

Active learning was applied, in the microbiology class for biology majors, for the students to learn about horizontal transfer, genetic recombination and how these processes change the phenotypic traits, such as antibiotic resistance, in bacteria. Active learning on these topics was conducted in both lecture as well as in the lab.

A study guide listing the concepts on these processes was given to the students a week before the active learning module. At the beginning of the lecture session, I asked recall questions on the component of the processes such as plasmid, phage. Then I asked them to have discussion with their neighbors on conjugation, transduction and transformation. I asked some volunteers to come up to the board and make diagrams to explain about the processes. For example, a student made diagrams to explain about F+ X F- mating, Hfr X F- mating while other students in the class also contributed to the explanation. From these interactions, I assessed that the students had some trouble dealing with transduction. This might be that they had not been introduced to the life cycle of phages. I clarified the muddiest points on transduction.

Summative assessment was done by asking the following questions:

1. Which of the following is false about a recombinant chromosome?
  - A. It has a new combination of genes
  - B. It has genes from two different DNA molecules.
  - C. In nature, it is not possible for a bacterial cell to have a recombinant chromosome.
  - D. It can change the phenotype of the cell.

Understanding 89% had the right answer

2. Which of the following statements is true about plasmids?
  - A. They are made up of phospholipids.
  - B. They are found in all organisms including humans.
  - C. All bacterial cells have F plasmids.
  - D. Plasmids are not needed for the cell to survive under normal conditions.

Recall 100% had the right answer

3. Phage having the bacterial DNA in its capsid
  - A. Is known as a transducing particle.
  - B. Protects the DNA of the bacterial cell.
  - C. In general, responsible for destroying the recipient cell.
  - D. Helps the chromosome of the donor cell to replicate.

Recall, understanding 83% had the right answer

4. When a F- cell and a F+ cell conjugate
  - A. After conjugation, there are two F+ cells.
  - B. F+ becomes F-
  - C. F+ acquires new genes.

D. In general, F<sup>+</sup> transfers a fragment of its chromosome .

Recall, understanding 72% had the right answer

5. Which of the following statement is false about Hfr cell?
- A. Has the F plasmid integrated in its chromosome.
  - B. In general, transfers the entire F plasmid to the F<sup>-</sup> cell.
  - C. F<sup>-</sup> cell becomes a recombinant cell after it conjugates with the Hfr cell.
  - D. Hfr cell makes the pilus.

Recall, understanding 83% had the right answer

1. Two different strains of *N. gonorrhoeae* were used for an experiment in the lab. One strain had the fimbriae (Strain A) while the other did not have the fimbriae (Strain B). The investigator killed the strain A using heat and added the dead bacteria to a tube inoculated with the live strain B. After incubation the tube had only the bacteria with fimbriae. Discuss in detail how Strain B might have acquired the gene to make the fimbriae.

90% of the students explained transformation.

Students were introduced to a similar situation when Griffith's experiment was discussed in class.

Active learning on these topics were applied in the lab two weeks after they were covered in lecture.

A study guide was given, as shown below, a week before the lab.

Active learning module – lab

Study guide

Review the concepts:

Transformation

Conjugation

Transduction

Mechanisms of antibiotic resistance

Experiments:

Expected results

Check the results and ask:

Did you get expected results?

If not, explain why you did not get the expected results?

Is your prediction wrong?

Or something went wrong with the experiment?

Interpretation of the results?

Explain the meaning of the results.

Purpose of controls

Transformation:

Explain about the plasmid used

Selection marker

What activates the expression of the gene and why?

How do you know cells have transformed?

Conjugation:

Difference between 2 strains used

Purpose of confirmation plates

Hypothesize which strain is the donor which strain is the recipient

What is the basis of your hypothesis?

Detailed description of events that happen on the mating plate.

Why the recombinant colonies are transferred on to different plates?

Transduction:

Difference between 2 strains

Explain about the phage used.

Do we get different results with the 2 different strains or same results? Explain why?

Everyone needed to study transformation, transduction and conjugation. Review of the concepts was done at the beginning of the lab. I explained the set-up of the experiments to the class (procedures with diagrams were given to the students a week before). The class was divided into three groups: group1 did transformation, group2 did conjugation, group3 did transduction. Each student in each group performed the experiments assigned to the group.

During the second lab session each group examined the results and discussed the interpretations. Then, there was a jigsaw group discussion – there were 3 jigsaw groups. In this case, the specialists were explaining the results to others in the jigsaw discussion group. For example, transformation people explained their results to other students in the jigsaw discussion group.

Formative assessment indicated that they were enthusiastic about explaining and analyzing. It was especially interesting to see how a group figured out the recipient and donor strains in the conjugation experiment.

Summative assessment was done on the lab exam using the following questions:

Questions that involve analysis, application of knowledge, case study

An E.coli strain is found to be resistant to tetracycline. What is the likely mechanism used by the bacteria to escape from the antibiotic?

- A. By changing the antibiotic target site on the ribosome.
- B. By developing an outer membrane
- C. In condensing the periplasmic space.
- D. By carrying on mitochondrial protein synthesis.

89% of the students had the right answer

A scientist released a strain of E.coli (strain S-) that does not ferment sorbitol and does not make any toxin into a pond that only has E.coli strain that ferments Sorbitol (strain S+) and produces a toxin known as chlorolyticase that kills algae. A few days later water sample from the pond was collected and the scientist isolated strain S- , but it produces the toxin chlorolyticase. Explain how the E.coli S- might have acquired this ability to kill algae. Hint: the pond is a rich source of phages.

85% explained about transduction

An essay question:

Explain about the 3 types of horizontal gene transfer that take place within a bacterial population, which contribute to the development of antibiotic resistance in bacteria.

95% had the right answer

Based on the formative and summative assessment, the active learning students have a better understanding of this learning objective than those who have learned the concepts during the previous semesters in the traditional setting (passive learning). During the discussions, the students were eager and enthusiastic about expressing their thoughts and opinions. They were happy to explain about the reasoning behind their statements by using what they have learned from the homework assignments.

I look forward to using active learning in the class on another learning objective next semester, which will start on the 19<sup>th</sup>. I will include some take home exams, study guide that is more specific for formative assessment. I will include more of higher order questions for summative assessment.

