

## Undergraduate Program-Specific Student Learning Outcome and Success Annual Report

### I. Program Information

Program/Department: Biology Program, Department of Biology and Chemistry

Department Chair: Mel Govindan

Department Assessment Committee Contact: John Ludlam (jludlam@fitchburgstate.edu)

### II. Program-Specific Student Learning Outcomes (Educational Objectives)

*List ALL Program-Specific SLOs first, and the assessment timeline (annual or bi-annual) for assessing each program SLO.*

Program SLO	Expected Timing of assessment (annual, semester, bi-annual, etc.)
Curriculum mapping of introductory and upper-level Biology courses to BioCore learning outcomes and Biology program skills (Appendix A)	2016-2017
Disciplinary knowledge	Spring 2017 (annual)
Skills/Competency Assessment in Capstone Course	2017-2018 (annual)

**III. SLO Assessment (Please report on the SLO's most recently reviewed)**

Using the table below, list and briefly describe the direct methods used to collect information assessing whether students are learning the core sets of knowledge (K), skills (S) and attitudes (A) identified as essential.

Dept. SLO #	Assessment description (exam, observation, national standardized exam, oral presentation with rubric, etc.)	When assessment was administered in student program (internship, 4 <sup>th</sup> year, 1 <sup>st</sup> year, etc.)	To which students were assessments administered (all, only a sample, etc.)
Disciplinary knowledge	Assessment of select BioCore learning outcomes in Introductory and Capstone Biology courses using non-credit exam.	1 <sup>st</sup> and 4 <sup>th</sup> year	All students in General Biology I and II and in Capstone Courses (Developmental Biology and Molecular Biology)

**IV. Summary of Findings:** Briefly summarize the results of the assessments reported in Item III above and how do these compare to the goals you have set?

<b>Other than GPA, what data/evidence is used to determine that graduates have achieved the stated outcomes for the degree? (e.g., capstone course, portfolio review, licensure examination)</b>	<b>Who interprets the evidence? What is the process? (e.g. annually by the curriculum committee)</b>	<b>What changes have been made as a result of using the data/evidence?</b>
Assessment of select BioCore learning outcomes in Introductory and Capstone Biology courses using non-credit exam.	Spring 2017 review by Assessment Committee of scores on exam. See Appendices B and C.	None to date

## V. SSC Data

Indicate a student success performance measure(s) that the department identified as a key measure that it wants to improve. Freshman retention, bottleneck courses, graduation rates, at risk student retention etc.

Student Success Measure (data point from SSC)	Rationale for selection	Planned or Implemented Intervention	Current score/ Target Score
Gateway course performance	Biology 1800 and Chemistry 1300 were identified as critical gateway courses for Biology majors. Student receiving less than a C had a very low probability of graduating in Biology.	To encourage students to master the content in Biology 1800 and Chemistry 1300 the department instituted the following policy in a Spring 2016 AUC proposal: Biology majors must earn a minimum grade of 2.0 in General Chemistry I and General Biology I. If a grade below 2.0 is earned, the course must be repeated before enrolling in General Chemistry II or General Biology II. Biology majors are limited to two attempts for these courses.	We will monitor the number of students needing to repeat these courses and the number affected by the 2 attempt policy.
Graduation Rate	SSC data shows that Biology majors have a substantially lower graduation rate than the Institution as a whole.	We have surveyed students in the major in Spring 2016 and 2017 using an online questionnaire. The main findings were (1) students were frustrated with the number of seats available in upper level Biology electives during registration and (2) students found required majors' coursework to be very demanding and time consuming.  In part in response to these concerns, the Department revised the B.A. in Biology to	Current 31.4% Target 56.4% (Full time graduation rate)

		<p>make it a viable pathway for students desiring a more broad-based education with an emphasis on courses that better prepare them for particular careers.</p> <p>In order to make upper-division biology elective courses more accessible the department has reduced the pre-requisites for three courses during 2015-16 academic year: Biochemistry; Foundations of Biochemistry and Cell Biology. The Chemistry faculty also revamped the Organic Chemistry sequence so that Organic Chemistry I would prepare students to take the biochemistry courses. These changes are expected to ease the students' concerns.</p> <p>We have submitted an AUC proposal to change the current General Microbiology course from a 3000-level course to a 2000-level course with fewer pre-requisites. This will make this course more accessible to students and prepare them better for other upper division courses. In addition, other curricular revisions are being considered to address the concerns of students as well as to make the curriculum suitable for the needs of the increased number of majors.</p>	

**VI. Phase I Data**

Indicate department success performance measure(s) that the department identified as a key measure that it wants to improve (from phase 1 data).

