COLL 100 Assessment — Course Portfolio Narrative Template

Use this template to write your Course Portfolio Narrative.

Description of COLL 100 from the COLL 100 Course Approval Form: COLL 100 courses are devoted to "big ideas": significant questions and concepts, beliefs and creative visions, theories and discoveries that have shaped our understanding of the world. COLL 100 courses challenge students to think rigorously and to develop and practice communication skills beyond the written word. COLL 100 courses introduce students to the College's library and other academic resources, and to the ways in which information is accessed, evaluated, and communicated.

Prefix, course number, and section number (e.g., HIST 100-01/AMST 100-01): BIOL 100 02

CRN: 25676 Course title: Atoms to Cells

Instructor name: Beverly Sher

Please briefly describe how your course addresses each of the following features of COLL 100 courses:

A. What is the big idea or ideas addressed in this course? What are the one or more significant questions and concepts, beliefs and creative visions, and theories and discoveries that have shaped our understanding of the world addressed in this course?

As I say in the syllabus, the big idea at the heart of this course is that size matters: life as we know it on Earth is only possible because of the way the world works at the nanoscale. The scientific consensus is that life's beginnings lie in physics and chemistry, and the constraints that physical laws impose on living things have shaped their evolution. Big questions that we address in the course include the following:

-What is life?
-How do the molecular machines that cells use work?
-How do cells manage and transfer information?
-How do cells produce and use energy?
-How might these cellular processes have evolved?

Theories and discoveries discussed in the course included many core ideas in physics (statistical mechanics, entropy, energy), chemistry (redox chemistry, enzymes, self-assembly of lipids into membranes), and biology (the theory of evolution, the origin of life, gene structure and function), all discussed at a level that a scientifically literate but non-specialist reader of good science writing could understand. We also discuss scientists and their work, from Boltzmann to Monod to Watson, Crick and Franklin.

B. How does this course introduce students to the excitement of scholarly inquiry?

Over the course of the semester, we read and discussed three books written by scientists for the general public: Peter M. Hoffmann's *Life's Ratchet: How Molecular Machines Extract Order from Chao*s, John Parrington's *The Deeper Genome: Why There is More to the Human Genome Than Meets the Eye*, and Nick Lane's brilliant *The Vital Question: Energy, Evolution, and the Origins of Complex Life*.

For each reading assignment, students prepared a set of discussion points, comments and questions on the reading that they wanted to talk about in class. They also posted their most important discussion point for the day to a discussion thread on Blackboard before class. I read and commented on each set of discussion points, and I found that doing this allowed me to have ongoing one-on-one conversations with my students which sometimes continued during office hours and often led to interesting tangents, including recommendations for more reading. These were generally received with enthusiasm- the students were truly curious about the material we discussed in class.

The books do a wonderful job of showing students the scientific process and the ways in which it plays out in the world. Each of the authors discusses the historical underpinnings of the field he presents: students learned about the lives of many eminent mathematicians and scientists, as well as about their contributions to science and the ways in which the social contexts in which they did their work affected its acceptance. All three authors also take students to the very edge of what is known in their fields, showing them the excitement of scientific inquiry. Hoffmann provides a thorough conceptual introduction to the interplay of energy and entropy in the nanoscale-level functions of molecular machines, and he enthusiastically discusses his research, in which he uses atomic force microscopy to study molecular machines and their properties, describing some of the most interesting unanswered questions in his field. Parrington describes not only the history of genetics and the role of DNA in the transmission of information, but many hot topics in biology, including the ENCODE project and the question of how much of the human genome is "junk," the 3D structure and function of the human genome, and the possibility of editing the human genome using CRISPR-Cas9 technology. Nick Lane discusses current theorizing about the possibility that life began in alkaline vents on the ocean floor, something that would explain the universal use of proton gradients in energy production by cellular life on Earth, and he also talks about how a single endosymbiosis that began with the engulfment of a bacterium by an archaeon may well have been the big event that led to the evolution of complex life. Lane's fascinating book takes students to the very edge of what is currently known in this field, and he makes well-supported, if highly speculative, arguments about how all of this might have taken place. Our discussions of these books showed the students the provisional, evidence-driven nature of science, as well as the excitement that ensues when a new piece of evidence upends previous ideas about how the world works.

Our Fermi problems also helped students understand the excitement of the scientific process: using numbers and approximations provided by *Cell Biology by the Numbers*, by Ron Milo and Rob Phillips, as well as information from some of our journal club papers, students were able to come up with estimates that helped them develop a better intuitive sense for the size, volume, and time scales at which important cellular processes operate. They were delighted to discover that they could use this information, along with some reasonable assumptions, to make back-of-the-envelope calculations that gave plausible answers to the questions posed in the Fermi problems. By the end of the semester, the experience of having done Fermi problems in class helped students to understand the thought processes underlying some of the arguments in Nick Lane's book: they recognized that he was doing Fermi problems, too!

