Elements of the Assessment Process
Form E-1-A for Boston College Departments/Programs

Department/Program_____Biology Department Core_____

1) **Have formal learning outcomes been developed? What are they?** (What specific sets of skills and knowledge does the department expect its majors to have acquired before they graduate?)

The Boston College Natural Science Core Curriculum learning outcomes are listed below.

Students completing the Natural Science core will:

1. expand their understanding of the principles, body of knowledge, and investigative strategies that comprise science and its technological applications;
2. develop a scientific literacy that will promote curiosity, respect for the scientific method, and general awareness of the limitations of scientific conclusions;
3. recognize the role of scientific discovery, past, present and future, in interrelated concerns such as human health, societal well-being, and planetary sustainability; and
4. appreciate the role of science in defining their relationship with the natural world and their position within the cosmos.

The Biology department has identified the following learning outcomes for students majoring in Biology.

Learning outcomes for students who complete a B.S. or B.A. degree in Biology include the following:

- Students will understand the core concepts of Biology:
  - Evolution
  - Cellular Structure & Function
  - Information Transfer & Gene Expression
  - Energy Transformation
  - Systems & Organismal Biology
- Students will apply the process of science through observation, experimentation and hypothesis testing.
- Students will be able to use quantitative reasoning in the analysis of dynamic biological systems
- Students will use bioinformatics and databases to study biological processes.
- Students will understand and practice the ethics surrounding scientific research.

For students who complete the B.S./M.S. degree in Biology, they are expected to acquire the additional learning outcomes:

- Conduct original, publishable research in a field of Biology.
- Demonstrate an in-depth knowledge of a specific area of expertise.

2) **Where are these learning outcomes published? Be specific.** (Where are the department's learning expectations accessible to potential majors: on the web or in the catalog or in your dept major handouts?)

Natural Science core learning outcomes are available on the Arts and Sciences Core website.

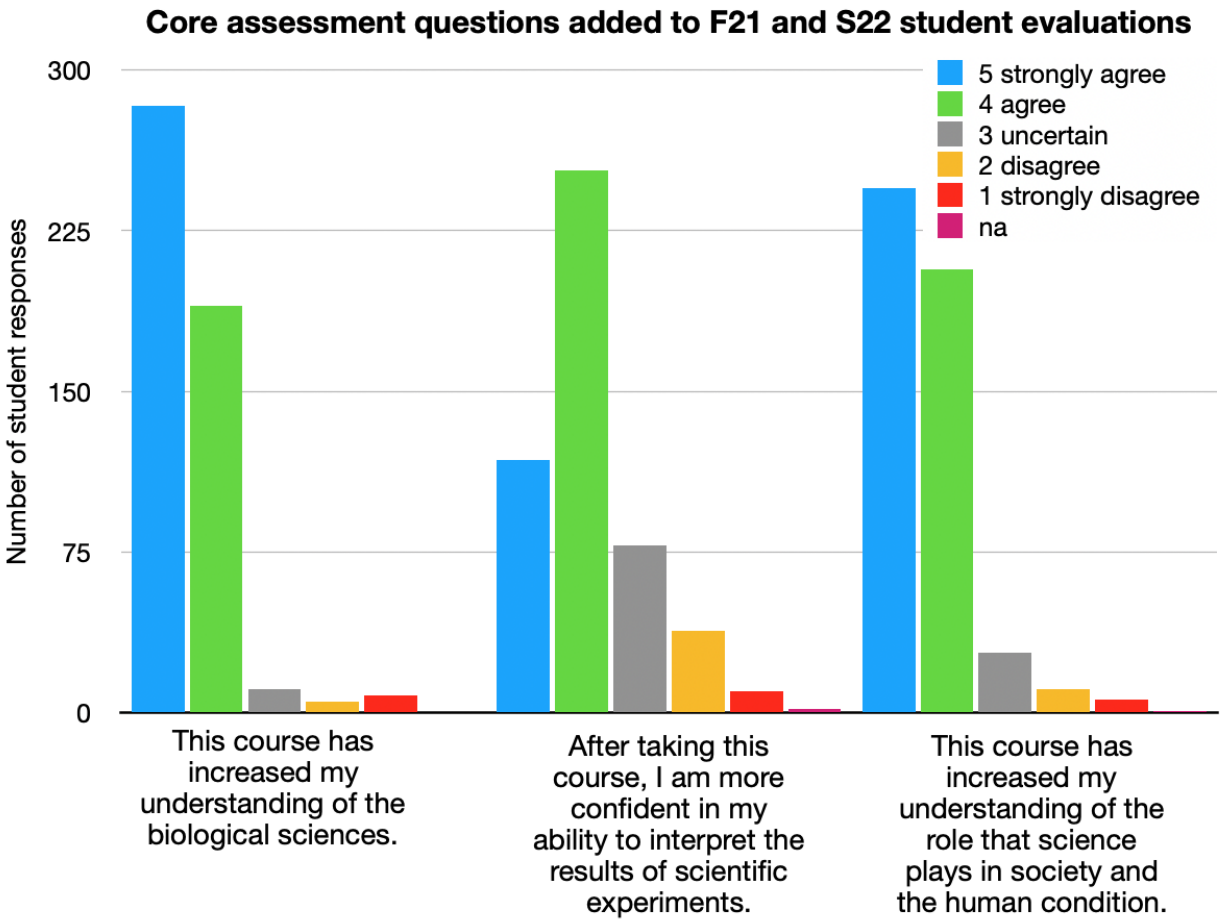
Biology department major learning outcomes are available on the biology department website undergraduate webpage.

