Microbiology uses an impactful, multimodal approach that creates high levels of engagement and promotes mastery of concepts. Each chapter contains relevant information that teaches important concepts central to the science of microbiology. Woven throughout are sections designed to encourage learners to directly think and interact with content and vocabulary as they learn. These sections use a metacognitive approach, as they teach students to access what they already know to work with new information. This scaffolding teaches the science and at the same time works on the acquisition of important learning skills.

To assist with this approach, 48 videos were developed for this course. The videos are important learning tools that cover concepts visually and aurally, incorporating new vocabulary. This leads to a better and more nuanced understanding of the concepts and vocabulary when learners hear and see them used in a more familiar and conversational context.

There are 18 labs and activities that were developed for the course so that learners can directly apply the vocabulary and concepts they are learning. This approach asks learners to use that information in labs designed for maximum engagement. The activities are meant to reinforce essential concepts and offer experiential learning.

- 1 semester
- 12 chapters
- 4^{th} – 7^{th} grade
- Foundational and topical science

The Parts of the Course

- Text (the Theory)
    - Woven through the course are sections designed to enhance mastery of the material at the same time they teach important metacognitive learning skills.
        - “Check for Understanding” sections ask learners to think through and answer questions about what they just learned.
        - “Vocabulary Check” sections ask learners to review vocabulary directly after it is covered.
        - “Thought Questions” are designed to help learners think about and apply what they are learning to a larger context.
        - “Scientific Modeling in 2-D” sections are designed to incorporate writing and drawing, to enhance the connection between writing and visual learning.

- “Hands-On Learning” sections incorporate a kinesthetic component directly into the text.
- “Research and Learn More” sections are incorporated into the text as a way of encouraging learners to think beyond the material in the text. In addition, they benefit from acquiring research skills.
- “Do You Remember?” sections are review sections that help refresh and cement vocabulary and concepts from earlier in the course as they are reintroduced.

- Thirty Videos: There are 30 videos integrated throughout the text sections of the 12 chapters.
  - Content videos are animated videos created exclusively for this course. They teach important science concepts that can be challenging to understand through reading alone. They build on learning through the introduction of interesting topics that relate to the text and excite learners with fun conversation and engaging images.
  - Curated videos are licensed content with narration from Blair Lee, MS. Many of these videos include stunning microscopy images that offer learners insight into the world of microbes and cells with a sense of wonder and awe.
  - All videos have closed captioning. This is important for those learners who rely on the closed captioning. Closed captioning is also a great way to bring a multimodal approach for those learners who are working on their reading skills.

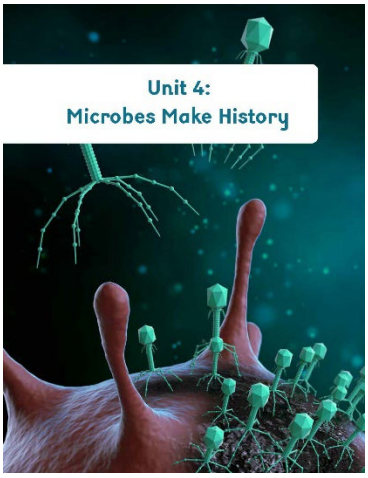
- Eighteen Labs and Activities
  - Each of the twelve chapters includes a lab that is a hands-on application of the theory covered in the text. Many of these labs focus on the important concept of scientific modeling. Scientific modeling focuses on active learner construction of conceptual and mathematical models. Studies have shown that students who engage in simple projects while learning to model the natural and physical world have a better understanding of science concepts and vocabulary.
  - There are 3 scaffolded writing activities, designed to guide learners to use vocabulary and concepts in context. This is an important strategy for teaching to reach mastery of the information.
  - The microscope labs are optional, for those who have a microscope. Many people are unaware that microbes are everywhere because they are

microscopic. These labs will open a learner's eyes to the microscopic world around them.

        - If you took a science lab class in college, the 18 videos that accompany each lab and activity will feel familiar. The videos start with an explanation covering the purpose of doing the lab. This is followed by an explanation of the science practices and techniques students will use. In addition, there is instruction about general information relevant to all lab work done in science.
    - Each chapter comes with a problem set. These can be used as a diagnostic tool, to work on the skill of test taking, or omitted.

How to Use *Microbiology*

Microbiology has 2 parts: a student text and an appendix.



