Supplemental Material

CBE—Life Sciences Education

Premo *et al.*

Supplemental Materials for, "Promoting Collaborative Classrooms: Impacts of cooperative learning on undergraduate interactions and achievement"

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Student Group work

Week of February 6, 2017

The following questions are related to the paper from Liu et al. "Bacteriophages of wastewater foaming-associated filamentous Gordonia reduce host levels in raw activated sludge" that you read for this week. You will have a quiz next week, (Feb 13) related to this material.

Question 1: What is the next set of experiments that the authors could/should do related to this project?

Question 2: Here are 3 sentences from the manuscript. If you were writing a manuscript, which section (introduction, Materials and Methods, Results, Discussion) would you place each statement in? Justify your answer.

A. "All isolates developed colonies with irregular margins and appeared white to beige at the beginning of incubation. Strain G1 produced a pink pigment, and G5 and G11 produced yellow and orange/red pigment, respectively, over prolonged incubation."

B. "Phages against filamentous bacteria, especially different species of mycolata, have been isolated and their therapeutic applications documented in several studies. Mycobacteria species in particular have been the subject of focused efforts. Multiple phages against *Rhodococcus equi* were characterized and demonstrated to be capable of reducing *R. equi* load in a soil matrix."

C. "… application of these phages resulted in repeatable, significant suppression of Gordonia levels in activated sludge conditions. This is surprising, given the considerable diversity and species richness observed in the micro- and macro organism community of the activated sludge, with different organismal groups responsible for complex functions including floc-forming, phosphorus removal, nitrite oxidation, and denitrification."

Question 3: Consider the following questions and answer them using the knowledge you have gained in the SEA-PHAGES lab.

A. The host range determination experiment most closely resembles which experiment that you will carry out in Biology 107?

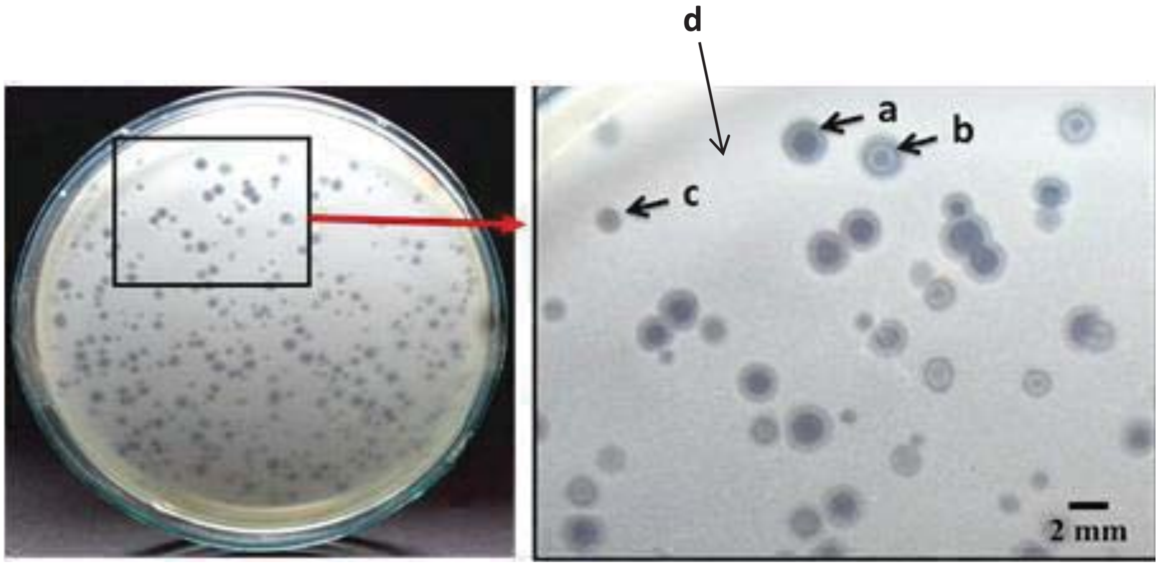
B. Why did the authors centrifuge the wastewater sample as their first step?

C. Why did the authors use 0.22 uM filters in their purification steps?

Student Group Work

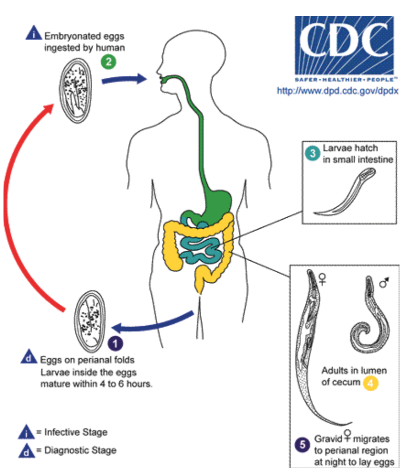
Week of February 13

This week's group work is related to Bacteria and Bacteriophages. You will take a quiz on this material during the week of Feb 20.



1. A. What kind of experiment is this?
B. Discuss the similarities and differences between Points a, c, and d on the plate above. What biological organism(s) is present in each location, and where did they come from in the experiment?