3) **Other than GPA, wheat data/evidence is used to determine whether graduates have achieved the stated outcomes for the degree?** (What do you use to assess which of the student learning outcomes are being achieved more or less well?)

1: Student's Perceptions of Learning

Each year, different aspects of the curriculum are assessed. This year the following likert-scale agree/disagree statements were added to student evaluations in the introductory courses, to assess the extent to which these courses are addressing the core learning objectives. These two courses (Molecules and Cells and Ecology and Evolution) are major requirements, and also satisfy the Natural Science core requirement. The results shared below are the compilation of 499 student responses from 5 different course sections taught by 5 different instructors. The results come from two sections of Ecology and Evolution (45% of responses) and 3 sections of (Molecules and Cells 55% of responses).

1. This course has increased my understanding of the biological sciences.
2. After taking this course, I am more confident in my ability to interpret the results of scientific experiments.
3. This course has increased my understanding of the role that science plays in society and the human condition.



Overall, 95.2% of student respondents agreed or strongly agreed with the first statement. Students overwhelmingly feel that our introductory courses increase their understanding of the biological sciences. Similarly, 91% of student respondents agreed or strongly agreed with the third statement that the course increased their understanding of the role that science plays in society and the human condition. There was broad agreement as well with the second statement, but it was less overwhelming. 74.7% of student respondents agreed or strongly agreed that after taking the course they were more confident in their ability to interpret scientific results. For this question, 78 students (16.6%) selected "uncertain" indicating that this may be an area where we can strive for more explicit, direct, and/or transparent instruction.

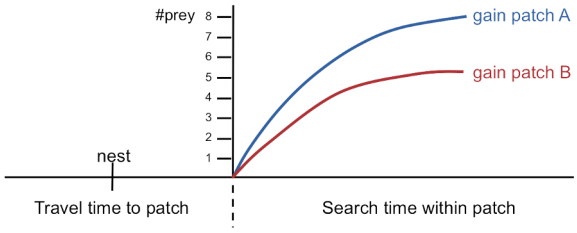
2: Scientific Data Analysis

To assess student's ability to analyze scientific data in a less subjective way, instructors in these courses also added data analysis questions to course final exams. In all cases, these questions provide evidence that students are able to interpret scientific data. In the future, we can include similar questions as a pre-assessment (as Prof. Warner did) to better assess the extent to which these analysis skills were gained during the course.

From Prof. Jeffrey DaCosta's Ecology and Evolution course

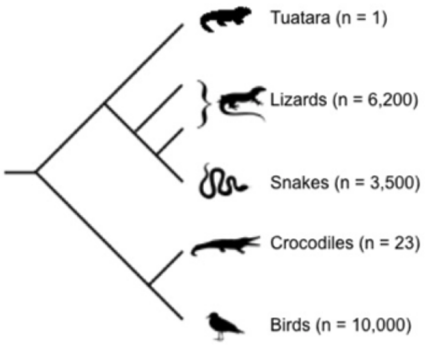
The following two questions on my final exam present a figure representing a biological model (question 1) or phylogeny (question 2) and ask students to interpret the data presented with respect to a topic covered in class. Correct answers are in bold, and the percentage of students marking each answer is given in parentheses. In each case, students were exposed to similar figures during the semester, but not the same ones given in these questions. The high percentage of correct answers is thus a reflection that students are able to interpret figures and transfer previous knowledge to a familiar, but different, situation.

