Provost’s Learning Innovations Grant for Faculty
Request for Full Proposal
2006-2007

Please hand-deliver your completed grant proposal (4 pages, plus attachments),
the original plus 10 copies, to:
Susan DeWoody, 1530 Wallace (5)
by 4:30 p.m.
No hand written proposals will be accepted.
Notification of awards will be made by Friday, April 7, 2006.

Active Learning in the General Biology Lab; Detecting GM Foods in
the Grocery Store and Determining Your Own Genotype

Applicant:

<table>
<thead>
<tr>
<th>Name</th>
<th>Jessa Jones</th>
<th>Telephone</th>
<th>475 5571</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dept.</td>
<td>Biology</td>
<td>College</td>
<td>Science</td>
</tr>
</tbody>
</table>
Active Learning in the General Biology Lab; Detecting GM Foods in the Grocery Store and Determining Your Own Genotype

Summary:
The aim of this project is to work with undergraduates to optimize a set of PCR-based labs to enhance, modernize, and personalize the General Biology Laboratory course. PCR (the Polymerase Chain Reaction) is the cornerstone technique of modern molecular biology and is used routinely throughout the world to amplify small quantities of DNA for analysis. The new labs will be designed to give introductory students hands-on experience performing PCR assays, and specifically focus on applications of genetics and molecular biology that are inherently interesting and relevant to students; genetically modified food, and DNA as unique identification.

In addition, I intend to involve the undergraduate(s) that work with me on this project at a high level in the development, optimization and writing of the labs. A second output of the project will be an “educational research” experience for the undergraduate(s) involved. This type of work is recognized as undergraduate research within our Department, and students participating would be expected to present their work orally at the College of Science Undergraduate Research Seminar.

❖ Lab 1: Can we Detect Genetically Modified Foods in our Local Grocery Store?

Students will isolate DNA from common grocery store food items. They will then use this DNA as a template for a PCR reaction that will detect the presence of a bacterial gene commonly engineered into corn crops to provide insect resistance. Once the PCR reaction has been performed, students will separate and visualize the DNA fragments using gel electrophoresis, to determine whether the food from the grocery store is genetically modified. In addition, students will make oral presentations on assigned “hot topics” from their own internet research regarding genetically modified food.

❖ Lab 2: What is your own Genotype?

Students will revisit the PCR technique in a very personal way; by using the technique to determine their own genotype at a highly variable spot in the human genome. They will use their own cheek cells to extract their DNA, perform PCR and analyze fragments of DNA. This exercise will highlight concepts in genetics, underscoring the application of DNA as a form of unique identification. This exercise will serve as an excellent lead-in to a related exercise where students will perform a simulated paternity test using both blood and DNA samples.

Project Plan: I intend to pull together various aspects of these exercises that have been successfully described elsewhere, and combine these with novel components that we will develop. This summer I will work with one or two students to develop, standardize and optimize a set of techniques and experimental protocols that will work robustly in student hands and with equipment available here at RIT. We will build on the successes and troubleshoot the failures I’ve experienced piloting aspects of these labs in the General Biology Laboratory this year (see appendix). The end result will be a set of high-quality labs that welcome introductory students into the heart of modern biology in a hands-on, relevant, and fun way.
Targeted learners:

General Biology Laboratory is taken in conjunction with General Biology by students in majors with a specific science requirement. These students come from a variety of disciplines across the Institute including computer science, engineering, chemistry, and medical sciences.

Number of students: ~180 during Fall, and ~160 during Spring.

Impact on Teaching and Learning

DNA and genetics are tough concepts for introductory students, and active learning is almost a necessity to engage the typical non-major General Biology student. Allowing students to personalize the topic by focusing on their own genome, jump into actually performing PCR instead of just reading about it, and then being tasked to assimilate complex information on a hot topic for oral presentation will help them learn the material in a very active way.

The new exercises will replace those labs historically used to illustrate the concepts of DNA structure/function and genetics. The existing labs are passive in nature with a heavy reading component. Students manipulate a set of plastic chromosome beads, simulate DNA structure with yarn, and observe pictures of cells (see appendix).

In contrast, the new labs focus on active learning. I have piloted some of the aspects of the labs described above in the last year. At the end of each quarter students have filled out an exit survey for General Biology labs. Many of the students described our first attempt incorporating PCR into the curriculum as their favorites over other labs. Student interest, excitement and participation in these pilot exercises was palpable. They also described the PCR exercises as the ones where they learned the most....even though in the pilot stage we had ambiguous results that were nearly impossible to read (See Appendix for examples). Based on preliminary data obtained from our pilot experiments, I’m confident that the PCR reactions we intend to perform can be optimized for robust results in student hands.

Impact on Student Success

Students routinely express that of the entire three-quarter General Biology sequence, the molecular biology topics are the most difficult for them. Part of this difficulty lies in the fact that unlike other more macroscopic areas of biology, it is tough for students to be able to imagine and identify with the invisible activities of molecules deep within a cell. The PCR-based labs address this problem in two ways

- Capturing their interest. These labs specifically focus on modern applications of molecular biology and genetics relevant to students.
- Making the invisible become visible. For example, PCR amplifies the minute amounts of DNA found in a student’s cheek cell, making their own DNA become visible as a specific band on a gel.