2. A. Describe the features or attributes that make an organism "living".
B. Using what you have learned so far this semester, would you consider bacteria to be living?
C. Using what you have learned so far this semester, would you consider viruses, and in particular bacteriophage, to be living?



3. A pinworm is a parasite that infects humans and lives and grows within our digestive tract.

A. In the pinworm-human interaction, which organism is the host and which is the parasite?

B. What does the host provide to the parasite?

C. How is the human-pinworm example related to bacteriophage and M. smegmatis? Describe the similarities and differences.

Student Group Work

Week of February 20

This week's group work is related to the Logic of Experiments.

1. A student is trying to decide whether or not to use a plaque assay or a spot test during their phage isolation. Which one(s) should they use under the following scenarios? Why?

A. The student has just completed an Enrichment

B. The student has just completed Direct plating and has a putative phage

2. A student is performing a spot test for a potential phage that they have isolated. On their plate, they spot a phage sample and there are two additional solutions that they spot. Which one is a positive control, and which one is a negative control?

A. The student spots 5 uL of their phage buffer

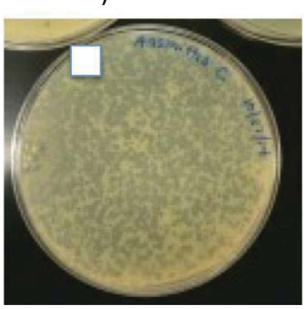
B. The student spots 5 uL of phage buffer with mycobacteriophage D29, a previously discovered phage.

3. A student is isolating a phage and on their first attempt they get the plate labeled "i" below. The student makes a single change in their experimental approach and they get the plate labeled "ii".

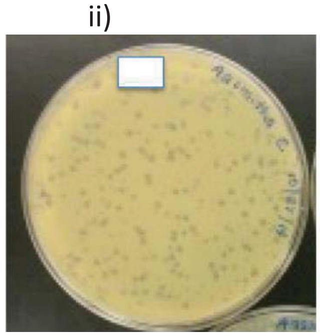
A. What do you think the single change in the experimental procedure was?

B. Why would a student want to use plate ii instead of plate i if they were to move forward with phage purification?

i)



ii)

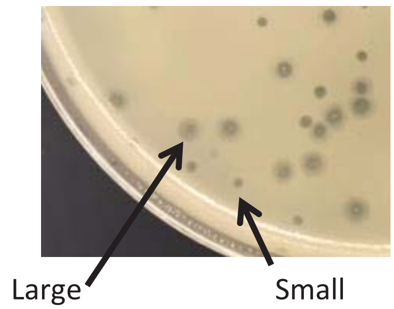


<u>Student Group Work</u>

Week of February 27

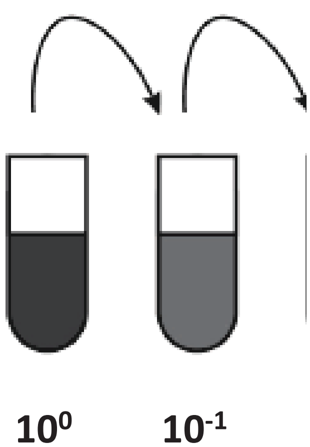
This week's group work is related to Experimental Troubleshooting. You will take a quiz on this material during the week of March 6.

1. A student is purifying their phage and they get a plate like that shown on the right. They do two follow up plates. For the first they pick a large plaque and get small and large plaques on their follow up plate. For the second they pick a small plaque and get only small plaques on their follow up plate. Explain these observations.



2. A student performs a spot test of their putative phage and sees a plaque. In the negative control they see a plaque, and in their positive control they see no plaques. What conclusions could be reached about this experiment?

3. A student is performing serial dilutions during phage purification. They take their original phage sample (10^0) and want to make 100 uL of a 10- fold dilution (10^{-1}) solution. They have some tubes with 90 uL of phage buffer and others with 100 uL of phage buffer. Which tube do they choose, and why?



<u>Student Group Work</u>

Week of March 6

This week's group work is related to using Phage as tools in biology. You will take a quiz on this material during the week of March 20 (AFTER SPRING BREAK!).

<u>1.</u> One application of phages is to quickly detect the presence of food-borne pathogenic bacteria in food. As an example, a microbiologist working for Chobani takes two batches of yogurt off of the production line. She suspects that one yogurt sample is contaminated with *Listeria*, a common food-borne pathogen, while the other one may or may not be contaminated.

A. The scientist takes an extract from the contaminated yogurt sample and adds 1000 *Listeria*-specific virus particles. After shaking and incubation for a day, what will happen to the number of phage particles in the sample? Why? Is this experiment selective for *Listeria* or could other bacteria lead to false positive results?

B. Based on your answer to Part A., how could the scientist tell if the second yogurt sample was contaminated with either *Listeria* or with *E. coli*, another potentially pathogenic bacterial species?

<u>2.</u> Phage therapy is an alternative to antibiotic treatment for bacterial infections. In phage therapy, phages specific to pathogenic bacteria are delivered to the site of an infection (e.g. on wound dressings, by oral ingestion, through an IV).

A. One side effect of antibiotic treatment is that these chemicals kill many beneficial bacteria in the human gut. Why might phage therapy, for example to combat a *Listeria* infection in the gut, be superior?

