

Program: Bachelor of Science, Biomedical Sciences

Department: Biological Sciences

Number of students enrolled in the program in Fall, 2011: 79*

Faculty member completing template: Jennifer Lundmark

(Date: January 20, 2012)

*we note that this concentration was just introduced in Fall, 2011.

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?*

Since 2004, the Department has engaged in an ongoing process of identifying critical learning outcomes that reflect modern biology, the needs of the scientific workforce, and the diverse interests of our students. Outcome identification was the topic of several departmental retreats (including one in which an external consultant led us through a large-scale outcome identification process). Using learning outcomes determined by all faculty and driven by the process of "Backward Design"¹, we developed and introduced a new lower-division introductory biology sequence – BIO 1 (Biodiversity, Evolution and Ecology) and BIO 2 (Cells, Molecules and Genes) - in Fall, 2006.

This was followed by a reexamination of the rest of the curriculum, with the ultimate goal of creating a structure that allows students to specialize within the biological sciences to meet the demands of a rapidly changing and sophisticated STEM workforce. Using Backward Design and scaffolded learning outcomes (introductory, mid-level, and advanced) we introduced specific programs, including the new BS concentration in Biomedical Sciences, in Fall, 2011. Developed to serve Bio Sci majors who express interest in pursuing health professional careers (over 50% of incoming students), it is already highly popular, allowing students to meet program requirements with fewer total units.

*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.

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:** 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.
 - 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.
2. *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.

3. 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

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

Described in: Sirum and Humburg, *Bioscene: Journal of College Biology Teaching* Volume 37(1) May 2011

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 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 at the conclusion of Bio 131, Systemic Physiology, will serve to capture the most students near the end of their degree.

Examples of Prompts for EDAT:

- a) Claims that a particular supplement prevents muscle atrophy during disuse are flooding the media. You are examining a group of athletes to decide upon the validity of the claim. What type of evidence would you like to see? How would you structure the investigation? Provide details of an experimental design.
- b) A new anti-hypertensive medication directly affects hormone release to obtain its effect. What type of evidence would you like to see to determine if it is both safe and effective? 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.

4. *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.

- 5. 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 and encouraged an entirely new concentration: Biomedical Sciences. Although only four months old, it already has 79 declared majors and continues to grow.

Our first declared graduates under our new program will complete their degrees in Spring 2012, and we plan to administer another survey (online) following their graduation to provide initial feedback on our programmatic changes.

- 6. 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?*

There is no accreditation for this concentration. However, the curriculum was designed to meet the specific requirements of health professional programs (e.g. medicine, dentistry, pharmacy, etc.). Students completing the Biomedical Sciences concentration automatically take (and receive credit toward the major for) the extended series of Organic Chemistry (plus lab), Physiology, and Anatomy, all of which were not required in the previous version of the major. This often led to pre-med (and other) students taking several extra classes (beyond the major) to meet the requirements of the professional program. There was also confusion on the part of students regarding which courses to take to gain entry into professional programs; this is now cleared up. Sac State students historically do quite well in gaining acceptance and performing in highly-competitive health professional programs, indicating that our curriculum is strong and we are successful in preparing our students to succeed in the more advanced curriculum. Thus, although we do not have a formal accrediting agency for our undergraduate curriculum, we do have course requirements for eligibility, which the new Biomedical Sciences concentration meets. Professional programs whose science pre-requisites are entirely met by the BS in Biomedical Sciences include: medicine (allopathic and osteopathic), dentistry, pharmacy, optometry, physician's assistant, nursing, nurse practitioner, podiatric medicine, and physical therapy.

7. 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).