The 2012 Astrobiology Teachers Academy begins with a 4-day summer workshop at the Rensselaer Polytechnic Institute (RPI) in Troy, NY on Monday, July 9 - Thursday, July 12. (8:30 AM - 3:30 PM each day). Teachers will participate with a team of NASA-funded scientists, educational assessment professionals, and high school science teachers/mentors in this Summer Institute in Astrobiology. Participants will receive a $500 stipend and a certificate for 28 hours of Professional Development upon completion. Expenses for travel and accommodation will be reimbursed for those teachers who are accepted to the program and live beyond a 30-mile radius of RPI.

More information about the program and application forms are available at http://www.origins.rpi.edu. Applications for this summers institutes are due by Wednesday, June 20, 2012.

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Forensics Who Dunnit?
A Visual, Active Class Participation Simulation of Gel Electrophoresis

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Increase student interest, comprehension and retention of the process of Gel Electrophoresis through this simulation of how DNA evidence can be used to link a particular suspect to a crime scene or how DNA evidence can be used to exonerate a suspect. These visual and active participation demonstrations should be used *prior* to students performing a DNA gel electrophoresis "wet" lab. The demonstrations can be followed with students viewing simplified animations of gel electrophoresis such as those cited in the Visual Aids section of procedure step 19.

Objectives:

At the conclusion of these demonstrations, the student should be able to:

1. List sources of DNA used in gel electrophoresis
2. Describe the role of each of the following in gel electrophoresis:
    a. Centrifuge

b. Restriction Enzymes
c. Loading Dye
d. Gel
e. Buffer Solution
f. Electricity
g. Positive end of the DNA gel box
h. Power Source
i. DNA stain
j. Micropipettes
k. Staining Tray

3. Explain how DNA is:
    a. Obtained from different types of cells in the body
    b. Released from the cell and nuclear membranes
    c. Separated from the rest of the cell's contents

4. Describe how DNA is cut into restriction fragments using specific restriction enzymes.

5. Show how *different* enzymes would produce different restriction fragments from the same strand of DNA when using two different restriction enzymes.

6. Describe how DNA restriction fragments are loaded into the gel. Answers should include:

    a. Which end of the gel box is used to load the DNA, the positive or negative end?
    b. The role of the loading dye
    c. The role of the loading wells
    d. The role of micropipettes

7. Differentiate between the role of loading dye and DNA stain. *(Loading dye being more dense causes DNA restriction fragments to sink to the bottom of the well) (DNA Stain bonds to the restriction fragments of DNA making the bands visible on the gel)*

8. Summarize the steps of gel electrophoresis beginning with obtaining a sample of DNA through analyzing the gel after gel electrophoresis.

9. Analyze the following errors in gel electrophoresis and propose a solution to correct those errors:
    a. DNA bands are too close together on the gel.
    b. DNA bands are not visible on the gel.
    c. DNA appears as one thick band on the gel.

10. Explain the role of marker or standard DNA in gel electrophoresis. *(Standard or marker DNA are known lengths of DNA used to estimate the size of each DNA restriction fragment.)*

11. Given a photograph of a gel, analyze the gel and determine if a match exists or doesn't exist between a suspect's DNA and the evidence DNA.

Materials

String

Scissors

Masking Tape

4 manila folders (to be held by students representing marker DNA) labeled with:
- 5,000 base pairs
- 10,000 base pairs
- 15,000 base pairs
- 20,000 base pairs

4-16 students (it would be helpful to have 4 students of varying heights to represent 4 different sized DNA restriction fragments)

Gel Electrophoresis Equipment (or photos of gel electrophoresis equipment)
- Power Supply
- Gel Box
- Comb
- Agarose
- Staining tray

Procedure

Part 1 Background

1. Show students the gel box, combs, gel, micropipettes, staining well, and power source so that they are familiar with the materials and apparatus used to separate DNA. (or show photos of the equipment)

