Graduate Program Learning Goals, Outcomes, and Assessment Plan
Doctoral program in Integrative and Systems Biology
Department of Integrative Biology
University of Colorado Denver

1. Statement of Purpose:

This document serves to describe the learning goals for the graduate programs of the University of Colorado Denver's Department of Integrative Biology. The learning goals, competencies, and outcomes described here with be used to: 1) conduct effective outcomes assessment of graduate student learning; 2) to better conceptualize what we expect a graduate of our M.S. and Ph.D. programs to be and think like upon graduation; 3) to better conceptualize why and how we assess graduate students as part of preliminary, comprehensive and thesis/dissertation examinations; and, 4) to strategically plan our graduate curriculum to align with learning goals and competencies.

These goals align with both the American Association of Colleges and Universities Essential Learning Outcomes and the American Association for the Advancement of Science Vision and Change for Undergraduate Biology Core Concepts and Competencies. We apply these goals to learning outcomes for M.S. and Ph.D. in the Department of Integrative Biology's graduate program.

2. Definitions:

- Learning goal: Learning goals are concise statements that explicitly describe the content, higher-order thinking, and skills that students are expected to learn over the duration of a curriculum.
- Core concept: Core concepts define the fundamental content and concepts that are emphasized in a curriculum.
- Core competencies: Core competencies describe what higher-order thinking and professional skills are emphasized in a curriculum.
- Outcomes assessment: Outcomes assessment is the process by which evidence is collected to measure the effectiveness of a program in carrying out its intentions (e.g., learning goals and core competencies).

3. Program Description:

The graduate program in Biology is a research-based program designed for students with interests in any of a broad range of basic science subjects including molecular, cellular, behavioral, evolutionary, ecological, or wildlife population biology. The Program is administered by the Department of Integrative Biology and the Graduate School at the University of Colorado Denver and offers a Master's of Science (MS) degree in Biology and a doctoral degree (PhD) in Integrative and

Systems Biology. The program consists of nearly 50 faculty members from 16 different departments and partnering organizations, and about 40 graduate students.

Graduate training in Biology at the University of Colorado Denver is intended to prepare students to become critical problem solvers who are qualified to address biology-related issues at national and international levels. The program philosophy recognizes science not as a collection of facts, but rather as a process designed to help make informed decisions about the nature of evidence; scientific methods are used to guide decisions about hypotheses. The program is designed to equip students with the background necessary to generate new ideas and to participate in scientific debates, both academically and publically. Therefore, the goal is to provide advanced training in the current concepts, theories, debates, and methods for modern biology from a curriculum that emphasizes critical thinking and communication through a series of seminars and research-oriented courses that are specifically tailored to student research programs.

4. Core Concepts and Competencies:

"Biology is evidence based and grounded in the formal practices of observation, experimentation, and hypothesis testing."

From the American Association for the Advancement of Science Vision and Change Core Competency of "Ability to Apply the Process of Science" and the American Association of Colleges and Universities Essential Learning Outcome of "Inquiry and Analysis.

Ph.D. Integrative and Systems Biology:

1) **Data and theory production:**

   Students must:

   a. Engage in rigorous and original research that advances knowledge in their field of study
   b. produce a quantity of original data or theory consistent with productivity of recent PhD graduates

2) **Specialized knowledge and skills within sub-discipline:**

   Students must:
   a. demonstrate specialized knowledge of content and methodology within their chosen subfield; and,
   b. demonstrate an ability to acquire knew knowledge and skills as the field changes.

3) **Apply the process of science through inquiry and analysis:**

   Students must:
   a. characterize the state of the field and identify critical gaps in knowledge or ability;
   b. identify a testable/doable question(s) that could contribute the gaps in the state of the field;
   c. evaluate reliability of sources of information and evidence;
   d. locate, summarize and explain how a study contributes to the field;
   e. develop and critique scientific hypotheses;
   f. design and conduct observational and experimental studies with attention to replication and statistical design constraints;
   g. analyze and interpret data to form conclusions;
   h. articulate variables and assumptions required by a study; and,
   i. place scientific findings into a larger intellectual/contextual framework.

4) **Use abstract/quantitative reasoning:**

   “Biology relies on applications of quantitative analysis and mathematical reasoning.”

   “Biology focuses on the study of complex systems. All students should understand how mathematical and computational tools describe living systems.”

   From the American Association for the Advancement of Science Vision and Change Core Competency of “Ability to Use Quantitative Reasoning” and the American Association of Colleges and Universities Essential Learning Outcome of

"Quantitative Literacy".

Students must:

a. manage and organize data sets;
b. create and interpret data visualizations (e.g. graphs, tables);
c. apply descriptive and inferential statistical methods of design and analysis for diverse study questions;
d. use data as evidence to draw conclusions about biological processes;
e. apply mathematical formulas to reason about biological processes and understand the underlying probability in the calculations;
f. describe the assumptions used to make a model and evaluate alternate models;
g. explain the effects of probability and uncertainty in biological models;
h. interpret models given changing variables;
i. create a conceptual model to represent related components and processes of biological systems;
j. create a quantitative model to represent related components and processes of biological systems; and,
k. interpret quantitative and conceptual models.

5) Communicate and collaborate

"Biology is a collaborative scientific discipline. Biological research increasingly involves teams of scientists who contribute diverse skills to tackling large and complex biological problems."

From the American Association for the Advancement of Science Vision and Change Core Competency of "Ability to Communicate and Collaborate with Other Disciplines" and the American Association of Colleges and Universities Essential Learning Outcomes of "Oral Communication ", "Written Communication", and "Teamwork".

