

TEACHER GUIDE

A Look inside the Lab: PCR

OVERVIEW

The VMP Next Step Science resources provide mini lessons, videos, and other materials related to the practice of science. These resources are meant to enhance the exploration of a particular topic or offer insights into the profession of scientific research.

The Next Step Science “A Look inside the Lab” series is comprised of reading passages and videos designed to introduce students to pieces of laboratory equipment and the scientists who use them. The series can be used to enhance an existing lesson or as a starting point for introducing a concept.

Each mini lesson includes:

- Short video featuring scientists from the Children’s Hospital of Philadelphia Research Institute discussing their work and how they utilize the lab equipment on a day-to-day basis
- Related reading passage
- Teacher guide
- Student worksheet

Additional VMP “A Look inside the Lab” videos and materials can be found at vaccinemakers.org/next-step-science.

OBJECTIVES

“A Look inside the Lab” series activities are designed to:

- Introduce students to equipment commonly used in medical research laboratory settings and explore how the technology impacts and serves society
- Introduce students to scientists, science careers, and the types of investigations that scientists conduct on a day-to-day basis
- Provide an opportunity for students to read informational text about scientific topics to enhance their understanding of how science is done and consider how scientists develop possible solutions to problems

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PCR lesson objectives:

- Students will understand the similarities and differences between DNA replication in the body and via PCR in the lab.
- Students will be able to identify ways that PCR is used in science labs and in society.

LESSON RESOURCES

- Lesson video, *A Look inside the Lab: PCR Machine*, <https://vimeo.com/530467334>
- Video transcript PDF: [https://vaccinemakers.org/sites/default/files/resources/Look in Lab PCR Machine video transcript FINAL.pdf](https://vaccinemakers.org/sites/default/files/resources/Look%20in%20Lab%20PCR%20Machine%20video%20transcript%20FINAL.pdf)
- Reading passage, *An Incriminating Sip*, [https://vaccinemakers.org/sites/default/files/resources/Look Lab PCR reading%20passage FINAL.pdf](https://vaccinemakers.org/sites/default/files/resources/Look%20Lab%20PCR%20reading%20passage%20FINAL.pdf)
- Student worksheet, lesson vocabulary: [https://vaccinemakers.org/sites/default/files/resources/Look Lab PCR vocab worksheet FINAL.pdf](https://vaccinemakers.org/sites/default/files/resources/Look%20Lab%20PCR%20vocab%20worksheet%20FINAL.pdf)
- Student worksheet, See-Think-Wonder graphic organizer: [https://vaccinemakers.org/sites/default/files/resources/Look Lab PCR SeeThink Wonder worksheet FINAL.pdf](https://vaccinemakers.org/sites/default/files/resources/Look%20Lab%20PCR%20SeeThink%20Wonder%20worksheet%20FINAL.pdf)
- Resources related to DNA replication
 - What is DNA replication? fact page, YourGenome, <https://www.yourgenome.org/facts/what-is-dna-replication>
 - DNA replication - 3D, animation, YourGenome, <https://youtu.be/TNKWgcFPHqw>
 - DNA Replication Steps and Process, article, ThoughtCo, <https://www.thoughtco.com/dna-replication-3981005>
 - DNA replication information page, National Human Genome Research Institute, <https://www.genome.gov/genetics-glossary/DNA-Replication>
- Resources related to Polymerase Chain Reaction (PCR)
 - Polymerase Chain Reaction, animation, DNA Learning Center, <https://dnalc.cshl.edu/resources/3d/19-polymerase-chain-reaction.html>
 - All About PCR, webpage, Genetic Science Learning Center, <https://learn.genetics.utah.edu/content/labs/pcr/>
 - What is PCR? webpage, YourGenome.org, <https://www.yourgenome.org/facts/what-is-pcr-polymerase-chain-reaction>
 - PCR resources from National Human Genome Research Institute

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- Information page: <https://www.genome.gov/genetics-glossary/Polymerase-Chain-Reaction>
- Fact sheet: <https://www.genome.gov/about-genomics/fact-sheets/Polymerase-Chain-Reaction-Fact-Sheet>
- PCR resources from Bio-Rad Explorer
 - PCR animation: <https://www.bio-rad.com/webroot/web/movies/lse/global/english/what-is-polymerase-chain-reaction/tutorial.html>
 - PCR-related video playlist: https://www.youtube.com/playlist?list=PL7_N-H8d6RiNVZ5Fi6ccX-uoxiIBT5tmU
- PCR resources from LabXchange
 - PCR simulation: https://www.labxchange.org/library/items/lb:LabXchange:f7f6962a:1x_simulation:1
 - PCR animation: <https://www.labxchange.org/library/items/lb:LabXchange:4fdc8a5c:video:1>
- Comparing PCR and DNA replication
 - Difference Between PCR and DNA Replication, article, Difference Between.com, <https://www.differencebetween.com/difference-between-pcr-and-vs-dna-replication/>
 - What is the Difference Between PCR and DNA Replication? article, Pediaa.com, <https://pediaa.com/what-is-the-difference-between-pcr-and-dna-replication/>

LESSON

The lesson progression outlined below can be completed in two to three 50-minute class sessions. If the “Extension” activity is included, additional time may be required.