Our journal club articles also helped students understand the excitement of scholarly inquiry. Our papers included a number of highly cited/ discussed scientific papers, including a recent paper on the linear relationship between the number of stem cell divisions in a tissue and the risk that cancer will develop in that tissue, as well as several papers that refined previous estimates of such things as the ratio of human cells to cells in the human microbiota. Students learned about the argumentative nature of scientists as well as the provisional nature of science from reading and discussing these papers.

C. Information Literacy – How does this course help students learn how to:

(1) find and assess intellectually reliable sources and to use these sources appropriately in arguments

Our discussions about source quality began with the first reading assignment, in which we talked about the sources used by our author, as well as his qualifications; we had similar discussions about the rest of the books used in the course. Throughout the course, in our discussions of the readings, we discussed the arguments that our authors made: were their assumptions warranted? Did the data they presented support their conclusions, or were there alternative interpretations?

In our Swem Library presentation, Lauren Goode also talked about source quality and how to evaluate it.

In addition, the authors of *Cell Biology by the Numbers*, which the students read for the course, talk extensively about how to find and evaluate information in the scientific literature, and they discuss the limitations of the information they present in thoughtful detail.

While solving the Fermi problems, students identified the numbers and approximations they used and thought carefully about whether a piece of information was a number or an approximation; they also listed the assumptions they made as they solved the problem. They also sketched the problem and described the way they had solved it. Going through these steps helped them to evaluate our journal club papers: many of the student questions during the discussions of those papers involved the assumptions that the scientific papers' authors had made and the quality of the information that they had used to support their arguments.

In addition, as students did the research for their semester projects, they carefully evaluated the quality of their sources, listed the assumptions they made as they came up with their estimates, and described each step in the solution of their problem. As the students presented their estimates in class on the last day, I was pleased to hear them talking about the uncertainties in their calculations- clearly, they were thinking about the strength of every component of their arguments.

(2) access and evaluate digital information as appropriate for the course?

This was a thread throughout the course, starting with our in-class discussions about high-quality sources of information, such as scientific journal articles and the BioNumbers website. Lauren Goode's library presentation reminded students about the electronic resources available through Swem Library, to which they had (presumably) been introduced in the fall semester.

D. Communication Skills:

(1) What communication skills beyond the traditional written word are developed in this course?

The course emphasized communication through appropriate use of visual information in several ways: through the sketching required for the Fermi problems, through the graphical abstracts, and through my insistence that students use assertion-evidence slides rather than bullet-pointed slides for their journal club presentations. Michael Alley's *The Craft of Scientific Presentations*, which was required for the course, helped students think carefully about effective slide design.

In addition, the Fermi problems and semester project required students to communicate quantitatively, through their use of estimation.

Finally, oral communication was integral to the course. Students solved the Fermi problems in small groups, a process that required a great deal of informal oral communication. The journal club presentation was a formal oral presentation, and it also required a great deal of informal oral communication as the groups planned their presentations. The semester project videos also required oral communication, as did the students' informal presentations of their results on the last day of class.

(2) How does this course help students develop the ability to present and defend what they have learned (focusing on the norms of communication beyond the written word for the particular discipline(s) of this course)?

See (1) above.

(3) How do assignments give students repeated opportunities, with feedback (instructor and/or peer), to develop their communication skills beyond the written word?

See (1) above.

For the journal club presentation, students were required to do a practice talk for their peers and receive feedback; in addition, the in-class group presentation was graded.
For the semester project video, students were required to do a practice talk for tat least one other student taking the course first and receive feedback; the final video was graded.
The Fermi problems and graphical abstracts were graded.

E. Connection between Course Assignments and Learning Expectations associated with COLL 100:

(1) How do the specific assignments (projects, tests, presentations, etc.) included in this course portfolio relate to and address **Learning Expectation 1:** "Students will construct and support an argument based on a variety of sources"?

All of the Fermi problems required this (the numbers and approximations came from a variety of sources).
The semester project also required this (the numbers and approximations came from a variety of sources, and the students also cited sources for their assumptions).

(2) How do the specific assignments (projects, tests, presentations, etc.) included in this course portfolio relate to and address **Learning Expectation 2:** "Students will communicate information effectively using media beyond the written word and into the realms of visual, quantitative, oral, digital, and/or multi-media expression"?

The journal club presentation (good slides, oral presentation) and and semester project (oral presentation video, calculations, sketch of the solution) required this, as did the Fermi problems (calculations, sketch of the solution).