Number of graduates, number of majors, credit production, substitutions etc.

<b>Department Performance Measure (data point from Phase 1)</b>	<b>Rationale for selection</b>	<b>Planned or Implemented Intervention</b>	<b>Current score/ Target Score</b>
<p>a. Retention Rate Biology Major (Freshman)</p> <p>b. Retention Rate Changed Major (Fresh.) - BIOL</p>	<p>Biology rates tend to be below institutional averages for both retention rates.</p>	<p>The 2.0 minimum/2 repeat policy for General Biology I and General Chemistry I will have two effects. It will encourage Biology majors to master essential course content needed for success in future majors' courses. The 2 repeat policy was also intended to encourage students to switch to a more appropriate major earlier in their academic career. Thus, we hope to see improvements in both freshman Biology retention and retention of students who transfer out of Biology but stay at Fitchburg State.</p>	<p>a. 55.56/70 b. 13.89/20</p>

## **VII. Activities and Adjustments to/Deviation from the Department Assessment Plan**

Describe any changes in the assessment plan including new SLOs, new assessments.

In order to determine which learning outcomes are covered in the various courses, departmental faculty contributed to a curriculum mapping of knowledge and skills for introductory and advanced coursework (Appendix A). As a result of this mapping several curricular changes are being considered. (1) Currently some Biology majors take BIOL 1200 and 1300 (A&P I and II) but these courses do not count towards the Biology major and many majors have limited exposure to physiology beyond the freshman introductory coursework. To remedy this, we are considering adding a requirement that Biology majors take one course in Physiology or Anatomy (Neuroscience, Animal Physiology, or Comparative Anatomy). (2) In addition, we also are considering developing a sophomore sequence in Human Anatomy and Physiology that would count as Biology electives and be required for the Health Science concentration. (3) Sophomore biology electives without high level pre-requisites are being added to provide students with additional elective options.

The assessment committee developed a new pre and post assessment exam with consistent questions to assess content knowledge in the major using a recently adopted set of national Biology learning outcomes (AAAS BioCore). Previous knowledge assessment were hindered because different professors used different questions in different courses for assessment. The pre and post-test assessment results generally agreed with the findings of the curriculum mapping described above (see Appendix B for more detail). Student improvement was strongest in cell, genetics, and molecular content and weakest in physiology and evolution content.

## Appendix A. Curriculum mapping of introductory and upper-level Biology courses to BioCore learning outcomes and Biology program skills

At the January 2017 departmental retreat the Assessment Committee presented the BioCore survey results again and highlighted learning goals that received less coverage in the four core courses (25% and 50% quartiles for cumulative coverage). Physiology had 7 of 19 learning goals in the bottom two quartiles, Molecular/Cellular/Developmental Biology had 7, and Ecology/Evolutionary Biology had 5 of 19. In order to determine which upper-level Biology courses cover these topics, faculty rated coverage of BioCore learning goals in these courses (only learning goals in the 25% and 50% quartiles were ranked). Competencies and skills were also ranked for introductory and advanced Biology courses.

Assessment and Curriculum met together in March 2017 to discuss the results of the learning goals and skills surveys. Non-metric Multidimensional Scaling (NMDS) was conducted to group courses based on coverage rankings of learning goals (Figure 1). Developmental Biology and Bioethics were not included in the analysis because of a faculty retirement. Three general clusters of courses were apparent from survey rankings of learning goals.

### **Anatomy and Physiology** (tight grouping)

Neuroscience, Animal Physiology, Comparative Anatomy, Anatomy and Physiology

### **Organismal/Evolution** (loose grouping)

Animal Behavior, Evolution, Conservation Biology

### **Molecular/Cellular/Developmental** (loose grouping)

Molecular Biology, Biochemistry, Immunology, Cell Culture, etc.

The BioCore learning goals survey highlighted weaker coverage of Physiology content and Molecular/Cell/Developmental content in the core courses. The department regularly offers a number of upper level biology electives in Molecular/Cell/Developmental though learning outcomes vary substantially across these electives. Upper level physiology courses are taught by a single faculty member and have limited seats. These physiology courses specifically address areas where intro courses have limited coverage. Evolution topics are introduced in General Biology II and outside of Evolution there are few electives with substantial evolution coverage.

