Lesson Plan: Cells, Microorganisms and Penicillin

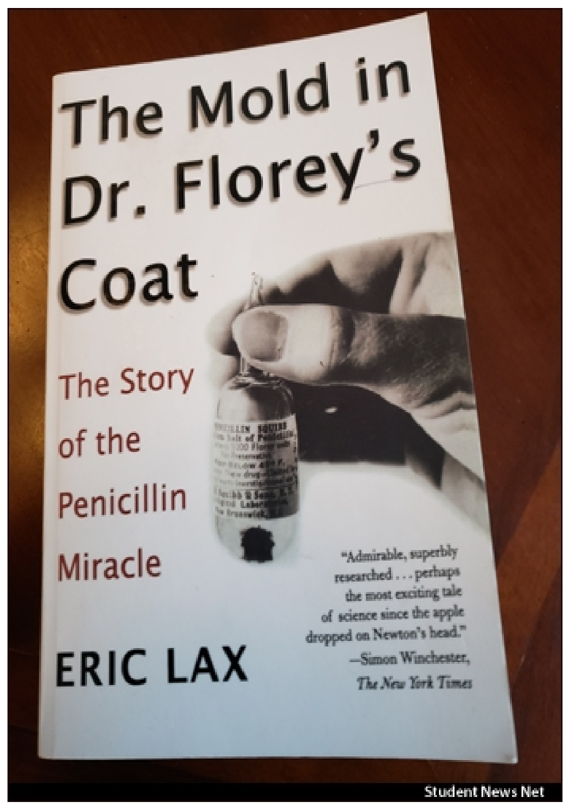
Grade: 5

Standards:

1. **S5L3.** Obtain, evaluate, and communicate information to compare and contrast the parts of plant and animal cells.
   a) Gather evidence by utilizing technology tools to support a claim that plants and animals are comprised of cells too small to be seen without magnification.
   b) Develop a model to identify and label parts of a plant cell (membrane, wall, cytoplasm, nucleus, chloroplasts) and of an animal cell (membrane, cytoplasm, and nucleus).
   c) Construct an explanation that differentiates between the structure of plant and animal cells.
2. **S5L4**. Obtain, evaluate, and communicate information about how microorganisms benefit or harm larger organisms.
   a) Construct an argument using scientific evidence to support a claim that some microorganisms are beneficial.
   b) Construct an argument using scientific evidence to support a claim that some microorganisms are harmful.

Anchor book

The Mold in Dr. Florey's Coat by Eric Lax



Themes and Constructs

1. basic structure of animal and plant cells
2. basic shapes of bacteria
3. discovery and mass production of penicillin
4. beneficial versus harmful bacteria

Objectives

As a result of successfully completing this lesson plan, students will be able to:

1. Compare and contrast parts of animal and plant cells.
2. Label three parts of an animal cell and five parts of a plant cell.
3. Define microorganism.
4. Cite evidence that some microorganisms are harmful and some are beneficial.
5. Relate the mass production of penicillin during World War II to its impact on treating infections and saving soldiers' lives.

Time needed: Two, 40-50 minute class sessions

Background Information (Mass production of penicillin during World War II)

The following discussion is a summary of the discovery and mass production of penicillin during World War II as told by Eric Lax in his 2005 book, *The Mold in Dr. Florey's Coat.* It's an excellent and detailed summary of the history.

Correcting a myth

First, a misconception must be addressed.

The discovery of penicillin starts in 1928 in London, England. Handed down from generation to generation is the story that Alexander Fleming, a physician and microbiologist at St. Mary's Hospital, accidentally left the lid off a petri dish that was placed near an open window when he went on an extended vacation. The petri dish was growing Staph bacteria. Mold spores landed on the dish and germinated. Upon his return, he noticed clear spots around the mold where the bacteria could not grow.

Fleming determined the clearing must have been from a byproduct produced by the mold that inhibited the bacteria. He saved the plate and tried to extract the mysterious substance. He called the substance *penicillin* because the mold was in the genus, Penicillium.

