TEACHER LESSON PLAN

Lesson 1 – Meet the Germs

LESSON QUESTIONS

- What is a virus?
- Who discovered viruses?
- How did the scientific method lead to the discovery of viruses?
- What are the differences between viruses and bacteria?

LESSON OBJECTIVES

- Identify features of a virus.
- Identify and summarize the application of the scientific method that led to the discovery of viruses.
- Organize and represent data showing the differences between viruses and bacteria.
- Identify who discovered viruses.

DOK 1 – 3

OVERVIEW

In this lesson, students learn about the differences between viruses and bacteria. The aim is for students to understand (a) that disease arises from different kinds of agents and (b) that there is a human story behind scientific discovery. Students read a passage about Martinus Beijerinck, a Dutch scientist who developed the hypotheses and procedures that led to his discovery of viruses. Students then research the differences between viruses and bacteria, compiling and organizing their information. This learning is reinforced by students analyzing the comparison using a T-chart. Students also learn about the causes of disease, sorting different diseases by their causes, whether viruses or bacteria. Finally, students share their information and take a short quiz to reinforce and evaluate learning.

LENGTH

Up to two 45-minute sessions

MATERIALS

Computer with internet access

GLOSSARY TERMS

bacteria, genetic material, microorganisms, virion, virology, virus

STANDARDS

Science standards are aligned to NGSS Grade 3. Language and math standards are aligned to Common Core State Standards (CCSS) Grade 4 (ELA/Literacy) and Grade 5 (Mathematics). However, parallel standards for other grade bands are readily applicable to this lesson for Grades 3-5.

Next Generation Science Standards (NGSS)	**3-LS1-1** From Molecules to Organisms: Structures and Processes *www.nextgenscience.org/dci-arrangement/3-ls1-molecules-organisms-structures-and-processes*	
	Performance Expectation	**Connections to Classroom Activity** *Students:*
	Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction and death.	• develop models of bacteria and virus life cycles, highlighting differences and similarities
	Science and Engineering Practices	
	Developing and Using Models	• identify limitations of models of virus structure and lifecycle
	Planning and Carrying Out Investigations	• evaluate how the scientific method was used to collect data and make observations that led to the discovery of viruses
	Using Mathematics and Computational Thinking	• use computation to analyze the relative sizes of bacteria and viruses
	Obtaining, Evaluating and Communicating Information	• use graphic organizers to combine information about features of viruses and bacteria and describe how they are supported by evidence
	Disciplinary Core Idea	
	LS1.B Growth and Development of Organisms – Reproduction is essential to the continued existence of every kind of organism. Plants and animals have unique and diverse life cycles.	• compare reproductive strategies of viruses and bacteria
	Crosscutting Concepts	
	Scale, Proportion and Quantity	• use standard units to describe the sizes of viruses and bacteria
	Systems and System Models	• identify function and structure of a simple virus • model a simple viral lifecycle
	Structure and Function	• relate the structure of a virus to its reproductive strategy

	Standard	Connections to Classroom Activity *Students:*
Common Core State Standards (CCSS) ELA/Literacy	**Key Ideas and Details**	
	RI.4.1 Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text.	• read a passage about the discovery of viruses and summarize information in a graphic organizer
	Craft and Structure	
	RI.4.4 Determine the meaning of general academic and domain-specific words or phrases in a text relevant to a grade 4 topic or subject area.	• study the meanings of glossary words related to the study of viruses and bacteria
	RI.4.5 Describe the overall structure (e.g., chronology, comparison, cause/effect, problem/solution) of events, ideas, concepts or information in a text or part of a text.	• interpret the story of how viruses were discovered in the context of the scientific method
	Integration of Knowledge and Ideas	
	RI.4.7 Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, time lines, animations, or interactive elements on Web pages) and explain how the information contributes to an understanding of the text in which it appears.	• create a graphic organizer to interpret information about viruses and bacteria
	Range of Reading and Level of Text Complexity	
	RI.4.10 By the end of year, read and comprehend informational texts, including history/social studies, science and technical texts, in the grades 4-5 text complexity band proficiently, with scaffolding as needed at the high end of the range.	• read a text about the history of how viruses were discovered

	Apply and Extend Previous Understandings of Multiplication and Division	
Common Core State Standards (CCSS) Mathematics	5.NF.B.3 Interpret a fraction as division of the numerator by the denominator (a/b = a ÷ b). Solve word problems involving division of whole numbers leading to answers in the form of fractions or mixed numbers, e.g., by using visual fraction models or equations to represent the problem.	• complete a problem requiring computation of the ratio of a bacterium's size to that of a virus
	Convert Like Measurement Units Within a Given Measurement System	
	5.MD.A.1 Convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multi-step, real world problems.	• complete a problem that requires conversion of nanometers to microns

