

DEPARTMENTAL PLAN FOR ASSESSMENT OF UNDERGRADUATE STUDENT LEARNING

DEPARTMENT: BIOLOGY

PROGRAM:

B.S. IN BIOLOGY

MISSION STATEMENT:

The 21st century will be the age of biology, extending a century-long revolution in the biological sciences. The future quality of human existence will be strongly dependent on advances in the life sciences. Consequently, the Biology Department has and will continue to play a key role in the central mission of the University of North Dakota, which is to enhance the quality of life for all citizens. Demand for programs in Biology has been increasing and will continue to do so because of a vital need for graduates trained in the core biological sciences, particularly related to cellular and molecular biology, medicine, evolution and ecology, and conservation biology. Furthermore, since non-scientists largely make the political, economic and ethical decisions regarding the application and use of emerging biological knowledge, there is an increasing need to enhance scientific literacy among the non-scientific public in order to facilitate effective societal decisions. In light of these emerging trends, the primary mission of the Department of Biology at the University of North Dakota is to excel in teaching, research, and service and to facilitate the application of basic scientific knowledge to emerging societal issues. We provide instruction to our own majors and to a large fraction of other UND students through service courses. Our instructional activities emphasize the nature of scientific inquiry, including its ethical context, and the subsequent state of knowledge regarding all levels of biological organization, from molecules to ecosystems. We encourage the integration of knowledge across levels of biological organization in both our teaching and research activities, since such integration will play a key role in the future maturation of biology as a scientific discipline. Instructional activities are conducted in conjunction with externally-funded, nationally and internationally recognized research programs of individual faculty members, which provides a significant opportunity for experiential undergraduate and graduate training in the basic nature of scientific inquiry. We impact the economic development of the state and region through our grant activity, service and community work, and by educating and training students to become successful alumni and assume leadership positions in disciplines related to the biological sciences. We respect and value the individuality of faculty members with regard to their research, teaching and service contributions, while accomplishing the overall mission of the Department.

STUDENT LEARNING GOALS AND ANTICIPATED EDUCATIONAL OUTCOMES

- 1. Students will possess a sound factual knowledge of the core concepts and techniques in modern biology associated with all levels of organization, from molecules to ecosystems.**

By the time students complete a B.S. degree in Biology at the University of North Dakota, they should be able to demonstrate an understanding of:

- a. core factual concepts associated with all levels of biological organization,
- b. the primary techniques used to study biological processes, and
- c. the relationship(s) among core concepts from all levels of biological organization.

- 2. Students will possess a clear understanding of the creative nature of scientific inquiry, including how new knowledge is created and communicated, and the role critical thinking and ethical considerations play in scientific inquiry.**

By the time students complete a B.S. degree in Biology at the University of North Dakota, they should be able to demonstrate an:

- a. understanding of key principles of scientific inquiry,
- b. ability to design simple experiments and descriptive studies to answer basic biological questions, including the ability to critically evaluate the appropriateness of experimental treatments and sampling strategies,
- c. ability to critically analyze and interpret data,
- d. ability to critically read and interpret scientific literature to solve problems and answer questions,
- e. ability to effectively and persuasively communicate biological information orally, visually and in writing, and
- f. understanding of key ethical considerations associated with scientific inquiry.

EDUCATIONAL EXPERIENCES: ACHIEVING THE LEARNING GOALS AND ATTAINING THE EDUCATIONAL OUTCOMES

The curriculum associated with the B.S. in Biology has five tiers, which are structured to provide vertical integration of knowledge throughout the educational experience. Each tier and its associated educational experiences are discussed below.

Tier I – General Education and Cognate Requirements

The goal of this portion of the B.S. in Biology curriculum is to effectively integrate general education with requirements for the major, while simultaneously providing the student with the adequate background in cognate areas necessary to understand an integrative science like biology. In this respect, general education is more directly incorporated into the biology curricula than for most other disciplines. As for all majors at UND, one year of written composition is required for Biology majors. In addition, one year of foreign language and a course in oral communication is either required or strongly recommended. Additional cognate courses that are required or recommended include physics, general and organic chemistry, biochemistry, mathematics, and statistics. Other general education courses are recommended, depending on the particular area of concentration.

