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. By working towards this goal, students should achieve the hallmarks of Performance Learning by which students have partnered with faculty members to develop student-driven experiences that coincide with biology, engage with outside individuals who can review their work, and participate in reflective processes that advance professional growth by critically examining the continuous cycle of doing, learning, and becoming scientists.

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 student 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 have been selected to provide specialized focus in the areas emphasized in biology goals #1, 2, and 4. For 2017/2018, we had a geneticist, two molecular/cell biologists, an ecophysiologist, an anatomist/ecoimmunologist, a microbiologist, an animal ecologist, two physiologists (one is teaching half-time and running our pre-professional program the other half), a plant biologist, an environmental biologist (teaching half time and preparing labs the other half), and an animal behaviorist/entomologist. Almost all (91%) have Ph.D.s in their specialized 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
- Biomedical Engineering

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 100 (average) majors and annually graduates an average of 24 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 65 pre-nursing majors and 45 exercise science majors by providing courses in anatomy and physiology and approximately 5 elementary education majors seeking concentrations in science. We also teach an average of 13-14 sections of MPSL laboratory science classes and honors seminars per year, 2-3 FLEX MPSL courses, 2 courses for the graduate nursing program, and 5-7 interdepartmental courses each year (Table 1).

Table 1. Biology Student Credit Hours (SCH) generated by Biology Faculty in the 2017/2018 academic year.

	Biology Majors SCH	IN/HN courses SCH	MPSL lab (BI 102) SCH	Service Courses SCH	Total
Fall 2017	726	144	492	544	1906
Spring 2018	698	165	548	391	1802
Total Student Credit hours	1424	309	1040	935	3708

Our faculty loads are often high, with 3-4 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). We averaged 370 student credit hours per faculty for 2017/2018. Our faculty also mentored 42 student credit hours for registered students in research projects, as well as internships and several projects not registered for credit.

Table 2. Biology Faculty loads for academic year 2017/2018. Credit hours are listed, then contact hours in brackets. Our departmental goal is 10 credit hours or 12 contact hours per semester averaged over the year. Upper level courses are listed**.** In Fall 2017, average number of credits taught per biology faculty (9.5 FTE) was 10.9 and 12.9 contact hours. In Spring 2018, we averaged 10.1 undergraduate credit hours taught per biology FTE and 12.5 contact hours.

Faculty Member	**Fall 2017**	**Spring 2018**
Dr. Sam Galewsky	15 [17] BI 407 Molecular Genetics	3 [5, Individual Instruction] Family Emergency Leave
Dr. Cynthia Handler (1/2 time)	4 [5] Gravett Pre-Professional Program	4 [10] Gravett Pre-Professional Program
Dr. David Horn	8[9, Individual Instruction] BI 314 Ecology	11 [13] BI325 Vertebrate Biology
Dr. Jeff Hughes	12 [14] BI330 General Microbiology Dir Study (2 students)	8 [12] BI 330 General Microbiology
Ros O'Conner (1/2 time)	5 [7] Lab Prep	8 [8] Lab Prep
Dr. Judy Parrish	10 [10] BI326 Plant Bio Dir Study BI481 Senior Seminar	11 [11] BI280/BI380 Ecological Journeys: Southern Africa
Dr. Marianne Robertson	9 [14] BI 303 Entomology	12 [12] BI481 Senior Seminar
Dr. Jen Schroeder	15 [18] BI 306 Comparative Animal Phys	17 [20] Graduate Physiology for Nurse Anesthetists (3)
Dr. Jenna Smith	9 [14]	9 [13] BI305/BI355 Molecular & Cellular Biology
Dr. Travis Wilcoxen	11 [13]	8 [9] BI 335 Physiological Ecology Chair Course Reduction Graduate Anatomy for Nurse Anesthetists (3)
Dr Laura Zimmerman,	8 [11]	11 [13] BI 312 Immunology

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, and further developed into individual Performance Learning opportunities. 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 should motivate 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. 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 for BIOLOGY DEPARTMENT GOALS

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 105/155), and Diversity of Life (BI 108/158). 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 entails a pre-test and post-test format. 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), which counts as 10% of their senior seminar course grade. Second, the theme of evolution is intentionally included in all appropriate courses 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 A). 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 this 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, which counts for 10% of their course grade. Students are charged a lab fee of $50 for this course (BI 471 or 472) to cover most of the expenses for this national exam. The results are used to evaluate the success of our program at providing adequate exposure and depth of biological knowledge.

