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Gel: The Visual Library of Molecular Biology Lab Techniques

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## Abstract

The author proposes the creation of Gel, a visual digital library of molecular biology laboratory techniques. This resource will be designed to meet the information needs of two main user groups: students studying molecular biology at the advanced high school and undergraduate levels, and the instructors of those molecular biology lab courses.

Gel will consist of a repository of short movies and still photos demonstrating common lab techniques for the benefit of molecular biology students. Narration and text will be included as appropriate. These resources will help students learn the subject matter, gain confidence, and hopefully reduce costly and occasionally dangerous mistakes in the laboratory.

The Gel digital library will also feature an interactive area, including a wiki and a message board. Molecular biology educators can use these areas to exchange ideas and collaborate. This interactive area will also be used by the Gel project manager as an ongoing evaluation tool and means of receiving user feedback.

Clearly there is a need for this type of resource, as there are a few existing molecular biology lab-related educational websites (Bacon Schneider, n.d.; Dellis, n.d.; Ramirez, Johnson, & Paul, 2004). However, these were usually designed to meet the needs of one specific class, and often include only a few still photographs to illustrate techniques. These resources are helpful, but the short movies featured by Gel will better fulfill users' information needs, and will also have the advantage of being more universally applicable to any molecular biology course.

## A. Introduction and Brief Description

Many molecular biology techniques are difficult to adequately describe in lab manuals and challenging to visualize. One misstep can easily ruin an experiment, and can even at times be dangerous. Carefully watching an experienced person carry out an experiment is the best way for novices to learn these techniques, and has traditionally been the method used for passing on this knowledge in research settings. Unfortunately, this approach is difficult to accomplish in anything other than an internship-like situation. It is nearly impossible in the large laboratory classrooms where these techniques are often taught.

To address this need, the author proposes the development of Gel, a digital resource that allows students to first watch someone carry out these techniques before attempting them themselves. . Gel is a play on the word *jell*, meaning to become cohesive and take on a definite form, and also references the gel electrophoresis techniques commonly used in molecular biology. Gel will consist primarily of digital photos and short movies of an experienced person executing basic molecular biology lab techniques. Experimental procedures such as agarose gel electrophoresis, SDS-PAGE gel electrophoresis, and various blotting techniques will be included. These are very common methods with a high probability of being used in any molecular biology lab course. These visual resources will be particularly valuable for students without much lab experience, for students in classrooms with large student to teacher ratios, and for students who are hesitant to ask questions or request additional help.

Gel will also include a few movies and photos depicting what-if scenarios, since students are often curious to know what happens if, for example, they accidentally transfer their Western blots backwards. These what-if resources can be done in a humorous way to help keep students engaged.

In addition to the visual resources, Gel will incorporate a few interactive features aimed primarily at engaging educators using the resource. Gel's interactive area will include a message board for educators to trade tips and share ideas, and also a wiki area for collaboration. The wiki will serve as one means of soliciting suggestions and user feedback for the digital library in an ongoing program of evaluation, and can eventually become a place for educators to post their own content for possible inclusion in Gel.

Gel will be deployed in phases. In the first phase, the wiki and message board areas will be made available to educators. During Phase Two, the digital library will be rolled out to the Wellesley College community. Finally, Gel's availability will be announced to a broader audience. This phased deployment allows ample opportunity to incorporate suggestions and feedback from users.

The Gel library of molecular biology lab techniques has three main objectives:

1. To provide educational resources to assist molecular biology students
2. To provide interactive areas for educator collaboration
3. To use interactive areas for ongoing evaluation and incorporation of user feedback

## B. Statement of Need

The field of molecular biology is growing exponentially. Recent completion of the sequencing of the human genome with all its potential for future medical treatments, ethical and legal ramifications of DNA fingerprinting and forensics, and perhaps even the popularity of certain television shows have contributed to growing interest in this area.

Science, technology and society are converging in ways that could not have been imagined even fifty years ago. Average citizens will need some understanding of molecular biology, since they will be making important decisions and voting on related ethical issues in the future. Genetically modified foods, stem cell research, and the rise of antibiotic-resistant bacterial strains are just a few of the molecular biology related issues that will need to be addressed in years to come. Partly because of this collision of science, technology and society, the science curriculums of educational institutions from grade school through college are devoting more time to teaching molecular biology (Marocco, 2000; McInerney, 1995; National Research Council, 1996).

Enrollment in molecular biology courses and programs is on the rise (Oliver, 2005; U.S. Department of Education, 2000). This rise in enrollment is compounded by the rise in numbers of graduates who are continuing their educations past high school. In the United States, an estimated 67% of high school graduates now enter college. (Mathews, 2007).

