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CUR Focus

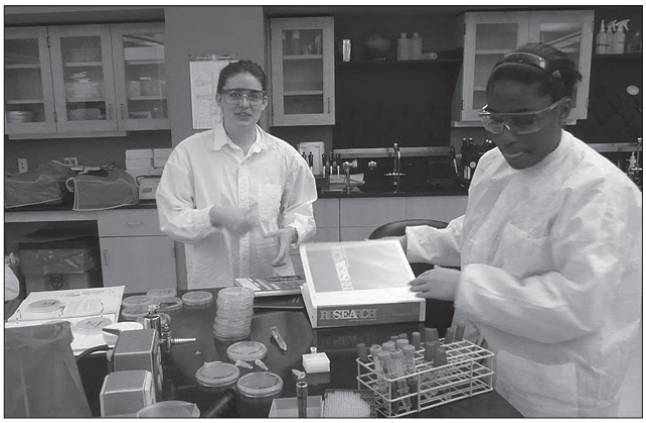
Peer Mentoring in an Introductory Biology Laboratory

Undergraduate research has shown that the incorporation of hands-on, inquiry-based activities produces a superior learning environment for all disciplines (Lopatto 2004; Seymour *et al*. 2004). The majority of undergraduate research takes place outside of the normal classroom laboratory experience, although embedding undergraduate research into courses is becoming popular. A novel approach to the challenges of conducting original undergraduate research in the classroom is a bacteriophage-discovery experience primarily for entering students, sponsored by the Howard Hughes Medical Institute (HHMI) Science Education Alliance (SEA) (Caruso *et al*. 2009).

Various types of institutions are part of this program, which uses bacterial virus discovery and analysis as an accessible research area—with the goal of attracting and retaining young scientists in biomedical fields. The authors are partners in this national project, which includes assessment that will track students through their college careers and beyond. By the end of the project at the end of 2013, at least 40 institutions and well over 4,000 students will have participated. While the program is too young to be thoroughly assessed, we are enthusiastic about one aspect that deserves to be shared, namely, undergraduate peer mentoring in the execution and success of the phage genomics course.

Course Details

During the fall semester, students select and isolate their own mycobacteriophage from a soil sample on the college's campus. They then isolate and purify a pure phage species and its genomic DNA. Confirmation of a phage species requires verification via spot tests and titer assays. Isolated genomic phage DNA is digested and verified with restriction enzymes on an agarose gel to determine the quality of genomic DNA, as well as the molecular weight of the phage genomic DNA. During this fall semester, students also send prepared electron-microscopic grids fixed with their purified phage for phage-morphology analysis at Lehigh University.



Catherine Mageeney, Cabrini College Undergraduate Peer Mentor, working with one of the students in the HHMI-sponsored phage course.

First-year students learn several important techniques during the fall semester in the process of characterizing their individual mycobacteriophage species. Prior to this program, these techniques were only offered in upper-level biology courses at most institutions. In order to purify a mycobacteriophage species, students must master aseptic technique. Students also learn molecular biological techniques such as isolation of genomic DNA, setting up restriction-enzyme digests, and proper interpretation of restriction-enzyme-digested DNA on an agarose gel.

Students work toward a deadline for obtaining a sufficient quantity of quality genomic purified DNA, typically by mid-November, in order for students' samples of mycobacteriophage genomic DNA to be sent away for sequencing. This sequencing then provides the material for the bioinformatics work to be done in the spring semester. The mid-November deadline is challenging because students typically need to repeat many of the steps along the continuum of identifying a mycobacteriophage from the soil sample to isolating enough quality genomic DNA to be sent for genomic sequencing. For instance, many students do not obtain phage plaques during their first round of plating from a soil sample. Also, students many times fail to isolate enough quality genomic DNA for sequencing during one or two

rounds of performing this important step. In spite of all these setbacks, most of our students have been able to eventually isolate enough quality genomic DNA from their mycobacteriophage species. Students are expected to maintain a proper laboratory notebook documenting all of their experiments.

