**Program:** Bachelor of Science, Cell and Molecular Biology  
**Department:** Biological Sciences

**Number of students enrolled in the program in Fall, 2011:** 97

**Faculty member completing template:** Jennifer Lundmark  
**(Date:** January 20, 2012)

**Period of reference in the template: 2006-07 to present**

1. Please describe your program’s learning-outcomes trajectory since 2006-07: Has there been a transformation of organizational culture regarding the establishment of learning outcomes and the capacity to assess progress toward their achievement? If so, during which academic year would you say the transformation became noticeable? What lies ahead; what is the next likely step in developing a learning-outcomes organizational culture within the program?

Molecular Cell Biology (MCB) faculty have worked together with all Departmental faculty to identify and integrate student learning outcomes (SLO) that reflect modern MCB, the needs of an expanding MCB workforce, and the diverse interests of our students. The Department as a whole developed SLO for key biology concepts and skills by the process of “Backward Design”¹ and introduced a new introductory biology sequence – BIO 1 (Biodiversity, Evolution and Ecology) and BIO 2 (Cells, Molecules and Genes) - in Fall, 2006.

That process led to a remarkable transformation of MCB culture and we have since designed an integrated and scaffolded set of SLO that links Introductory Level learning directly to an intermediate Expansion Level and, in turn, to a Mastery Level that allows the necessary specialization for success in a sophisticated MCB workforce. The integrated MCB Core gives our students advanced experiential learning and state-of-the-art concept and skills training. The eight core courses will be fully implemented by Fall 2012 and development of SLO-based assessments are underway.

2. Please list in prioritized order (or indicate no prioritization regarding) up to four desired learning outcomes ("takeaways" concerning such elements of curriculum as perspectives, specific content knowledge, skill sets, confidence levels) for students completing the program. For each stated outcome, please provide the reason that it was designated as desired by the faculty associated with the program.

   [NOTE: We have no prioritization]

   a) Students will develop a base of factual and conceptual knowledge of basic and applied biological processes.
      a. **Rationale:** Biological Sciences Faculty members recognize that students must achieve a certain level of competence in basic biological knowledge and concepts. This knowledge is the basis for more complex thought processes within the discipline.

   b) Students will be able to generate and communicate scientific knowledge.

¹ From the book *Understanding By Design* (Wiggins and McTighe, 2005). Briefly, Backward Design is the process of identifying desired learning outcomes, determining acceptable evidence of success, and then planning the learning experience accordingly.
a. **Rationale:** Far more important than any knowledge that students obtain is the ability for students to learn the skills of experimental design and communication and dissemination of their findings. Employers want candidates who can read complex texts, solve complex problems and express and communicate complex thoughts. Our Faculty are acutely aware of the importance of this element of the scientific process.

c) Students will develop and appreciate the importance of connections between other academic disciplines and the biological sciences and the social relevance of biology.
   a. **Rationale:** Biological Sciences faculty members recognize that biology does not happen “in a bubble”. We wish to convey the importance of biological principles, concepts, and the process of science in making informed decisions as citizens and scientists. The ability to draw these connections is also important within and between the various scientific disciplines as the Broader Impacts of science are becoming increasingly important to funding agencies and the general public.

d) Students will be able to implement the skills needed to be life-long learners in any field of study.
   a. **Rationale:** Skills pertaining to the acquisition of knowledge and an appreciation of connections between different academic disciplines form the basis of a student’s lifelong learning skills. By learning reasoning, critical thinking and experimental skills, the program instills these attributes in all Biological Sciences students. We are acutely aware that science and technology are changing so rapidly that much of the specific knowledge students learn with us will be outdated by the time they are seeking jobs, so learning how to learn is what is a critical outcome.

3. **For undergraduate programs only, in what ways are the set of desired learning outcomes described above aligned with the University’s Baccalaureate Learning Goals? Please be as specific as possible.**

**Competence in the Discipline** is met by the combination of Student Learning Outcomes (SLO’s) a, b, and c (as listed for #2, above). Competence in scientific disciplines pertains not only to factual and conceptual knowledge (a), but also to laboratory/field-based skills (b) and the ability to clearly communicate findings to the rest of society (c).

**Knowledge of Human Cultures and the Physical and Natural World:** The biological sciences focus on the study of the living world, and because scientific understanding (SLO a) is pursued on some level by all human cultures, science is really a global endeavor. At all levels of study within our department, contributions of various cultures to the study of science are highlighted and given appropriate focus, aligning with SLO d, social relevance.

**Intellectual and Practical Skills** are developed at all levels of our “three-tier” curricular design (introductory, intermediate, advanced). As described in Question 4, below, assessment instruments will specifically test the progression of this development in a practical, applied manner. By its very nature, science involves critical thinking, analysis, quantitative and
technological literacy, and problem-solving (both individually and in groups). As an example, students work with lab/activity partners in all introductory and intermediate courses, as well as most advanced classes. Expectations of student lab performance, data analysis, and experimental design scale upward as the student progresses through the curriculum.

