

A Research-Based Curriculum for Students of the Life Sciences

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We designed an “inquiry-based” lab to support an introductory Molecular and Cell Biology course that covers basic principles through the lens of the neurobiology of disease, and is focused on guiding students through the stages of an authentic research project and manuscript preparation. The course format allows students to apply and connect lecture material to the research process from which fundamental concepts are formulated while maintaining continuity between experiments. The goal of the course is broad exposure to the field coupled to immersion in a research experience that can foster critical evaluation of the scientific process.

Keywords: PCR Polymerase Chain Reaction; SDS-PAGE Sodium Dodecyl Sulphate-PolyAcrylamide Gel Electrophoresis.

Introduction

One of the biggest challenges Biology educators face is how to enable their students to think critically and elaborate on the information they have learned. In Biology, the initial learning process is often based on memorizing observable phenomena and the mechanisms that regulate them. An individual may begin to think critically and generate hypotheses only after reaching a certain level of experience and confidence about the acquired knowledge. Therefore, it is a challenge to help new students, who have just begun forming their first impressions of the field, think critically about new information. In our program, we strive to create synergy between Molecular and Cellular Biology concepts and their potential applications in a way that stimulates the type of critical thinking that is important in a research setting. We believe that the direct application of Molecular and Cellular Biology concepts in the lab will strengthen the students’ understanding of and critical approach to these topics, and help them more effectively retain the newly learned information. In addition, we hope to create an environment where students are stimulated to ask and answer scientific questions.

Learning Objectives and Outcomes

Our main goal is to use a real research experience to contextualize and apply concepts of Molecular and Cell Biology learned in class. This will lead to three main potential positive outcomes:

- 1) Students are exposed to research, and therefore can learn lab skills and techniques while learning about how scientific research is conducted. The research they conduct in the lab is relatively novel, and is related to a research area that is actively being investigated by pharmaceutical companies.
- 2) Students are continuously stimulated to connect experimental procedures and rationale to information learned in lecture. Giving context to and applying the information learned in class strengthens their understanding of the topic.
- 3) Students learn to think critically about their experiments. This result is achieved by reading the background scientific literature of the project and by discussing failed experiments.

Although the outcome of the experiment, when performed successfully, can be predicted, students often run into unexpected results as a consequence of using a different analytical approach or of experimental failure. We aim to teach our students that failure is a fundamental component of scientific progress: often, failed experiments or unexpected results teach more than successful ones, as they force the scientist to deepen the analysis of the causes and consequences of their experiments. In this way we hope our students will learn that the real challenge is not of preventing failure, but of learning how to deal with failure by thinking about possibilities and finding solutions, while reconsidering the project rationale and approach.

Lectures and Lab are Intertwined Approaches

The lab project develops in sync with the lecture content, and focuses on replicating a portion of the work of a previously published scientific article on the cellular and molecular neurobiology of a neurodegenerative disease (Molecular and Cellular Neuroscience 2002 Feb;19(2):175-85). In the first part of the course, Molecular Biology, including DNA replication and protein translation, is taught in lecture. In the lab, students apply these concepts by subcloning the DNA of a protein of interest (the beta secretase BACE involved in Alzheimer's disease) and expressing it in mammalian cells. In the second part of the course, the lecture curriculum moves to content inherent to Cell Biology, such as cellular compartments and protein localization. Students in the lab apply these concepts by studying how the function of the protein may relate to its intracellular localization using techniques such as PCR, SDS-PAGE and Western Blotting, and immunocytochemistry.

Continuity of the Project: Support in Class and in the Lab

Students are introduced to the scientific objective of the project during pre-lab, a lecture time dedicated to guiding the students through the weekly lab manual. During this time, we also emphasize technical and scientific aspects of the week's experiment, how they relate to the previous week's experiment and to the rationale of the research project as a whole. The Lab Instructor encourages students to make connections between the concepts applied in the lab and those covered in lecture. In this way, students are stimulated to envision their weekly lab experience within the context of a developing project. This fosters an ability to develop a broad view of these topics, with the hope of minimizing a collection of scattered information.

Assignments

Assignments are designed to support the students' developing knowledge. The first three assignments are designed to help students approach the reading of scientific literature. Specifically, students read a review article and two research articles related to the topic of the experiment, and answer questions about scientific content. With these assignments we hope that the students will become more familiar with reading and understanding research articles, and with the scientific background specific to the lab project. In the fourth and final assignment, students write the lab project in the format of a research article. With this assignment we hope to help students practice complex analysis and synthesis.

Mission, Review Process & Disclaimer

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