2. Demonstrate how the agarose gel is heated and poured into the gel box containing ~~a~~ comb.

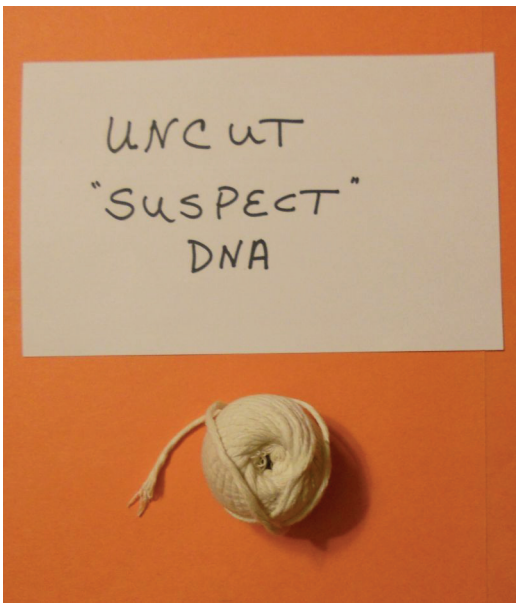
3. Remove a comb from a previously poured gel box so students can see the wells.

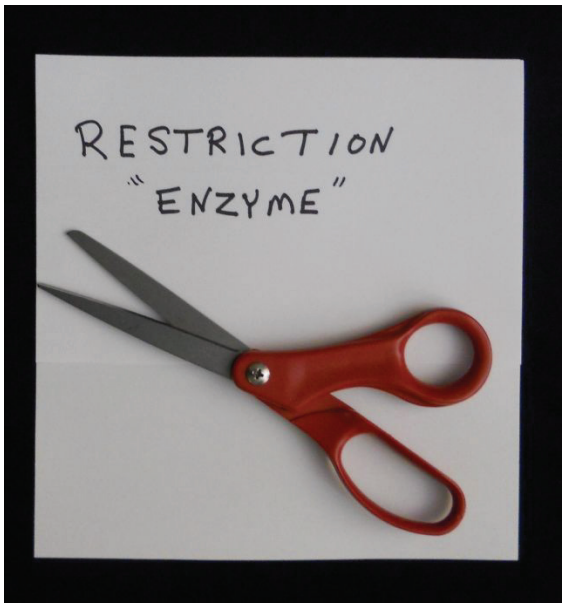
4. Describe a crime or a case study where DNA evidence left at the crime scene was used to help solve the crime. (Refer to the book entitled Picking Cotton cited in step 22 of Procedure)
   a. Indicate in this demonstration that there are two suspects whose DNA will be compared to the evidence DNA collected at the crime scene.

b. Draw on the board a sketch of a gel with four lanes. Label the first lane as the marker or standard DNA, Suspect #1 DNA, Suspect #2 DNA, Evidence DNA.

