

# Adventures along the Road to Inquiry: The Journey So Far

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The concept that students learn more effectively by doing than by being told what to do has prompted a move toward the increased use of active learning in the classroom and open-inquiry in the laboratory. At the University of Maryland we are in the process of transitioning away from “cookbook” fixed-inquiry exercises and toward more open-inquiry experimentation in our introductory biology labs. Having worked through administrative and logistical hurdles, the first truly open lab experiences proved as challenging as expected, but also demonstrated an unexpected level of student enthusiasm and ability of teaching assistants to guide students and make it a positive experience.

**Keywords:** Curriculum design, Inquiry, Ecology lab, Molecular biology laboratory

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## Introduction

*“It’s a dangerous business ... going out your door. You step onto the road, and if you don’t keep your feet, there’s no knowing where you might be swept off to.”*

– J.R.R. Tolkien

Life science majors at the University of Maryland take an introductory sequence of two courses that are prerequisites for most upper level courses. BSCI105 (cellular and molecular biology) and BSCI106 (ecology and evolution) are independent of each other, yet both have evolved learning goals that go beyond disciplinary knowledge to higher order skills of reasoning and synthesis. The labs have been moving towards an emphasis on science as a process, in parallel with national trends, and a concerted effort has been made to transition from traditional exercises to an open-inquiry model. Past lab exercises in both courses have been largely fixed-inquiry with a focus on following protocols, data collection and analysis, and support of lecture topics. Over the last two years, both labs have made changes to support open-inquiry, focusing on hypothesis testing and experimental design. The spring semester of 2014 was the first semester with full implementation of these new goals.

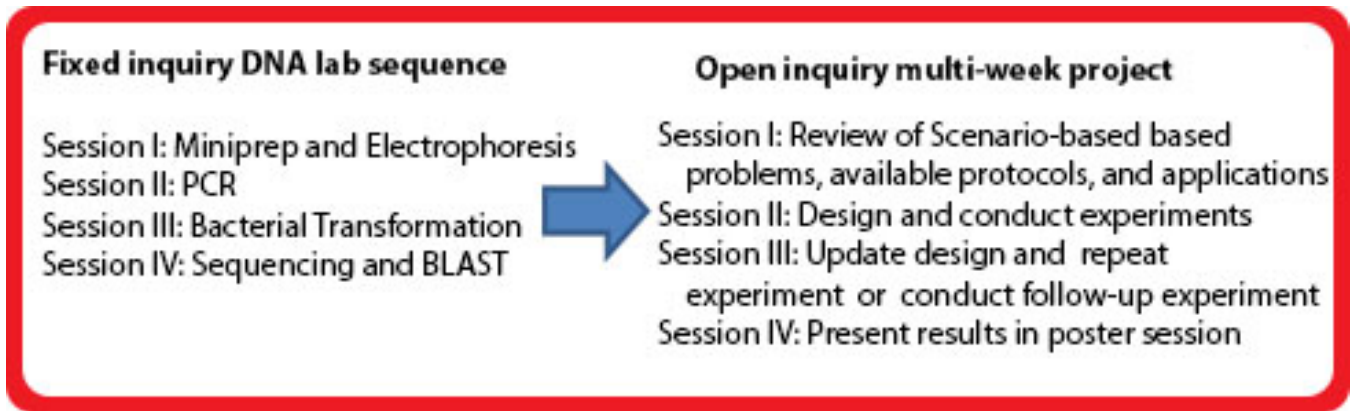
A nationwide trend towards adding inquiry-based labs into introductory courses gained prominence follow-

ing calls to change, such as BIO2010 (NRC, 2003), Vision and Change (AAAS, 2011), and modifications to the AP curriculum (College Board, 2013). This coincided with the administration giving its support to the courses to implement these changes. The reaction from the instructors involved with the courses, as well as those in the higher level courses, was mixed. Undaunted, the Lab Coordinators and Supervisors from the two courses pressed on with the development of the new lab curricula. As we discussed what these changes would look like, it quickly became clear that the needs of the two courses, and the paths they would take to get there, were very different.

In BSCI105, there has historically been only a peripheral tie-in to the lecture material as the lab was designed to complement lecture, rather than directly support it. This provided an opportunity to rearrange the lab material with minimal impact on student performance in lecture. The lab exercises gradually shifted over a two year period, integrating the scientific method throughout the semester and partitioning the material into three units:

- Tools of the Trade
- Protocol Development
- Molecular Biology Research

The starting point for the redesign of the BSCI105 labs

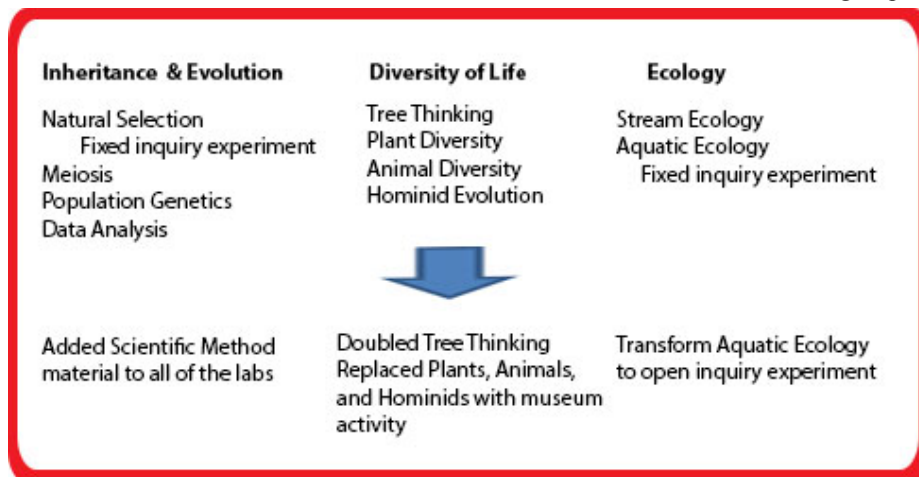


**Figure 1.** The BSCI105 labs fully transitioned from fixed- to open-inquiry during the third, and last, unit of the semester (weeks 10-13).

was the final unit on molecular biology research. Originally this consisted of a traditional set of lab exercises with fixed directions that led students through a series of techniques to answer a defined set of questions raised by an introductory scenario. There was no open aspect, and each lab group used their own data to write individual lab reports that all looked fairly similar. At the end of the semester, pairs of students worked together to design and present a poster on an unrelated topic. The redesigned, open-inquiry version of this unit starts with the same scenario, and generates the same questions to address, but now the groups in a lab have to work together as a team and divide up experiments to answer all the questions collaboratively. Each group takes responsibility for a question and has to decide what methods would best address it from a general protocol and applications guide at the end of the lab manual. Each group designs their experiments using the appropriate protocols, having time to update and repeat their design as needed. There is also time for follow-up questions to be explored, and for the class to share their results among groups. Individuals are asked to write a data analysis

and summary for the entire set of questions, and each group gives a presentation on their experiment and results, and how it addresses their assigned question.

BSCI106 faced competing pressures to use laboratory time to directly support lecture material and incorporate more of the scientific process. To meet both of these goals, instruction on the scientific process was woven into existing labs during the beginning of the semester when we cover inheritance and evolution. This required the streamlining of some previous content and the replacement of a multi-week experiment with one that only takes one lab period to complete. To make room for additional instruction on tree thinking (Gregory, 2008) and for a longer, open-inquiry experiment at the end of the semester, three diversity labs were removed from the course. This was not a popular decision among faculty, but most agreed that the changes were worth it. To offset some of the loss of diversity in the course, we added an extensive assignment that requires students to visit the Smithsonian Museum of Natural History. Ultimately, this leaves room for a four week long sequence of inquiry labs.



**Figure 2.** The BSCI106 labs underwent changes throughout the semester, culminating in an open-inquiry experiment.

In these labs, based on Chen (2013), student groups design and conduct an experiment focused on water quality issues. They begin with a lab devoted to the procedures that they need to use in the experiment. This is followed with them designing and setting up a preliminary experiment test their hypotheses, followed by a more extensive experiment. Each student then produces a report detailing their procedures and results.

After a semester, we have learned a few lessons. The first is that the TAs need to be on board with the curriculum and confident that they can teach it. If they are not, students will not respond to the extra effort that goes into inquiry labs. This type of course is likely different than what they have done in the past, so they need to understand the goals and expectations of the course. With this in mind, we have found that students start out timid, but as the semester goes on, they quickly gain confidence and thrive in this system. The biggest lesson that we learned is that students can do it. They need to be given the tools and guidance to succeed but when they are given these, it led to our biggest surprise: the students liked it.

The development and implementation of an inquiry-based curriculum is not a static process. We are continuing to improve the exercises and assessments. In addition to better integrating the scientific method material throughout the course, we would like to add more options to the open-inquiry exercises at the end of each course. Another focus is to increase TA training so that they are better ready to teach inquiry labs. Training TAs for teaching inquiry curricula is a new challenge for which there is limited previous experience. While some naturally understand the process, other TAs view their role as the dispensers of answers, and these require more training to most effectively employ inquiry-based lab exercises. In addition, many of our TAs are undergraduates and may not have much cognitive advancement beyond the cookbook stage themselves. A problem distinctive to the transition to inquiry is that TAs, even those who took the same course here, generally do not know the inquiry process or have seen how to teach it; this necessitates that the Lab Coordinators allocate extra planning and time for training on the new approach. In addition, we could like to work with the lecturers to integrate scientific method material more completely throughout the course.

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Michael earned a B.S. from the State University of New York at New Paltz, an M.S. from Villanova University, and a Ph.D. from the University of Missouri, Columbia. He was a post-doctoral fellow at the National Institute of Child Health and Human Development where he studied developmental genetics in zebrafish. He is currently a lecturer at the University of Maryland where, until recently, he was the Lab Coordinator for Principles of Biology I (BSCI105).

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