

Purposeful Integration of Laboratory and Lecture in an Advanced Cellular Biology Course

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Extended Abstract

Introduction

Laboratory instruction in biological science courses should integrate with the lecture components. However, both students and instructors frequently treat these components as separate and non-related entities. Students fail to see the connections and relevance between lab and lecture and are unable to apply information learned in one setting to the other. Curriculum is often designed so that each portion can be delivered independently and by different instructors, negating the value of presenting the concepts in an authentic and cohesive manner. An opportunity arose to more purposefully integrate these components during the development and presentation of a third year advanced cellular biology course. In it, content and assessments were specifically designed to dovetail between all course components using 'cellular differentiation' as the overall theme.

Laboratory Exercises

Each lab activity was designed to support and inform students in the investigation of differentiation of the PC12 cell line. Students utilized authentic cell biology techniques when completing this project. Several of the lab exercises were adapted from those published on this subject by Adler *et al.* (2006) and Schwartz *et al.* (2007). Prior to beginning the PC12 cell based experiments, students became familiar with examining diversity in cellular morphology by staining several cell lines with vital dyes and fluorescent markers. These initial exercises also provided a necessary review of light microscopy techniques and concepts, including bright field and fluorescence. Several sessions were then scheduled to train students in mammalian tissue culture techniques. Once students became comfortable with sterile manipulation of cell lines, they plated PC12 cells in the presence of differentiating chemicals and examined changes in morphology over a 1-week period (Adler *et al.*, 2006). A variety of treatment protocols were utilized and class data was ultimately shared. Cells were harvested, protein levels of lysates were quantified, and acetylcholinesterase activity was measured as described by Schwartz *et al.* (2007). As an additional measurement of cellular differentiation, students resolved protein lysates on SDS-PAGE and immunoblotted them for GAP-43 (Das *et al.*, 2004). In total, these activities covered 8 weeks of 3-hour laboratory sessions. To conclude the project, each student wrote a formal laboratory report including an abstract, introduction, methods, results, and conclusions, based on his or her data from the term. In this lab report, students were expected to use specific lecture content and examples from lecture assessments to ably describe the mechanisms underlying the PC12 cell differentiation processes they had examined during the laboratory activities.

Lecture Assessments and Content

Lecture content was focused to support laboratory themes and concepts on cellular differentiation. Content topics that were especially relevant included cellular lineage, signal transduction and differentiation pathways, and synaptic signaling. The most relevant signaling pathways, including those involving cAMP and MAP kinases, were discussed in sufficient detail to provide students with mechanistic understanding of the activation of differentiation pathways seen in PC12 cells in response to Nerve growth factor (NGF), forskolin, PACAP, and other chemicals. As a lecture assessment, students read and analyzed the original primary paper published on establishment of the PC12 cell line by Greene *et al.* (1976). In a second lecture assessment, early in the term, students were directed to read and analyze a primary article on muscle cell differentiation. This paper was chosen because it contained exam-

ples of the types of experimental approaches and techniques commonly used when studying cellular differentiation, and was representative of the type of information students would study in lab. For the poster assignment, students were asked to analyze and present a primary paper of their choosing within the broad field of cellular differentiation. Papers were vetted for both appropriate rigor and diversity of experimental approaches used. Students produced an annotated bibliography on an additional five primary resources that provided background and context for their primary article. Posters presented the main content of the cellular differentiation paper, including a broad introduction, description of figures, conclusions and future directions, all written in the student's own words, with only the figures being taken directly from the primary article. Students presented their posters orally to small groups of individuals, as is commonly done at a scientific meeting. Participants were asked to critique the posters and presentations of their peers. In total, the lecture assessments maintained the cellular differentiation theme, and provided students with an opportunity to show their understanding of concepts and analytical skills through both written and oral forms. The content and techniques learned during the lecture component were also clearly applicable to the laboratory portion of the course.

Conclusions

Overall, this course provided students with a complete and authentic learning experience where lecture content and laboratory activities were designed to specifically connect and build towards the goals of understanding, examining, and presenting information on cellular differentiation processes. Students demonstrated their understanding of course concepts through varied assessments including examinations, laboratory reports, oral presentations, and primary literature analysis. From the instructor's perspective, the value of being able to consistently refer to both lecture and lab activities when explaining course content can't be overstated.

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