

*A Common Core State Standards & Next  
Generation Science Standards-Aligned  
Discussion & Project Guide for  
Grades 3 to 7*

# ALL IN A DROP: HOW ANTONY VAN LEEUVENHOEK DISCOVERED AN INVISIBLE WORLD

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Written by Lori Alexander  
Illustrated by Vivien Mildemberger  
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*For fans of the “Who Was” series, this lively, accessible, and full-color chapter book biography shows how a self-taught scientist was the first to observe the microbial life in and around us. By building his own microscope, Antony van Leeuwenhoek advanced humanity’s understanding of our oft-invisible world around us.*

*Microbes are everywhere: in the soil and oceans, in snow, and inside our bodies. But in Antony van Leeuwenhoek’s time, people believed that what they saw with their own eyes was all that existed in the world. How did a simple tradesman—who didn’t go to college or speak English or Latin like all the other scientists—change everyone’s minds?*

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Guide created by  
Debbie Gonzales, MFA



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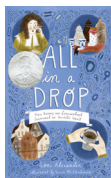
### Meet the author, Lori Alexander:

Lori Alexander loves to read and write! She has written picture books like BACKHOE JOE and FAMOUSLY PHOEBE as well as the FUTURE BABY board book series. She also writes non-fiction chapter books, such as ALL IN A DROP and A SPORTING CHANCE, both from Houghton Mifflin Harcourt. Lori resides in sunny Tucson, Arizona, with her scientist husband and two book loving kids. She runs when it's cool and swims when it's hot. Then she gets back to reading and writing. Visit Lori at [www.lorialexanderbooks.com](http://www.lorialexanderbooks.com) or on Twitter @LoriJAlexander or Instagram @lorialexanderbooks.



### Meet the illustrator, Vivien Mildenerger:

After graduating from Art Center College of Design with honors in Illustration, Vivien Mildenerger packed up her pencils and moved to a lovely farm just outside of Nashville, Tennessee, where she is a part of the Warren Studio of artists. There she works on her illustrations, pottery, and other general magic-making. She loves illustrating for children most of all. Vivien's art is filled with wonder, quirky characters, and nods to history.



## Discussion Questions

***Anthony sells his pet worms to a silk spinner in the market square. Their cocoons will be used to make delicate thread for yarns. The sale earns Anthony a small profit. Already, he has a head for business (pg. 13).***

- Both of Anthony's parents were industrious business people. He spent much of his childhood surrounded by community and enterprise. Consider how his family life influenced his interests as an adult.
- Could being a child during the Golden Age have something to do with Anthony's inquisitive and productive nature? Explain your answer.
- Unlike standard earthworms, silk worms require consistent care. They eat special food and live in a dark, warm place. What does Anthony's marketing success in selling silk worms reveal about his character?

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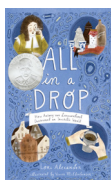
***Anyone who works hard is welcome here. Anthony watches the city construction: buildings grow taller, canals grow wider, houses spring up everywhere (pg. 16).***

- Anthony found life in the bustling city of Amsterdam to be energizing. He found the energy to be engaging and alive. Determine why he found city-life more appealing than studying to become a lawyer in Benthuisen.
- Examine reasons why Anthony decided to leave Amsterdam to return home to Delft after completing his apprenticeship.
- The word *independent* means to be a free-thinker, bold, and self-made. Which of these three words best describes Anthony at the age of twenty-two?

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***While in London, Anthony hears chatter about an English scientist named Robert Hooke, who uses lenses to examine fabric, as well as plants and insects. The scientist uses the lenses in a tool called a microscope (pg. 24).***

- Is Anthony most interested in learning more about Hooke's book, his fabric examining techniques or the microscope he uses to do so? Explain your answer.
- The word *curious* means fascinated, inquisitive, or questioning. The author repeats the word curious when describing Anthony's interest in Hooke and his work. Discuss how the deep sense of curiosity surrounding *Micrographia* served as a defining moment in Anthony's life.



***Antony is “unlearned both in sciences and languages.” But they do like that he is “exceedingly curious” about nature. After more thought, the group finds his observations of the mold and bees and live quite informative (pg. 33).***

- The Scientific Method is a factual, practical, and verifiable method of obtaining and gathering knowledge. Communication within the Royal Society centered around careful observations, hypotheses-based experimental findings, and measurable deductions. Predict why they first rejected Antony’s correspondences. Were their reasons justifiable? How so?
- Examine the phrase “unlearned both in sciences and language” (pg. 33). Identify both the truth and misconceptions about Antony the phrase represents.
- Nonetheless, the Royal Society found Antony’s observation to be informative. Why do you think this was so?

