Millikin University
Student Learning in Biology

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GOALS

The Department of Biology at Millikin University in an attempt to educate students in the knowledge and practice of biology agrees that the following goals are of sufficient rigor and coverage to produce highly competitive graduates of the program. The following goals have been developed and approved by the members of the department.

Graduates with a Biology Degree should:

1. Understand and be able to apply the concepts of evolution and natural selection.
2. Have exposure to the following general areas of biology: ecology, taxonomy, morphology, function, molecules/cells and genetics/reproduction.
3. Be able to use and apply critical thinking to life situations.
4. Be able to present in oral and written form a completed research project, using testable hypotheses, logical arguments and appropriate methodologies and equipment.

These goals have been reviewed in terms of the connectivity with the university goals in the following ways.

- Goal 1. Millikin University students will be prepared for **professional success.**
  Our goals (1-4) give biology students a strong biological background to prepare them for success in many professional areas: a strong pre-professional curriculum for medicine, dentistry, veterinary medicine etc; a thorough exposure to research skills needed for graduate, industrial and environmental programs; a rigorous secondary education program for teaching high school science.
- Goal 2 Millikin students will actively engage in the responsibilities of **citizenship in their community.**
  The goal of developing good reasoning and logical skills (3) as well as the knowledge students obtain (goals 1, 2, 4) will be of immeasurable value in dealing with the biological issues facing society such as pollution, health, medical treatment, stem cell research, reproductive issues, etc.
- Goal 3 Millikin students will discover and develop a **personal life of meaning and value.**
  Goal 4, and to some extent 3, help to develop in biology students self confidence that they can do well in the world. It gives them a feeling of self worth by completing the difficult task of taking on an investigation and coming up with a meaningful interpretation and conclusion. This skill is essential to their education.

SNAPSHOT

The Department of Biology is located in the Leighty Tabor Science Center on the second and part of the third floor, with an animal facility in the basement and a greenhouse on the fifth floor. The faculty has been selected to provide specialized focus in the areas emphasized in biology goal #1 and 2. We have a geneticist, a molecular/cell biologist, two microbiologists, an animal ecologist, two physiologists (one is teaching half-time), a plant biologist, an environmental biologist (teaching half time and preparing labs the other half), and an animal behaviorist. Almost all (90%) have

Ph.D.s in their special areas and have training to be able to provide backup for at least one other area as well as the skills to teach in more general freshman level courses. The curriculum has been divided into the following study tracks:

- General Biology
    - Traditional Track
    - Pre-Professional Preparation
    - Secondary Education
    - Environmental Biology
- Allied Health Preparation
    - Pre-PT/OT
    - Pre-Med Tech
- Cellular/Molecular Biology

These tracks prepare students for careers in almost any area of biological research, including organismal or molecular/cellular research, medicine, dentistry, veterinary medicine, environmental biology, high school teaching, physical therapy, occupational therapy, and medical technology. The department advises and provides biological training of 150 (average) majors and annually graduates an average of 28 students. The largest areas of specialization for students are the Pre-Professional and Allied Health tracks. In addition to providing training for our majors, the department services about 50 pre-nursing majors and 35 exercise science majors by providing courses in anatomy and physiology and approximately ten elementary education majors seeking concentrations in science.. We also teach an average of 15 sections of MPSL laboratory science classes per year.

STORY

Student learning in biology requires an extensive exposure to methods and examples of life situations. This is accomplished to a great extent through the hands-on-experience in the laboratory. Our science building was designed to provide ample laboratory space for the various biological areas listed in departmental goal #2. At maximum, teaching labs can accommodate 16-20 students; these small numbers enable us to give each student personal attention. This personal attention motivates students to perform at a high level, as they are under the personal view of the instructor. This motivation leads to increased understanding of the concepts associated with our learning areas and this learning becomes self propagating as the student begins to enjoy the connectivity of what he/she is doing in the classroom with what he/she anticipates doing upon graduation.

Just as the curriculum helps the department achieve goals for student learning outcomes and helps students actualize their plans of study, so too does the advising process. Advising in the Department of Biology facilitates and integrates reasoned choices that promote the student's growth as a person and as a major. In order to realize this mission, we work with students to: (1) Develop plans of study for successfully achieving their degree and career goals, (2) Select courses each semester to progress toward fulfilling their plans of study, (3) Use the resources and services on campus to assist in fulfilling their plans of study, and (4) Graduate in a timely manner. One or more times per semester, students meet in person with their academic advisors to discuss fulfillment of the plan of study.

Curriculum Map

Courses listed below each goal provide information and experiences necessary for students to complete the departmental goals in a timely manner during their four years at Millikin.

Academic Year	Goal #1	Goal #2	Goal #3	Goal #4
Freshman	BI 105, BI 108	Only courses level 200 and above can be used for this goal	BI 105, BI 155, BI 108, BI 158	BI 155
Sophomore	Expanded in all other courses taken	See Appendix B	BI 206 and 207 or BI 300	BI 350
Junior	Expanded in all other courses taken	See Appendix B	*Course with research project OR BI 391 or 392	*Course with research project OR BI 391 or 392
Senior	Expanded in all other courses taken	See Appendix B	BI 481 or 482	BI 481 or 482

*Courses with student designed research projects are starred in Appendix B

ASSESSMENT METHODS

Goal #1, understanding the concepts of evolution and natural selection, is met in two ways. First, students learn about evolution and natural selection by successfully completing the freshman courses, Ecology and Evolution (BI 105), and Attributes of Life (BI 108). These courses give freshmen the strong background needed to understand evolution and natural selection and the reasons for the diversity of living organisms and their physiologies. Assessment is done using a pre-test and post-test format (Appendix A). Testing is conducted at four times using a test consisting of evolution related questions from the freshman courses, Evolution and Ecology (BI 105) and Attributes of Life (BI 108). The first test is given at the beginning of BI 105 and the second one at the end of BI 105. A third exam is given at the end of Attributes BI 108 and a final one when students complete the senior seminar course (BI 481 or 482). Second, the theme of evolution is intentionally included in every course taught in the department. How it is incorporated is described in each course syllabus.

Goal #2, the exposure to the various areas of biological study, involves emphasis on the approaches taken to study six majors areas of biology: ecology, taxonomy, morphology, function, molecules/cells and reproduction/genetics (See Appendix B). Because students are required to take courses in each of these areas, they not only gain additional understanding of the essential nature of these concepts to biology but also explore the continued theme of adaptation and diversity that living organisms exhibit. Students are expected to take 6 courses, one in each area, and complete each course with a grade of C- or better. Students must retake or take another course in this content area if their grade is D+ or lower. This applies to every student in every concentration. We are also considering requiring that seniors take the ETS field test in biology during their senior seminar. Students would be charged a lab fee of $50 for this course (BI 471 or 472) to cover most of the expenses for this national exam.

