Millikin University
Student Learning in Biology

Department of Biology
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Division of Natural Science and Mathematics
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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 goals#1 and 2. We have a geneticist, a molecular/cell biologist, a microbiologist, an ecophysiologist, a mammalogist, 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 (82%, with one more who has defended his dissertation and has only final committee approval to complete) 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 120 (average) majors and annually graduates an average of 26 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 and honors seminars per year teach 2-3 PACE MPSL courses, two courses for the graduate nursing program, and 5-7 interdepartmental courses each year (Table 1).

Table 1. Biology Student Credit Hours generated by Biology Faculty in the 2011/2012 academic year

	Biology Majors	IN courses	MPSL lab (BI 102)	Service Courses
Fall 2011	822	321	436	330
Winter immersions, PACE	4	27	96	32
Spring 2012	772	318	480	254
Summer 2012	4	0	44	0

Our faculty loads are often high, with 4-7 faculty members on overload each semester. We try to even out loads, with an average of 10 credit hours or 12 contact hours over the academic year, and at least one upper level course per full time faculty member per year (Table 2). With 9.67 FTE in our department, we averaged 197.4 student credit hours per faculty member (plus an average 31 student credit hours per FTE in immersions and PACE) in Fall 2011, and 188.6 SCH per FTE (plus 11 SCH per FTE in immersions and PACE) in the Spring 2012.

Table 2. Biology Faculty loads for academic year 2011/2012. Credit hours are listed, then contact hours in brackets. Our departmental goal is 10 credit hours or 12 contact hours averaged over the year. Upper level courses are listed.

Faculty Member	**Fall 2011**	**Spring 2012**
Dr. Sam Galewsky	BI 407 Molecular Genetics 12 [14]	BI 305 Cell/Molecular Biology 9 [13]
Dr. Cynthia Handler (1/2)	BI 302 Histology +Graduate Anatomy for Nurse Anesthetists (1/2 of 3) 4 [6]	4 +
Dr. David Horn	BI 314 Ecology 12 [13]	BI 340 Conservation Biology 11 [12]
Dr. Jeff Hughes	BI 300 Genetics 9 [16]	8 [10]
Gregg Marcello ABD final submission	+Graduate Anatomy for Nurse Anesthetists (1/2 of 3) 8 [13]	BI 325 Vertebrate Biology 8 [11]
Ros O’Conner (1/2 time)	7 [7]	7 [7]
Dr. Judy Parrish	BI 326 Plant Biology BI 380 S.Africa 12 [18]	9 [10] ½ Senior Seminar, BI 482 Chair Reduction
Dr. Marianne Robertson	BI 303 Entomology 9 [15]	BI 323 Animal Behavior ½ Senior Seminar, BI 482 8,[10] Gravett
Dr. Jen SchultzNorton	BI 306 Comparative Animal Physiology Graduate Physiology for Nurse Anesthetists (3) 10 [12]	11 [11]
Dr. Sangeetha Srinivasan	8 [11]	BI 330 General Microbiology 9 [12]
Dr. Travis Wilcoxen	BI 482, Senior Seminar 10 [13]	BI 360 Physiological Ecology 8 [15]

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 field and 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. Those in the pre-professional programs have both an academic advisor and a pre-professional advisor whose job it is to ensure that students are aware of requirements and prepared for application to professional schools.

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 (Table 3)

Table 3. Biology department goals and courses that focus on them in each academic year.

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 300 lab
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

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 Diversity 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, Ecology and Evolution (BI

105) and Diversity 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 Diversity of Life, 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 major areas of biology: ecology, taxonomy, morphology, function, molecules/cells and reproduction/genetics (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 six courses, one in each area, and complete each course with a grade of C- or better. Students must retake or take another course in a particular content area if their grade is D+ or lower. This applies to every student in every concentration. We also require that seniors take the ETS field test in biology during their senior seminar. Students are charged a lab fee of $50 for this course (BI 481 or 482) 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. We use a portfolio system to collect two papers, one written the first year at Millikin, and then one from senior seminar research. These papers must be of an investigative nature that draws 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 health 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 Diversity 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 is also used in assessment of this goal.
- Two papers, one from the freshman year, and the senior seminar capstone research paper, are collected and evaluated using the rubric for goal #3 (see above rubric). Transfer and other students without the first paper to evaluate are excluded from the analysis.
- 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 and Program 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.

ANALYSIS OF ASSESSMENT RESULTS

- GREEN LIGHT –
  - At the introductory level, testing indicates that we are approaching a high level of success. Goal #1 is 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 12 or better.
  - 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 post-tests 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 10 – 15% must repeat courses to achieve a C- or better in each.
  - Goal #3 - Two papers have been placed in the student's portfolio, with less than 20% improvement. Average evaluation score for the senior paper is 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 two papers in the student's portfolio, with an average evaluation score for the senior paper of less than 11.
    - Goal #4 - Average oral presentation score for seniors is below 18 and average poster score is less than 13.

