

Proposal for Neuroscience Minor

Goal: To establish an interdisciplinary neuroscience minor. The intent is to develop a curriculum by creating neuroscience courses rather than simply repackaging existing offerings. Additionally, the program will serve the core by supplying students with attractive introductory and upper level courses that satisfy the core science requirement.

Introduction: Neuroscience is highly interdisciplinary and one of the remaining “frontiers” of science. Evidence for this abounds as neuroscience stories appear regularly in the popular media. More importantly, neuroscience has a growing base in the technical literature. For example, *Nature*, a premier journal for all of science, has developed seven review journals, one of which is dedicated to neuroscience. The others include genetics, microbiology, cancer, molecular and cell biology, immunology, and drug discovery—all clearly important “frontier” topics. An Internet search of the top 100 liberal arts colleges indicates that 60% of all schools and all but two in the top 25 have developed some sort of neuroscience program. Presumably, this is a good indication that neuroscience as a topic of interdisciplinary study is not viewed as a passing fad. See Appendix A for more specific detail.

A bold neuroscience curriculum is proposed here that will be genuinely new, truly interdisciplinary and a valuable addition to the Division and the College. The structure of this proposal heavily integrates the role of chemistry in the neuroscience program; survey of similar neuroscience programs across the country shows that this proposal is unique in that respect. Of course, the biology and psychology departments, the more common homes to neuroscience programs, are still strongly present in this plan. In contrast, the neuroscience programs at many schools similar to Concordia appear (with rare exception) to be a simple repackaging of existing courses along with perhaps an introductory course and/or a “capstone” course of some kind. This seems to be the case for the three MIAC schools (Carleton, St. Olaf and Macalester) that currently offer a neuroscience program. Appendix B includes a more detailed analysis of neuroscience programs at other institutions.

The proposed neuroscience program will be unique in its strengths among not only Concordia’s principle competitors but also among Tier 1 and 2 institutions across the country. A new rigorous, highly interdisciplinary neuroscience program will provide a point of distinction for Concordia and serve as an expansion point for the sciences. The opportunity exists to build off of the current exceptional science division already in place. The development of a bold new neuroscience program complements well the plans for a new or heavily revised science building. Not only do we expect Concordia to be demonstrating the drive for a modern, progressive science curriculum through a new physical building, but prospective students will also see a strong commitment to providing cutting-edge science training if this proposal is accepted.

Several lines of evidence, both quantitative and qualitative, point to a significant interest in neuroscience among the students in the Science Division. A survey involving over 300 current Concordia science students from all undergraduate levels provides strong numerical support for the development of some sort of neuroscience program. The data are discussed in detail in Appendix C but, as an overview, they do indicate that the neuroscience courses proposed below will be well populated. Enrollments in recently developed neuroscience courses (see Appendix C) have also demonstrated considerable student interest in this program. Three new

neuroscience courses and one new psychology course have been offered in the last two years and enrollments have been high, ranging from 14-24 students/class. This high level of enthusiasm exhibited by students suggests our proposed program is likely to succeed. Further, members of the neuroscience program development committee attended a recent Project Kaleidescope conference on undergraduate neuroscience. The sheer number of schools in attendance with neuroscience programs or those aggressively developing such programs supports the claim that neuroscience is an important program and one that Concordia should pursue.

Currently, the training students receive in the sciences at Concordia is outstanding and there is every reason to expect that same level of excellence will be achieved in the neuroscience program. The skills the students learn will provide them with a number of attractive post-degree opportunities. All opportunities that our current science graduates have would be available. Additionally, these students could well have a competitive advantage for jobs in the biotechnology industry that require combined biological and chemical skills. Competitive advantage is also expected for those entering the health professions. Concordia chemistry graduate, Hugh V. Nguyen '94, a medical resident at the University of Chicago, indicated during a recent homecoming visit that he is very enthusiastic about the development of a neuroscience program and explicitly stated that this will offer Concordia students an advantage in medical school. Finally, since many research groups in the biology, chemistry and psychology departments of major research universities are pursuing applications to neuroscience, Concordia graduates in all three of these fields will have an advantage when it comes to getting into and succeeding in graduate school. See Appendix D for a discussion of the opportunities open to students.

