Supplemental Material

CBE—Life Sciences Education

Staub *et al.*

Table S1. A comparison of lab activities carried out by every student in a typical SEA-PHAGES course and in the Gonzaga Phage Discovery Lab.

Lab Activities/Techniques[1]	SEA-PHAGES First semester	Gonzaga Phage Discovery Lab
Direct plating of soil extracts[2]	X	
Enrichment cultures of soil extracts[3]	X	X
Spot tests of putative plaques[4]	X	
Serial dilutions of plaque lysate plated out	X	X
Medium-titer lysate from "web" plate[5]	X	X
Determine titer of medium-titer lysate	X	X
10 plate infection to produce "web" plates	X	
High-titer lysate from 10 plate infection	X	
Determine titer of high-titer lysate	X	
Negative staining for transmission EM	X	X
Phage DNA isolation	X	X
DNA quantification	X	X
Restriction analysis	X	X
Agarose gel electrophoresis	X	X
Quality-control gel to assess DNA integrity for sequencing	X	

[1] Standard bacteriophage microbiology, TEM, and molecular biology techniques. Many of these protocols are posted at www.phagesdb.org.

[2] Soil soaked in phage buffer

[3] Soil incubated in bacterial growth medium containing host bacteria

[4] A series of lysate dilutions are spotted onto a lawn of host bacteria to estimate titer of the lysate, the concentration of plaque-forming units in the lysate

[5] A webbed plate forms when phages are plated at a certain density so that the edges of the plaques touch each other. The residual bacterial lawn appears as a wispy web. This allows the maximum number of phage particles to be produced on a plate.

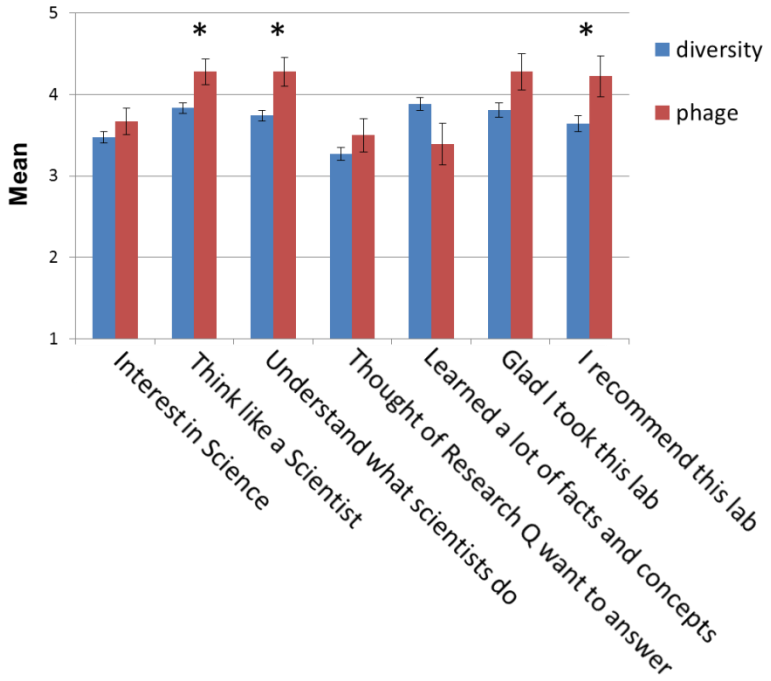


Figure S1. Post-course survey results for 149 Introductory Laboratory students in 2011-2012. 131 students from the Diversity of Life lab (44% of total students in 19 fall and spring sections) and 18 students from pilot implementations of the Phage Discovery lab (40% of total students in 3 spring sections) responded to an email invitation for a survey. The survey items can be found in Appendix 1 (Supplemental Materials). The response choices were on five-point scales from most negative (1 point) to neutral (3 points) to most positive (5 points). The bars represent the mean response. The error bars represent one standard error above and below the mean. Analysis with unpaired *t* tests showed significant differences between the means ($p < 0.05$, 2-tailed) for the items marked with asterisks. When reanalyzed with the nonparametric Mann-Whitney test, the same three items were significant.

Appendix 1. Post-course survey used to compare the one-semester pilot Phage Discovery lab with the traditional lab for introductory biology. 149 students completed this survey in 2011-2012.

(Ratings are scored 1-5, where 1 is most negative, 3 is neutral, and 5 is most positive.)