In his book, Lax said the story is impossible. (p. 16) Among other aspects of the story that could not be proven, he points to the fact that based on how the lab was set up, a window could not have been left open. Lax debunks the myth and concludes the true story of how Fleming discovered penicillin has been lost to history. There is no doubt Fleming discovered Penicillium mold had antibacterial properties. He isolated a compound he called penicillin but it was very unstable. He couldn't work with it. He wrote a paper in 1929 but by 1932, he had abandoned penicillin as a focus of his research.

Dunn School of Pathology lab at Oxford – Dr. Howard Florey

Almost ten years later at the University of Oxford in England, Ernst Chain, a biochemistry researcher in Dr. Howard Florey's lab at the Dunn School of Pathology, read Fleming's 1929 paper. He was curious.

In January 1939, Dr. Florey submitted a grant request to fund research. At the time, Britain was preparing for war. Lab employees dug trenches while also conducting penicillin research. They began carrying gas masks after Nazi Germany bombed Edinburgh on Nov. 1, 1939.

Germany had invaded Poland two months before. At the same time, Norman Heatley, a scientist working for Dr. Florey in his lab, figured out how to extract penicillin from the agar medium on which the mold was growing. It was a pivotal discovery.

On May 25, 1940, lab scientists began testing penicillin on eight mice that had been injected with strep bacteria. Results were dramatic. Infected mice given penicillin survived. Mice not given penicillin died.

In the midst of their research, the war in Europe escalated. More than 300,000 British troops were trapped around Dunkirk, France. By June 4, a flotilla of British ships, answering a plea from British Prime Minister Winston Churchill, safely evacuated 350,000 men from Dunkirk. France fell to Germany on June 22, 1940.

In July 1940, Dr. Florey's lab tested 50 mice, giving 25 of them penicillin after injecting strep. All 25 mice without penicillin died and 24 of the 25 mice given penicillin survived. The one mouse given penicillin that died had another unrelated condition that led to its death.

After France fell in June, Hitler turned his attention to England. Germany's Luftwaffe, their air force, began bombing strategic sites along the British coast in July. Fearful of losing their mold cultures if Germany bombed their lab, Dr. Florey and his scientists rubbed Penicillium spores on their lab coats so they could again grow the mold if their lab was destroyed

Blitz

The Nazi Blitz began on Sept. 7, 1940 and continued for 57 consecutive nights. London and other major cities in England were bombed but miraculously, Britain's Royal Air Force (RAF) fought off the Blitz. England remained a sovereign country. About 40,000 British citizens were killed during the year of bombing.

In late June 1941, Dr. Florey and Norman Heatley traveled to the United States. They needed to grow the Penicillium mold in quantities to support production of large amounts of penicillin. While Dr. Florey visited pharmaceutical companies to find a private partner for large scale production, Heatley collaborated with scientists at the U.S. Department of Agriculture (USDA) Northern Regional Research Lab in Peoria, Illinois. The lab had researched the use of corn steep liquor extracted from cornstarch as a medium to support growth and fermentation of molds.

Florey was able to interest Merck, Squibb, and Pfizer in penicillin production. In October, the U.S. government coordinated a meeting with those companies to discuss a strategy going forward. After Pearl Harbor and America's entry into the war in December 1941, penicillin production became an urgent necessity.

Pfizer acquired an old ice factory in Brooklyn, New York where it researched deep tank fermentation to produce large quantities of penicillin. It eventually installed 14 tanks each holding 7,500 gallons.

First clinical trial

In spring 1942, the first clinical trial in the United States was performed on a critically ill woman with bacterial sepsis following a miscarriage one month before. Given a course of penicillin, she recovered.

In May 1943, Dr. Florey traveled to North Africa where he tested penicillin on injured soldiers. Back at the Oxford lab, Ernst Chain unraveled the chemical mystery of penicillin. At its base was a beta-lactam ring of three carbon atoms and one nitrogen atom, a chemical structure never before seen in a naturally occurring product. Chain immediately realized penicillin would be very difficult to synthesize. They would need to grow large quantities of the mold to extract the chemical antibiotic.

At the USDA lab in Peoria, scientists were testing thousands of strains of Penicillium from around the world to find one that would produce large quantities of penicillin. In summer 1943, the lab acquired a moldy cantaloupe from a local Peoria market. The Pencillium strain isolated from the cantaloupe was a super strain. It produced about 200 times the amount of penicillin as other strains. And then researchers applied ultraviolet (UV) light to the mold and it produced 1,000 times the amount. The super strain was labeled NRRL 1951.

