The Research Question
American Foulbrood Disease (AFB) is the leading bacterial cause of honeybee colony loss in the US and worldwide. The etiologic bacteriophages (viruses that infect bacteria) that are able to infect and lyse Paenibacillus larvae.

1. Can we develop a phage buffer in which these phages are stable?
2. What is the host range of the various phages?
3. Are the putative lysins predicted on the various phage genomes active? Can we produce them recombinantly?

Students in the current semester are addressing research questions that were formulated by the students who took the course last year:

1. Evaluate the work of others using the intellectual standards for critical and creative thinking.
2. Apply critical and creative thinking skills and intellectual standards in the process of solving problems and addressing questions.

Evaluating Literature and Formulating Questions
Student Assignment Prior to Class: Identify the overall question or problem addressed by this paper. Define the scope of the problem that was explored (depth, breadth, perspectives). Select one experiment detailed in the results section of the paper, and summarize:

1. What was the overall question/problem addressed by this paper? Define the scope of the problem that was explored (depth, breadth, perspectives).
2. Select one experiment detailed in the results section of the paper, and summarize:
   a. What question was addressed? How was it significant to the study?
   b. What was done (broadly, not specific protocol steps)? Were the methods employed appropriate to address the problem/question?
   c. State the result obtained and its relevance in the overall question addressed by the paper.
   d. Who is the intended audience for the article? Was the article written with clarity for the intended audience?
   e. Did the conclusions follow logically from the data? Provide an example.
   f. Did the authors provide alternate conclusions of the data? Provide an example. Are there any interpretations that you thought about that the author did not consider?
   g. Given the findings and approach taken in this work, what questions does it lead you to with respect to our research project? List as many research questions as you can think of. Select one and briefly provide a possible methodology to pursue. Explain why you selected the above research question from among your alternatives.

Critical Thinking Scenario Example

1. What does the author of the graph want you to infer? Does the data strongly support this conclusion?
2. Give an alternate explanation for the data shown in the graph.
3. Suggest further data that you could gather to investigate the alternative above.

References
1. AFB-infected comb: http://www.mol-ecol.uni-halle.de/research/genomics/honeybees_6/

Students each write an original evidence- and data-driven lab report on their research findings that includes title, introduction, materials and methods, results, discussion/future work, and reference sections. Instructions map to specific intellectual standards for critical and creative thinking.

Each lab report is subject to peer review by a classmate using a rubric based on the intellectual standards for critical and creative thinking (available upon request). Students receive peer feedback, but peer evaluation of lab reports does not affect report grades. Peer reviews, themselves, are graded by the instructor. For the final report, students evaluate their own work using the rubric, in addition to the work of a peer.

Lab reports are assessed by the instructor using a rubric based on skills and behaviors of critical and creative thinkers that were developed in conjunction with the NC State QEP (available upon request).

NC State Standards of Critical Thinking

- Clarity: Is the idea clear to the person who is listening or reading?
- Accuracy: Is the idea based on facts and experience or is it mere speculation?
- Precision: Is the idea precise or vague?
- Relevance: Is the idea relevant to the current topic?
- Depth: Are there layers to the idea? Is it merely the surface?
- Breadth: Is the idea broad and sweeping or narrow?
- Logic: Is the idea logical and consistent?
- Significance: Is the idea important? Is it a solution to a problem?
- Fairness: Is the idea fair to all concerned?

Originality and Intellectual Standards of Critical Thinking

- Originality: Is the idea of value to the discipline? Is the idea of original value to the discipline?
- Flexibility & Adaptability: Is the idea adaptable to changing conditions? Is the idea adjustable to new evidence?
- Appropriateness: Is there a good fit between the constraints of the problem and the properties of the solution?
- Contribution to the Domain: Is the new idea of value to the discipline?