Results from 2011/2012, compared to preliminary results from 2005/2006 and results from 2006/2007, 2007/2008, 2008/2009, 2009/2010, and 2010/2011

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

Summary of the Evolution assessments for 2011/2012

When we gave the test to EE students early in the semester, 53 students took the exam, averaging 6.2 out of 25 (Table 4). At the end of the semester, 41 students took it, and averaged 17.8/25, improving by 44.6 percentage points directly after the content was covered in class.

In Diversity of Life, 38 students took the exam, and averaged 15.6 of 25 points, a slight decline from mid semester, but in line with scores in other years.

The 24 seniors who took the assessment in 2011/2012 senior seminars averaged 18.6 of 25. Four seniors earned 23-25, eight 20-22, three 18-19, eight 15-17, and only one below 15. So 4% of the 2011/2012 seniors did not pass the evolution exam. 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, 29% failed in 2008/2009, and in 2009/2010 and 2010/2011 only 14% of the seniors did not pass. The test counts as 10% of the senior seminar grade.

The data from all 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 and good, with scores from the test in Diversity 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. The mean scores on the objective assessment test thus give good evidence that students understand the basic context of evolution well. 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 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 80% 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 was incorporated into them. Similar results hold for the syllabi in 2010, and 2011 (83% in fall and 80% in spring). The Anatomy/Physiology courses are not strongly centered on the concept of evolution, and that is because they are human, not comparative, and mainly aimed at nursing students. We decided as a department that it is reasonable for the A&P courses NOT to have a core theme of evolution, since only the human species is discussed, and we have decided to remove them from this portion of the assessment. Our goal is to have evolution as a core theme in all other classes, and we are meeting that goal (Table 5).

Table 4. Breakdown of percent correct answers for each question on the pre- and post-test for knowledge of evolution for Fall 2011 and Spring 2012.

Question	% Correct New Freshmen (53)	% Correct Midyear Freshmen (41)	% Correct End of First Year (38)	% Correct Senior Seminar (24)
1 Species	41.5	100	92.5	87.5
2 Evolution	49.1	92.6	85.2	83.3
3Adaptation	24.5	95.1	85.2	79.2
4 Mutation	71.7	92.6	96.3	95.8
5Analogous	18.9	63.4	55.6	62.5
6 Vestigial	39.6	92.6	77.8	95.8
7 Nat. Sel	24.5	95.1	70.4	95.8
8 Converg.	13.2	73.2	33.3	70.8
12 Mech. (5)	30.94	74.6	57.0	75
13aNatSel	1.9	17.1	22.2	45.8
13bMutatio	15.1	41.5	29.6	36.8
14 Direc.Sel	13.2	58.5	62.9	58.3
15 Disr. Sel	15.1	65.8	74.1	54.1
16 Phylog.	37.7	97.6	78.1	83.3
17 Fitness	1.9	75.6	40.7	79.2
18. Variatio	43.4	80.5	96.3	91.7
19 Endosym	24.5	73.2	100	91.7
20 Nat Sel (4 pts)	11.3	46.3	39.8	81.2

Average 2011/2012	26.5%	71.1%	62.4%	74.4%
Average 2010/2011	23.2%	79.32	63.5	69.4%
Average 2009/2010	32.4%	69.2%	70.16%	72.56%
Average 2008/2009	26.93%	68.97%	56.8%	60.9%
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 5. Direct coverage of evolution on syllabi for Fall 2011 and Spring 2012 Classes for Biology Majors

Class	Instructor	Evolution directly addressed
BI 105 Ecology and Evolution	Parrish and Robertson	Yes and Yes
BI 108 Diversity of Life	Hughes and Parrish	Yes and Yes
BI 300 Genetics	Hughes	Yes
BI 302 Histology	Handler	Yes
BI 303 Entomology	Robertson	Yes
BI 305 Cell and Molecular Biology	Galewsky	Yes
BI 306 Comparative Animal Physiology	Schultz-Norton	Yes
BI 314 Ecology	Horn	Yes
BI 323 Animal Behavior	Robertson	Yes
BI 325 Vertebrate Biology	Marcello	Yes
BI 326 Plant Biology	Parrish	Yes
BI 330 Microbiology	Srinivasan	Yes
BI 360 Physiological Ecology	Wilcoxen	Yes
BI 380 Ecological Journey: South Africa	Parrish	Yes
BI 407 Molecular Genetics	Galewsky	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 for 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 encouraged our more senior students to study in all six areas. In fall 2007, 8.94% and in spring 2008, 6.94% of the grades earned were below C- . In fall 2008, 5.93% and in Spring 2009, 6.89% of students received grades below C- in the content area courses, and in Fall 2009 and Spring 2010, 6.03 % and 4.6%, respectively. For Fall 2010 and Spring 2011, 5.48% and 2.25% of biology majors received grades below C- in content area courses. For Fall 2011/Spring 2012, 6.02% of our students did not successfully complete content area classes (Table 6). These data fulfill the criteria for a green light for the number of students needing to repeat upper level courses in the content areas.