Survey Questions:

"After taking this lab, my INTEREST IN SCIENCE is _____ it was before I took the lab."
Much lower than, a bit lower than, the same as, a bit higher than, much higher than

"After taking this lab, my ABILITY TO THINK LIKE A SCIENTIST is _____ it was before I took the lab."
Much lower than, a bit lower than, the same as, a bit higher than, much higher than

"After taking this lab, I think I UNDERSTAND WHAT SCIENTISTS DO _____ before I took the lab."
Much worse than, a bit worse than, the same as, a bit better than, much better than

"I thought up RESEARCH QUESTIONS I WANTED TO ANSWER as a consequence of some of the lab activities"
I strongly disagree, I disagree, I am neutral, I agree, I strongly agree

"I learned a lot of BIOLOGY FACTS AND CONCEPTS in my lab."
I strongly disagree, I disagree, I am neutral, I agree, I strongly agree

"I am GLAD I took this lab."
I strongly disagree, I disagree, I am neutral, I agree, I strongly agree

"I RECOMMEND THIS LAB for anyone who needs to take a science lab."
I strongly disagree, I disagree, I am neutral, I agree, I strongly agree

What was your favorite thing about this lab?
[Text box available]

Do you want us to know anything else about your experience taking the lab course?
[Text box available]

If you want to participate in the drawing for a $10 gift certificate to the Zag Shop, please enter your email address so that we can contact you. Thank you for taking this survey!

Appendix 2. Phage Discovery Lab Concept Survey

The following survey is designed to help the instructors of this course identify concepts that students might have difficult time learning. Your performance will not affect your grade in this course. However, if you complete the survey during the last class, you may receive extra credit for doing it.

For each of the ten (10) questions, please choose the best answer. (Please give your best effort on these questions.)

1. A bacteriophage is a _____.
   a. very small bacterial cell
   b. clearing on a lawn of bacteria
   c. virus that replicates in a specific bacterial host
   d. virus that eats bacterial cells
   e. bacterial cell with a prophage integrated in its DNA

2. When a bacteriophage infects a bacterium, _____.
   a. its proteins enter the cell and its DNA remains outside the cell
   b. it breaks open the cell (lyses it) in order to get inside it
   c. its DNA enters the cell and its proteins remain outside the cell
   d. its membrane fuses with the bacterial cell membrane
   e. both its DNA and its proteins enter the cell

3. Bacteriophages and bacterial cells are microscopic (too small to see with the naked eye). However, it is possible to separate them on the basis of size by passing a solution containing bacteriophages and bacteria through a filter. How does this separation work?

   a. The phages can flow through the holes in the filter, but the bacteria are too large and cannot flow through.
   b. The bacteria can flow through the holes in the filter, but the phages are too large and cannot flow through.
   c. The filter eliminates contaminants in the solution, but allows the bacteria and the bacteriophage to pass through as a purified solution.
   d. The phages are broken when they go through the filter, but the bacteria pass through undamaged.
   e. The bacteria are broken when they go through the filter, but the phages pass through undamaged.

4. 150 microliters (μL) is equivalent to _____ milliliters (mL).
   a. 1.5
   b. 0.0015
   c. 15
   d. 0.015
   e. 0.15

5. A solution contains viruses in a concentration of 6×10^9 viruses/mL. You have 30 mL of this solution in a tube. How many viruses are in the tube?

a. 1.8×10^{12}
b. 1.8×10^{11}
c. 1.8×10^{10}
d. 2×10^8
e. 5×10^{-9}

6. A solution contains 1000 bacterial cells/mL. You take 0.5 mL of this solution and you add it to 4.5 mL of H_2O. What is the concentration of bacterial cells in the new solution?

a. 10,000 cells/mL
b. 100 cells/mL
c. 10 cells/mL
d. 2000 cells/mL
e. 500 cells/mL

7. During the crabbing season, you love to drop your crab cages to the bottom of the bay and see how many crabs you can trap. This season, you would like to test whether peanut butter is an effective bait. You gather three identical crab cages for your experiment. Each day, you place a glob of peanut butter in the first cage. You don't place anything in the second cage. You don't place anything in the third cage, but you remove the trap door so that any crabs that walk into the cage can easily walk back out. To carry out your study, you use all three cages each day for ten days, and you count how many crabs are present in each cage when you pull them up at the end of the day.