Curriculum Plan:

We are proposing the development of a neuroscience minor with the following learning goals:

1. Students will understand the nature of science – its methods of inquiry, social practice and particular viewpoints.
2. Students will be able to describe and apply facts, concepts and theories of neuroscience.
3. Students will become familiar with the literature in the field and be able to think critically about neuroscience research, theory and topics.
4. Students will learn laboratory skills that provide a foundation for answering research questions in the field of neuroscience.
5. Students will integrate material from several disciplines in their study of neuroscience and they will understand that problem solving involves the use of many disciplinary perspectives.

The proposed neuroscience program calls for the development of six new courses, three of them with laboratory components. The courses are as follows (course numbers will ultimately be determined by the registrar):

Neuroscience 109A: *Introduction to Neuroscience*. 1.00 credit. E2. Core Science Course

This course will serve as the introductory course for the program and it will cover the basics of neuroscience, which will be expanded upon in other neuroscience courses. This course will have a lab associated with it. Prerequisites: None

Neuroscience 109L: *Introduction to Neuroscience Laboratory*. 0.00 credit. E2. The laboratory associated with Neuro 109. The experiments will serve to reinforce concepts from the lecture and also introduce the students to neuroscience laboratory techniques.

****Neuroscience 252:** *Physical Neuroscience*. 1.00 credit. A2. This course will build upon the physical principles underlying neuroscience that were surveyed in Neuro 109. Topics include passive and active potential propagation, membrane and ion channel energetics, and the physical events underlying neurotransmitter release and binding. Prerequisite: Neuro 109.

Neuroscience 331*: *Neurophysiology*. 0.5 credit. E1. This course deals with electrophysiology at an advanced level beyond that of Neuro 109. This course will have a lab associated with it. Prerequisites: Neuro 109.

Neuroscience 331L: *Neurophysiology Laboratory*. 0.00 credit. E1. The laboratory associated with Neuro 331. Here the students will learn the fundamentals of electrophysiological experiments.

* The future and nature of this course will be largely determined by external funding.

Neuroscience 400. *Neurobiology*. 1.0 credit. E2. Upper-level course that expands upon the basic neurobiology skills learned in Neuro 109. Topics include neurotransmission, information processing, neurodevelopment, neuroregulation and psychoneuroimmunology. Prerequisite: Bio 222. Cross-listed as Biology 4XX.

Neuroscience 400L. *Neurobiology Laboratory*. 0.00 credit. E2. The laboratory associated with Neuro 400. Examination of nervous system anatomy, the cells of the nervous system, neurotransmission, neuropathways and medical case studies are included. Cross-listed as Biology 4XX.

Neuroscience 406: *Senior Seminar* 0.50 credit. E2. This senior level course will serve as the capstone for the program. The students will perform literature research and prepare a research proposal. Prerequisites: Senior standing and completion of all other neuroscience program requirements.

****Neuroscience 475:** *Neurochemistry*. 1.00 credit. A2. This junior/senior level course studies the chemical and biochemical aspect of neuroscience including ligand binding, pharmacokinetics and second messenger cascades. Prerequisites: consent of instructor. Recommended: Neuro 109 and Chem 373. Cross-listed as Chemistry 4XX

**Indicates courses that have been previously taught.

In addition to these courses, Neuroscience 380 would be available for special topics courses, Neuroscience 480 for independent study and Neuroscience 490 for research.

The program in neuroscience would be completed as follows (5.50 course credits).

Neuroscience required courses:

- Neuro 109 and 109L
- Neuro 400 or Psyc 319
- Neuro 475 or Psyc 324

- Neuro 406
- 2 additional courses, one from each list below:

List 1	List 2
Neuro 252	Chem 373 or 374 (<i>Biochemistry I, II</i>)
Neuro 331 (.5)	Bio 306 (<i>Anatomy & Physiology</i>)
Neuro 380	Bio 345 (<i>Molecular Biology</i>)
Neuro 475	Bio 380 (<i>Animal Behavior</i>)
Neuro/Psyc 328 (<i>Human Neuropsychology</i>)	Bio 415 (<i>Genetics</i>)
	Psyc 318 (<i>Learning and Behavior</i>)
	Psyc 319 (<i>Behavioral Neuroscience</i>)
	Psych 323 (<i>Perception</i>)
	Psyc 361 (<i>Cognition</i>)