The Biology Department also contributes to the general education of non-scientists across campus through its non-majors (Biol 111/111L) course. This course emphasizes the basic nature of scientific inquiry and the relevance of core principles in the life sciences to key issues of societal concern, particularly related to molecular technology, evolutionary theory, and human-induced environmental change.

Tier II – Introduction to Biology and Scientific Inquiry

The goal of this portion of the curriculum, as represented by a two-semester lecture and laboratory course in introductory biology (Biol 150/150L, Biol 151/151L), is to provide a broad overview of the nature of scientific inquiry and core concepts related to all levels of biological organization, from molecules to ecosystems. The lecture portion of the course emphasizes the factual basis of the discipline, while placing these facts in the context of the ongoing and dynamic process of scientific inquiry. The laboratory portion of the course introduces students to some of the basic techniques used in biology and the thought processes associated with scientific inquiry.

Tier III – Core Concepts in Biology

The goal of this portion of the curriculum, as represented by a four course core sequence required of all Biology majors, is to provide an in-depth introduction to the principles and techniques associated with three key levels of biological organization (molecular, cellular, and organismal), along with an in-depth introduction to the evolutionary process that unites these levels. The courses required include Genetics (Biol 315), Cell Biology (Biol 341), Ecology (Biol 332), and Evolution (Biol 312). In addition, optional laboratory courses are available for Cell Biology (Biol 341L) and Ecology (Biol 332L). Because core classes usually enroll 150-200 students, primary emphasis in these classes is placed on an in-depth discussion of key principles and laboratory techniques associated with the core areas, rather than refining oral and written communication skills associated with scientific inquiry. The core principles and techniques learned in the four core courses, however, serve as the basis for additional training in potential areas of concentration, where written and oral communication skills are increasingly emphasized.

Tier IV – Areas of Emphasis

The goal of this portion of the curriculum, as represented by four potential areas of emphasis, is to provide students the opportunity to specialize in areas related to key societal interest, including general biology, molecular-cellular-developmental biology, pre-health science, and ecology - evolutionary biology. Courses in the specialization serve to refine student understanding of the core principles and factual information related to molecular, cellular and organismal levels of organization, while addressing additional levels of biological organization not directly covered in the core sequence. Furthermore, since courses in the area of specialization normally have fewer students enrolled, they increasingly emphasize instruction in critical skills associated with the process of scientific inquiry, including the ability to critically read and interpret scientific literature and the ability to effectively communicate biological information, in both written and oral form.

Tier V – Senior Capstone Course

The senior capstone experience consists of a required, 3 credit course (Biol 477). The course is wide ranging. It potentially includes a discussion of topics of current interest in biology. The course also assesses the student's ability to critically analyze, synthesize, and communicate scientific information. After a brief review of key principles related to scientific communication and ethical considerations, students perform an independent research project. Normally, the research project is literature based but it can also be based on data associated with a student's individual research experience. Results of the research project are summarized in appropriate written and oral format and the written report is evaluated by at least two members of the Biology faculty.

MEASURING EDUCATIONAL SUCCESS: DIRECT ASSESSMENT METHODS, TIMELINE, AND RESPONSIBILITY

To directly and quantitatively determine whether students are attaining the stated educational goals and desired educational outcomes, student assessment is focused on two primary areas. Area 1 includes the goals and outcomes associated with a sound factual knowledge of key concepts and techniques in biology (goal 1 a - c), along with their relationship to the process of scientific inquiry (goal 2 a - c). Area 2 includes the critical analysis, interpretation and synthesis of scientific literature, along with the effective and ethical communication of this information (goal 2 d - f). The two areas use different assessment approaches, which are discussed in detail below.

Area 1 Assessment - Key Concepts and Techniques in Biology and Their Relationship to the Process of Scientific Inquiry (goals 1 a - c and 2 a - c)

Our approach to direct and quantitative assessment of the goals and outcomes associated with this area uses a standard repeated measures experimental design, where attributes of individual subjects are measured before and after some "treatment," but without an untreated control group. The "treatment" in this case is the "educational experience" of the student associated with Tiers I – IV of the curriculum. Lack of an adequate control group prevents effective separation of the relative influence of student maturation from educational experience in causing a change in student performance. The design does, however, provide valuable and insightful information as

to the knowledge of the initial and final student product and the influence of their educational experience.

