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Establishment of a Neurochemistry Track under the New ACS Guidelines

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Abstract

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The new guidelines put forth by the ACS for approved chemistry degrees provide departments with greater flexibility in designing their ACS majors. Under these guidelines, students receive foundational and in-depth chemistry training while allowing individual departments to use their creativity in developing a curriculum that best meets the needs of their students and plays to the strength of the department. The chemistry department at Concordia College has developed an ACS Neurochemistry track and shares how the program arose, some of the practical matters in developing it, and how it can be made to work well within a liberal arts college.

Recently the ACS changed its guidelines for approval of ACS chemistry degrees. ACS approved departments will be expected to meet the new guidelines by 2012. Under these guidelines, students take *foundation courses* where they must receive the equivalent of one semester of material from each of the core areas of chemistry beyond the general chemistry level. Further, students must take at least four *in-depth courses*, which build upon prerequisite foundation courses (see ref *1* for complete details). This model offers the potential for greater flexibility in the ACS major.

The spirit of the new guidelines is to allow individual departments to use their creativity in developing a curriculum that best meets the needs of their students and plays to the strength of the department. In that regard, there exists the freedom to develop "tracks" within the ACS major (*1*). These tracks may also incorporate courses from other departments. For example, a track in chemical physics might include several advanced physics courses among its requirements.

The chemistry department at Concordia College embraced this spirit in developing a track in neurochemistry. (At Concordia College, the track is officially referred to as a concentration to allow consistency for the registrar.) The purpose of this essay is to present, as an example for other departments, how the program arose, some of the practical matters in developing it, and how it can be made to work well within a liberal arts college.

Concordia College is a medium-sized (2800 students) liberal arts college located in northwestern Minnesota. The chemistry department has seven full-time faculty and has been ACS approved since 1961. In a typical year, the department graduates approximately 20 majors with around 4 being ACS approved. In 2004, two members of the chemistry department faculty (the current authors) comprised half of a team of four faculty that worked to developed a neuroscience program. This program is distinct among peer institutions in a number of aspects, including the degree to which physical science and especially chemistry is thoroughly integrated into the curriculum (see Box 1). Neuroscience became a minor at Concordia College in 2008. The arrival of the neuroscience program and the strong presence of chemistry faculty in that program provided a unique opportunity to establish an ACS track in neuroscience. (The department also offers a "traditional" track, which is very similar to the old ACS curriculum.) The neurochemistry track was ratified by the college senate January 25, 2010.

Several points of discussion went into developing this track including (i) what courses within the chemistry offerings should be required and which ones should be left as electives; (ii) what courses from other departments should be required; (iii) how can we ensure that the courses identified as *in-depth* had sufficient chemical content, which means they build upon the content from least one foundation course; and (iv) what is the total course credit size of the track. (See Boxes 2 and 3 for highlights of the advantages and challenges of developing this track.) Full details of the ACS track can be found in Tables I and II; we only highlight some challenges and course content from two of the three neuroscience courses,

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Box 1: The spirit of the neuroscience program at Concordia College

The connections between the physical and life sciences is a curricular direction encouraged by science educators, and neuroscience is fertile ground for making these connections in a way that is both natural and meaningful. It is increasingly important to integrate the physical/chemical with the biological and behavioral perspectives in neuroscience. The Neuroscience program at Concordia College is distinct among peer institutions in a number of aspects. One principal way is in the degree to which physical science and especially chemistry is thoroughly integrated into the curriculum. Physical science is an important component of the program because as the field of neuroscience matures, solutions to problems will require more physical analysis.

Box 2: Advantages of a Neurochemistry Track

- Neuroscience research is becoming increasingly chemistry based. Students with a strong background in chemistry have distinct advantages when entering this frontier field.
- At many colleges neuroscience programs have only peripheral participation by chemistry departments. An ACS track in neurochemistry can enhance the participation of chemistry departments in neuroscience programs.
- As more students are drawn to molecular biology, it will be increasingly challenging for departments at small colleges to populate their ACS courses. A track in neurochemistry will draw from a different pool of students.
- An ACS track in neurochemistry can be a strong attraction for prospective students as they are considering colleges.

Box 3: Challenges for Interdisciplinary Tracks

- It is difficult to balance the need to bring in a variety of important requirements from the courses offered by other departments with the need to maintain a reasonable course credit size to the track.
- Upper level courses for the track may well need to serve other majors/minors. Thus creative thought must go into tailoring these courses to ensure that they have sufficient chemistry content to count as in-depth courses.
- A unique challenge for liberal arts colleges is to ensure the track, which could be quite sharply focused and heavy in course credits, is consistent with the philosophical mission of the college. Beyond this, one must be conscious of how a specialized "professional" track will impact the college's classifications by outside accrediting bodies.

Physical Neuroscience and Neurochemistry, because we assume most readers are familiar with the traditional chemistry courses listed in Tables I and II and have a good sense of what Introduction to Neuroscience might entail.

Physical Neuroscience, a sophomore-level course offered every other spring semester, exemplifies the emphasis on physical science within that program. Four main topics are covered: action potential (voltage-gated channel dynamics and Hodgkin−Huxley equations), neurotransmitter release (SNARE complex structure and dynamics, calcium sensing, and protein regulation), neurotransmitter reception (ligand-gated channel structure and dynamics), and long-term potentiation (protein regulation of NMDAR dynamics and AMPAR recruitment). Neurochemistry is an upper level (Junior/Senior) course that is offered every other year (opposite to Physical Neuroscience). This course covers the neurochemical events underlying neural signaling, synaptic transmission, signal transduction, and neurodegenerative diseases. This is a seminar-style course, with an active learning format.