Required supporting courses: Biology 101 or 121; Chemistry 142 or 373

Implementation:

Since we began discussions about this program, a number of courses have been offered or are in the planning stages. Two neuroscience courses have been taught as CHEM 380 courses. Molecular Neuroscience (to be Neuro 252) and Neurochemistry (to be Neuro 475) were successful courses with enrollments of 24 and 16, respectively. This semester, BIOL 380: Neurobiology, is being offered by the biology department with an enrollment of 17 students. Finally, in Fall 2007, the Biology department will offer an Introduction to Neuroscience course as part of the Core curriculum. A course in Perception, not offered by the psychology department in over a decade, is being offered this semester with an enrollment of 19.

The opportunity for continued offerings of new neuroscience courses exists as a result of recent new faculty lines at the college. When the chemistry department submitted a proposal to hire a new biochemist, they submitted a course-rotation plan for their department that included the offering of Molecular Neuroscience and Neurochemistry on alternate years. The biology department also is hiring a new faculty member next year and their new hire will be in the area of Neurobiology, thus they will continue regularly offering Introduction to Neuroscience and Neurobiology. On a related note, Introduction to Neuroscience has been proposed as a core course. Given these new hires and related course rotation plans, we expect to be able to offer four of our proposed new courses on a regular basis.

It is our expectation that with the creation of our program and the addition of a new neurobiologist in the biology department, we will also be able to offer an upper division Neurophysiology course on an occasional basis as well. The prospect of offering this course, however, depends on the opportunity to purchase a significant amount of equipment. Currently, the neuroscience program planning team is working on a Keck grant application and if funded, we will be able to purchase the equipment necessary for this course. This grant will also be used to purchase equipment for the other new courses we are proposing, though the offering of these courses is not predicated upon obtaining this grant.

In terms of additional offerings, the psychology department recently hired Dr. Mikel Olson, a physiological psychologist. With the addition of Dr. Olson to the psychology department, they envision being able to more regularly offer Human Neuropsychology and Perception, two courses that will play supporting roles in our new program. Discussions have taken place regarding the feasibility for faculty from the psychology department to teach the Senior Seminar course we propose for our minor.

Program administration will occur as follows: There will be a program chair, officially appointed by the Academic Dean to three-year terms. The program planning team will nominate Julie Mach for this position. Members of the neuroscience program will include all faculty teaching courses in this program. Voting members will be faculty who teach NEURO designated courses, including NEURO courses that are cross-listed with another department, and they will oversee decisions on, for example, hiring student workers/support staff, if such opportunities arise, responses to new course proposal for NEURO designations, and approval of additional supporting courses. Faculty who teach supporting courses in the program (List 2 above) can be involved in dialogue and conversation about the program but will not be voting faculty.

Department chairs from departments affected by this minor have seen this curriculum proposal and are willing to support it by having their faculty teach within the program. This initiative is supported at the institutional level and the Dean has encouraged the program planning team to seek external funding to support some of the new laboratory courses that will be offered.

Summary:

An innovative and distinctive neuroscience program will set the college apart in interdisciplinary science training. The proposed program will be attractive to prospective students. Once these students enter the program they will receive quality training at the level already expected and achieved by the Science Division. This training will provide the students with a competitive advantage in a myriad of different fields including the biotechnology industry, the health professions, and graduate school.

APPENDIX A: Interest in undergraduate neuroscience education

The 2006 US News and World Report College Rankings were used to determine the level of interest in undergraduate neuroscience education across higher education. The number of other nationally ranked liberal arts colleges offering neuroscience or neuroscience-related (such as psychobiology) programs was determined from these rankings. While we have identified the programs offered at both Tier 1 and 2 liberal arts colleges, it seemed most useful to survey colleges comparable to, though ranked slightly higher than Concordia. Therefore, all of the Tier 2 colleges were reviewed. This included colleges ranked between 50 and 110. It was determined that 22 of 60 colleges (37%) offer a neuroscience program. That 37% of Tier 2 liberal arts colleges offer some sort of neuroscience education suggests a strong interest in neuroscience, even at the undergraduate level. As an aside, it was noted that some schools that did not offer neuroscience programs did offer other interesting interdisciplinary science programs and others offered students the opportunity to create their own interdisciplinary emphasis.