B. One problem with antibiotics is that they are typically unstable and quickly degrade in the body resulting in the need for frequent, high doses during treatment. What advantage would phage therapy have over antibiotic treatments in this respect?

3. *Leuconostoc* is a type of bacteria that is used widely in food fermentation, including during the production of wine. Many reports have surfaced of phages negatively influencing wine making by killing *Leuconostoc* bacteria.

A. Discuss with your partners if you think either lytic, lysogenic, or both types of phages would have a major, negative impact on wine making.

B. How could wine makers reduce their chances of losing *Leuconostoc* bacteria during wine making?

Student Group Work

Week of March 20

This week's group work is related to the Replication of Experiments. The first two questions are related to the notebook entry below.

"Feb 1, 2015. Title: Enrichment of Environmental Samples. Procedure: A soil sample was obtained. After shaking and incubation, the culture was transferred into a 3 ml syringe filer unit using aseptically using a transfer pipet. Using a micropipettor dispense 50 uL of the undilulted enrichment sample into a culture tube and mix well. After this allow the tube to sit at room temperature for 5 minutes and allow the phage to infect bacteria. Next, draw a grid on the bottom of an agar plate and label blocks of the grid by the positive control, negative control, and each of the dilutions of the enrichment sample. Obtain heated top agar, and after adding bacteria evenly spread the agar of the agar plate and allow the plates to sit for ten minutes. After cooling and solidification of the agar plates. Transfer 5 uL of the negative control using a micropipettor to the negative labeled block of the surface of your plate. Follow by transferring 5 uL of positive control and enrichment culture dilution to the positive labeled blocks on your agar plate and incubate after allowing the agar to solidify. Check these plaques after 24 hours.

Feb 7, 2015. Plaques obtained on positive control and environmental sample, no plaques for negative control."

1. You are looking for a phage that infects Mycobacterium to use in phage therapy. The passage above was a student group's notebook entry related to the initial phase of phage isolation. Is there additional data you would need to request before you would consider using that phage in your experiments? If yes, what data would you need to collect?

2. You decide to try and reproduce the laboratory experiment given above. You and your team find different results where your negative and positive controls appear to work correctly, but you get no phage from the environmental sample. What conclusions can be drawn from these two findings?

3. Why is it important that experimental observations be written down accurately and completely?

Student Group Work

Week of March 27

This week's group work is related to Serial Dilutions.

1. You are counting plaques on your plaque assay plates made from serial dilutions of your high titer lysate. Your 10^{-5} plate has 615 plaques although some are butting up against each other so it is a judgment call. Your 10^{-6} plate has 42 plaques, and your 10^{-7} plate has only 1 plaque. Which plate would probably yield the most accurate titer calculation of your phage and why is it more trustworthy than the others?

2. You are given a phage lysate and a culture of bacterial cells. You are asked to determine the titer (# of phage/mL). You make three serial dilutions of 100-fold and a final 10-fold dilution of the sample. After infecting the host with 0.5 mL of the last dilution and plating with top agar, the lawn of bacteria generate 40 plaques. What was the titer of the original phage sample?

3. You and your partner are isolating a new phage and have produced both a High titer lysate of ~10^{11} phage/mL and a Medium titer lysate of ~10^{5} phage/mL. You have your tubes with the HTL and MTL sitting on your bench when your partner accidently squirts ethanol on the two tubes, erasing all of the non-permanent sharpie markings on them. Both tubes have very similar volumes and look identical in nearly every way. What is a quick experiment you could perform that would allow you to assess which tube held the MTL and which one held the HTL without using up too much of your samples?

Student Group Work

Week of April 3-Plagiarism

This week's group work is related to **Plagiarism**.

1) A student likes the way a statement is written in a manuscript, and wants to use that statement in their own lab report introduction. What precautions should they take to be sure they are not going to plagiarize the material?

2) A student emails their lab report to a friend for ideas about how to write the discussion section of their lab report. The student's friend copies some of the student's discussion word for word, and when the assignments are turned in, the instructor detects the identical sentences in the SafeAssign plagiarism software used in Biology 107. Who is at fault for this act of plagiarism, and should the punishments be the same for both the student and their friend?

3) What are the reasons that students plagiarize materials? What precautions can they take to minimize the risk?

Student Group Work

Week of April 10

This week's group work is related to DNA Preparation. You will take a quiz on this material during the week of April 17

1) The phage capsid protects phage DNA from environmental factors. During the process of phage DNA preparation, how can you take advantage of the capsid to assure acquisition of phage DNA without contaminating DNA from the bacterial host in the lysate?

2) Guanidinium thiocyanate denatures proteins, making it hazardous to users and is used in preparation of phage DNA. What role(s) does the process of protein denaturation play in the DNA purification process, and what precautions can be used by students to minimize their exposure to this chemical?

3) Some students get poor DNA recovery during the phage DNA preparation, with little DNA to show for their efforts. Why might some student pairs have low DNA yields while others have strong yields?