The Student Text

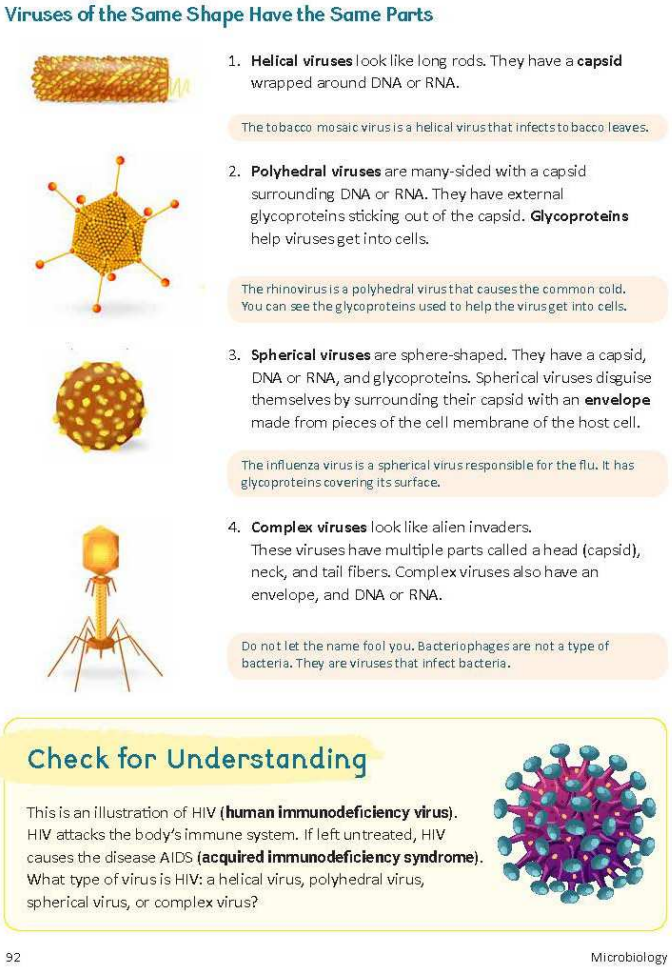
- The student text has 12 chapters. Each chapter has a text section and a lab.
- Six of the 12 chapters have an additional microscope lab or writing assignment. The text has been thoughtfully written so that students interact with what they are learning as they learn it.
- The 12 chapters are separated into 5 units, each focusing on an important area of microbiology.

CHAPTER STRUCTURE

In this 3-page sample from Chapter 6 in Unit 4, I will explain the basic steps for using the text sections.

There is a text section that is directly followed by a section checking for understanding. This helps learners immediately assess their learning. It also hooks their attention and keeps them engaged.

Students will read the text and then answer the question.



Viruses of the Same Shape Have the Same Parts

1. **Helical viruses** look like long rods. They have a **capsid** wrapped around DNA or RNA.

The tobacco mosaic virus is a helical virus that infects tobacco leaves.

2. **Polyhedral viruses** are many-sided with a capsid surrounding DNA or RNA. They have external glycoproteins sticking out of the capsid. **Glycoproteins** help viruses get into cells.

The rhinovirus is a polyhedral virus that causes the common cold. You can see the glycoproteins used to help the virus get into cells.

3. **Spherical viruses** are sphere-shaped. They have a capsid, DNA or RNA, and glycoproteins. Spherical viruses disguise themselves by surrounding their capsid with an **envelope** made from pieces of the cell membrane of the host cell.

The influenza virus is a spherical virus responsible for the flu. It has glycoproteins covering its surface.

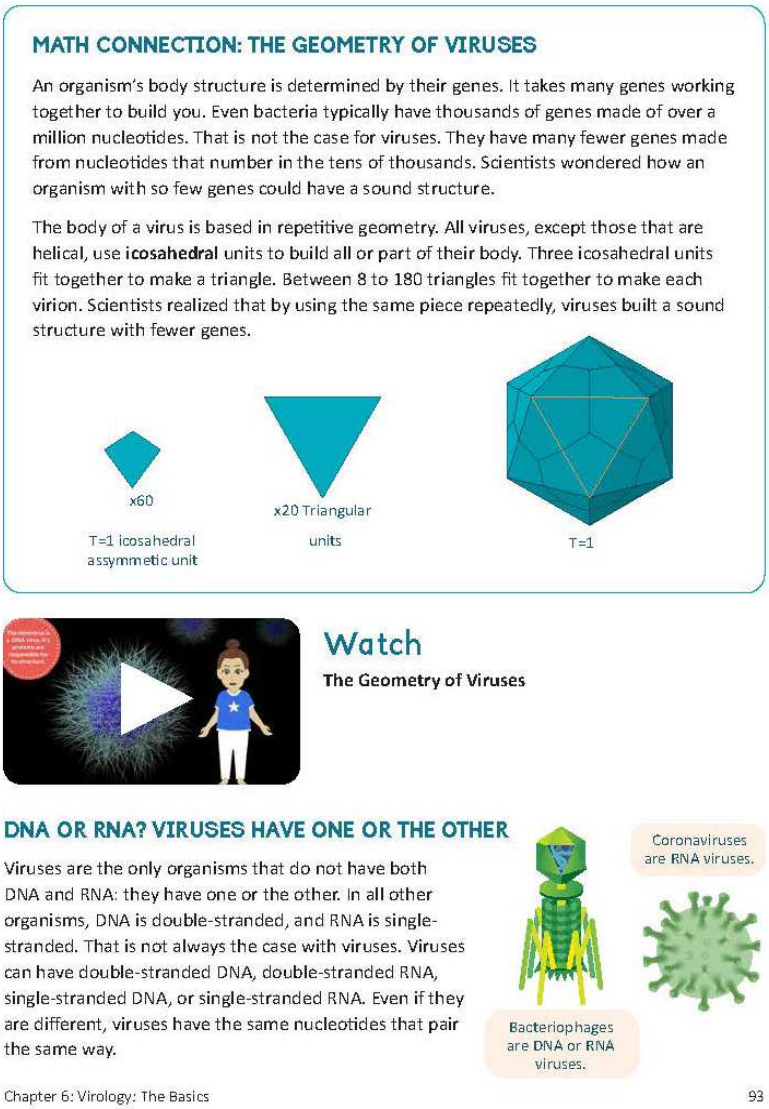
4. **Complex viruses** look like alien invaders. These viruses have multiple parts called a head (capsid), neck, and tail fibers. Complex viruses also have an envelope, and DNA or RNA.