Other evidence for interest in neuroscience undergraduate education comes from The 2003 ANDP Survey of Neuroscience Graduate, Postdoctoral and Undergraduate Programs. This survey included 23 programs offering undergraduate neuroscience education and 86 offering graduate education, reflecting a trend in higher education toward graduate education in the neurosciences. Based on this survey, it can be concluded that interest in neuroscience program is steadily increasing. On average, there were 85 students enrolled in undergraduate neuroscience programs (based on a survey of 23 programs), up from 55 in 2001, and many of these students are interested in pursuing graduate education. This supports a growing interest in neuroscience being expressed at the undergraduate level. Based on a survey of 86 graduate and post doctoral programs, the ANDP survey found that the number of students applying for graduate education in neuroscience is increasing [42 students per program in 1991; 66 in 2001; 82 in 2003]. Of the 82 applicants to neuroscience graduate programs, 22 were accepted into a program. Students that were accepted had an undergraduate GPA of B+/A-, median GRE scores in the 79th percentile and research experience. These data speak to growing interest in neuroscience education and the competitive nature of graduate programs.

APPENDIX B: Distinctiveness of Proposed Neuroscience Program

As stated in Appendix A, 37% (22 of 60) of Tier 2 liberal arts colleges offer a neuroscience program. It was of interest to look at these programs in terms of what courses are offered, what departments and faculty are included in the program, and how the proposed curriculum compares to those identified in Tier 2. From this analysis, it is anticipated that the neuroscience program at Concordia will reflect national trends in neuroscience education and be extremely marketable as it will be truly distinctive.

Roughly half of the neuroscience programs at colleges similar to Concordia have independent neuroscience courses, usually with a neuroscience designation. Of these, most have only an introductory course and possibly a seminar course. Taking select courses from the psychology department, biology department, and to a lesser extent the chemistry, physics, and philosophy departments completes the rest of the program requirements. In the proposed program, six courses, designed exclusively for neuroscience, are included in the curriculum. Thus the courses themselves are interdisciplinary, not just the program.

Though some neuroscience programs do offer chemistry electives, very few included chemistry faculty within the program. In addition, the chemistry courses offered in these neuroscience programs are those that many students would take for biology or chemistry program requirements. The proposed curriculum will have a uniquely strong presence by the chemistry department as two of the six neuroscience courses will be taught by chemistry faculty. Even at Tier 1 institutions where most offer a major, the neuroscience programs are predominantly fulfilled by taking courses offered out of the psychology and biology departments.

It is felt that to effectively study neuroscience at an advanced level, hands-on laboratory experiences are critical. Of the 22 schools identified as having neuroscience or neuroscience-related programs, only four offered a neuroscience laboratory as part of the required coursework. The neuroscience program outlined here has three laboratory courses in the curriculum, two being required for the minor. It is thought that this will result in a program with greater curricular depth than our competitors and make our students more competitive for graduate school admission. In that regard, it is worth mentioning that of the schools that do offer a neuroscience lab in their program (Drew University, Muhlenberg College, St. Lawrence University and Ursinus College), all offer a major in neuroscience.

Compared to institutions ranked slightly to moderately higher than Concordia, the minor in neuroscience proposed here is novel, innovative and has characteristics that are unique among neuroscience programs in the liberal arts colleges. In summary, looking at the 110 top liberal arts colleges, two features of our program set our proposal apart; 1- the emphasis on the physical sciences within the program, and 2-offering multiple courses developed specifically for the neuroscience program.

APPENDIX C: Interest in neuroscience expressed by Concordia College students

** Please note: the data described below were collected just over two years ago. Since this survey was completed, the college has offered/is offering 3 new neuroscience courses and 1 psychology course that fits in this proposed program. Enrollment in these courses has ranged from 14-24 students, suggesting that the interest expressed in the survey data described below are borne out in student enrollments. It is noteworthy that none of these courses fulfilled any direct requirement of the student's major or minors, and therefore were taken as elective credit. It is also noteworthy that in the first new neuroscience course offered (Molecular Neuroscience) students enrolled were majoring in cross section of departments, including chemistry, biology, psychology, physics and mathematics. **

In October of 2004, 323 Concordia College students (approximately half of the current science students) were surveyed about their level of interest in neuroscience education. Students surveyed were currently enrolled in Biology 121 (Vertebrate Biology), Biology 224 (Botany), Chemistry 127 (General Chemistry I), Chemistry 341 (Organic Chemistry I), Psychology 111 (General Psychology) and Psychology 206 (Developmental Psychology). Of the students surveyed, 186 were enrolled in the 100-level courses. Below the results from three specific questions asked of students are discussed. These questions were (a) what is your level of interest in taking a neuroscience course (with lab), (b) what is your level of interest in completing a neuroscience minor, and (c) what is your knowledge of the field of neuroscience.

