Grant Training Center

1901 N Fort Myer Drive
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# NSF Course Transformation

**Project Description**

**Goals and Objectives**

The goal of the current proposal is to teach undergraduate students how to investigate biological structures using digital imaging technology. The objectives are to 1) Develop a laboratory manual with special emphasis on image processing and quantitative methods for microscopy, and including biologically meaningful investigations that apply the protocols. 2) Create datasets of serial section slides and digital images as well use commercially available datasets that can be used to teach image processing and quantitative analysis. 3) Use readily available software (NIH Image, ImageJ, Adobe Photoshop®and IPTK plugins) to teach image processing and analysis using wireless networked iBook computers directly at the benches in biology laboratories. 4) increase the use of TEM and SEM by reducing the time required to prepare images for analysis.

**Detailed Project Plan**

Technology has created a renaissance in the study of biological structures. The technology extends from digital processing of bright field microscope images to laser scanning confocal and multiphoton imaging, 3 dimensional digital reconstructions of histological sections, multiple color fluorescent and low light imaging, to digital capture and processing of electron microscope images, from both TEM and SEM. Most biological research laboratories have at least one digital camera connecting a microscope to a computer, and journals now accept figures in digital format. Adobe Photoshop®is standard software in most biology labs.

Along with the technological revolution in digital microscopy technology is a quieter revolution in quantitative imaging methods. For example, there are now powerful and relatively simple stereological methods for extracting quantitative 3 dimensional information (such as number, volume, density, distribution, and orientation of organelles) from 2 dimensional tissue slices (Howard et al., 1992; Russ and DeHoff, 2000). These tools encourage workers to build statistical thinking into what have traditionally been mostly qualitative studies.

The revolution is extending to undergraduate laboratories. A search of NSF-funded projects that involved digital imaging in biology reveals at least 15 projects funded in recent years under the CCLI program, and many more if one includes the former ILI program (including a previous grant to the PI in 1992) and projects in chemistry and physics. For relatively modest amounts of money most undergraduate institutions can now have basic digital microscopy workstations for light microscopy available for student use. Making the equipment available is an essential first step, but is just the first part of the process. More difficult is developing protocols and materials for investigative laboratories and teaching the technology effectively. Fortunately, most of the pieces needed to create investigative laboratories are available, but they need to be assembled, adapted for and tested in a classroom setting, and distributed.

My proposal addresses three obstacles to effective instruction in quantitative digital microscopy. Briefly, the obstacles and my proposed solutions are:

1. How does one teach digital biological imaging when there are no texts or manuals suitable for undergraduate laboratories? I propose to create a laboratory manual with step-by step instructions for using easily available software (Adobe Photoshop®and Image Processing ToolKit plugins) to solve common problems in biological image processing and analysis.

2. How does one teach quantitative methods in microscopy? I propose to have students create a standard set of serial sections tissue slices, supplemented with commercially available slides and images, and use these datasets for teaching basic stereological methods.

3. How does one teach computer and software skills in the context of a biological laboratory? I propose to equip the lab with laptop computers, small and mobile enough to be kept right at the lab bench where biology happens, but wirelessly networked for ease of communication.

The project is designed to extend and modify a successful existing course at UR called Microanatomy. To understand the context of the proposed changes it will be helpful to know how the existing course is structured.

*The existing course in microanatomy*

The overall goal of the course is to provide students both with basic knowledge of tissue structure and with the skills to pursue their own investigations. The objectives are that by the end of the semester a student will be able to take an unknown tissue sample, prepare it for light and electron microscopy, generate image sof the tissue, identify and describe the characteristic cells and structures of the tissue, and explain how the structures support its function. The course meets for 2 hours, three times per week and meets in a teaching laboratory. Class times are a mix of presentations on vertebrate histology (some by the instructor and some by students) and demonstrations of lab techniques. Lecture topics include microscope optics (light and electron), histology of basic tissue types, and histology in depth on a few selected organ systems.

Students pursue semester-long projects of comparative histology, using the same tissue from a mouse and a frog. They make all their own preparations, doing most of their project lab work outside of class time. Students are evaluated on their observation and identification skills by weekly quizzes for the first 8 weeks. Two essay exams test their ability to interpret structure in terms of function (and vice versa). Their projects are evaluated by assessing their lab 5 notebooks, their slides and other lab specimens, an oral presentation, and a paper that includes labeled micrographs.

Course materials currently include a boxed set of 90 commercially prepared histology slides for each student and Kodachrome transparencies of these slides used for lectures. The class textbook is Wheater's Functional Histology (2000), which includes an atlas of color micrographs of specimens similar to those of the slide sets. Lab protocols are distributed as handouts for standard procedures such as fixation and staining. Lab exercises are provided as a

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series of weekly tasks to be completed, such as producing a set of slides stained by different methods, identifying a certain cell type in their preparations, or learning how to capture an image and label it with a scale bar. These weekly exercises introduce the skills students need to complete their lab projects.