Goal #3, the use of critical thinking, is essential to the sciences. Many of our courses include laboratory research and reports that assess critical thinking skills. Our plan is to use a portfolio system to collect two papers, one written the first year at Millikin, and the one from senior seminar research. These papers must be of an investigative nature that draw conclusions from data personally collected or analyzed by the student. The following rubric is used to evaluate how well students used logic and critical thinking in their work.

	Excellent (5 points)	Adequate (3-4 pts)	Nominal (1-2 pts)
Format	• Paper in proper scientific form, with all standard categories • Tables and figures correctly constructed with good legends • Standard use of grammar and spelling. Fewer than one error per two pages • Logical organization • Literature appropriately used and cited	• Section(s) missing, or some material in wrong section • Same data presented more than once, or inappropriate figures used • Some grammar errors and spelling errors (Fewer than one per page) • Some literature used, but inadequate or improperly cited	• Non-scientific form • Data not presented, or raw data presented • One or more grammatical and spelling errors per page. • Poorly organized • Little or no literature used
Design	• Key variables considered • Appropriate Experimental Design with testable hypothesis • Alternate hypotheses considered • Design adequate to test hypotheses • Appropriate use of data analysis • Includes Control, Experimental groups testing one variable	• Design only partially addresses foreseeable variables • Alternative hypotheses not eliminated • Design insufficient to test hypotheses • Incorrect use of data analysis	• Poor design, does not separate variables • Hypothesis not testable, or design does not test primary hypothesis • No use of data analysis
Conclusions	• Accurately reflect data presented • Correct use of logic • Fit study into broader context • Adequate summary of paper. • Considers where the work should go from here	• Some conclusions not based on results • Contains faulty logic • Study weakly related to broader context	• Many conclusions not related to data • Poor use of logic • No attempt to fit study into broader context

Goal #4, research report and evaluation, is the culminating experience of graduating biology students. It consists of the following components:

- Selection of an appropriate research topic.
- A thorough search of relevant research using primary literature.
- Collaborative wet-bench research with a member of the faculty or critical analysis of existing literature on the topic. The culmination of this will be the development of a well-supported position (hypothesis) on the topic.
- Presentation of this position consists of an oral presentation before faculty and peers, a poster display similar to those presented at scientific meetings, and a scientific paper patterned after current research literature.

As the curriculum map indicates, this goal will most likely be fulfilled in Senior Seminar, BI 481 or 482. Because of the large number of majors, the limited resources of faculty and space, and the limited need for allied students to do research, we do not require hands on research of all students to satisfy this goal. We have included the option of researching the primary literature in biology in order to meet this goal. Senior Seminar gives our students the opportunity to present their analyses and conclusions in a formal setting. Evaluation of the poster and oral presentation are based on guidelines presented in the following rubrics. The scientific paper is evaluated using the rubric for goal #3.

POSTER PRESENTATION	
Content	
5	Emphasis on student testable, novel hypothesis that would extend research in the field.
	All required components included (Abstract, Introduction, Methods and Materials, Results, Discussion, Acknowledgements, Literature Cited) with correct and necessary information included in each section.
	Rigorous experimental data and appropriate statistics presented with emphasis on student interpretation of data.
3	Reasonable hypothesis but difficult to test, not completely novel and would not really extend knowledge in the field.
	All required components included but some with information in wrong section or not included.
	Experimental data and statistics presented data not overly rigorous, statistics unclear or incomplete, student interpretation of data not emphasized.
1	Hypothesis not testable, novel or adequate. No extension of knowledge beyond that already known would result.
	Some components missing and information incomplete.
	Experimental data weak, statistics inappropriate or absent, no novel data interpretation by student.
Tables/Figures	
5	Used effectively and appropriately (proper use of table versus figure, proper type of figure used), high quality with title positioned properly and axes properly labeled.
3	Need for better use of visuals, not all tables/figures of the appropriate type, average quality with mistakes in title positioning or some axes either not labeled or labeled incorrectly.
1	Visuals not used effectively, inappropriate type of table/figure used, minimal quality with title incorrectly positioned or missing and most axes not labeled or labeled incorrectly.
Use of Literature	
5	Thorough search of the literature with fundamental papers used, minimum of 10 relevant, recent (last decade) primary papers used, all in-text citations formatted correctly, Literature Cited formatted correctly.
3	Most literature used was appropriate, but at least one fundamental paper was not found or used, incomplete search of literature but at least 6 relevant, recent primary papers used, most in-text citations formatted correctly, minimal mistakes in Literature Cited section.
1	Student's search of the literature incomplete with crucial papers not found or used, fewer than 6 relevant, recent primary papers used, many mistakes on in-text citations and Literature Cited section.
Aesthetics	
5	Correct spelling, grammar, and punctuation, only main points presented with text minimized and emphasis on tables and figures, tables and figures large and easy to read, text readable from a distance, professional colors used, all margins cut straight, no glue showing, layout correct.
3	Occasional but limited errors in spelling, grammar, or punctuation, too much text with some tables and figures difficult to read, text readably from a distance but should be a bit larger, colors distracting, some margins cut unevenly, minimal glue showing, layout acceptable but some pieces out of place.
1	Heavily flawed with frequent errors in spelling, grammar, and punctuation, too much text, tables and figures minimal, text too small to read from a distance, colors friggin' ugly, many margins uneven and much glue showing, layout with many pieces out of place.