#	Question	Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree
1	Helping a classmate when they need help will ensure they help me when I need help.	1	2	3	4	5
2	I am willing to help classmates outside of class if they need it.	1	2	3	4	5
3	I know my classmates from outside of class.	1	2	3	4	5
4	Class is more enjoyable when I work with other students.	1	2	3	4	5
5	The more classmates participate in class discussions, the more I understand.	1	2	3	4	5
6	My reputation in class is something that I value.	1	2	3	4	5
7	I feel that I need to cooperate with my classmates.	1	2	3	4	5
8	If I help a classmate with a question they will help me with other questions later.	1	2	3	4	5
9	Friendships I have in this class also exist outside of class.	1	2	3	4	5
10	I would rather help a classmate when I finish my work than sit around and wait.	1	2	3	4	5
11	I learn best when working with classmates.	1	2	3	4	5
12	Classmates' ideas positively increase my learning experience.	1	2	3	4	5
13	Classmates I help tend to help me back.	1	2	3	4	5

14	My classmates expect me to cooperate with them.	1	2	3	4	5
15	It is expected that I will work well with my classmates.	1	2	3	4	5
16	I have friends in class that I spent time with outside of class.	1	2	3	4	5
17	I put more energy into working cooperatively than my classmates.	1	2	3	4	5
18	I spend time helping my classmates during class.	1	2	3	4	5
19	I would rather work alone than with a partner.	1	2	3	4	5
20	I spend a greater amount of time helping classmates than I get helped.	1	2	3	4	5
21	I receive better grades in classes where I work with other students.	1	2	3	4	5
22	When classmates share their ideas in class it helps me learn.	1	2	3	4	5
23	I am tend to spend more energy thinking of good ideas than do my classmates.	1	2	3	4	5
24	If I help a classmate with their homework they will help me with mine later.	1	2	3	4	5
25	I prefer to take classes where students work together to solve problems.	1	2	3	4	5
26	My classmates spend less time helping me than I help them.	1	2	3	4	5
27	I want to have a good reputation in my classes.	1	2	3	4	5
28	I expend more personal resources during cooperative exchanges than my classmates do.	1	2	3	4	5

29	It is assumed that I will be cooperative towards others in the classroom.	1	2	3	4	5
30	The amount I understand is increased by classmate ideas.	1	2	3	4	5
31	I care what my classmates think of me.	1	2	3	4	5
32	I help other classmates during class when they need help	1	2	3	4	5
33	I dedicate energy to making sure my classmates receive the help they need.	1	2	3	4	5
34	What gender do you identify with? / What is your gender?	Male(1)	Female(2)	Other(3)		
35	What is your race?	White/Caucasian(1)	Latino/a(2)	Asian/Pacific Islander(3)	African/ African American (4)	Other/ Multiracial (5)
36	Approximately how many undergraduate science courses have you completed prior to this semester?	0 (1)	1-2 (2)	3-5 (3)	6-10 (4)	More than 10 (5)
37	Are you currently interested in pursuing a profession in a science related field?	Yes (1)	No (2)	Undecided (3)		

Supplemental Table 1

Confirmatory factor analysis results for Cooperative Classroom Environments Measure (CCEM) Pre-test and Post-test

Subscale (Cronbach's alpha pre/post)	*Items*	*Pre-test Subscale Loadings*	*Post-test Subscale Loadings*
Reciprocity α = .80/81	Helping a classmate when they need help will ensure they help me when I need help.	.78*	.75*
	If I help a classmate with a question they will help me with other questions later.	.84*	.80*
	Classmates I help tend to help me back.	.46*	.58*
	If I help a classmate with their homework they will help me with mine later.	.68*	.73*
Willingness to help peers α = .72/.70	I am willing to help classmates outside of class if they need it.	.58*	.51*
	I would rather help a classmate when I finish my work than sit around and wait.	.53*	.53*
	I spend time helping my classmates during class.	.61*	.55*
	I help other classmates during class when they need help	.60*	.64*
	I dedicate energy to making sure my classmates receive the help they need.	.69*	.62*
Friendship presence α = .83/.84	I know my classmates from outside of class.	.78*	.74*
	Friendships I have in this class also exist outside of class.	.69*	.85*
	I have friends in class that I spent time with outside of class.	.86*	.79*
Preference for cooperation α = .87/.85	Class is more enjoyable when I work with other students.	.74*	.72*
	I learn best when working with classmates.	.84*	.82*
	I would rather work alone than with a partner. (inverse)	.66*	.65*
	I receive better grades in classes where I work with other students.	.75*	.65*
	I prefer to take classes where students work together to solve problems.	.77*	.77*
Benefit from classmate ideas α = .82/.84	The more classmates participate in class discussions, the more I understand.	.64*	.69*
	Classmates' ideas positively increase my learning experience.	.72*	.78*
	When classmates share their ideas in class it helps me learn.	.84*	.80*
	The amount I understand is increased by classmate ideas.	.72*	.78*