**Personal and Social Responsibility** are highlighted in all applications of science and are specifically highlighted in SLO’s b and d, above. As science progresses, especially in its applications to human health, ethical, legal, and societal questions multiply. In answering to these SLO’s, aspects of personal and social responsibility are consequently addressed.

**Integrative Learning:** As a science, biology has its foundations in the disciplines of mathematics, physics, and chemistry; as such, it is really an applied science that integrates these “basic” sciences along with many other fields that affect its application to our society (psychology, sociology, and philosophy, to name a few). SLO’s b, c, and d specifically address this area of learning.

4. **For each desired outcome indicated in item 2 above, please:**
   a) Describe the method(s) by which its ongoing pursuit is monitored and measured.
   b) Include a description of the sample of students (e.g., random sample of transfer students declaring the major; graduating seniors) from whom data were/will be collected and the frequency and schedule with which the data in question were/will be collected.
   c) Describe and append a sample (or samples) of the "instrument" (e.g., survey or test), "artifact" (e.g., writing sample and evaluative protocol, performance review sheet), or other device used to assess the status of the learning outcomes desired by the program.
   d) Explain how the program faculty analyzed and evaluated (will analyze and evaluate) the data to reach conclusions about each desired student learning outcome.

As our new curriculum was just implemented (Fall 2011), we do not yet have assessment data, but have researched a number of validated tools to monitor our students’ progress. We’ve identified one instrument, called the Experimental Design Ability Test (EDAT)\(^2\), which will address each of the outcomes above (a-d) by examining student-driven experimental design. Understanding how to design an experiment is a fundamental skill for all graduates of a biological sciences program. The EDAT assesses students’ knowledge of the basic and critical elements of a good experiment, and depending on the prompt used, the EDAT can be adapted to assess specific factual and conceptual knowledge important to different fields within the biological sciences (outcome a). The EDAT will further evaluate students’ ability to generate and communicate scientific knowledge, as it requires students to design and describe their own experiment in essay format (outcome b). The prompts for this instrument are generated to address authentic problems that have relevance to students’ lives. Students must understand the process and nature of science, but also have the ability synthesize information and make connections to other disciplines in order to evaluate real-world scenarios (outcome c; see

\(^2\) **Experimental Design Ability Test (EDAT)**

*Described in: Sirum and Humburg, Bioscene: [Journal of College Biology Teaching Volume 37(1) May 2011](http://example.com)*
examples of prompts below). Lastly, students must employ creativity and other higher order thinking skills, as they analyze the information provided in the prompt, evaluate the claim, and ultimately solve the problem (outcome d).

Mastery of the knowledge and skills addressed in outcomes a-d will require time and practice. To track the development of these skills as students progress through their major, we intend to administer this test at the beginning of Bio 1 (the first lower division core course), after Bio 100 (a new, intermediate course focused on developing students’ scientific reasoning skills) and at the culmination of the degree program. This test is not content-specific, but rather focuses on important skills – such as reasoning, communication, and creativity. Therefore, surveying students in Bio 187, Advanced Cell Biology, will serve to capture the students at the end of their degree.

Examples of Prompts for EDAT:

a) Advertisements for an herbal product, ginseng, claim that it promotes endurance. To determine if the claim is fraudulent and prior to accepting this claim, what type of evidence would you like to see? Provide details of an investigative design.

b) The claim has been made that women may be able to achieve significant improvements in memory by taking iron supplements. To determine if the claim is fraudulent and prior to accepting this claim, what type of evidence would you like to see? Provide details of an investigative design.

The open-ended format makes the EDAT highly informative, yet a straightforward rubric ensures that evaluation is relatively rapid and consistent across multiple scorers. The scorer examines the student essay for the inclusion of 10 elements that may appear in a well-designed experiment, and if identified, the box by that item is checked. The score is then tallied, with a minimum of zero and a max score of ten. Elements in the rubric include, but are not limited to, the identification of dependent vs. independent variables, the description of how the dependent variable is measured, and understanding of the placebo affect, awareness that sample size will affect the experiment and that replicates are important. Students are not required to use specific terminology associated with experimental design (e.g., dependent vs. independent variable), but rather, must demonstrate they understand how to think through the problem and test the claim. Unlike on a multiple-choice test, students’ thought processes can be examined and correct answers cannot be arrived at using incorrect logic.

