

**FREE**



# PANDEMIC

Causes, Cures, and Responses



**A Unit Study Exploring the History and Science of Worldwide Disease**

Includes lessons and activities for ages 5 to adult

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“Make a Simple Plague Mask” and “Pandemics and Process” © Samantha Matalone Cook

“Keeping a Quarantine Journal” © Amy Sharony

“Protecting Yourself from Pathogens,” “How Dirty Can They Really Be?,” “Winning the War on Pathogens,” and “A Winning Weapon: Hand Sanitizer” © Blair H. Lee

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## Introduction

A colleague emailed me an article from Forbes.com titled “50 Ways Companies Are Giving Back During the Coronavirus Pandemic” and asked how Pandia Press was responding. I didn’t have an immediate answer although I had been wracking my brain for ideas on how my company—a small, family-owned science and history publishing house—could help.

Large, multinational organizations around the world have already found innovative ways to help during this unprecedented time. Uber Eats is feeding thousands of first responders. Apple is sourcing and donating millions of masks. More than 600 distilleries are suddenly making hand sanitizer. Even the Metropolitan Opera is streaming encore presentations in HD for free! But what could a tiny “multinational” company like Pandia Press do that could hope to have any impact? Then, during a strategy session with one of my history writers, it hit me. We should do what we do best—educate.

### Knowledge Is Power

Even though this is a “novel” strain of virus, we are not without knowledge of how viruses work or what we’ve done in the past to combat them. To put what’s happening into context through the science behind and history of pandemics, we’ve put together this free Pandemic Unit Study. Knowing how pathogens and disease come into existence and spread, and how viruses work, is paramount to understanding how to best take care of your environment and yourself. The history of how humankind has fought similar battles with diseases in the past with far less understanding and tools than we have today is also important. Learning how people coped, progressed, and persevered may help alleviate anxiety about what’s going on around us in the present. We hope to arm you with facts and context. And, like everything else we publish, we challenge you to use your critical thinking skills to analyze, focus on those facts, and see the bigger picture.

### The Unit Study

Parts of the unit study come from Pandia Press’s publications and some are original entries by the writers. There are lessons and activities for all ages. Young children can learn just how germmy their hands are and read a story about how people faltered and weathered through the Black Death in the Middle Ages. Older students (and adults) can learn about the progress we’ve made since the Spanish Flu a hundred years ago. Everyone can learn the science behind viruses and how to protect against them.

Not everyone will do every component of this unit study. But if you are planning to do several, we recommend you complete them in order. Each activity stands alone, but there is reasoning to the order presented.

### The Writing Team

When I contacted our amazing team of history and science writers and asked for their input, they quickly and enthusiastically agreed to help and worked diligently to create this unit study in just a few days. They are amazing and passionate professionals. Please see the contributors biographies on page 72 to read of their accomplishments and the exciting projects they are working on.

### Learning for the Future

We hope this Pandemic Unit Study helps you and your children gain knowledge that helps twofold. First, by offering students understanding through scientific facts and historical context. Second, by strengthening critical thinking skills so that when faced with adversity in the future, students can approach the situation rationally.

Stay well and don’t forget to wash your hands,

Kate Johnson  
Publisher



# Pandemic History

Part one of the Pandemic Unit Study covers the history behind some of the world's most famous pandemics. It focuses on a comparative view, not only to learn about the history of these events and the progress made since, but also to underline that studying history can help us understand and cope with current issues. History can guide us toward solutions. It is in this spirit that we believe knowledge is power, and is empowering. We encourage you to use this unit study as a way to help your student feel empowered and productive during this global pandemic.

## The Black Death

A read-aloud story of the Black Death (bubonic plague), a devastating pandemic during the Middle Ages.

Age recommendation: 5–12

## Make a Simple Plague Mask

Create a plague mask like those worn by doctors during the Black Death in medieval Europe.

Age recommendation: 5+

## Pandemics and Progress

What makes the Spanish Flu of 1918 and the COVID-19 virus particularly unique? What have we learned in the 102 years between these two pandemics? What has not changed? In this guided research activity, we'll explore these questions and more.

Age recommendation: 12+

## Keeping a Quarantine Journal

For this project, it's your job to create a detailed historical record of this unprecedented moment in time—a document that will serve as a primary source for this period of history.

Age recommendation: 10+



## THE BLACK DEATH

THE BLACK DEATH was a pandemic. A pandemic is a serious disease that affects many people in a large region or even throughout the world. It can be scary to think about deadly diseases, so before we learn more about the Black Death and its place in history, let's get a few things straight.

First of all, the Black Death, also called the bubonic plague, is something that is very curable in modern times. We know now what causes it, and we can treat it with antibiotics. Have you ever had an ear infection or strep throat? If so, you probably took antibiotics to kill the bacteria that made you sick. Antibiotics work on minor diseases like ear infections, and they also work on major diseases like the plague. The Black Death is not something we have to worry much about today.

The second thing to know about the Black Death is that it didn't happen just in one area of the world. Very few infections are limited to only one place or one group of people. A common error is thinking that the plague only affected Europeans while the rest of the world went on with business as usual. In truth, millions of people in North Africa, the Middle East, Mongolia, India, China, and other lands suffered from the disease in the 1300s. Europeans kept detailed records about the plague, so we know a lot about its effects in that region, but diseases don't stop at a country's border. Nearly half the world's population may have died from the Black Death.

Historians believe that the plague began somewhere in China and traveled via the Silk Road, infecting people along the way. Merchants used the Silk Road to trade fancy goods like silk and gold to far-off places. Religious beliefs moved across the trade route too. When merchants from one religion interacted with merchants from other religions, they exchanged ideas and influenced each other. Through trade, people from far-apart places were able to meet one another, share ideas, and learn about cultures different from their own. But along this highway of goods and ideas came a nasty stowaway—the plague.

In the mid-1300s, the disease didn't take long to travel all the way across Asia to the Crimean Peninsula in modern-day Ukraine. There, Italian merchants became infected. They jumped in their ships and fled toward home, but it was too late. By 1348, the plague had spread throughout Russia and Europe, all the way to England and Scandinavia.

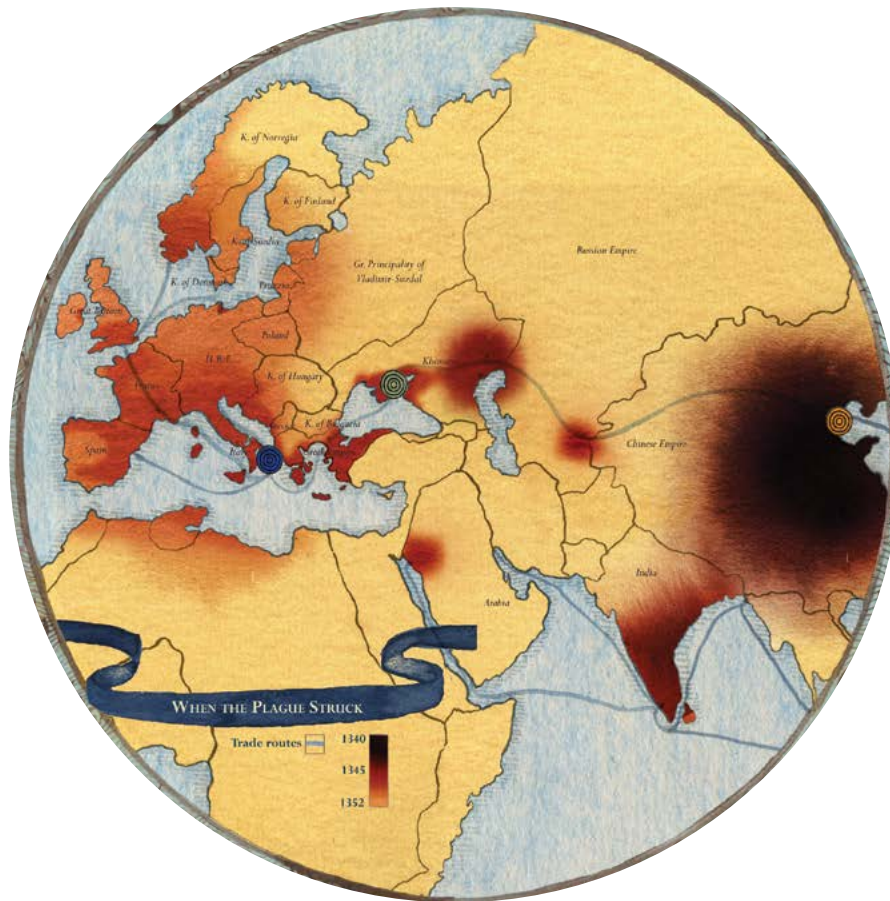
People infected with the plague developed swollen areas on their bodies. They caught fevers and chills, and they suffered from terrible pain. The Black Death was a horrible disease. It struck quickly and caused a lot of suffering.

How do you think the people of Europe reacted when this happened? What do you think they most wanted? Whenever something really terrible happens, people want to know why. They want answers. They want it to stop. They want a cure.

Today we have a lot of resources to help give people answers and to take action. About a hundred years ago, 3 to 4 million people, every year, in the United States got a disease called measles. Measles is caused by a virus. Hundreds died and thousands more became sick enough to go to the hospital. But in the 1960s, scientists figured out how to prevent this disease by giving children a shot called the measles vaccine. It's not much fun to get a shot, but it's much better than having the measles! The measles vaccine is a good example of how doctors prevent diseases in modern times.

Europeans suffering from the Black Death didn't have a vaccine and they didn't have antibiotics. They couldn't have developed either of these things because they didn't know about germs! Medieval doctors had not yet figured out where diseases came from. That can be hard for us to understand. We all know we have to wash our hands for twenty seconds to get rid of germs. Yet the only reason we know germs are there in the first place is because of scientific discovery. We can't actually see the bacteria or viruses on our hands, and neither could the people of the Middle Ages. Without this important knowledge, they came up with their own explanations.

Some medieval thinkers thought they could find the reason for the plague by looking at the night sky. They noticed that the planets Saturn, Mars, and Jupiter were all lined up with each other around the time that the plague arrived in Europe. They guessed that this alignment created a fog of "bad air" that infected everyone on our planet. Of course, their idea was not true. The movement of the planets cannot cause "bad air." But while this theory was wrong, at least they didn't try to blame the plague on innocent people. Sadly, another theory did just that.



Map courtesy of Serena Malyon: <https://smalyon.wordpress.com/2012/02/10/black-death/>

Some European Christians, particularly in Germany, believed that Jewish people caused the plague by poisoning the water wells. Their theory was also completely false, and it led to even more suffering. People who believed this lie attacked the Jews, burning down their homes and killing them. On top of those who died of the plague itself, tens of thousands of Jewish people were murdered because of false rumors fueled by anti-Semitism. Anti-Semitism means hostility toward or prejudice against Jews.

The most widespread belief about the plague was that it was a punishment from God. Some Christians thought they had done too many bad acts, called sins, and that their God sent the plague to teach them a lesson. They thought that if they acted more humbly and lived more simply, they could escape this punishment. Unfortunately, one thing people in medieval times did to prove they were humble and simple was avoid taking baths. Taking a bath was considered fancy, lavish living. Many medieval Europeans stopped bathing, hoping it would help. Today we know a lack of hygiene probably made things worse.

Some fearful folks thought they should do even more to show their God how sorry they were. They took off their shoes and paraded barefoot through the towns of continental Europe.



As they walked, they flung whips over their shoulders and hit themselves across the back over and over. This is called self-flagellation. They thought if they punished and hurt themselves, God would notice, realize the people were sorry, and end the disease. We know that's not how diseases work. Diseases don't care if a person is good or bad. Germs don't check a "naughty or nice" list before choosing who to infect.

When people don't know why something is happening, they may think up bad theories or even panic, which makes the problem harder to solve. People tried all sorts of ideas in search of a remedy for the Black Death. Some thought that the human body needs to have the perfect balance of blood, phlegm, and bile. They believed plague patients had too much blood. So they tried making deep cuts on a patients' arms and legs, called bloodletting, to let "bad" blood drain out. Others tried to keep the disease at bay by breathing in smoke or good-smelling herbs. Men, known as plague doctors who treated Black Death patients, wore masks with long bird-like beaks stuffed with herbs in an effort to protect themselves. Still others soaked plague patients in vinegar. None of these actions worked. Without antibiotics, there was really no hope.