ORAL PRESENTATION	
Content	
7-10	Emphasis on student testable, novel hypothesis that would extend research in the field.
	All required components included (Abstract, Introduction, Methods and Materials, Results, Discussion, Acknowledgements, Literature Cited) with correct and necessary information included in each section.
	Rigorous experimental data and appropriate statistics presented with emphasis on student interpretation of data.
3-6	Reasonable hypothesis but difficult to test, not completely novel and would not really extend knowledge in the field.
	All required components included but some with information in wrong section or not included.
	Experimental data and statistics presented data not overly rigorous, statistics unclear or incomplete, student interpretation of data not emphasized.
1-2	Hypothesis not testable, novel or adequate. No extension of knowledge beyond that already known would result.
	Some components missing and information incomplete.
	Experimental data weak, statistics inappropriate or absent, no novel data interpretation by student.
Knowledge of Material	
5	Clear confident presentation with audience questions answered in a way to illustrate a complete knowledge of the topic.
3	A good presentation but lacking clarity or confidence with inability to answer some audience questions.
1	An awkward, weak presentation with inability to handle audience questions.
Delivery	
5	No reading from notes or screen, eye contact with audience, appropriate voice inflection, no annoying mannerisms, no usage of um/uh or stumbling over words, proper time allowed for each slide, professional clothing.
3	Some reading from notes or screen, some eye contact with audience, minimal voice inflection, few annoying mannerisms, some usage of um/uh and some stumbling over words, some slides rushed through, clothing acceptable.
1	Over-reliance on notes or screen, minimal or no eye contact with audience, no voice inflection (monotone or robotic), many annoying mannerisms, excessive usage of um/uh and much stumbling over words, slides rushed, clothing not professional.
Visual Aids and Aesthetics	
5	Correct spelling, grammar, and punctuation, only main points presented on slides without being text-laden, tables and figures appropriate, axes labeled, large and easy to read, professional colors and background used.
3	Occasional but limited errors in spelling, grammar, or punctuation, some slides too busy with too much text, some tables and figures difficult to read, some mistakes in title positioning, colors or background distracting.
1	Heavily flawed with frequent errors in spelling, grammar, and punctuation, slides with too much text, tables and figures inappropriate or with too much small, hard to read data, colors and background inappropriate.

ASSESSMENT DATA

The following data are collected and averaged:

- The average improvement between pre- and post- scores on the evolution assessment in Ecology and Evolution, the average score on the evolution assessment given in Attributes of Life, and the average score for evolution assessments for both semesters of senior seminar. The percentage compliance of syllabi for direct ties to evolutionary concepts
- List of classes taken and grades below C- for objective 2. The ETS field test may also be used in assessment of this goal, but the department is still investigating this option.
- Two papers, one from the freshman year, and the senior seminar capstone paper, will be collected and evaluated using the rubric for objective 3.
- Evaluation scores for objective 4 for paper, poster, and presentation
- We also have assessments of biology secondary education majors available through LiveText on performance of students on the Candidate Assessments necessary for completion of an NCATE-accredited teacher education program in biology. Results from rubrics for assessing Student Learning (CA10), Social Context of Science (SCI PA8) in two sections, and a science lab safety manual (SCI PA6) are reported.

Assessments in Goal 3.

- For this 2009 assessment on, we can evaluate both papers collected using the same rubric. Transfer and other students without the first paper to evaluate will be excluded from the analysis.

ANALYSIS OF ASSESSMENT RESULTS

- GREEN LIGHT –
    - At the introductory level, testing indicates that we are approaching a high level of success. Goal #1 will be judged successful if we are able to demonstrate a 25% improvement between the pre-test and the post-test scores during the freshman year and a maintenance of this through the senior year. Over 90% of syllabi should show direct relationship of evolutionary concepts.
    - Goal #2 – All students complete a course in each content area, all grades for the six courses elected by all graduating students are C- or better, and less than 10% must repeat courses to achieve this goal.
    - Goal #3 – Two papers are placed in the student's portfolio, there is an average of 20% improvement from freshman to senior, and the average review score for seniors is 10 or better [will change green light to a score of 12].
    - Goal #4 – At the completion of Senior Seminar capstones, the oral presentation scores average 20 or better and poster evaluation scores average 15 or better.

- YELLOW LIGHT –
    - Goal #1 – Definite improvement between pre and posttests but less than 25 %. Seventy five percent of syllabi for majors courses show direct relationship to evolutionary concepts.
    - Goal #2 – Some students are not completing one or more of the content areas, or more than 10% must repeat courses to achieve a C- or better in each.
    - Goal #3 - Two papers have been placed in the students portfolio, with less than 20% improvement. Average evaluation score for the senior paper is 9 [change to 11].

    - Goal #4 – Average evaluation score for the oral presentation is between 18 and 20, and the poster score between 13 and 15.

- RED LIGHT –
    - Goal #1 - Little or no improvement between pre and post-tests, or little retention of concepts. Less than 75% of syllabi for majors courses show direct relationship of evolutionary concepts.
    - Goal #2 – More than 10% of students do not complete one or more of content areas, or more than 15% must repeat courses to achieve C- or better.
    - Goal #3 - Fewer than 2 papers in the folio, with an average evaluation score of less than 9 [change to 11].
    - Goal #4 - Average oral presentation score for seniors is below 18 and average poster score is less than 13.

Results from 2008/2009, compared to preliminary results from 2005/2006 and results from 2006/2007 and 2007/2008

Goal #1 *Understand and be able to apply the concepts of evolution and natural selection*.

Summary of the Evolution assessments for 2008/2009

When we gave the test to EE students early in the semester, 72 students took the exam, averaging 6.7 out of 25 (Table 1). At the end of the semester, 61 students took it, and averaged 17.9, improving by 42 percentage points.

In Attributes of Life, 42 students took the exam, and averaged 14.2 of 25 points.

The 35 seniors who took the assessment in 2008/9 senior seminars averaged 17.3 of 25. Three seniors earned 23-25, twelve 20-22, four 18-19, six 15-17, and ten below 15.
In 2006/2007, 35% of seniors did not earn at least a 60% on the assessment. In 2007/2008, 43% of the seniors did not pass the assessment. In 2008/2009, 29% of the seniors did not pass the assessment. At this time, we are using these data for assessment of the department only, but are discussing consequences for students who fail to meet the goal.

The data from all four years of assessment have similar trends, showing that the students do not have much understanding of evolution when they start the program, and that their performance improves much more than our 25% target, with about three times as many right answers on the test at the end of the first semester. The retention of the basic understanding of evolution was similar, with scores from the test in Attributes of Life at the end of the first year and from senior seminar being very similar to scores on the ecology and evolution post-test, just after concentrated teaching of the concepts. This part of the assessment strongly falls into the "green light" category.

In addition to the above effort to assess our teaching of evolution as a central theme of biology, the faculty developed new syllabi for courses including departmental goals and a demonstration of how evolution is addressed in each course. In spring 2006, only 6 of 14 majors syllabi included departmental goals (42.86%), and only 3 of the 14 showed directly how evolution is addressed in the course (28.57%). In both 2006/2007 and 2007/2008, all biology majors' course syllabi included departmental goals (100%). Seventy-five percent of Fall 2006 syllabi, and eighty percent of Spring 2007 syllabi, directly demonstrated how courses covered evolutionary themes. In fall 2007, 81.8% and in spring 2008, 91% of the majors courses directly demonstrate how evolution is incorporated into them. Similar results hold for the syllabi in 2008/2009 (81.8% in fall and 90% in spring, Table 2 a and b). We will continue to encourage further improvement in intentional linkage of evolution to material in the remaining courses. We are very close to the 90% compliance necessary for a green light.