Researchers had struck gold. That specific species (Penicillium chrysogenum) produced most of world's early supply of penicillin. As pharmaceutical companies continued their research into large scale production, Pfizer perfected deep tank fermentation. Fleming's strain was Penicillium notatum.

By the end of 1943, penicillin production was the War Production Board's second highest priority. The combined effort of the pharmaceutical companies, the USDA lab in Peoria, the War Production Board, and British scientists had paid off. Production soared.

The U.S. Army needed millions of doses in preparation for the D-Day invasion on June 6, 1944. By D-Day, companies were producing 100 billion units of penicillin per month, enough to treat 40,000 infections. (p. 223) Thousands of soldiers' lives were saved on D-Day and in the weeks after because of penicillin.

Most of the penicillin used on D-Day was produced by Pfizer in Brooklyn. By the end of the 1940s, Pfizer was supplying more than one-half of the world's supply. As production soared, the price declined significantly so that by the end of 1945, the price to treat one case declined from $200 to $6. (p. 223)

1945 Nobel Prize

Sir Alexander Fleming, Sir Howard Florey and Ernst Chain were jointly awarded the 1945 Nobel Prize in Physiology and Medicine. On June 12, 2008, the American Chemical Society declared Pfizer a National Historic Chemical Landmark for its production of penicillin through the deep tank fermentation method the company perfected.

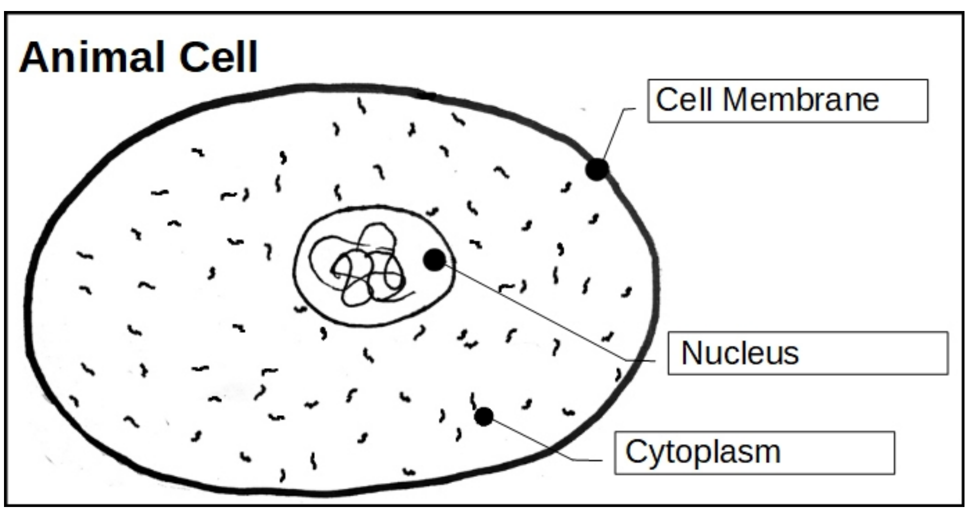
Penicillin is still effective against strep bacteria and used today. It can no longer be used to treat Staph infections because Staph bacteria quickly became resistant to it.