Question 1. Under the marginal value theorem, when a bird is returning to its nest from patch A it is expected to have _____ prey items compared to returning from patch B.



- **a. more (98.5%)**
- b. less (0.5%)
- c. the same (1%)

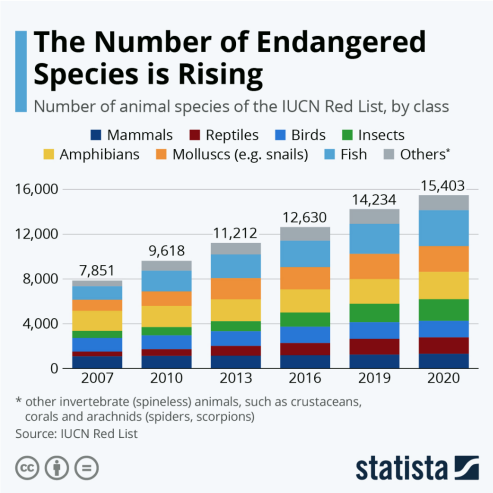
Question 2. This phylogeny shows the relationships among five lineages and the estimated number of extant species within each lineage. Which lineage should receive conservation priority based on the phylogenetic diversity metric?



- **a. tuatara (84.3%)**
- b. lizards (3.4%)
- c. snakes (0%)
- d. crocodiles (7.8%)
- e. birds (4.4%)

From Prof. Heather Olins' Ecology and Evolution course

This chart shows the numbers of threatened species on the IUCN Red List from 2007 to 2020, broken down by class of animals. Please select all of the true statements based on this chart.

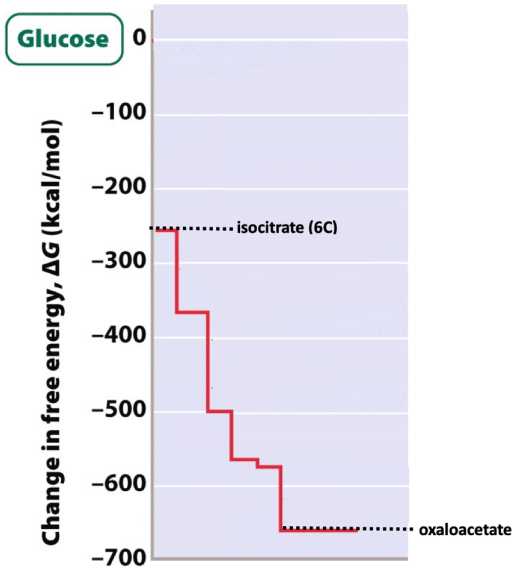


Between 2007 and 2020 the number of endangered species has come within a few hundred species of doubling.	144 respondents	**92 %** ✓
There are more endangered species of fish than any other class of animals.	144 respondents	**92 %** ✓
The number of threatened species increased between each measurement period.	147 respondents	**94 %** ✓
All classes of animals show similar patterns of increase.	46 respondents	29 %
The largest increase in the number of threatened species took place between 2019 and 2020	7 respondents	4 %

While only 58% of students earned full credit on this question, the vast majority of students selected the three correct statements. In hindsight, the 4th statement (which 29% of students selected) was too vague to accurately assess comprehension.

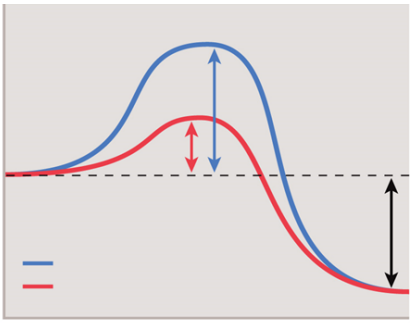
From Prof. Rebecca Dunn's Molecules and Cells course

The figure to the right shows the energy changes in part of the citric acid cycle, beginning with isocitrate and ending with oxaloacetate. According to the image, how many enzymes function in this part of the citric acid cycle?
(133 responses)
0% A. 2
0% B. 3
5.3% C. 4
87.2% D. **5 (correct answer)**
7.5% E. 6



From Prof. Doug Warner's Molecules and Cells course

These two questions from the Final Exam evaluated the ability of the students to interpret the results of a scientific experiment and understanding how biological systems work:



62) Consider the above Figure, what type of reaction is this?

