Cell Biology & Neuroscience Curriculum Assessment AY2015/2016

Background

The CBN program was reviewed by external experts in in spring 2015. The external report stated that:

> "Despite numerous challenges stemming from both internal (MSU) as well as national (e.g., NIH) changes in funding paradigms, the Department Faculty remain deeply committed to providing a first-rate education to their undergraduate CBN majors as well as other students in the large "service" courses for which CBN has primary responsibility. For example, CBN has taken the lead in adjusting courses and topics covered to prepare undergraduates for the revised version of the MCAT. Despite inviting other Departments to do so collaboratively, CBN seems to be the pioneer in such efforts. Of note in this regard, 83% of CBN undergraduate who apply to medical, dental or other vocational programs are successful in securing a spot. This rate is especially impressive given the national average is <50%."

> "The challenges in delivering the complex CBN undergraduate curriculum are many: First, the courses cover vast material in cell and molecular biology, molecular genetics, neuroscience, and cancer biology - in many academic institutions each of these fields is covered by individual departments with 15-20 faculty; to cover them in a single department with a small faculty is a major challenge indeed….. Needless to say, success in both research and teaching requires much time, and this has been a central challenge for CBN. They have thoughtfully considered several options regarding how they can serve their large number of undergraduate majors, as well as non-majors that enroll in CBN "service" courses, while maintaining active research programs, given the small number of faculty. Several strategies have served them well, but the current situation is untenable and unsustainable."

Since this review, the enrollment in CBN courses has continued to grow, with SCH up 2.7% since 2013; however, faculty hires have only been sufficient to replace senior faculty departures. The SCH increase has primarily been in our lower division (entry level) classes and points to CBN increasingly becoming a service department for multiple health-related majors. This disproportionate growth of student enrollment versus faculty hiring can be seen quite clearly in the key performance indicators and Delaware study tracked by the MSU office of planning and analysis. Indeed, the Delaware study identifies CBN as the worst supported department at the University in terms of instruction expenditures per student SCH[1].

1. http://www.montana.edu/opa/restricted/delaware/Graphs_FY14.pdf

Unfortunately, despite two consecutive external reviews of the CBN department identifying and stressing the same strengths and weaknesses, Provost Potvin chose to ignore the taxpayer funded, BOR-mandated external review. Instead, her response was to chastise us for the number of our graduate students and for what she viewed as a low teaching load. This, despite the external review clearly stating that:

"As mentioned, signs of the sacrifices that have already been made are evident in that CBN has had little time to devote to their graduate program. Obviously, this affects a prime MSU mission – student education. Moreover, it sets in place a dangerous downward spiral: due to insufficient faculty size and resources, CBN has not been able to give their graduate program the level of attention required for it to be a vibrant program; as a result, CBN has fewer graduate students; as a result, CBN faculty have a smaller pool of graduate students who can participate in their research programs; as a result, research productivity will falter; as a result, CBN faculty will be less successful in renewing grants or obtaining new ones. At this stage in this self-perpetuating spiral, the way back to success would be difficult. However, the immediate infusion of additional new faculty and new operating resources, could reverse this negative course and effectively allow CBN to reach and sustain its full potential as a nationally recognized faculty that delivers top graduate and undergraduate curricula and that drives nationally competitive research programs, furthering the success of CBN, the college, and MSU as a whole."

National Standards

Cell Biology and Neuroscience curricula have no nationally agreed upon standards or metrics, but the majority of students in these curricula are destined for careers in the health sciences, and many go on to take the MCAT exam for entrance to medical school. The MCAT exam has changed to incorporate more analytical skills and less content memorization, so changes to our curriculum need to take this into account[2]. The new exam has well defined goals and tests for competence in many of the areas our majors should be proficient in, so we as a faculty have examined it and compared it with the content and goals of our curricula. This new curriculum was then incorporated into the spring semester offering of BioB260, our introductory cell and molecular biology class.

Program Learning Outcomes

Our program learning outcomes has not changed since 2015.

Our graduates will:

- Understand intra and inter-cellular signaling pathways at the molecular level.
- Be able to describe the functional organization of sensory and motor systems of the human nervous system both in terms of structure and function.

2. https://aamc-orange.global.ssl.fastly.net/production/media/filer_public/24/19/2419a765-fc49-466b-bcf8-b6470a8ff273/mcat-bb-content-outline.pdf

- Be able to describe the function and physiology of major organ systems such as the heart and kidney.
- Be able to describe some of the signaling mechanisms that mediate embryonic development.
- Understand the relationship of genetics to inherited diseases, the development of new therapies, and the molecular basis for these diseases.
- Be able to read a modern cell biology or neuroscience paper published in a top journal, appreciate the strengths and weaknesses of the paper's approach and develop a coherent, synthetic review of this paper's place in our knowledge.
- Be able to design and carry out experiments that address fundamental questions about cell biology or neuroscience.
- Effectively communicate complex biological concepts in presentations and in writing.