Animal and plant cells

Animal cell

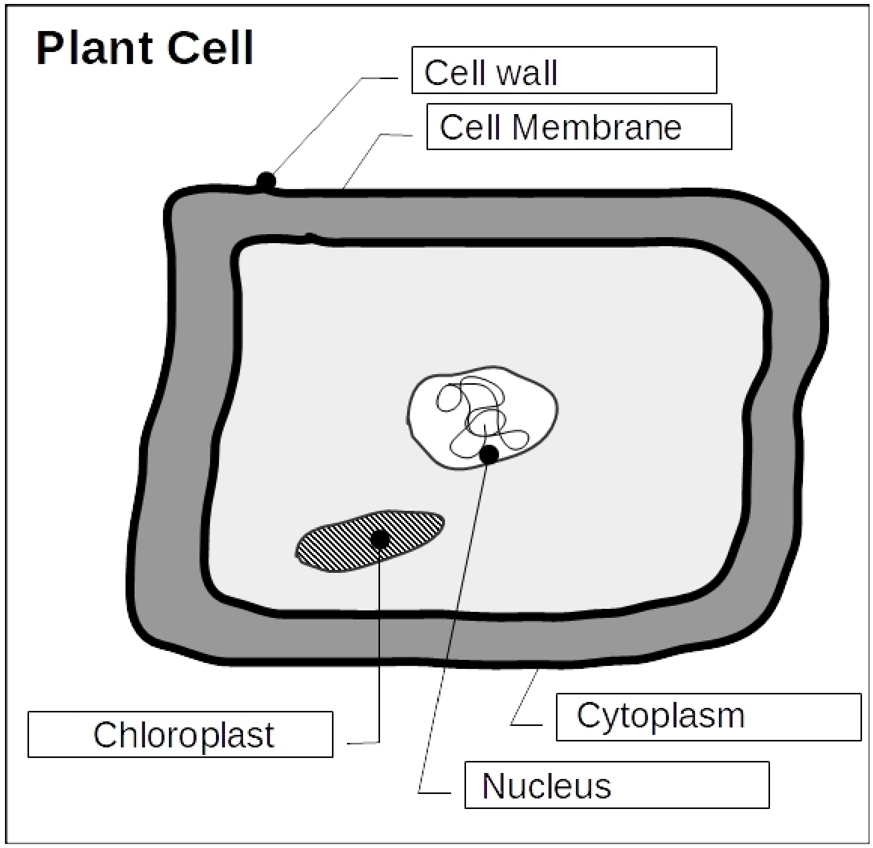
All animals and humans have billions of cells in their bodies. The cell is the basic unit of life. There are more than 200 types of cells in the body depending on function. For example, red blood cells (RBCs) carry oxygen to every cell in the body so cells can perform their intended function. Nerve cells look much different from red bloods cells. Every cell needs oxygen to live and divide.

All cells share common parts. Every cell has a cell membrane that surrounds the cell. At the center of the cell is the nucleus where DNA directs the cell. Between the nucleus and the cell membrane is cytoplasm where proteins are made and metabolism takes place.



Plant cell

Plant cells differ from animal cells. To give plants their rigid structure, plant cells are surrounded by a cell wall that is another layer over the cell membrane. And plant cells have chloroplasts, structures that are needed so plant cells can absorb sunlight and carbon dioxide from the air to make their own food, a process called photosynthesis. The end product of photosynthesis is oxygen that plants release into the air for animals and humans to breathe.



Bacteria are microorganisms

Bacteria are microorganisms, living cells that are too small to be seen by the naked eye. Bacteria are single cell microorganisms with a cell structure different from plant and animal cells.

Bacteria come in three general shapes – rods, circles and spirals. Bacteria are single cells that have a simpler structure than animal and plant cells. Billions of bacteria live normally in animals and humans. But some can be harmful. An example of bacteria that can be both harmful and beneficial is Escherichia coli – E. coli.

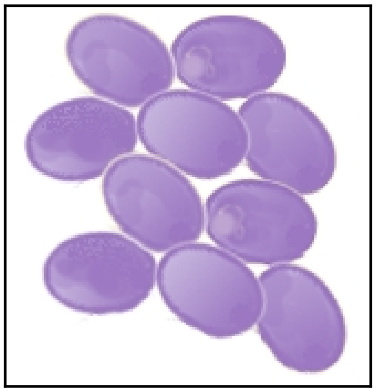
Billions of E. coli bacteria are needed in the intestines to maintain health. However, a few types of E. coli are harmful to the body if ingested through contaminated food. These harmful E. coli produce toxins that can result in serious disease.