Reputational concern α = .79/.81	My reputation in class is something that I value.	.79*	.84*
	I want to have a good reputation in my classes.	.82*	.79*
	I care what my classmates think of me.	.62*	.72*
Cooperative Norms α = .70/.70	I feel that I need to cooperate with my classmates.	.70*	.72*
	My classmates expect me to cooperate with them.	.62*	.72*
	It is expected that I will work well with my classmates.	.65*	.66*
	It is assumed that I will be cooperative towards others in the classroom.	.59*	.59*
Relative investment in cooperation α = .71/.73	I put more energy into working cooperatively than my classmates.	.34*	.41*
	I spend a greater amount of time helping classmates than I get helped.	.74*	.64*
	I am tend to spend more energy thinking of good ideas than do my classmates.	.56*	.66*
	My classmates spend less time helping me than I help them.	.73*	.61*
	I expend more personal resources during cooperative exchanges than my classmates do.	.50*	.62*

Note that the factor loadings are correlations between student answers for an item and the subscale factor (e.g. reciprocity). A factor loading is can be considered adequate if >.30.

*$p < .05$

#	Indicators of Prosocial Behavior	Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree
1	Students do not behave in ways which are distracting to peers.	1	2	3	4	5
2	Students display behaviors indicative of listening to one another during discussion.	1	2	3	4	5
3	Students voluntarily offer ideas in the classroom without being prompted.	1	2	3	4	5
4	Students show support for their peer's ideas during discussion.	1	2	3	4	5
5	Students appear to enjoy working with one another.	1	2	3	4	5
#	**Discussion Practices**	**Strongly Disagree**	**Disagree**	**Neither Agree Nor Disagree**	**Agree**	**Strongly Agree**
6	Students reference what their peers are saying when presenting their own ideas.	1	2	3	4	5
7	Students build on their classmate's ideas during discussion.	1	2	3	4	5
8	Students provide evidence to support their ideas.	1	2	3	4	5
9	Students go into depth with ideas when discussing.	1	2	3	4	5

Observation Protocol Item Descriptors

Indicators of Prosocial behavior (items in bold, descriptors underneath)

Students do not behave in ways which are distracting to peers.

- Students are not doing the following:
  - doing other work
  - on phone (including texting),
  - talking about non-content topics

Students display behaviors indicative of listening to one another during discussion.

- Students are generally doing the following:
  - Have their heads up when during discussion (unless writing)
  - Turn to face speakers.

Students voluntarily offer ideas in the classroom without being prompted.

- Prompts can be from either the instructor or fellow students (specifically in small groups or pairs)
  - Example: Once the instructor asks a question multiple students answer without having to ask for answers in between each question.
  - Example 2: Both students (pairs) or all students (groups) discuss without some students never contributing (social loafing).

Students show support for their peers ideas during discussion.

- Adds nothing to the science content specifically but shows peer support for either each other towards task. Includes:
  - Agreeing head nods
  - Verbal support (including praise)
    - Examples: “good idea” “I agree”
  - Helping out another student that has a question or can’t answer a question
    - Example 1: A student asks a question and another student answers it.
    - Example 2: A student can’t come up with an question asked by another student or the instructor and another student helps them by answering it or contributing to an answer.

Students appear to enjoy working with one another.

- This item is focused on behavioral expressions of student enjoyment. Includes:
  - Smiles
  - Laughter
  - General positive feel and energy in student interactions

Discussion Practices

Students reference what their peers are currently saying when presenting their own ideas.

- This item looks at continuity between contributors in the conversation. (explicitly)
  - Example: Instructor asks "What do you know about viruses?" John says "I know that viruses are small.." and Jane adds "I agree with John and also _______"
  - NON-Example: Instructor asks "What do you know about viruses?" John says "I know that viruses are small.." and Jane says "They aren't alive"

Students build on their classmate's ideas during discussion.

- This item also looks at continuity between contributors in the conversation.(implicitly)
  - Example: Instructor asks "What do you know about viruses?" John says "I know that viruses are small.." and Jane adds "Yeah they are small and also _______"
  - NON-Example: Instructor asks "What do you know about viruses?" John says "I know that viruses are small.." and Jane says "They aren't alive"

Students provide evidence to support their ideas.

- This item looks at student sources of ideas with more evidence being present being an indication of more effective discussion. All types are equal in this item so any type can support agreement.
  - Sources of evidence can include textbook, instructor statement, lecture/lab material, logic, internet, experience, logic etc.
    - Example for *source evidence*: Instructor asks "What do you know about viruses?" John says "I read in the textbook/notes/ Dr. Davis said in lecture that viruses are small"
    - Example for *experience evidence*: Instructor asks, "What is the next step we should take in X situation?" Tammy replies, "Our group had that happen last week and we did ____"
    - Example for *logic evidence*: Instructor asks, "What is the next step we should take in X situation?" Zeke replies, "Well we just finished doing X so we need to complete protocol Y to see the results"

Students go into depth with ideas when discussing.

