Lesson 4 – On the Shoulders of Heroes: Toward a World without Polio

LESSON QUESTIONS

- What are the causes and consequences of polio?
- How did scientists apply the scientific method to creating a polio vaccine?

LESSON OBJECTIVES

- Identify the causes of polio.
- Relate the consequences of polio to the need for a scientific solution.
- Analyze how the scientific method was applied toward creating a polio vaccine.

DOK 1 – 4

OVERVIEW

In this lesson, students study the process and history of science as it relates to the understanding of polio. The lesson shows students how scientists worked toward development of a polio vaccine (DOK2). Working in seven teams, students are assigned scientists or teams of scientists to research. They determine who, what (they discovered), when (they made their discovery), where (they did their research) and why (contributing to treatment, understanding or vaccine development). Students pool their data to create a class timeline and map showing how each discovery was related to the preceding ones and where each discovery was made (DOK2). Students work independently or in their existing groups to draw conclusions about how science is done (DOK3). The lesson concludes with a class discussion to synthesize individual group conclusions and analyze how they illustrate the scientific method of gaining new knowledge (DOK3-4). As an extension, students research the life of Franklin D. Roosevelt and how he influenced polio vaccine campaigns through non-scientific support.

LENGTH

Up to two 45-minute sessions

GLOSSARY TERMS

polio, poliomyelitis, epidemic, iron lung, cell culture, oral polio vaccine, inactivated polio vaccine

STANDARDS

- **Next Generation Science Standards**
  - Science and Engineering Practices: Developing and Using Models—Develop and use a model to describe phenomena
  - Crosscutting Concepts: Influence of Science, Engineering, and Technology on Society and the Natural World—The uses of technologies and limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions.
  - Engineering Design: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem (MS-ETS1-2).
  - Connections to the nature of science: Scientific knowledge is open to revision in light of new evidence.
  - Connections to the nature of science: Scientific investigations use a variety of methods.
  - Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions (MS-ETS1-1).
- **Common Core State Standards**
  - RH.6-8.5 Describe how a text presents information (e.g., sequentially, comparatively, causally).
  - RH.6-8.7 Integrate visual information (e.g., in charts, graphs, photographs, videos, or maps) with other information in print and digital texts.
  - RH.6-8.9 Analyze the relationship between a primary and secondary source on the same topic.
  - RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.
  - RST.6-8.2 Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.

- RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

- RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

MATERIALS

- Computer with internet access
- Index cards

BACKGROUND FOR TEACHER

The goal of this lesson is for students to understand how science and scientific knowledge evolve through introduction to and research about different scientists (or groups of scientists) who did polio research and ultimately, developed the polio vaccine. Before the vaccine became available, polio literally devastated lives.

Known from antiquity, by the mid-1800s, doctors realized that the disease called "infantile paralysis" could be contagious. The German doctor Adolph Kussmaul coined the word "poliomyelitis" combining the Greek *polios* meaning "grey" with *myelos* meaning "marrow" and "-itis" (inflammation), given observations that the disease caused gray matter in the spinal cord to become inflamed. In the early 1900s, Austrian scientists hypothesized that polio was caused by a virus; however, research contributing to the understanding of the virus was important to paving the way toward development of a vaccine. As with any scientific question, different scientists will approach different questions that contribute collectively to the body of knowledge, and some will approach the same question in different ways. The polio vaccine is perhaps one of the most familiar examples of the latter as Jonas Salk and Albert Sabin took starkly different approaches to vaccine development. These different versions each played an important role in polio vaccine prevention in the U.S. and around the world and, even, at different times in history.

Sabin's vaccine was given by mouth, and it contained live, weakened polio virus. Because the virus in the vaccine was live, it replicated in the intestine of vaccine recipients. This afforded recipients and society with benefits over the Salk version. First, the replication in the intestine meant that the immune response was generated at the intestinal surface and in the circulation. So, when a vaccine recipient was exposed to the virus in the environment, antibodies present in the intestine would provide a first line of defense stopping most infections, and antibodies in the bloodstream provided a second line of defense against infection of the nervous system which was the cause of paralysis. Second, vaccine recipients would “shed” virus in their feces, so the weakened form of the virus spread in the community indirectly protecting others who were exposed to this weakened form of the virus even though they had not, themselves, been vaccinated (this is called “contact immunity”). Unfortunately, this vaccine also had a “darker” side because the weakened poliovirus would occasionally regain its ability to cause paralysis. About 1 of every 2.4 million vaccinated people would become paralyzed when the vaccine virus reverted back to being able to attack the nervous system.

