

DRIVING QUESTION: HOW DO RESEARCHERS COMPARE DNA?

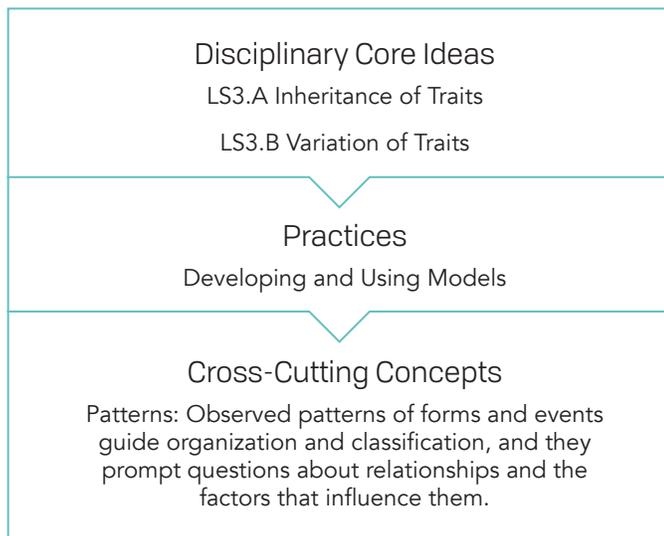
LENGTH: 1 hour

OBJECTIVES: Students will be able to:

- demonstrate knowledge of the gel electrophoresis process

Standards:

Next Generation Science Standards Addressed



Materials:

- Computers with internet access (1 per student or class computer with projector)
- Copies of Lesson 6 Student Handout: Electrophoresis Exploration (1 per student)
- Optional: gel electrophoresis lab kits for extension

Suggested Video:

“Gel Electrophoresis” by Kahn Academy Medicine

<https://www.youtube.com/watch?v=mN5lvS96wNk> (6:58)

Lesson Context

This section provides guidance for teachers for how lessons build on each other.

Back in Lesson 2, the students extracted DNA from fruits and vegetables. This is where they first learned that DNA is a large molecule of genetic information. They also learned that with the use of restriction enzymes, certain genes can be cut out of the DNA molecule and sorted by running them through a gel

electrophoresis process. During Lesson 6 the students will learn more about gel electrophoresis as they view a video on a gel electrophoresis lab. This lesson culminates with an online virtual lab of electrophoresis where students “run a gel,” summarize each step and create an icon for each major step in the process.

KEY CONCEPTS: Gel electrophoresis is a process that enables researchers to take a closer look at DNA. An electrical current passes from a negative electrode, through a gel (like a slab of Jello) to a positive electrode. Samples of DNA of different lengths are placed into the gel at one end, and their negative charge carries them with the current toward the positive electrode. The smaller molecules move faster, and the DNA molecules are thus sorted according to their size. A large number of molecules of a specific size will move at the same rate and appear as a band in the gel, which can be made visible with UV light. Researchers can compare different bands of DNA to detect changes in the DNA sequence.^{xv}

SETUP:

- Ensure computer settings allow access to the gel electrophoresis simulation site and video.
- Prepare copies of the student handout.
- If you do not have access to an electrophoresis kit, it may be helpful to prepare a short slide deck showing electrophoresis equipment.

Outline:

1. Ask the students to recall what they know about the structure of DNA. Remind students that in eukaryotic organisms chromosomes are found in the nucleus of the cell. Chromosomes are made up of DNA. Genes on the DNA (genotype) code for specific traits (phenotype). Ask students to consider: How do scientists distinguish one set of DNA from another?
2. Explain that scientists discovered that DNA could be made to move through a gel using electrical charge.
3. Distribute student handout Electrophoresis Exploration. Preview the handout with students.
4. Play the video “Gel Electrophoresis” by Kahn Academy Medicine, found at <https://www.youtube.com/watch?v=mN5lvS96wNk>
5. Ask students to recall key words or short pieces of information from the brief video. Have students first capture these on their handout and then share.
6. Walk students through the process in greater detail. Challenge students to listen for key components of the process and capture notes on the student handout.
 - Just like a motorcycle can move more quickly through heavy traffic than a large truck, smaller molecules move more quickly than larger molecules through this gel.