Table 6. Courses that meet biology content area requirements for majors, number of biology majors enrolled in each course, and number of students failing to meet the required C-.

Fall 2011 and Spring 2012 Course offerings			
Course Title	Course Number	Number enrolled	Number earning lower than C-
A&P I*	BI 206	14	1
A&P II*	BI 207	12	2
Principles of Micro*	BI 230	4	0
Genetics	BI 300	38	5
Histology	BI 302	16	2
Entomology	BI 303	8	1 (2 W)
Molec. Cell Biol	BI 305	26	0
Comp.Animal Phys	BI 306	9	0 (1 W)
Ecology	BI 314	11	0
Animal Behavior	BI 323	5	1
Vertebrate Bio	BI 325	13	0
Plant Biology	BI 326	6	0
General Micro	BI 330	13	0
Conservation Bio	BI 340	9	1
Physiol. Ecology	BI 360	13	0
Ecological Journey	BI 380	9	0
Molec. Genetics	BI 407	10	0
Percent Below Cutoff Grade of C-			6.02%

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

Since Spring 2010, we have required that our seniors take the Educational Testing Service field exam for biology. Scores have been consistently very near the national averages (Fig. 1)

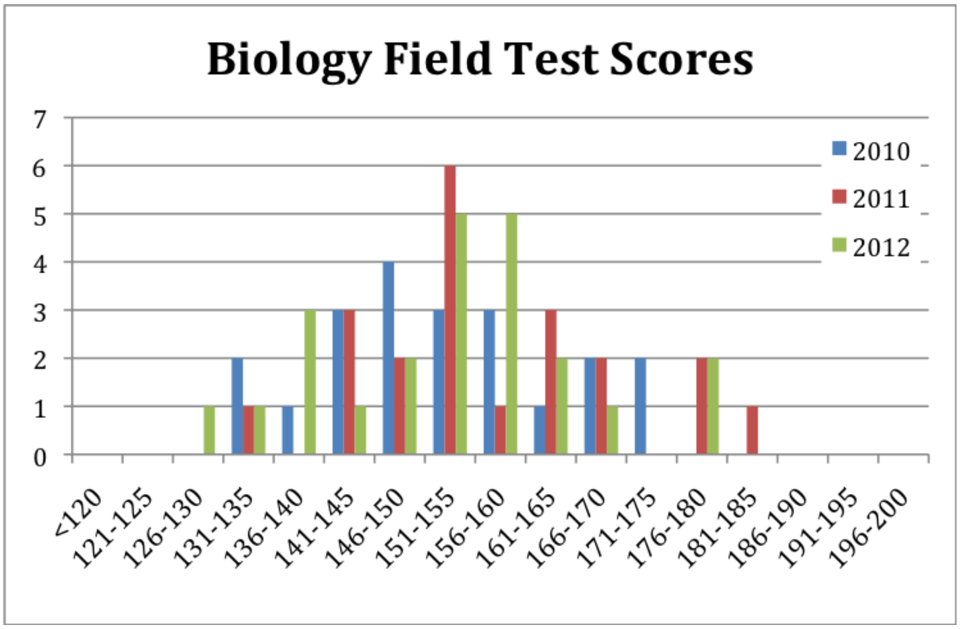

Figure 1. Educational Testing Services Biology Field Test Scores for 2010, 2011, and 2012.

In 2011/2012, 15 of the 23 seniors taking the exam scored 150 or above, at the 40th percentile or above for all students taking the exam nationwide (scaled overall test score ranges from 120 – 200). Three more students, for a total of 11/23, scored below the mean score of 153.2 nationwide. Millikin's mean total was 150.8 for 2012, compared to 156.24 in 2011 and 152.05 in 2010. Five of the 23 students taking the exam this year did score above the 75th percentile nationwide. The range of scores was 127 – 176 for this year's seniors. In 2010/2011 and 2009/2012, 15 of the 21 seniors taking the exam each year scored 150 or above.

Of the four main subsets of scores, Millikin students performance was slightly below national averages in each subtest except for population biology, ecology, and evolution, and lower than for the last two years (Table 7).

Table 7. Mean ETS Biology Field test subset scores for Millikin students in 2010, 2011, and 2012, and national average for each subset for 2012.