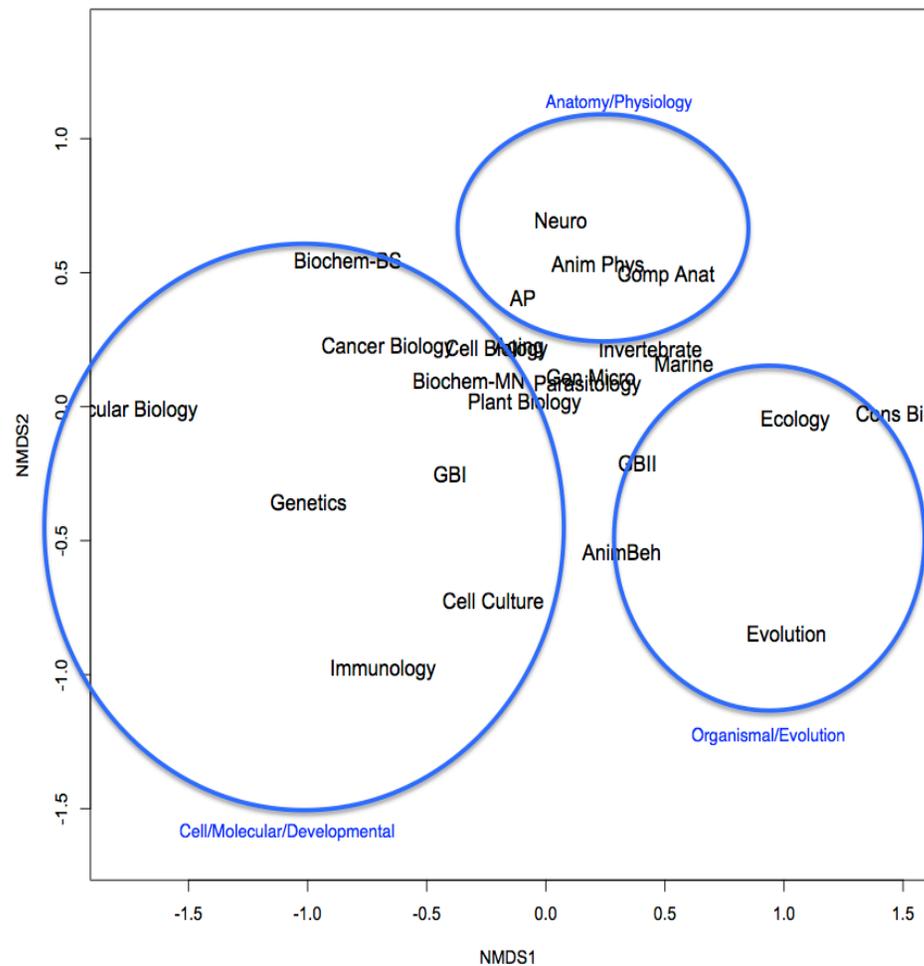


Figure 1. Non-metric Multidimensional Scaling (NMDS) plot grouping Biology courses based on reported coverage rankings of BioCore learning goals. **Courses that had high coverage of the same learning goals are grouped more closely together.** Ovals drawn on top of results show grouping of courses into three general clusters.

Appendix B. Assessment of select BioCore learning outcomes in Introductory and Capstone Biology courses using non-credit exam.

**Disciplinary knowledge and skills.** Students should understand and be able to apply their understanding of all biology sub-disciplines and use appropriate research skills to solve problems in these areas. These areas of knowledge, based on the AAAS BioCore, include: Evolution, Pathways and Transformations of Energy and Matter, Information Flow, Exchange and Storage, Structure and Function, and Systems. Students in Introductory (General Biology I and II, Pre-assessment) and Capstone (Developmental Biology and Molecular Biology, Post-assessment) courses were assessed on a multiple choice exam of introductory biology content in near the start of the semester in Spring 2017. The same questions were given in pre and post assessment. Only Biology majors taking General Biology for the first time were included in the pre-assessment. Transfer students were included in the assessment since transfer students are a substantial proportion of our majors.

In general, pre and post-test results supported the findings from our curriculum mapping. Students scored highly in pre and post assessment on basic cell and molecular biology content (#9, 10, 11). More advanced ideas like “Your bone cells, muscle cells, and skin cells look different because different genes are active in different types of cells” (#12) and explaining the genetic mechanism of natural selection (#4) showed strong improvement from pre to post assessment. Students typically take multiple courses in cell, genetics, and molecular biology throughout the curriculum and are repeatedly exposed to these ideas like gene expression and alleles. However, while students were generally comfortable defining natural selection and mutation (#5, 6, ~60%) on the pre-test, questions about speciation and fitness (#3, 7) had low scores on the pre-test and the post-test failed to show strong improvements. In our curriculum students may not be exposed to evolutionary processes outside of a few lecture in freshman biology. Similarly, little improvement was found for physiology topics (#8, 13). Curriculum mapping showed that few physiology courses were available to students outside of the health science concentration. Students generally performed poorly on questions related to energy transformation on pre and post-tests, but showed improvement (#1, 2). Finally, students showed gains in the ability to identify dependent and independent variables in experiments and identify the purpose of control groups (#14, 16).