Which part of the experiment serves as a negative control for your test?

a. The third cage with no bait and no trap door.
b. There is no negative control in this experiment.
c. The second cage with no bait.
d. The first cage with the peanut butter.
e. A fourth cage that you do not drop into the bay.

(The following experiment will be used for questions 8 and 9.)

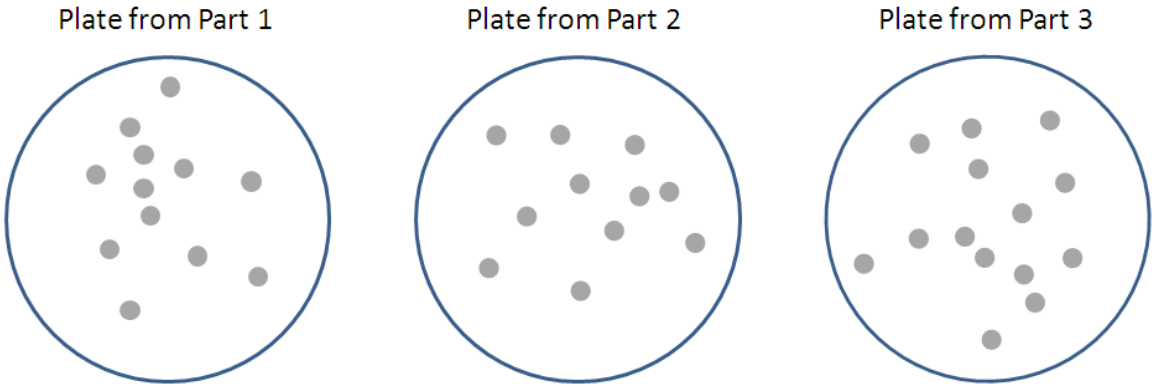
You are interested to find out whether any bacteria remain on your skin after you use hand sanitizer. To test this, you prepare sterile cotton swabs (sticks with a small bunch of cotton at the end), a batch of sterile water and a batch of petri dishes containing bacterial growth medium. You also have a petri dish on which bacterial colonies have already grown. You rinse your hands with hand sanitizer.

- In Part 1 of the experiment, you take a cotton swab, dip it in the water, rub it on the skin of your hand, then rub it on a petri dish.
- In Part 2, you take a cotton swab, dip it in the water, rub it on a bacterial colony on a petri dish, then rub it a new petri dish.
- In Part 3, you take a cotton swab, dip it in the water, then rub it on a new petri dish.

You incubate the petri dishes overnight and observe the petri dishes the next day.

8. Which part of the experiment is a positive control?
   a. part 3
   b. parts 1 and 2.
   c. part 1
   d. part 2
   e. This experiment has no positive control.

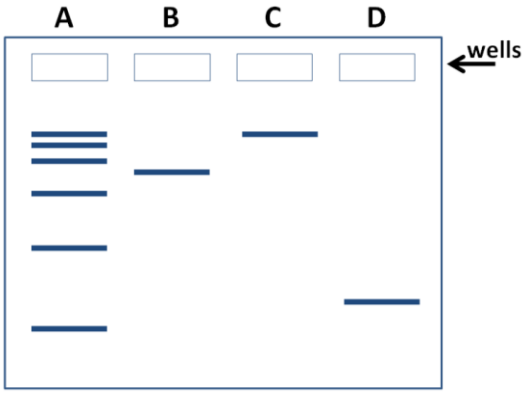
9. This is what the petri plates looked like the following day:



What is the best conclusion you can draw from the results of this experiment?

   a. There are bacteria on your skin, but you can draw no conclusions from Part 2 of the experiment because it must have been contaminated with bacteria.
   b. There are bacteria on your skin, but you can draw no conclusions from Parts 2 and 3.
   c. There are bacteria on your skin, but you can draw no conclusions from Part 3 of the experiment because it must have been contaminated with bacteria.
   d. There are bacteria on your skin.
   e. You cannot conclude whether or not there are bacteria on your skin.

10. Fragments of DNA have been loaded into the wells of an agarose gel, followed by electrophoresis. After staining for DNA, this is what the gel looks like:



Which of the following statements is true?

a. The fragment in lane B is the same length as the fragments in lane C and D.
b. The fragment in lane B is shorter than the fragment in lane D.
c. There is a fragment in Lane A that is larger than all of the other fragments on the gel.
d. The fragment in lane D is the longest fragment on the gel.
e. The fragment in lane B is shorter than the fragment in lane C.