	Cell Biology	Molecular Biology & Genetics	Organismal	Population Biology and Ecology and Evol
Millikin 2010	52.47	49.04	50.19	56.28
Millikin 2011	52.76	57.90	56.24	55.57
Millikin 2012	48.78	49.42	49.63	55.0
National Average 2012	53	53	53.5	52.6

Although students from Millikin biology programs have scored close to national averages for the field test, we can see that there are some areas in which they are generally weaker than others (Table 7). The only one of the nine subtypes of questions on the exam in which our students score lower than 40% is in organismal plant biology (Fig. 2). Three quarters of our students never take a plant course, so their only exposure to plants is in a small section of our Diversity of Life class in the first year. However, we are apparently preparing students well in most of the areas, particularly cellular biology and ecology, and our students scored well in analytical skills. Our department has a strong emphasis on critical thinking and application rather than memorizing facts, and we are glad to see that this emphasis is reflected in performance. ETS assessment of goal 2, yellow to green light.

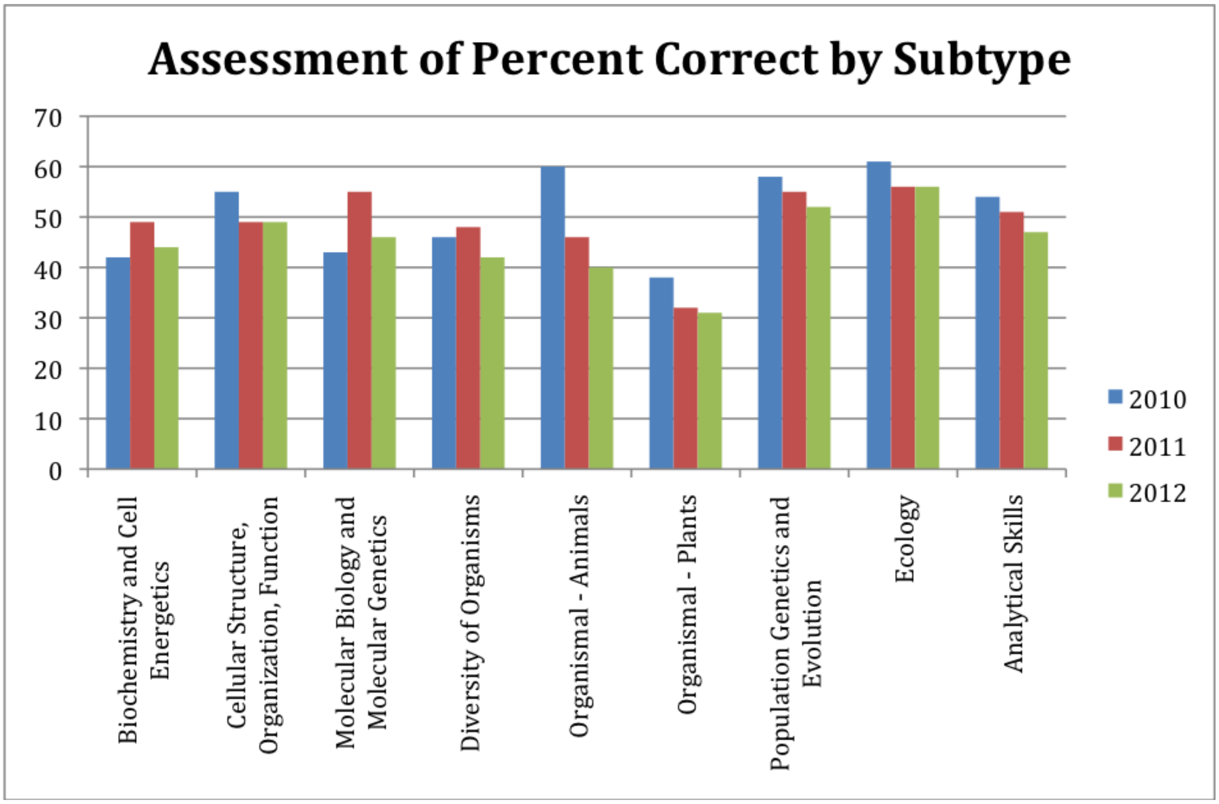

Figure 2. Average score of Millikin students for each of the subtypes of questions asked.

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, from the freshmen course, Ecology/Evolution, to the senior course, Senior Seminar, emphasize application of concepts to life situations. In order to assess this critical thinking goal, papers from the freshman year are compared to papers from the senior year to look for improvement. The two papers have to be from the same student to be included. A common rubric of three sections, worth five points each, is used to score the papers. The rubric sections are Format, Design and Conclusions (see above rubric). Our department decided an average improvement of 20% from freshman to senior years, in addition to an average overall score of 12/15 for the senior papers, would be used as a "green light" and therefore an indicator of teaching success for data evaluation and curriculum improvement decisions.