Salk’s vaccine, the first polio vaccine available in the U.S. in 1955, was an inactivated (i.e., killed) version that was given as a shot. Because the vaccine virus was inactivated, it did not replicate. This meant that it was safer since the virus could not regain its ability to infect the nervous system and cause paralysis, but it also meant that it did not provide contact immunity. Since the vaccine virus did not replicate in the intestine, vaccine recipients only had the second line of immune defense – in the bloodstream. As it turns out, this line of defense was sufficient to protect the recipient from paralysis, but it also meant that people might be exposed to the virus which would replicate in their intestine. Even though these people were not typically sick, they would shed the virus in their feces thereby spreading it in the community.

Although several Scandinavian countries were able to completely eliminate polio using only Salk’s vaccine, spread of the virus following replication in the intestine of vaccinated (and unvaccinated) people would have made it difficult to rid the U.S. of poliovirus. The Scandinavian countries were successful because they made sure that almost 100 percent of people were vaccinated. In the U.S., by the 1960s, the oral polio vaccine was the version given to infants. After the virus was no longer common, Salk’s version was again employed for infants born in the United States (2000). The oral version is still used in other parts of the world.

As students research the scientists and learn about the vaccines, they should come to an understanding of how 1) different approaches to scientific understanding are important and useful, 2) different technologies may be more or less applicable at any point in history, and 3) how the findings of different groups of scientists collectively contribute to a greater understanding by all.

TEACHER NOTES

The over-arching question of this lesson is how did varied approaches by scientists contribute to society's collective understanding of polio and development of the polio vaccine? In completing the lesson, students will be able to relate the scientific process to a real-life problem and its solution through introduction to scientists who contributed to the human struggle to defeat polio. Students integrate their understanding of the process of science with the problem of polio to understand that the scientific enterprise underlying technological progress is more complex than just a scientist in a lab completing the scientific method. As numerous scientists work on gaining knowledge related to the same societal problem, they take different approaches, ask different questions and contribute to the development and evolution of knowledge. In this sense, students will learn that knowledge itself evolves as old ideas are jettisoned and new ideas supersede them.

As students complete the research phase of this lesson, particularly if they are completing online research only or supplementing the reading passages, they may come across non-polio-related accomplishments of some researchers or slightly different dates for particular discoveries. As time allows, use this opportunity to discuss the conduct of science. For example, students will be researching John Enders as part of the Robbins, Weller, Enders team. Their work developing cell culture for polio virus was crucial to polio vaccine development; however, later in his career, John Enders went on to develop an early version of the measles vaccine. Similarly, Jonas Salk worked on development of his inactivated polio vaccine for several years before it was proven to work in children. While most publications date this "discovery" as occurring in 1955 (because that is when the clinical trials concluded), Dr. Salk began testing the vaccine in the early 1950s and the trial including 1 million children occurred in 1954. For this reason, students may find dates that appear to conflict or are confusing. Remind students that scientists may spend their whole careers working on one body of knowledge, so they may make multiple important contributions and a particular contribution may be recorded as occurring at slightly different times in the literature. If this happens, students should be encouraged to use a range of dates for the timeline activity. This approach will also help students to see how scientific studies take time and overlap with those of other scientists.

Please note that some content related to polio may be distressing to students since it concerns severe disability and illness among children. If students show sensitivity, consider an approach that emphasizes how wonderful it is that scientists have mostly eradicated polio and that many fewer suffer today than in the past. If you have a student who is confined to a wheelchair, consider the opportunity to share the challenges with fellow students.

LESSON RESOURCES

- Lesson video:
  - *I Am a Polio Survivor* (5:28) https://vimeo.com/237784670

- Reading passage:
  - *Polio Scientists*

- Additional resources that may be helpful:
  - Jan Nichols' story online, Parents PACK Program, Vaccine Education Center at Children's Hospital of Philadelphia, http://www.chop.edu/centers-programs/parents-pack/personal-stories/polio
  - Polio Global Eradication Initiative, http://polioeradication.org, provides weekly updates on the status of polio eradication efforts
    - Timeline for the History of Polio, http://polioeradication.org/polio-today/history-of-polio/
  - UC Berkeley model of the scientific process, http://undsci.berkeley.edu/article/howscienceworks_02

