

A Focus on the Biology Undergraduate Curriculum & Student Experience Fall 2015

PART ONE. ANALYSIS OF CURRENT CURRICULUM

For the current analysis of the Biology curriculum, we have drawn on our previous Fall 2014 curriculum analysis completed as part of our Strategic Plan and we have obtained and analyzed more recent data available through the University. Furthermore, we made a special effort to ask our students about their learning experience as Biology majors and have obtained data from three sources: 1) the Office of Academic Planning and Assessment conducted focus groups of 24 Biology seniors to explore their experiences as Biology majors in Fall 2014 (see Appendix A for report); 2) 38 Biology majors who attended our Finals Week Rejuvenation Station completed surveys of their Biology experience in May 2015; 3) the Department formed the Biology Majors Advisory Committee (BMAC) to better communicate with our students in Fall 2015; 80 BMAC students met with 4 faculty members on October 28, 2015 to discuss their experiences as Biology majors and to identify and prioritize action items to better serve our students.

Question 1. Identify and describe the primary gaps your current curriculum has in supporting your goals for your students.

a. Curricular coherence and accessibility.

Finding #1. Our ability to effectively deliver a coherent Biology curriculum to our majors is limited by the size of our major relative to the size of our instructional faculty.

Enrollment in the Biology major is high and growing rapidly. We have seen an 11% increase in the number of majors since Fall 2012 (OIR snapshot data: 1,115 Biology majors in Fall 2012; 1,241 Biology majors in Fall 2015). We have experienced a similar increase in the number of our majors in the Commonwealth Honors College; there has been a 12% increase in the number of CHC students who are Biology majors (OIR snapshot data: 250 CHC Biology majors Fall 2012; 279 CHC Biology majors in Fall 2015). These data result in a student/faculty ratio of 32:1 and a CHC student/faculty ratio of 7:1 based on 40 full time faculty members (30 Tenure Track (TT), 9 Lecturers, 1 Extension faculty member; not included are 2 TT faculty on multi-year leaves). On average, we offer 55 Biology courses/year to undergraduates that provide a broad training in the key subdisciplines of Biology; several of these courses are taught both semesters and some have multiple sections. These courses account for 27,928 Student Credit Hours (SCH)/year and serve not only our own Biology majors, but other life-science and science majors, students preparing for health careers, and non-science students fulfilling their Gen-Ed Biological Sciences requirement. These courses range from large active-learning, lecture-based courses to small lab-intensive experiences. Taken together, we offered 9320 seats to undergraduate students in 2015.

Finding #2. One of the large challenges in our major is the limited availability of our courses. This significantly limits our students' access to required courses in the Biology major, and the problem has been significantly exacerbated by the increased enrollment.

In our Strategic Plan we noted that with regard to access to courses, our graduating seniors ranked us 15-20% below the college and campus satisfaction means (~ 65% of 2015 Biology graduating seniors were very or somewhat satisfied). Most of our courses are filled to capacity and overenrolled each semester (Figure 1). Several of our courses fill within the first 24 hours of registration. The result of running a curriculum that is at or overcapacity is that only students

with early enrollment appointments (seniors) have their choice of courses. Some seniors and juniors, and especially sophomores, are left selecting from available courses rather than courses that fulfill their requirements or, more importantly, that suit their interests and career plans.