Do not let the name fool you. Bacteriophages are not a type of bacteria. They are viruses that infect bacteria.

Check for Understanding

This is an illustration of HIV (**human immunodeficiency virus**). HIV attacks the body's immune system. If left untreated, HIV causes the disease AIDS (**acquired immunodeficiency syndrome**). What type of virus is HIV: a helical virus, polyhedral virus, spherical virus, or complex virus?

92 Microbiology



MATH CONNECTION: THE GEOMETRY OF VIRUSES

An organism's body structure is determined by their genes. It takes many genes working together to build you. Even bacteria typically have thousands of genes made of over a million nucleotides. That is not the case for viruses. They have many fewer genes made from nucleotides that number in the tens of thousands. Scientists wondered how an organism with so few genes could have a sound structure.

The body of a virus is based in repetitive geometry. All viruses, except those that are helical, use **icosahedral** units to build all or part of their body. Three icosahedral units fit together to make a triangle. Between 8 to 180 triangles fit together to make each virion. Scientists realized that by using the same piece repeatedly, viruses built a sound structure with fewer genes.

DNA OR RNA? VIRUSES HAVE ONE OR THE OTHER

Viruses are the only organisms that do not have both DNA and RNA: they have one or the other. In all other organisms, DNA is double-stranded, and RNA is single-stranded. That is not always the case with viruses. Viruses can have double-stranded DNA, double-stranded RNA, single-stranded DNA, or single-stranded RNA. Even if they are different, viruses have the same nucleotides that pair the same way.

This math connection is interesting. It is a reading section that brings the discussion back to the structure of viruses. After answering the question, students will come back to the reading.

When they are finished they will watch a video that connects to what was just covered as it includes a discussion about the connection between structure and genetics, a topic covered previously in the course.

In the eBook versions of the course, the video is accessed directly by clicking on the graphic of the video. All versions come with a PDF document with hyperlinks to the videos. This is how users of the print version will access the videos.

After watching the video, there is more information about how viruses are classified, coming back to a further discussion about genetics. The “Do You Remember?” section on page 94 covers previously taught material. The question is designed to work on metacognition, helping learners access what they already know about the subject. This is an impactful strategy in learning that builds confidence and leads to the mastery of concepts.

Do You Remember?

What are the names of the nucleotides that make DNA and RNA?

Write the four nucleotides that make DNA and how they pair.

Write the four nucleotides that make RNA and how they pair.

The Lifecycle of Viruses: The Lytic Cycle

Most viruses reproduce using the **lytic cycle**, pictured in the illustration on the next page. During the lytic cycle, the host cell makes more and more virions until the cell can no longer hold them. When that happens, the virions burst from the cell, killing it. The ruptured cell membrane is a source of material for the envelopes used by spherical viruses. When virions burst out of an infected cell it is called **lysis** (not to be confused with the lysogenic cycle).

Viruses must be very good at reproducing because the world is full of them!

LABS AND ACTIVITES

The labs and activities are written to be paired with the text. All versions of the schedule have the labs scheduled to be completed directly following the reading for enhanced learning of the concepts.

The Appendix

1. There are two basic schedules for completing the course:
    - 12 weeks: This schedule follows the course using few outside resources.

12-week schedule	Day 1	Day 2	Day 3
2 days a week	Reading and videos	Lab and Problem set	
3 days a week	Reading and videos	Lab	Problem Set

    - 14 weeks: This is the timeframe used when it is taught as a live, online class. Using this schedule, learners write 2 reports. One after Chapter 5 and one after Chapter 12. In the reports learners can share either research they have completed about a high-interest topic, or a lab they have conducted.

    This schedule uses the same format except that learners are given 1 week to write a report/presentation in weeks 7 and week 14.
2. Materials lists: Alphabetically and by Chapter
3. Answer key
4. Glossary
5. Chapter-by-chapter format teacher's guide, including:
    - Video links for the course
    - Materials needed that week
    - Key learning points
    - Weekly schedule
    - Suggested reading and video to use to learn more
    - Consumables
    - Problem Sets

- Citations and photo and video attribution