- The following resources were used to develop the reading passages:
  - http://vaxpackhero.com/vaccine-heroes
  - https://www.salk.edu/about/history-of-salk/jonas-salk/
  - http://www.sabin.org/legacy-albert-b-sabin
  - http://www.notablebiographies.com/Ro-Sc/Sabin-Albert.html
  - http://www.nytimes.com/2013/04/21/us/hilary-koprowski-developed-live-virus-polio-vaccine-dies-at-96.html
  - http://www.nasonline.org/publications/biographical-memoirs/memoir-pdfs/bodian_david.pdf
  - http://www.nytimes.com/2008/08/27/us/27weller.html
  - http://www.nasonline.org/publications/biographical-memoirs/memoir-pdfs/enders-john.pdf
  - http://www.aai.org/About/History/Notable-Members/Nobel-Laureates/FrederickCRobbins
  - https://amhistory.si.edu/polio/virusvaccine/history3.htm
  - http://www.polioplace.org/people/john-rodman-paul-md
  - http://doc1.med.yale.edu/publichealth/publichealth2.html
  - http://www.nasonline.org/publications/biographical-memoirs/memoir-pdfs/paul-john-r.pdf
  - http://www.neonatology.org/pdf/EmersonInfantRespirator.pdf
  - http://www.polioplace.org/people/john-h-emerson

ENGAGE

1. Ask students if they recognize who is in a photo of President Franklin Roosevelt (FDR). Ask if they know what disease he had.
2. Show students a photo of FDR confined to a wheelchair. Explain that FDR got polio as an adult which is different from many people who get it as a child. Also explain that although he recovered, he was mostly confined to a wheelchair, but that very few photos exist showing him in his wheelchair because when he became president, he asked the media not to take picture of him in his wheelchair. He felt such images would reflect a message to the world that weakened the United States if their president was confined to a wheelchair.
3. Show the video *I Am a Polio Survivor*. Jan Nichols tells what it was like to be a child during the time before a polio vaccine was developed. She also shares her experience with polio and how it affected her family, including causing the death of her twin brother, Frankie. Ensure that students realize that Ms. Nichols contracted polio during the 1950s.
4. Provide some statistics about polio today, explaining that scientists have developed vaccines against polio leading to its near-eradication. Some points you might consider making include:
    - Polio is caused by a virus.
    - While some people recover with minimal effects from polio (like Jan), others are paralyzed (like FDR) and some die (like Frankie).
    - Polio is almost eradicated because of vaccination. (To give students most up to date information on polio eradication, visit Polio Global Eradication Initiative website listed in additional Lesson Resources section.)
5. Explain to students that they will explore how scientists learned about polio and eventually developed polio vaccines.

EXPLORE

1. Divide the class into seven teams: (1) Jonas Salk, (2) Albert Sabin, (3) Hilary Koprowski, (4) Isabel Morgan and David Bodian, (5) Frederick Robbins, Thomas Weller, and John Enders, (6) John Paul, and (7) John Haven Emerson. Note: If you need an additional group, David Bodian can be researched independently from Isabel Morgan as he made important contributions to the understanding of polio virus before Isabel Morgan arrived in Baltimore. Paragraph 1 in the readings focuses on his independent work, and paragraph 2 focuses on their joint work.
2. Students work in small groups so that each group researches their assigned scientist or group of scientists. Depending upon how much time you have, students can either exclusively use the reading passages included with this lesson

or do online research and use the reading passages to gain more information about each scientist or team.

3. Instruct groups that for each scientist (who), they research 1) what the person or group researched? 2) Where they did their research (geographically)? 3) When (what years) did they make their main discovery? 4) Did their work relate to understanding or treating the disease or creating a vaccine for it (why)? Ensure that students realize some scientists may have contributed to more than one of these areas. See rubric for information about which groups contributed in more than one area. By answering these questions, students will start to understand more about their individual or team. Later in the lesson as groups share their findings, the compiled information will aid students in understanding how scientists work competitively, yet collaboratively to develop scientific knowledge.

EXPLAIN

1. Post a U.S. map and a timeline that spans the years 1920-1970 where the class can see it.
2. Have each group:
    a. Mark the map to show where their scientist or team of scientists were working.
    b. Add their scientist(s)' major discoveries to the timeline; use color-coding on the timeline, so that students can also indicate whether the discovery was related to treatment of polio, understanding of the virus, or vaccine development.
3. Have each group present to the rest of the class:
    a. What their scientist or group of scientists discovered or accomplished.
    b. Whether the work was more focused on understanding polio, treating polio, or developing a vaccine against polio.

ELABORATE

1. Have students work in their previous groups or independently to record their observations about what the map, timeline and discoveries of each group teaches about how science is done.

EVALUATE

Have a class discussion in which individuals or teams share their observations. Use the discussion guide in the rubric to ensure that students synthesized conclusions from each of the research questions to understand how science is done.