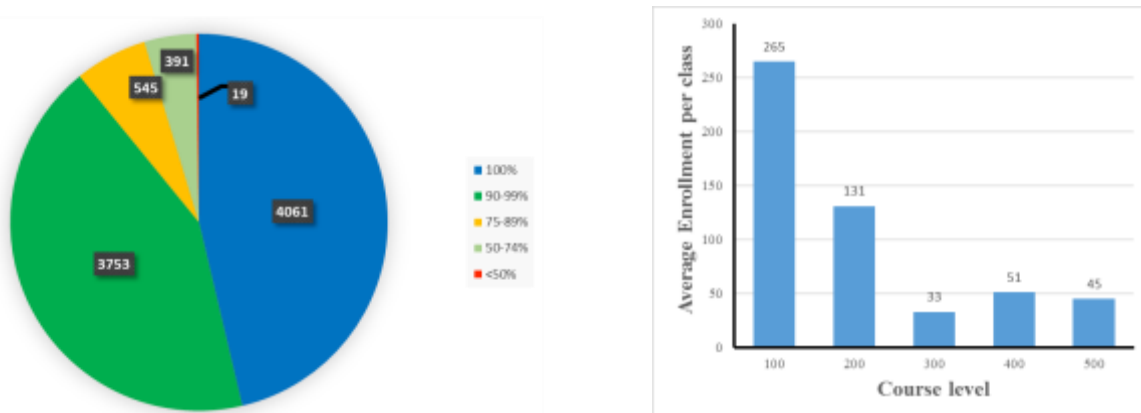


Figure 1. Left Panel. Comparison of course enrollment versus capacity for all Biology courses taught in 2015. In 2015, most Biology courses were at or near full capacity (90-100%). Courses at or near capacity served the majority of students (e.g., 4061 students were in classes at 100% capacity). Right Panel. Average course enrollments in 2015 Biology courses by course level (Biology 153 data not included). Both panels include data from the 72 Biology courses taught in 2015 (some were offered both semesters and/or had multiple sections).

This is a particular challenge for Biology as it is a broad discipline. We serve students with interests as varied as understanding how life evolved on earth, the mechanisms of cell division and growth, or the synaptic function responsible for behavior and learning. The lack of course availability leads to student and instructor frustration when students learn that their carefully planned SPIRE shopping cart of courses is irrelevant by the time they get to register for classes. This frustration is compounded for our CHC students who require two small enrollment (<25 students) Biology honors courses as well as a year-long thesis (499Y/T). Despite our recent successful efforts in strengthening our departmental honors program, we are unable to provide laboratory-based thesis options for all of our majors. To meet the need, we rely on non-Biology mentors for our CHC students as well as classroom-based, year-long capstones offered by CHC.

Feedback from our students revealed that the scheduling of our courses itself creates course conflicts and further limits course access. For example, the scheduling of Bio 494LI Life After Biology, one component of our Integrated Experience general education requirement, conflicts with many of our lab sections. We are assessing our scheduling of courses in order to eliminate or reduce this impediment to class access.

Finding #3. The result of this limited access to courses is that the curriculum for many Biology majors lacks cohesion and coherence. When students are continually forced to take available courses outside their area of interest, rather than the courses they choose, they sacrifice the ability to craft a coherent curriculum aligned with their career goals.

Our students have requested that our major incorporate concentrations to guide them through an appropriate sequence of courses aligned with their interests. In response, we are proposing to introduce three concentrations within the Biology major to complement a general Biology track, in an effort to provide curricular cohesion and streamline the progression of students through the

major. The concentrations are: Genomics, Evolution and Biodiversity; Neurobiology and Animal Physiology; and Cellular, Developmental and Genetic Mechanisms. A detailed analysis of current course offerings and their alignment with the proposed concentrations revealed that we have an unequal distribution of courses across the concentrations (see Appendix B). Therefore, successful implementation of the concentrations will rely on investment in appropriate upper level course offerings to offer a coherent curriculum for students interested in these different areas of biology and so that we can respond to student demand for a particular concentration.

Finding #4. The lack of coherence in and accessibility to the Biology curriculum is also driven by factors other than access to courses.

Linked to many of our challenges in providing a cohesive and accessible Biology major is our inability to provide adequate advising to our majors. *Advising was the #1 concern of our majors in all of our measures of their satisfaction with their major (senior focus groups, surveys, and BMAC conversation)*, and the Biology Graduating Senior Survey data revealed that 32% of students were dissatisfied with advising. At this time, Biology majors are not required to seek advising because we do not have the resources to implement such a requirement. As we discussed in our 2014 Strategic Plan, successful advising of all students is critical for student success, timely progression, and satisfaction with their Biology experience. One idea we are exploring is to utilize *Appointment Plus* software to provide easier access to scheduling and to better match a student questions with an individual with appropriate expertise. We look forward to working with CNS and the University in developing strategies to improve advising in Spring 2016.