In the post-Sputnik era, science curriculums in the United States have typically combined traditional classroom education with hands-on experimental learning. Molecular biology is no exception. However, molecular biology is an intellectually complex field. Many molecular biology experimental techniques are unique to the field, such that even students with solid scientific backgrounds may have a difficult time visualizing and understanding the experiments and apparatus involved. These techniques are also challenging for teachers to describe, and stakes are high since much of their failure or success hinges upon proper setup in three-dimensional space. For example, students can correctly assemble an agarose gel electrophoresis apparatus, properly measure, mix and pour the agarose gel, calculate desired concentrations, mix their samples accordingly and load them into the gel accurately, only to have the entire venture ruined by connecting the leads backwards. This is one example of how a very small mistake can ruin several days' worth of experimental work. In this case, thankfully, the mistake wasn't even a dangerous one.

The best way to address these issues is by the educator demonstrating the complete experimental setup to each student in turn. In the example above, the teacher could walk through the experiment with three or four students at a time. Unfortunately, devoting this degree of individual attention can be nearly impossible to accomplish in large laboratory courses, especially given current enrollment pressures. The Gel digital library seeks to alleviate this problem by allowing students to see lab techniques demonstrated before trying them themselves. Gel even goes beyond what is possible in a conventional classroom setting by providing a way for students to view a technique repeatedly, to pause a video to take notes, and to permit multiple viewing angles of a technique.

Clearly there is a need for this type of resource, as there are a few existing molecular biology lab-related educational websites (Bacon-Schneider, n.d.; Dellis, n.d.; Ramirez, Johnson, & Paul, 2004). However, these were usually designed to meet the needs of one specific class, and often include only a few still photographs to illustrate techniques. These resources are helpful, but the short digital movies featured by Gel will better fulfill users' information needs, will represent the techniques in a medium more closely approximating three-dimensional space, and will also have the advantage of being more universally applicable to any molecular biology course.

Molecular biology lab equipment is an expensive investment. Some schools do not have the financial resources necessary to outfit an entire classroom. Gel could even serve as a virtual lab experience for students in these educational environments.

### C. Target Audience

Gel serves two main user populations:

1. Students in molecular biology courses at the advanced high school and undergraduate levels
2. Educators of those courses

Gel meets the needs of the student user group by providing molecular biology educational resources that support learning, build confidence, and reduce costly and dangerous laboratory mistakes. Gel will meet the information needs of its student user group through the provision of movies and pictures to demonstrate common molecular biology laboratory techniques. Goals for the student user group are supported by providing an opportunity for students to watch experiments carried out by an experienced person prior to attempting them themselves. The setting of this portion of the Gel digital library is in support of formal education.

Gel meets the needs of the educator user group by building community and interaction between educators in a job that can feel isolated. Additionally, some instructors may be unfamiliar with these molecular techniques; Gel will update their knowledge and help them keep current in the field. Goals for the educator user group are supported by Gel's message board and wiki features in addition to the visual content. The setting of this portion of the project is in support of both formal education and life long learning.

### D. Project Goals and Objectives

User requirement plans (Please see also Timeline, Tasks 1.1.1 through 1.1.3)

User requirement plans include the solicitation of input from both user classes at all stages of Gel's lifespan. For the educator user group, input on content will be solicited from molecular biology instructors, faculty, and graduate teaching assistants through interviews, and emails. User feedback will be solicited throughout the project's lifespan via Gel's interactive features.

Input will be solicited from students to address the requirements of the student user group. This input will be gathered from interviews, emails, and by surveying current molecular biology students at Wellesley College via FirstClass, the Wellesley email and bulletin board system.

#### Evaluation (Please see also Timeline, Task 1.2.4 and Objective 1.3)

Gel's interactive area, consisting of a wiki and message board, will be provided to educators before the visual resources are in place. The interactive area will also be used to help gather ideas for Gel's content, in addition to serving as one means for ongoing evaluation over the lifespan of the project.

Gel's project manager will conduct talk-aloud protocols with representatives of both student and educator user groups prior to the project's official launch. Results of this feedback will be implemented as appropriate. The project manager will monitor the wiki and message board areas of Gel in an ongoing fashion, and will act on feedback and suggestions as appropriate.

Gel will also be evaluated via quantitative methods. Once the project is online, the project manager and technical advisor will monitor quantitative measures such as load times and movie streaming to ensure continued usability of the resource. Server logs will also be monitored for errors on an ongoing basis.

#### Content, Technologies, and Metadata (Please see also Timeline, Tasks 1.1.4 through 1.1.7)

Gel's content will consist primarily of short movies of molecular biology laboratory techniques, with text and narration as appropriate. Movies will be presented to users as small GIF thumbnails on the main Gel visual resource interface, which will click through to QuickTime video segments (McDonough, 2004; "Audio/video capture", n.d.).

