Using Lecture Demonstrations to Visualize Biological Concepts

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INTRODUCTION

The use of visual aids in biology has traditionally focused on laboratory activities and demonstrations (3, 6, 8, 12, 15–18). However, a limited number of authors have suggested activities suitable for lectures. Such activities reinforce the concepts taught and require less equipment, time, and expense than laboratory activities (1, 4, 9, 13, 14, 19, 20, 22). Moreover, simple demonstrations are easy for students to remember and can be repeated when studying independently.

Simple demonstrations that use three-dimensional, concrete objects and kinesthetic processes help students comprehend abstract concepts such as the structure of organic macromolecules, protein synthesis, DNA replication, and gene linkage/recombination. We describe two demonstrations targeted for introductory biology, cell biology, genetics, and molecular biology courses. The demonstrations are lecture oriented, can be used in large classrooms, are inexpensive, and can be easily performed because they use readily available objects as props. We conducted an IRB-approved study showing that student performance is enhanced using these and three additional demonstrations, the description of which can be found at: https://sites.google.com/site/tamari26. We report the results in the research section of this issue.

PROCEDURE

Following are the instructions for two demonstrations that have been successfully used in an introductory biology and genetics course.

1. Macromolecule Monomers and Polymers

Students experience challenges in distinguishing the different types of macromolecules, the monomers that comprise each, and the types of bonds and linkages that form the macromolecules.

Begin this demonstration by describing the similarities between the macromolecule classes, including the formation of polymers from monomers by dehydration synthesis reactions in all four classes. Have the students participate in generating a table summarizing the monomers, bonds and linkages, and examples for each macromolecule (Table 1).

For the visual part of this demonstration, use a chain or necklace with links. Demonstrate that individual links within the chain represent monomers (monosaccharides, amino acids, or nucleotides). The entire chain represents a carbohydrate, polypeptide, or nucleic acid. Illustrate that connections between the links represent linkages and bonds, and that they are glycosidic linkages, peptide bonds, and phosphodiester bonds for the above macromolecule classes (Fig. 1).

2. Translation

Begin by describing the assembly of ribosomes and the molecules involved such as mRNA and tRNA. Illustrate the structure of the ribosome using the drawing shown in Figure 2. First, draw the exit (E), peptidyl (P), and aminoacyl (A) sites of the ribosome (Fig. 2a, EPA). For this demonstration, two student volunteers representing tRNA initially stand in the P and A sites each holding a paper clip representing attached amino acids (Fig. 2a). Take the clip from the student in the P site, illustrating breaking of the bond between the first amino acid (methionine) and the first tRNA, and attach it to the clip (second amino acid) that the student in the A site (second tRNA) is holding (Fig. 2b). Illustrate the formation of a peptide bond by linking the clips. Explain the role of peptidyltransferase catalyzing the formation of a peptide bond. The student in the P site slides to her/his right (E site) and eventually leaves the ribosome while the second student now holding two attached clips (amino acids) moves to the P site. Holding another paper clip (third amino acid), move to the A site (Fig. 2c). Break the bond between the student (tRNA) and the two amino acids he/she is holding and form a peptide bond between the second amino acid and the third amino acid in the A site. The second student slides right, to the E site. Holding three amino acids, slide to the P site and explain how the reaction continues (Fig. 2d).
CONCLUSION

Active student engagement is likely to facilitate learning. Comprehension increases with the number of different learning methods employed, especially those involving kinesthetic learning (2, 5, 7, 10). The use of such low-cost demonstrations has been explored (11, 21) and found to be very successful.

These demonstrations provide a visual advantage for students who may be under-prepared before arriving to a college setting, those who may be returning to college after a long break from formal learning, or those who are speaking English as a second language. In each of these cases, a visual demonstration of an abstract concept, particularly one that involves not only an image projected on the screen, but also some type of three-dimensional object and/or kinesthetic experience, will greatly improve their ability to understand and retain the information presented. Another advantage for the use of demonstrations is the ease with which these students can replicate any of these demonstrations later, when studying on their own. The tools are readily available, easy to recall, and simple to put into practice.

To evaluate the effectiveness of these demonstrations (and three additional ones described at: https://sites.google.com/site/tamarif26) on student learning, we conducted an IRB-approved study at Kingsborough Community College with students in majors general biology, nonmajors human genetics, and majors genetics. The data support our hypothesis (please see the research section of this issue). We have shown that overall, across all courses and all demonstrations, students perform better on tests when the topics are accompanied by demonstrations.

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REFERENCES