We need to remember that we shouldn't be too hard on people in the past who used remedies that seem silly to us today. Scientific knowledge is growing and expanding all the time. You can probably ask an older family member to name something everyone believed was completely healthy when they were a kid, which we know nowadays is not safe. For example, parents and grandparents might remember a time when hardly anyone wore seat belts and almost no one wore bicycle helmets. Medieval people who tried to cure the plague with herbs, smoke, and bloodletting were just doing their best with the information they had. Besides, not all ideas to fight the plague were faulty.

Citizens of the Italian port city of Ragusa came up with a wise idea to try to stay safe. When ships arrived from plague-infested lands and entered the harbor, authorities made sailors and merchants stay at sea on their ships. If they weren't sick after 30 days, they could come ashore. This way, authorities could be sure that nobody on board was infected. Other cities adopted this same idea, but they changed the length of time from 30 days to 40 days. The Italian word for 40 is *quaranta*. Today when we separate sick people from healthy people until the danger has passed, we call that a quarantine.

Medieval European historians did a great job of documenting the plague, but to learn more, we need to look to recent researchers. In 1894, two different scientists, Kitasato Shibasaburo [shih-bah-sah-BOO-ro] and Alexandre Yersin, discovered the bacterium that causes bubonic plague. That bacterium is called *Yersinia pestis*, which means that Yersin got the "honor" of having one of the worst pathogens in history named after him. Scientists have found evidence of *Yersinia pestis* in bones and teeth of plague victims from the Black Death, as well as the Plague of Justinian, which had happened in ancient times.

One modern theory about the Black Death is that it started off in the bodies of fleas. Fleas like to hang out on the fur of rodents like rats and gerbils. According to the theory, the fleas

bit these rodents, infecting them with the disease. When the rats died of the plague, the fleas looked for a new warm place to live. They hopped onto the nearest humans and took a bite, passing on the plague again and again. Another theory states that infected fleas might not have hopped from rodents to humans at all. Instead, the fleas picked up the plague by biting infected humans, jumping onto other humans, and passing the disease along that way. Scientists to this day are still researching and debating how the plague spread so quickly and became so deadly.

This particular outbreak of Black Death lasted until 1351 in Europe, but it came back several times over the next few centuries. All in all, about 50 to 70 million Europeans died of bubonic plague, or roughly one out of every three people living in Europe at the time. It took 300 years for the population to return to its previous level. Worldwide, up to 200 million people lost their lives to the disease. Some places were hit harder than others. For example, the city of Florence, Italy lost ninety percent of its residents to the plague.

The massive loss of life wasn't the only effect of the Black Death. Life actually improved for those who managed to survive. With fewer mouths to feed, there was more food to go around. More jobs became available, and workers earned higher wages when everyone needed their services. People who didn't own land now had the chance to do so. Oddly enough, the plague weakened Europe's rigid feudal system.

The Black Death was also a wake-up call when it came to science. People realized that they needed better medical knowledge if they were going to beat the next big disease to come along. New schools and colleges opened. The Scientific Revolution in Europe didn't happen until about two hundred years after the Black Death, but the disease may have planted some of the seeds that grew into a widespread interest in science all those years later.

*Notes: Our description of the specific symptoms of the Black Death here is intentionally general and vague due to the age and sensitivity of our readers. The swollen areas described in the reading are called "buboes" (singular bubo), large bacteria-laden lymph nodes that may rupture and weep.*

*The outbreak of the plague in the 14th century was not the only one. The earliest recorded plague outbreak occurred in the 6th century, and the plague returned several times after the 14th century as well.*

*The Catholic Church condemned the practice of self-flagellation as heretical, or, against church teachings.*

The story about the Black Death is an excerpt from an upcoming *History Quest* Middle Ages publication written by Lindsey Sodano from Pandia Press. The *History Quest* series takes children on a journey into the past to experience the rise and fall of civilizations, empires, and cultures around the world. Designed as a read-aloud for elementary-age children, an independent read for older students, or a journey of exciting adventures for family storytime, *History Quest* presents an immersive study of history in an engaging and memorable format.



## MAKE A SIMPLE PLAGUE MASK

by Samantha Matalone Cook

Plague doctors were hired and paid by cities, towns, and villages to treat those infected with the bubonic plague. Because they were paid a salary, they treated both the poor and the rich, although they often made extra money by offering special preventatives or curative services to those who could afford them. Some plague doctors were trained physicians or physicians-in-training, while others were brought in from other professions when there weren't enough doctors to treat the sick. It was a risky job and hard to find willing people. Plague doctors treated the sick, did autopsies on and buried the dead, and collected and recorded public information on the number of cases and deaths, details of symptoms, and their own observations.

Although the bubonic plague had been coming through the world in waves since at least the 6th century (first recorded epidemic), the practice of plague doctors wearing a special costume didn't come into fashion until the 17th century. The idea for these costumes is credited to Charles de L'Orme, a French medical doctor notably known for his excellent reputation as the personal physician to the Medici family in Italy and chief physician to three French kings: Henri IV, Louis XIII, and Louis XIV. Plague costumes were usually long coats covered in scented beeswax, a shirt tucked into pants, pants tucked into boots, a leather hat and gloves, a wooden cane to examine patients without touching them, and a mask. Every inch of skin was to be covered, so that nothing could penetrate the clothing. The mask, made of leather or waxed cloth, was usually shaped like a bird with a long beak, which was stuffed with aromatic herbs, meant to protect the wearer from miasma, the (now debunked) theory that diseases like the plague were caused and spread through bad or poisoned air. Some plague doctors used theriac, a compound of more than 55 herbs that originated in Ancient Greece and evolved over time in composition. Others used whatever common herbs they could find. There aren't many primary sources to indicate why the mask was beak-shaped, though there are descriptions of it being the perfect shape to hold the herbs. A few secondary sources suggest that it might have had to do with the belief of some that the disease was transmitted by birds, and that by assuming the appearance of a bird, one could ward off illness.

Unfortunately, these costumes didn't do much to protect the people who wore them. Most scientists think that the plague was caused by the bacterium *Yersinia pestis* which is spread through contact with contaminated fluid or tissue, inhaling the droplets from the coughs or sneezes of an infected person, or from infected animals, usually transmitted by a flea bite. The plague masks, however did continue in popularity, not as a medical device, but as a sinister costume prop in theatre, especially as the character "Il Medico della Peste" (The Plague Doctor) in the Italian commedia dell'arte and in the carnivals of Venice. These masks are usually made of leather or plaster. We can also see that covering one's face did evolve in medical practice, all the way to modern medical masks, which do indeed help protect doctors and nurses from some illnesses.

### Materials:

- Templates (see page 89)
- Paper for printing templates (optional)
- Paper (cardstock works best but any paper will do)
- Transparency sheet (or any clear plastic)
- Pencil
- Scissors
- Hot glue gun with glue sticks
- (regular glue will not dry fast enough)
- Paint and paintbrushes (optional)
- Herbs (optional)

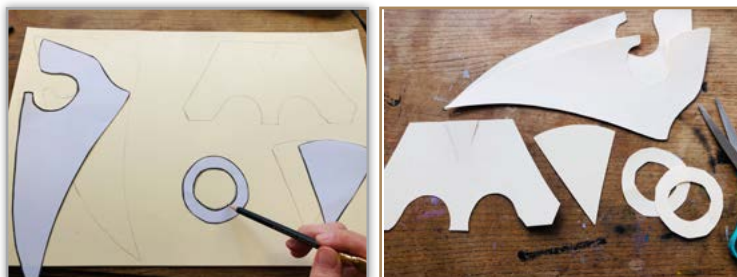


### Procedure:

1. Print out the templates, or if you don't have access to a printer, sketch the shapes onto paper. Cut out the template shapes.



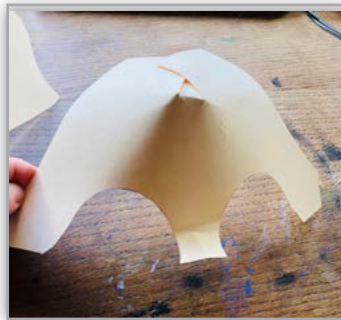
2. Trace and cut out the templates onto your sturdier piece of cardstock. Remember to trace two of the sides and two of the eyepieces. (Alternatively, you can make a mask from these template pieces on printer paper. They won't be as strong, but will work! Just remember to trace and cut out two of the sides and eyepieces.)



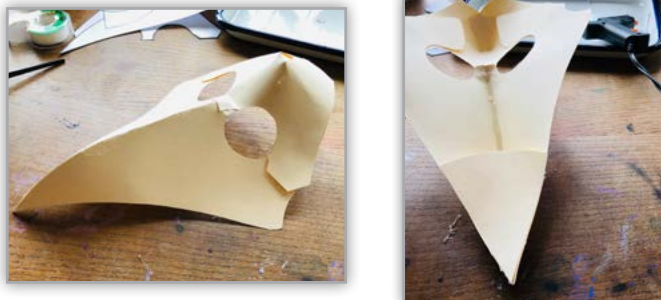
3. With hot glue or tape, join the two side pieces down the middle. (Pro-tip: You can tape the outside seam to hold it in place while you hot glue the inside seam. When dry, gently pull off the tape for a clean look.)



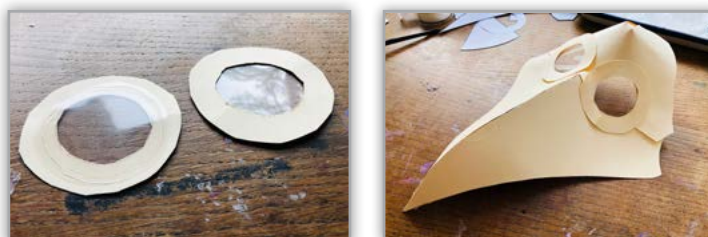
4. Bend the two sides of the middle flap you cut on the top piece and glue or tape in place. Bend the bottom of the top piece (where the nose will be) outward a little bit.



5. Tape or glue the top piece to the two sides. Then tape or glue the bottom piece to the underside of the beak, starting at the point.



6. Cut out small circles from the transparency sheet (or other clear plastic) and attach to the back of the eyepieces. Then attach (glue or tape) the eyepieces over the holes in the mask.



7. Cut a long strip (about 1" wide) of the paper you are using for the mask, to create a strap that will hold the mask to your head. The length will vary depending on how big your head is. Try your mask on to ensure a secure fit.

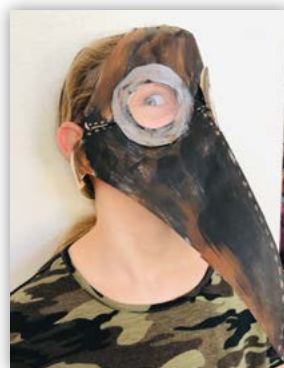


8. If desired, paint your mask. You can use browns and blacks for leather, or white for plaster. You can even add paint stitch lines, to mimic how the mask would have been sewn together.

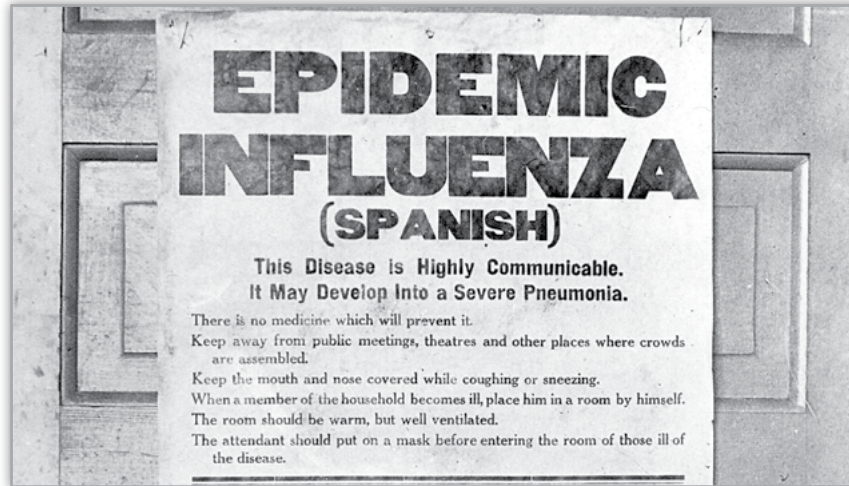


9. If you'd like to add herbs, do this last. You can take a small amount of loose herbs and wrap them in a paper towel or cheesecloth and stuff them down the beak (from the underside). You can also use tea bags in a pinch. Popular herbs and spices used for this purpose included rosemary, rose petals, mint, lavender, cinnamon, cloves, camphor, myrrh, and other common herbs.