During the spring semester, students receive their mycobacteriophage's genomic DNA sequence from the Joint Genome Institute. Students then use gene-searching tools to identify likely genes contained within the class's sequenced mycobacteriophage. Students also use software to conduct comparative genomics studies to see if their mycobacteriophage is similar to the known, characterized mycobacteriophage genomes. The students have been able to master the bioinformatics software with relative ease. The greatest hurdles during this phase have been computer software glitches that occurred from time to time throughout the semester.

Training the Peer Mentor

The phage genomics course requires an intensive time commitment that includes a series of tightly coupled procedures and clear deadlines. Tasks of teaching, supervising, and coaching first-year students during the course are also labor intensive for faculty. Thus, the employment of a talented peer mentor to share the supervisory load is a key factor in the success of the course. At Cabrini College, the peer mentor (one of this article's authors) is compensated and paid on an hourly basis for her time during normal laboratory classroom instruction, which is four hours per week. The peer mentor is paid through Cabrini's Center for Teaching and Learning. The peer mentor is not compensated for time spent outside of class preparing for the laboratory, which usually involves 10 to 15 hours of additional work per week by the peer mentor.

"Peer mentor" is a term that includes a variety of student roles, ranging from peer teaching in large courses to experienced students assisting with an undergraduate research team (Henderson, *et al*. 2008; Varma-Nelson 2004). Lopatto (2009) reported on self-evaluation of peer-mentoring experiences in undergraduate research groups. He found a range of benefits to both peer mentors and their student colleagues, including an increased understanding of the research, an increased sense of responsibility, improvement in oral communication skills, and enjoyment of teaching. Both peer mentors and the students they influenced reported larger learning gains from the research experience than did undergraduate researchers without a peer mentor in their group.

Recent studies have demonstrated the merit of undergraduates serving as peer mentors in the biological sciences (Henderson *et al*. 2008). Currently, there are 27 institutions involved in the HHMI-sponsored phage genomics course, with another 12 institutions set to implement the course during the fall 2010 semester. Of the institutions currently teaching the course, only a handful make use of undergraduate peer mentors. For institutions that do use them, the undergraduate peer mentors—along with technicians and graduate teaching assistants—receive an intensive one-week training in phage genomic research at HHMI prior to undertaking their roles.

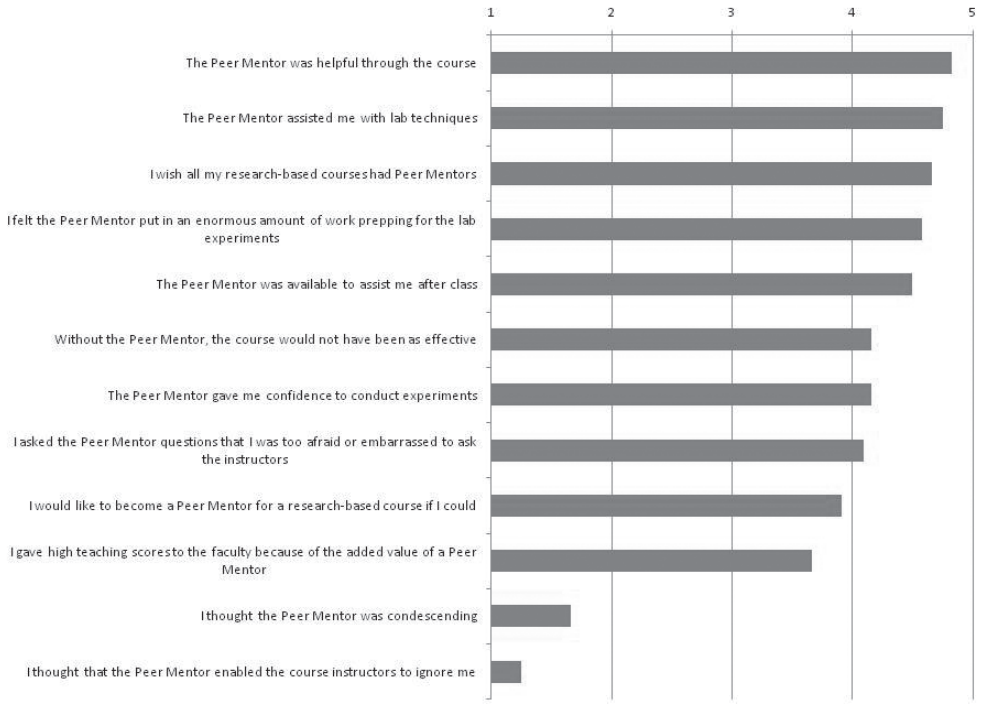
During their training session, peer mentors experience the wet labs that students taking the course conduct during the fall semester and learn different techniques needed during the semester. Under the tutelage of trained staff, peer mentors learn how to trouble-shoot experiments and to anticipate the kinds of pitfalls students typically encounter. Peer mentors also learn course expectations for the fall semester, course logistics, and how to be a mentor to students.