Gel will also include some collections of still photographs. These will be presented to users as small GIF thumbnails, which click through to larger JPEGs (Library of Congress, n.d.).

The entire initial set of visual assets will be created by Gel's project manager and digital video advisor. Some Gel content may ultimately be made by educator users and submitted for inclusion via the Gel wiki.

Metadata for both movie and photographic resources will follow the Dublin Core metadata standard (*Dublin Core*, 2007). METS and MPEG-7 standards were also considered for this task. Dublin Core was chosen for best combining a good general metadata standard for image resources with extensibility and significant ease-of-use (Wactlar & Christel, 2002).

In addition to the visual content, Gel will also have an interactive content area consisting of a wiki and message board. The wiki will be set up via Pbwiki (*Pbwiki.com*, 2007) and the vBulletin forums package will be used to provide the message board (*vBulletin*, 2007).

## E. Key Staff

### - Project manager: Jen Ferguson

The project manager will have ultimate responsibility for all aspects of Gel's design, content, and daily operation. To this end, the project manager will solicit and act upon feedback from Gel's advisors and users, will help create the visual content for the site, will create the metadata for Gel's visual assets, and will help deploy the project. Once Gel is functional, the project manager will help maintain the digital library, monitor feedback from users, and evaluate the efficacy of the project on an ongoing basis.

The project manager holds B.S. and M.S. degrees in biology, over ten years of experience in molecular biology, several years of teaching experience, and is currently enrolled as a graduate student in the M.S.L.I.S. program at Syracuse University.

### - Advisors and consultants

#### Technical/computing advisor: Jon Ferguson

The technical advisor will create the framework to house Gel's digital assets, monitor quantitative feedback measures, and provide expertise in network and programming issues.

The technical advisor holds a B.S. in computer science and has over fifteen years of experience with computer systems, programming, and networks, including extensive experience in higher education.

#### Content advisors: Kate Bacon Schneider, Jennifer Hood-DeGrenier, Carol Ann Paul

The content advisors will suggest appropriate content for Gel.

All content advisors hold advanced degrees in biology. All have experience in molecular biology lab work and teaching. Additionally, Bacon Schneider created a small pilot project of molecular biology lab digital resources (Bacon Schneider, n.d.), and Paul created The Neuron Connection, an online educational resource for biology students (Ramirez, Johnson, & Paul, 2004).

#### Digital video consultant: Kathy Cannon

The digital video consultant will help create, edit, upload and maintain Gel's digital visual assets.

The digital video consultant is an educational technology consultant with some library experience. She also has several years of experience with digital video and online educational content management.

## F. Timeline – Please see Appendix A.

G. Evaluation Plan – Please see section D and Appendix A.

H. Dissemination (Please see also Timeline, Tasks 1.1.10 and 1.2.3)

Gel will be deployed in three phases as described in section A. This phased rollout allows Gel's creators to better respond to user feedback and incorporate suggested improvements.

In the first phase, Gel's interactive area will be made available to educators. The wiki and message board will be publicized to the educator user group through various means, including word-of-mouth, emails, and listserv messages.

Once the visual content area is in place, Gel will be rolled out to the Wellesley College community, thus reaching both student and educator user groups. News of Gel's availability will be disseminated via word of mouth in molecular biology lab courses, plus announcements on First Class (the Wellesley email/bulletin board system), campus flyers, and coverage in the campus newspaper.

The final phase of Gel's deployment will be marked by promotion to a broader community. This broader promotion will be accomplished by further listserv messages and emails to molecular biology instructors, faculty, and college education offices. Gel can also be promoted via the websites of the National Science Teachers Association and state teachers' union websites, which will reach both high school teachers and some college instructors. The project manager plans to promote Gel at the Society for College Science Teachers conference in Boston in summer 2007.

### I. Sustainability

Startup costs for Gel will be funded through this grant.

Going forward, Gel's creators will seek support from Wellesley College. Wellesley's molecular biology courses are enjoying increased popularity among students, who could greatly benefit from having Gel's educational content readily available to them. Wellesley clearly has an interest in these types of biology education resources, as the college is providing ongoing support to the Neuron Connection site. Additionally, Gel's project manager and two content advisors are Wellesley College employees. For these reasons, we are fairly confident of securing a commitment from Wellesley for ongoing support of Gel.

To ensure continued availability of the resource, Gel's creators will request that Wellesley retain the Gel project manager for a small number of hours per week (or on a per-semester basis) to monitor feedback, incorporate changes, and generally keep the digital library maintained and functional.

Ultimately, some Gel content may be created and contributed by educator users and submitted for inclusion via the wiki, thus helping sustain and renew Gel's content.