10. Put on your mask, and good luck with your new job as a plague doctor!\*



*\*Of course the mask does not actually protect you from anything, including getting sick.*



## PANDEMICS AND PROGRESS: THE SPANISH FLU OF 1918 AND COVID-19 OF 2020

A Guided Research Activity by Samantha Matalone Cook

### Materials:

- Paper or a notebook
- Pen or pencil
- Computer or tablet with Internet access

Your life has probably changed a lot in the last few weeks. Most, if not all, of your classes and activities have likely been canceled, and you may not be able to hang out with friends and extended family right now. The world is dealing with a virus called COVID-19, and countries around the world are taking critical measures to slow the spread and give scientists time to try and answer questions like: How does this virus spread and act? Can we find a vaccine and medications that this virus will respond to? What are the most effective ways to control the spread of the virus so we have enough medical staff and equipment to handle the most severe cases? Can history help us solve any of these questions?

It's that last question that both historians and scientists have in common. There have been pandemics before, but what makes the Spanish Flu of 1918 and the COVID-19 virus particularly unique? What have we learned in the 102 years between these two pandemics? What has not changed? In this lesson, we'll explore these questions and more, but what we do know as historians is that this isn't the first time humans have faced epidemiological (health and disease) and environmental (the natural world and human activity) challenges. In these times of crisis, humans have shown ingenuity, compassion, and bravery in the face of fear and uncertainty. Learning this history gives us perspective and knowledge on how to approach problem-solving now. History is relevant and useful in solving current issues, and our actions today write the history of tomorrow.

## Pandemic vs. Endemic vs. Outbreak

When we look at the spread of disease, it's important to understand scale and significance. First, let's define what a pandemic is and how it relates to other ways diseases spread.

Read this article and watch the video and then answer the questions below:

1. Define these terms:

Outbreak:

Endemic:

Pandemic:

This article does not define the word *epidemic*, but it's another word that is important to know. An epidemic is the event of a widespread infectious disease in a community at a specific time. It is bigger than an outbreak and can escalate into a pandemic if the disease spreads globally and affects a large portion of the population.

2. Infectious disease specialist Dr. Pritish Tosh gives an example of dengue fever on the Big Island of Hawaii. How were these cases different than dengue fever cases in other parts of the world? Why were the cases on the Big Island considered an outbreak? How did they stop the outbreak?
  
  
  
  
  
  
  
  
  
  
3. Why are the Spanish Flu of 1918 and the current COVID-19 virus considered pandemics?

Check out this article on Visualizing the History of Pandemics. It shows some of the world's deadliest pandemics in visual form, and then answer the questions below:

4. Look at the visual graphic and/or chart of pandemics.

The Scientific Revolution of the 16th and 17th centuries saw the emergence of modern science, changing how society viewed nature through advancements in math, physics, chemistry, astronomy, and biology (including human anatomy and medicine). How many of the deadliest pandemics on this list happened before the 16th century?



The Golden Age of Science in the 19th century promoted the rapid expansion of scientific knowledge, application, and invention. Many scientific discoveries based on experimentation and the analysis of other scientists improved many people's way of life and began to move society toward a holistic understanding of science and the way things work. How many of the deadliest pandemics on this list happened before the 19th century?

The Golden Age of Medicine is considered to have start in the 1930s through the 1950s, when the way healthcare was structured changed dramatically and new advancements in research, treatment, and prevention benefited every level of society. How many of the deadliest pandemics on this list happened before the 1930s?

The Age of Modern Medicine generally began in the 1980s, with the integration of modern technology into research and healthcare. How many of the deadliest pandemics on this list happened before the 1980s?

What effect do you think the historical events listed above had on the outcomes of the pandemics that happened during that time?

How many pandemics have happened after 1980?

Looking back on this information, how many of the 20 pandemics listed occurred before 1980? What percentage is this? Is the death rate higher or lower after 1980? Why do you think this is?

What has changed over time in the way we respond to pandemics? What has not changed in the spread of disease?

## The Spanish Flu of 1918

The Spanish Flu of 1918 was one of the most devastating pandemics to hit the world since the Black Death, perhaps even in the whole of history. It spread worldwide, traveling quickly because of and made even more catastrophic by World War I. It affected over a quarter of the world's population at the time, and caused severe illness and a higher-than-normal death rate for influenza. There are many articles and news stories comparing the current COVID-19 crisis to the Spanish Flu of 1918, but why? First, we need to learn a bit about the Spanish Flu in order to understand the similarities and differences and what we can learn from the past to help us deal with the current problem.

1. The picture below is of an emergency hospital at Camp Funston in Kansas in 1918, where one of the first established cases of this pandemic was found. This picture is considered a primary source. A primary source is any source of information (photograph, art, manuscript, letter, diary, recording, artifact, etc.) that was created during the time you are studying. Look carefully at the picture. Answer the questions that follow.



*From the collection of the National Museum of Health and Medicine*

What do you see?

What is happening in this photograph?

Who is caring for the patients?

Where was this photograph taken? Is the place important?

How does fresh air get in?

How do you think it feels to be a patient in this emergency hospital?

What do you wonder about this picture?

How does this picture make you feel?

What can we learn from this picture as a primary source?

Read *The Spanish Influenza Pandemic: A Lesson from History 100 Years After 1918* and then answer the questions below:

2. How did World War I contribute to the spread of the Spanish Flu?
3. Describe the first, second, and third wave of the Spanish Flu.
4. What did scientists think caused influenza? Who presented the hypothesis that influenza is caused by a virus and when? When was it officially recognized that influenza was caused by a virus? When were scientists able to isolate the first human virus?
5. Name three public health measures from 1918 that are similar to what we are currently doing to curb the spread of COVID-19. Are there any that are no longer relevant?
6. Why was this pandemic called the “Spanish Flu”? What problems might be caused by calling an international pandemic after a specific country? Have we seen this problem with COVID-19?

7. How many people were infected and how many died of the Spanish Flu of 1918? What percentage of those infected died? What was the overwhelming cause of death?
  
8. According to this article, what improvements to public health were a result of the 1918 pandemic?

Read this article on how the 1918 pandemic revolutionized public health and then fill in the chart and answer the questions below:

	<b>Before the 1918 Pandemic</b>	<b>After the 1918 Pandemic</b>
<b>What did healthcare look like?</b>		
<b>What were the medical treatments available for the virus?</b>		
<b>How was the study of epidemiology approached?</b>		
<b>What public health measures helped prevent the spread of disease?</b>		

9. How were public healthcare policies influenced by the idea of eugenics before 1918? How did people justify this viewpoint? Do we see any examples of this attitude today?

10. The World Health organization's (WHO) constitution states (as it was written in 1946) "The enjoyment of the highest attainable standard of health is one of the fundamental rights of every human being without distinction of race, religion, political belief, economic or social condition." How did this idea and assertion influence the way future pandemics were approached?

### Extra Research:

If you are interested in learning more about the Spanish Flu of 1918 and its effect on World War I, go to this interactive map, where you can see simulations of how the war significantly helped the disease spread, and what would have happened if there had been no war, or if the war had continued longer. It is a fascinating case study!

### COVID-19: Learning from the Past and Preparing for the Future

Looking at the Spanish Flu of 1918 and the current COVID-19 pandemic, we can start to see both similarities and differences. We have improved technology, healthcare, and public health measures that could help us to avoid the devastation that befell the world in 1918, but how are we putting that into practice? Let's take a look.

Read this article on what we can learn from the Spanish Flu of 1918 to help us get through the current COVID-19 crisis, and then answer the question below:

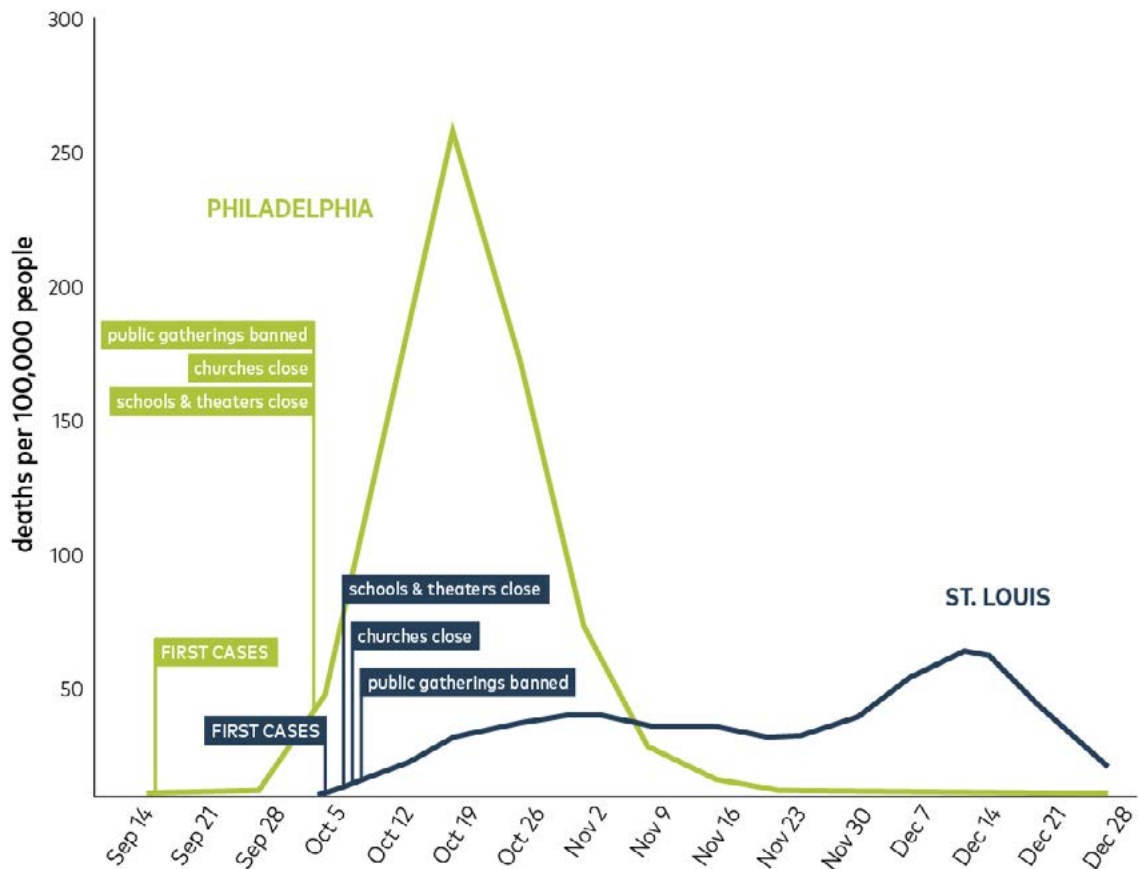
1. What are the four main lessons this article points out as similarities between the two pandemics, and that we should learn from in order to protect as much of our population as possible?

Everybody is using the term "social distancing" but what does that really mean? Social distancing is simply increasing the physical distance between people to slow the spread of disease. Because of the way we are all connected with technology, perhaps the term "physical distancing" is more accurate. With video conferencing and social media, there is more social solidarity and community available, even when we are physically distancing, than ever before.



## Delaying preventative measures made the 1918 flu pandemic much worse for some cities.

St. Louis managed to flatten their curve by implementing social distancing measures rapidly, whereas Philly decided to go ahead with a parade scheduled on September 28. Their pandemics turned out very differently.



Source: Hatchett et al, PNAS (2007)

- Compare how the two cities of Philadelphia and St. Louis responded to the 1918 pandemic, referencing both the video and the chart above. What was the outcome for each city? Now compare it to the graph you created for question 3. What do you notice?





## Moving Forward

Let's go back to the questions we asked at the very beginning of this lesson: There have been pandemics before, but what makes the Spanish Flu of 1918 and the COVID-19 virus particularly unique? What have we learned in the 102 years between these two pandemics? What has not changed? How can history help us understand and cope with current events?