A. Endergonic
B. Exergonic
C. Null reaction
D. Z scheme
E. Non-spontaneous reaction

63) Still considering that figure ----Which arrow shows the net change in free energy of this reaction?

A. Leftmost
B. The middle Arrow
C. Rightmost
D. None of the Above

Question Results:

Question62	B	4.96	**94.21**	0.83	0.0
Question63	C	3.31	1.65	**94.21**	0.0

In both cases 94% of the students were correct in their answer, a similar question was introduced in a previous midterm in which ~60% of the students were correct.

3: Applying Ecology and Evolution Concepts

To more deeply interrogate the extent to which students in the Ecology and Evolution course are able to apply course learning to the real world, Profs. Olins and DaCosta had students reflect on the following question towards the end of the semester. This was an in-class, non-graded (low stakes) assignment designed to see how well students could articulate real-world connections without preparation. ~10% of student reflections (15 responses from each section) from both sections were randomly selected and anonymously analyzed by the instructor of that section.

Reflection Prompt:

Current climate change and its impacts on the biosphere and human society will be one of the most prominent subjects of the next century. Climate change has become highly politicized, however, which obscures and undermines our scientific understanding of the topic. Suppose that a person in your life thinks that climate change is happening but "is not a big deal." Drawing on your experience in this class, choose and describe THREE specific themes/subjects/concepts that you would use to demonstrate to this person that climate change is important at a local and/or global level.

Scoring Rubric:

1. Poor: Response does not adequately address the prompt, contains inaccurate information, and/or does not identify 3 themes from the course
2. Adequate: Response identifies 3 relevant themes from class without making a case that climate change is relevant and important
3. Good: Response demonstrates ability identify relevant aspects of course content and lays out a logical argument/demonstration
4. Excellent: Response demonstrates detailed knowledge and the ability to build an effective and thoughtful argument

Overall the combined average score across both sections was 3.4. This demonstrates a solid and consistent ability to recall course material, make connections, and formulate an appropriate argument.

Responses from Prof. DaCosta's students were about a page each, so examples are not included here. Responses from Prof. Olins' students were shorter, possibly due to less time in class allotted to this assignment. If we attempt this again, we can standardize conditions to make comparing across sections more appropriate. For both courses, annotated student responses and evaluation explanations are available upon request.

Summary explanation from Prof. DaCosta (Average score 3.3)

Students broadly did well in identifying important biological factors related to climate change, mostly from material that was presented in class. In most cases enough pertinent details were provided to support the statements being presented. Students could improve in describing why the changes of these biological phenomena are important to a lay person.

Summary explanation from Prof. Olins (average score 3.5)

All of the 15 randomly selected responses demonstrate the ability to identify relevant course content and select 3 themes/subjects/concepts that could be used to demonstrate that climate change is important at a local and/or global level (scores greater than 2). The average score was 3.5. Only one response fell below the "good" threshold (a score of 2.5) because while it listed 3 relevant themes, it did not describe them, and therefore the overall case made was minimal. All other responses demonstrated

understanding of relevant concepts and the ability to connect them into a compelling argument in only a few minutes, and without any advanced notice.

Example adequate/good response (score of 2.5):

> "human health and connection between pollution and climate change | the differences between 1 and 1.5 degree increases | the keeling curve and warming levels caused by industrialization"