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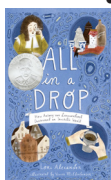
***Antony has never seen animals this small. No one has! Until now, people believed that what they see with their own eyes is all that existed in the world. Could there actually be another world, invisible and hidden from human eyes (pg. 39)?***

- Predict what Antony must’ve felt when he first saw the microbes thriving in the pond water. Shocked? Frightful? Surprised? Horrified? Excited? Confused? How do you know?
- The sequential steps of the Scientific Method are 1) Ask a question, 2) Construct a hypothesis, 3) Test with an experiment, 4) Analyze the data, 5) Draw conclusions based on the hypotheses, 6) After reproducing and retesting the experiment, report results. Examine Antony’s response to discovering the microbes in the light of following the Scientific Method.
- No one in the world had ever seen or heard about microbes, even the Royal Society. If so, why do you think the Royal Society’s response to Antony’s discovery was favorable? Why did they begin to respect Antony’s work? What brought about their change in point of view regarding Antony’s research methods?
- Which of Antony’s discoveries were ultimately most instrumental in enhancing the world of science, his microscope or microbes? Explain your answer.

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***Indeed, viewing hidden worlds takes patience. Most people do not want to concentrate for more than a few minutes. Antony has become a skilled scientist because he looks at his samples for hours at a time (pg. 54-55).***

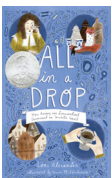
- Explain why Antony’s discoveries gained worldwide interest. What caused people – worldwide – to become fascinated by his work?
- The word *patience* means determination, perseverance, and calmness. Which of these terms best describe Antony’s approach to sharing his findings with others. How so?
- Examine Antony’s training to become a “skilled” scientist. How did it happen?





***In Antony's time, less was known about the health benefits of personal hygiene, food safety, and household cleanliness. Once the connection between germs and illness was made, practices began to change, including handwashing, keeping sewage out of the water supply, and avoiding the sick (pgs. 66-67).***

- Historically, people were unaware that practices such as hand washing before eating or allowing livestock to live in the house might cause illness. Study the illustration depicting a group of people crowded together in a home. List the number of actions taking place that are examples of poor personal hygiene, food safety, and household cleanliness.
- Of all of Antony's discoveries, identify which has had the most lasting impact on the world. Explain your answer.



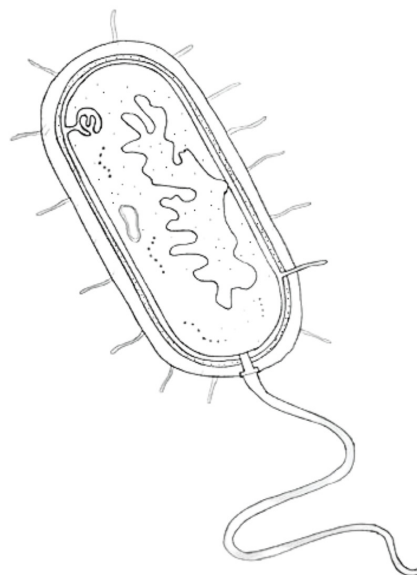
## Meet the Microbe

*At such perfection in this tiny creature I did greatly marvel (pg. 88).*

**Objective:** To develop a model describing the function of an organism in terms of its components and their interactions.

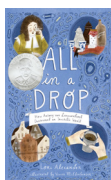
### Materials:

- The Parts of the Bacteria (Guide, pg. 7)
- The Parts of the Bacteria Answers (Guide, pg. 8)
- Design a Bacterium (Guide, pg. 9)
- Research resources
- Markers or colored pencils
- Writing materials



### Procedure:

- Lead a discussion exploring Antony van Leeuwenhoek's remarkable discovery of the microbe, a living creature.
- Discuss the following terms relating to understanding the various types of microbes:
  - A microbe is a microscopic organism that exists either as a single-celled microorganism or as a colony of cells. The word microbe is a more general term and includes bacteria, as well as fungi, algae, and viruses.
  - Bacteria are microscopic, single-celled organisms that exist in every environment, both inside and outside of other organisms.
  - Fungi includes microorganisms such as yeast and molds, as well as mushrooms.
  - Algae is a large group of photosynthesis single-celled organisms, meaning microbes that synthesize sunlight to create nutrients to thrive.
  - Viruses are infectious microbes that reproduce inside living cells of an organism.
- Instruct students to research microbes, becoming familiar with the functionality of its parts.
- Distribute copies of **The Parts of the Bacteria** template. Instruct students to match the definitions on the left of the page with the correct terms on the right. Then, using the alphabetized list of terms to label the various parts in the diagram at the bottom of the page.
- Use the **The Parts of the Bacteria Answer** guide to check their work.
- Using the **Design a Microbe** template as a guide, encourage students to create their own microbe. Making sure that their microbe includes all of the parts listed in **Design a Bacterium** template, have them illustrate and label a unique form of bacteria, then write a brief essay summarizing its imagined functionality. Encourage students to share their work with the class.



