

ELECTROPHORESIS OBSTACLE COURSE¹

An Electrophoresis Simulation

INTRODUCTION

This lesson will demonstrate the theory behind the separation of DNA molecules in an agarose gel. Agarose gel (horizontal) electrophoresis is most commonly used to separate DNA fragments, but may also be used to separate proteins. How a molecule migrates through a gel is dependent upon its size, electrical charge and shape. Smaller molecules will travel faster through pores of an agarose gel, whereas larger molecules will migrate more slowly. Negatively charged molecules will run toward the positive (red) pole of the gel, while positively charged molecules will migrate toward the negative (black) pole. Migration of a molecule is also affected by the density of the gel and the type of buffer used.

The abstract concept of DNA size separation is made concrete by using an obstacle course as an analogy. As an agarose gel solidifies, it becomes an “obstacle course” for molecules which travel through it. In this lesson, an obstacle course is set up to represent the agarose gel while the students become “DNA molecules” of varying lengths. By having the students travel through the obstacle course, it demonstrates how the agarose matrix separates DNA fragments of different sizes.

PURPOSE

From this exercise, the students will be able to:

1. explain how DNA fragments are separated by size
2. correlate the steps of electrophoresis with the obstacle course analogy

MATERIALS

- 3 different colored paper shapes
- hallway, gym or outside area

SAFETY PRECAUTIONS

If performing the demonstration outside, be aware of any potential hazards (busy streets, parking lots, gopher holes)

PROCEDURES

1. Set up three different lanes with each lane a different color paper marker. The lanes should be the same distance, with the same number of paper shapes to gather. Lay out the lanes to weave in and out of the same number of obstacles. Obstacles can be man-made (desks, cars) or natural (trees), depending on your location.
2. Have the entire class stand side-by-side holding hands. This is your “DNA molecule”.
3. Explain to the students how DNA is cut into fragments using restriction enzymes. Demonstrate this by separating the “DNA molecule” into three pieces.

- a. 1 student = 2-3 base pair fragment
- b. 3 students = 10 base pair fragment
- c. rest of the class = 100 base pair fragment

¹ Adapted from “Electrophoresis Obstacle Course: Electrophoresis Simulation” (1995)
http://eagle.clarion.edu/~faculty/biscuits/Obstacle_course.html (8 May 2002)

4. Explain the basic concepts of electrophoresis using the obstacle course as an analogy.
 - a. agarose gel matrix = obstacles
 - b. loading wells (negative pole) = starting line
 - c. bottom of gel (positive pole) = finish line
 - d. lanes = path of the colored pieces of paper
5. Take the three “DNA molecules” to the starting point of the obstacle course. Put each fragment into its well.
6. Explain the rules of the obstacle course to the students.
 - a. The students are to hold hands throughout the entire activity.
 - b. The students must move as quickly as possible to the end of the finish line.
 - c. The back of the line MAY NOT pass the front of the line.
 - d. The last person in line must pick up the appropriate pieces of colored paper.
 - e. Once the first group crosses the finish line, the other two groups must stop where they are.
7. Discuss how the results of the obstacle course represent what occurs in an agarose gel.

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Analysis of Results

1. What part of electrophoresis does the obstacle course represent?
2. What does the starting line represent? To what does the colored paper correspond?
3. Toward which pole do the DNA molecules travel (positive or negative)? Based on this, what is the charge of the “DNA molecules”?
4. Which “DNA molecule” reached the finish line first? Which one was closest to the starting line?
5. What was the most important factor that determined how fast the “DNA molecule” moved through the obstacle course? How does this correlate to what happens to real DNA molecules during electrophoresis through an agarose gel?

TEACHER NOTES

If time permits, it is possible to demonstrate how gels of different densities can affect how DNA fragments separate. To simulate a denser gel, place more obstacles in each lane. Likewise, a less dense agarose matrix is represented by fewer obstacles. Have students compare the different distances traveled in each obstacle course.