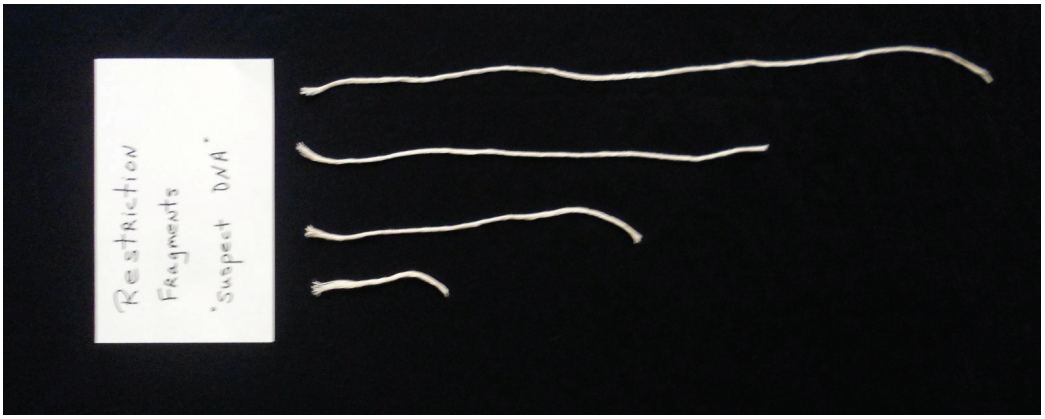
Part 2 DNA preparation

5. Using a ball of string and a scissors, describe the role of restriction enzymes which cut DNA at specific locations resulting in 4 different sized restriction fragments. Demonstrate how the scissors moves along the DNA (string) and makes cuts at specific locations (recognition sites) resulting in four DNA restriction fragments of varying lengths





6. Hold up for the students to view each of the four varying lengths of string that represent the four DNA restriction fragments.

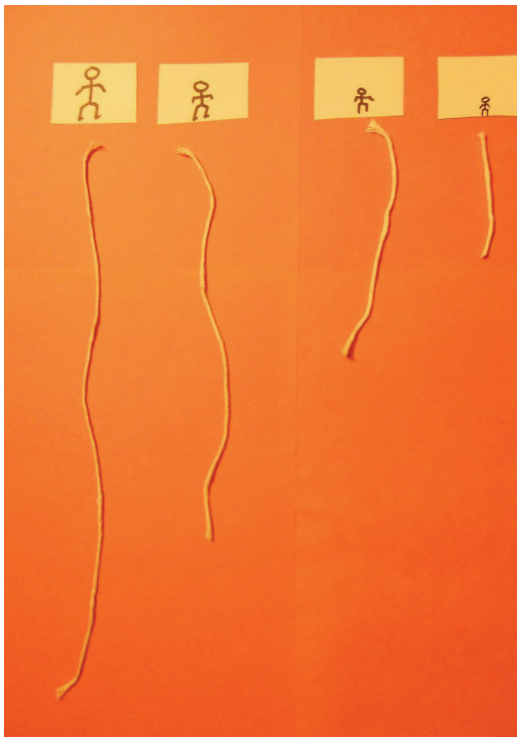


Part 3 Student participation

7. Turn off/ dim lights to indicate that the power going to the gel box is off.

8. Select 4 students (try to find students ranging in height from tall to short)

9. Give each of the four students one of the 4 strings. Be sure to give the tallest student the longest strand of DNA and the shortest student the shortest piece of string.



10. Explain that each of the four students represent the four different sized restriction fragments of DNA from Suspect #1.

11. Tell the four students representing the four DNA restriction fragments of Suspect # 1 that they (DNA fragments) are loaded into the well labeled Suspect #1. Use the aisle in between desks to represent a lane where DNA is loaded. Indicate to students that the area in front of that aisle represents the well). Remind the students that these fragments are loaded at the negative end of the gel box because DNA is negatively charged and will "run to red" (towards the positive end of the gel box) when the power is turned on.

12. Load the well

a. Ask the 4 students to bunch together at the beginning of an aisle.

b. Students should wiggle and bunch in a tight area representing the four DNA restriction fragments being pipetted into the well.

13. Questions:

a. Ask students what do you need to do to have the four DNA restriction fragments move through the gel?
(Turn on the power box. You can simulate this by turning on the lights)

b. Ask students what was added to the DNA fragments to ensure that the DNA would not float away but would sink to the bottom of the well.
(Loading Dye)

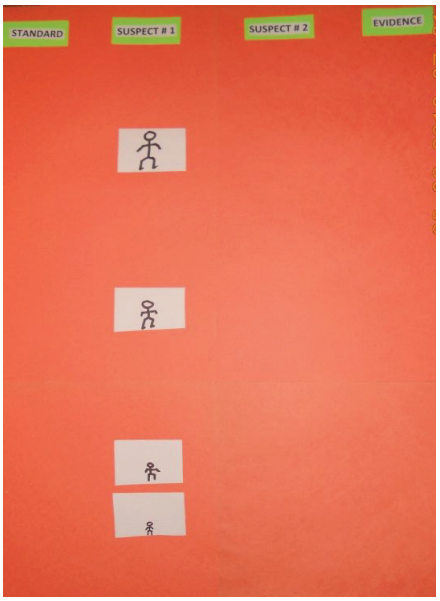
c. Ask students what will actually sort the restriction fragments?
(Different sized pores within the gel help to sort the fragments by size)