BACKGROUND FOR TEACHER

The goal of this lesson is for students to understand that viruses and bacteria differ in significant ways. To engage students, they learn the human story behind the discovery of viruses. The lesson resources include a 3-5 grade level passage about Martinus Beijerinck (pron. "mahr-ty-nuhs by-ehr-ink") who discovered viruses. The Vax Pack Hero website also has a brief biography about him, and other resources are available online. Likewise, students will be able to find ample information online regarding the differences between viruses and bacteria. Depending on class ability and grade, student learning could include any or all of this information about viruses:

- Size
- Life-form
- Definition
- Mode of reproduction
- Structure
- Types of infection
- Treatment
- Prevention

TEACHER NOTES

The over-arching question of this lesson is "How do we stay healthy?" Students will understand that diet and exercise are parts of a healthy lifestyle. Most students will also have received vaccinations and will understand that these protect from disease. Students may also know that germs lead to disease. However, students may not realize that

different kinds of germs cause different kinds of diseases. In this lesson, students learn about the two main different kinds of germs. In particular, they conduct research to distinguish between viruses and bacteria. The main differences between these two causes of disease include (1) viruses are much smaller than bacteria, (2) viruses require a host cell's machinery to reproduce and (3) we consider viruses to be non-living (partly because of their inability to reproduce without living cells). Students relate these concepts to a real-life scientist who made the initial discoveries. By viewing a scientific discovery through the human story, students not only learn the facts of viruses and bacteria, but also come to understand that such facts are revealed by a scientific process. This is the same process that underlies all scientific discoveries.

LESSON RESOURCES

- Lesson Glossary
- Martinus Beijerinck biography
- Vax Pack Hero Meet the Germs
  http://vaxpackhero.com/meet-the-germs
- Lesson animations (optional):
  - *A Virus Attacks a Cell* (run time: 1:36)
    https://vimeo.com/user20611452/review/198062527/ae3f1b4dc6
  - *How Do Viruses Reproduce?* (run time: 1:34)
    https://vimeo.com/user20611452/review/198068487/f60adb448b

ENGAGE

1. Ask students to list different diseases they have heard of.
2. Encourage students to note details about the diseases.
3. Ask students to hypothesize what causes different types of diseases. Consider a group activity to help students develop ideas.
4. If necessary, lead students to conclude that different diseases are caused by different kinds of germs.
5. Tell students that they will learn about how scientists discovered that there are different kinds of germs.
6. Ask students (in groups if desired) to consider what kinds of differences there may be between germs.
7. Students individually read the story about Beijerinck.

EXPLORE

1. Students work online in small groups to research differences between viruses and bacteria.
2. As students work, encourage them to take notes, paying particular attention to features such as sizes and structures of viruses and bacteria.
3. If needed, students can use graphic organizers to clarify their information.

4. Tell students that they will use the graphic organizers in the next part of the lesson.

Note: Student studies during Explore can include library work and group discussion as well as online research. Students explore online sources and the lesson glossary, completing the vocabulary table in their worksheets.

EXPLAIN

1. Students can work in pairs or small groups.
2. Ask students to determine the best way to present a comparison between viruses and bacteria.
3. Students create a T-chart showing the differences between viruses and bacteria.
4. As a class, compose a T-chart visible to all. Students can offer information from their groups to populate the chart.
5. Use this opportunity to discuss the main differences between viruses and bacteria and answer questions that the class may not have resolved in their small group discussions.
6. Once the T-chart is completed, have students focus on the size difference to bring the discussion back to Beijerinck's story. As a class, discuss the Beijerinck story.
7. Ask students to write a sentence or short passage to identify which of his actions apply to each part of the scientific method (it may help students to look at the story frames):
    a. Ask a question
    b. Do background research
    c. Construct a hypothesis
    d. Test the hypothesis with an experiment
    e. Analyze data and draw a conclusion
    f. Communicate results.
8. Guide a student discussion on how scientists communicate results formally and how scientific information is dispersed. The discussion could include a compare and contrast between communication methods today versus during the time Beijerinck did his work.

Note: For comparing viruses and bacteria, a T-chart is ideal but, if preferred, students can use a different type of graphic organizer, such as a Venn diagram. If time allows, use the optional animations (see resources list) to develop the class discussion in Step 5.

ELABORATE

1. Students build on their learning to sort germs into groups of viruses and bacteria. (The Vax Pack Hero Meet the Germs section has information on various diseases and their causes.)
2. Depending on time, consider assigning students three or four diseases to research, or allow them to choose some that interest them. Ensure that each group studies at least one bacterial and one viral disease.
3. Students add the information about diseases to their T-charts.

Note: You may need to guide students on information-gathering and organization strategies. For example, they could make index cards with disease information including: type of germ, areas of infection, symptoms and scientists who studied the disease.

EVALUATE

1. Provide time for groups to share their findings and conclusions with others.
2. Consider using a teaching strategy such as journaling to allow summative assessment. In this strategy, students can use pictures and writing to summarize their findings and synthesize information.
3. Depending on student age and ability you may wish to use the quiz for summative assessment. Alternatively, consider using some or all of it early in the lesson for formative assessment.