Choose one or more of the following projects to apply your knowledge and skills about pandemics:

1. Write an essay or article that answers one or more of the questions posed in the above paragraph based on this lesson, and any other research you've done.
2. Write an essay or article on another historical event that you think would help us solve a modern challenge. Support with evidence.
3. Do research on one of the following: The Scientific Revolution, The Golden Age of Science, The Golden Age of Medicine, or The Age of Modern Medicine. Create an analysis of this historic period in art form: writing, fine art, theatre, puppetry, animation, a song, etc. This is your vision, so spend time crafting a complete work. If you feel comfortable, share your art piece with others for both entertainment and education.
4. Create a project based on a problem, question, or challenge that will have a social impact on your community. Some ideas to get you started are:
  - a. How can I get my community to understand the importance of physical distancing?
  - b. What is the single biggest challenge in epidemiology and how can we solve it?
  - c. What systems should be put in place for future pandemics to support our community and economy? Come up with an actual plan.
5. Check out this project by historian Ethan Kytle entitled "Dispatches from Fresno, 1918-19: Following the 'Spanish' Flu Pandemic in Real Time" in which he chronicles the responses of his hometown to the pandemic. Start collecting news articles and/or a list of URLs to stories, and write down things you hear people (journalists, leaders, community members, family members) say to chronicle the response your own city has to the COVID-19 pandemic as primary sources. If you are doing the project "Keeping a Quarantine Journal" and recording your own experience as a primary source, keep that handy. At the end of this pandemic, collect what you have gathered and recorded and assemble it into a portfolio of some kind, either physical or digital. Create a summarized article based on your primary sources. Keep this portfolio for future historians!



## KEEPING A QUARANTINE JOURNAL

by Amy Sharony

You are always living in history. You may have heard older people talk about patching their shoes during the Great Depression, or about what it was like when their schools ended segregation, or even about the Y2K scare in 1999. They were just going about their regular lives—just like you are!—while world-changing events were happening around them.

Sometimes, though, you recognize the historical significance of a moment while you are living it, and this is one of those moments. Can you remember another time when people were encouraged to stay at home, when schools were closed for weeks during the school year, or when people bought the stores out of toilet paper and pasta? There's a good chance that you'll be telling the stories about your time in quarantine to younger people, just as your family tells the story of the moon landing or the September 11 attacks.

One of the best tools historians have for understanding the past is a primary source. A lot of what we read about history comes from secondary sources—works that collect and interpret historical information. But primary sources are the first-hand accounts of people living through historical moments—on the ship, on the front lines, in the castle, or, yes, in quarantine. So think of yourself as a historian on the front lines. For this project, it's your job to create a detailed historical record of this unprecedented moment in time—a document that will serve as a primary source for this period of history.

**Supplies you will need:**

- A blank notebook (or binder or pages stapled together or a journal—anything you can write many pages in!)
- Colored pencils, a pen
- A newspaper or access to news sites (we upgraded to the print edition of *The New York Times* for this project, but you can print articles online, too)
- A camera (a phone camera is fine) and a way to print some of your pictures (a black-and-white printer is fine, or you can get them printed somewhere like Snapfish)
- Glue sticks or clear tape
- And the most important thing: Open eyes and an open mind!

**Part One:** Set up your notebook. Write or paste your name, age, and address inside the front cover. (Use your best handwriting! Future historians will thank you.)

**Part Two:** Find a newspaper article from today or yesterday, and paste it on the front page of your notebook. It can be about the COVID-19 virus (and a lot of news probably will be about that), but you aren't limited to virus-related news. Choose an article that is interesting to you. Write a few sentences explaining why you included this article in your journal—with all the different stories you had to choose from, what made you pick this one? Ideally, you'll continue to add a new article every day or two.

**Part Three:** Write about your life. Take a few minutes every day to write several sentences (or several pages, if you're so inspired!) about your life. Be sure to write the date at the top of each entry, including the month, day, and year. These suggestions can get you started, but, really, you can write about whatever is interesting to you. (Doodling is encouraged!)

- Write about yourself. How old are you? What do you like to do? Do you have a pet or wish you had a pet? What is your favorite video game? Your favorite song? Your favorite movie?
- Write about your family. Where do you live? Who do you live with? What kind of work do the people in your house do? Does all of your family live together?
- Write about your friends. How did you meet? What do you do together? What kinds of things do you talk about?
- Write about something that is different because of the quarantine. (For instance, maybe you used to go to the park on Tuesdays, but now you play in the backyard instead.)

- Write about something funny that happened because of the quarantine. (My kids think it's hilarious that the stores near us are out of toilet paper and ground beef. "What on earth are people doing that they need massive quantities of those two specific things?" my son asked.) You could draw a cartoon for this.
- Write about something that worries you about the quarantine.
- Write about something that you miss doing.
- Write about something you look forward to doing.
- Write about something nice someone has done for you or your family in the last few weeks.
- Write about something nice you or your family has done for someone else in the last few weeks.
- Write about something you're learning.
- Write a fact about the COVID-19 virus that you think is interesting. Be sure to explain why you think it's an interesting fact.
- Keep a schedule of your day, and write down how you spend your time. How is a day now different from a day this time last year? What do you spend the most time doing?
- Ask a friend to send you a letter about how they're spending their time right now. What has changed for them since the self-quarantine started? Paste their letter in your journal. Write a little about your friend and how you know them.
- Ask an adult in your life to write down three things that have surprised them about recent events. Paste their list in your journal. Be sure to explain who the adult is and what your connection to them is.
- Make a list of the chores you do around the house. Have any of them changed? Be specific about how you do your chores—when you wash the dishes, do you rinse them and put them in the dishwasher, or do you scrub them clean and put them in a drying rack? Do you make your own cleaning supplies or buy them? Do you do a good job with your chores, or do you just try to get them done as quickly as possible? Are there any chores you enjoy?
- Watch out your window for a few hours, and write down all the activity you see. Do you notice anything interesting? Does anything seem different from the norm? (For instance, if you have a school across the street, it may seem strange not to see children playing outside at recess on a Tuesday afternoon.)

- Write about how the quarantine has affected the rest of your family. Maybe you have siblings who are home from college and working online, or you may have adults in your house who are working from home instead of going to work.

**Step Four:** Snap a photo every day. It can be any kind of photo—a cool bird in your backyard, the soup you make for dinner, your fuzzy dinosaur slippers, your sister’s online class project, or anything else that interests you. Print two or three photos a week, and paste them in your journal. Write a note about the photo: what it shows, where you were, and why you decided to include it.

**Need more inspiration?** These books (both fiction and nonfiction) show how interesting first-person accounts like journals can be:

*The Diary of a Young Girl* by Anne Frank: Anne started her diary as a personal journal, but after her family went into hiding from the Nazis, she was aware that she was writing not just for herself but for people in the future, too.

*Diary of a Wimpy Kid* by Jeff Kinney: Gregg isn’t particularly good at anything except keeping an irresistibly interesting diary, full of doodles and anecdotes—but it’s his ordinariness that makes him such a great protagonist.

*Feeling Sorry for Celia* by Jaclyn Moriarty: This fictional collection of postcards, letters, notes, and other strange messages recounts a complicated season in the life of an Australian teenager.

*Unusual Chickens for the Exceptional Poultry Farmer* by Kelly Jones: Told through letters, quizzes, to-do lists, and a chicken care correspondence course, this story of a girl’s adjustment to life on a farm with some strange chickens is a lot of fun.





# Pandemic Science

Part two of the Pandemic Unit Study contains science information, exploratory labs, and other activities that will help students better understand how infections happen and what can be done to minimize your chance of getting one. The information presented is not specific to COVID-19. What you will find are the foundational fundamentals for understanding the germ theory of disease, how viruses and bacteria cause illness, and what can be done to prevent or eradicate them.

## Are Viruses Alive?

An explanation of the characteristics all living things share. Included is a discussion of the ongoing debate on whether viruses are living. You will also discover how viruses reproduce and how they infect people.

Age recommendation: 8+

## Polio

A guided research activity focused on the polio virus, a devastating worldwide disease that was nearly eradicated not that long ago.

Age recommendation: 10+

## Bacteria—Good and Bad

Bacteria are everywhere! Most species of bacteria are benign but some are pathogens.

Age recommendation: 10+

## The Good Guys

Examine beneficial bacteria under the microscope.

Age recommendation: 10+

## Death to the Prokaryotes!

Did you know that pasteurization was invented before the famous scientist Louis Pasteur developed the germ theory? Science meets cooking and history in this activity that examines how heat kills pathogens and makes canned food safe to eat.

Age recommendation: 10+

## Discovering Cells

This microscope lab recreates the famous experiment conducted by Robert Hooke in 1665, where he was the first to look at cells.

Age recommendation: 10+

## The Warrior Systems

This lesson and activity teach about the immune and lymphatic systems and how your body works to keep pathogens out and to fight against infection when they do get in.

Age recommendation: 10+

## Bacteria Out of Control

This activity teaches about unicellular binary fission and exponential growth, the two reproductive strategies that make bacteria effective pathogens.

Age recommendation: 10+

## Protecting Yourself from Pathogens

With the discovery of the germ theory and the knowledge that pathogens cause many infectious diseases, scientists were able to begin working on ways to kill pathogens without harming patients. The first step is to stop people from getting infected.

Age recommendation: 10+

## How Dirty Can They Really Be?

In this lab, you will investigate how dirty your hands can really be.

Age recommendation: 5+

## Winning the War on Pathogens!

This activity teaches appropriate handwashing technique.

Age recommendation: 5+

## A Winning Weapon: Hand Sanitizer

Make your own hand sanitizer!

Age recommendation: 5+

## Alexander Fleming: Infection, Antibiotics, and War

This research activity focuses on the life-saving invention of antibiotics.

Age recommendation: 10+

## Smallpox

This research activity focuses on smallpox, which, like COVID-19, is a viral disease. Disease eradication and different types of immunity are investigated.

Age recommendation: 10+

Many of the lessons, labs, and activities are excerpted from *REAL Science Odyssey Biology 2*, a publication written by Blair Lee from Pandia Press. *Biology 2* is a comprehensive hands-on course for life science at the middle school to high school level (grades 5–9). It engages young people’s minds at the same time they are actively participating in the learning of biology. For more information please visit [www.PandiaPress.com](http://www.PandiaPress.com).





# Are Viruses Alive?

## Lesson

Many of the pandemics throughout history were caused by a virus. COVID-19 is caused by the coronavirus. But are viruses alive? Living things are called organisms. In order to answer that question, you need to know the characteristics of and how scientists define “living.”

### Characteristics of Life

There are many different kinds of organisms in the world. If you were asked to compare them, it would be easier to list their differences than their similarities. There are nine characteristics that all organisms have in common.

1. **All organisms are made of one or more cells.** Some organisms, like bacteria, are made of one cell. Others, like you, are made from many cells. You started out as one cell. Your cells keep making more and more cells as you grow. When you are an adult, you will be made of about 100 trillion cells.



one or more  
cells



Take in energy

2. **All organisms take in energy.** You probably think of energy as electricity and light. So how do you take in energy? Food is energy for organisms. But where does food energy come from? It comes from sunlight. The sun shines on plants. Plants change sunlight to food energy they can use. The rest of the organisms on Earth get their energy from plants. Even animals, like cats, that are *carnivores* (meat eaters) get their energy from other animals that got their energy from plants that got their energy from the sun.

3. **All organisms have some type of respiration.** How do organisms get energy from eating food or absorbing sunlight? *Respiration*, that's how. In people, blood takes food molecules and oxygen molecules to the cells. Inside your cells, the food molecules and oxygen react together to release energy.

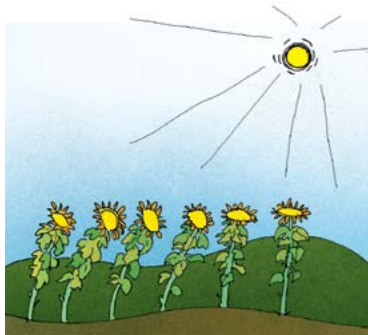


4. **All organisms have some type of circulation.** Organisms use *circulation* to move food and waste throughout their cells and bodies. Your heart pumps your blood, and your blood circulates through your body. Your blood circulates food to your cells, so they can make energy. Your blood also removes waste products from your cells.
5. **All organisms get rid of waste.** The word *waste* refers to quite a few things for organisms. You get rid of waste by breathing out, sneezing, blowing your nose, coughing, burping, defecating, urinating, crying, blinking, and (when you are sick) vomiting.