## Parts of the Bacteria Diagram

**Directions:** Match each term with its definition or description. Then, using the terms, identify the numbered structures in the bacterial cell diagram. Use research references as needed.

- |   |                    |
|---|--------------------|
| _____ 1. Provides support and maintains cell shape.                               | A. Flagellum       |
| _____ 2. Bilayer that allows for movement of materials into and out of the cell   | B. Cytoplasm       |
| _____ 3. Internal, gel-like region of the cell.                                   | C. Cell wall       |
| _____ 4. Cell in which the genetic information is found                           | D. Plasmid         |
| _____ 5. Longer, whip-like structure used for mobility                            | E. Plasma membrane |
| _____ 6. Site of polypeptide/protein synthesis.                                   | F. Nucleoid        |
| _____ 7. Small, circular DNA fragment in the cytoplasm                            | G. Pili / Fimbriae |
| _____ 8. Hair-like structures assisting the cell stick to other cells or surfaces | H. Ribosomes       |



9. \_\_\_\_\_

10. \_\_\_\_\_

11. \_\_\_\_\_

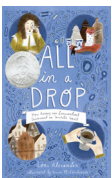
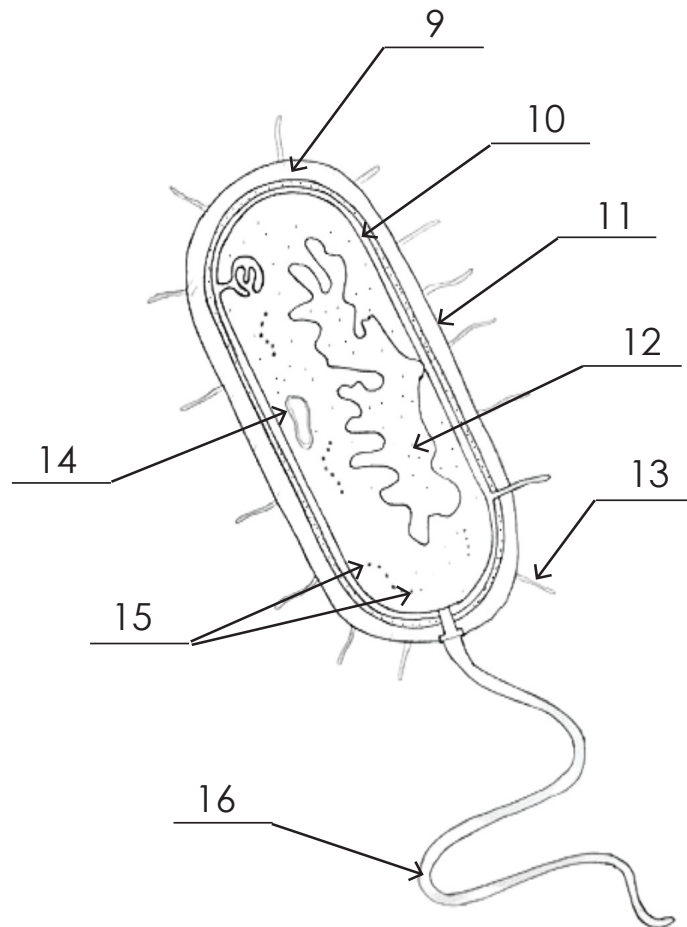
12. \_\_\_\_\_

13. \_\_\_\_\_

14. \_\_\_\_\_

15. \_\_\_\_\_

16. \_\_\_\_\_



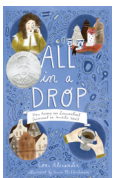
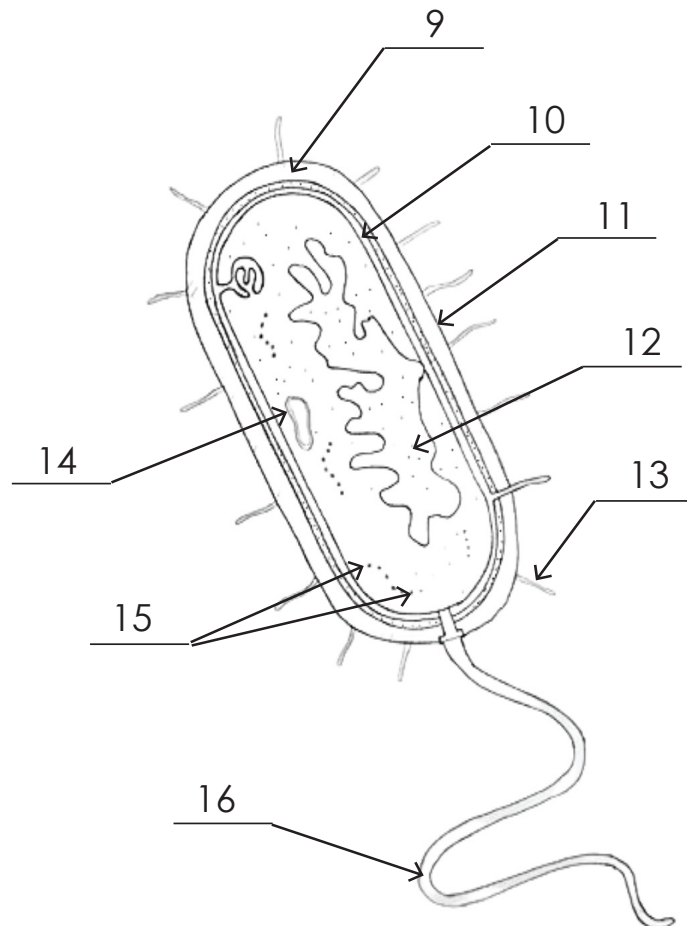
## Parts of the Bacteria Diagram Answers