14. Movement of DNA Restriction Fragments

a. Ask the 4 students representing the restriction fragments from Suspect #1 to simulate moving through the gel.

b. Students should move with the shortest fragment moving further down the gel than the longer fragments.

c. The result will be that the four strands of DNA are sorted from shortest to longest.

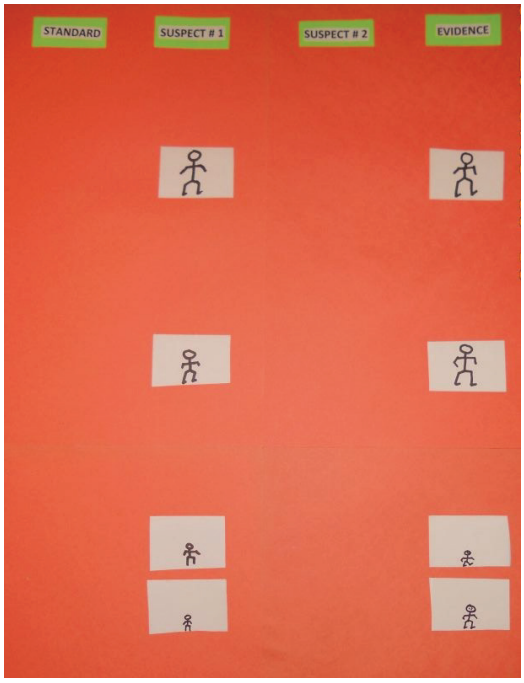


15. Comparison with Evidence DNA

a. You could select four other students to represent the evidence DNA and have those students loaded into the well and sorted by the gel electrophoresis simulation.

b. Ask students representing the evidence DNA to line up showing a match with the suspect's DNA.

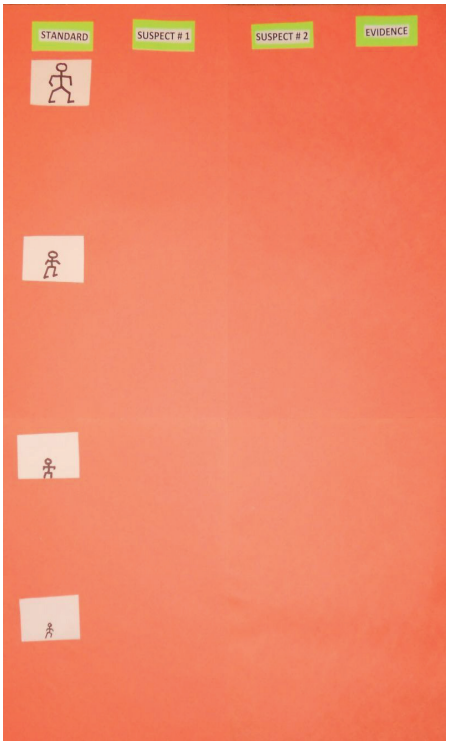
c. Ask students to rearrange showing that the evidence DNA did not match the suspect's DNA.