During the winter break between the fall and spring semesters, peer mentors are trained alongside the faculty members teaching the course on the bioinformatics aspects of the class. During this training period, faculty and peer mentors help in annotating a previously uncharacterized mycobacteriophage genome, as well as undertaking comparative genomics using the same software employed by the students during the spring semester.

Benefits of the Peer Mentor

The faculty members teaching the course at our institutions felt that without an upperclassman as a peer mentor, many, if not most, students would not have been successful in accomplishing all of the goals set for them during the fall semester. The peer mentor assisted

Figure 1: Peer-mentor Assessment Survey.



students with their experiments not only during normal scheduled laboratory time, but also helped students during non-lab hours seven days a week. This proved critical since students needed to perform most steps several times before they achieved the desired results. The peer mentor stayed in constant contact with students via e-mail during the academic year and even created a "phagebook" Facebook page in which faculty agreed not to be involved. The peer mentor also made up all the necessary laboratory reagents and made sure that students had a sufficient supply of necessary items and equipment, regardless of what step they were working on. Our peer mentor also agreed to check students' laboratory notebooks and offer students helpful suggestions concerning proper procedures for laboratory notebooks. Additionally, the peer mentor helped the faculty teach the course by performing demonstrations for the entire class or for individual students so that they mastered and understood the techniques they were employing. Students became so comfortable with our peer mentor that they utilized her extensively in understanding biological concepts taught in the lecture portion of Introductory Biology—which is not part of the phage course. Despite all the responsibilities, the peer mentor benefits by gaining hands-on experience working as a technician in a laboratory environment; gains confidence in performing the tasks at hand and in assisting the students in the class; and feels a sense of camaraderie working towards a common goal for the class and students. See accompanying photo that shows Cabrini peer mentor Catherine Mageeney assisting one of our phage genomics students during a laboratory session.

Another critical role played by the peer mentor at Cabrini College is archiving all of the mycobacteriophage species isolated by our phage genomics students. Archiving these samples requires creating electronic folders that have electron microscopic images of the mycobacteriophage, pictures of restriction digestion agarose gels, the GPS coordinates where the mycobacteriophage was isolated, pictures of agar plates demonstrating plaque morphology, as well as the quantity and purity of isolated genomic DNA. Lysate samples are also sent to HHMI for their archiving records, along with detailed

information on the mycobacteriophage species described above. Mycobacteriophage lysates, as well as purified genomic DNA, are also stored for potential future studies at Cabrini College or any other institution interested in any of the mycobacteriophage species isolated.

We discovered that students enrolled in the year-long phage genomics course at Cabrini valued the role of the peer mentor, based on comments culled from anonymous student-written evaluations administered near the end of the spring semester. The following student testimonials demonstrate the merit and value of Cabrini's peer mentor:

> "The peer mentor was really helpful. She was real easy to approach."
>
> "I thought it was really helpful having the peer mentor because she was always around and if they professors were busy helping others, it was really helpful having the assistance of a peer mentor who knew exactly what she was doing."
>
> "I thought the peer mentor was great. She was always there for us. I respect her and don't know how she does it all.""She was very relatable because she was a student as well."
>
> "The peer mentor was phenomenal. I was one of the students really behind in the wet lab portion of the course and the peer mentor really helped me catch up with the other students."
>
> "I think that she was absolutely amazing. I really admire her for everything she did, because she was there so much for us. I mean, she basically lived in the science building and we would never have been able to do it without her."