A “pre-treatment” assessment allows us to quantitatively establish baseline knowledge of students entering the program. The assessment tool is administered to all students who declare themselves biology majors at the start of our first semester Introductory Biology class (Biol 150). While this approach does not provide a “pre-treatment” assessment for students that transfer into the program, it results in a significant pool of students for assessment purposes who will complete their entire program at UND. The assessment tool is a series of questions that establishes individual demographic data, previous educational background, and understanding of key principles in five core areas of interest: genetics/molecular biology, cell biology, ecology, evolution, and the nature of scientific inquiry. The structure and administration of the exam is patterned after other comparable assessment tools, including Advanced Placement and Graduate Record Exams. In order to effectively measure an increase in knowledge among students over time, questions in the “pre-treatment” assessment tool reflect a strong gradation of difficulty, ranging from factual recall of basic ideas that were likely covered in the student’s prior biological education, to interpretation of sophisticated data, and synthesis of complex ideas related to multiple levels of biological organization. The exam is constructed and administered by the Biology Department Associate Chair for Curriculum and Assessment (ACCA). Potential questions for inclusion on the exam are solicited from all faculty members in the department, but particularly from instructors in the introductory and core courses. Questions are also obtained from previous Advanced Placement and Graduate Record Exams. The assessment tool is constructed by the ACCA in consultation with the Chair of Biology, but the entire faculty of the department eventually approves the final form of the exam. Demographic data, educational background, and performance of each student in each of the five key areas of knowledge is recorded by the ACCA in a data base permanently maintained within the department.

A “post-treatment” assessment given to each major completing the program allows us to quantitatively establish success of the Tiers I – IV educational experience in achieving the stated learning goals and desired educational outcomes (goals 1 a - c and 2 a - c). The “post-treatment” assessment is administered at the start of the Senior Capstone Course (Biol 477) and is required of all students for completion of the course. The “post-treatment” assessment is identical in structure and content to the “pre-treatment” assessment, with a strong gradation in difficulty of questions, from simple factual recall to those requiring considerable background and complex thinking skills. It includes an update of the student’s demographic data, previous educational experience and a direct assessment of their knowledge of the concepts in the five core areas of interest: genetics/molecular biology, cell biology, ecology, evolution, and the nature of scientific inquiry. For each student, updated demographic data, educational background, and performance on each of the five key areas is recorded by the ACCA in the data base permanently maintained within the department.

Area 2 Assessment - Critical Analysis, Interpretation, and Synthesis of Scientific Literature, Along with Effective and Ethical Communication of this Information (goal 2 d – f)

The objective of the Area 2 assessment is to directly establish the student’s ability to engage in three key areas related to scientific inquiry: (1) effective use of information technology to locate scientific literature relevant to a particular area of inquiry, (2) the ability to critical analyze, interpret, and synthesize literature or data-based information, and (3) the ability to effectively communicate information orally and in writing. The independent research project each student

completes in the Senior Capstone Course (Biol 477) serves as the basis for Area 2 assessment. The result of each student's research project is independently evaluated by at least two members of the Biology faculty. Scoring of student performance is done with explicitly defined metrics to assess both written and oral aspects of scientific inquiry (see Attachments # 1 and 2). Scores for each student on their analytical and communication abilities are provided to the ACCA, who records them in the permanent data base maintained in the department.

MEASURING EDUCATIONAL SUCCESS: INDIRECT ASSESSMENT METHODS, TIMELINE, AND RESPONSIBILITY

In addition to direct assessment, the department also gathers indirect measures of student success. On an annual basis, the ACCA obtains summary statistics for four indirect measures of student success and this information is maintained in a data base maintained within the department. Many of these are obtained directly from the Office of Institutional Research. These measures include:

- **Student Success in Introductory and Core Courses:** the percentage of students passing/failing and dropping our Introductory and Core Courses,
- **Retention and Graduation Rates:** the percentage and number of students initially enrolled in the program that actually graduate,
- **Student Evaluations:** student evaluations for both majors and non-majors are aggregated for a department-wide analysis of not just student perception of the quality of instruction, but also the clarity of the learning goals in our courses and how well students thought they actually achieved those learning goals, and
- **Alumni Surveys and Career Development:** alumni are regularly surveyed regarding their impressions of the program and their progress in obtaining positions related to their field of interest.

