Making a Cell Physiology Teaching Laboratory More Like a Research Laboratory

Teaching Biology as Biology Is Done

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Undergraduate biology programs are presently undergoing a reform to involve students in biomedical research (Jarmul 1997). These changes are due to a number of national reports suggesting that traditional science courses do not reflect the actual practice of science (AAAS 1990; National Research Council 1996; Sigma Xi 1990; Fox 1998). Recommendations focus on pedagogical techniques emphasizing open-ended and investigative laboratories that foster critical thinking and problem-solving skills. Many education specialists agree that learning is a constructive process accomplished through active learning methods. Students do not remember scientific details when they are taught simply as facts, and studies show that students are weakest at understanding and interpreting scientific knowledge (NSTA 1996–1997). Many current science textbooks offer hands-on activities; however these are usually cookbook techniques with specific directions and calculated outcomes.

Engaging students in more active, hands-on experiments where students design and perform their own investigations provides them with an inquiry-based approach to learning, which traditional teaching methods (i.e. the lecture model) fail to provide (Lumpe & Oliver 1991). Active learning methods allow students to discover scientific principles for themselves, to develop techniques of critical thinking and problem solving, and to appreciate how knowledge arises. The “learning by doing” model gives students the opportunity to take knowledge, apply it and comprehend its application. The use of active learning models attracts students to the biomedical sciences and demonstrates that science can be both meaningful and fun. Laboratory experience can thus make a big difference in the student’s comprehension as well as motivation to “do” science (Knabb 1997/98).

These ideas provided the basis on which I began to structure an undergraduate cell physiology course that I was asked to develop. The course was to be research oriented and was thus capped at 12 students per laboratory section. With no technical assistance, limited supplies and equipment, and a request not to overlap with the laboratories of the cell biology, biochemistry, or molecular biology courses, I was faced with a difficult challenge. I viewed these restrictions as my biggest dilemma. In the end they proved to be my most valuable asset.

I reflected on the laboratories to which my prospective students had already been exposed. Most of these laboratories were designed for completion in one session of about three hours. This meant that all of the solutions used were prepared ahead of time by a technician and all of the materials and equipment needed for the lab were present for student use. The students simply followed the instructions and obtained the expected results. Often a prewritten laboratory manual was used for students to fill in the answers.

My goal for the cell physiology course was to introduce students to the world of “real” scientific research, where results are not known, solutions are not already prepared, and equipment is not available within an arms distance (Heppner 1996). I wanted them to record results and calculations into “their” notebooks and not one prewritten for them. I wanted them to think through their experiments. This meant understanding the background information in order to formulate a hypothesis, determining the experimental design, deciphering the solutions needed and preparing them, as well as understanding which equipment was needed and gathering it. In addition, the students needed to achieve a level of understanding that would enable them to make pre-determinations about their experimental outcomes. Ultimately, my goals were to make a teaching laboratory more like a research laboratory, and to teach biology as biology is done.

Laboratory Exercise Design

The laboratories were designed to introduce modern molecular techniques used to study cellular pro-