## Appendix A: Timeline

Goal 1: Create Gel molecular biology lab digital library				
Objective 1.1: Provide resources to assist molecular biology students				
Task Number	Description	Personnel	Date	Deliverable
Task 1.1.1	Solicit input on content	Project manager	03/23/07	Notes re: what questions to ask
Sub-Task 1.1.1.1	Input from educators	Project manager	03/23/07	Emails, listserv postings, notes from conversations
Sub-Task 1.1.1.2	Input from students	Project manager	03/23/07	As above
Task 1.1.2	Review input from above sources	Project manager; consult w/ advisors as necessary	04/13/07	Notes
Task 1.1.3	Decide on specific items for initial content	Project manager; consult w/ advisors as necessary	04/19/07	Notes
Sub-Task 1.1.3.1	Decide on format for each content item (movie, pictures, etc.)	Project manager; consult with digital video advisor if needed	04/19/07	Notes
Task 1.1.4	Create content & upload	Project manager; digital video advisor	05/11/07	Content created and uploaded
Sub-Task 1.1.4.1	Take photos and upload	Project manager; consult with digital video advisor if necessary	05/11/07	Uploaded photos
Sub-Task 1.1.4.2	Take movies and upload	Project manager, digital video advisor	05/11/07	Uploaded movies
Task 1.1.5	Edit content	Project manager, digital video advisor	06/05/07	Edited photos and movies
Sub-Task 1.1.5.1	Edit photos	Project manager, digital video advisor	06/01/07	Edited photos

Objective 1.1: Provide resources to assist molecular biology students (con't.)				
Task Number	Description	Personnel	Date	Deliverable
Sub-Task 1.1.5.2	Reshoot any necessary photos	Project manager	06/05/07	New photos
Sub-Task 1.1.5.3	Edit movies	Digital video advisor, project manager	06/01/07	Edited movies
Sub-Task 1.1.5.4	Reshoot any necessary movies	Digital video advisor, project manager	06/05/07	New movies
Task 1.1.6	Add descriptions, captions to movies and photos	Project manager	06/11/07	Described, captioned content
Task 1.1.7	Add metadata to content	Project manager	06/27/07	Metadata
Task 1.1.8	Create web page/framework to house content	Technical advisor, project manager	06/20/07	DL web page/framework
Sub-Task 1.1.8.1	Add content from task 1.1.4	Technical advisor, project manager	06/20/07	Content added to framework
Sub-Task 1.1.8.2	Add text to web pages, describing content	Project manager	06/20/07	Text added to framework
Task 1.1.9	Launch Gel digital library	Technical advisor, project manager	07/01/07	Remotely accessible, functional digital library
Task 1.1.10	Promotion	Project manager	07/20/07	Gel announcement to user groups
Sub-Task 1.1.10.1	Limited promotion to Wellesley community	Project manager	07/07/07	Announcements on FirstClass, emails, campus paper
Sub-Task 1.1.10.2	Broader promotion	Project manager	07/20/07	Listservs, emails to local college educators, post to web pages, etc.

Objective 1.2: Provide interactive area for instructor collaboration				
Task Number	Description	Personnel	Date	Deliverable
Task 1.2.1	Set up wiki	Technical advisor, project manager	03/26/07	Operational wiki
Task 1.2.2	Set up message board	Technical advisor, project manager	03/26/07	Operational message board
Task 1.2.3	Promote Gel interactive area to instructor user group	Project manager	04/01/07 and ongoing	Listserves, emails to local college educators, post to state educational union web page, etc.
Task 1.2.4	Encourage further feedback	Project manager	(ongoing)	Posts to wiki, message board inviting suggestions

Objective 1.3: Ongoing evaluation & incorporation of user feedback				
Task 1.3.1	Evaluation: Talk-alouds with user groups prior to launch	Project manager	06/30/07	Notes from talk-alouds
Sub-Task 1.3.1.1	Talk-alouds with students	Project manager	06/30/07	Notes from talk-alouds
Sub-Task 1.3.1.2	Talk-alouds with advisors, educators	Project manager	06/30/07	Notes from talk-alouds
Task 1.3.2	Study user feedback, including message board feedback, findings from talk-alouds	Project manager	(ongoing)	Notes
Sub-Task 1.3.2.1	Decide whether to act on specific suggestions	Project manager	(ongoing)	Notes
Sub-Task 1.3.2.2	Implement suggestions where appropriate	Project manager; technical advisor and/or digital video advisor as necessary	(ongoing)	Updates to content
Task 1.3.3	Evaluate effectiveness	Project manager	(ongoing)	Evaluation notes
Sub-Task 1.3.3.1	Qualitative: user suggestions and feedback from message boards	Project manager	(ongoing)	Notes, changes to site as deemed appropriate
Sub-Task 1.3.3.2	Quantitative: server logs, network monitoring, load time for pages etc.	Technical advisor, project manager	(ongoing)	Notes, changes as appropriate

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