USE OF DIRECT AND INDIRECT ASSESSMENT RESULTS: DOCUMENTATION AND DECISION MAKING

Results from direct and indirect assessment are summarized annually by the ACCA and presented to the entire faculty for discussion during the spring semester. The annual summaries are maintained as part of a permanent record in the department. In addition to annual reports, multi-year trends in assessment results are provided to the faculty by ACCA when deemed appropriate, but at a minimum of every 7 yrs, associated with the undergraduate program review and evaluation. Based on assessment results, the faculty is encouraged to express any concern(s) it might have about the pattern of student performance and, more importantly, suggest how deficiencies in student performance might be improved, either by additional resources or restructuring of pedagogical approaches and course offerings. The Chairperson of Biology, in consultation with the departmental Executive Committee and the ACCA, then makes recommendations to the department's faculty and higher level administration, regarding the need for curricular adjustments and/or additional resources to enhance student performance.

PROPOSED SENIOR CAPSTONE COURSE

Proposed Required Senior Capstone Course:

Biol 477. Senior Capstone Course. 3 credits. Prerequisite: Senior status in biological science and completion or concurrent registration in the required core sequence of courses, or consent of instructor. Key aspects of scientific inquiry and communication are investigated and assessed.

The course will be offered every semester with current enrollment anticipated to be 25-30 students per semester. One faculty member will serve as the coordinator for the course per semester. The goal is to have at least 4 faculty members willing to serve as coordinator, so that an individual faculty member would coordinate the course at most once every four semesters. The course will be wide ranging. At the start of the course the students will read and discuss recent literature related to the integration of core biological concepts across multiple levels of biological organization. The coordinator will then provide all students with a brief review of key principles related to effective communication in the sciences, including the social nature of scientific communication, principal forums for communication, reading and writing research reports, reviewing prior research, preparing oral presentations, and ethical considerations associated with scientific communication. Students will then conduct a literature search on a topic of their choice and present the results of that search in both written and oral format. All written reviews and oral presentations will be graded with established rubrics (see attachments 1 and 2). Faculty coordinators will have flexibility in structuring the details of the course as they deem appropriate but grading with established rubrics will be required to allow comparisons among students for assessment purposes. A possible progression related to the topic development, writing of the final review paper, and oral presentation of the results is illustrated below, as adapted from Porter (2005):

1. **Selection of topic** – The student tentatively chooses a topic paper on which they will base their research project. The topic can either be based on their specific interests or selected from a list provided. Each member of the faculty will be asked to supply potential topics and topic papers from their respective areas of interest to be included on the list.
2. **Preliminary research** – A preliminary literature search is conducted using sources with which the student is familiar.
3. **Information literacy instruction** - The student receives formal instruction from an information specialist on bibliographic resources (electronic and paper) and their use.
4. **Topic paper selection** – The student makes the final topic paper choice.
5. **Preliminary topic choice** – The student reformulates the preliminary topic statement and performs the search once approved by the course coordinator and the information specialist.
6. **Topic refinement** – The topic statement is refined, and additional searches are performed using all of the available resources. If necessary, the student seeks additional guidance from either the course coordinator or individual faculty in the topic area of interest.

7. **Update bibliographic list (assignment 1)** – The student develops a list of 25-30 articles that updates the topic of the topic statement. The bibliographic list is graded using the associated rubric (attachment 1).

8. **Preparation for abstracting** - Three articles are chosen from the updated list, and these are read for clear understanding.

9. **Abstracts (assignment 2)** - Abstracts are written for the three articles chosen (due 2-3 weeks after assignment 1). The abstracts are graded using the associated rubric (see attachment 1).