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 and 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 draw conclusions from data personally collected or analyzed by the student. The following rubric is used to evaluate how well students use 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	• 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

	testing one variable		
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 is by working towards this goal that Biology majors have the best opportunities for Performance Learning. 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 emphasis of this is 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 similar to those presented at scientific meetings, and a scientific paper patterned after current research literature.

As the curriculum map indicates, this goal is 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; however, these projects must offer a new analysis of existing research and not simply report on the state of a field of study. 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 6 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.
- Presentations of student research at international, national, state/regional, and on-campus scientific meetings.
- Evaluation scores for objective 4 for paper, poster, and presentation as well as documentation of student presentations at scientific meetings, grant writing, and publication of manuscripts.
- 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 maintain this through the senior year. Over 90% of syllabi 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 more than 10% 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 (10% or less), 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.

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

Summary of the Evolution assessments for 2017/2018

When we gave the test to Ecology and Evolution students early in the semester, 54 students took the exam, averaging 6.05 out of 25 (Table 4). We have results from 28 students who took it at the end of the Fall semester, and they averaged 17.43 out of 25, improving by 45.5 percentage points.

In Diversity of Life, we have results from 40 students who took the exam, and averaged 14.2 of 25 points, demonstrating a decline from the end of the Fall Semester (keeping in mind that the end-of-Fall semester scores were from immediately after concentrated teaching of evolution, demonstrating fairly good retention).

The 28 seniors who took the assessment in 2017/2018 averaged 19.63/25. Four earned 24-25/25, 9 earned 20-23/25, 9 earned 18-19, 4 earned 15-17, and 2 earned under 15/25, for a 7.14% failure rate. For comparison of student performance in this assessment at the beginning of this 10-year assessment period, in 2006/2007, 35% of seniors did not earn at least a 60% on the assessment. In 2011/2012, we started making the test count as 10% of the senior seminar grade, and we are making progress in ensuring that our seniors understand and retain concepts of evolution.

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 correct 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 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 in most years, just after concentrated teaching of the concepts. This part of the assessment strongly falls into the GREEN light category.

Table 4. Breakdown of percent correct answers on the pre and post test for knowledge of evolution

Question	% Correct New Freshmen	% Correct Midyear Freshmen	% Correct End of First Year	% Correct Senior Seminar
AVERAGE 2017/2018	24.21% (54)	69.71% (28)	58.6% (40)	78.5% (28)
PREVIOUS YEAR	29% (52)	72.6 (47)	67.8% (18)	81.4% (26)
10 YEAR AVERAGE	21.85%	67.88 %	62.69%	71.29%
FIRST YEAR ASSESSED	23.11%	63%	61.2%	60%

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, just prior to the start of this 10-year assessment period, 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%). The Anatomy/Physiology courses are not strongly centered on the concept of evolution, 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 this goal (Table 5).

Table 5. Direct coverage of evolution on syllabi for Fall 2017 and Spring 2018 Classes for Biology Majors

Class	Instructor	Evolution directly addressed
BI 105 Ecology and Evolution	Parrish, Robertson, and Wilcoxen	Yes, Yes, Yes
BI 155 Ecology and Evolution Lab	Parrish, Robertson, Wilcoxen, O'Conner, Smith	Yes, Yes, Yes, Yes, Yes
BI 108 Diversity of Life	Parrish and Schroeder	Yes, Yes
BI 158 Diversity of Life Lab	Schroeder and Zimmerman	Yes, Yes
BI 300 Genetics	Hughes	Yes
BI 302 Histology	Handler	Yes
BI 303 Entomology	Robertson	Yes
BI 304 Developmental Biology	Schroeder	Yes
BI 305 Molecular & Cellular Biology	Galewsky	Yes
BI 306 Comparative Physiology	Schroeder	Yes
BI 312 Immunology	Zimmerman	Yes
BI 314 Ecology	Horn	Yes
BI 325 Vertebrate Biology	Horn	Yes
BI 326 Plant Biology	Parrish	Yes
BI 330 General Microbiology	Hughes	Yes
BI 335 Physiological Ecology	Wilcoxen	Yes
BI 380 Ecological Journey: Southern Africa	Parrish	Yes