6. **All organisms grow.** I wonder how tall you were when you were one year old. How much have you grown since then? Do you think that some bacteria grow faster than other bacteria the way some people grow faster than other people? What about insects?

- 7. All organisms move.** You can see it when people move. What about plants, though? Have you ever noticed a plant growing next to a window? Most of the leaves of the plant will be facing toward the window. Plants need to get sunlight on their leaves to make energy. The leaves of the plant move toward the window to get more sunlight on them so they can make more energy. This type of movement in plants is called **phototropism**.



move



respond to environment

- 8. All organisms respond to their environment.** Two ways you respond to your environment are sweating and shivering. When you are hot your body sweats to help you cool down. When you are cold your body shivers to help you warm up. Many plants respond to hot and cold too. When the weather gets cold, they lose their leaves. The leaves grow back again when the weather gets warmer.

- 9. All organisms reproduce.** Organisms make new organisms.



reproduce

## Viruses! Living? Or not?

You usually know when something is living or not without really thinking about it. You do not need a list to tell you that a cow or a tree is an organism. Most of the time it is straightforward to determine if something is alive, but not always.

There is a question that has led to a debate among biologists: Are **viruses** organisms?

**Let's look at what has led to this debate.**

Viruses *do not*

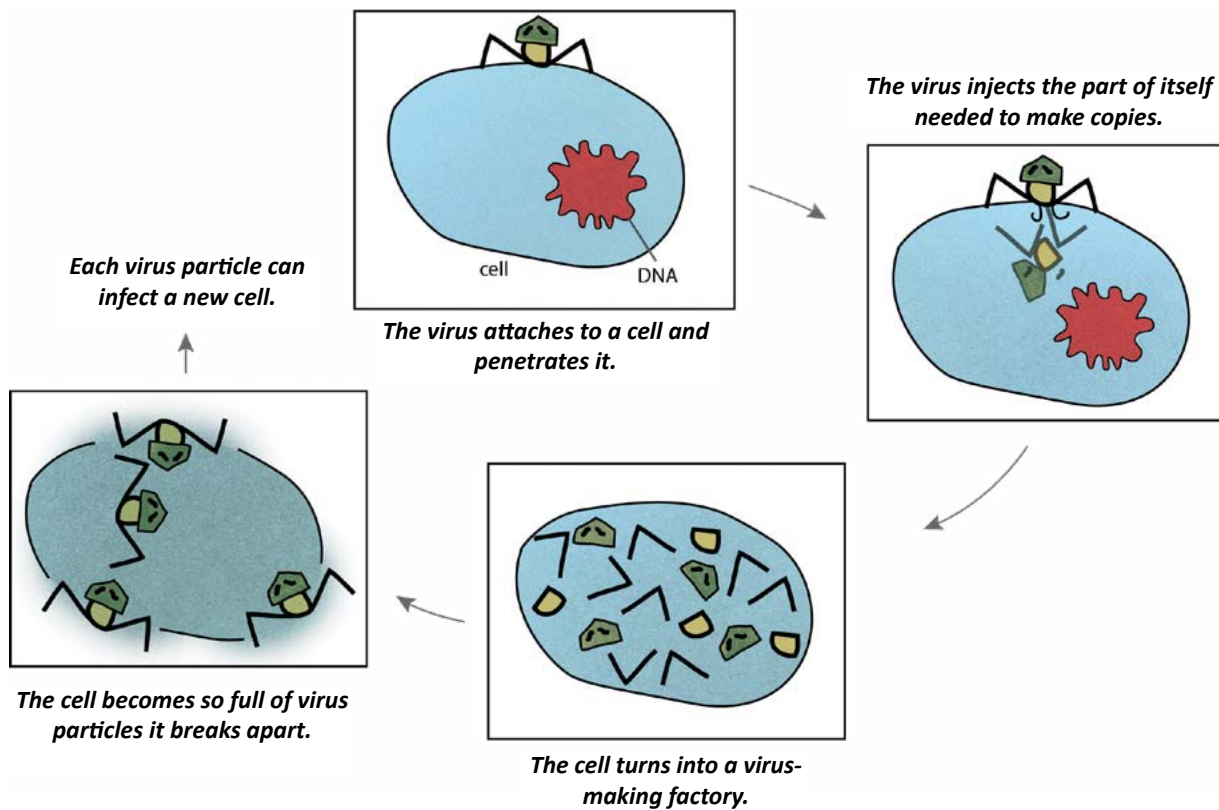
- ★ take in or use energy (virus-infected cells do, however)
- ★ get rid of waste
- ★ move
- ★ grow
- ★ have a type of circulation
- ★ have a type of respiration

and . . . viruses *are not*

- ★ made of cells

At this point you might be wondering what the debate is. It sounds like viruses are not living, doesn't it? What viruses do really well, though, is reproduce!

**Virus Reproduction Cycle**



*Viruses have a unique method of reproduction.*

Viruses reproduce differently than anything else. First, a virus attaches to the cell of an organism. Next, it penetrates the cell. After that, it injects the parts of itself needed to reproduce into the cell. This turns the cell into a virus-making factory. The cell becomes so full of newly made viruses that it breaks open and these new copies of the virus hunt for more cells to attack. If there are more cells around, the virus attacks the cells and makes more and more copies of itself.

If there are no cells around, viruses cannot reproduce. A dishful of virus particles with nothing else will sit there and never make copies of itself. Because a virus needs other, non-virus organisms to reproduce, some scientists think the ability to reproduce is not enough to reclassify viruses as organisms.

Scientists also disagree on whether viruses respond to their environment. Some scientists argue that of course viruses respond to their environment. They are able to respond to a cell in their environment and infect it. Other scientists say that viruses cannot move on their own so they cannot respond to their environment.

Viruses are considered right on the border of living and nonliving. Some scientists want to change the definition of an organism to include viruses. They think viruses should be classified as organisms. Other scientists say that viruses are not organisms.

### Weighing In on the Debate

Now that you know the facts, what do you think: Are virus alive? Should the definition of organism be changed to include viruses, and why or why not?



I think viruses are  Living  Not Living

I think this because . . . (make sure your response is scientific)

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# Polio

## Research

*This is a research activity. Use your computer to find the answers to the following questions. Suggested answers can be found at the end of this unit study.*

Living or not, viruses have a big effect on organisms. Most people in this country are vaccinated against polio, so you might not have heard of it. There was a time when people lived in fear of it. (Vaccines will be covered later in this unit study.)

### **Polio (Poliomyelitis)**

What is polio? How is it transmitted?

What does it do to a person who is infected with it? What is paralytic polio?

## Research *continued*

How long has polio been infecting people?

Which U.S. president had polio? When did he serve as president? How old was he when he contracted polio?



Who discovered the polio vaccine?

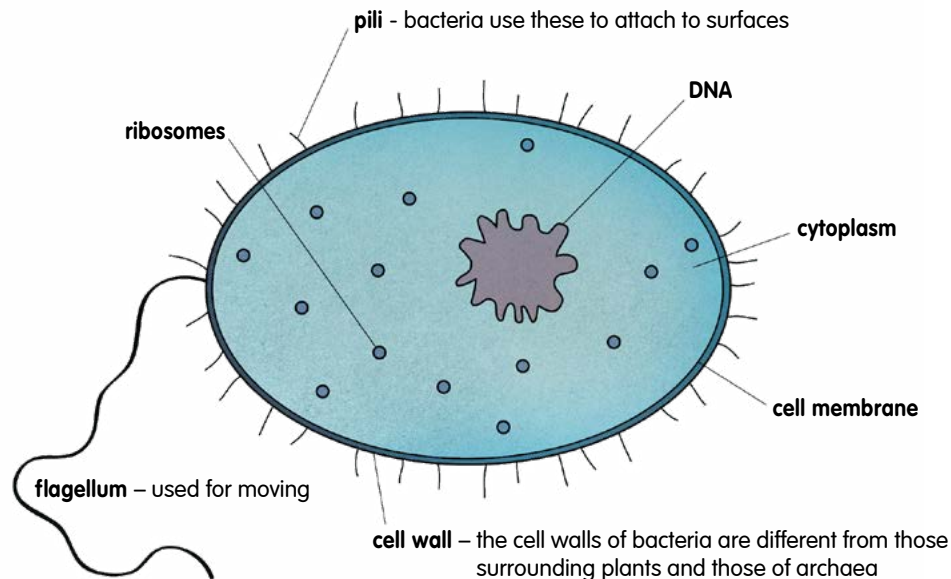
The vaccine for polio was invented by a true American hero, Jonas Salk. Salk spent his life trying to find cures for deadly diseases like AIDS and polio. When he did find a vaccine that worked, he refused to patent it. Vaccines that are not patented are cheaper to produce and therefore available to more people. How did the U.S. president in the image above help in the fight against polio?



# Bacteria – Good and Bad

## Lesson

### Cross-section of a Bacterium Cell



There are many species of bacteria. They live everywhere. They are inside your intestines, on your skin, and in the deepest trenches of the oceans in Antarctica. Most species of bacteria are benign or harmless. Some, like those in your gut, are beneficial. Other beneficial bacteria are essential for a healthy ecosystem. Many of these species of bacteria are decomposers. They cycle carbon, nitrogen, and sulfur. Still others are disease-causing. Disease-causing bacteria are called **pathogens**.

There are many different traits among the species of domain Bacteria. There are some traits, though, that all the different species of bacteria share.

#### Bacteria . . .

- ★ are unicellular
- ★ are prokaryotes; inside their cells they have
  - no nucleus
  - no (or very few) membrane-bound organelles, except ribosomes
- ★ have one chromosome that is a double strand of DNA in a ring shape
- ★ reproduce asexually through binary fission
- ★ are organisms (They are alive!)









## Classifying Bacteria

Four shared traits are used to classify bacteria:

- #1. Shape and the way they group or clump together
- #2. Feeding strategy
- #3. Conditions in which they grow
- #4. Similarities and differences in DNA sequences

### #1. Bacteria are classified by shape and the way they clump.

Coccus are spherical	Bacillus are rod-shaped	Spirillus are spiral	Diplo are in groups of two	Staphylo are in clusters	Strepto are in a chain
					

### #2. Bacteria are classified by feeding strategy.

There are bacteria that are autotrophs and there are bacteria that are heterotrophs. Autotrophs, such as most plants, produce their own food. Heterotrophs, such as yourself, do not.

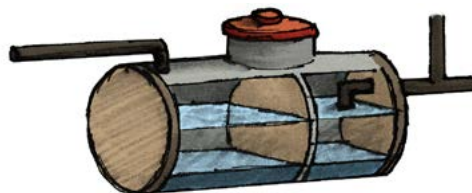


Cyanobacteria (blue-green algae)

Much like plants, cyanobacteria turn light energy into chemical energy, but they do not have chloroplasts. They photosynthesize using chlorophyll embedded in their cell membranes.

### #3. Bacteria are classified by the conditions in which they grow.

Aerobic bacteria need atmospheric oxygen to survive. Anaerobic bacteria cannot survive in the presence of atmospheric oxygen.



This septic tank has anaerobic bacteria that break down and decompose waste.

### #4. Bacteria are classified by the similarities and differences in DNA sequences.

A dog and a cat are two different species of animals. They have differences in their genes that make one a dog and one a cat. Different species of bacteria have differences between their DNA too. These differences in DNA sequences are used to classify bacteria.



# The Good Guys

## Microscope Lab

*If you have access to a microscope, use this lab to view helpful bacteria.*

You know bacteria, they aren't so different from people. You have your good guys and your bad guys . . .

Bad bacteria, pathogens, can make a person sick and in extreme cases even kill them. On the other hand, *without* good bacteria inside us, we would die! Good bacteria are bacteria that are beneficial for your health. Your intestines are full of good bacteria that are essential for your body to digest food. Good bacteria also live on your skin and in your mouth, protecting you from pathogens. When these bacteria encounter pathogens, they secrete chemicals that fight them.

Yogurt is full of good bacteria. Over the next two days, you will look at bacteria in yogurt. Today you will use your microscope to look at the good bacteria in the yogurt. Then you will put the yogurt in a warm, dry place and look at it 24 hours later. What do you think will be different about it?



