget for the program. Currently, the support for running the courses, e.g. lab supplies, is being absorbed by the biology department. Obviously, we will need to establish an independent budget for the program in order for it to continue to grow.

3. Don't reinvent the wheel

In addition to *The Journal of Undergraduate Neuroscience Education*, many resources are available to those considering development of a neuroscience program. The Faculty for Undergraduate Neuroscience website (www.funfaculty.org) includes links to existing neuroscience programs. Many different model programs have been developed at a variety of colleges and universities. We found that conversations with those individuals involved in building the neuroscience programs very important in the development of our neuroscience program. Project Kaleidoscope is an excellent resource for papers on undergraduate neuroscience education (Wiertelak, 2003). Lastly, a flexible and easily adaptable

framework for neuroscience programs has been well described by Ramirez (1997).

4. Seek external support

While it is absolutely critical that there is institutional support for the program, obtaining external support through such programs as the NSF-CCLI program or the NSF-CAREER program (pre-tenure faculty only) is beneficial for obtaining the necessary laboratory equipment and release time to develop the program. The NSF-CCLI award allowed us to purchase laboratory equipment that is used in the introductory and capstone neuroscience courses, some of the flagged courses, as well as other general education and majors biology courses.

5. Reach that critical mass

Finding an advocate to initiate the development of the program is important; however, for the program to come to fruition, a critical mass of interested individuals must eventually be recruited to participate in the program. Once we began teaching the first neuroscience course, it became apparent there was sufficient student and departmental interest in biology and psychology to begin building the framework of the program. Hiring Drs. Behensky and Fraley was the final step that allowed the program to become a reality.

6. Maximize what you have and be creative in program development

Admittedly, the core of our neuroscience program consists of very few faculty members, a challenge that many small, liberal arts schools face. We discovered that the more interdisciplinary we could make the program, the more potential resources we had. For example, the task force discovered that there were many existing courses at Hope with significant neuroscience content. Therefore, we purposefully designed the program to integrate these courses into the program. In addition, Hope College has a long-standing tradition for excellence in student/faculty collaborative research. Therefore, we decided to build our program around a capstone research experience. This approach was consistent with the teaching philosophy of the college, “to learn by doing,” and we felt it was an excellent way to teach students about neuroscience.

7. Embrace the challenges of an interdisciplinary program

While the interdisciplinary aspect of the neuroscience program has provided great opportunities, there have been significant challenges associated with working with faculty members across departments and college divisions. First, we quickly learned that the Social Science Division and the Natural Science Division at Hope use different methods to assign contact hour credit for each course. Therefore, we had to work with the administration so that each faculty member received the same credit for teaching the same course. Second, the “core neuroscience faculty” (Drs. Behensky, Chase, and Fraley) must balance their contributions to their home departments and the Neuroscience Program. In order to make sure that all of the neuroscience courses are covered each semester, the core neuroscience faculty members have developed a three-year teaching plan for the neuroscience courses and have provided their department chairs a copy of this plan. We have learned that long-term planning is a necessity to make sure enough faculty resources are available to cover courses associated with the Neuroscience Program. Third, the program is open to all majors at Hope College; therefore, we have students coming into the program with very different backgrounds. Thus, we have had to work hard to design the introductory course curriculum with sufficient background in the scientific method, basic biology and biochemistry, and thorough treatment of the fundamental concepts of neuroscience. Fourth, we have had to communicate regularly with our neuroscience students in scheduling classes so that we can avoid scheduling the core classes during time-slots that are already occupied by courses required for the students’ majors. Currently, we have students with six majors in the program, and we are using student surveys to determine potential course conflicts in scheduling each course.

8. Patience, patience, patience

Perhaps our greatest advice is to remember to be patient. The idea of bringing neuroscience to Hope began in 1990, and it was fifteen years later that the *Introduction to Neuroscience* course was offered for the first time. Remaining focused on the big picture while celebrating the smaller successes along the way will eventually lead to important change.

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