Table 1. Breakdown of percent correct answers for each question on the pre- and post- test for knowledge of evolution

Question	% Correct New Freshmen* (72)	% Correct Midyear Freshmen* (61)	% Correct End of First Year (42)	% Correct Senior Seminar (35)
1 Species	56.9	91.8	85.7	91.4
2 Evolution	45.8	67.2	66.7	74.3
3Adaptation	27.8	72.1	61.9	85.7
4 Mutation	83.3	91.8	97.6	94.3
5Analogous	25	67.2	64.3	57.1
6 Vestigial	38.9	85.2	73.8	85.7
7 Nat. Sel	19.4	86.8	78.6	85.7
8 Converg.	30.6	60.6	35.7	45.6
12 Mech. (5)	30.6	75.7	60.0	69.1
13aNatSel	6.9	44.3	21.4	45.7
13bMutatio	6.9	57.4	38.1	40
14 Direc.Sel	26.4	78.7	45.2	54.3
15 Disr. Sel	29.2	75.4	38.1	71.4
16 Phylog.	37.5	91.8	88.1	100
17 Fitness	11.1	63.9	40.4	68.6
18. Variatio	47.2	80.3	76.2	88.6
19 Endosym	35.7	82.1	90.5	91.4
20 Nat Sel (4 pts)	9.2	32.2	19.6	56.2

Average 2008/2009	26.93%	68.97%	56.8%	69.2%
Average 2007/2008	8.82%	61.2%	Not Done	61.2%
Average 2006/2007	23.11%	63%	61.2%	60%
2005/2006	28.4	78.8	Not Done	75.6%

Table 2a. Direct coverage of evolution on syllabi for Fall 2008 Classes for Biology Majors

Class	Instructor	Evolution directly addressed
BI 105 Ecology and Evolution	Parrish, Horn, and Robertson	Yes, Yes, and Yes
BI 206 Anatomy and Physiology I	Hughes	No
BI 300 Genetics	Matthews	Yes
BI 303 Entomology	Robertson	Yes
BI 306 Animal Physiology	Wilkinson	Yes
BI 308 Plant Physiology	Parrish	Yes
BI 314 Ecology	Horn	Yes
BI 413 Advanced Cell Biology	Galewsky	No
BI 407 Molecular Genetics	Galewsky	Yes

Table 2b. Direct coverage of evolution in syllabi for Spring 2009 Classes for Biology Majors

Class	Instructor	Evolution directly addressed
BI 108 Attributes of Life	Matthews and Parrish	Yes and Yes
BI 207 Anatomy and Physiology II	Hughes	No
BI 305 Cell and Molecular Biology	Galewsky	Yes
BI 312 Immunology	McQuistion	Yes
BI 323 Animal Behavior	Robertson	Yes
BI 330 Microbiology	McQuistion	Yes
BI 360 Conservation Biology	Horn	Yes
BI 360 Endocrinology	Schultz Norton	Yes
BI 404 Evolution	Matthews	Yes

For Goal #2 *Have exposure to the following general areas of biology: ecology, taxonomy, morphology, function, molecules/cells and genetics/ reproduction.*

The Biology Department determined which courses best cover the six general content areas of biology, with one course fitting into no more than two categories. Each student must choose which of the two categories that course will satisfy. After a review of transcripts of 20 recent graduates in the three general tracks, we found that our Allied Health students were often not taking courses that cover ecological concepts. Because their programs are often very tight, we decided to allow the summer immersion, field ecology (BI 220) to count to satisfy the ecology area for Allied Health. We submitted our proposal to require all biology majors to successfully complete at least one course from each of the six content areas (Appendix B) for division and school approval. This requirement became effective for students entering the program during the 2007/2008 academic year, but we encourage our more senior students to study in all six areas. In fall 2007, only 8.94% and in spring 2008 only 6.94% of the grades earned were below C- . In fall 2008, 5.93% and in Spring 2009 only 6.89% of students received grades below C- in the content area courses (Table 3). These data fulfill the criteria for a green light for the number of students needing to repeat upper level courses in the content areas. Our 2010 assessment will be the first to include graduates who were required to take one course from each of six content areas and earn a "C-" or better in each.

Table 3. Courses that meet biology content area requirements for majors, number of biology majors enrolled in each course, and number of students

Fall 2008 Course offerings			
Course Title	Course Number	Number enrolled	Number earning lower than C-
A&P I	BI 206	3*	0
Genetics	BI 300	40	5
Entomology	BI 303	8	1
Animal Phys	BI 306	14	0
Ecology	BI 313	16	1
Plant Physiology	BI 308	7	0
Molecular Genetics	BI 407	19	0
Advanced Cell	BI 413	11	0
		118	7
Percent below Cutoff Grade of C-			5.93%

Spring 2009 Course offerings			
A&P II	BI 207	6*	1
Molec. Cell Biol	BI 305	26	1
Immunology	BI 312	18	1
Animal Behavior	BI 323	6	2
General Microbiol	BI 330	18	1
Endocrinology	BI 360	7	0
Conservation Biol	BI 360	12	1
Ecological Journey	BI 380	11	0
Evolution	BI 404	12	1
		116	8
Percent Below Cutoff Grade of C-			6.89%

*Only biology majors considered – most of the students are in nursing and athletic training programs.

Goal #3 *Be able to use and apply critical thinking to life situations. (This success is inferred by their ability to write critically in biology)*

Most of our courses emphasize application of concepts to life situations. Our students write a paper on a project they design and carry out as freshmen in our ecology and evolution class. Then, all of our students take genetics in the second or third year. In both, there is considerable emphasis on application of concepts. Our efforts to evaluate this goal began in the Spring 2006 semester. For their Senior Seminar course (BI 481 or 482), all seniors are required to write a critical paper on a research topic they are actively involved in via independent research or as a strong interest. Our department first decided that a cutoff of around 10 points earned from the rubric to evaluate papers could be used as an indicator of teaching success for data evaluation and curriculum improvement decisions. However, a score of 12 is a more rigorous green light.

This year, we compared that senior seminar paper with the one done as a first year student in ecology and evolution using the same departmental rubric, for seven students (Figure 1). The total score on the papers increased 25%, from 10.07 to 12.64, and all seven students improved by 20% or more. Paired t-tests showed that the total rubric score on the paper increased significantly ($p = 0.0002$), as did scores on format ($p = 0.004$) and conclusions ($p = 0.0002$). The score for research design did not change ($p = 0.44$). Both the fact that seniors are scoring higher than 10 [now 12] and that there is at least a 20% improvement in scores fit within the criteria for a green light for meeting this departmental goal.