BI 407 Molecular Genetics	Galewsky	Yes

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 fulfilling 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 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 students. Our proposal to require all biology majors to successfully complete at least one course from each of the six content areas (Appendix B) was approved by division and school and became effective for students entering the program during the 2007/2008 academic year. We have since required that students take both BI206 and BI207 in order to count those courses as a content area course. All students in all programs are exposed to a broad background in biology.

This year, 6.95% did not achieve a C- or above in a biology content class (Table 6). This is consistent with the average since we began using this criterion (Table 7). This year's data fulfill the criteria for a GREEN light for the number of students required 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-.

Course Title	Course Number	Number Enrolled	Number earning D+ or below
*A & P I	BI 206	11	3
*A & P II	BI 207	5	1
Genetics	BI 300	27	4
Histology	BI 302	9	0
Entomology	BI 303	11	0
Developmental Biology	BI 304	8	1
Molecules and Cells	BI 305	27	2
Comparative Physiology	BI 306	10	1
Immunology	BI 313	12	0
Ecology	BI 314	8	1
Vertebrate Biology	BI 325	11	0
Plant Biology (Dir Study)	BI 326	1	0
General Microbiology	BI 330	17	0
Physiological Ecology	BI 335	15	0
Ecological Journey – Southern Africa	BI 380	6	0
Molecular Genetics	BI 407	9	0

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

Table 7. Comparison of percentage of biology students not achieving a C- in a content class.

Semester	Percentage of students earning below a C-
FIRST YEAR ASSESSED (2006/2007)	7.94
10 YEAR AVERAGE	5.98
PREVIOUS YEAR	1.7
FALL 2017 / SPRING 2018	6.95

Since Spring 2010, we have required that our seniors take the Educational Testing Service field exam for biology (Fig. 1).