- The DNA molecules can be allowed to proceed for a given amount of time and then frozen in place by removing the electrical current before all molecules have time to get to the end. If the whole class were told to run to the end of the hall and when the fastest student got near the end all were told to freeze, the students would be spaced out.
 - To help students grasp this concept, you may want to facilitate this activity with students in a large, safe area. Prior to having students move, instruct a portion of the class to run, a portion to walk quickly, and a portion to walk slowly.
 - This process is used to sort DNA into a line from small to large strands.
 - Strands of the same length appear as though they clump together. These strands form distinct bands. The bands can then be compared with a known DNA composition of the same organism to determine which proteins are present. Each organism has a unique series of bands.
 - Think of these DNA bands as a secret code. If you have the “decoder” (known DNA composition of an organism), you can use that to identify unknown DNA.
 - Whole DNA, like the DNA extracted in Lesson 2, does not show this banding pattern. Cutting the DNA with “restriction enzymes” generates the banding pattern. These enzymes recognize specific DNA sequences, usually 6–8 base pairs in length, and cut the DNA strand at that site. Fragments of the same length will then move through the gel at the same speed.
7. Have the students access the Genetic Science Learning Center website at the University of Utah at <http://learn.genetics.utah.edu/content/labs/gel/>. If student computers are not available, access the site using a projector and screen. Conduct the step-by-step virtual gel electrophoresis. You may wish to have students work independently or in pairs.
 - As students work, have them summarize each step in three to five words on the student handout.
 - If you do not have access to internet in class, you may wish to take screen shots of the process prior to class and share with your students.
 8. After the virtual lab is complete, have students finish the handout by creating an icon for each step in the electrophoresis process covered in the simulation.
 - After students have created an initial draft, have students work in pairs to review one another's work and provide feedback.
 - Have students revise their process summary and submit.

ENRICHMENT OPPORTUNITY: You may wish to have students conduct a real gel electrophoresis experiment. You can learn how to build an electrophoresis chamber at http://learn.genetics.utah.edu/content/labs/gel/build_gel_box.pdf or search a major laboratory supplies distributor for an electrophoresis kit.

Additional Content Support

Pre/Post Assessment

This section provides a suggested assessment tool that may be used before and after a lesson to assess student readiness. See the Pre/Post Assessment file for a ready-to-distribute copy for your students.

1. What is gel electrophoresis? A lab technique for separating cellular information such as DNA or protein based on their size.
2. Why is electricity used during gel electrophoresis? DNA has a negative charge and the attraction to the positive side (anode) of the gel electrophoresis box allows the DNA samples to migrate down the gel over time.
3. What is the purpose of the gel in gel electrophoresis? The gel acts like a filter that sorts the DNA strands based on their size. The shorter stands of DNA will move farther away from the starting point than the longer strands of DNA. DNA strands of the same length will move at the same speed and end up grouped together.
4. In what ways does the process of gel electrophoresis assist scientists? DNA strands or genes of the same length will move at the same speed and end up grouped together on the gel. Scientists can cut the desired genes out of the gel to utilize in future tests.

Suggested Accommodations

This section provides optional tools to enrich learning and meet students where they are.

1. For students struggling to meet performance expectations:
 - a. After the Khan Academy video but before the online virtual lab, students should view the video from Lesson 2 again to make the connection of the role gel electrophoresis plays in gene isolation and use. <https://www.youtube.com/watch?v=nfC689EIUVk>
2. For students who have already met performance expectations and have high interest:
 - a. Electrophoresis is one of those inventions that has changed modern science in remarkable ways. Have students research Oliver Smithies' work as a scientist, which includes being the first to use starch as a medium for gel electrophoresis in 1955.
3. For students who are English Language Learners, have special needs or are reading below grade level:
 - a. Partner students during the online virtual lab of electrophoresis.
 - b. You may wish to guide ELL students through the gel electrophoresis online lab.
4. For engaging ways to connect learning to students' home and community:
 - a. Forensics science on television has become one of the most popular themes influencing countless crime shows. Have the students list some crime shows they

know of on television. Ask if they have ever heard of the term of "DNA fingerprinting." DNA fingerprinting uses gel electrophoresis to distinguish between samples of genetic material through the size sorting characteristic of the gel. The sorted genetic material form bands. For individual people, the bands of DNA created through this process will have a pattern that is specific to the individual. In forensics, suspects can be eliminated if their DNA pattern does not match the pattern of the DNA molecules found the crime scene.

- b. Consider posting the gels of a gel electrophoresis after a run and show how these can be used to match or eliminate suspects.