**Directions:** Match each term with its definition or description. Then, using the terms, identify the numbered structures in the bacterial cell diagram. Use research references as needed.

- |          |   |                    |
|----------|---|--------------------|
| <u>C</u> | 1. Provides support and maintains cell shape.                               | A. Flagellum       |
| <u>E</u> | 2. Bilayer that allows for movement of materials into and out of the cell   | B. Cytoplasm       |
| <u>B</u> | 3. Internal, gel-like region of the cell.                                   | C. Cell wall       |
| <u>F</u> | 4. Cell in which the genetic information is found                           | D. Plasmid         |
| <u>A</u> | 5. Longer, whip-like structure used for mobility                            | E. Plasma membrane |
| <u>H</u> | 6. Site of polypeptide/protein synthesis.                                   | F. Nucleoid        |
| <u>D</u> | 7. Small, circular DNA fragment in the cytoplasm                            | G. Pili / Fimbriae |
| <u>G</u> | 8. Hair-like structures assisting the cell stick to other cells or surfaces | H. Ribosomes       |



9. E  
 10. B  
 11. C  
 12. F  
 13. G  
 14. D  
 15. H  
 16. A

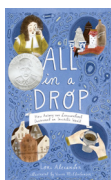




## Design a Bacterium

**Directions:** Illustrate and label your own microbe consisting of the following elements. Give your microbe a name. Write a short essay describing your microbe identifying its habitat and functionality. Is it helpful or harmful? Explain why. Share your illustration and description with the class.

- \_\_\_\_\_ 1. Cell Wall: Provides support and maintains cell shape.
  - \_\_\_\_\_ 2. Plasma Membrane: Bilayer that allows for movement of materials into and out of the cell
  - \_\_\_\_\_ 3. Cytoplasm: Internal, gel-like region of the cell.
  - \_\_\_\_\_ 4. Nucleoid: Cell in which the genetic information is found
  - \_\_\_\_\_ 5. Flagellum: Longer, whip-like structure used for mobility
  - \_\_\_\_\_ 6. Ribosomes: Site of polypeptide/protein synthesis.
  - \_\_\_\_\_ 7. Plasmid: Small, circular DNA fragment in the cytoplasm
  - \_\_\_\_\_ 8. Pili / Fimbriae: Hair-like structures assisting the cell stick to other cells or surfaces
- 



## First to See

*I have spent a lot more time than many people (pg. 89).*

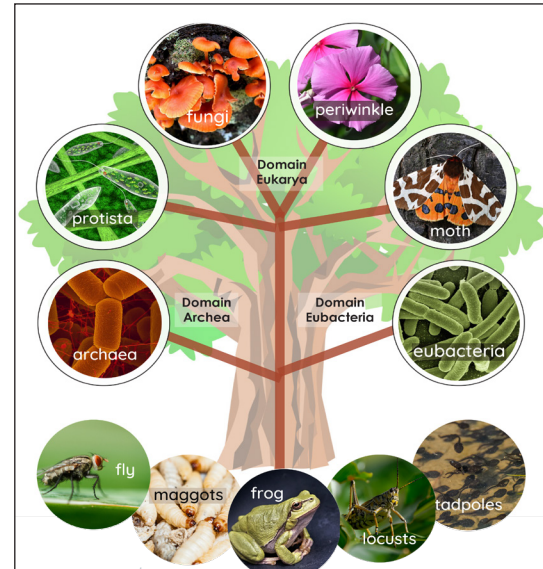
**Objective:** To examine the taxonomy of the animal kingdom by making observations about the diversity of life in various habitats.