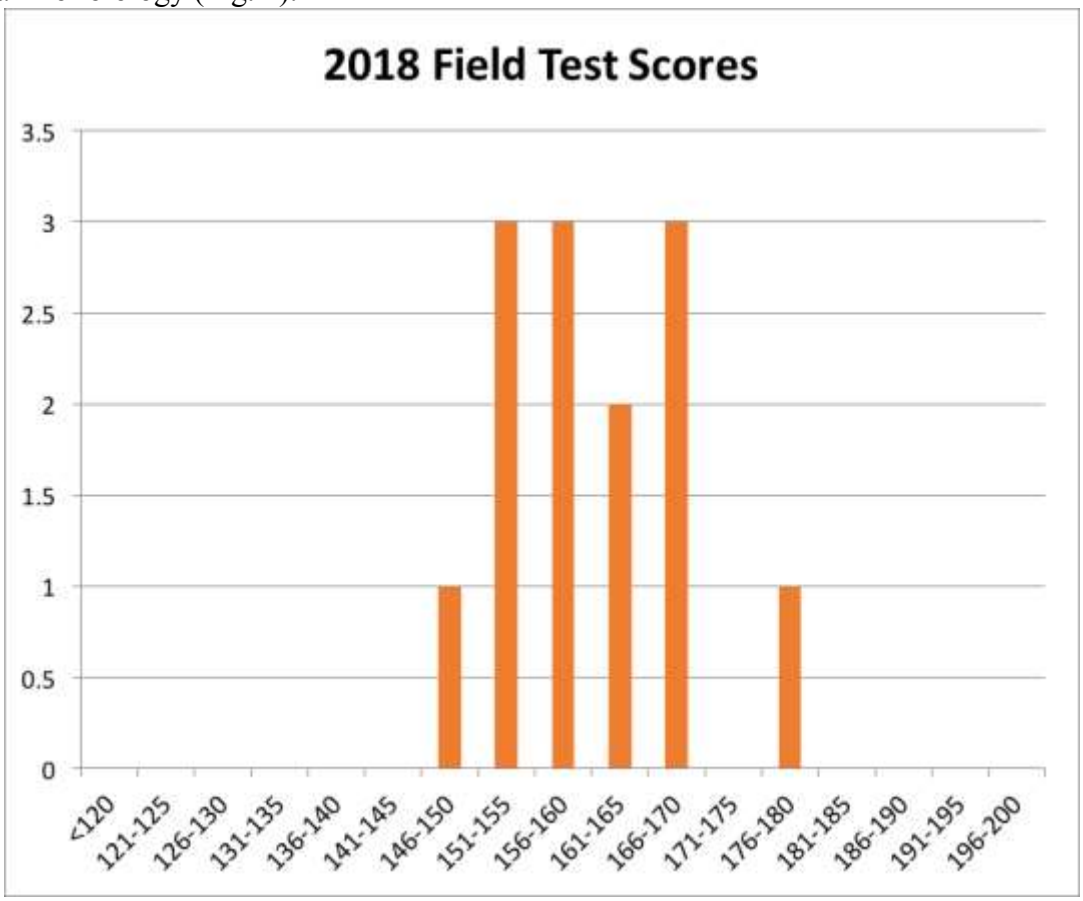

Figure 1. Educational Testing Services Biology Field Test Scores for Millikin seniors 2018.

In 2017/2018, 22 of 28 (78.8%) scored at least 150, at the 40th percentile or above for all students taking the exam nationwide (scaled overall test score ranges from 120 – 200). The range of scores was 136 - 177 for this year's seniors. In 2016/2017, 65.8% scored at least 150 or above. Millikin's mean total for 2017/2018 was 155.9, compared to 154.7 in 2016/2017, and an 8-year average of 153.7.

Of the four main subsets of scores, Millikin students performance was above the national averages for all four areas in 2017/2018 (Table 8).

Table 8. Mean ETS Biology Field test subset scores for Millikin students in 2010 - 2018, and national average for each subset for 2017.

	Cell Biology	Molecular Biology & Genetics	Organismal	Population Biology and Ecology and Evol
FIRST YEAR ASSESSED	52.47	49.04	50.19	56.28
8 YEAR AVERAGE	52.3	51.5	53.1	55.52
PREVIOUS YEAR	52.7	49.1	57.3	55.7
CURRENT YEAR	54.8	54.41	55.24	56.2
NATIONAL AVG (2017)	53.0	52.7	53.3	52.0

Students from Millikin biology programs have scored close to or above national averages for the field test, although over the past 9 years, there have been multiple years where students performed comparatively lower in the organismal-plant section of the Field Test (Fig. 2). Historically, 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. To prepare our students better for work in biology, we need to encourage most of our students to take a course in plant biology, especially those in the organismal disciplines. However, we are preparing students well in most of the areas, and our students scored well in analytical skills. Our department has a strong emphasis on critical thinking and application rather than merely memorizing facts, and we are glad to see that this emphasis is reflected in performance. ETS assessment of goal 2, GREEN light.