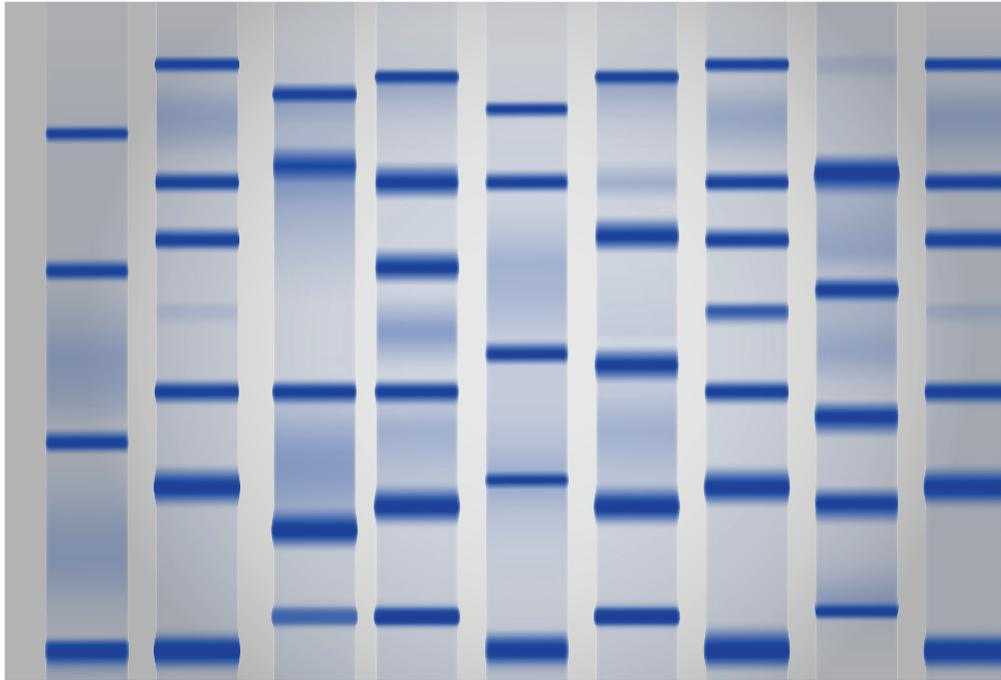
Rubrics

We have created two optional tools for evaluating learning at the end of each lesson.

- **LESSON RUBRIC:** This can be provided to students and used by the teacher for evaluation.
- **STUDENT REFLECTION:** This can be provided to students to empower them to self-assess learning before turning in the rubric and completed work. The general Student Reflection sheet can be found at the end of this educator guide.

NAME: _____ DATE: _____ CLASS PERIOD: _____

ELECTROPHORESIS EXAMPLES



← Gel Electrophoresis Separation Sample

→ Gel Electrophoresis Equipment



NAME: _____ **DATE:** _____ **CLASS PERIOD:** _____

ELECTROPHORESIS EXPLORATION

What is gel electrophoresis?

Why is it used? What is the purpose?

Complete the virtual lab at <http://learn.genetics.utah.edu/content/labs/gel/>. Summarize each major step you took in the gel electrophoresis laboratory in three to five sentences below.

Create an icon for each major step in the electrophoresis process.

GRADING RUBRIC – FOR TEACHER

Gel electrophoresis is defined and explained clearly. Score ____/____	Each major step in the electrophoresis process is listed and an icon is included to support. Score ____/____	The student lab is thoroughly completed. Score ____/____
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NAME: _____ DATE: _____ CLASS PERIOD: _____

Pre/Post Learning Assessment

1. What is gel electrophoresis?

2. Why is electricity used during gel electrophoresis?

3. What is the purpose of the gel in gel electrophoresis?

4. In what ways does the process of gel electrophoresis assist scientists?

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RUBRIC

		ADVANCED	PROFICIENT	NOVICE
DISCIPLINARY CORE IDEAS	Inheritance of Traits	<p>Student can explain that genes with desired traits can be sorted using gel electrophoresis and that the reason they sort is the variation in the size of the DNA samples. Students can further explain the sorted genes are cut out of the gel in isolation to be used in genetic engineering through transgenics.</p>	<p>Student can explain that genes with desired traits can be sorted using gel electrophoresis and the reason they sort is the variation in the length of the DNA segments.</p>	<p>Student can explain that desired genes can be sorted using gel electrophoresis.</p>
	Variation of Traits			
PRACTICES	Developing and Using Models	<p>Student followed the gel electrophoresis virtual lab, created icons for <u>each</u> major step of gel electrophoresis and <u>included detailed descriptions</u> of the step the icon represents.</p>	<p>Student followed the gel electrophoresis virtual lab and created icons for <u>each</u> major step of gel electrophoresis.</p>	<p>Student followed the gel electrophoresis virtual lab and created icons for the steps of gel electrophoresis but <u>missed one or more</u> major steps.</p>
CROSS-CUTTING CONCEPTS	Patterns	<p>Student can explain the reason DNA samples band in the gel at different distances from the starting point due to their lengths in numbers of base pairs as compared to a DNA size standard sample that was run as a comparison. They can also accurately estimate the length of the DNA sample in base pairs of the virtual electrophoresis lab.</p>	<p>Student can explain the reason DNA samples band in the gel at different distances from the starting point due to their lengths in numbers of base pairs as compared to a DNA size standard sample that was run as a comparison.</p>	<p>Student can explain the reason DNA samples band in the gel at different distances from the starting point due to their lengths in numbers of base pairs.</p>