For the 2011/2012 school year, we compared the Senior Seminar papers and freshmen Ecology/Evolution papers of ten students (Figure 3). The average total score on the papers increased 36%, from 10.05 to 13.70. Paired t-tests showed that the total rubric score on the paper increased significantly ($p = 0.0002$), as did scores on format ($p = 0.003$), design ($p = 0.001$) and conclusions ($p = 0.0001$). Both the fact that seniors are scoring, on average, higher than 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. However, not all senior papers were used due to the lack of corresponding freshman papers, so the sample size was smaller than it should have been.

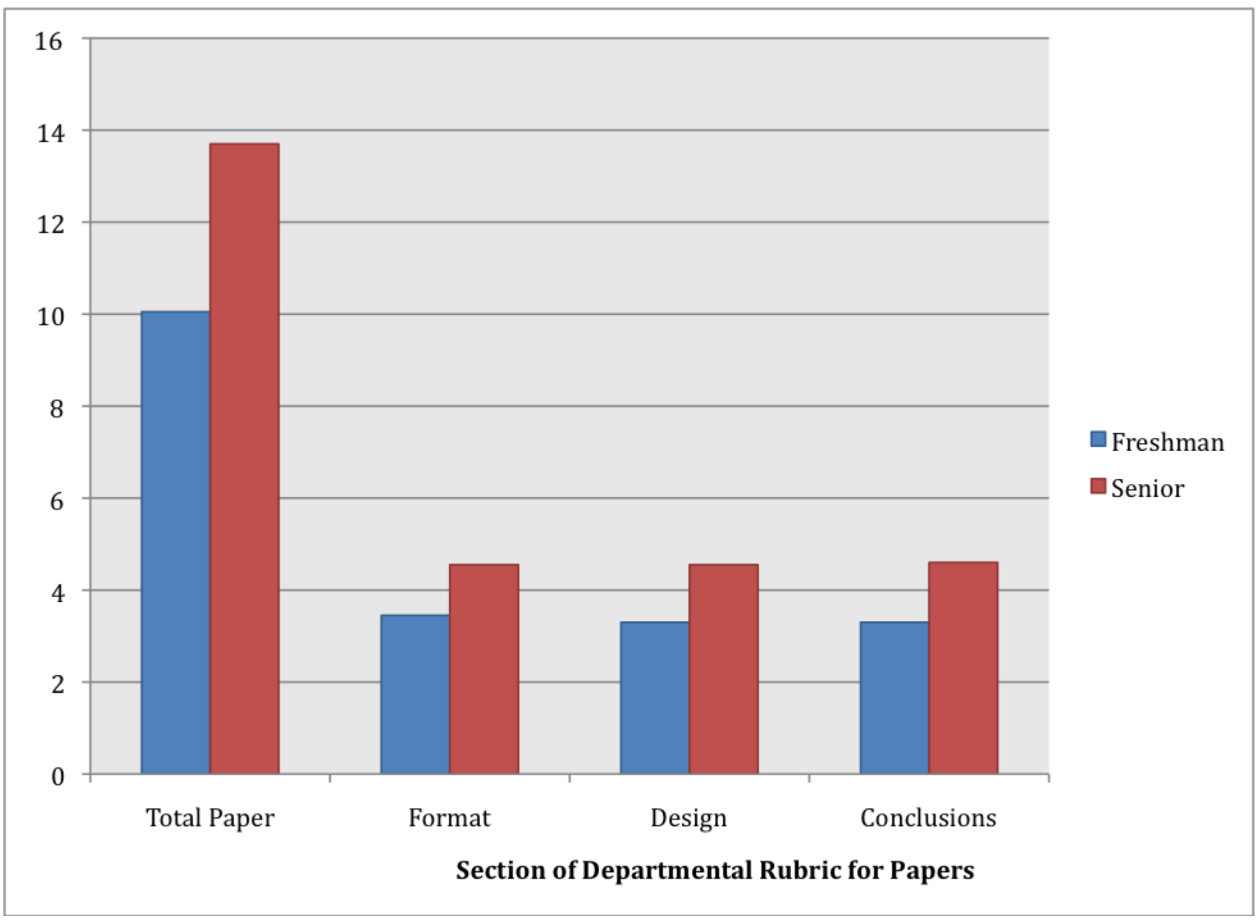

Figure 3. Comparison of scores on the grading rubric for Freshmen (entering fall 2008) papers from Ecology and Evolution class with Senior Seminar papers from the same students (fall 2011/spring 2012). Total possible point value is 15, with each of the three portions (Format, Design, Conclusions) of 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 research 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 for the poster presentation of 15 was set by the department after three semesters of assessment, and has been met in most semesters (Table 8). Seven of 24 students did not score above 15/20 on the poster in this academic year. Average for all posters were above the 15/20 set by the department, earning a green light. Scores in each of the categories used to evaluate poster content and form show that students are generally meeting our expectations (Fig. 4).