- This item also looks at whether students will remain on the surface level of an idea or actually unpack the details related to it. If you have to prompt students to do this than it *does not count*.
  - Example: Instructor asks "What do you know about viruses?" James says "I know that viruses are not alive…" Lisa responds "How do we determine that?" Ashley responds, "I think they use _____"
  - NON-Example: Instructor asks "What do you know about viruses?" James says "I know that viruses are not alive.." and Lisa says "Yeah and they are small"

Supplemental Table 2
Cooperative Classroom Observation Protocol (CCOP)

Subscale (Cronbach's alpha)	*Item*	*Loading*
Indicators of Prosocial Behavior (α = .70)	Students do not behave in ways which are distracting to peers.	.29*
	Students display behaviors indicative of listening to one another during discussion.	.61*
	Students voluntarily offer ideas in the classroom without being prompted.	.57*
	Students show support for their peer's ideas during discussion.	.72*
	Students appear to enjoy working with one another.	.55*
Discussion Practices (α = .74)	Students reference what their peers are saying when presenting their own ideas.	.50*
	Students build on their classmate's ideas during discussion.	.67*
	Students provide evidence to support their ideas.	.68*
	Students go into depth with ideas when discussing.	.70*

Note that the factor loadings are correlations between student answers for an item and the subscale factor (e.g. Discussion Practices). A factor loading is can be considered adequate if >.30. Correlations between undergraduate and graduate TA ratings tended to increase by week and showed a higher correlation for prosocial behavior ($r = .51$) than for discussion practices ($r = .35$).
$^*p < .05$

Biology 107 Laboratory

Spring 2017

Quiz 1 – Week of February 13, 2017

2 Points total; 0.5 points per question

1. Below are two statements taken from a student's laboratory report in Biology 107. In which section of the lab report should the student place each statement (Introduction, Materials and Methods, Results, Discussion)?

A. "Using the plate from the spot assay procedure, each plaque was labeled and circled. 90 uL of SM buffer was added to a microcentrifuge tube. Using a pipet tip to poke the plaque, the phage was transferred to the SM buffer microcentrifuge tube."

B. "The calculated titer of 1.04×10^{9} (pfu/mL) was slightly lower than the required 1.0×10^{10} minimum to move on to isolating and purifying the genomic DNA of the phage. This low concentration may have been caused by the concentration of purified phage being transferred for the Titer Assay being too low as well."

2. A common experimental approach in phage hunting is to centrifuge an environmental sample taken from, e.g. wastewater or a soil sample incubated in buffer. Why would a scientist centrifuge their sample before beginning a bacterial infection assay?

3. A scientist is working with a mixture of phage and bacteria. They grab a 5 um filter off the shelf and use it to filter a mixture of bacteria and phage. What will be present in the filtrate, and what will be trapped in the filter?

Biology 107 Laboratory

Spring 2017

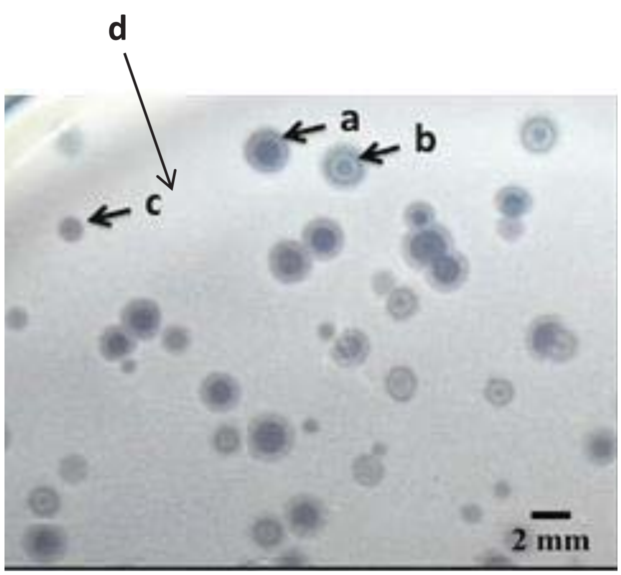
<u>Quiz 2</u> – Week of February 20, 2017

2 Points total; 0.5 points per question

1. Below are two statements. For each, fill in the blank with either <u>bacteria</u>, <u>viruses</u>, or <u>both bacteria and viruses</u>.

A. _________________________ are able to generate their own energy using only external sources such as sunlight or glucose. Therefore they are considered living.

B. _________________________ are able to infect other organisms. This does not tell a scientist if they are living or non-living.



2. If a student were to grow organisms from Points a and d on the experimental outcome shown above, what would they obtain?

Point	Bacteria (Y/N)?	Phage (Y/N)?
a.		
d.		

Biology 107 Laboratory

Spring 2017

Quiz 3 – Week of March 6, 2017

2 Points total; 0.5 points per question

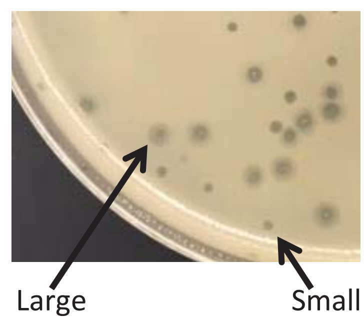
1. A student is performing a spot test and does both a negative and a positive control. For each situation below, indicate if the student should move forward with their experiment or not (Yes/No).

A. The student sees a plaque on their positive control and no spot on the negative control.

B. The student sees a spot on the negative control, but no spot on the positive control.

2. To make 100 uL of a 10^{-2} phage sample, a student should use ____________ uL of phage buffer and ____________ uL of a 10^{-1} phage stock.