## Materials

- Plain, active-culture yogurt
- Microscope
- Toothpick
- Water
- Dropper
- Lab sheet
- Slide and slide cover
- Methylene blue stain (optional)

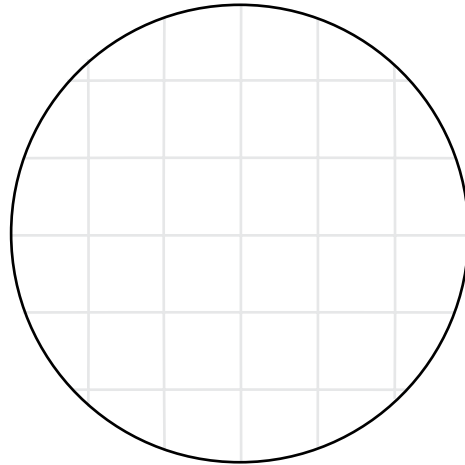
## Procedure

- Day 1**
1. Use the toothpick to smear a small sample of yogurt onto the slide. Put a drop of water on the slide and place a slide cover on top. Wait 15 minutes for the bacteria to settle on the slide.
  2. Use 100x magnification to locate a sample with a good number of bacteria. Then switch to the 400x magnification to find a sample to sketch. Draw what you see on the lab sheet and answer the questions for Day 1. Optional: Stain the slide for a view with better definition of organism, but without movement. Stain kills bacteria.
  3. Put the yogurt container in a dark and fairly warm location. Leave the container for 24 hours.
- Day 2**
4. Use the toothpick to smear a small sample of yogurt onto the slide. (Try to smear the same amount as you did yesterday.) Put a drop of water on the slide and place a slide cover on top.
  5. Use 100x magnification to locate a sample with a good number of bacteria. Then switch to the 400x magnification to find a sample to sketch. Draw what you see on the lab sheet and answer the questions for Day 2.

# The Good Guys

## Microscope Lab Sheet

Specimen \_\_\_\_\_ Magnification \_\_\_\_\_

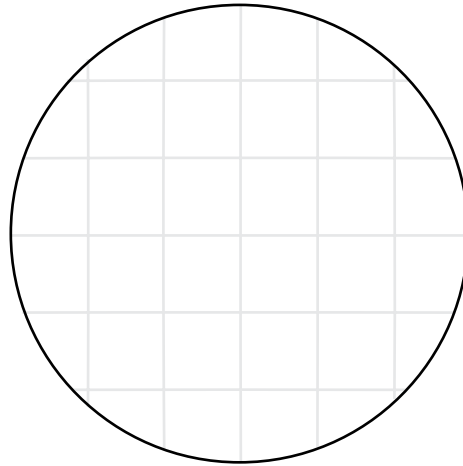


**Day 1**

### Day 1

Read the label of the yogurt container. Write the names of the types of bacteria in the list of ingredients.

The bacteria in yogurt can be recognized by their shape or grouping arrangement. Search the names of the bacteria on your computer, ask, "What shape are (*bacteria name*)?" Record the types of bacteria you see with your microscope. Which bacteria are most abundant? Which bacteria are least abundant?

**Lab Sheet** *continued***Day 2****Day 2**

Did you see anything new? Did the abundance of any type of bacteria change more than others? Give explanations with your answers.

We have a symbiotic relationship with the good bacteria found in yogurt. These bacteria help us digest food and fight pathogens that get inside us. What benefit do we provide to the bacteria?



# Death to the Prokaryotes!

## Lab



In 1795, Napoleon Bonaparte needed to feed the French army while they were on the march. In those days most armies traveled by walking. The French were at war, and men at war doing all that fighting and walking need to be well fed. A famous quote of Napoleon's is, "An army travels on its stomach." This means a hungry army doesn't do very well, and a well-fed army does. He was concerned about the quality of the food available to his men. Food spoilage was a major problem in those days. There were no refrigerators. Food was kept safe by salting it, drying it, smoking it, or cooking with sugar. Napoleon wanted something healthier. He offered a prize of 12,000 francs to the person who figured out a better method for preserving food.



In 1809, a French chef named Nicolas Appert claimed the prize. Appert had spent ten years experimenting with a method that eliminated air from containers of food. At that time, people thought air caused food to spoil, which is why Appert's method focused on eliminating it. Appert discovered that if you heat jars with a cork tightly sealing the jar to make it an airtight container, the cork will form an airtight seal and the food will not spoil. Appert is considered the "father of canning." If you have ever eaten food that comes out of a jar or a can, you have eaten canned food.

## Lab *continued*

It was not until 50 years later that the famous scientist Louis Pasteur determined the true cause of spoilage. It was not the air. The cause of the spoilage was microorganisms in unsterilized foods. One major type of microorganism that causes spoilage is bacteria, which are prokaryotes. This discovery along with work done by the doctors Joseph Lister and Robert Koch led to the germ theory. The germ theory states that certain diseases are caused by infections from pathogens that are too small to see without a microscope. Diseases, like polio, caused by pathogens are called infectious diseases.

The experiment you are performing today deals with the area of biology referred to as food safety. Food safety is as important today as it was in Napoleon's day. Unless you eat food fresh from scratch every time you eat, you eat food that has been preserved, most likely by someone you do not know. Every so often, you hear in the news about a food processing plant that has not been careful about following all the steps needed to keep the food they sell safe. Today you are going to learn what some of those steps are.

In this lab, you are going to can applesauce. The process of sterilizing food in containers using heat is called canning, even when you use a jar. You will be using a similar method to that developed by Nicolas Appert. The equipment used has changed quite a bit, but the method hasn't changed much since it was developed more than 200 years ago. Microorganisms, which are invisible to the naked eye, are all around you and on the food you eat. Many of them, like those in yogurt, are good for you. Some are harmful. Using heat to destroy microorganisms kills them. When you kill the organisms that cause spoilage, you stop the spoilage from occurring. You will be killing lots of prokaryotes when you heat the applesauce. When the jars are boiled, air is forced out of the jar and a vacuum seal forms between the lid and the jar. This prevents new microorganisms from entering and contaminating the food. Sterilizing the contents of the jars takes time. It does not take very long to force the air from the jars, but it takes several minutes of boiling to kill certain strains of bacteria. One sample will not go through the sterilization process, so you can see what happens to unsterilized applesauce. Do you think it will spoil? What will happen to the applesauce that is sterilized? Let's experiment and find out.

## Lab *continued*

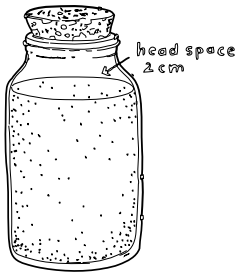
### Materials

- Two ½-pint canning jars
- Two unused rings and lids that fit the jar
- Hot water, for washing the jars and lids before use
- Dish soap
- 1 kg 500g (about 3½ lbs) Apples (any variety works). This seems like a lot of apples, but it isn't. DO NOT use bruised, old, or rotting fruit.
- Knife
- ½ cup sugar (optional)
- Apple peeler
- Cutting board
- Tall pot, tall enough for the jars + 8 cm (3 in) of water + some room above that so the water does not boil over
- Lid for pot (optional)
- Pot for cooking applesauce
- Plastic container with lid
- Cooking source
- Wooden spoon
- Food processor or blender for smooth applesauce (optional)
- Potato masher for less chunky applesauce (optional)
- Permanent marker
- Timer

### Procedure

1. Wash the jars, rings, and lids with hot, soapy water. Rinse them well and set them aside.
2. Wash and peel the apples. Cut away any bruises you see. Chop the apples, discarding the apple cores with their seeds.
3. Put the apples and sugar (if using) into a pot on your stove. Turn the burner to medium. Set the timer for 20 minutes. Stir occasionally. Do not let the bottom scorch. The heat of stove burners varies; therefore cooking times vary. The apples in the applesauce should be soft when the applesauce is done.
4. Take a small sample of applesauce, let it cool and taste it, and make sure there is enough sugar. Add a little more sugar if necessary. When the apples have softened, turn off the heat. Let the apple mixture cool until it is cool enough for you to mash or processor in a blender.
5. Use the potato masher to mash the applesauce until it has very few chunks. If you want applesauce that has no lumps, you can put this mixture into a food processor or blender, and process until it is smooth.

## Lab *continued*



6. Fill the two jars with applesauce. It is VERY important you leave headspace in the jar. Headspace is air between the top of the jar and the product being canned. Make sure there is 2 centimeters, a little less than 1 inch, headspace between the top of the jar and the applesauce.



7. Wipe the rim of the jars. Set the lid onto the jar and screw the ring over the top of the lid.

8. Take  $\frac{1}{4}$  cup of the applesauce and put it into the plastic container. Set the cover on the container but do not seal the container. This applesauce will sit loosely covered, until it begins to go bad. Once it starts to spoil, you will be looking at lots of microorganisms. You cannot see just one; there have to be lots for you to see them. Do not eat this now or at any time. There is a range of time this will take to spoil. If you live somewhere warm and humid, the applesauce will spoil quickly. If you live somewhere cool and dry, the applesauce will take longer to spoil.



9. The rest of the applesauce is for you to eat today.

10. Put the two jars into a pot. Fill the pot with water so that the water is 8 centimeters above the top of the jars. Put a lid on the pot. Turn the heat up to high. When the water boils, set your timer for 30 minutes. You can turn the heat down, but make sure the water continues to boil.

11. After 30 minutes has elapsed, turn off the heat. The jars and water are VERY hot right after the canning process is complete. When the water has cooled, take the jars out of the water. Press lightly on the tops of the lids. The lids should feel tightly sealed.

12. Dry the jars.

13. With a permanent marker, write the date that is two weeks away on one of the jars and the date that is two months away on the other jar. Those are the dates you get to open and eat your applesauce. You have preserved it and killed a whole lot of prokaryotes in the process, so it will be okay to eat.

14. Complete the lab sheet.

15. When you are ready to eat the applesauce, make sure the lids are still vacuum-sealed. If they are not, DO NOT eat the applesauce. That means the applesauce has spoiled.

**Preparation for the next lab: Soak a cork in water the night before.**



# Death to the Prokaryotes!

## Lab Sheet



There are several steps in the canning process that need to be followed to make sure canned food is safe. Explain the danger to food safety at each of the following steps if the proper procedure was not followed.

If old or rotting apples were used . . .

If bruises were not cut from the apples . . .

If the jars, rims, and lids were not clean . . .

If the seal between the jar and rim was not tight . . .

If the applesauce was not cooked as long as it should have been . . .



# Discovering Cells

## Microscope Lab

\* **Lab preparation: Soak the cork in water the night before performing this lab.**

\* **Caution: Adult supervision required for slicing the cork with an X-Acto knife.**



Robert Hooke

In 1665, Robert Hooke cut a very thin slice from a piece of cork. Then he put the cork under a compound microscope that he made. Looking through his microscope, he saw tiny boxlike structures that reminded him of monk's cells, the living quarters of monks. That is how cells were discovered and named.

The cork cells that he saw were dead cells. For that reason, he did not see a nucleus, cell membrane, cytoplasm, or genetic material. He saw the cell wall that surrounds plant cells and gives plants their structure, even after the cells have died.

In this experiment, you will take a thin slice of cork and look at it under your microscope. Through the lens of your microscope, you will “discover” cells, just as Robert Hooke did almost 350 years ago.

You will make a wet mount slide. Wet mount slides are made with a slide, a specimen, a little bit of water, and a slide cover. The water fills up the space between the slide cover and the slide, this allows light to pass more easily through the prepared slide. Many types of specimens look better using the wet mount technique.

## Material

- Compound light microscope
- Slide
- Slide cover, .17" thick (glass is preferred over plastic)
- Optical lens wipes
- Bottle cork
- X-Acto knife with new blade
- Cutting board
- 1 cc syringe, without the needle (optional, but very handy when making wet mount slides)
- Glass
- Water
- Tweezers with pointed tips, optional

## Procedure

### How to Prepare a Wet Mount Slide

- ★ Do not let wet mount slides sit too long after they have been prepared. They will dry out.
- ★ Make sure your slide and slide cover are clean with no fingerprints or other smudges. Slides and slide covers should be handled on the sides to avoid this.