Components of Program Learning Outcomes

- Understand intra and inter-cellular signaling pathways at the molecular level.
- Be able to describe the action potential as it travels down an axon and the synaptic function it controls.
- Be able to diagram and succinctly describe a G-protein coupled receptor pathway, describing at least 8 molecular components of the signaling.
- Be able to describe a pathway whereby an extracellular signal leads to a change in gene transcription within the nucleus.
- Be able to describe at the molecular level, an example of where aberrant signaling leads to human disease.
- Be able to give examples of molecular conformational changes that lead to signaling, in proteins, DNA and/or RNA.
- Be able to understand the role of the cytoskeleton in the cell and how it pertains to cellular processes such as chemotaxis and migration.
- Be able to describe vesicular trafficking as it relates to synapses, protein and cell cargo delivery.
- Be able to understand the role of motor proteins, how they function and their contribution to cell signaling
- Be able to describe the major proteins and their roles in promoting cell-cell adhesion and cell-extracellular matrix adhesion.
- Be able to describe the functional organization of sensory and motor systems of the human brain both in terms of structure and function.
- Be able to distinguish the components of the peripheral and central nervous system.
- Be able to diagram and label a chemical synapse vs an electrical synapse.
- Be able to describe long term depression and long term potentiation and their roles in memory.
- Be able to describe the function and physiology of major organ systems such as the heart and kidney.
- Be able to describe for each system the controlled variable, the sensors, integrating mechanisms, effector mechanisms, and how these work so the body can respond to stress.
- Be able to describe the sliding filament model of muscle contraction, power stroke and excitation-contraction coupling.
- Be able to describe some of the signaling mechanisms that mediate embryonic development.

- Be able to describe the types of extracellular signals and intracellular signals that regulate cell division, cell survival, cell migration, cell differentiation and how these events ultimately orchestrate embryonic development.
- Understand the relationship of genetics to inherited diseases, the development of new therapies, and the molecular basis for these diseases.
- Students will comprehend the difference between dominant and recessive modes of inheritance.
- Students will be able to compute the frequency of progeny who will be unaffected non-carriers, unaffected carriers, and affected given the genotype of any two parents.
- Students will comprehend that mutations in DNA manifest dysfunction at the protein level and how this results in disease.
- Students will recognize that genetic diseases have different degrees of penetrance that can be altered by environment and genetic background.
- Students will comprehend the difference between gene and pharmacological therapies and the distinct ways these therapies are developed.
- Be able to read a modern cell biology or neuroscience paper published in the top journals, appreciate the strengths and weaknesses of the approach and develop a coherent, synthetic review of this paper's place in our knowledge.
- Be able to read and understand a current basic research paper published in a top journal.
- Be able to acknowledge deficiencies in understanding the paper and remedy those gaps with background reading and research.
- Be able to diagram each experiment and the logic that leads to the conclusions in the paper.
- Be able to describe feasible experiments that would further test the proposed models in the paper.
- Be able to organize and present a coherent presentation on the paper that summarizes the strengths and weaknesses of each experiment.
- Be able to write synthetically a coherent summary of the paper in one page of grammatically correct sentences and paragraphs.
- Be able to design and carry out experiments that address fundamental questions about cell biology or neuroscience.
- Understand the philosophical structure of scientific knowledge and experimentation, being able to recognize strong predictions and experiments and clearly distinguish between scientific hypotheses and correlative observations.
- Be able to write simple computer programs for the analysis of data sets from experiments. Be versed in the computations tools and strategies to retrieve and analyze DNA, protein, and 3 dimensional protein structures.
- Understand the time and scale of the biology that occurs within organelles, cells, and organ systems.
- Be able to describe the modern experimental approaches and measurements that are the foundation of biological knowledge including patch-clamp recordings from excitable cells, DNA sequencing, mRNA analysis and gene expression profiling, protein interaction studies, and conditional knockouts at the genomic level.
- Effectively communicate complex biological concepts in presentations and in writing.
- Effectively integrate data from multiple experiments and knowledge from multiple scientific sources in support of (or to refute) a hypothesis. Clearly communicate these arguments orally and in writing with accurate use of figures, statistics and citations.
- Understand and effectively communicate proper ethical design and reporting of

scientific experiments as well as bioethical concerns in research utilizing animal and human subjects.

Assessment Plans

Time Table for assessment activities over the current academic year.

Assessments for Fall 2016 will be discussed in faculty meetings in January 2017, while assessments for the spring semester will be discussed in our final faculty meeting in May 2017. Both meetings will focus on necessary curricular changes for AY2017/2018.

Plan for assessments from AY 2014 through 2018

2014/2015	2015/2016	2016/2017	2017/2018	2018/2019
Pre-test of basic neuroscience concepts in BioH440	Pre-test assessment of cell biology concepts and signaling pathways in BioB425	Pre-test assessment of cell biology concepts and signaling pathways in BioB425	Pre-test assessment of cell biology concepts and signaling pathways in BioB425	Pre-test of basic neuroscience concepts in BioH440
Evaluation of analytical skills and literacy in BioH455	Assessment of fundamental genetics concepts with strategically placed questioned in BioH320 final	Assessment of fundamental neuroscience concepts with strategically placed questions in BioH313 final	Assessment of fundamental genetics concepts with strategically placed questioned in BioH320 final	Evaluation of analytical skills and literacy in BioH 455
Completed	Completed	Ongoing		

Summary of outcomes and changes for 2013-2015 academic years.