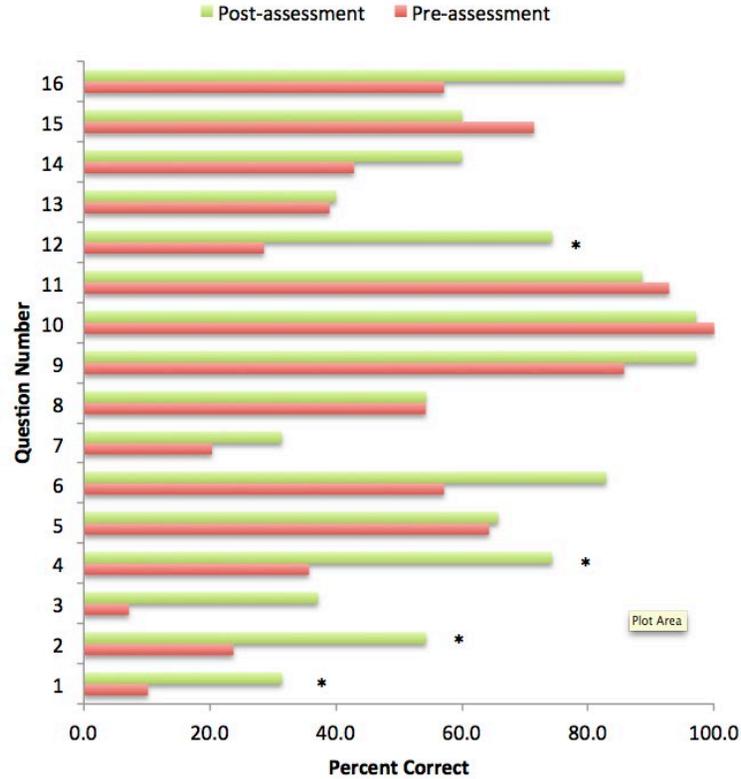


Figure 1. Percent correct on pre and post-assessment exam by Biology majors. Stars indicate a statistically significant difference between pre and post-test without correction for multiple testing. With correction for multiple testing, no differences were statistically significant, probably due to low sample sizes (n=14 in some instances).

### Assessment Questions used in pre and post-test

1. A tropical rainforest is an example of an ecosystem. Which of the following statements about matter and energy in a tropical rainforest is the most accurate?

- A. Energy is recycled, but matter is not recycled.
- B. Matter is recycled, but energy is not recycled.**
- C. Both matter and energy are recycled.
- D. Neither matter nor energy are recycled.

2. The organisms at the top of a food web:

- A. accumulate all of the energy that existed in the consumed organisms that were lower in the food web.
- B. have less available energy than trophic levels below it.**
- C. have the same amount of accumulated energy as each of the trophic levels below it.
- D. have available to it all of the energy of the food web.

3. If an organism has a greater fitness than other individuals of the same population, then the organism \_\_\_\_\_.

- A. lives longer than others
- B. competes for resources more successfully than others
- C. mates more frequently than others
- D. utilizes resources more efficiently than others
- E. leaves more offspring than others**

4. In an imaginary insect species, the dominant allele G codes for dark green color and the recessive allele g codes for light green color. Suppose a population of these insects moves into a habitat with light-colored leaves, such as a grassland. The lighter insects are better camouflaged and can escape predators. What changes would you expect in subsequent generations?

- A. No change in frequencies of alleles or phenotypes.
- B. Increase of the recessive allele frequency, but no change of phenotype because that allele is recessive
- C. Increase of the frequency of the dominant allele and the dark color
- D. Increase of the frequency of the recessive allele and light color**
- E. Increase of the recessive allele and eventually genetic co-dominance

5 & 6. The process of 5. \_\_\_\_\_ generates variation while 6. \_\_\_\_\_ produces adaptation to the environment.

- A. natural selection
- B. mutation
- C. genetic drift
- D. gene flow

7. Speciation requires \_\_\_\_\_.

- A. periods of rapid evolutionary change
- B. genetic isolation**

- C. long periods of time
- D. geographic isolation

8. Consider the following three species of ectotherms.

Species	A. <i>Plethodon cinereus</i>	B. <i>Rana catesbiana</i>	C. <i>Thamnophis sirtalis</i>
Surface Area =	16 cm <sup>2</sup>	400 cm <sup>2</sup>	200 cm <sup>2</sup>
Volume =	2 cm <sup>3</sup>	500 cm <sup>3</sup>	50 cm <sup>3</sup>
Surface Area/Volume =	8	0.8	4

Write the letter (A, B or C on your bubble sheet) of the species that will heat up the fastest if lying in the sun.

