The Science of mRNA Vaccines and How They Protect Against COVID-19

Plus: Using Data to Predict Outbreaks

TEACHING GUIDE
Science and ELA Activities Investigating Vaccine Science and Research Careers

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Biomedical Research and Vaccines: The Fight Against Infectious Disease

Have students take on the role of biomedical researchers as they study a simulated pathogen and design an immunity-building vaccine.

Objective
Students will synthesize information using a range of sources and write for a domain-specific purpose.

Standards
NGSS
• MS-LS1-3 Body subsystems
• HS-LS1-2 Interacting body systems

CCSS Literacy in Science
• RST.1 Cite evidence when analyzing science texts
• RST.9 Compare and synthesize information from a range of sources
• W.4 Produce writing appropriate to task

Time
75 minutes + additional time to complete activity sheets as needed

Materials
► Pathways magazine
► Paper, scissors, rulers
► Find Your Inner Scientist activity sheet
► Model mRNA Vaccine Science activity sheet
► Optional: Vocabulary sheet at scholastic.com/pathways

1. Ask student volunteers to take turns reading the magazine aloud. Acknowledge that many of us have been impacted by COVID-19. Discuss how science can be an empowering way to address a challenging situation.

2. In pairs, have students do the Find Your Inner Scientist activity sheet.

3. Model how to create a “paper pathogen” (see diagram below), Direct students to work in pairs and create a few paper pathogens of their own. Encourage pairs to experiment and come up with varied “spike” shapes.

4. Explain that a pathogen is an organism (e.g., bacterium, fungus, virus) that causes disease. Say: This pathogen is a virus. On its surface (point to spikes) there are antigens—substances your immune system recognizes as foreign to your body and so it produces antibodies in response.

5. Ask pairs to choose their most interesting paper pathogen and cut one of its antigenic spikes free. Have students observe and record a description of the antigen’s shape, its measurements, and the location of its notable features.

6. Then, tell students to create a one-page guide with instructions for how to create a copy of their antigen (students may template their antigen by tracing it).

7. Have students trade their guide with another student pair.

8. Ask pairs to use the instructions they’ve received to create four identical copies of the antigen and design four antibodies that can fight it. For example, they may trace the antigen, then cut around that “negative space” to create shapes that fit the spikes like puzzle pieces. Affix them to a bulletin board.

9. Distribute the Model mRNA Vaccine Science activity sheet. Discuss which parts of their classroom activity represent real-world mRNA vaccine science. Have students fill in steps 1–4.

10. Point to the bulletin board. Ask students to explain how the body would react to a collection of new antigens. Prompt for: build antibodies.

11. Move one of the antigens to your whiteboard, draw a rectangle around it, and title it like a “Wanted / Have you seen this antigen?” poster. Explain that once your body creates enough antigen-fighting antibodies, it will “remember” and be on the lookout for the antigen. Hold up an intact paper pathogen, pointing to a spike. If the body encounters the antigen again, it will know what to do—reacting quickly with the right antibodies to fight an infection.

12. In groups, finish the Model mRNA Vaccine Science activity sheet.

13. Wrap up with a discussion about new and surprising learnings about vaccine science, careers in biomedical research, and questions students would like to research next.

Activity Sheet Answers: Classroom: 1. paper pathogens created, 2. observations recorded, 3. guides with instructions created, 4. instructions received and antigen copies made, 5. antibodies made, 6. “antigen wanted” poster created, 7. original pathogen/antigens revisited

Magazine: 1. COVID-19 outbreak, 2. Dr. Corbett computer sequencing, Dr. McLellan mapping the antigen, 3. instructions for producing spike protein in stabilized shape are packaged into lipid nanoparticles in the vaccine, 4. muscle cells make copies of spike protein, 5. immune system makes targeted antibodies, 6. memory cells remember instructions, 7. vaccinated immune system reacts more swiftly than it otherwise could, 8. COVID-19 vaccine trials enrolled 30,000 people
Science is everywhere. There is science in drawing, music, and all aspects of our lives. In sports, there are tons of things to explore, like biomechanics, sports medicine, and data analytics.

Add math. Many students find that math is much more interesting outside of the textbook, in the real world, when it’s used to solve problems—like how to stop the next pandemic!

Go ahead and game. Playing video games when I was younger taught me problem-solving and other ways of thinking—and to make connections between old and new challenges. I still play them!

**Step 1:** Circle or highlight your top interest(s) as well as your traits and skills, or add your own on a separate sheet. Reflect on how you can combine these to embark on a career in science.

**Traits:** Patient | Flexible | Creative | Caring | Curious | Analytical | Detail-oriented

**Skill Areas:** Communication | Numeracy | Logic | Critical Thinking | Organization

**Step 2:** Choose an area of research from the list below. Then, on a separate page, write a persuasive paragraph that explains how you could use your unique interests and skills to contribute to biomedical research and advancements in the area of research you chose.

**Disease**
- Aging
- The Brain
- Biomechanics (how the body moves)

**Growth & Development**
- The Heart
- Genetics
- Pharmacology (medications)

**Immunology & Viruses**
- Data, Modeling & Artificial Intelligence (AI)
- Mental Health
- Chronic Pain
# Model mRNA Vaccine Science

Which steps from your “paper pathogen” classroom simulation align with real-world mRNA vaccine science? Record related facts and information from your Pathways magazine to support your understanding.

<table>
<thead>
<tr>
<th>In the Classroom</th>
<th>In the World</th>
<th>Supporting Facts and Information From the Magazine</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td>A new pathogen emerges that endangers human health.</td>
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<td><strong>Step 2</strong></td>
<td>Scientists work to identify the pathogen and use tech like genome sequencing and cryo-electron microscopy to identify the structure of an antigen (foreign substance) at the atomic level.</td>
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<td><strong>Step 3</strong></td>
<td>Scientists develop an mRNA vaccine that packages how-to instructions for building the antigen.</td>
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<td><strong>Step 4</strong></td>
<td>The vaccine is given to people in clinical trials. Cells in the body use the instructions to create copies of the antigen.</td>
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<td><strong>Step 5</strong></td>
<td>The immune system responds to the presence of antigens by creating antibodies.</td>
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<td><strong>Step 6</strong></td>
<td>The immune system stores a “memory” of the antigen so that it “remembers” what to do if it encounters it again.</td>
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<td><strong>Step 7</strong></td>
<td>If the body encounters the virus, the immune system recognizes the antigen and is prepared to react swiftly to fight infection—quickly generating the antibodies it already knows how to make.</td>
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<td><strong>Step 8</strong></td>
<td>Scientists analyze data from clinical trials to confirm the vaccine is safe and effective; then it’s given to the general public.</td>
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