As described in our 2014 Strategic plan, our course numbering system is composed of a suite of five 200-level courses that follow the first year introductory sequence (Appendix B). The majority of upper division classes are numbered in the 500 range (65%), with very few intervening 300 or 400 level offerings (35%). The large size of the major has led to oversubscribed courses at all levels, resulting in many junior or senior majors enrolled in 200 level classes; on average in 2015, 24% of seats in our 200 level courses were occupied by Biology seniors (see Table 1). As many 200 level courses are prerequisites for upper level classes, this has generated much student frustration. We also noticed that a subset of students, either through choice or necessity, take the bulk of their courses at the 200 level, failing to take advantage of the rich upper level courses. In order to improve access to courses and progression through the major we have proposed to: 1) redesign the core requirements for the Biology major by reducing the number of required 200 level courses, 2) renumber our courses to provide a clear course order, and 3) provide concentrations to guide students in course selection.

Biology majors are required to earn a C rather than a C- in each of the courses required for the Biology major; this includes courses in Chemistry, Physics, and Math Departments. This requirement is impeding the progression of a small subset of our majors through the curriculum and creates lack of curricular cohesion between the eight life science majors on campus. For example, a Biology major earning a C- in Chem 111 is allowed to progress to Chem 112, yet our rules dictate that they must repeat Chem 111 for credit in the Biology major. Students majoring in all other life science majors (e.g., Biochemistry and Microbiology) who earn a C- in Chem 111 receive credit toward their major. Examination of rosters of Chem 111, 112, 261, 262; Physics 131, 132; and Math 127 from 4 semesters (Fall 2013 to Spring 2015), revealed that 147 Biology majors earned a C- in one of these courses and had to repeat it. We are proposing to

substitute a C- as the minimum grade for Biology majors in required courses in Chemistry, Physics and Math.

Finding #5: We have identified specific gaps in the general biology curriculum and the curricula of the proposed concentrations.

In our 2014 Strategic plan, we identified two specific gaps in our Biology curriculum. First, our curriculum lacks a modern research experience for entering students. To address this gap, we are redesigning the Introductory Biology laboratory (Biology 153), so that students experience a lab with the facilities and course curriculum appropriate for modern 21st century biology. Second, we identified a gap in lab training in genetics and evolution. To address this gap, we are developing a 200-300 level Genetics and Evolution Laboratory course specifically for Biology majors. The institution of a lab fee should make it possible to reach these curricular goals and planning is underway.

In recent conversations about forming concentrations within the Biology major, groups of faculty identified gaps in these concentrations. Here are some examples. First, the Biology curriculum currently offers *no upper level laboratory courses* in the neurobiology and animal physiology concentration, a serious situation for our students, especially premedical students.

This concentration is also lacking courses in introductory neurobiology, developmental neurobiology, and neuropharmacology. The Genomics, Evolution and Biodiversity Concentration identified need for laboratory courses in the areas of evolutionary biology and genomics and more field components to their courses. The Cellular, Developmental, and Genetic Mechanisms Concentration identified a serious gap in the number of seats in upper level courses in this area, and propose increasing the frequency of offerings of Biology 559, Biology 523, Biology 477H, and Biology 486H to address the problem.

Finding #6: Some students can complete the Biology major without satisfying the Learning Goals for Biology majors.

We have begun a discussion to determine which Biology Learning Goals are met by individual courses (see Appendix B). Our objective is to ensure that the varied combination of courses assembled by individual students to meet their Biology major requirements include each of our Learning Goals. We began this analysis during our effort to assemble the curricula for the proposed concentrations. We will continue this ‘deep dive’ into the features of individual Biology courses. Our early data suggest that the large size of many of our courses limits the opportunities such as writing, delving into the scientific primary literature, and participation in authentic scientific research. By providing smaller courses for our majors, we can ensure that every Biology major is exposed to each of our Learning Goals and develops the skills and perspectives we deem important for a successful biologist.

b. Clarity of communication.

Given the size of our major, effective communication with our students is difficult. There is no current structure where Biology majors come together, as a whole or even by class. One obvious conduit for communication is through the Biology Advising Office. We cannot afford mandatory advising, so students themselves determine when they meet with Biology advisors. Some students meet with an advisor regularly while the majority are infrequent visitors to the advising office or never seek out advising at all.