### Materials:

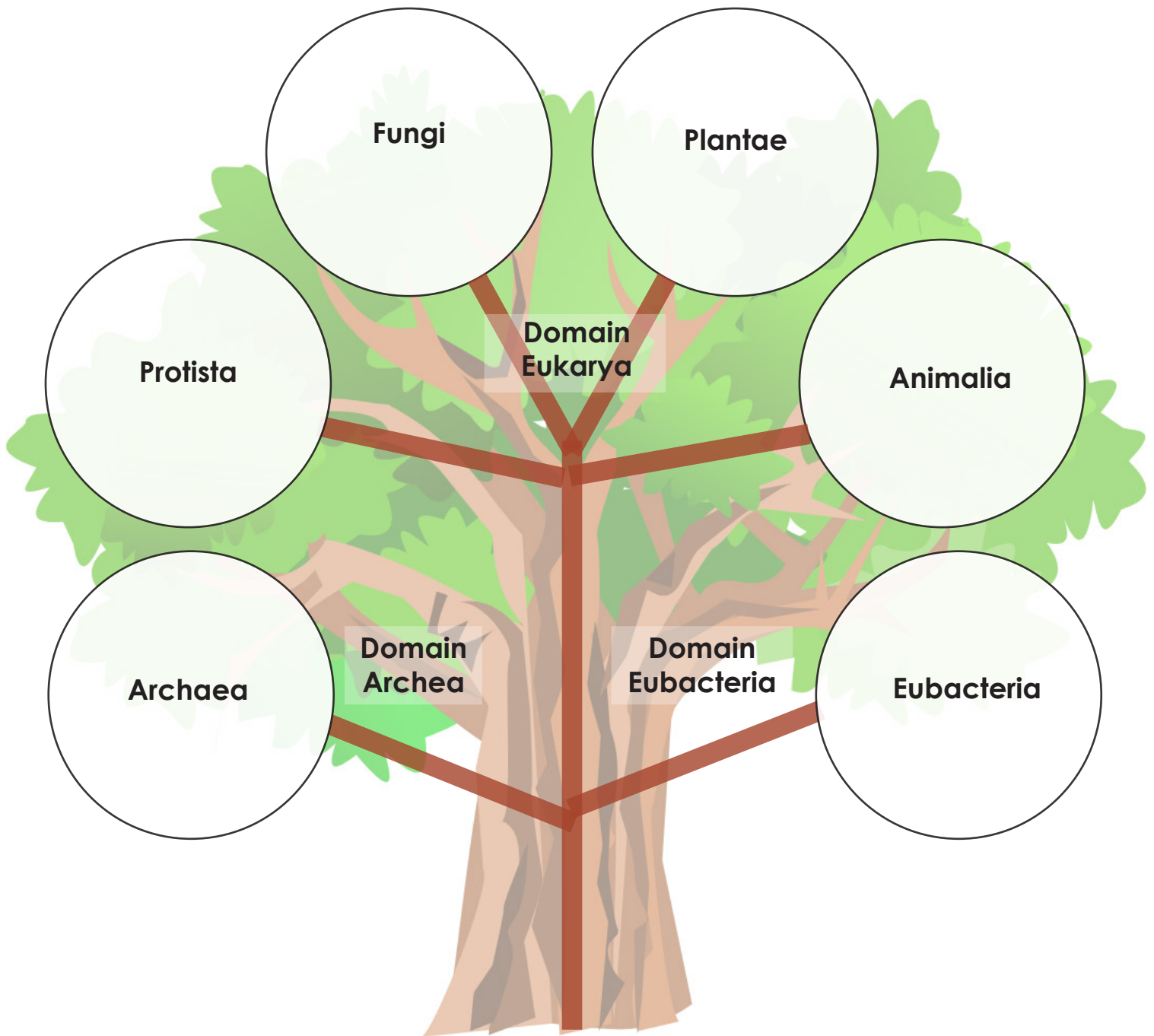
- ALL IN A DROP: HOW ANTONY VAN LEEUWENHOEK DISCOVERED AN INVISIBLE WORLD, the book
- Tree of Life Match Up (Guide, pg. 11)
- First to See Graphics (Guide, pg. 12)
- Cardstock
- Scissors
- Writing materials

### Procedure:

- Print **Tree of Life Match Up** and the **First to See Graphics** on cardstock. Explain that the First to See Graphics represent a number of specimens Antony Van Leewenhock was the first person to study closely. Use scissors to trim around the borders of the images.
- Lead a discussion about Antony Van Leewenhock's life work, using pages 56 and 57 as a reference. Consider the following topics as foundation for the discussion:
  - Review the list of specimens Leewenhock was the first person to closely study in great detail. Locate each specimen in the list found on 56 and 57. Which specimens do you find to be intriguing? Identify those that surprise you. Which ones do you find to be revolting? Explain why this is so.
  - Determine how some of the specimens similar. How are they the same?
  - Contrast the specimens listed. Examine their differences.
  - Are there aspects or elements that all other specimens share? Explain your answer.
- Instruct students associate the **First to See Graphics** with the domains labeled on the **Tree of Life**. Review the following terms with the students.
  - Biologists categorize living organisms in three large domains.
  - The first two domains, *Arachea* and *Eubacteria*, are single-celled organisms or bacteria.
  - The third domain, *Eukarya*, consists of four kingdoms, all of which are mult-cellular.
  - Each domain is divided into one of more different kingdoms being *Archaea*, *Eubacteria*, *Protista*, *Fungi*, *Plantae*, and *Animalia*.
- Associate **First to See Graphics** in their corresponding kingdom by placing the circular image in the space provided. Mix the **First to See Graphics** up, then sort them according to their paired kingdoms. Examine the relationship between the domains. Discuss the interdependencies between each domain.
- Consider Leewenhock's motivation to study these and hundreds of other specimens. Do you think he was aware of the magnitude of his discoveries? Explain your answer.
- Instruct students to write a personal response to the discussion involving the **Tree of Life**, the **First to See Graphics**, domains, kingdoms, and Leewenhock's role in classifying the natural world. Have them share their work with the class.