16. Role of Marker DNA or Standard DNA

a. Select four other students of varying heights.

b. Give each of the four students one of the manila folders labeled with different number of base pairs (20,000; 15,000; 10,000; 5,000)

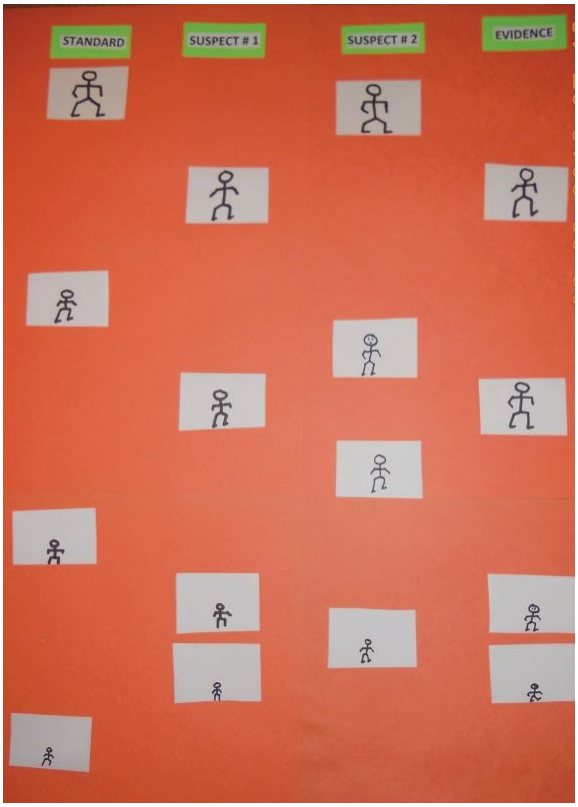


c. Ask the students to show how they would demonstrate how the marker DNA would be:
   i. Loaded into the well
   ii. Sorted by the gel based on size

d. Comparison of marker DNA (or Standard DNA) bands to other bands.
   Ask students to estimate the size of the bands found in the evidence DNA based upon the location of the evidence bands compared to the location of the marker or standard DNA bands

17. If time permits, repeat the process with four other students of varying heights to represent the DNA restriction fragments for Suspect # 2.

    The completed "gel" demonstration should be similar to the photo right.



18. <u>Role of DNA stain</u>
    a. After the students have been "sorted by size" on the gel, explain the role of DNA stain.
    b. Demonstrate how DNA staining and de-staining is done using a staining well, extra stain and water.
    c. Ask students to explain how to correct over-staining and under-staining of the gel so that bands are clearly visible.
       i. Over staining: needs to destain the gel longer
       ii. Under staining; need to stain the gel for a longer time

19. <u>Visual Aids</u>
    After students have seen these demonstrations, view the following websites:
    http://lpscience.fatcow.com/jwanamaker/animations.htm
    (created by J. R. Wannamaker)
    Select "Gel Electrophoresis"

http://learn.genetics.utah.edu/content/labs/gel/
Genetic Science Learning Center, University of Utah,
"Virtual Lab Gel Electrophoresis"
http://learn.genetics.utah.edu/content/labs/gel/forensics/
Genetic Science Learning Center, University of Utah,
"Can DNA Demand a Verdict?"

20. After the students have performed these visual class participation demonstrations and have viewed the different animations, they are ready to do the actual DNA gel electrophoresis "wet" lab.

21. **Alternative activity**: Instead of showing the students this activity, ask the students to devise their own visual demonstration that would simulate the process of gel electrophoresis.

22. **Extended Study:** Have students investigate how innocent persons have been released from long-term jail sentences after DNA evidence was used to show that they were wrongfully convicted.

References:

Innocence Project: http://www.innocenceproject.org/

Thompson-Cannino, Jennifer; Cotton, Ronald; Torneo, Erin: Picking Cotton, St. Martin's Griffin, NY, 2009

Patricia Nolan* Bertino** *taught biology and forensics at Scotia-Glenville High School for thirty-four years. She and her husband, Anthony (Bud) Bertino co-authored the high school forensic textbook* ***Forensic Science: Fundamentals and Investigations*. They currently are involved with teacher education by instructing and organizing The Bertino Summer Forensic Institute for Teachers. Both Patti and Bud are also frequent presenters at local, state and national conferences.*

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Note: Classroom photos: These are photographs of participants in our summer Bertino Forensics Summer Institute doing the DNA Simulation.