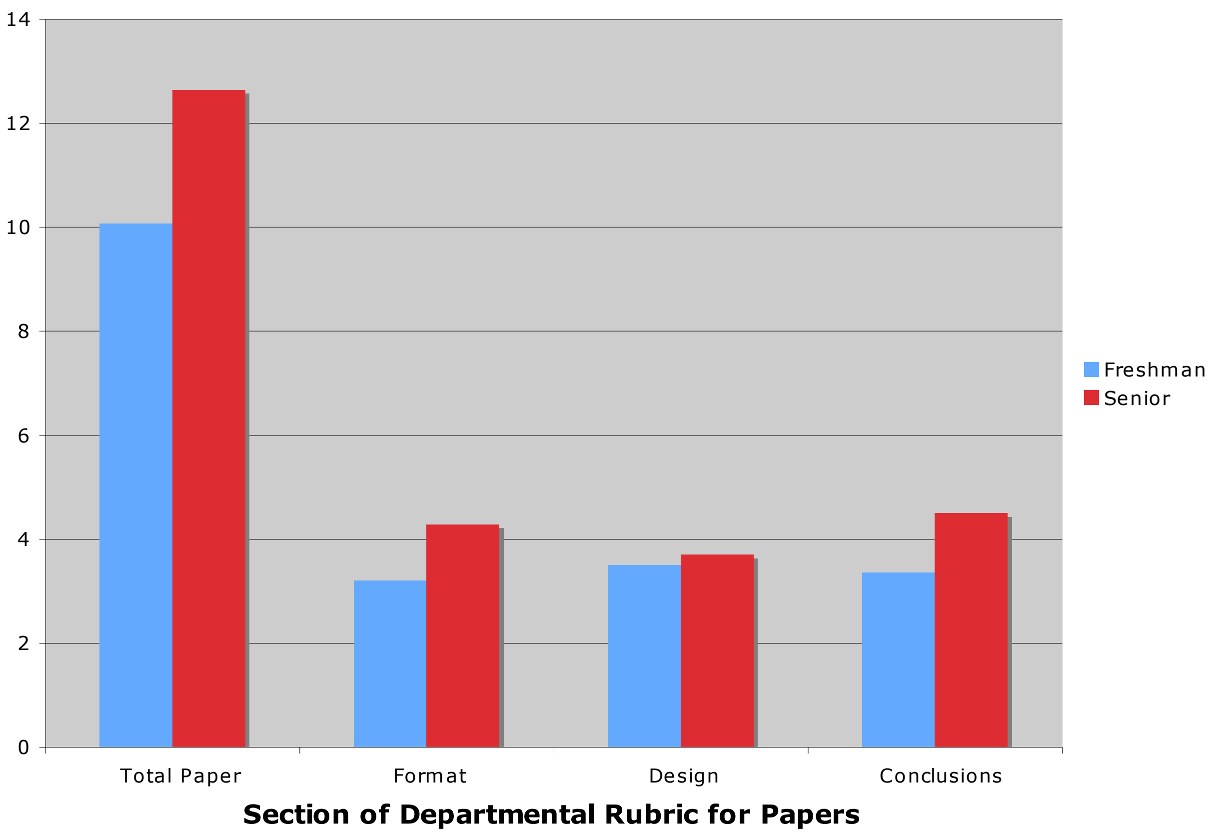

Figure 1. Comparison of Freshman (entering fall 2005) papers from Ecology and Evolution class with Senior Seminar papers from the same students, in spring 2009. Total possible point value is 15, with each of the three portions of the rubric worth a possible five points.

Goal #4. *Be able to present in oral or written form a completed research project, using testable hypotheses, logical arguments and appropriate methodologies and equipment.*

This goal is assessed by means of a poster and an oral presentation in the Senior Seminar Course. Students are required, using either personally conducted wet bench research or using published literature, to develop a testable hypothesis and then proceed to develop a logical argument supporting or falsifying that hypothesis. This is often most successful with experiments actually performed by the student. Prior to their oral presentations, students construct and display a poster using guidelines appropriate for a national meeting. A minimum average score of 15 was set by the department after three semesters of assessment, and has been met in most semesters (Table 4). In spring of 2009, the mean total score for the poster did not quite meet this goal. However, when scores for fall 2008 and spring 2009 are averaged, the mean poster score was 16.45, within the green light criteria. Ten of the 34 students enrolled in senior seminar for 2008/2009 did not achieve 15 points of the 20 possible on the poster component of senior seminar. However, all students do have to pass the senior seminar course in order to receive a degree in biology.

Table 4. Mean scores on departmental rubrics for evaluating senior seminar performance. Actual range of individual scores is listed for recent semesters.

Semester (Number of students)	Mean Total Paper (Range 0-15)	Poster (Range 0-20)	Oral (Range 0-25)
*Fall 2008 (16)	13.3 (9-15)	18.31 (12 – 20)	21.75 (10 – 25)
Spring 2009 (18)	12.6 (9 – 14.5)	14.8 (8.5 – 17.8)	19.4 (10.4 – 23.7)
Spring 2006 (20)	11.8	17.0	20.6
Spring 2007 (20)	12.2	15.3	19.2
*Fall 2007 (10)	12.5 (11 – 15)	15.9 (12 – 19)	19.1 (16 – 24)

*Scores from only one faculty member, the senior seminar instructor. Scores from Spring 2006 and Spring 2009 were averages of four or more faculty member evaluations.