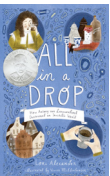


## Tree of Life Match Up



Think about this...

The classification of the animal kingdom, known as Linnaean Taxonomy, was developed by Swedish botanist Carl Linnaeus in the 1700's. Antony Leewenhook first discovered microbes in 1674. Consider the importance of Leewenhook's discoveries in establishing the complete taxonomy of the animal kingdom.







ants



bees



beetle



cochineal insects



eel



flea



fly



frog



gnat



locusts



maggots



millipedes



moth



shrimp



silkworms



snail



spider



tadpoles



periwinkle



wheat



archaea



protista



eubacteria



fungi



## The Biography Map

*“I found an unbelievably great company of living animalcules.” (pg. 89)*

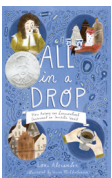
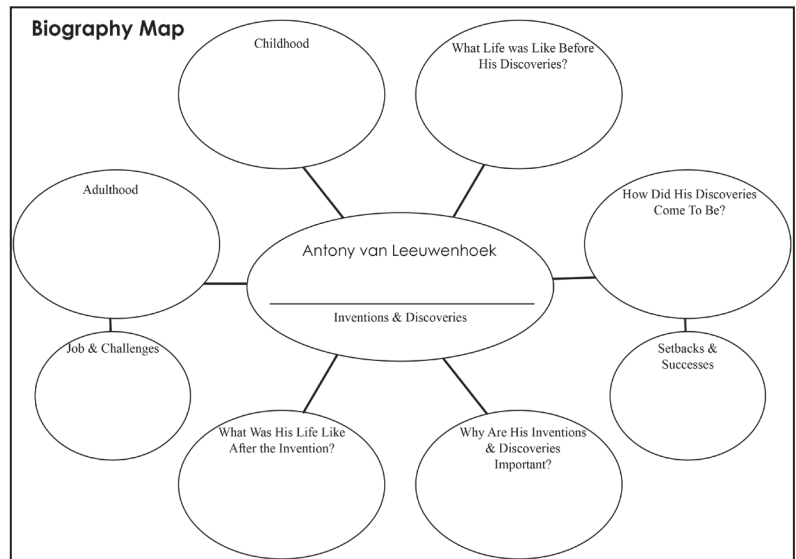
**Objective:** To identify, analyze, and summarize key aspects and contributions of an individual’s life.