E. coli are shaped as rods.

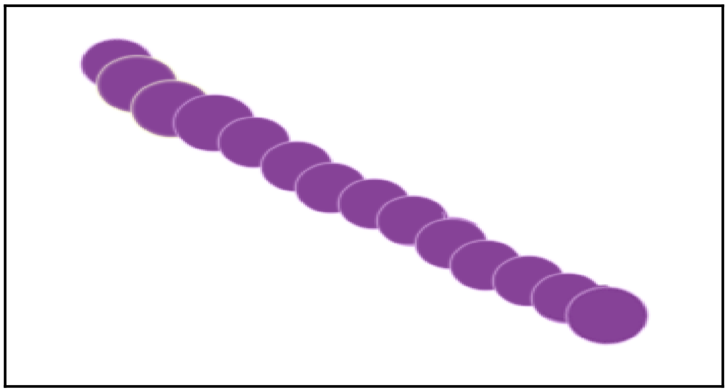
Other examples of bacteria that can be both beneficial and harmful are staph and strep. Billions of staph bacteria are normal on the skin. But some types of staph cause nasty infections of the skin. When a wound is infected, it swells, becomes red and hurts. Pus forms as a way for the body to get rid of the bacteria but antibiotics are often needed to prevent bacteria from multiplying.

And a harmful type of strep causes strep throat, a painful infection that needs to be treated with antibiotics, such as penicillin, to prevent more serious disease. Strep bacteria can also cause pneumonia, a serious lung infection. However, there are also many normal types of strep.

Staph and strep are shaped as circles. Staph bacteria look like clusters of grapes. Strep bacteria look like chains.



Staph



Strep

CLASS SESSION 1

1. Through this link, introduce the basic structure of animal and plant cells through diagrams at the end of the story. Emphasize the cell is the basic unit of life.
   a) Animal cells (animals and humans): There are more than 200 different types of cells in the human body. Those include red and white blood cells, nerve cells (neurons), and muscle cells. All of these cells have the same general structure with a cell membrane, a nucleus that directs the action and cytoplasm where proteins are made and metabolism (using food to make energy) takes place. Find photos of those types of cells to show.
   b) Plant cells differ from animal cells in two main ways. First, around the cell membrane is a rigid cell wall that gives plants strength. Animal cells do not have a rigid cell wall. Second, plant cells have chloroplasts in the cytoplasm that are engines for photosynthesis, the process by which plants capture energy from the sun, carbon dioxide from the air and water from the ground to make their own food – sugars. Animal and human cells do not have chloroplasts or make their own food. Animals and humans ingest food to metabolize and generate energy.
   c) Introduce bacteria as microorganisms that cannot be seen with the naked eye. A microscope is needed to see animal, plant and bacterial cells. Point out that bacterial cells are different from animal and plant cells with a much simpler structure. Bacteria can live normally in the body but can also cause harm to the body through infections. Through the diagrams in the story, review the three shapes of bacteria – rods, circles and spirals. Point out that circles that look like clusters of grapes are Staph bacteria. Circles in chains are Strep. Molds, such as the Pencillium mold, are not bacteria but a type of fungi with cells similar in structure to animal/human cells.
2. Read the story and watch the video to prepare for the next class session on the discovery and mass production of penicillin during World War II.

CLASS SESSION II

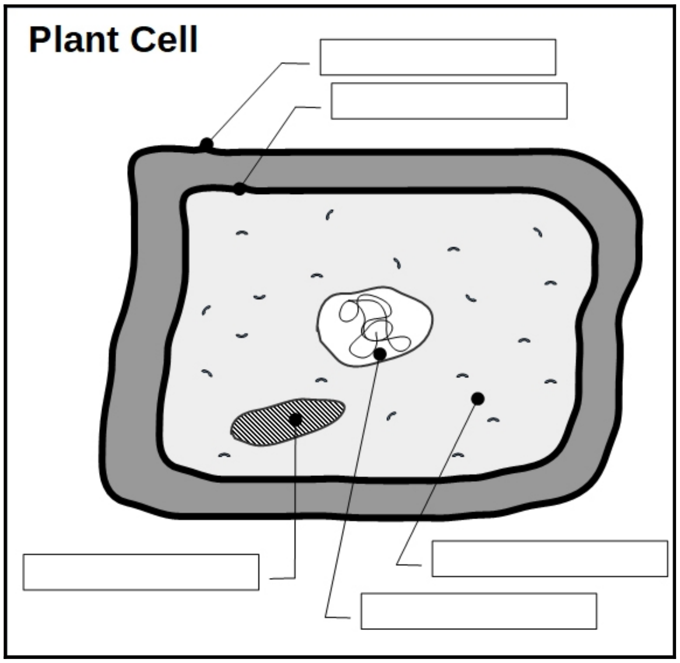
1. Review animal and plant cells.
2. Review the three basic shapes of bacteria. Emphasize some bacteria are beneficial and some are harmful. Ask students to name common bacterial infections, such as strep throat, bacterial pneumonia (a type of strep as well) and skin/wound infections (often caused by staph bacteria).
3. Review molds as fungi with cells similar to animal and human cells and not bacteria. Molds can produce toxins that kill bacteria by preventing the outer covering of bacteria to form. The toxin produced by some species of the Penicillium mold killed some types of bacteria. That toxin was named penicillin, an antibiotic. Penicillin saved thousands of soldiers' lives during WWII.
4. Read the portion of the story about the discovery and mass production of penicillin out loud.
5. Watch the USDA video again. Discuss.
6. Through the photo of the penicillin ad in LIFE Magazine, discuss the breakthrough penicillin represented in the 1940s to treat infections. Discuss the fact that the War Production Board in 1943 named penicillin production as their second highest priority as they prepared for the D-Day invasion to liberate Europe from Nazi Germany in June 1944.
7. Once mass production of penicillin was achieved, the price dropped from $200 to treat one case to $6. Ask students to think of another product that was very expensive when it first came out and then dropped significantly in price (supply and demand).
8. Complete the learning activity that follows.