## Microscope Lab *continued*

1. Take the cork out of water. Slice as thin a slice of cork as you can. Be VERY CAREFUL when making these slices so you do not cut yourself. The slice does not need to be very big around. You are going to look at it under a microscope. The slice I used was .3 cm by .15 cm. Make several slices. You will get better making thin slices with some practice. If the cork is too thick, you will not have a good clear view of the cells. For the best view, the light from the base of the microscope needs to shine through the cork.
2. When you have a cork slice you are satisfied with, put it on the slide.
3. Syringe up about 4 ml of water. One drop at a time, drip water onto the cork on the slide. One to two drops should be enough. Make sure the cork does not float off the slide. Do not use too much or too little water. The more slides you make the better you will get at judging the amount of water to put on the slide. Be careful to keep the specimen on the slide and under the slide cover with very little to no visible air. Do not worry about it being off center a bit.
4. Put the slide cover on, being careful not to make fingerprints. You want to have the slide cover on the slide with no, or very few, air bubbles. Do not worry about water squishing out of the slide cover at this point. If air bubbles are visible under the slide cover, take the cover off, drip one or two more drops of water onto the slide and put the cover back on. Squeeze all the water out of the syringe into the glass of water. Very carefully, so you do not break it, press on the slide cover with the end of the syringe to try to squeeze the air out. If this doesn't work, you may need to shave a thinner slice of cork.
5. If water has leaked out from under the slide cover, put the end of a paper towel on the water so that the paper towel passively soaks up the water. Do not let it soak up all the water from under the slide cover, though. Make sure there is no water on the bottom of your slide.

### Viewing the Slide

- ★ **Warning:** You need to be very careful when rotating and focusing the higher-magnification objective lenses. The objective lenses can break the slides if they are focused down too hard; even worse, you could damage the objective lens. Just pay attention and always start with the 40x objective lens when you are focusing on a specimen.
6. Rotate the nosepiece so that the lowest-power objective lens, 40x, is focused on the stage.
  7. Put the cork slide onto the stage using the stage clips to hold it in place. To do this: Pull back on the lever on the right stage clip, then put the slide resting against the bottom corner of the left side stage clip. With your finger, carefully let the right side stage clip close to hold the slide in place.

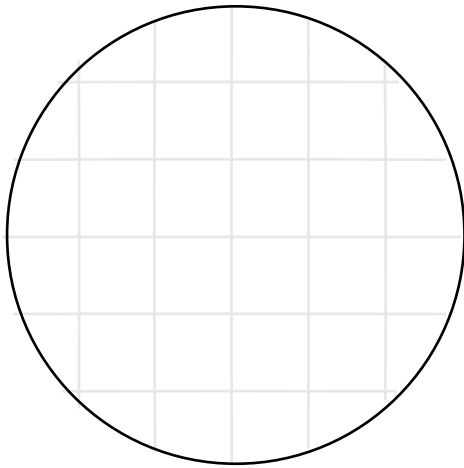
## Microscope Lab *continued*

8. Turn on the microscope light. Use the knobs on the stage to move the specimen into the circle of light coming from the illuminator up through the specimen. Take your eyes away from the microscope and slowly move the slide with the knobs on the stage. Notice that when you do this the slide moves in the opposite direction you would expect. This is called ***microscopic inversion***.
9. Look through the eyepiece:
  - A. Center the specimen.
  - B. Turn the coarse focusing knob while you are looking through the eyepiece. Stop turning the knob at the clearest point for this knob.
  - C. Adjust the amount of light using either the diaphragm or the condenser lens.
  - D. Refocus with the coarse focusing knob.
  - E. Focus with the fine focusing knob.
10. You should see the cork cells clearly. If you have a very small specimen, you might see all of it. Look over the specimen. Find the part that looks the thinnest; this is where the most light is getting through the sample. You might need to move the stage knobs to move the cork. Check for air bubbles. Move away from air bubbles; they interfere with your view. If the thinnest part of the cork is also the part with air bubbles, you might want to work with the slide some more. Possibly make a thinner slice from the cork or take off the cover and add more water.
11. Draw what you see through the eyepiece on your microscope view sheet. Your view will have many similar-looking cells:
  - Draw the entire outline of the specimen, if the specimen does not take up the entire field of view.
  - Draw a few of the cells.
  - Note on your view sheet that the rest of the inside of the specimen looks like what you have already drawn.
12. Turn the nosepiece so the 100x lens is focused on the specimen. Look at the specimen. Do you still see cork? When you look at a higher magnification, you are looking at a smaller overall area. Sometimes the part you are looking at will no longer be in the area seen through the lens. If you don't see the cork, move the stage knobs so the lens is centered on the cork. Use the focusing knobs so that the cork is at its clearest.
13. Draw the view through the eyepiece on your lab sheet. Use the same strategy you used at 40x.
14. Turn the nosepiece to the 400x lens and repeat the above procedure.

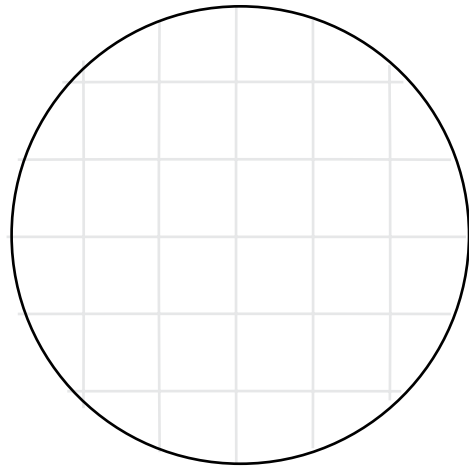
# Discovering Cells

## Microscope Lab Sheet

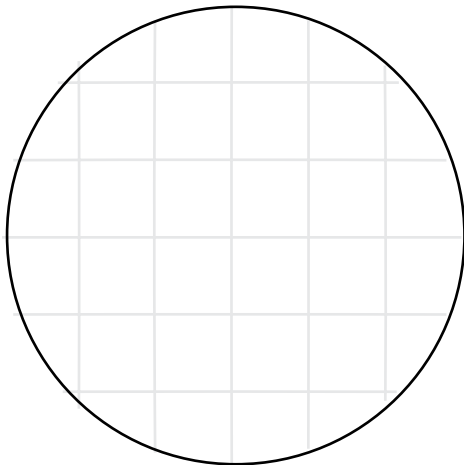
Specimen \_\_\_\_\_



40x



100x



400x

Comments:



# The Warrior Systems

## Lesson

### Immune System and Lymphatic System

#### The Purpose

- ★ To keep your body from getting sick

The primary organs are your lymph nodes, lymphatic vessels, tonsils, thymus, spleen, and Peyer's patches.

*Your immune system and lymphatic system are waiting to do battle with invaders.*

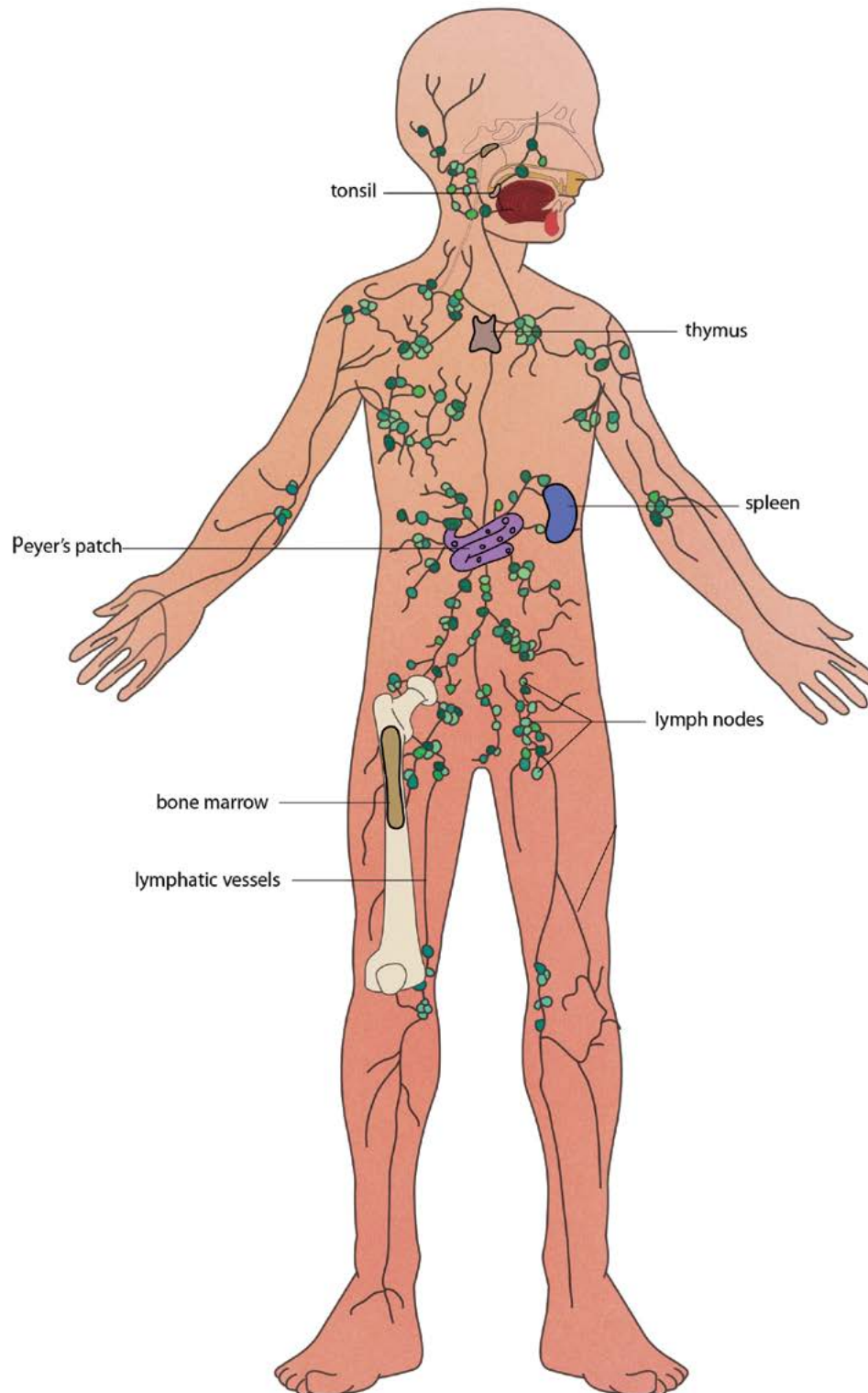
BAM! CRASH! SPLAT! Did you feel that? Your body is constantly bombarded with disease-causing agents, called **pathogens**. Pathogens are microscopic bacteria and virus particles. They are so small you don't feel it when they collide with you.

Pathogens want inside you! It is warm and moist in there, a perfect place to live. They get in through the air when you breathe, through food and drink, or from putting your hands into your mouth. They can also get in through cuts. Your body protects itself against pathogens and fights back when they get inside it.

Your **integumentary system** (your skin) forms a barrier between you and the rest of the world. Pathogens cannot get through your skin unless you have a cut, an opening. Your **respiratory system** uses mucus, coughing, and sneezing to remove pathogens. Your **digestive system** has pathogen-fighting chemicals in your saliva, liver, and pancreas. There is also strong acid in your stomach that kills most pathogens. Sometimes, though, an invader gets past these defenses. When they do, your **immune system** and **lymphatic system** are waiting to do battle with the invaders!

Your immune system fights pathogens that get inside you, past your body's first defenses. The first time your body encounters a pathogen, it can take days for your immune system to figure out how to kill it. When this happens, you get sick. Your body is able to recognize pathogens it has seen before, though. The next time it encounters the same pathogen, your body is able to deal with it right away. You will have become **immune** to that type of pathogen. This is the purpose of **vaccines**. When you are given a vaccine, the "dreaded shot," the vaccine contains a less dangerous form of the pathogen. This exposes you to it. Your immune system recognizes it and you cannot get that disease. Your lymphatic system connects the organs of your immune system.

## Immune and Lymphatic Systems





The pathogen is going to attack! Fortunately, the white blood cells destroy it.