10. **Outline of paper** – The student reads additional papers and formulates the outline of the final paper using the headings provided (“Background,” “Principal Approaches,” “Present Knowledge,” “Future Directions,” and “Conclusions”). The course coordinator provides feedback on the basic outline.

11. **Initial draft of paper (assignment 3)** – The student is given the grading rubric for the paper prior to the writing assignment (attachment 1). The student then writes the initial draft of the paper. If necessary, the student seeks help in science understanding from either the course coordinator or a faculty member in the area of interest. The student can also seek help in grammar, syntax, and sentence structure from the Writing Center on campus. The initial draft is graded by the course coordinator using the rubric. Special emphasis is placed on providing feedback on how to improve the clarity of the presentation,

12. **Final draft of paper (assignment 4)** – The student writes the final paper (due at the end of the semester). The final paper is graded using the rubric by two faculty members; the course coordinator and a faculty member in the topic area of interest.

13. **Oral presentation (assignment 5)** - The student gives a 15 minute oral presentation at the end of the semester, summarizing the results of the paper. The presentation is of a form and style that meets the expectations of a scientific audience and is presented with a sense of purpose that reflects the audience being addressed. The oral presentation is graded by the course coordinator and the other students in the class, using the associated rubric (attachment 2).

ATTACHMENT # 1

**BIOLOGY 477 – SENIOR CAPSTONE COURSE
SCORING RUBRIC FOR LITERATURE SEARCH, ABSTRACT
PREPARATION AND “STATE OF THE ART” PAPER¹**

DIMENSION**LEVEL OF ACHIEVEMENT****Bibliographic
Search**

	<i>Excellent</i>	<i>Competent but Needs Work</i>	<i>Needs Substantial Work</i>
	25-30 articles Cited	20-25 articles cited	less than 15 articles cited
	Topic statement clear	Topic statement general or unclear	Topic statement missing or not interpretable
	Articles clearly related to the topic statement	Some articles not related to the topic statement	Many articles not not related to the topic statement
	Citation format followed exactly	Citation format inconsistent or or frequently not as specified	No consistent format for citations
	Spelling correct	Some spelling errors	Frequent spelling errors

**SCORE _____
(70 POINTS POSSIBLE)**

Abstracting Of Papers

<i>Excellent</i>	<i>Competent but Needs Work</i>	<i>Needs Substantial Work</i>
3 abstracts	2 abstracts	< 2 abstracts
Abstracted papers clearly related to the topic	Some abstracted papers not clearly related to the topic	None of the abstracted papers are clearly related to the topic
Abstracts grammatically correct; precise, clear wording, spelling correct	Some abstracts are not clear or organization is mixed or incomplete; some grammar and spelling errors	No adherence to the format of an abstract; excessive grammatical and spelling errors

SCORE _____
(30 POINTS POSSIBLE)

“State-of-the-Art” Paper

<i>Excellent</i>	<i>Competent but Needs Work</i>	<i>Needs Substantial Work</i>
------------------	-------------------------------------	-----------------------------------

Content

Arguments clear and complete and easy to follow	Arguments nearly complete but lack clarity and sometimes hard to follow	Arguments and content incomplete, poorly worded and unclear, and difficult to follow
Content accurate, thorough, complete concise, and coherent	Content inaccurate, wordy, illogical or incomplete	Content illogical, paper lacks any focus
Relationships among concepts easy to follow	Relationships among concepts sometimes difficult to follow	Relationships among concepts largely absent

Draws conclusions logically and consistent with evidence	Some conclusions illogical	Conclusions largely lack logic
Effectively weighs alternative points of view	Considers alternative points of view	Ignores alternative points of view

Organization and Format

Paper effectively structured to illustrate complex relationships	Relationships among structural components present but poorly developed	Incoherent structure
Headings and sub headings effectively used	Headings and sub headings present but ineffective	Headings and sub headings absent
Sentence structure complete, clear, and grammatically correct	Sentence structure and spelling show regular errors	Sentence structure poorly developed with many errors
Quotations infrequent and only when necessary	Several quotes that could have easily been omitted	Excessive use of quotations
Spelling accurate	Some misspellings	Many misspellings
Paper format followed precisely	Format nearly correct but not followed precisely	Format mostly not followed
References always used when needed	Some references missing	Many missing references
Reference style in text and bibliography consistent and correct	Reference style inconsistent and some incorrect	Reference style very inconsistent and many incorrect
Tables and figures used when appropriate	Figures or tables missing or poorly incorporated	Figures or tables are ineffective