Although the new guidelines do offer flexibility, there are challenges in building an interdisciplinary track such as neurochemistry. One significant challenge is meeting the requirement that the in-depth courses have sufficient chemistry content such that students need at least one foundational course for proper preparation for the course. Obviously, courses from other departments will not specifically list the chemistry foundation courses as prerequisites. To include such courses in the track, one solution is to simply require them as additional courses. This approach brings with it the danger of prescribing a track that requires a very large number of credits for the students to complete. This may be an issue for the students simply on the basis of scheduling, or there may be institution-specific issues of too many credits in a major versus the core. A second approach is to modify the additional courses to include sufficient chemistry content. For the specific case of the neurochemistry track at Concordia College, Introduction to Neuroscience, Physical Neuroscience, and Neurochemistry were viewed as essential courses for the Neurochemistry track, largely because of their integrative nature and emphasis on how chemical principles are applied to neuroscience problems. However, different strategies were taken for incorporating each of these courses into the neurochemistry track. Introduction to Neuroscience and Physical Neuroscience could not be made into an in-depth course and still be able to serve its home program of neuroscience. Therefore they were simply added as an additional requirement in the neurochemistry track. Neurochemistry,

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on the other hand, is cross-listed between neuroscience and chemistry. This course is used to satisfy one of the in-depth course requirements, which brought up the challenge of establishing sufficient chemical content. Since the there are two routes to this course, it cannot have a foundation course as an explicit prerequisite. This is handled in two ways. First, ACS majors must have taken or be coenrolled in the foundational course in biochemistry before taking Neurochemistry. Second, specific assignments in the course are tailored for those students who are ACS majors. The primary example of this is the requirement that these students base their student-led reports on papers from ACS journals, such as (but not limited to) *ACS Chemical Neuroscience*.

Because Concordia College is committed to providing a liberal arts education, there is pressure to limit the specialization and size of majors. Indeed, the ACS major with neurochemistry track is the largest science major in terms of total credits, and it is one of the largest offered by the college. Consequently, it was important to articulate to the larger faculty that the neurochemistry track remains with the college goals for liberal learning. (Indeed, this very point was a topic of discussion in the faculty senate during the ratification process.) With those goals in mind, the course curriculum of the neurochemistry track strives to stimulate critical thought both through classroom assignments and investigative laboratory experiments, to instill a life-long love of learning by connecting the core chemistry training with student interest, and to develop a sense of broader engagement through classroom discussion and assignments that stimulate reflection by the student on the interplay between science and social, economic. and political forces.

Although initially we do not expect to graduate a large number of majors under the neurochemistry track, we do expect the numbers to grow as the neuroscience program gains momentum. Our goal is to eventually graduate approximately equal numbers of neurochemistry track majors as traditional track majors. Further, since the neurochemistry track draws from a largely different pool of students, we anticipate growth in the total number of ACS-approved majors.

To be certain, unique circumstances led to the neurochemistry track at Concordia College. We imagine, however, that other liberal arts institutions have different but equally unique situations that might

Table I. Foundation Training Requirements for the ACS Major at Concordia College[a]

Foundational Training
• CHEM 330—Analytical Chemistry I, 4 credits
• CHEM 341—Organic Chemistry I, 4 credits
• CHEM 351—Physical Chemistry I, 4 credits
• CHEM 373—Biochemistry I, 4 credits
• CHEM 462—Advanced Inorganic Chemistry, 4 credits
Seminar
• CHEM 403, 404—Senior Seminar I and II, 1 credit each
Additional Supporting Courses
• MATH 121−122—Calculus I and II, 4 credits each
• PHYSICS 111−112—General College Physics I and II, 4 credits each **OR** PHYSICS 128−211—Physics for Scientists and Engineers I and II, 4 credits each

[a] General chemistry not shown.

Table II. In-Depth Training Requirements for the Traditional Track and the Neurochemistry Track

traditional concentration	neurochemistry concentration
In-depth Training	In-depth Training
• CHEM 342—Organic Chemistry II, 4 credits	• CHEM 342—Organic Chemistry II, 4 credits
• CHEM 352—Physical Chemistry II, 4 credits	• CHEM 374—Biochemistry II, 4 credits
• CHEM 431—Analytical Chemistry II, 4 credits	• CHEM 475—Neurochemistry, 4 credits
• 4 credits from the following:	• 4 credits from the following:
− CHEM 344—Spectroscopy, 4 credits	− CHEM 344—Spectroscopy, 4 credits
− CHEM 374—Biochemistry II, 4 credits	− CHEM 352—Physical Chemistry II, 4 credits
− CHEM 445—Organic Chemistry III, 4 credits	− CHEM 431—Analytical Chemistry II, 4 credits
− CHEM 475—Neurochemistry, 4 credits	− CHEM 445—Organic Chemistry III, 4 credits
− CHEM 490—Introduction to Research, 4 credits	
	Additional Requirements
	• CHEM 490—Introduction to Research, 4 credits
	• NEURO 109—Introduction to Neuroscience, 4 credits
	• NEURO 252— Physical Neuroscience, 4 credits

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allow them to use their strengths to develop an "outside-the-box" ACS track. We hope this essay can serve as an example and as inspiration for other departments as they engage in discussions about their response to the new ACS guidelines.

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