**Materials:**

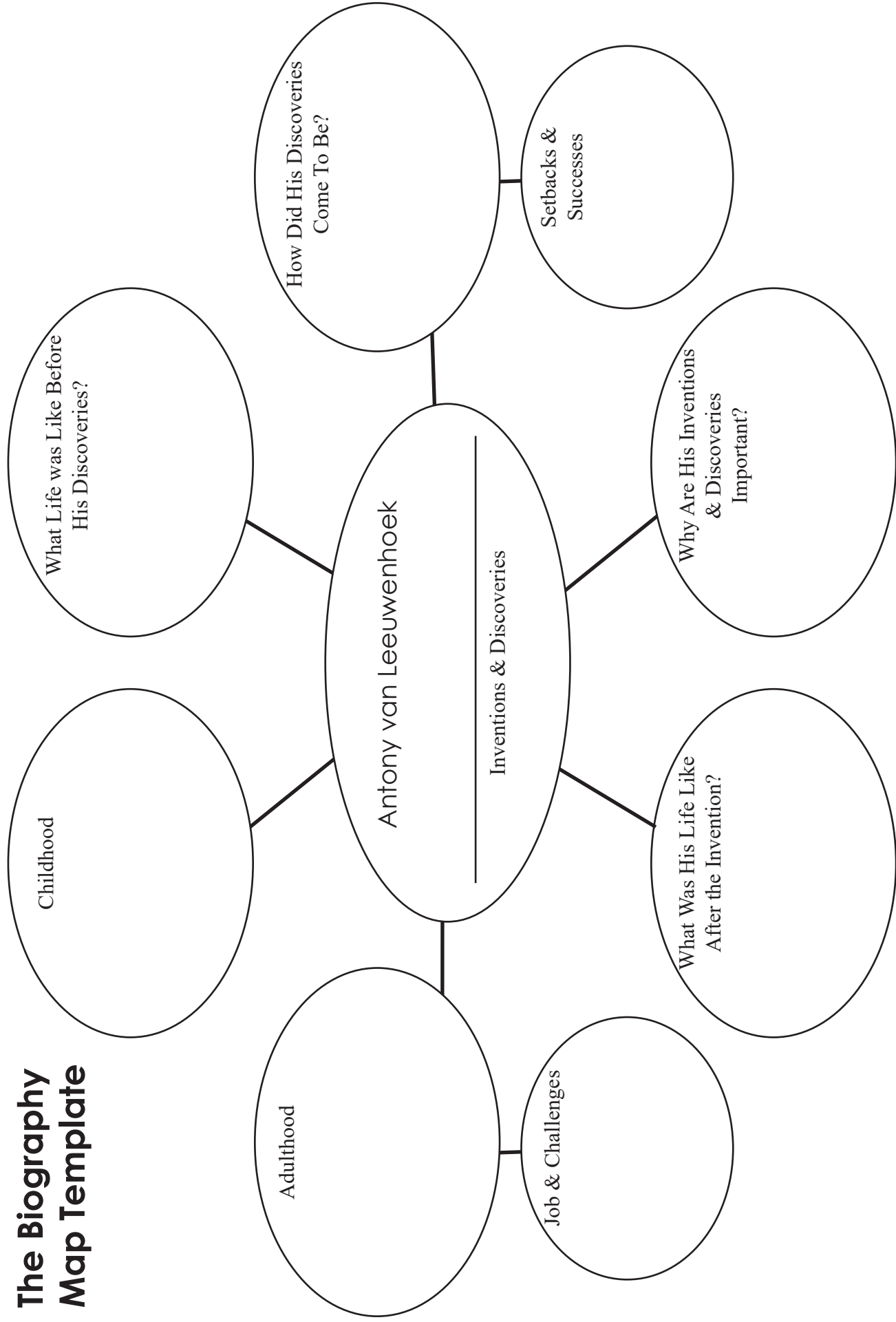
- ALL IN A DROP: HOW ANTONY VAN LEEUWENHOCK DISCOVERED AN INVISIBLE WORLD, the book
- The Biography Map (Guide, pg. 14)
- Writing Materials

**Procedure:**

- Using **The Biography Map Template** as a guide, lead a discussion about the life and times of Antony van Leeuwenhoek.
- Antony van Leeuwenhoek’s discoveries were broad and have had a wide impact on the lives of individuals all over the world. Encourage the students to identify one of his discoveries that most intrigues them as their central focus of establishing a biography map of his life. Which of Leeuwenhoek’s discoveries were the most impactful from each student’s point of view?
- Instruct students to cite references in the book to confirm their statements.
- Examine Leeuwenhoek’s life as it relates to his discoveries and inventions
- Describe what life was like before Leeuwenhoek’s key discovery.
- State how his childhood experiences inspired his inquisitive nature.
- Detail key events in Leeuwenhoek’s adulthood that led to his discoveries.
- List the jobs and challenges Leeuwenhoek experienced as an adult.
- Discuss reasons why Leeuwenhoek’s key discovery is important.
- Explain how his discovery came to be.
- Identify his successes and setbacks while researching his discoveries.
- Summarize what life is like after Leeuwenhoek’s discoveries. How has his work impacted the world?
- Using the information and citations gathered in The Biography Map, have students write an informational essay exploring how Leeuwenhoek’s discoveries and inventions had a lasting impact on the world.
- Have students share their work with the class.