9. What does it mean for a gene to be “expressed”?

- A. It is transcribed to RNA and then translated into a protein**
- B. It is mutated to a different form
- C. It is inserted into a bacterial plasmid
- D. It is inactivated using methyl groups
- E. It is quickly replicated during cell division

10. A main form of energy stored inside a cell is:

- A. DNA
- B. ATP**
- C. RNA
- D. Ribosome

11. Choose the process that requires an input of energy

- A. Active transport**
- B. Movement of water through a plasma membrane
- C. Diffusion of glucose across a plasma membrane down a concentration gradient
- D. Diffusion of oxygen across the plasma membrane

12. Your bone cells, muscle cells, and skin cells look different because

- A. Different genes are active in each kind of cell**
- B. They contain different numbers of genes
- C. Each cell contains different kinds of genes
- D. Each cell has a different mutation

13. If the body is too warm, glands in the skin secrete sweat to cool the body. This is an example of:

- A. **homeostasis using negative feedback**
- B. homeostasis using positive feedback
- C. osmoregulation using negative feedback
- D. thermoregulation using positive feedback

14. You want to measure the effect of light waves on plant photosynthesis. You design an experiment that exposes corn plants to light at 4 different wavelengths and measure O<sub>2</sub> production as an indication that photosynthesis is occurring. In this experiment

- A. corn is the dependent variable and wavelength is the independent variable
- B. wavelength is the dependent variable and corn is the independent variable
- C. **O<sub>2</sub> is the dependent variable and wavelength is the independent variable**
- D. wavelength is the dependent variable and O<sub>2</sub> is the independent variable

15. Which of the statements below best describe the hypothesis being tested in the experiment described above?

- A. There is a relationship between O<sub>2</sub> production and the variety of corn.
- B. There is a relationship between the growth of corn plants and the amount of O<sub>2</sub> they produce.
- C. There is a relationship between the growth of corn plants and the amount of light to which they are exposed.
- D. **There is a relationship between the amount of O<sub>2</sub> produced by corn plants and the wavelength of light to which they are exposed.**
- E. There is no relationship between photosynthesis and production of O<sub>2</sub> in corn plants.

16. The role of a control in an experiment is to

- A. ensure that the experiment is repeatable
- B. identify all factors in the experiment that affect the dependent variable
- C. **provide a basis of comparison to the experimental group**
- D. evaluate if lab equipment is working correctly in the experiment

## Appendix C. Biology Learning Outcomes and Skills

**1. Problem Solving Skills.** Students should be able to define problems clearly, develop testable hypotheses, design and execute experiments, analyze data using appropriate statistical methods, understand the fundamental uncertainties in experimental measurements, and draw appropriate conclusions.

**2. Disciplinary knowledge and skills.** Students should understand and be able to apply their understanding of all biology sub-disciplines and use appropriate research skills to solve problems in these areas. These areas of knowledge, based on the AAAS BioCore, include:

- Evolution
- Pathways and Transformations of Energy and Matter
- Information Flow, Exchange and Storage
- Structure and Function
- Systems

**3. Biological Literature and Information Management Skills.** Students should be able to retrieve information efficiently and effectively by searching the biological literature, evaluate scientific articles critically, and manage many types of biological information.

**4. Laboratory Safety Skills.** Students should be able to demonstrate and apply their understanding of the concepts of safe laboratory practices. They should be able to evaluate and assess safety risks associated with laboratory experiences. Students must be able to:

- carry out responsible disposal techniques
- comply with safety regulations
- properly use personal protective equipment to minimize exposure to hazards
- recognize chemical and physical hazards in laboratories, assess the risks from these hazards, know how to minimize the risks, and prepare for emergencies.

**5. Communication Skills.** Students should be able to present information in a clear and organized manner, write well-organized and concise reports in a scientifically appropriate style, and use relevant technology in their communications.

**6. Team Skills.** Students should be able to interact effectively in a group to solve scientific problems and work productively with a diverse group of peers.

**7. Ethics.** Students should understand and demonstrate responsible treatment of data, proper citation of others' work, and the standards related to plagiarism and the publication of scientific results. Students should also be able to explain the role of biology in contemporary societal and global issues.