3. A student is purifying their phage and they get a plate like that shown on the right. They pick a small, isolated plaque and get both small and large plaques on their follow up streak plate. After 3 more plates, thy still get a mixture of large and small plaques on their streak plates.



At this point, which of these two scenarios is more probable? Why?
i. They have two different phages and they cannot separate them
ii. They have one phage that shows 2 different plaque morphologies that depend on the local environmental conditions in the top agar

Biology 107 Laboratory

Spring 2017

<u>Quiz 4</u> – Week of March 20, 2017

2 Points total; 1 point each question

1. A food scientist is working for a dairy farm and she suspects that a dangerous strain of E. coli may have contaminated a batch of milk. Describe an experiment that would allow the scientist to quickly and selectively screen for the presence of *E. coli.*

2. Phage therapy has been shown to have advantages over traditional chemical antibiotics.

A. What is one reason that salmonella phages be preferred over chemical antibiotics to treat a salmonella infection in the human gut?

B. How many doses of salmonella phages would a doctor need to supply, in theory, if a patient came in with a salmonella infection? Compare this to the standard, 5-7 day course of antibiotics that are normally used.

Biology 107 Laboratory

Spring 2017

Quiz 5 – Week of March 27, 2017
Material related to Replication of Experiments

2 Points total; 1 point each question

1. You want to see which, if any, phages in your lab section will infect *Mycobacterium tuberculosis* as part of a phage therapy project. Your lab colleague hands you their notebook related to the phage that they have isolated and as you review the days reporting the isolation of their phage, you find the following information clearly noted:

- The GPS coordinates of two soil samples
- Experimental details of a direct enrichment experiment, including the bacterial species used
- Pictures of an enrichment plate indicating plaques from the positive control and several plaques in the experimental area of a plate.

If you needed to, could you reproduce this experiment? If not, what information is missing in the experimental details?

2. Your work this semester is part of a national research project related to bacteriophage discovery and characterization. Name two types of individuals who would be interested in your results and might have reason to read your lab notebook and who would want to be able to reproduce your experimental results

Biology 107 Laboratory
Spring 2017

<u>Quiz 6</u> – Week of April 17, 2017
Material related to Phage DNA Preparation

2 Points total; 0.5 points each question part

1. You have a liquid sample that contains intact phage particles and ruptured bacterial cells.

a. Where would you expect to find DNA in this sample?

b. How can you treat this sample so that at the end of your work you will maximize the yield of phage genome and minimize the yield of potential interfering nucleic acids?

2. Two student groups, labeled Group 1 and Group 2, performed the gDNA isolation protocol incorrectly. Group 3 performed the gDNA isolation protocol correctly.

a. Group 1 treated the HTL lysate with resin before they added nuclease but followed all other steps. What would be the expected DNA concentration and purity for Group 1 as compared to Group 3?

b. Group 2 forgot to add nuclease but otherwise completed followed all other steps. What would be the expected DNA concentration and purity for Group 2 as compared to Group 3?

Supplemental Table 3

Confirmatory factor analysis model assessing the extent to which the weekly quizzes were assessing a common factor (hypothesized to be science content knowledge).

	Quiz Number	*Loading*
Science content knowledge	One	.51*
	Two	.45*
	Three	.39*
	Four	.50*
	Five	.09
	Six	.32*

Note that quiz number five did not share significant common variance with other weekly quizzes and thus was not included in the analyses. Factor loadings are correlations between student answers for an item and the subscale factor (e.g. Discussion Practices). A factor loading can be considered adequate if >.30.

*p <.05

Supplemental Table 4
Model selection using class level factors to predict late prosocial behavior (CCOP).

Initial model and terms dropped	Changes in Model Fit				
***Outcome*: late prosocial behavior**	df	R^2 (adjust)	Residual df	ΔR^2	AIC
Initial Model: rater level (grad) + initial prosocial behavior + course achievement + initial science career motivation + percentage female + percentage interest in a science career + percentage with low science experience + initial reciprocity + initial friendships + initial willingness to help peers + initial reputational concern + initial perception of cooperative norms + initial relative investment in cooperation + intervention + change in reciprocity + change in friendships + change in willingness to help peers + change in reputational concern + change in perception of cooperative norms + change in relative investment in cooperation + (change in reciprocity x change in relative investment in cooperation)		.487	76		143.22
– change in cooperative norms	1	.480	77	-.007	142.50
– change in reputational concern	1	.484	78	.004	139.52
– change in willingness to help peers	1	.487	79	.003	134.05
– initial relative investment	1	.482	80	-.005	135.95
– initial perception of cooperative norms	1	.473	81	-.005	135.81
– initial reputational concern	1	.476	82	.003	133.38
– initial willingness to help peers	1	.475	83	.001	131.79
– initial friendships	1	.478	84	.003	129.56
– initial reciprocity	1	.481	85	.003	127.47
– percentage with low science experience	1	.483	86	.002	125.46
– percentage interest in a science career	1	.486	87	.003	123.29
– percentage female	1	.488	88	.002	121.46
– initial science career motivation	1	.494	89	.006	118.94
– rater level (grad)	1	.488	90	-.006	118.65
Final Model: initial prosocial behavior + course achievement + intervention + change reciprocity + change investment + change friendships + (change in reciprocity x change in relative investment in cooperation)					

Each factor subtracted from the initial model are shown in the far left column. The development of the model was cumulative moving downward from the initial model to the final model. Factors not meeting the removal criteria are not shown (and retained in the final model). Removal criteria were met if 1) removal of the factor decreased model AIC by < 2 or 2) If ΔAIC was 2 > |x| > 0 then the factor was removed to retain the most parsimonious model. If removing a factor resulted in an increase of AIC >2 this was retained in the model.