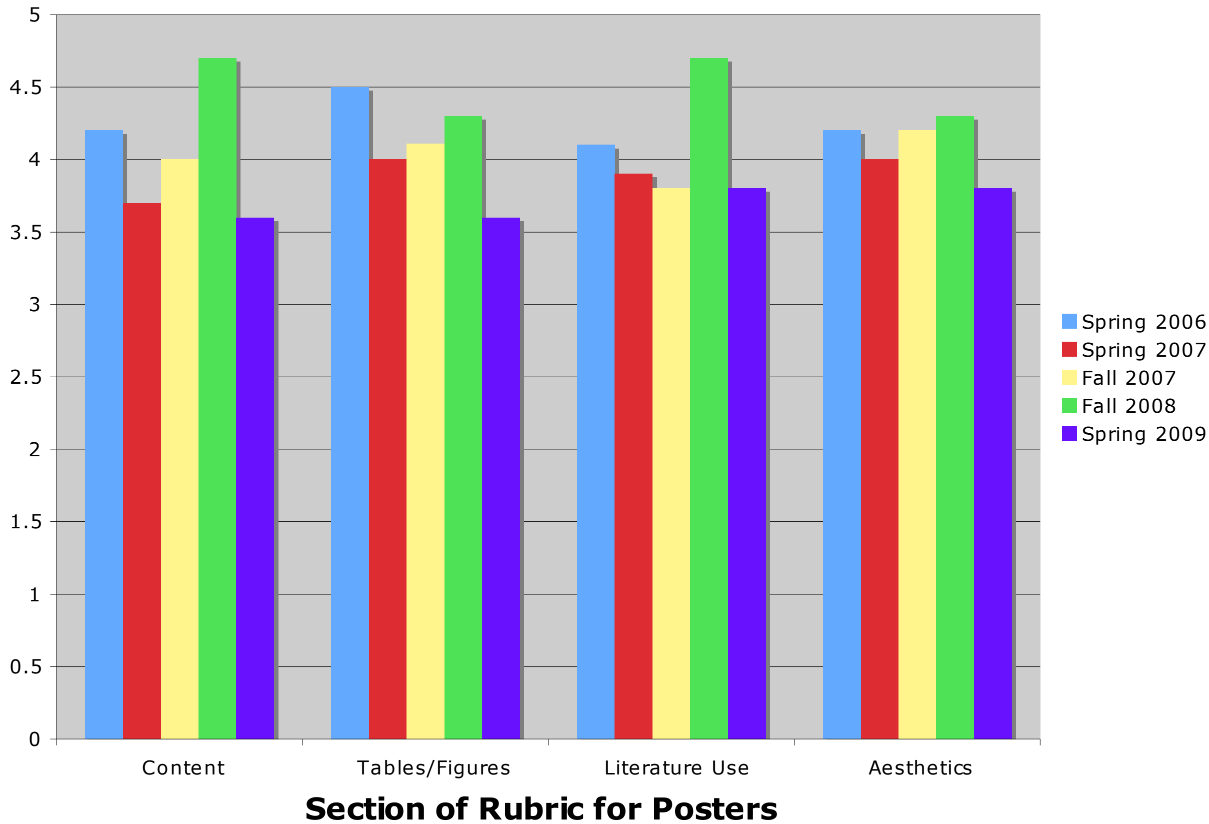

Figure 2. Mean scores for posters presented by students in Senior Seminar for five different semesters. Total possible was 20 points, with five points for each category of the rubric.

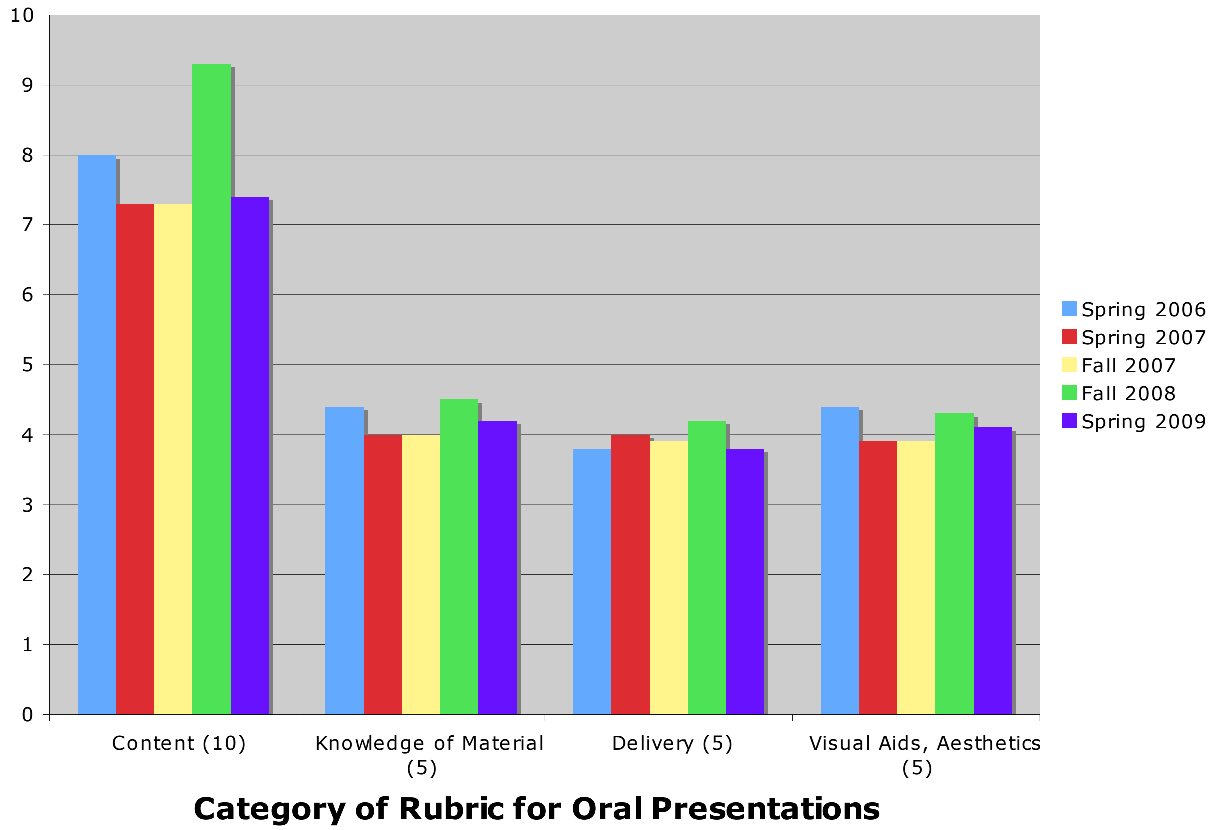

Figure 3. Mean scores on departmental rubrics for oral presentations in Senior Seminar for five different semesters. Total possible points was 25 for the presentation.

For the oral presentations, the department set a goal for a minimum total average of 20/25 to achieve a "green light". This goal was only achieved in two of the evaluated semesters (Fig. 3). Averaging fall 2008 and spring 2009 data, the mean total score was 20.5 for this year, just within the green light criteria. However, 11/34 of the 2008/2009 students did not score at least 20 points on the presentation.

Secondary Education Program

All secondary education students must complete 10 Candidate Assessments, as well as some program assessments specific to biology. These assessments are a part of the education courses in the curriculum as well as Biology 110 and Student Teaching. During the 2008/2009 academic year, Christie Magoulias developed a LiveText system for documenting performance of our students in meeting the specific requirements for accreditation within NCATE for the National Science Teachers Association. Rubrics were developed to track performance meeting the requirements, with proficient performance required and commendable performance exceeding requirements.

