

Lesson Overview:

How many days are needed to teach this lesson?	2
Grade Level(s)	High School
Subject	AP Biology
Lesson Summary	Students diagnose cholera patients, model the biological mechanisms of an infection, learn about vaccine issues in Bangladesh, conduct research about local vaccine safety and effectiveness, and design vaccine awareness flyers.
Standards	<p>AP Biology Learning Objectives:</p> <p>2.5.A Describe the mechanisms that organisms use to maintain solute and water balance.</p> <p>2.8.A Describe the processes that allow ions and other molecules to move across membranes.</p> <p>4.2.B Describe the role of components of a signal transduction pathway in producing a cellular response.</p> <p>4.3.B Explain how a change in the structure of any signaling molecule affects the activity of the signaling pathway.</p>
Focus Pulitzer Center news story/stories	<p>“Meet the Bangladeshi Scientist Who’s Helping the World Fight Cholera” by Martin Enserink</p> <p>“In the Cradle of Cholera,” from Meet the Bangladeshi Scientist Who’s Helping the World Fight Cholera by Martin Enserink</p>
Notes on Context	This lesson was taught to AP Biology students who have already completed introductory biology and chemistry.

Lesson Plan

Lesson Objective(s) or Essential Question(s)

- Lesson Objectives:
 - Describe the social and environmental barriers in cholera-impacted countries.
 - Describe the mechanism of a G-protein coupled receptor (GPCR).
 - Explain how a cholera infection impacts cellular solute and water homeostasis.
 - Increase community awareness of vaccine safety and effectiveness.

Focus Pulitzer Center News Story/Stories

“[Meet the Bangladeshi Scientist Who’s Helping the World Fight Cholera](#)” by Martin Enserink

“[In the Cradle of Cholera](#)” by Martin Enserink

Lesson Steps

Additional Lesson Resources:

- Video: [The Story of Cholera](#)
- Optional Video: [John Snow and the 1854 Broad Street cholera outbreak](#)
- Video: [How does cholera make people sick? Understanding G-protein signaling](#)
- Book: [The Story of Life](#) by Sean B. Carroll, Chapter 2: “First Do No Harm”

Day 1: Part A-C

1. Students take on the role of health practitioners to diagnose their patients by examining simulated stool samples. They compare a healthy stool sample to a sample from a person with cholera.

- Teacher prep: Create simulated stool samples the day before by mixing 200 mL of molasses, 40 mL of water, and 40 mL of gelatin in a large bowl. Set half of the sample aside (healthy stool). Add 5 g of yeast to the second sample and additional water (cholera-affected stool). Flour can also be added to thicken the samples, while keeping the cholera-affected sample more watery. Mold the stool samples into the desired shapes on watch glasses and create enough samples for each lab group. Cover the samples with plastic wrap and refrigerate them overnight. *Note: Yeast cells are used instead of bacteria in the cholera-affected samples because yeast are easier to see under a dissecting microscope.*
- Distribute the worksheet [Gut Check: Cholera, Vaccines, and the Biology of Student Health](#) to each student. Use this student worksheet to guide the lesson sequence outlined in this lesson plan.

- Working in groups, have students examine the simulated stool samples from both a healthy (Sample A) and a cholera-affected (Sample B) individual. Students should note the visual differences and use a dissecting microscope for closer analysis. Then draw, color, and label the images of the samples on the worksheet and answer Questions 1 and 2 for Part A. When the students have finished their analysis, teachers should dispose of the stool samples in a biohazard bag for added impact.
- Elicit a discussion of what differences they observed between the two samples. Students should notice that Sample A has a more solid consistency, while Sample B is more watery and has dots or flakes. Sample B represents “rice water diarrhea” from a person infected with cholera bacteria.

2. Students learn more about cholera and a Bangladeshi scientist named Dr. [Firdausi Qadri](#), who is working to combat cholera infections.

- Distribute a hard or digital copy of the short article “[Meet the Bangladeshi Scientist Who’s Helping the World Fight Cholera](#)” by Martin Enserink for each student to read.
- Students should answer Question 3 for Part A on the student worksheet, then discuss their answers to the three questions with their table partner.
- As a whole class, discuss the answers to Question 3 for Part A and record their responses on the board. Possible student wonderings: What is cholera? How does it spread? How does it cause infection? Why is it making a comeback? Which countries are most impacted? Why is climate change making cholera infections worse? How does the oral cholera vaccine work?

3. Students examine a map of the countries affected by cholera and watch a video explaining how cholera infections spread.

- Working in pairs, provide students with a hard copy of a [WHO map and graph](#) (Figures 1 and 2) depicting countries and regions impacted by cholera. Alternatively, teachers can project the figures on a screen for the class to view together or provide a link to the map and graph.
- Students should answer Questions 1 and 2 for Part B and then discuss the answers as a whole class.
- Play the 4:28 video [The Story of Cholera](#). Then have students answer Question 3 for Part B on the student worksheet and discuss the answer as a whole class.
- Optional Extension Activity: Show students [the video about the cholera outbreak that Dr. John Snow, the Father of Epidemiology, investigated](#) at the Broad Street pump in London in 1854 to stop the epidemic.