Supplemental Table 5
Model selection using class level factors to predict late discussion practices (CCOP)

Initial model and terms dropped	Changes in Model Fit				
***Outcome*: late discussion practices**	df	R^2 (adjust)	Residual df	ΔR^2	AIC
Initial Model: rater level (grad) + initial discussion practices + course achievement + initial science career motivation + percentage female + percentage interest in a science career + percentage with low science experience + initial reciprocity + initial friendships + initial willingness to help peers + initial reputational concern + initial perception of cooperative norms + initial relative investment in cooperation + intervention + change in reciprocity + change in friendships + change in willingness to help peers + change in reputational concern + change in perception of cooperative norms + change in relative investment in cooperation		.312	74		170.54
– change in friendship	1	.321	75	.009	167.14
– change in cooperative norms	1	.329	76	.008	163.92
– initial willingness to help	1	.336	77	.007	160.95
– initial perception of cooperative norms	1	.343	78	.007	158.00
– initial investment in cooperation	1	.351	79	.008	155.03
– percentage female	1	.348	80	-.003	153.69
– percentage interest in a science career	1	.348	81	.000	151.98
– percentage with low science experience	1	.356	82	.008	149.15
– initial science career motivation	1	.362	83	.006	146.71
– initial discussion practices	1	.361	84	-.001	145.20
Final Model: rater level (grad) + course achievement + initial reciprocity + initial friendships + initial reputational concern + intervention + change in reciprocity + change in willingness to help peers + change in reputational concern + change in relative investment in cooperation					

Each factor subtracted from the initial model are shown in the far left column. The development of the model was cumulative moving downward from the initial model to the final model. Factors not meeting the removal criteria are not shown (and retained in the model). Removal criteria were met if 1) removal of the factor decreased model AIC by < 2 or 2) If ΔAIC was 2 > |x| > 0 then the factor was removed to retain the most parsimonious model. If removing a factor resulted in an increase of AIC >2 this was retained in the model.

Supplemental Table 6
Multi-level model examining intervention impacts on average quiz score

	Intercept Only Model		Model 2		Model 3		Model 4		Model 5	
	γ	SE	γ	SE	γ	SE	γ	SE	γ	SE
Intercept	1.58*	.03	1.53*	.049	.67*	.10	.17	.22	.20	.21
TA			Var.*	Var.	Var.*	Var.	Var.*	Var.	Var.*	Var.
Course % grade					.11*	.01	.01*	.001	.01*	.001
Science interest							.56 *	.23	.52*	.23
Intervention									.04	.32
AIC	-26.95		-21.29		-91.87		-95.74		-92.15	
x^2	-30.95		-25.29		-95.87		-99.75		-96.15	
Δ_x^2 (*df*)			5.66(6) [a]		-70.58(1)* [a]		-4.01(1)* [a]		3.60(1) [a]	
Residual (Class-level)	.011		.005		.001		>.001		>.001	
Residual (Student-level)	.049		.049		.041		.041		.041	
% Variance class-level	18.3		9.3		2.4		.7		.7	

[a] compared to the prior model
Note: Var. = Varied, TA was entered as a categorical factor into the model. For ease of model comparison these have been presented as a single row, but estimates varied by TA (despite being significant overall).

Steps in Model Building

1) Intercept Only Model - Classroom was added as a random effect in an intercept only mixture model to examine the proportion of total variance that was accounted from by classroom alone.

2) Model 2 - The prior model was retained and TA (instructor of the lab) was added as a categorical level one fixed effect into the model. While this did result in worsening of model fit, TA was able to account for approximately half of the between classroom variance. Given that the purpose of the model was to control for between classroom variance in quiz scores, TA was retained in the model.

3) Model 3 - The prior model was retained and student course percent grade (final) was added as a continuous level one fixed effect. This resulted in a significant increase in model fit (as indicated by both chi-squared and AIC changes). In addition, student course percentage grade was able to account for an additional ~ 7% of student level variance and reduced between classroom variance to only 2.4% of total variance.

4) Model 4- The prior model was retained and student science interest was added as a final level 1 fixed effect into the model. This resulted in a significant increase in model fit (as indicated by both chi-squared and AIC changes). In addition science interest accounted for 1.7% of between classroom variance and reduced total between classroom variance to less than 1%.

5) Model 5 – With between classroom variance largely accounted for, intervention was added as a categorical fixed effect into the model. As seen above in intervention participation did not account for significant variance in student quiz performance (indicated by a non-significant parameter estimate).