EXTENSIONS

- Students play the Vax Pack Hero game and take note of where they encounter germs in the body. This can be extended to include looking online to determine if the germ was battled during the game in the part of the body it infects in real-life.
- To reinforce learning, provide students with a simple diagram of a bacterium so that they can see its complexity compared to a virus, e.g., http://hyperphysics.phy-astr.gsu.edu/hbase/Biology/imgbio/cellprokaryote6.gif
- The idea that viruses may be non-living and yet are able to reproduce may confuse some students. To show how such a relatively simple structure as a virus gains entry into cells and reproduces, show the animations *A Virus Attacks a Cell* and *How Do Viruses Reproduce?*

RUBRIC: STUDENT WORKSHEET

- Vocabulary table- refer to the lesson glossary for correct definitions of the terms.

- Difference between virus and bacteria table- Students should recognize that viruses are much smaller than bacteria, viruses require a host cell's machinery to reproduce, and viruses are considered to be non-living (partly because of their inability to reproduce without living cells).

RUBRIC: SCIENTIFIC METHOD ACTIVITY (EXPLAIN)

7. Ask students to write a sentence or short passage to identify which of his actions apply to each part of the scientific method (it may help students to look at the story frames):

a. Ask a question: e.g., *What is making my plants sick?*
b. Do background research: e.g., *I see bacteria can make my plants sick.*
c. Construct a hypothesis: e.g., *Something other than bacteria is making my plants sick.*

d. Test the hypothesis with an experiment: e.g., *Filter a mixture of viruses and bacteria and expose plant to the filtrate (part without the bacteria)*. [Note: Ensure that students understand this step would be repeated several times.]
e. Analyze data and draw a conclusion: e.g., *Plants get disease from filtered solution, so they can get diseases from something other than bacteria.*
f. Communicate results: *Publish a paper with results.*

RUBRIC: QUIZ QUESTIONS

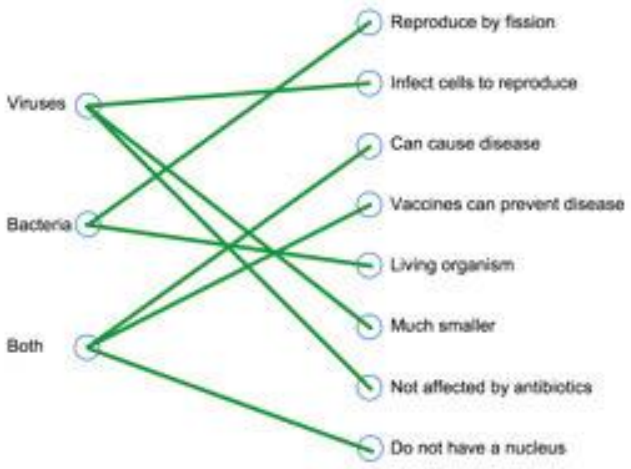
1. What was Beijerinck's major insight regarding how to identify viruses?

    a. A filter can be used to separate viruses from bacteria because of their different sizes.

2. What did Beijerinck conclude from his study of viruses?

    b. Viruses could only replicate in cells.

3. Draw a line to connect each concept comparing viruses and bacteria. Choose all that apply.



4. Viruses and bacteria have differences in structure.
Write Y (yes) or N (no) to indicate which structures can be found in each.

Structure	Virus	Bacteria
Protein coat (also called capsid)	**Y**	**N**
Sugar coat (also called capsule)	**N**	**Y**
Cell wall	**N**	**Y**
Cell membrane	**N**	**Y**
Genetic material	**Y**	**Y**

5. What is the main difference between how viruses and bacteria reproduce?

a. Viruses must infect a living cell. Bacteria can reproduce without being in a cell.

6. Write a short passage to explain why many scientists consider viruses to be non-living.

- Answers may vary. Sample answer: Scientists consider viruses to be non-living because they can reproduce only by using structures inside a living cell. Also, viruses can be crystallized, unlike living cells. Viruses do not have chemical reactions inside them like living cells.

7. Indicate which of the following statements are true or false.

a. All viruses have the same shape. **F**
b. Viruses can be bigger than bacteria. **T**
c. Viruses reproduce by taking over cells. **T**
d. All viruses cause disease. **F**
e. All viruses are comprised of protein molecules. **T**

8. If a virus is 200 nanometers long and a bacterium is 10 microns long what is the ratio of their lengths? Show your work.

b. 1:50

9. Order the events in the life-cycle of a virus by writing the letters from the list into the correct box.

C	**E**	**B**	**D**	**A**

a. The new virus is released
b. The cell makes copies of viral proteins
c. Virus particle attaches to host cell
d. Virus particle assembles
e. Genetic material is inserted

10. Classify the diseases according to whether they are caused by a virus or bacteria.

Disease	Virus	Bacteria
Influenza	✓	
Common cold	✓	
Zika	✓	
Pertussis		✓
Smallpox	✓	
Hepatitis B	✓	
Tetanus		✓
Measles	✓	
Mumps	✓	