4. Students examine a G-protein coupled receptor (GPCR) to understand what is happening on a cellular level to people in cholera-impacted countries. *Note: This model was created in BioRender*

- Play the 2:00 video [How does cholera make people sick? Understanding G-protein signaling](#) as outlined on the student worksheet, showing how a G-protein coupled receptor (GPCR) works normally in the gut and how the cholera toxin impacts its function as they complete Part C of the student worksheet. Begin by showing the class 1:04 minutes of the video two times at a slower playback speed (0.75). The first showing, have students just watch the video. On the second showing, have students number each step on the healthy individual model. To verify they did this correctly, teachers should walk through the correct sequence of events afterward.
- Show the class 1:05-1:19 of the cholera video twice. Have the students watch the first time, then the second time use the letters A, B, and C to describe how the receptor is deactivated (dashed-arrows on the healthy individual model), and verify they did this correctly.
- Additional teacher details added to the diagram that are not included in the video are that Protein Kinase A (PKA) phosphorylates CFTR and the Na^+/H^+ antiporter to activate the channels, and water moves via osmosis toward the ions in the intestinal lumen (hypotonic → hypertonic).
- Show the class 1:20-2:00 of the cholera video twice. The students should then draw, color, and label the model of the afflicted individual and provide a written description of how cholera impacts the receptor on the lines provided. Students should note that cholera's toxin impacts the G-protein coupled receptor, preventing it from hydrolyzing GTP back to GDP. The receptor is therefore continually activating everything afterward, leading to excessive ions being pumped into the intestinal lumen, then water follows by osmosis, causing extensive water and ion loss if left untreated.
- If students do not complete their models in class, have them finish their models and descriptions for homework.

Day 2: Parts D-G

5. Students learn more about a Bangladeshi scientist, Dr. Firdausi Qadri, the “Queen of Cholera,” to understand her efforts to get an oral vaccine to Bangladesh and other cholera-impacted countries.

- Have students read the Pulitzer Center article “[In the Cradle of Cholera](#)” by Martin Enserink.
- Then respond to the questions in Part D located on the student worksheet. Teachers should then have a class discussion about the key takeaways from the article.

6. Students put [Immune Cartoon Cards](#) in the correct order to model how the body fights off pathogens without and with vaccines.

- Teacher prep: Print class sets in color of the Immune Cartoon Cards by Dr. Valentina Hoyos Vélez. Teachers may wish to laminate them or print them on cardstock. In one color marker, add letters A-J to the first 11 images (slides 2-11). The letters should not be in the correct order of the slides. Then cut the comics apart on slides 12 and 13, and using a different color marker, add letters A-H to the comics and cards on slides 12-17. Like before, the letters should not be in the correct order of the slides.
- Working in groups, provide students with the first set of cards showing how the immune system responds to a pathogen when a person is unvaccinated. These cards depict how SARS-CoV-2 causes a COVID-19 infection. Have students put the cards in the correct sequence, and be prepared to explain their order sequence and describe the events happening in the comics. Teachers should walk around the room as the students work to answer questions and provide clarification as needed.
- Randomly select a student group to present their card sequence to the whole class to build a consensus of how a pathogen generates immunity, but also can lead to complications.
- Provide students with the second card set showing how the immune system responds to a pathogen when a person is vaccinated. Like before, randomly select a group to present their card sequence and clarify any misunderstandings. While this card sort example depicts the COVID vaccine, connect the concepts from this card sort to how the oral cholera vaccine created by Dr. Firdausi Qadri equips the immune system to fight cholera if exposed to the bacteria. *Note: The COVID vaccine is an mRNA vaccine, while the oral cholera vaccine described in the article is a dead or weakened version of the cholera pathogen.*

7. Students read chapter 2, “First Do No Harm”, from the book *The Story of Life* by Sean B. Carroll, on how one misguided doctor in 1998 reignited vaccine skepticism and how this triggered the current mistrust by many people today regarding vaccine safety.

- Working in pairs, provide students with the book *The Story of Life* or have them read the [digital copy](#) of chapter 2 “First Do No Harm”. Then have them answer the student worksheet questions for Part F.
- As a whole class, discuss the key takeaways from this chapter.

8. Students research online why some people locally are still hesitant to trust vaccines and what a trusted science-backed organization states regarding vaccine safety and effectiveness.

- Have students visit the website: ivaccinate.org and direct them to visit the section: Commonly Asked Questions: [Answering Your Questions - I Vaccinate](#). *Note: Other reputable websites may be used if approved by the teacher.*

- Encourage students to browse the commonly asked questions about vaccines section or type in their own questions about vaccines to learn more. Then choose which one/s they think are worth dispelling as myths as they create a vaccine awareness flyer, hand-drawn or using an online program like Canva.
- After the vaccine advocacy flyers are created, display the flyers in the hallway and/or on social media to educate others across the school and community. Teachers should grade these flyers as the summative component of this learning experience using the provided rubric.

Performance Task(s)

Students do an extended online research project on vaccine safety for homework and create flyers to display across the school and/or on social media. This community-centered project aims to raise awareness of vaccine safety and effectiveness, inspired by the work of Dr. Firdausi Qadri in Bangladesh, featured in the Pulitzer Center articles.

Assessment

Formative assessments are embedded in the lesson sequence, modeling cholera's impact at a cellular level in the small intestine, and sequencing cards depicting how vaccines generate immunity. The summative assessment is the performance task of students creating flyers on vaccine safety and posting them in the school and/or on social media.