On a scale of 1-5, with 1 being "not at all likely" and 5 being "absolutely," 94 students [24.8% of our sample] indicated a 4 or 5 when asked how likely they would be to take a neuroscience course (with lab) if one were offered at Concordia. Of these students 24 reported that they would absolutely take a neuroscience lab course. When looking only at the students enrolled in the 100-level courses, we see that 51 students responded with a 4 or 5, representing 27.4% of the 100-level students surveyed. These numbers suggest that Concordia students have a strong interest in taking a neuroscience course and it is likely that were Concordia to offer an Introductory Neuroscience course as part of the science curriculum, the course would easily attract 25 students per year. Additionally, given the overwhelming interest in taking an introductory neuroscience course, it is likely student enrollment would be high in other neuroscience offerings.

On a scale of 1-5, with 1 being "not at all likely" and 5 being "absolutely," 38 students [10% of our sample] indicated a 4 or 5 when asked how likely they would be to minor in neuroscience were it possible to do so at Concordia. Of these students 7 reported that they would absolutely minor in neuroscience. When looking only at the students enrolled in the 100-level courses, we see that 21 students responded with a 4 or 5, representing 11.3% of the 100-level students surveyed. These numbers suggest our students also are interested in the possibility of minoring in neuroscience. That we see 38 students interested in a neuroscience minor is comparable to, if not larger, than enrollment in other interdisciplinary program on our campus. For instance, in the academic year 2003-2004, Women's Studies graduated 6 minors and Environmental Studies graduated 4 majors and 2 minors.

A correlational analysis was conducted on the level of interest students expressed in taking a neuroscience course and their self-reported knowledge about neuroscience (ranked on a scale of

1 to 5, with 1 being “nothing” and 5 being “a great deal”) and this was significant, $r(320) = 0.38$, $p < .0001$. Analyses also revealed a significant relationship between students level of interest in a neuroscience minor and their self-reported knowledge about neuroscience, $r(319) = 0.36$, $p < .0001$. These analyses indicate that the more students know about neuroscience the more interest they have in pursuing neuroscience education and this was true of both students in the 100-level and upper division courses. From this, it could be inferred that with appropriate recruiting and information about neuroscience, the level of student’s interest in an interdisciplinary neuroscience program could be increased both while at Concordia and before they arrive here. Based on these correlations, it can also be inferred that as high school education emphasizes more neuroscience-related topics, students will be arriving at college with a greater interest in neuroscience education. This may mean that when selecting colleges, prospective students may be more likely to consider colleges that have a neuroscience program.

The expressed interest in neuroscience based on the above quantitative data speaks for itself. However, anecdotal data from students also support the interest in and need for a neuroscience program at Concordia. Recent graduate Rebecca (Frederick) Gilbertson, 2001, who is a fourth year graduate student at the University of Kentucky in the Behavioral Neuroscience and Psychopharmacology program writes:

While at Concordia, I took courses such as Drugs and Behavior and Physiology through the Psychology Department. Although the background that I received in these courses was valuable, I wish that there would have been a more organized, cohesive neuroscience program that I could have completed. Additional neuroscience educational opportunities would have been very helpful to me in smoothing my transition to graduate school. Within my first semester in graduate school, I found myself wishing that I had had additional training in chemistry and biology. Courses such as an in-depth neuroanatomy course, biopsychology, in-depth physiology, and hands on lab training would have made my transition to graduate school easier. While I was interested in neuroscience as an undergraduate, I was intimidated by the hard sciences. I feel that had there been a neuroscience program at Concordia, I would have felt less intimidated of courses offered in chemistry and biology that were connected with neuroscience, something I was interested in. Thus, I feel that I would have taken advantage of these courses and have been better prepared for graduate school in terms of science training and my future career. Having a neuroscience program would give students motivation for completing certain difficult courses. Further, it would make these students competitive when applying for graduate school.