We propose to redesign the Biology website to enhance communication with our majors. The current site is outdated (designed in 2009). The site fails to engage students, and is difficult to navigate. For example, our website contains both our Learning Goals document for Biology majors and recommended course sequences for Biology majors. Yet, when queried, the vast majority of students in our senior focus groups were *unaware* of these documents. We propose a major overhaul of the website so that it becomes the “go-to” place for information for our majors.

Our ability to communicate with our majors is also limited by a lack of community within the major. Biology majors do not have their own introductory Biology course sequence; they take their first year courses with students from all the other life science majors, doubling the size of the already large course. After the first year, Biology majors do not share a common unifying curriculum. To remedy this we are first redesigning our core major curriculum so that all students take the same three courses (Bio 283, 280 and 284). Second, we believe that our plans to develop concentrations within the major will help us establish smaller communities within the large major and will increase the opportunities for faculty-student interactions. Further, our recent establishment of the Biology Majors Advisory Committee (BMAC), comprised of students in the major, has already yielded benefits in communication. We will work with the BMAC to prioritize our action plan; each member of BMAC can converse with their fellow Biology majors about ideas and plans to improve the Biology major, and in doing so we will ‘connect’ with 500-600 students, almost half of our majors, on a regular basis.

c. Class size goals by student level.

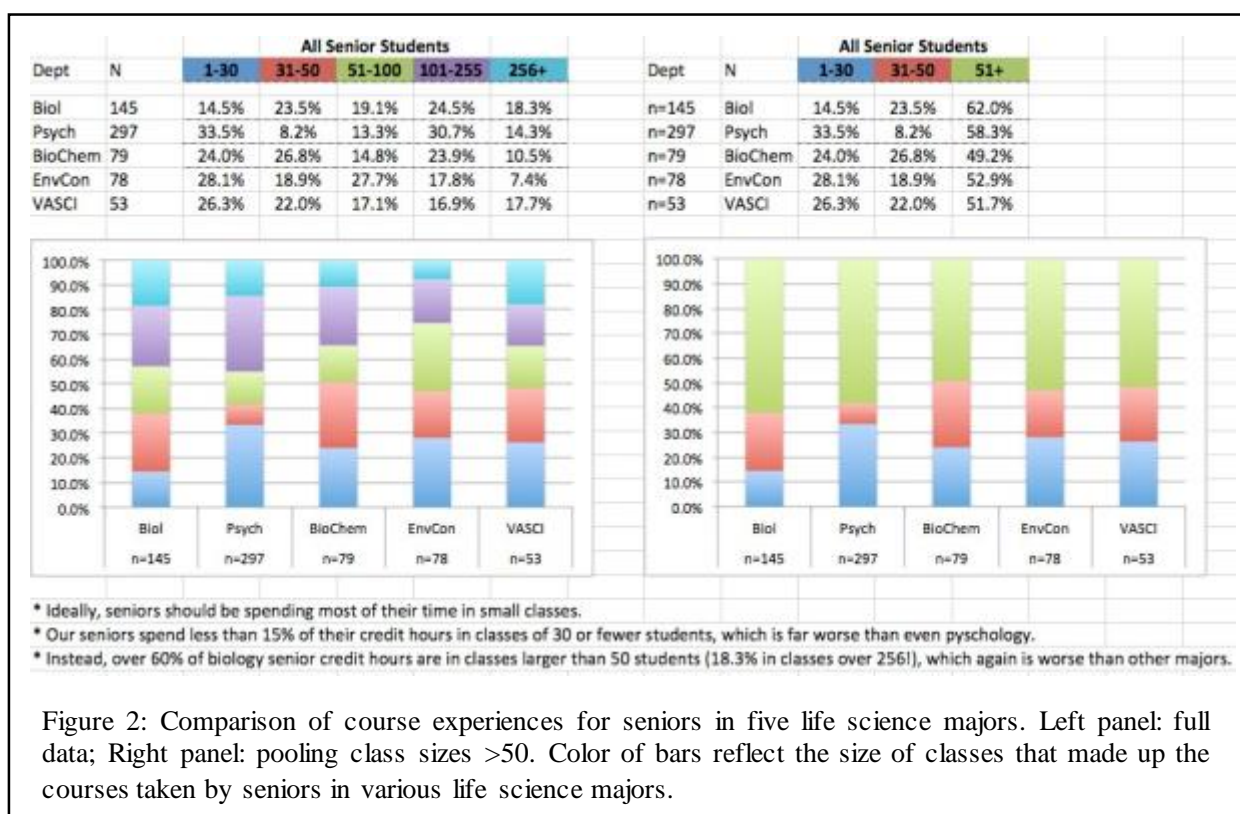
In response to the rapid growth in the UMass undergraduate population, and life science and Biology majors in particular, the Biology Department has responded by becoming increasingly efficient in delivering its curriculum. We have expanded course sizes, operating at full enrollment capacity (+5%) in most of our courses. We have added course sections, new courses, stopped providing teaching releases for faculty with heavy service loads, and expanded the number of Lecturers in the Department. This efficiency has come at the significant cost of limiting the ability of students to receive a coherent Biology curriculum in 4 years at UMass, as we have emphasized above. We are currently unable to offer enough small upper level classes to serve all of our seniors and juniors; instead senior and juniors are forced to fulfill their requirements with large enrollment (>60 students) courses. For example, as of today, 11/18/15, Spring 2016 sections of Biology 283, 285, and 288, sophomore-level prerequisites for upper-level courses in the major, are already over 50% enrolled by upperclassmen, and Spire registration for sophomores is not yet open. This is a common trend: in 2015, ~15-40% of seats in Biology 200 level core courses are filled by senior Biology majors (Table 1). Thus Biology has been exceptionally effective in delivering the needed seats for Biology and life science majors, but we remain severely challenged to deliver the type of curriculum and student experience we require and our students desire.