Students must:

a. Engage in a dialogue with other scientists about content, design, analysis, and techniques in an appropriate manner;
b. demonstrate an understanding of context, audience, and purpose in writing and other communications;
c. display appropriate conventions of organization, content, formatting, presentation, and style in writing and other communications;
d. correctly cite high-quality, relevant sources to support arguments; and,
e. communicate scientific understanding to both scientific and general audiences
f. explain areas of uncertainty in their field.

6) Context of Science

“Biology is conducted in a societal context. Biologists have an increasing opportunity to address critical issues affecting human society by advocating for the growing value of science in society, by educating all students about the need for biology to address pressing global problems.”

From the American Association for the Advancement of Science Vision and Change Core Competency of “Ability to understand the relationship between science and society” and the American Association of Colleges and Universities Essential Learning Outcomes of “Ethical Reasoning” and “Civic Engagement”.

Students must:

a. Explain the implications of their research for society;
b. Explain relationships between biological principles and global, economic, environmental and societal issues;
c. Describe how the history of scientific thought has shaped the development of scientific principles; and,
d. Understand the philosophy of science
e. Articulate ethical issues in their area of research.

5. Curriculum Mapping:

The following is a matrix of learning experiences, i.e., core graduate courses, which will provide students an opportunity to learn the skill or knowledge listed:

	Core Courses				Elective Courses (Including Special Topics (BIOL 7050))
A student should be able to:	Seminar (BIOL 6655)	Biological Workshop (BIOL 6705)	Biological Data Analysis (BIOL 6764)	Integrative and Systems Biology (BIOL 7010)	
1. Specialized knowledge and skills within sub-discipline:	✓			✓	✓
2. Apply the process of science through inquiry and analysis:	✓	✓	✓		
3. Use abstract/quantitative reasoning:			✓		
4. Communicate and collaborate	✓	✓	✓		
5. Context of Science	✓			✓	✓

6. Assessment Approaches:

Assessment data will be collected at two time points: 1. A student's thesis proposal defense (M.S.) or comprehensive examination (Ph.D.) in which a dissertation proposal was defended; and, 2. At a student's thesis/dissertation defense.
Each committee member will evaluate a student's performance using the rubric and submit it to the Graduate Program Assistant within 5 working days. The data will be analyzed and visualized by the Program Director in collaboration with the Program Assistant.

The rubric is presented in appendix A.

7. Report of Assessment Results:

The Graduate Program Director, in consultation with Integrative Biology's Graduate Advisory Committee, will produce an assessment report each year

Appendix A – Assessment Rubric and Instructions

INTEGRATIVE BIOLOGY GRADUATE PROGRAM
Program Assessment Rubric

This rubric is designed to collect data for program-level assessment. It is not intended to be used to assess an individual student's skills and knowledge, although it does provide a context for a committee member to consider a student's progress in our graduate programs related to our graduate program's core concepts and competencies. We will use the assessment data, in summary form, to evaluate how well our graduate program trains students.

Instructions: Each member of a proposal defense, including the Ph.D. comprehensive examination, and thesis/dissertation defense committee should evaluate a student's current knowledge and skills. Each committee member should return the completed rubric directly to the Graduate Program Assistant within 1 week of the defense. These data will not be given to the student or any faculty member except as in a summary assessment report that does not identify individual committee members or students.

While completing the rubric, faculty should give an honest assessment of the student's knowledge and skills. In rating student performance for each of the five categories, look over all of the criteria for that category relevant to the performance you ae reviewing, and make a summary rating for each category, and then look across each category to make an overall summary rating.

Student Name:

Evaluator Name:

Date:

Check One: Proposal Defense ____   Thesis/Dissertation Defense ____

PROGRAM LEARNING OUTCOMES:	Below Proficient	Proficient	Above Proficient
1. Specialized knowledge and skills within sub-discipline Students must: a. demonstrate specialized knowledge of content and methodology within their chosen subfield; and, b. demonstrate an ability to acquire new knowledge and skills as the field changes.			
2. Process of science through inquiry and analysis Students must: a. characterize the state of the field and identify critical gaps in knowledge or ability; b. identify a testable/doable question(s) that could contribute the gaps in the state of the field; c. evaluate reliability of sources of information and evidence; d. locate, summarize and explain how a study contributes to the field; e. develop and critique scientific hypotheses; f. design and conduct observational and experimental studies with attention to replication and statistical design constraints; g. analyze and interpret data to form conclusions; h. articulate variables and assumptions required by a study; and, i. place scientific findings into a larger intellectual and contextual framework.			
3. Abstract/quantitative reasoning			

Students must: a. manage and organize data sets; b. create and interpret data visualizations (e.g. graphs, tables); c. apply descriptive and inferential statistical methods of design and analysis for diverse study questions; d. use data as evidence to draw conclusions about biological processes; e. apply mathematical formulas to reason about biological processes and understand the underlying probability in the calculations; f. describe the assumptions used to make a model and evaluate alternate models; g. explain the effects of probability and uncertainty in biological models; h. interpret models given changing variables; i. create a conceptual model to represent related components and processes of biological systems; j. create a quantitative model to represent related components and processes of biological systems; and, k. interpret quantitative and conceptual models.			
4. Communication and collaboration Students must: a. Engage in a dialogue with other scientists about content, design, analysis, and techniques in an appropriate manner; b. demonstrate an understanding of context, audience, and			

purpose in writing and other communications; c. display appropriate conventions of organization, content, formatting, presentation, and style in writing and other communications; d. correctly cite high-quality, relevant sources to support arguments; and, e. communicate scientific understanding to both scientific and general audiences;			
5. Context of Science Students must: a. Explain the implications of their research for society; b. Explain relationships between biological principles and global, economic, environmental and societal issues; c. Describe how the history of scientific thought has shaped the development of scientific principles; d. Understand the philosophy of science;			