Table 8. 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)
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)
*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)
Fall 2009 (6)	Combined	12.8 (7.3 – 17.6)	17.1 (12 – 23.2)
Spring 2010 (21)	For 9, 12.4	15.2 (7.75 – 19.5)	19.8 (12 – 23.2)
Fall 2010 (6)	Combined	17.4 (14.75 – 19)	21.0 (17.07 – 23.57)
Spring 2011 (15)	For 9, 13.6	16.5 (10.7 - 19)	21.71 (16.8 - 24)
Fall 2011 (5)	Combined	16.8 (13.33 – 19.33)	21.00 (16.8 – 22.85)
Spring 2012 (19)	For 10, 13.7	15.77 (8.34 – 19.34)	20.09 (12.12 – 23.4)

*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. From Fall 2010 on, posters are the average evaluations from three faculty members, and oral presentations the average from all faculty present, usually 6 or more.

**Starting in 2010, only papers with first-year BI 155 comparisons were evaluated using the rubric. Papers from both semesters of the academic year were used, so data are reported only in spring when comparisons were made. All papers were graded by the senior seminar instructor and faculty mentor, but not included here.

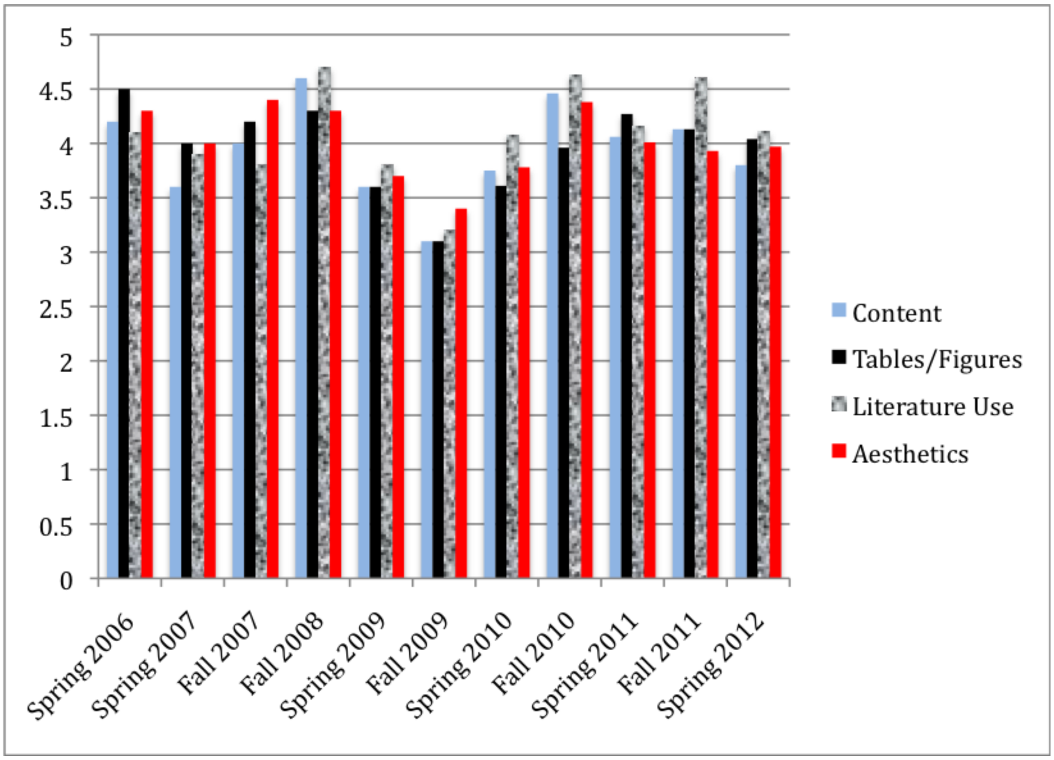

Figure 4. Mean scores for posters presented by students in Senior Seminar for ten different semesters. Total possible for the poster was 20 points, with five points for each category of the rubric.