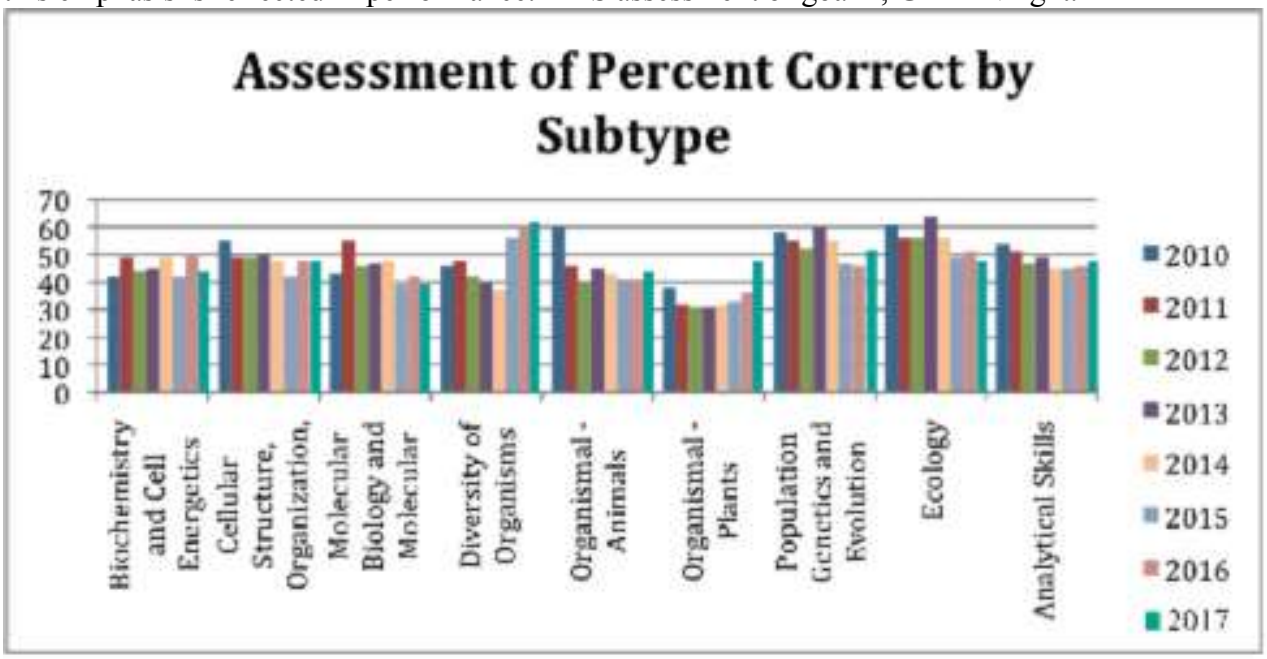

Figure 2. Average score of Millikin students for each of the subtypes of questions asked.

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 evaluation score improvement of 20% from freshman to senior years, in addition to an average evaluation

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 2017/2018 school year, we compared the Senior Seminar papers and freshmen Ecology/Evolution papers of eleven students (Fig. 3). The average evaluation score on the papers increased 22%, from 12.00 to 14.54. Paired t-tests showed that the total evaluation scores on the papers increased significantly ($p = 0.002$), as did design ($p = 0.03$) and conclusions ($p = 0.02$). Scores did not significantly improve for format ($p = 0.37$), but this was driven by one student who did not include an abstract in their senior paper as well as a number of high scores for the freshmen. 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 this departmental goal.

