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Tips & Tools

Use of a Modified POGIL Exercise to Teach Bacterial Transformation in a Microbiology Course

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INTRODUCTION

The allied health microbiology course at Kingsborough Community College (KCC) includes a unit on bacterial lateral gene transfer, which considers the process of transformation. KCC's diverse student population often finds this abstract concept challenging. Compounding this is apathy, because students do not see the topic as useful for their chosen career path, which manifests as a lack of engagement. This learning challenge provides an ideal opportunity for students to engage in a collaborative assignment using summaries and diagrams, which are known to be effective learning methods (2, 6). Collaborative assignments are high-impact educational practices that are encouraged in higher education (7). This paper describes a modified process-oriented guided-inquiry learning (POGIL) exercise used to teach transformation. POGIL is one type of small group activity in which students are engaged by giving them specific roles as they proceed through the activity's exploration, concept development, and new concept application phases (5, 8). POGIL is well-established for chemistry classes (4, 10), and is also an effective learning technique for biology students (1).

PROCEDURE

Students enrolled in Microbiology in Health and Disease divide into groups of three or four, allowing each to have a defined role. Additionally, small groups help students stay engaged with the material (5). Standard POGIL roles include a "manager" who keeps the group on task, a "recorder" who keeps written answers to the assigned questions, and a "presenter" who orally presents the group's answers to the class (9). Groups are given a series of questions and background information in the form of text and images (Fig. 1) on the essential experimental findings of Frederick Griffith's work leading to the discovery of bacterial transformation. Using the information, groups discuss questions intended to guide students through the logic required to explain Griffith's results. The instructor monitors each group's progress, and acts as a facilitator when groups are having difficulty (3, 5). Instead of supplying answers, the instructor poses questions designed to lead the team in the direction of the answer to their original question. Students learn that the two strains of *S. pneumoniae* are different, one virulent, one avirulent, and that the trait responsible for virulence is a capsule. Additionally, students begin to understand that cell differences are encoded in the DNA; a new trait requires new DNA encoding that trait. Once students assimilate this information, they synthesize a new concept: live, avirulent *S. pneumoniae* cells are able to acquire DNA from the heat-killed virulent bacteria. Questions to help students scaffold this logical thinking start with basic background information:

- Why is genetic diversity important for prokaryotes?
- What is the difference between a virulent and an avirulent strain of bacteria?

Students then move on to questions about the trial groups (Fig. 1):

- In trial group C, would you expect the observed result given the results of trial groups A and B? If not, what would you expect?
- Why can some strains of *S. pneumoniae* make a capsule while others cannot?

Finally, students are asked:

- Why did Griffith find a live virulent *S. pneumoniae* strain in the dead mice in trial group D?

Upon reaching a consensus, groups record their answers for each question. At defined intervals, after reviewing background material and working through the experimental results, groups present answers to the class. The class then discusses differing answers, coming to a class consensus. Finally, students leave class with the task of individually answering one of the following questions:

- How does transformation help explain why adding antibiotics to animal feed can lead to the development of antibiotic-resistant bacteria in humans?

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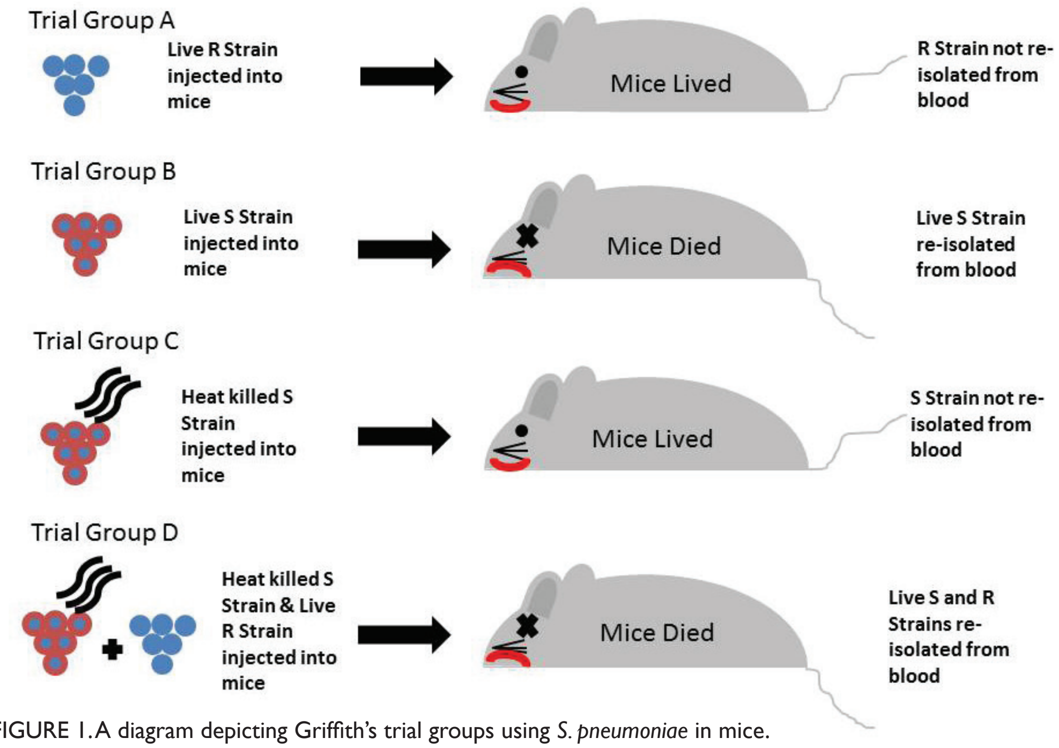

FIGURE 1. A diagram depicting Griffith's trial groups using *S. pneumoniae* in mice.

- Which is most advantageous for the bacteria in a given population: (a) no transformation, (b) all cells transform identically (i.e. all get a capsule) or (c) cells transform differently (i.e. some acquire a capsule, others fimbriae, others penicillin resistance, etc.). Provide an explanation for your choice.

CONCLUSION

Classes that used this exercise had a maximum of 16 students, but as long as individual student groups are limited to three to four students, large classes can be accommodated. This activity is a modified POGIL exercise because groups do not grade themselves and any student within the group may ask the instructor a question. Normally, asking questions is the responsibility of solely the "manager." However, in the author's experience, allowing anyone to ask questions helps create an open classroom in which students become comfortable asking questions throughout the course, long after this exercise is completed. Finally, POGIL exercises are normally conducted throughout the course whereas here it has been used to facilitate learning of one specific topic.

Students were skeptical about the exercise but after completion, reported they enjoyed and preferred it to lecture. One student said, "I got to do something; it was active." Another reported, "Seeing how [the scientists] figured out how it worked helped me understand it." Due to this positive feedback, the number of lectures replaced by this type of exercise is being expanded.

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