2013 marked the first year we did comprehensive assessment. The assessment was done with a pre-test at the beginning of BioH 440 and an evaluation of papers submitted by senior students in BioH445. The assessment revealed two glaring deficiencies in our student's learning: 1) fundamental concepts about the structure and function of the nervous system taught at several different levels, in different courses, were not being retained by the students. The results of the pre-test are attached, and they demonstrate that the majority of our students were able to correctly answer far less than half of the questions. 2) the majority of our senior students are not prepared to analyze the basic literature and write synthetically. These are skills crucial to success in future MCAT exams as well as in many biomedical professions.

Given these poor results, we felt that changes needed to be made. Inspection of our curriculum lead to the realization that we were requiring the students to take too much introductory biology courses that focused on vocabulary and memorization (3 full courses) before they entered upper level courses that taught analytical skills. We dropped Biol 258 from our curriculum, which enables us to move students more quickly into smaller, upper level courses. We also decided to offer BioB 260 each semester to lower the size of the class and focus more on delivering a course that stresses concepts rather than memorization.

The other significant change made to the curriculum involved the upper level Biol 425 course. Because this is required for all of our majors, it provided another opportunity to adjust the curriculum and stress analytical skills. Two faculty were assigned to the course rather than one, and small sections were established to go over basic research papers with the students in a hybrid model of large lectures and small discussion sections. <u>While we feel that this change was useful and that it had a significant, positive impact on outcomes, unfortunately it proved to be unsustainable. CBN just does not have enough faculty to permanently assign two individuals to teach one class.</u>

Outcomes for AY 2015/2016 and adjustments for AY 2016.

BioB 425 was assessed on schedule. In general the students performed well on the pre-test (average class score of 86.4%) but there were three areas of significant concern that were then addressed.

1) Students have not yet mastered fundamental concepts in gene regulation, transcription, and protein translation. This appears to be due to a lack of emphasis in the introductory class BioB 260 and again in Biochem 380. Two changes were then implemented. Working with the instructors for BioB260, material was added on transcription/translation and gene regulation, and emphasizing the necessity of mastering this material as background for many of our upper level courses. The spring 2016 BioB260 offering was also altered to focus on analytical skills by making every Friday a small group discussion, where students read a short paragraph adapted from a research paper along with associated graphs or figures, and then had to interpret the data and answer a series of questions. This approach mimics the format of the new MCAT and forces students to read and critically analyze research data.

2) There were obvious weaknesses in basic chemistry. These weaknesses reflected misunderstandings of the material taught in introductory chemistry as well as what should have been learned in biochemistry. In particular, students have a fundamental lack of understanding of basic chemical bonds (covalent, ionic and H-bonds) relevant to biological macromolecules. Because these are fundamental concepts and skills taught by the chemistry department, we have been at a loss as to how we might improve this part of our students' curriculum. Our only solution was to use the first week in our BioB260 course to teach basic chemistry to students who had already completed Chemistry 141. While this is a poor use of limited BioB260 class time, it is the only solution we have at our means. Similarly, an additional chemistry lecture was then incorporated into the beginning of BioB425 to cover important topics of biochemistry that will be critical to mastering the cell biology concepts. We suggest that a discussion with the Chemistry department might help rectify these learning objectives.

3) The third adjustment that was made to BioB425 is to offer the course twice per year, rather than the previous spring-only schedule. This was done with the goal of reducing class size in order to facilitate more small group discussions. In addition, this will help students who are out of sequence finish their degree a semester (or year) earlier. Unfortunately, given the limited number of faculty in CBN, this also meant that we could no longer staff BioB425 with two faculty each semester – thereby losing one of the positive changes we had made in 2015.

BioH 320 was assessed on schedule. This assessment focused on three questions embedded in the final exam that covered basic Mendelian genetics. The questions covered material that is in the new MCAT, and which has been covered in both this course and introductory ones. On average the students got 55% of the questions correct, and 1 in 5 got all three correct. This is an improvement over the previous AY. One particular topic seemed to be the most problematic for students: predicting the frequency of genotypes versus phenotypes. This may be a fundamental problem in the mathematical/statistical skills of the students. Discussions are ongoing as to how we can improve on this. Unfortunately, in order to accommodate the need to teach basic chemistry, some of the Mendelian genetics was removed from BioB260 this last year. This may compound the problem for the coming AY.

Neurophysiology (BioH313) will be assessed at the end of the spring semester.

Two adjustments to Neurophysiology were made for the current AY. Firstly, to reduce class size, and to provide a re-take opportunity for students who drop or do poorly, the class will now also be offered in spring semesters, starting 2017. Secondly, we will add an assessment of student's comprehension of fundamental neuroscience concepts with questions embedded in the final exam. Previously, we had assessed this at the beginning of BioH440, which will continue, but by adding this assessment at the end of BioH313 we will more accurately assess what they learned during the semester, as well as whether the students have retained this understanding when they take BioH440.