Several other institutions using peer mentors for their phage genomics course have had similar success. For instance, faculty evaluations at one institution said that "having lab aides helped the course run a little more smoothly, especially during lab prep, answering students' questions, and general troubleshooting." Faculty at another institution indicated that "it would have been near impossible to run the course without the assistance of an undergraduate peer mentor." Faculty at one institution did not use undergraduate peer mentors during the first year of the course, but did so in the second year, recruiting several experienced students who had taken the course the previous year. Having experienced the benefit of using several peer mentors, the course instructors indicated that they "will never teach phage genomics again without undergraduate lab aides functioning as peer mentors in the classroom." Another institution used two seniors as peer mentors for the phage course, and a faculty member there said "it worked out beautifully!" The faculty "had hoped to have last year's students serve as peer mentors, but the laboratory course structure keeps their sophomores busy in the afternoon when they teach the Phage course.

Assessing Undergraduate Peer Mentors

Near the end of the spring semester we surveyed our students regarding the merits and benefits of a peer mentor for the course, using a Likert-scale survey (N = 12). Figure 1 shows how students rated the effectiveness of the peer mentor in several categories. Students rated the mentor particularly highly in the categories of peer mentor helpfulness (4.83) and assistance with laboratory techniques (4.75). Students also gave the peer mentor a high score for after-class availability (4.5). Interestingly, although students felt that the peer mentor added much value to the course, the students rated the peer mentor somewhat lower (3.66) for the reason they gave the faculty high teaching evaluation scores. We interpret this as meaning that although students honored the merits of the peer mentor, they still recognized the expertise of the faculty instructors. This was the case in spite of the fact that many times throughout the course students indicated to faculty members that the peer mentor actually "ran the course at times."

Students did realize the amount of time and effort the peer mentor put into the course, as Figure 1 shows. For instance, the survey produced a 4.58 score for a question concerning whether the peer mentor put in an enormous amount of time preping for the course. This might explain why the students gave a somewhat lower score to the category of wanting to become a peer mentor themselves (3.91), since they realize the amount of work the

peer mentor needed to dedicate to the course and might be unwilling to spend that amount of time themselves serving in such a capacity.

Challenges

Cabrini College is a primarily undergraduate institution and does not have the use of graduate students in the science department. Student pools for peer mentors are small and sometimes there is not always a "perfect fit" for a faculty member's course. Also, in most cases compensation is low for the amount of time spent as a peer mentor, and this may play a role in potential peer mentors' motivation and willingness to assist the students and instructor during the laboratory. The peer mentor in the phage course was compensated through the college's Center for Teaching and Learning. Peer mentors at other institutions were either compensated through departmental funds or through their school's work-study program. Institutions with graduate students selected graduate assistants who expressed an interest in teaching. Peer mentors at other institutions agree that there is a large time commitment involved in peer mentoring for the phage genomics course. For instance, one peer mentor at another institution indicated that "the major downside was the intense time requirements of the first semester." A peer mentor at yet another institution indicated that although she/he was definitely glad for the opportunity to act in this role, the downside was "the inordinate time commitment involved with the course."

Another challenge related to the phage genomics course was ensuring that the students understood what they were doing. Many students felt uncomfortable asking the instructor what was going on, but would frequently meet with the peer mentor to ask for assistance.

Conclusions

The HHMI-sponsored course was implemented in fall 2008 and fully immerses undergraduates in cutting-edge research in the classroom. Mycobacteriophages are captured, isolated, and their DNA genomes sequenced and annotated. Students participating in the program are instructed and led by a mixture of trained faculty and peer mentors. Many times the peer mentors are simply more-advanced undergraduates who have excelled in areas of peer mentoring and research. These peer mentors receive intensive training from HHMI and are positioned to link the faculty instructors with the students enrolled in the course. Based on our experiences, we feel that an ideal peer mentor demonstrates confidence in teaching other students experimental protocols and techniques and must possess patience and excellent bench skills.

Cabrini College and several other institutions now realize how crucial the peer mentor is for the success of the phage genomics course. At primarily undergraduate institutions such as Cabrini, where there are no graduate teaching assistants or dedicated laboratory technicians, peer mentors are vital for the success of any science-based laboratory course in which a great degree of original research is conducted. Thus for success in such courses, strong departmental and administrative support is needed for a robust peer-mentoring program involving mentor training and appropriate compensation for the significant time commitment involved.

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