Summary

**Paper goes well beyond
minimum expectations**

**Paper achieves
minimum
expectations**

**Lacks considerably
in coherence and
style**

**SCORE _____
(100 POINTS POSSIBLE)**

**TOTAL SCORE _____
(200 POINTS POSSIBLE)**

¹Adapted from: Porter, J.R. 2005. Information Literacy in Biology Education: An Example from an Advanced Cell Biology Course. Cell Biology Education 4: 335-343.

ATTACHMENT #2

**BIOLOGY 477 – SENIOR CAPSTONE COURSE
SCORING RUBRIC FOR ORAL PRESENTATION¹**

DIMENSION	LEVEL OF ACHIEVEMENT		
	<i>Excellent</i>	<i>Competent But Needs Work</i>	<i>Needs Substantial Work</i>
<u>Style</u>	Spoke clearly, slowly and with sufficient volume; modulated voice tone and quality; intelligible	Mumbled, spoke too fast or too slow; inappropriate volume; droned but still intelligible	Mumbled, spoke too fast or too slow; inappropriate volume; droned; intelligibility compromised
	Used expressive and appropriate body language and maintained eye contact	Body language did not distract but remained rigid; no eye contact ; some distraction from content	Remained rigid and fidgeted; never looked at the audience; body language seriously distracted from content
	Presented information in own words; did not read material	Mixed reading of presentation with own words	Read presentation
	Effectively used time allotted	Timing was too long or too brief	Barely used time allotted or used much too much time
	Supportive material and technology effectively used	Supportive material and technology used; some fumbling but did not distract from presentation	Supportive materials and technology ineffectively used, distracted from presentation

**STYLE _____
(30 POINTS POSSIBLE)**

Organization

Well organized, with introduction, body, and conclusion	Mostly well organized but problems with clarity of the relationship between introduction, body, and conclusion	Rambled , with little evidence of an introduction, body, or conclusion
Organization highlighted and made clear through use of appropriately captioned graphics or other materials	Used materials to create sense of organization but too wordy or too vague to assist the audience in an effective manner	Materials were not used or did not assist in creating a sense of organization in any significant way

**ORGANIZATION _____
(30 PPOINTS POSSIBLE)**

DIMENSION	LEVEL OF ACHIEVEMENT		
	<i>Excellent</i>	<i>Competent But Needs Work</i>	<i>Needs Substantial Work</i>
<u><i>Content</i></u>			
	Facts and examples were detailed, accurate, and appropriate	Facts and examples were mostly detailed, accurate and appropriate but there were lapses	Facts and examples were seriously lacking in detail and were inaccurate or inappropriate
	Theories or hypotheses referenced were accurately described and appropriately used	Theories or hypotheses were referenced but they were not accurately described or not appropriately used	Theories or hypotheses were inaccurately described and inappropriately used or not referenced or used at all
	Analysis, discussion, and conclusions were explicitly linked to the examples, facts, and theories	Connection between analysis, discussion, and conclusions is evident or implied but not explicitly linked to examples, facts, and theories	No clear connection between the analysis, discussion, and conclusions, and the facts, examples, and theories
	Openly considered various points of view related to the issue	Considered various points of view but dismissive of legitimate points of view	Ignored all alternative points of view in the literature
	Drew conclusions consistent with the evidence	Most conclusions consistent with the evidence but some were not	Conclusions inconsistent with the evidence

CONTENT _____
(40 POINTS POSSIBLE)

Summary

Clearly meets the standards of a professional oral presentation	Lacking in some components of a professional oral presentation	Clearly does not meet the standards of a professional oral presentation
---	--	---

TOTAL SCORE _____
(100 POINTS POSSIBLE)

¹Adapted from: Stevens, D. D. and A. J. Levi. 2005. Introduction to Rubrics. Stylus Publishing, Sterling, VA. 131 pp.