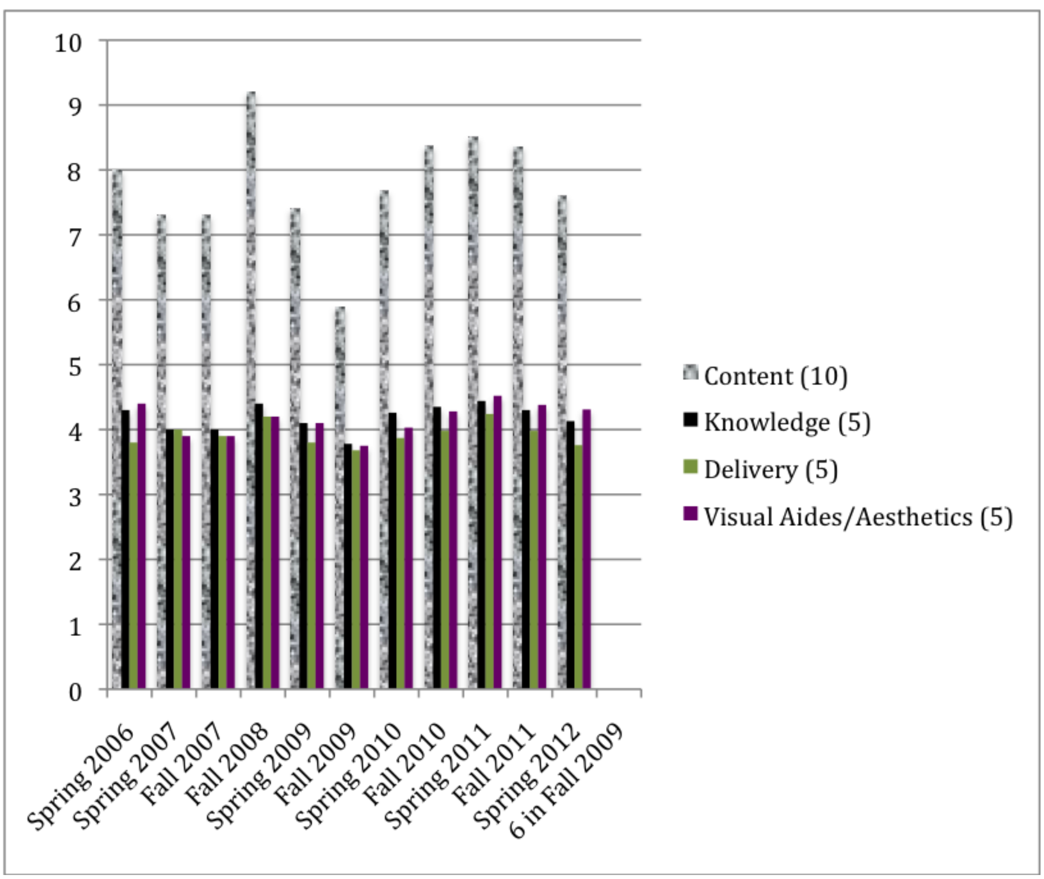

Figure 5. Mean scores on departmental rubrics for oral presentations in Senior Seminar for ten different semesters. Total possible points was 25 for the oral presentation.

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 three of the evaluated semesters before this year (Table 8). In 2009/2010, only 11/32 individual presentation scores were 20 or over, and in 2010/2011, 15 of 21 scored over 20. In 2011/2012, averages were above 20/25 in both semesters, with only 7 of 24 students scoring below 20. Again, students are meeting our expectations in all categories of evaluation of the presentation (Fig. 5). It appears that our efforts to improve student preparation for their professional presentations are working, and we will continue to ensure that students receive early and frequent mentoring.

Secondary Education Program

All secondary education students must complete 11 Candidate Assessments, as well as eight 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.
We had no biology students who completed student teaching this academic year, but all biology students attempting to pass the candidate assessments and programs assessments were successful, often achieving commendable ratings.

IMPROVEMENT PLANS

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 (although only their first attempts are 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 the field test from ETS also improves our assessment of this goal.

The requirement for each student in each program to succeed in at least one course in each of the six content areas went into effect students graduating in 2011. 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 approved our summer immersion course in Field Ecology (BI 220) 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. We used the results to determine the appropriate standard that students should meet in order to deem our teaching efforts acceptable. Since that time, research papers from the freshmen Ecology/Evolution course and Senior Seminar course have been collected and assessed, for comparison, using the above rubric.

One area needing improvement is the collection and storage of the freshmen papers. In 2009/2010 both freshmen and senior papers were available for seven students, in 2010/2011 the number was nine and in 2011/2012 the number was ten. For the 2011/2012 year, there were 17 seniors that were freshman in 2008 and we had 10 of their freshman papers, so we were over 50% but, it would be more beneficial to have a freshman paper for all seniors. We have good results collecting the Senior Seminar papers. The challenge is making sure that a paper is collected for every freshman, and then stored for four years so that it is ready for the comparison with the senior paper. It is recommended that papers be collected and stored electronically in a G Share file.

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 and faculty mentor score the poster and paper. 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. At least two faculty members evaluate each poster and paper now, and all faculty present, usually at least six, evaluate the oral presentations. In some previous semesters, assessments were 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. We need to be sure that all students, especially transfers, attend senior seminars so that they can understand and plan for their own capstone experience. First year students are required to attend 5 seminars each semester, but students who transfer into the department as upper classmen sometimes attend only when they are enrolled. Advisors need to strongly encourage our transfer students to attend and to start thinking about what they will choose to work on for their capstones. There is also a need for early feedback to allow time for remediation on projects. Some students do excellent research with a faculty member, worthy of presentation at regional and national meetings, or 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, three to take an incomplete and prepare an acceptable analysis over the summer or winter break, 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. Average scores on paper, poster, and presentation have improved and are now consistently reaching the standards adopted by the department. We are working to ensure that all students have the tools needed to succeed in meeting the goals of the biology department. We also plan to start keeping our own data about what our alums are doing, with senior seminar mentors responsible for keeping up with each student (via phone, visits, Facebook, e-mail, etc.).