Given our knowledge of our curriculum and student experience, we were not surprised by cumulative class size data results for Biology majors. The University’s goal is to have smaller class sizes from freshman to senior year as students progress through their major. As these data demonstrate, and consistent with what we reported in our 2014 Strategic Planning document, the Biology majors’ experience does not meet this goal. Instead, the data reveal that Biology major cohorts have lost ground every year since 2003, especially in their experience in classes with enrollments less than 31. This is due to the fact that we have been forced to increase the size of our courses in order to provide enough seats. The results are more severe for our non-CHC

students since 25% of our majors are CHC students with mandated smaller classes. Over their four years as Biology majors, our seniors spend more time in classes of 31-50 or 51-100 students than they did their first year. When compared to other life science majors, Biology majors fare the worst (Figure 2).

TABLE 1: % Senior Biology Majors Enrolled in Large-Enrollment Core Courses. These courses are sophomore-level prerequisites for upper-level courses in the major.

200 Level Course	2015 Semester	% Enrollment: Senior Biology Majors
Bio 273	Fall	39
Bio 280	Fall	15.6
Bio 280	Spring	21.2
Bio 283	Fall	19.8
Bio 283	Spring	27.7
Bio 285	Fall	18.7
Bio 285	Spring	17.5
Bio 287	Fall	24.2
Bio 287	Spring	26.7
Bio 288	Fall	19.8
Bio 288	Spring	33.9



While we offer a number of small high-end resource-intensive lab courses (<25 students; e.g., Bio 383H, 397MH, 477H, 486H, 383H), we are unable to provide this experience to all of our majors because of limited instructional resources. Due to the growth of our major, our Bio 312 Writing in Biology sections primarily serve seniors rather than the target junior population.

Thus, the Biology major's experience deviates strikingly from the aspirational goal. Rather than an idealized triangle with a broad base and narrow peak, the course-size distribution our majors experience is better described as a trapezoid with a broad, flat top.

PART TWO. GOALS FOR STUDENT LEARNING AND THE STUDENT EXPERIENCE

Response 2. Student Learning Goals and Objectives.

a. Learning Goals and Objectives

The Learning Goals for Biology Majors remain robust and useful despite the fact that they have been in place since 1999. Upon review however, we note that some revision is needed and it is underway. We will bring the following additional learning goals and objectives to our faculty for discussion and will then update the Biology Learning goals posted at the website of the Office of Academic Planning and Assessment. The proposed additions to the Learning Goals for Biology Majors follow and are italicized.