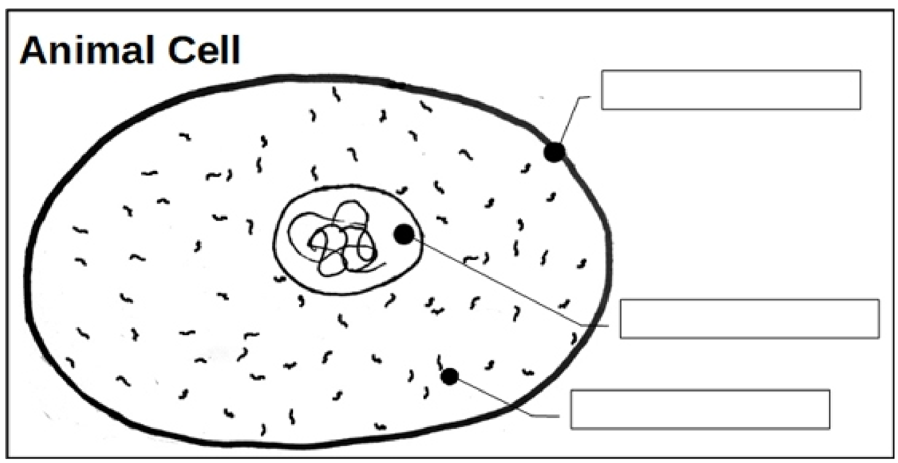
Learning Activity

Name: ____________________________

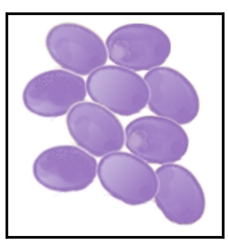
Class: ______________________________

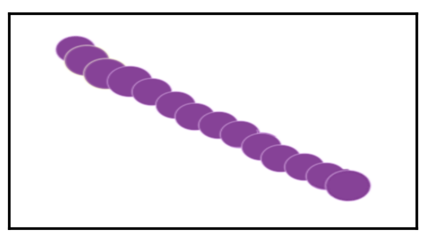
1. Label the following diagrams of an animal and plant cell.





2. Label the following with an example of the bacteria shown.





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3. The syllables in the words *microorganism* and *antibiotic* tell their story. For those two words, research the meaning of the following syllables:

   micro: ____

   organ: ____

   anti: ____

   bio: ____

4. Using the syllables above, think of five new words that use one or more of those syllables. Write the word and its meaning on the lines below.

   a. Word: ______________________ Meaning: ____________________

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   b. Word: ______________________ Meaning: ____________________

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   c. Word: ______________________ Meaning: ____________________

      ____

   d. Word: ______________________ Meaning: ____________________

      ____

   e. Word: ______________________ Meaning: ____________________

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5. Why was the mass production of penicillin so important during World War II?

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6. From the story about how penicillin was discovered, isolated and finally produced, discuss how important it was for scientists to be curious.

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