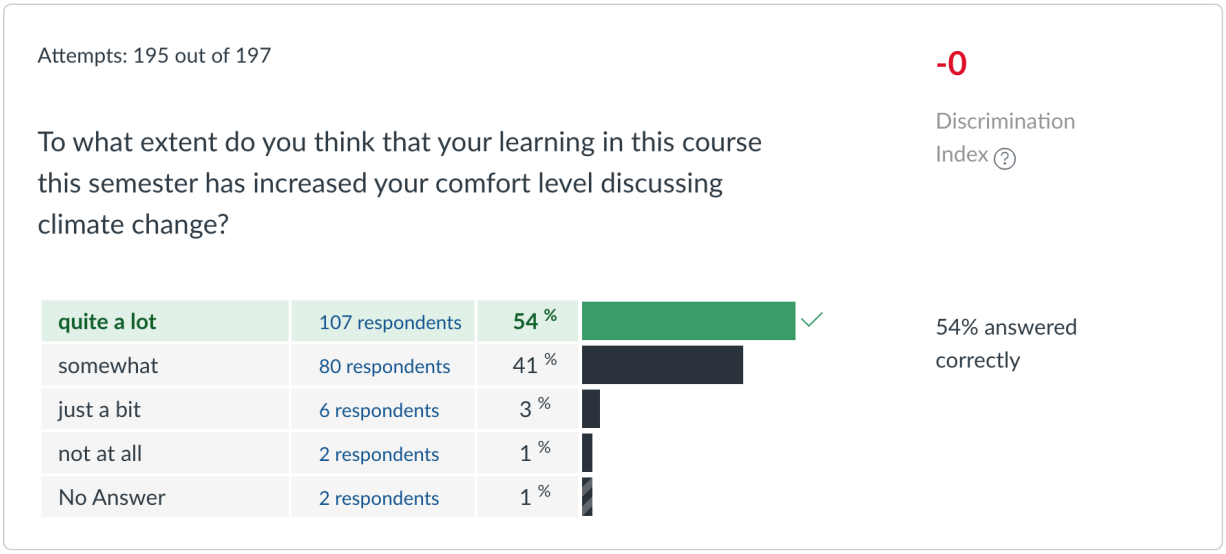
Example good response (score of 3):

> "I would first argue that at some point the consequences of human actions against the environment are irreversible and cannot be corrected. I would then add that there are several human health consequences related to global climate change, meaning that it should be important to any person who wishes for good health. Lastly I would remind them of the unpredictable nature of agriculture due to the change in climate, which would change the entire economy and intake of food and other resources in their daily life"

Example excellent response (score of 4):

> "- Climate change is causing ice sheets in the Arctic to melt. This is causing sea levels to rise tremendously. It's protected that in decades to come, places bordering the ocean, such as major cities like Miami, will be completely underwater. This will displace people living in this threatened areas and will cause a surge of people moving inland, increasing population density.
>
> - Climate change also means temperatures are rising. Specifically, near the equator, summer months are becoming unbearable. This has begun to cause serious health effects among communities in this region. Mosquitoes thrive off warm, damp climates, causing the spread of insect borne illnesses among humans. As well, high heats are worsening heart health, asthma, and cause heat stroke.
>
> - As well, climate change is warming the ocean's temperature. This ocean warming will have a multitude of effects on marine organisms, specifically coral reefs. A slight increase in temperature makes water unlivable for coral. WE have already seen major coral reef systems, like the Great Barrier Reef, decline in size as coral dies off. This affect marine ecosystems, as many organisms depend on coral for habitat and resources. As well, the loss of these coral reefs is a loss of a beautiful part of the world that humans will not be able to get back"

In Prof. Olins' course, this reflection included the following multiple choice question. 95% of students stated that their learning in the course had increased their comfort level discussing climate change outside of class either "quite a lot" or "somewhat".



4) **Who interprets the evidence? What is the process?** (Who in the department is responsible for interpreting the data and making recommendations for curriculum or assignment changes if appropriate?)

Department Core Representative and faculty teaching in the core.

5) **What changes have been made as a result of using the data/evidence?** (Have there been any recent changes to your curriculum or program? Why were they made?)

In previous years, this assessment focused on non-majors courses. The shift to our introductory courses occurred this year, so we look forward to implementing changes and being able to discuss the results of those changes next time around.

6) **What evidence do you have that the changes have resulted in improved learning outcomes?**

See previous response. We anticipate that an increased emphasis on applied data analysis, and discussions highlighting the relevance of these skills, will lead to higher overall agreement with statement 2 above (After taking this course, I am more confident in my ability to interpret the results of scientific experiments) in subsequent rounds of assessment.

7**)** **Date of the most recent program review.** (Your latest comprehensive departmental self-study and external review.)

2019-2022 (in progress). Previously completed in 2007.