Revised Skills for Biology Majors

Ability to observe and describe nature accurately

- | *Develop data collection strategies*
- | *Use standard assays and techniques*
- | *Be familiar with standard instrumentation*

Ability to find, evaluate, and appropriately utilize diverse information resources

- | *Assess the reliability of information resources*
- | *Navigate and use the primary literature*

Ability to construct logical arguments in biology

- | *Reason across hierarchical scales of organization (e.g.; chemical, biological, ecological)*

Ability to communicate ideas and arguments effectively both orally, *graphically*, and in writing

Ability to apply quantitative reasoning *and computational techniques* to biological questions

- | *Organize, transform, and analyze raw data*
- | *Construct and interpret scientific figures, graphs, and plots*

Revised Perspectives for Biology Majors

Appreciation of science as a human endeavor

Recognition of the importance of ethics in science

b. Diversity

In an effort to align the student experience of Biology majors with the University's Diversity Strategic Plan, we propose to address diversity in three of our courses that will soon be taken by all Biology majors. Biology can present its students with a unique view on diversity by addressing these issues from a biological perspective. We will discuss incorporating units to address diversity (e.g.; the genetics and evolution of human diversity) in our core genetics course, Biology 283 and our core evolution course, Biology 280. In addition, we will work with our instructors in Biology 312 Writing in Biology to determine how best to incorporate a discussion of racial diversity into our junior writing courses.

c. Internationalization

In an effort to enhance the exposure of Biology majors to internationally relevant experiences, we will expand the biological topics with global impact and perspectives that

are included in our curriculum. Several topics are already included in many of our courses, but we will work to expand the topics (e.g., biodiversity, global warming, deforestation, use of genetically modified organisms, the threat of pandemics).

We offer two ‘internationalized’ courses, Biology 487H Tropical Field Biology and Biology 596Z Amazon Aquatic Ecology, where students travel abroad to explore Central American and Amazonian ecosystems. In the course of their travel, these students are exposed to the people and cultures of these regions.

About 17% of our students travel abroad during their time at UMass. Given the University’s commitment to internationalization and the recognized value of a semester abroad, we will listen to BMAC student opinions about their experience and perceptions of a semester abroad and will work to improve the ability of Biology majors to meet their major requirements while on a semester abroad experience.

PART THREE. CURRICULAR REVISION ACTION PLAN

RESPONSE 3a. What specific actions can you take now, within existing resources?

Below is a list of action items we propose that, if implemented, would likely result in increased cohesion of the Biology curriculum and increased student access and progression through the major. Each of these items could be implemented with existing departmental resources. A projected time for implementation follows each action item.

| In order to improve access to courses and progression through the major we propose to:

- 1) Redesign the core requirements for the Biology major by reducing the number of required 200 level courses. (*Need Department and Faculty Senate approval 6-9months*)
- 2) Renumber our courses to provide a clear course order. (*Need Department and Faculty Senate approval 6-9months*)

| Feedback from our students revealed that the scheduling of our courses creates course conflicts and limits course access. We will assess our scheduling of courses in order to eliminate or reduce this impediment to class access. (*Will identify and address by Spring enrollment; 4 months*)

| Biology majors are currently required to earn a C rather than a C- in each of the courses required for the Biology major; this includes courses in Chemistry, Physics, and Math Departments. This requirement is impeding the progression of a small subset of our majors through the curriculum and creates lack of curricular cohesion between the 8 life science majors on campus. We propose to substitute a C- as the minimum grade for Biology majors in required courses in Chemistry, Physics and Math. (*Need Department and Faculty Senate approval 6-9months*)

| In order to improve communication with our students, we propose to:

- 1) Develop and make available online an ‘Advising Frequently Asked Questions’ (FAQ) sheet for Biology majors. (*Available for Fall 2016*)
- 2) Develop and make available online an ‘Advising FAQ’ sheet for Honors (CHC) Biology majors. (*Available for Fall 2016*)

| We will discuss the pros and cons of increasing the capacity of Biology 285 Cellular and Molecular Biology and Biology 288 Introductory Physiology. If enacted, this will result in a gain of two instructors to teach two upper level courses and will help to decrease the class sizes for our upper level Biology majors. (*Decision by 2016 Spring enrollment period*)

| To address the inadequate supply of upper level Biology courses and their large class sizes for upper level Biology majors, we propose to work with the CNS Life Science community (Life Science Steering Committee, Life Science Curriculum Taskforce and life science departments) to integrate instructors from life science departments into the teaching of the introductory biology sequence (Biology 151 and 152). This will make current Biology instructors available to teach other courses thereby increasing the offerings and reducing the class sizes of upper level Biology courses. (*12-24 months*)

| To address the limited capacity of Biology 283 General Genetics, we propose to work with the CNS Life Science community to increase access to a core genetics course by developing a shared genetics curriculum for the 4 undergraduate core genetics courses currently being taught in CNS and to evenly distribute the students and instructional resources among them. (*12 months*)

| We will consider Biology's investment in teaching BS general education courses. A reduction in the number of general education courses we teach would allow reassignment of some faculty to teach smaller upper level Biology courses and better direct our resources toward serving our Biology majors. (*3-6 months*)

| We will identify and discuss mechanisms to incorporate diversity into our biology curriculum through units in Biology 283 General Genetics, Biology 280 Evolution, and Biology 312 Writing in Biology. (*Target date: Fall 2016 or Spring 2017*)

| We will identify and discuss mechanisms (with Biology faculty and students) to ensure that our major is compatible with study abroad opportunities. (*6 months*)

RESPONSE 3b. *If there is a gap you have identified in meeting these goals that can only be addressed with additional resources, describe what you would like to do and what resources would be needed?*

Below is a list of action items that, if implemented, would likely result in increased cohesion of the Biology curriculum and increased student access and progression through the major. Each of these items requires investment of additional resources for implementation. A projected time for implementation follows each action item.

| We propose that we redesign the Biology 153 laboratory course into a modern research experience that uses techniques and approaches appropriate for the 21st century. This will require renovation of the introductory laboratory suite (Morrill 301, 302, 303, and 304). With time, the new laboratory fee structure should provide the equipment and supplies needed for this modernized course. (*Full implementation is dependent on the availability of renovation funds; some new equipment and new lab unit will be in place in Spring 2016*)

| We propose a new 200 level Genetics and Evolution Laboratory course (Biology 284) for Biology majors. Progress has been made on this Strategic Plan goal; an instructor has been identified, a curriculum is being developed, and the course will be as a small pilot section in Spring 2016. (*In place for Spring 2016*)

| Our ability to effectively deliver a coherent Biology curriculum to our majors is limited by the size of our major relative to the size of our instructional faculty. We must bring more instructional resources to bear in order to offer the sufficient number and sized courses to resolve our problems of student access, student satisfaction, and curricular cohesion. This can be accomplished with the hiring of new faculty who will participate in the delivery of the Biology curriculum. Alternatively, reassignment of current life science faculty or assignment of the hires resulting from current life science IALS searches to teach courses serving Biology majors is a less expensive means to this goal. (*Undetermined time line*)

| We propose to introduce three concentrations within the Biology major in an effort to provide curricular cohesion and streamline the progression of students through the major. To make these concentrations functional and successful at meeting our goals, we must ensure that each concentration meets our departmental learning goals and that students have access to the courses in the concentrations. Given the identified needs for new courses and the imbalance in student interest and current course offerings across the proposed concentrations, investment in instructional resources is required, including an increase in faculty, teaching assistants, and equipment, supplies, and instructional support for new lab courses. (*Undetermined time line*)

| We will assess the design and capabilities of *Appointment Plus* software to determine if it will provide our students with easier access to scheduling and a better matching of students to the right advisor. Given the size of our major, the number of advising appointments/month, and the number of advising calendars, the estimated annual fee for the software is from \$800-\$1,200. (*A decision in 6 months*)

| We propose to redesign the Biology Department website so that it becomes the “go-to” place for information for our majors. Funds will be needed to achieve this goal. (*Time line dependent of availability of funds*)

Table of Appendices

Appendix A. Office of Academic Planning & Assessment Fall 2014 Biology Focus Group Report

Appendix B. Alignment of Biology Curriculum and Learning Goals