While the EDAT will provide a strategy for assessing key learning outcomes of our new curriculum, faculty in MCB have already designed and implemented two other student surveys. The first is a Technology Concepts Inventory that was administered to students at different academic levels to gauge familiarity with a range of techniques and technologies (including computer-based technologies) that are currently being used, or will soon be incorporated, into the new MCB curriculum. In additional course survey was developed for BIO 121, a required, mid-level course for MCB students. Through a series of questions, this instrument attempts to link student performance with information about course history (e.g., what courses they’ve
taken as well as when and where) and study habits. The survey is anonymous, with the primary goal of improving instruction by identifying correlations or trends that are predictive of student success/failure.

5. Regarding each outcome and method discussed in items 2 and 4 above, please provide examples of how findings from the learning outcomes process have been utilized to address decisions to revise or maintain elements of the curriculum (including decisions to alter the program’s desired outcomes). If such decision-making has not yet occurred, please describe the plan by which it will occur.

Results from the first EDAT will be discussed at the August, 2012 faculty retreat, and annually thereafter, with results providing formative assessment for programmatic and curricular change.

6. Has the program systematically sought data from alumni to measure the longer-term effects of accomplishment of the program’s learning outcomes? If so, please describe the approach to this information-gathering and the ways in which the information will be applied to the program’s curriculum. If such activity has not yet occurred, please describe the plan by which it will occur.

Our latest alumni survey (2009; via US mail), garnered 187 responses, most of whom had graduated within the previous three years. Of this group, 90% indicated that they were either satisfied or very satisfied with the overall quality of instruction provided by the Biological Sciences faculty, and almost all felt they had good access to faculty during their time here (47% were “very satisfied”). They indicated that they were intellectually challenged and inspired by their time as students with us (83% agreed/strongly agreed), and that they enjoyed the variety of teaching techniques employed by their professors in the department (81% A/SA). We have used this positive feedback to inform faculty as to the rigor level of courses and pedagogical approach.

Information about alumni employment is also of paramount importance, and has assisted us in the design of our major concentrations. Over 50% of our students enter with the intent of working in the health professions, and in fact the largest subset of alumni found work in the health care arena (27%), with others working in clinical or research labs (20%) or for the government in some capacity (16%). 20% were in graduate or professional school. Only 2% were in a field unrelated to biology. Perhaps even more telling, 86% of respondents indicated that their employer considered it important that their degree be in the biological sciences. This information encouraged us to increase our focus on laboratory skill development.

7. Does the program pursue learning outcomes identified by an accrediting or other professional discipline-related organization as important? Does the set of outcomes pursued by your program exceed those identified as important by your accrediting or other professional discipline-related organization?
Molecular Cell Biology (MCB) does not have an accrediting organization; however, feedback from employers and alumni indicate that the academic preparation of our majors exceeds expectations. We are currently implementing a redesigned core curriculum that is based on a fully integrated set of student learning outcomes (SLO) that spans an Introduction Level for freshmen and sophomores, an Expansion Level for sophomores and juniors, and a Mastery Level for senior students. The three-tier MCB core includes eight courses for which we are developing SLO as an integrated series. The Introduction Level exposes students to eight fundamental Key Concepts and five Key Skills determined through a Backwards Design process by the Department to be the most basic essentials of training in MCB. This Level includes our Introduction to Cells, Molecules and Genes (BIO 02). Detailed SLO for BIO 02 are under development around each Key Concept and Key Skill. The Expansion Level includes four courses that take the Key Concepts and Key Skills established earlier and delves deeper into the theoretical and factual material at their core. The detailed SLO at this level will reiterate the major ideas that students encountered in BIO 02 and move on to the regulatory mechanisms of those learned concepts and application of learned skills. The core courses at this Level include Introduction to Scientific Analysis (BIO 100), Molecular Cell Biology (BIO 121), Genetics (BIO 184) and Biochemistry (CHEM 161). The Mastery Level gives our senior students advanced level instruction that includes experiential learning in the scientific method and in-depth laboratory skills. The SLO at this Level will focus on experimental design and laboratory technologies necessary to generate new data in Molecular Cell Biology. The core courses at the Mastery Level include Advanced Molecular Biology (BIO 180), Advanced Cell Biology (BIO 187) and Evolution (BIO 188).

8. **Finally, what additional information would you like to share with the Senate Committee on Instructional Program Priorities regarding the program’s desired learning outcomes and assessment of their accomplishment?**

Over the last seven years, Biological Sciences faculty members have focused efforts on a revision of the Biological Sciences curriculum with a focus on student learning outcomes and Backward Design. The outcome of this arduous process has been a set of learning outcomes that focus on higher-order thinking and applied skills, rather than being content-based as in previous curricula. Courses that were content-based and independent of one another transitioned into a series of courses (lower and upper division core) that show an interdependency of skills and scaffolding of learning outcomes throughout the curriculum, from the lower division (introduction), through the intermediate and advanced levels. While we are in the infancy of this revision, we are hopeful that assessment data over the next several years will indicate positive gains in student learning, particularly with regard to scientific skills (experimental design, analysis, synthesis of knowledge) and communication (written and oral communication skills).