Engage

Time: 15-20 minutes

Have students:

- Brainstorm a list of types of evidence that may be found at a crime scene. Have students do this individually, then in small groups or as a class. Create a master list of all ideas.
- Engage in a class discussion that focuses on how this evidence can help identify victims and connect specific other individuals (potential suspects) to the crime scene. Ensure that evidence that a person might leave at a crime is part of the discussion (e.g., blood, saliva, hair). If the class discussion does not progress to a

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discussion about DNA, prompt the class, so that by the end of the discussion the class has considered the importance of DNA evidence in identifying victims and perpetrators.

Explore

Time: 20-30 minutes

Introduce students to the concept that quantities of DNA at a crime scene may be very small and that a lab technique known as polymerase chain reaction, or PCR, can help scientists increase the sample size, so they can learn more from it.

Have students:

- Read the passage, *An Incriminating Sip*, which introduces how PCR is used to amplify small traces of DNA.
- Have students review the lesson vocabulary and look up or discuss any terms that may be unfamiliar.

Vocabulary list:

amplification, annealing, DNA, DNA polymerase, DNA replication, DNA template, denaturation, deoxyribonucleotides (dNTPs), extension, polymerase chain reaction (PCR), primer, Taq polymerase, thermocycler

Explain

Time: 20-30 minutes

Have students:

- Review how DNA replication occurs in the body, using previous classroom materials, resources provided in this guide or by having students locate resources on their own.
- Watch the short video, *A Look inside the Lab: PCR Machine*.
- Explore 2 additional resources related to PCR, using previous classroom materials, resources provided in this guide or by having students locate resources on their own.
- Have students complete the “I see ... I think ... I wonder ...” graphic organizer.

Elaborate

Time: 15-20 minutes

- Have students share their PCR-related graphic organizers in a small group. Groups should discuss any conflicting ideas and each “wonder” statement to see if others know the answers or if they can find answers.

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Evaluate

Time: 30-45 minutes

- Have each group create a learning tool (infographic, concept map, explainer video, etc.) that compares DNA production in cells and by the PCR machine.

Extension (Optional)

Time: Variable

Have students:

- Review the following list of situations where PCR is used:
 - Providing DNA evidence to determine crime-related guilt or innocence
 - Supporting medical research, including screening for diseases
 - Helping to determine parentage or ancestry
- Select one of these and compose a short paragraph about why they think this is an important (or unimportant) use of the technology.

RUBRIC: STUDENT WORKSHEET – Lesson Vocabulary

Amplification	Amplification is the process by which a targeted section of DNA is replicated using the PCR to make a large number of copies.
Annealing	In PCR, the step occurring after denaturing. The temperature of the sample is lowered to allow the DNA primers to attach to the template DNA.
DNA	Abbreviation for deoxyribonucleic acid. DNA is the molecule that holds an organism's genetic information. DNA is comprised of two strands that wind around each other, known as a double helix. The two strands are connected by chemical bonds between deoxyribonucleotides (dNTPs).
DNA polymerase	An enzyme that enables nucleotides to be added to a strand of DNA.
DNA replication	The process by which DNA is copied. Every time a cell divides, the two resulting cells must contain the genetic code. This process allows for production of the code necessary for the new cell.
DNA template	In PCR, the strand of DNA used to create new pieces of DNA.

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Denaturation	The step occurring at the start of PCR. The sample is heated to separate DNA into two single strands, so that the primer can bind to the template.
Deoxyribonucleotides (dNTPs)	Deoxyribonucleotides are the building blocks of DNA. There are four types of dNTPs: adenine (dATP), cytosine (dCTP), guanine (dGTP), and thymine (dTTP). Adenine bonds with thymine, and cytosine bonds with guanine.
Extension	The extension step of PCR occurs after annealing. The temperature of the sample is raised and Taq polymerase is activated, so a new strand of DNA can be created. The extension step is also sometimes referred to as the elongation step.
Polymerase chain reaction (PCR)	Also known as PCR, this laboratory technique models DNA replication, allowing scientists to synthesize DNA. PCR can rapidly generate thousands to millions of copies of a specific DNA sample, so previously small samples of DNA can be amplified for further analysis or experimentation.
Primer	Short single-strand pieces of DNA that are used as the starting point for DNA synthesis in PCR. Primers are used to direct the location of DNA replication, so that a particular section of DNA is amplified.
Taq polymerase	A heat-stable DNA polymerase isolated from the bacterium <i>Thermus aquaticus</i> that is commonly used in PCR.
Thermocycler	A laboratory instrument used to amplify DNA using the polymerase chain reaction (PCR). The machine can be programmed to raise and lower the temperature of samples to facilitate the steps of the PCR process. The apparatus is also sometimes referred to as a thermal cycler, PCR machine or DNA amplifier.