Table 5. Number of students receiving each rating in assessment rubrics for biology secondary education.

Rubric	Not Proficient	Marginal	Proficient	Commendable
Analysis of student learning (CA 10) Teacher Work Sample, phase I				
Context of Learning	0	0	0	1
Learning Goals	0	0	1	0
Assessment Plan	0	0	1	0
Design for Instruction	0	0	0	1
Conventions; Grammar, spelling	0	0	0	1
Social Context of Science, Section 1				
Unifying concepts of science	0	0	2	1
Important applications of science	0	0	1	2
Historical and cultural development of science	0	0	0	3
Philosophical tenets, assumptions, goals, and values that distinguish science from other ways of knowing	0	0	1	2
Multiple methods of inquiry	0	0	2	1
Socially important issues, processes of decision making	0	0	1	2
Ways to relate science to the community, involve stakeholders, use resources to promote learning	0	0	2	1
Social Context of Science, Section II				
Proper citation of sources used	0	0	0	2
Chosen contextual components accurately portrayed in depth	0	0	0	2
Contextual components enhanced with variety of supplemental resources	0	0	0	2
Lab Safety Manual	0	0	0	1

All biology students attempting to pass the candidate assessments and programs assessments were successful, often achieving commendable ratings.

<u>IMPROVEMENT PLANS</u>

How we might better meet the goals of the department:

Goal #1 – We developed four different versions of the pre-post test and have used each, improving it each time. The first version had no material from BI 108, and two of the questions used did not directly relate to evolution. The second version, which included concepts from BI 108 ended up being too long, requiring a whole class period to complete, and also had quite a few questions that were only tangentially related to evolution. In the fall of 2008, the department decided that the questions on names of scientists addressed memory, not concepts, so we removed them. The final version (Appendix A) is what we will use from Fall 2008 on at the beginning and end of BI 105, Ecology and Evolution, at the end of the second semester in BI 108 and during senior seminar course BI 481 or 482. Faculty efforts to incorporate evolution into their courses will be judged by the course syllabus. All syllabi should contain specific examples of how the concept evolution will be applied, and are assessed by department chair.

Biology Secondary Education students must pass the evolution test, and are given a second chance after study (only their first attempt is included in our assessment report). It is often the allied health track students who fail the evolution test, and these students typically have not taken upper level ecology or other organismal courses. Our requirement for all students to take one upper level course in each of six areas of biology should improve the mastery of evolutionary biology for those students. Also, until fall 2007, allied health majors were not required to take genetics and cell and molecular biology, in which concepts of evolution are further examined and applied. Many of these students became overly focused on human systems and did not have a broad background in biology. Our changes in the departmental curriculum should allow students to specialize without overly limiting their exposure to the field.

Goal #2 – The first step in completing this goal was to develop a list of courses that provide meaningful exposure to the six areas of emphasis in Biology (shown in Appendix B). We submitted our curricular changes to the Division of Natural Sciences and Mathematics and to the College of Arts and Sciences for approval in November 2006, and began to use the new requirements for biology majors entering in the Fall of 2007. We have developed a check sheet to be included in the advising folder of each student. It will be the annual responsibility of the advising professor to check the progress of advisees to be certain they are in compliance both for exposure and grades. The number of students falling below a C- in the content area courses will be used to assess our effectiveness in giving the students the exposure they need. Adding a field test from ETS will also improve our assessment.

The requirement for each student in each program to succeed in at least one course in each of the six content areas goes into effect for this year's juniors. We expect to see more breadth in the program choices of our students. Because it is difficult for the Allied Health students to work in a course in the ecology content area, we have approved our summer immersion course in Field Ecology to count in the ecology area for Allied Health.

Goal #3—During the spring semester of 2006, we collected and evaluated the writing of seniors in the Senior Seminar course BI 482. We used the results to determine the appropriate standard that students should meet in order to deem our teaching efforts acceptable. We began collecting papers from BI 155 in the fall of 2005, and have data in spring of 2009 to compare freshman and senior papers. These papers are evaluated using the writing rubric for Goal #3 and placed in their student folders.

Goal #4 – The senior seminar instructor evaluates the performance of seniors in the seminar course BI 482 using the evaluation rubrics on oral presentations, posters, and papers.

We had all faculty participate in assessment of the posters and presentations in 2006 to develop our criteria, then returned to having only the senior seminar instructor score the poster and presentation. This spring, the department again focused efforts on rigorous assessment, and four to nine faculty members evaluated each poster and oral presentation, according to the rubrics developed in 2006. The process of assessment of senior seminar performance as developed by Drs. Marianne Robertson and Jeffrey Hughes have allowed us to become much more objective and quantitative in the evaluations, and we should be able to compare performance from semester to semester better. In some semesters, we have had assessments completed by only one faculty member, and those vary widely. With a formalized system for departmental evaluation, semester to semester comparisons, and therefore rigorous assessment allowing for justification of changes in the curriculum, can be made.

Another issue, which we have not adequately addressed, is the issue of consequences for individual failure of a student to meet the expected objectives. Obviously if the problem is wide-spread, it requires adjustments in the department teaching and curriculum. Individually, however, we need to formulate how students would be remediated in order to bring them up to the level expected by our objectives. There is a need for early feedback to allow time for remediation. Some students do excellent research with a faculty member, worthy of presentation at regional and national meetings, and even publication. Others have worked entirely without a mentor, often on "book reports" that do not result in success. Before we began developing firm criteria for performance, no student had failed senior seminar. Since we began developing the rubrics in the Fall of 2005, we have encouraged three students to drop senior seminar and retake it when they were more prepared, five students to redo analyses and posters and present later in the semester, one to take an incomplete and prepare an acceptable analysis over the summer, and five students have failed. Students are now required to work with a mentor throughout the preparation for senior seminar, and that mentoring relationship is becoming more formalized and successful. We are working to ensure that all students have the tools needed to succeed in meeting the goals of the biology department.

Report Summary

Overall it appears that we have set realistic goals and that progress is being made toward achieving these goals.

- **Goal 1.** Freshmen students demonstrated a more than 25% improvement, from 26.9% to 68.97%, in their knowledge of evolutionary principles. At the end of the next semester, freshman scored 56.8%. From the test results of graduating seniors, this knowledge appears to be retained fairly well. Seniors performed very similarly to the students who had freshly studied evolutionary principles, 69.2%. Green light.