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 26.5% to 71.1%, in their knowledge of evolutionary principles. At the end of the next semester, freshman scored 62.4%. 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, 74.4%. GREEN light.

  Biology faculty are successfully showing how evolution is incorporated into their majors courses, with all but the Anatomy and Physiology I and II demonstrating how courses directly relate to evolutionary concepts. These two courses do not center around evolution, and as a department we agreed that those courses should not, as they examine only human anatomy and physiology. We will therefore not consider it negatively that they do not, and have removed them from our analysis of this goal. Green light.
- **Goal 2.** In 2011/2012, biology majors took 216 upper division classes that meet the criteria for goal #2, with 94% of students earning a C- or above. The responsibility of keeping track of successful progress for each student needs to be completed by faculty advisors, an we are making some progress along these lines. GREEN light.

  Scores for Millikin students on the ETS biology field tests are very close to national averages (for students completing programs that choose to use the test), demonstrating that our program is effective at preparing students in biology. GREEN light.
- **Goal 3.** Results assessing the critical skills of our students using scientific papers 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 the seniors’ paper format, design and conclusions was 13.7 out of 15. This exceeds the minimum cutoff value of 12, which indicates we are providing satisfactory instruction for students to succeed in this area. We were able to compare ten sets of papers from students as freshmen and seniors, and found that there was a significant mean improvement of 36% in their rubric scores. GREEN light.

  Not all students have two papers in their portfolio when they reach their senior year (discounting transfer students). YELLOW light.
- **Goal 4.** Average oral presentation scores for the 5 students in fall 2011 were 21.0**,** and 20.07 for the 19 students in the spring of 2012, both exceeding the 20/25 needed for a green light. Average poster scores were 16.80 in the fall and 15.8 in the spring, again exceeding the 15/20 criterion for a green light. Although the rubrics are not used consistently by all faculty members 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 more biology faculty in the scoring process for assessment, we have more consistent data that can be used for program planning and improvement. GREEN light

APPENDIX A

Evolution and Natural Selection Survey – Biology Department

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 2012** **revised 6-1-2012**

Complete **ONE** from Each Category with "C-" or better. (Does **Not** include First Year Core Courses)

Each Course May Count for Only ONE Category
(e.g., if BI 325 Vert.Bio is taken for Taxonomy, then it cannot also be counted for Morphology or any other category.) Refer to "Biology Projected Course Offering Schedule" for availability of specific course.

Ecology ①	Taxonomy ②	Morphology ③	Function ④	Molecules/ Cells ⑤	Reproduction/ Genetics ⑥
BI 220-320 Field Ecology **(PT/OT & Allied Health)**	**BI 303** Entomology	**BI 204** Essen. Of A&P **(Sec.Ed only)**	**BI 204** Essen. Of A&P **(Sec.Ed only)**	**BI 300** Genetics	**BI 300** Genetics
BI 314 Ecology	**BI 311** Virology	**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 323 Animal Behavior	**BI 324** Ornithology	**BI 207** A & P II **(PT/OT, PA & Allied Health & Sec Ed)**	**BI 207** A & P II **(PT/OT, PA & Allied Health & Sec Ed)**	**BI 305/355** Molecular and Cell Biology	**BI 404** Evolution **(recommend)**
BI 340 Conservation Biology	**BI 325** Vertebrate Biology	**BI 301** Comparative Anatomy	**BI 301** Comparative Anatomy	**BI 311** Virology	**BI 407** Molecular Genetics
BI 360 Physiological Ecology	**BI 326** Plant Biology	**BI 302** Histology	**BI 304** Developmental Biology	**BI 312** Immunology	
BI 380 Ecological Journey	**BI 330** Microbiology	**BI 303** Entomology	**BI 306** Comparative Animal Phys.	**BI 330** Microbiology	
BI 404 Evolution **(recommend)**	**BI 380** Ecological Journey	**BI 304** Developmental Biology	**BI 308** Plant Physiology	**BI 407** Molecular Genetics	
		BI 322 Neurobiology	**BI 312** Immunology	**BI 413** Advanced Cell Biology	
		BI 325 Vertebrate Biology	**BI 322** Neurobiology		
		BI 326 Plant Biology	**BI 324** Ornithology		
			BI 360 Physiological Ecology		
			BI 413 Advanced Cell Biology		