EXTENSION

As an extension activity, students research the life of Franklin D. Roosevelt and how he influenced polio vaccine campaigns through non-scientific support. Alternatively, students can research the history of the March of Dimes and how the organization got its name. Students can use their findings to compare and contrast how people raised funds for polio vaccine development and how they raise funds to contribute to scientific research today (e.g., Relay for Life, crowdfunding, charity runs, etc).

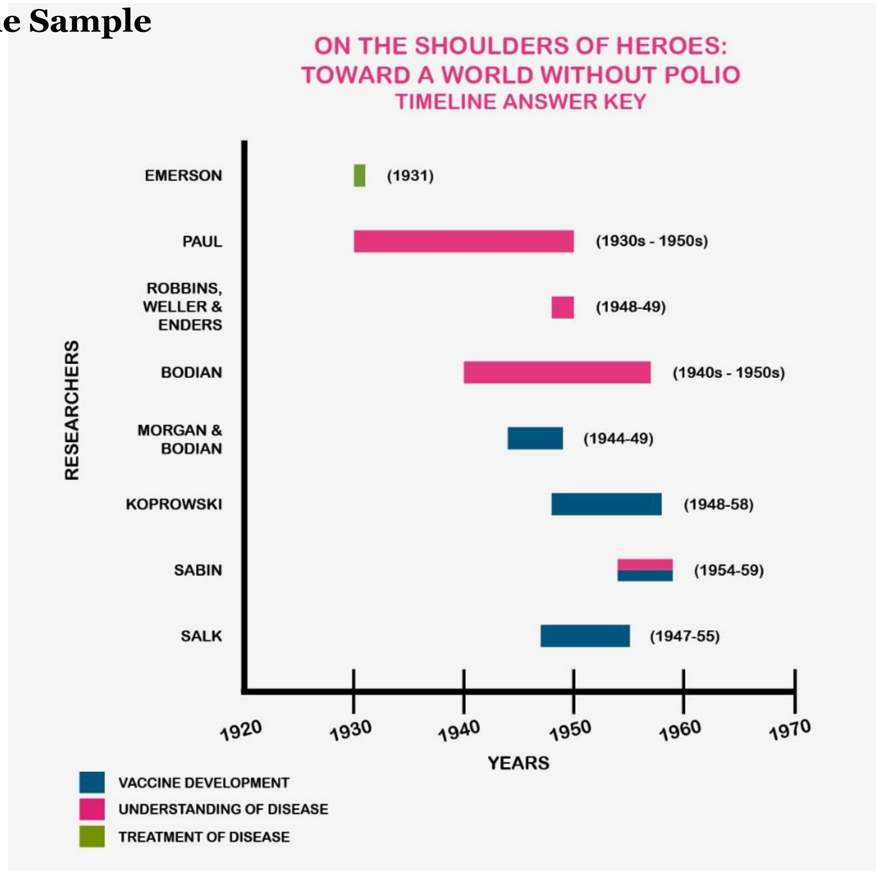
RUBRIC: STUDENT WORKSHEET

Research Table Key

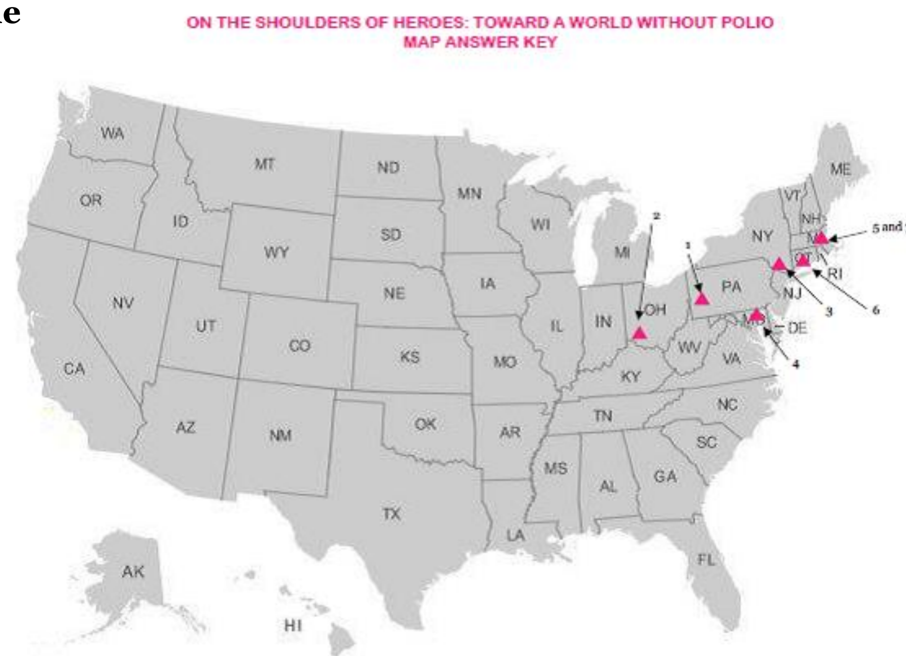
Scientist or team of scientists	What was studied? (1)	Where (map) (2)	Year(s) of main discovery (3)	(a) Understanding (b) Treatment or (c) Vaccine development (4)
Emerson	Improvements to iron lung	Cambridge, MA	1931	Treatment
Koprowski	Oral polio vaccine dev	Pearl River, NY	1948-1958	Vaccine dev.
Bodian*	Biology of infection (mouth to digestive tract to blood to nervous system)	Baltimore, MD	1940s to 1950s	Understanding
Morgan & Bodian*	Vaccine for monkeys	Baltimore, MD	1944-49	Vaccine dev.
Paul	Spread of polio, polio virus in sewage and flies, types of polio, course of illness	New Haven, CT	1930s-1950s	Understanding
Robbins, Weller, & Enders	Grew virus in cell culture	Cambridge, MA	1948-49	Understanding
Sabin	Polio virus grew in small intestine and oral polio vaccine dev	Cincinnati, OH	1954-1959	Understanding and vaccine dev.
Salk	Inactivated polio vaccine dev	Pittsburgh, PA	1947-1955	Vaccine dev.

*If only 1 group is doing Morgan & Bodian (and none are doing Bodian alone), ensure that the group realizes and reports on Bodian's independent contributions to the understanding of polio virus.

Timeline Sample



Map Sample



1. Salk – Pittsburgh, PA
2. Sabin – Cincinnati, OH
3. Koprowski – Pearl River, NY
4. Morgan & Bodian – Baltimore, MD
5. Robbins, Weller, & Enders – Cambridge, MA
6. Paul – New Haven, CT
7. Emerson – Cambridge, MA

Discussion Guide

During the class discussion, ensure that students make the following observations. You may need to guide the conversation to help students synthesize all aspects of the class activities and group work.

1. (where) Multiple people may be working on the same questions in different places at the same time – they are competing, but also learning from one another.
    - *Good example of this: showing how there were labs in Pittsburgh, Philadelphia, Baltimore and CT (Yale) all working on polio vaccine development.*