  Biology faculty are successfully showing how evolution is incorporated into their majors courses, with over 85% demonstrating how courses directly relate to evolutionary concepts. Green to yellow light.
- **Goal 2.** In the fall of 2008, biology majors took 118 upper division classes that meet the criteria for goal #2, with 95.1%, earning a C- or above. In the spring of 2009, 116 upper level content area classes were taken, with 93.1% earning a C- or above. There were 32 seniors, three of whom did not successfully complete the requirements for graduation. We will begin to be able to assess the content area change with this year's juniors. The responsibility of keeping track of successful progress needs to be completed by faculty advisors, but is not at this time. Green to Yellow light.
- **Goal 3.** Results assessing the critical skills of our students using scientific reports show that our seniors have developed the skills we feel are necessary for them to succeed in their future careers. The average score for evaluating paper format, design and conclusions was 13.3 and 12.6 out of 15 for fall 2008 and spring 2009. This exceeds the minimum cutoff value of 10 [to become 12] which indicates we are providing satisfactory instruction for students to succeed in this area. We were able to compare seven sets of papers from students as freshmen and seniors, and found that there was a significant mean improvement of 25%, and that all seven improved at least 20% in their rubric scores. Green light.
- **Goal 4.** Average oral presentation scores for the 16 students in fall 2008 were 21.7, and 19.4 for the 18 students in the spring of 2009. This averaged to 20.5, within the criteria for a green light. Average poster scores were 18.31 in the fall and 14.8 in the spring, for an average of 16.4 for the year. Green light.

- Although the rubrics have not been used consistently in grading, we have found that having them, and making them available within the syllabus for senior seminar, has made expectations more clear to our students and evaluation more consistent. The responsibility for instructing senior seminar rotates through the department, with a different person in charge each semester. With the addition of participation of all biology faculty in the scoring process for assessment, we should have more consistent data that can be used for program planning and improvement.

APPENDIX A

Evolution and Natural Selection Survey – Biology Department, Spring 2009

Name________________________

1. Natural populations of organisms that can interbreed and produce fertile young and are reproductively isolated from other such groups are known as ____________________________.
2. A change in frequency of a particular trait in a population over time is___________________________.
3. A particular structure, behavior, or physiological function that allows organisms possessing it to survive and reproduce more than individuals in the population that lack it _________________________________.
4. A permanent change in a cell's DNA, usually caused by errors in copying the DNA, that is the raw material for evolution__________________________
5. A structure with similar function but different ancestral origins is a(n)_________________________ structure. (Example: bee's wings and bird's wings)
6. A structure that no longer has a function in an organism, that has a function in related organisms, is a(n)_______________________________structure. (Example: pelvic bones in whales)
7. What is **the** mechanism of adaptive evolution?__________________________________
8. The apparent similarity between marsupial mammals in Australia and ecologically equivalent mammals in other parts of the world is an example of __________________________ evolution.
9. The five major mechanisms of evolution are:

   __________________________ __________________________

   __________________________ __________________________

   ____

10. What TWO evolutionary mechanisms play a major role in resistance to HIV?________________________ and ____________________________.
11. A type of natural selection that acts to eliminate one extreme from an array of phenoptypes is called__________________________________ selection.
12. A type of natural selection that eliminates intermediate phenotypes while favoring both extremes is called _________________________ selection.
13. The evolutionary history of an organism, represented in the form of an evolutionary tree, is called _______________________________.
14. The genetic contribution of an individual to succeeding generations, a relative term comparing the contribution of one individual to others in a population gene pool ______________________________.
15. The advantage of sexual reproduction over asexual reproduction is that sex generates ____________________________ (which makes evolution by natural selection possible) and asexual does not.
16. The _________________________________ Theory suggests that chloroplasts and mitochondria of eukaryotic cells were derived from bacteria living in other bacteria.
17. Explain the mechanism of natural selection using conditions that lead to adaptation. **(write your essay on back)**

Word Bank for all but number 17. Some terms may be used more than once, and some may not be used

1. Adaptation
2. Adaptive Radiation
3. Analogous
4. Character displacement
5. Commensalism
6. Convergent evolution
7. Directional
8. Disruptive
9. Divergent evolution
10. Endosymbiotic theory
11. Evolution
12. Fitness

13. Genetic Drift
14. Genetic Variation
15. Homologous
16. Migration, Movement between populations
17. Mutation
18. Mutualism
19. Natural selection
20. Non-random mating
21. Parasitism
22. Phylogeny
23. Species
24. Stabilizing
25. Vestigial

APPENDIX B

Biology Content Category Courses

Fall 2007 revised 1

Complete **One** from Each Category with “C-” or better. (Does **Not** Include First Year Core Courses)
Complete at least ONE with embedded research project OR take research (BI 391/392)

Each course may count for only one category.
(e.g., if Vert. Bio. is taken for Taxonomy, then it cannot be counted for Function or any other category

Ecology	*Taxonomy*	*Morphology*	*Function*	*Molecules/ Cells*
BI 220/320* Field Ecology (PT/OT & Allied Health)	**BI** Medical Entomology	**BI 204** Essent. of A&P **(Sec. Ed only)**	**BI 204** Essent. of A&P **(Sec. Ed only)**	**BI 300** Genetics/Lab
BI 314* Ecology	**BI 303** Entomology	**BI 206** A & P I (PT/OT, PA & Allied Health & Sec. Ed.)	**BI 206** A & P I (PT/OT, PA & Allied Health & Sec. Ed.)	**BI 302** Histology
BI 323* Animal Behavior	**BI 307*** Parasitology	**BI 207** A & P II **(PT/OT, PA & Allied Health)**	**BI 207** A & P II **(PT/OT, PA & Allied Health)**	**BI 305** Molecular and Cell Biology/Lab
BI 380* Ecological Journey	**BI 325*** Vertebrate Biology	**BI 301** Comparative Anatomy	**BI 301** Comparative Anatomy	**BI 312** Immunology
Conservation Biology	**BI 326*** Plant Biology	**BI 302** Histology	**BI 304** Developmental Anatomy	**BI 330*** Microbiology
	BI 328 Ornithology	**BI 303** Entomology	**BI 306** Animal Physiology	**BI 407*** Molecular Genetics
	BI 330* Microbiology	**BI 304** Developmental Anatomy	**BI 308*** Plant Physiology	**BI 413** Advanced Cell Biology
	BI 380*	**BI 322**	**BI 312**	

	Ecological Journey	Neurobiology	Immunology	Endocrinology	
	BI 404 Evolution	**BI 326*** Plant Biology	**BI 322** Neurobiology		
			BI 325* Vertebrate Biology		
			BI 328 Ornithology		
			BI 413 Advanced Cell Biology		

*__Courses with student/designed research projects – students must take at least one of these courses__

Appendix C. Examples of posters.