In practice, I’ve been summarily impressed with the ability of Gen Bio Lab students to rise to the occasion and master complex information when it is presented to them in a manner highly relevant to their lives. The purpose of the laboratory component of the General Biology course is to enable students to supplement their understanding of lecture material through doing. These labs will take a huge step toward accomplishing that goal for the genetics/molecular biology lecture topics. I anticipate that will translate into a decreased failure rate for the lecture exams on these topics.
Measures of Impact
Students will be evaluated by both a pre-test/post-test mechanism on the material, and by completing surveys designed to probe the effectiveness of the new laboratory over earlier techniques. To conserve use of class time, the clickers already in use in General Biology will be used to administer the pre/post tests and the survey.
Once developed and optimized, the new PCR labs will be disseminated as examples of active learning at the quarterly Department of Biology’s Active Learning Wine & Cheese. In addition, the undergraduate(s) participating in the project will present the results of the lab development at the College of Science Undergraduate Research Seminar.

Rationale
a.) Why not regular college business
Developing, optimizing, and creating written materials for labs that use the PCR technique is quite time consuming. Previous attempts to develop these labs on my own time incrementally during the previous two years have been both encouraging and frustrating. It is clear that students relish the opportunity these labs bring to the curriculum, yet it is very frustrating when their results are uninterpretable, ambiguous, or simply blank. (See appendix for examples). To fully develop and optimize a set of labs that are robust in the hands of Gen Bio Lab students given our reagents and equipment will require a specific effort that is not possible without dedicated release time.

b.) Relevance to college competencies
Developing the ability to organize, assimilate, and understand complex processes is a central feature of the college experience, and is applicable to all students regardless of discipline. These labs enhance the ability of non-major students in a service course to master the complex topic of molecular biology. Furthermore, the oral presentation aspect of the GM Food lab provides introductory students with an opportunity to enhance the core competencies of research and oral presentation skills through team-feedback and constructive criticism.

c.) Relevance to other faculty, transfer your success to other faculty
The techniques and strategies used for optimization of the PCR reactions can be used by other faculty members developing PCR-based labs for upper level courses within the Department of Biology. In addition, similar strategies can be shared with colleagues for use in their research programs.

d.) Relevant credentials, experience of involved faculty/staff
As the cornerstone of molecular biology, PCR is used to develop reagents for nearly every aspect of any molecular biology experiment. I have been designing primers, troubleshooting and optimizing PCR reactions throughout my professional life. In addition, I have piloted aspects of these lab exercises with recent students, and have gained feedback which will guide the lab development process.

e.) How this innovation is in your discipline or program
Developing PCR-based labs to enhance the General Biology Lab curriculum is squarely within the domain of the Biology discipline.

Timetable
June 2006:
• Brainstorm ideas to enhance piloted lab exercises with undergraduate(s) student.
• Design new primers for Cry1A and other Cry genes from bacteria.
• Obtain positive control samples, and prepare grocery store corn product DNA templates
• Optimize Cry gene PCR reactions

July 2006:
• Prepare written materials for GM Food lab: protocols, introduction/background, companion questions, quiz/lab practical stations, and oral presentation guidelines.
• Optimize DNA extraction from human cheek cells
• Design new primers for Chromosome 1 polymorphism amplification
• Optimize chromosome 1 PCR reaction using cheek cell DNA

August 2006:
• Prepare written materials for What is your Genotype lab: introduction/background, cheek cell DNA isolation methods, PCR reaction protocol, data analysis and companion questions/lab practical stations.
• Use PCR to build reagents for simulated DNA paternity test.
• Optimize blood and DNA paternity test protocols.
• Wet-test new labs, and fine tune optimization and written materials.
• Incorporate new labs into laboratory manual and print for Fall Quarter 2006

Fall Quarter 2006:
• Roll out new labs to all 180 General Biology students, collect feedback using surveys and clickers
• Undergraduate(s) present project results at COS Undergraduate Research Seminar.
• Assimilate impact data and write final report
APPENDIX:
AI. New PCR-based labs will replace labs that relied heavily on reading and manipulation of plastic chromosome beads to present concepts in genetics to students.

Chromosome beads: Historically used to teach concepts of DNA and genetics to students.
AII. Example results from piloting aspects of the labs to be developed.

By far, most samples show failed PCR, with no amplification of either the gene tested. Occasionally, amplification of one of the two genes tested was successful. The PCR product (white band) of a general corn gene is indicated by the arrow.

This is a typical student gel from a pilot experiment performed in a lab class. The students were attempting to amplify a bacterial gene from grocery store corn products. Most students were not able to see any bands corresponding to the expected PCR amplification products, not even a positive control band corresponding to a general corn gene. The most likely failure of amplification is due to the PCR reaction not being optimized. The process of optimizing PCR can be time consuming, but is relatively straightforward. A fully optimized PCR reaction with robust amplification of test and control genes is a significant output of this proposal, and is necessary to continue development of this lab for permanent incorporation into the curriculum.
Examples of some student comments regarding the piloted PCR-based labs during Fall 2005, *despite* the fact that the labs were based on largely uninterpretable data. (See example above).

**The course:**
What labs were your favorites, what did you hate?

LOVED the PCR lab! Instructive & fun.
Hear about PCR all the time - so very relevant.

**The course:**
What labs were your favorites, what did you hate?

I enjoyed the Respiration and PCR reaction labs.
as they contained many interesting steps and gave us access to tools which I had never used before.

**The course:**
What labs were your favorites, what did you hate?

The PCR lab was the best.

**What labs were your favorites, what did you hate?**

Enjoyed the metabolic respiration lab, didn't enjoy the yeast lab too boring, definitely enjoyed the PCR lab

**What labs were your favorites, what did you hate?**

I liked the corn DNA lab.