2. (when) Some information is needed before other discoveries can be made.
    - *Both Paul's and Bodian's discoveries about how polio infections occurred and spread were important to making vaccines that would be effective.*

3. (what/why) People may take different, but related, approaches to resolving situations.
    - *Several groups were working on vaccine development: Koprowski and Sabin were working on live viral vaccine (oral) strategies and Salk and Bodian/Morgan were working on inactivated vaccine (injected) strategies.*
    - *Others were working on treating infection: Emerson improved the iron lung.*

4. Science is dynamic (not linear).
    - *All of these groups were working around the same time – competing yet learning from one another. Additionally, people like Bodian were working to both better understand the disease and work on preventing it.*

Additional Teacher Note related to class discussion

Because the lesson is only providing a snapshot of the timeline related to the understanding and treatment of polio and polio vaccine development, it is possible that students may come to some incorrect conclusions; therefore, ensure that students do not leave the lesson with these incorrect impressions:

1. *Women didn't contribute to research.*
   Remind students of the period when these discoveries were being made. Some women like Isabel Morgan were named, but many women weren't named.

2. *All polio research was done in the 1940s and 50s*.
Remind students that this activity gave us a snapshot of polio research, but polio was studied before the 40s and 50s and continues to be studied today.

   Examples:
   - By the mid-1800s, doctors realized that the disease called "infantile paralysis" could be contagious.
   - In the early 1900s, Austrian scientists hypothesized that polio was caused by a virus, and as we continue to try to eradicate polio, scientists and public health officials continue to try to better understand the virus today.

3. *All polio research was completed in the northeastern part of the U.S.*
Remind students that research was occurring around the world as polio was affecting other populations too and that the research community collaborates, but also takes independent approaches. Each lab is not alone in seeking answers to an individual question.

   Example:
   - The group who reads about Koprowski will learn that although he had a lab in New York, many of his clinical trials were completed in other countries. To do this, he would have been collaborating with research and clinical teams in those places.