Cell Biology & Neuroscience Curriculum Assessment

Introduction

KPI data & Delaware Study

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%.**

Furthermore, the external review states that

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 then enrollment in courses the department teaches has continued to grow, but faculty hires have only been sufficient to replace senior faculty departures. 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]. In this context, the curriculum we deliver involves balancing the resources and faculty available with the goals we have for our students.

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.

Program Learning Outcomes

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.
- 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.

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[1] http://www.montana.edu/opa/restricted/delaware/graphs.pdf

[2] https://www.aamc.org/initiatives/mr5/

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.

- Will 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 academic year.

The first faculty meeting in January will be devoted to going over the results of the assessments of fall courses, and the final faculty meeting of the semester in May will be used evaluate all of the assessment materials collected in the fall and spring semesters. The meeting in May will be an extended one, focusing on what changes might be necessary to the curriculum delivered the following year.

Plan for assessments from 2014 through 2018

2014	2015	2016	2017
Pre-test assessment of basic neuroscience concepts in BioH 440	Assesment of cell biology concepts and mastery of signaling in BioB 425 with pre-test	Pre-test assessment of basic neuroscience concepts in BioH 440	Assesment of cell biology concepts and mastery of signaling in BioB 425 with pre-test

Evaluation of analytical skills and literacy in Bio H 455	Assessment of fundamental genetics concepts and approaches with strategically placed questions in the final exam of BioH 320	Evaluation of analytical skills and literacy in Bio H 455	Assessment of fundamental genetics concepts and approaches with strategically placed questions in the final exam of BioH 320
	External review of the program, as required by BOR policy		

Outcomes for 2013/2014 academic year.

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.

Adjustments/Changes made for 2014/2015 academic year.

Given the poor results of our assessments, 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. involves 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. While this change involves a higher work load for the faculty, it is a change at a crucial node in the path through our curriculum that we hope will have a significant, positive impact.

Outcomes and adjustments for 2015 academic year.

BioB 425 was assessed on schedule. In general the students performed well on the pre-test, but there were two areas of significant concern.

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 Bio 260, and working with the instructors we will be adding material and emphasizing the necessity of mastering this material because it is necessary background for many of our upper level courses.

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. Because these were fundamental concepts and skills taught by the chemistry department, we are at a loss as to how we might improve this part of our students curriculum.

3) The course will incorporate at least one lecture at the beginning to cover important topics of biochemistry that will be critical to mastering the cell biology concepts.

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 50% of the questions correct, and 1 in 40 got all three correct. Discussions are ongoing as to how we can improve on this, and the instructor has suggested that teaching better study skills earlier in our curriculum could pay off over the long haul.

External Review of the department. The third component of our assessment in 2015 was the BOR-mandated external review. This was done by two impressive faculty

recruited by the Provost's office to review the department over the course of two days, May 11-12, in 2015.

They found failings in integration across departments and in the academic leadership of MSU:

> *The entire MSU undergrad bioscience curriculum merits review and requires better integration across Departments within a school as well as across schools. Such integration could identify and resolve gaps and redundancies in the undergrad bioscience curricula and allow for a fair distribution of work load across Departments and schools. This would also clearly be of great benefit to students, and potentially mitigate the worrisome increase in the time to graduation metric.*
>
> *Finally, the poor transparency in MSU leadership policies and practices hampers students and faculty in all schools.*
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> *The last external review of CBN occurred in 2008, in line with the University's requirement for such assessments every seven years. The review committee was provided with a copy of the 2008 review at the time of the on-site visit (May 11-12, 2015). Of note, despite the seven-year interim period, many of the conclusions and recommendations made here to the MSU Administration echo those made previously. During none of the meetings with Academic Administrative leaders was the 2008 review mentioned nor why its recommendations were not acted on.*

They found that our department has been working to adjust our curriculum and respond to the challenges of the new MCAT with little help:

> *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.*

They found that the current conditions are unsustainable and will have long term consequences to research programs and a very small graduate program:

> *Several strategies have served them well, but the current situation is untenable and unsustainable. The major reason that they have been successful is their unusually high level of dedication to teaching and research missions of MSU.*

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.

While the department has been able to close the assessment loop this year - regarding the assessments done in the two courses - it is the larger structural problems identified in the external review that will continue to impact the curriculum.