# The Biography Map Template



# Common Core State Standards

		Discussion	Meet the Microbe	First to See	Biography Map
<b>English Language Arts Standards » Reading: Informational Text</b>					
CCSS.ELA-LITERACY.RI.3.1	Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers.	X	X	X	X
CCSS.ELA-LITERACY.RI.3.2	Determine the main idea of a text; recount the key details and explain how they support the main idea.	X	X	X	X
CCSS.ELA-LITERACY.RI.3.3	Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect.	X	X	X	X
CCSS.ELA-LITERACY.RI.3.7	Use information gained from illustrations (e.g., maps, photographs) and the words in a text to demonstrate understanding of the text (e.g., where, when, why, and how key events occur).	X			X
CCSS.ELA-LITERACY.RI.3.10	By the end of the year, read and comprehend informational texts, including history/social studies, science, and technical texts, at the high end of the grades 2-3 text complexity band independently and proficiently.	X	X	X	X
CCSS.ELA-LITERACY.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.	X	X	X	X
CCSS.ELA-LITERACY.RI.4.2	Determine the main idea of a text and explain how it is supported by key details; summarize the text.	X	X	X	X
CCSS.ELA-LITERACY.RI.4.3	Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.	X			X
CCSS.ELA-LITERACY.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.	X	X	X	X
CCSS.ELA-LITERACY.RI.5.1	Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text.	X			X
CCSS.ELA-LITERACY.RI.5.2	Determine two or more main ideas of a text and explain how they are supported by key details; summarize the text.	X	X	X	X
CCSS.ELA-LITERACY.RI.5.10	By the end of the year, read and comprehend informational texts, including history/social studies, science, and technical texts, at the high end of the grades 4-5 text complexity band independently and proficiently.	X	X	X	X
CCSS.ELA-LITERACY.RI.6.1	Cite textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.	X			X
CCSS.ELA-LITERACY.RI.7.1	Cite several pieces of textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.	X	X	X	X
CCSS.ELA-LITERACY.RI.7.3	Analyze the interactions between individuals, events, and ideas in a text (e.g., how ideas influence individuals or events, or how individuals influence ideas or events).	X	X	X	X
<b>English Language Arts Standards » Writing</b>					
CCSS.ELA-LITERACY.W.3.2	Write informative/explanatory texts to examine a topic and convey ideas and information clearly.		X	X	X
CCSS.ELA-LITERACY.W.3.8	Recall information from experiences or gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories.		X	X	X
CCSS.ELA-LITERACY.W.4.2	Write informative/explanatory texts to examine a topic and convey ideas and information clearly.		X	X	X
CCSS.ELA-LITERACY.W.4.8	Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources.		X	X	X
CCSS.ELA-LITERACY.W.4.9	Draw evidence from literary or informational texts to support analysis, reflection, and research.		X	X	X

		Discussion	Meet the Microbe	First to See	Biography Map
<b>English Language Arts Standards » Writing</b>					
CCSS.ELA-LITERACY.W.5.2	Write informative/explanatory texts to examine a topic and convey ideas and information clearly.		X	X	X
CCSS.ELA-LITERACY.W.5.8	Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources.		X	X	X
CCSS.ELA-LITERACY.W.5.9	Draw evidence from literary or informational texts to support analysis, reflection, and research.		X	X	X
CCSS.ELA-LITERACY.W.6.2	Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.		X	X	X
CCSS.ELA-LITERACY.W.6.9	Draw evidence from literary or informational texts to support analysis, reflection, and research.		X	X	X
CCSS.ELA-LITERACY.W.7.2	Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.		X	X	X
CCSS.ELA-LITERACY.W.7.9	Draw evidence from literary or informational texts to support analysis, reflection, and research.		X	X	X
<b>English Language Arts Standards » Speaking &amp; Listening</b>					
CCSS.ELA-LITERACY.SL.3.1	Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on <i>grade 3 topics and texts</i> , building on others' ideas and expressing their own clearly.	X	X	X	X
CCSS.ELA-LITERACY.SL.3.2	Determine the main ideas and supporting details of a text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally.	X	X	X	X
CCSS.ELA-LITERACY.SL.3.4	Report on a topic or text, tell a story, or recount an experience with appropriate facts and relevant, descriptive details, speaking clearly at an understandable pace.		X	X	X
CCSS.ELA-LITERACY.SL.3.6	Speak in complete sentences when appropriate to task and situation in order to provide requested detail or clarification.	X	X	X	X
CCSS.ELA-LITERACY.SL.4.1	Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on <i>grade 4 topics and texts</i> , building on others' ideas and expressing their own clearly.	X	X	X	X
CCSS.ELA-LITERACY.SL.4.2	Paraphrase portions of a text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally.	X			X
CCSS.ELA-LITERACY.SL.4.4	Report on a topic or text, tell a story, or recount an experience in an organized manner, using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.		X		X
CCSS.ELA-LITERACY.SL.5.1	Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on <i>grade 5 topics and texts</i> , building on others' ideas and expressing their own clearly.	X	X	X	X
CCSS.ELA-LITERACY.SL.5.4	Report on a topic or text or present an opinion, sequencing ideas logically and using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.		X		X
CCSS.ELA-LITERACY.SL.6.1	Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly.	X	X	X	X
CCSS.ELA-LITERACY.SL.7.1	Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 7 topics, texts, and issues, building on others' ideas and expressing their own clearly.	X	X	X	X



## Next Generation Science Standards

		Discussion	Meet the Microbe	First to See	Biography Map
<b>5-LS2-1 Ecosystems: Interactions, Energy, and Dynamics</b>					
Developing and Using Models					
	Modeling in 3–5 builds on K–2 models and progresses to building and revising simple models and using models to represent events and design solutions.		X	X	
	Develop a model to describe phenomena.		X	X	
Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena					
	Science explanations describe the mechanisms for natural events.		X	X	
Systems and System Models					
	A system can be described in terms of its components and their interactions.		X	X	