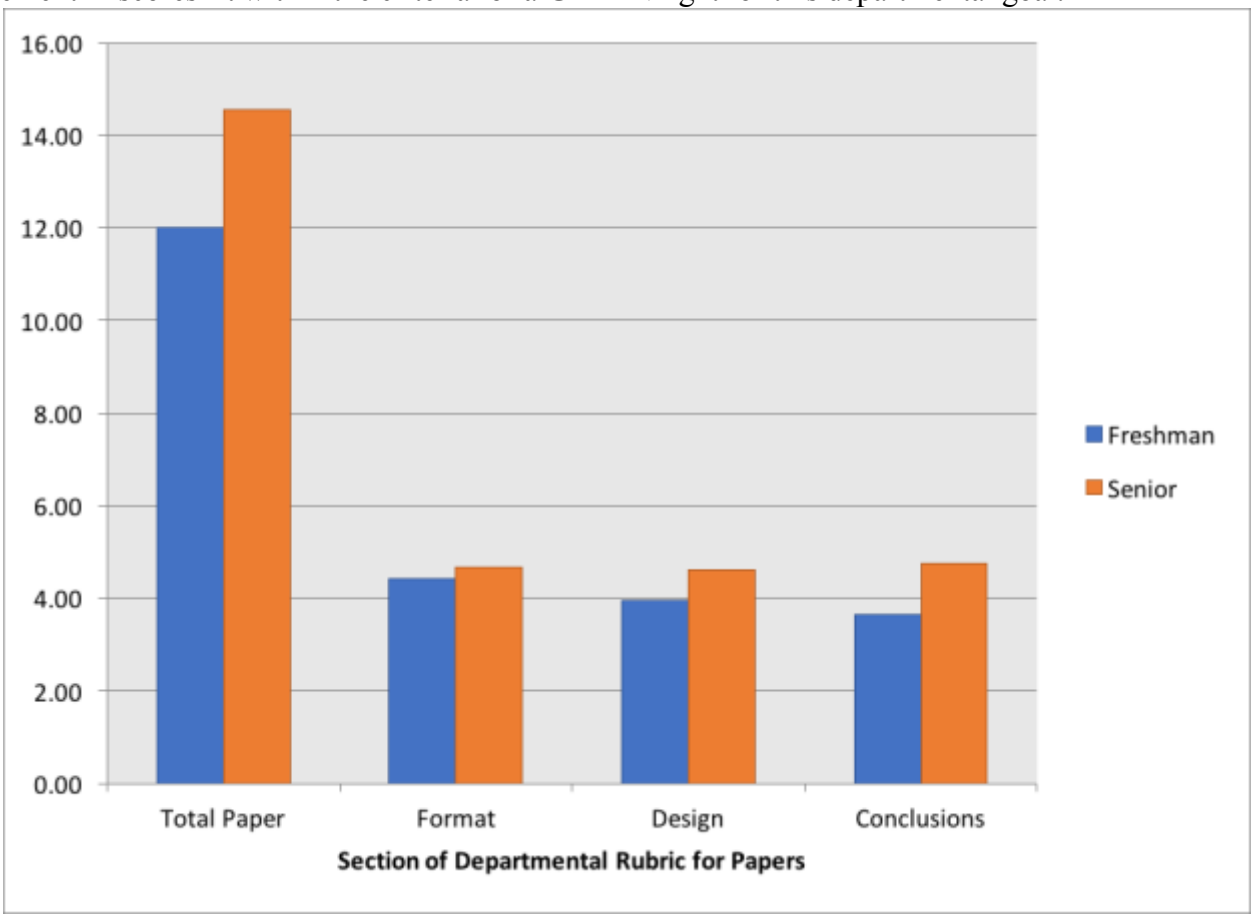

Figure 3. Comparison of Freshmen (entering fall 2013) papers from Ecology and Evolution class with Senior Seminar papers from the same students (fall 2017/spring 2018). Total possible point value is 15, with each of the three portions (Format, Design, Conclusions) of the rubric worth a possible five 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 hands-on, original research 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 9). Three of 26 students did not score above 15/20 on the poster in this

academic year. The average for all posters was 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, on average, students are generally meeting our expectations (Fig. 4). Overall, this is good evidence of student success, but with 11.5% of our students not individually meeting our threshold criteria, we will continue our mentoring efforts.

In addition to the poster and oral presentations for Senior Seminar, which meet the Performance Learning goals, students in our department also gave 9 presentations at the Beta Beta Beta North Central-1 District Convention, 12 presentations at the Illinois State Academy of Science Annual Meeting, and 16 presentations at Millikin's Celebration of Scholarship. Over the course of the 2017/2018 academic year, Biology students received two external research grants and six papers with student first authors were accepted for publication and/or published this year.

Table 9. 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)
FIRST YEAR ASSESSED	12.2	16.15	19.9
PREVIOUS YEAR	14.34 (9.75 – 14.48)	16.9 (9.7 – 19.83)	20.8 (16.4 – 23.7)
10 YEAR AVERAGE	12.95 (11.9 – 14.54)	16.3 (10.8 – 17.4)	20.36 (17.1 – 21.75)
Fall 2017	Combined	16.6 (9.7 – 20.0)	21.5 (15.1 – 23.7)
Spring 2018	14.54 (12.5-14.75)	15.2 (9.5 – 19.3)	20.0 (14.0 – 23.5)

*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 in attendance, 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.

Our 10-year average exceeds our goal of at least 20/25 points earned on the oral presentations (Table 9). In 2009/2010, only 11/32 individual presentation scores were 20 or over, This year, 19 of 28 students met or exceeded the goal of 20/25 on the oral presentations. Again, generally students are meeting our expectations in all categories of evaluation of the presentation. It appears that our strategies to prepare students 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 8 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 did not have any Biology Education students complete the requirements this year.