Former student, Nicole Shirkey, 2005, currently in graduate school in the neurosciences, writes:

I would have found it extremely helpful to at least have the option of taking a neuroscience lab course, or even a minor in neuroscience. This would have been particularly valuable to me because my “competitors” that are applying to neuroscience graduate programs most likely have a major in neuroscience, if not at least a minor. Since I did not have the option of having a neuroscience minor, or taking a neuroscience lab course, I may be at a bit of a disadvantage. As the interest in and importance of neuroscience in all areas, not only those scientific, continues to expand, the need for discussion of this topic is especially crucial, especially in academic institutions. Given that, to my knowledge, neither NDSU,

MSUM offer even a neuroscience minor, the need for neuroscience discussion and education in the area is even more pressing. Addition of neuroscience lab courses and/or neuroscience minor is necessary for Concordia to continue its academic excellence and individuality... not to mention the fact that it would undoubtedly be a very rewarding investment in the college and its community of students and educators!

In conclusion, both quantitative and anecdotal evidence support the interest in the development of a neuroscience program and the creation of neuroscience laboratory courses.

APPENDIX D: What can be done with a neuroscience education

Students pursuing an education in neuroscience have numerous options available to them. A review of websites devoted to questions about careers related to neuroscience reflect that students who study neuroscience at the undergraduate level go on to graduate school, medical or other health professional schools, or obtain jobs.

Students with a neuroscience minor attend graduate education in the neurosciences or other life sciences (including psychology). As with any discipline, only a small percentage of students from a neuroscience minor will attend graduate school. That said, a survey of schools with neuroscience programs note that many of their students go on to graduate education in neuroscience and many of these students pursue graduate programs specifically devoted the neurosciences. Students also pursue graduate education in other sciences, most notably psychology and biology. Additionally, neuroscience background may assist students pursuing graduate education in fields like clinical psychology. The 2003 ANDP Survey of Neuroscience Graduate, Postdoctoral and Undergraduate Programs indicates that the number of students applying for graduate education in neuroscience is also increasing (see Appendix A). There is also clear interest for advanced neuroscience education among Concordia students and anecdotal information suggests that with each passing year the number of students interested in pursuing graduate work in a neuroscience-related program is increasing. For example, currently, Susan Larson has three students in her laboratory intending to apply to graduate school in neuroscience areas (e.g., biopsychology, brain plasticity, neuropsychology) and all of these students would benefit considerably from the opportunity to take a neuroscience lab-based course and/or minor.

Students with a neuroscience minor pursue health professions. More and more, medical education is focusing on neuroscience as a key area of training. Medical schools in the past few decades have routinely added neuroscience programs. It is acknowledged often in popular media that neuroscience-related problems, such as depression and Alzheimer's disease, are some of the pressing health conditions facing North Americans. Thus, students entering into medical professions with a background in neuroscience are likely better equipped to deal with these problems. One school (William and Mary College) note that as admission requirements for medical schools change, and there is less emphasis on accepting students with a traditional biology major, students with neuroscience training may be at a slight advantage for admission to medical school. Brown University notes that 70-80% of their neuroscience majors pursue medical school after graduation and neuroscience students from the University of Pennsylvania attend a wide array of medical schools. While one must be cautious directly applying these data to Concordia, they do support the suggestion that Concordia students with a neuroscience minor will be well equipped to pursue medical school or other health profession schools.

Students with a neuroscience minor obtain positions in industry, including research positions. Students with undergraduate neuroscience education can obtain employment comparable to students with other science undergraduate training. University of Pennsylvania publishes a list of the jobs graduates have taken. A majority of them end up working as research assistants in many different capacities, for instance, for pharmaceutical or biotechnology firms, or within a university system. Other jobs included work as a pharmaceutical specialist, network systems engineer, physical therapist aide, editorial assistant, pharmaceutical sales representative, paralegal, and toxicology lab technician. This is not an exhaustive list but simply meant to provide some examples of the kinds of jobs student with neuroscience training are able to get.

Other schools report similar data most frequently citing jobs as research assistants, and employment with biotechnology companies and hospitals as being the most common employment for neuroscience students.