IMPROVEMENT PLANS

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, was 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 have used from Fall 2008 to the present 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 are judged by course syllabi. 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 as one of their specific program assessments, and are given a second chance after study (although only their first attempts are included in our assessment report). 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 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 (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 developed a check sheet to be included in the advising folder of each student. It is the annual responsibility of the advising professor to check the progress of advisees to determine whether they are in compliance both for exposure and grades. The number of students falling below a C- in the content area courses is used to assess our effectiveness in giving the students the exposure they need. Adding the field test from ETS improved our assessment of this goal.

The requirement for students in all programs to succeed in at least one course in each of the six content areas went into effect for 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.

Due to previous assessment report recommendations, our efforts to increase the collection and storage of the freshmen papers are typically much greater than the initial introduction of this assessment tool. In 2009/2010 both freshmen and senior papers were available for only seven students, whereas in 2016/2017, we had papers for 16 students, and we had papers for 11 students in 2017/2018.

Goal #4 – The senior seminar instructor calculates the scores of seniors in the seminar course BI 482 using the evaluation rubrics on oral presentations, posters, and papers submitted by the biology faculty.

We had all faculty participate in assessment of the posters and presentations in 2006 to develop our criteria, then returned to having the senior seminar instructor and the faculty mentor score the poste and the final 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 three faculty members evaluate each poster now, and all faculty in attendancet, usually at least six, evaluate the oral presentations. In some previous semesters, assessments were completed by only one faculty member, and those varied 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 improvement in evaluating posters is that we now have students present for the poster evaluations which are performed by three faculty members, in a manner very similar to how posters are presented at professional poster symposia.

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 will be remediated in order to attempt 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 five 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. Many students do excellent research with a faculty member, worthy of presentation at regional and national meetings, or even publication. Others have worked with little mentoring, some of whom complete projects that are more like "book reports" that do not result in success. Before we began developing firm criteria for performance, no student had failed senior seminar. 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. Students cannot sign up for the class until they have written approval from a mentor and an approved topic. Average scores on paper, poster, and presentation have improved and are more 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 we have set realistic goals and progress is being made toward achieving these goals.

- **Goal 1.** Freshmen students demonstrated a more than 45% improvement, from 24.2% to 69.7%, in their knowledge of evolutionary principles. At the end of the next semester, freshman scored 58.6%. From the test results of graduating seniors, this knowledge appears to be retained well. Seniors performed similarly to the students who had freshly studied evolutionary principles, 78.6%, retaining the concepts well. GREEN light.

  Biology faculty are successfully showing how evolution is incorporated into their major courses, with all demonstrating how courses directly relate to evolutionary concepts. GREEN light.

- **Goal 2.** In 2017/2018, biology majors took 187 upper-level classes that meet the criteria for goal #2, with 93.05% 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, and we have made progress along these lines. GREEN light.

Scores for Millikin students on the ETS biology field tests exceed averages, demonstrating that our program is effective at preparing students in biology. We have results slightly above the national averages in all four subsets of the discipline on the ETS test. 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 14.54 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 11 sets of papers from students as freshmen and seniors, and found that there was a significant mean improvement of 22% in their rubric scores. GREEN light.

- **Goal 4.** Average oral presentation score for the students in fall 2017 was 21.5**,** and the average was 20.0 for the students in the spring of 2018, both meeting, or exceeding the 20/25 needed for a green light. Average poster scores were 16.6 in the fall and 15.2 in the spring, again exceeding the 15/20 criterion for a GREEN light. The responsibility for instructing senior seminar rotates through the department, with a different person in charge each semester. The addition of participation of more biology faculty in the scoring process for assessment has produced more consistent data that can be used for program planning and improvement. Not only have students given a collective 37 presentations beyond the Senior Seminar requirements, many of those presentations were award-winning. Our students meet our internal goals and stand out among their peers from other institutions. GREEN light.

APPENDIX A **Biology Content Category Courses Fall 2018**

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		