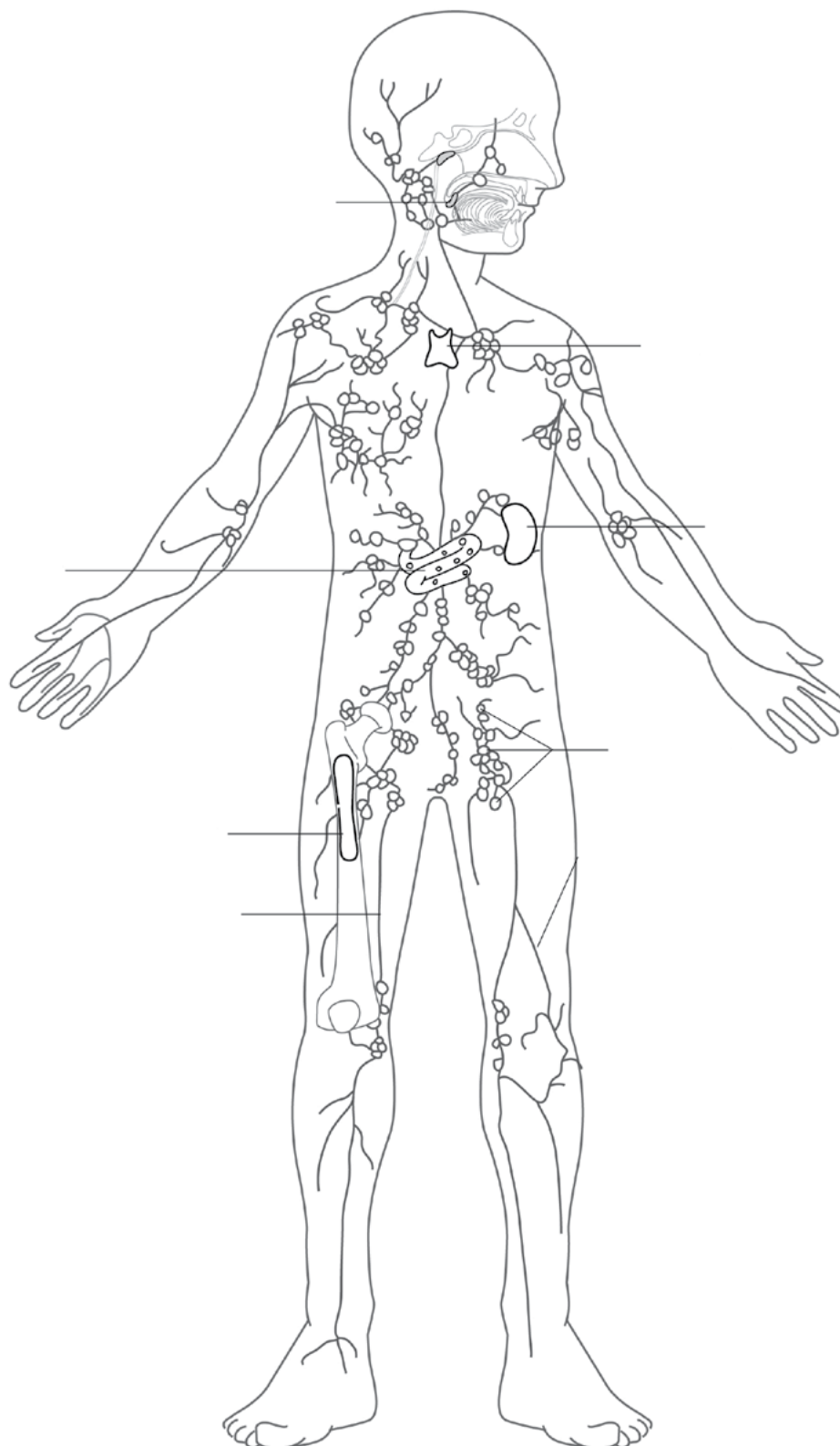
## Color and Label the Immune and Lymphatic Systems

Refer to the illustration on the last page as you read about the immune and lymphatic systems below. Follow the underlined steps, coloring and labeling the immune and lymphatic systems.

1. **Lymph nodes** are found throughout your body. Lymph nodes drain a clear fluid, called **lymph**, from your tissue. They filter out pathogens and then return the pathogen-free lymph back to your tissue. Color and label the lymph nodes.
2. The organs of the immune system are connected by **lymphatic vessels**. These vessels run alongside your veins and arteries, so they can exchange cells and fluid back and forth. Lymphatic vessels contain lymph. Trace over and label the lymphatic vessels.
3. **Tonsils** contain white blood cells that filter out harmful bacteria as they enter your body through your nose and mouth. Color and label the tonsil.
4. Your **thymus** makes white blood cells that fight pathogens. Color and label the thymus.
5. Your **spleen** filters your blood. White blood cells in your spleen attack and remove pathogens. Your spleen also removes old red blood cells from your blood. Color and label the spleen.
6. **Peyer's patches** destroy pathogens before they get into your blood. They generate **memory lymphocytes**, a type of white blood cell that remembers pathogens your body has encountered before. These lymphocytes make you immune to the pathogens. Color and label the Peyer's patches.
7. **White blood cells** are made in your **bone marrow**. White blood cells are carried by your blood and lymph. They are the disease-fighting soldiers of your immune system. When a pathogen enters your body, white blood cells attack it. They kill the pathogen with chemicals or they engulf it and "eat" it. **Fevers** are caused by your own immune system. Your higher body temperature helps fight infection by "cooking" pathogens. Color and label the bone marrow.



# Lymphatic & Immune Systems



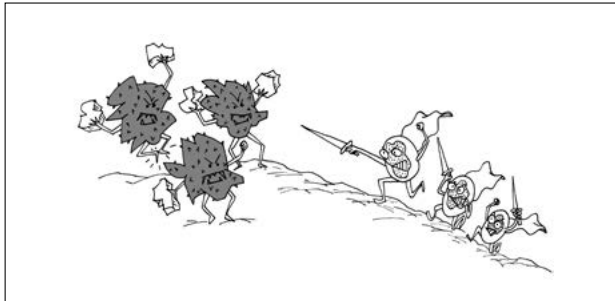


# Bacteria Out of Control

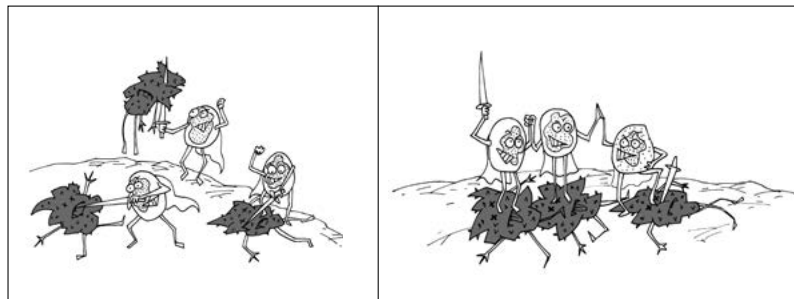
## Activity

Your immune and lymphatic systems work hard to keep you healthy. They constantly scour your body looking for pathogens. Despite all their hard work, sometimes you still get sick. The war between the immune and lymphatic systems and dangerous bacteria has been going on for millions of years. Bacteria have an important weapon in their arsenal—the ability to reproduce quickly. This is one of the advantages for organisms, like bacteria, that reproduce asexually.

*Bacteria infect an organism. The immune system does battle, conquering the bacteria.*



*After that, the organism's immune system recognizes that type of bacteria and it cannot make that organism sick anymore.*



All organisms are made of one or more cells. You are made from many cells, bacteria are made from one cell. Cells only come from existing cells. In a process called cell division, one cell divides to become two cells. This is an important process because it is how you grow and bacteria reproduce.

## Asexual Reproduction

Humans use cell division to grow, heal wounds, and replace cells. Some organisms use cell division for **reproduction** (to make more copies of themselves). This type of reproduction is called **asexual reproduction**. The offspring are genetically identical to their parent. Forms of asexual reproduction include binary fission, budding, vegetative propagation, and regeneration.

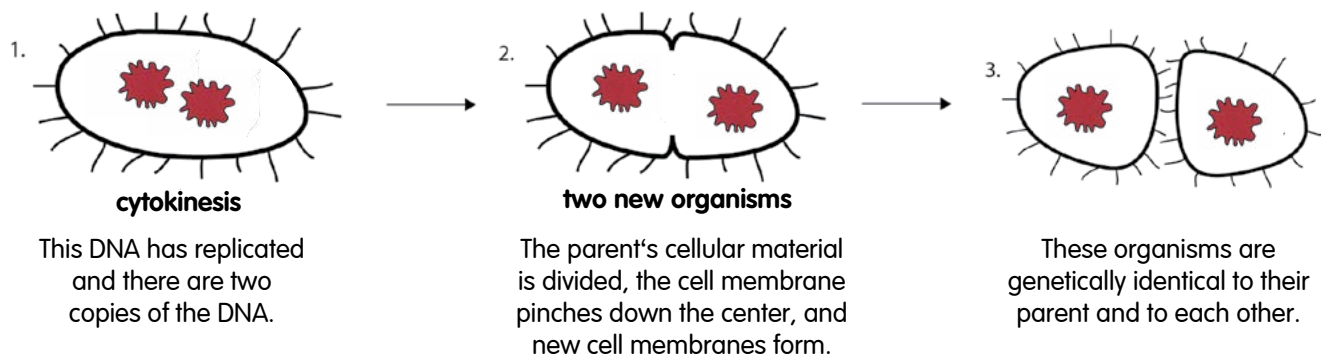
## Activity *continued*

### Binary Fission

**Binary fission** occurs when a unicellular organism, such as bacteria, divides into two genetically identical cells. The parent is gone.

If conditions are ideal, like the warm and moist inside of your body, the average time for bacteria to reproduce (to divide) is 15 minutes. One bacterium divides into two, 15 minutes later those two bacteria divide in two, making four bacteria; and then those four bacteria divide in two, making eight bacteria. It takes less time than you would think to have over 1,000 bacteria. Today you will see just how long that takes.

It usually takes one or more cells from your immune system to deal with one cell of an invader.



When bacteria are multiplying so rapidly, it is a lot of work for your body to keep up and kill the bacteria. Your body responds with fevers and by making more white blood cells.

Today's lab will give you an idea what your immune and lymphatic systems have to contend with, dealing with an invader that can reproduce so quickly. Today's bacteria are cleverly disguised as a piece of paper, "*bacteria papericium*." With it, you will discover how fast real bacteria can multiply just by doubling every 15 minutes.

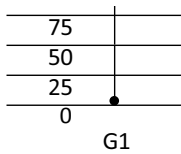
## Materials

- 8 ½" x 11" piece of plain paper
- Calculator
- Lab sheet

# Activity *continued*

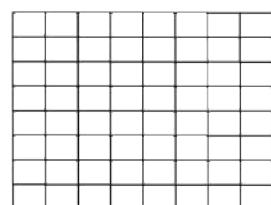
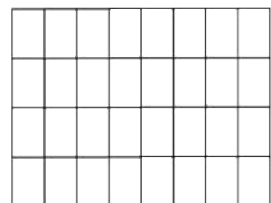
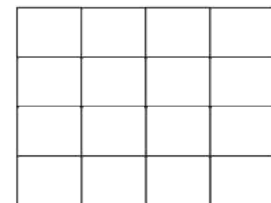
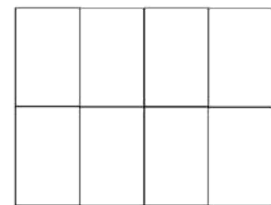
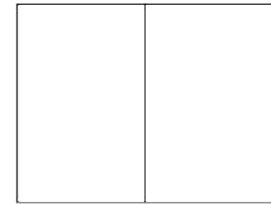
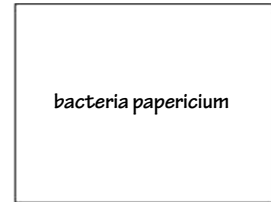
## Procedure

- In the middle of the piece of paper write *bacteria papericum*. This will be the original parent organism, the infecting cell of bacteria.
- Take a look at the graph on the lab sheet. The X-axis (going across from left to right) is the generation axis. G1 is the first generation, G2 is the second generation, G3 is the third generation, and so on up to G11, which is the eleventh generation. Each time *bacteria papericum* reproduces, which occurs each time you rip the paper "organisms" in half, it is a new generation. The Y-axis (moving up the graph from the bottom to the top) is the number of organisms in that generation. At G11 you will have halved each piece of paper ten times (not eleven because G1 starts with the first piece of paper).
- Start by counting the parent organism (the entire piece of paper) which equals 1. Make a dot on the graph at this point. The point is at (G1, 1) like this:



Note: The points you will graph from G1 through G4 are very close to the X-axis. 1 is slightly above the 0 line. You do not need to worry about being exact with where you place your point. An approximate placement is good enough for this lab.

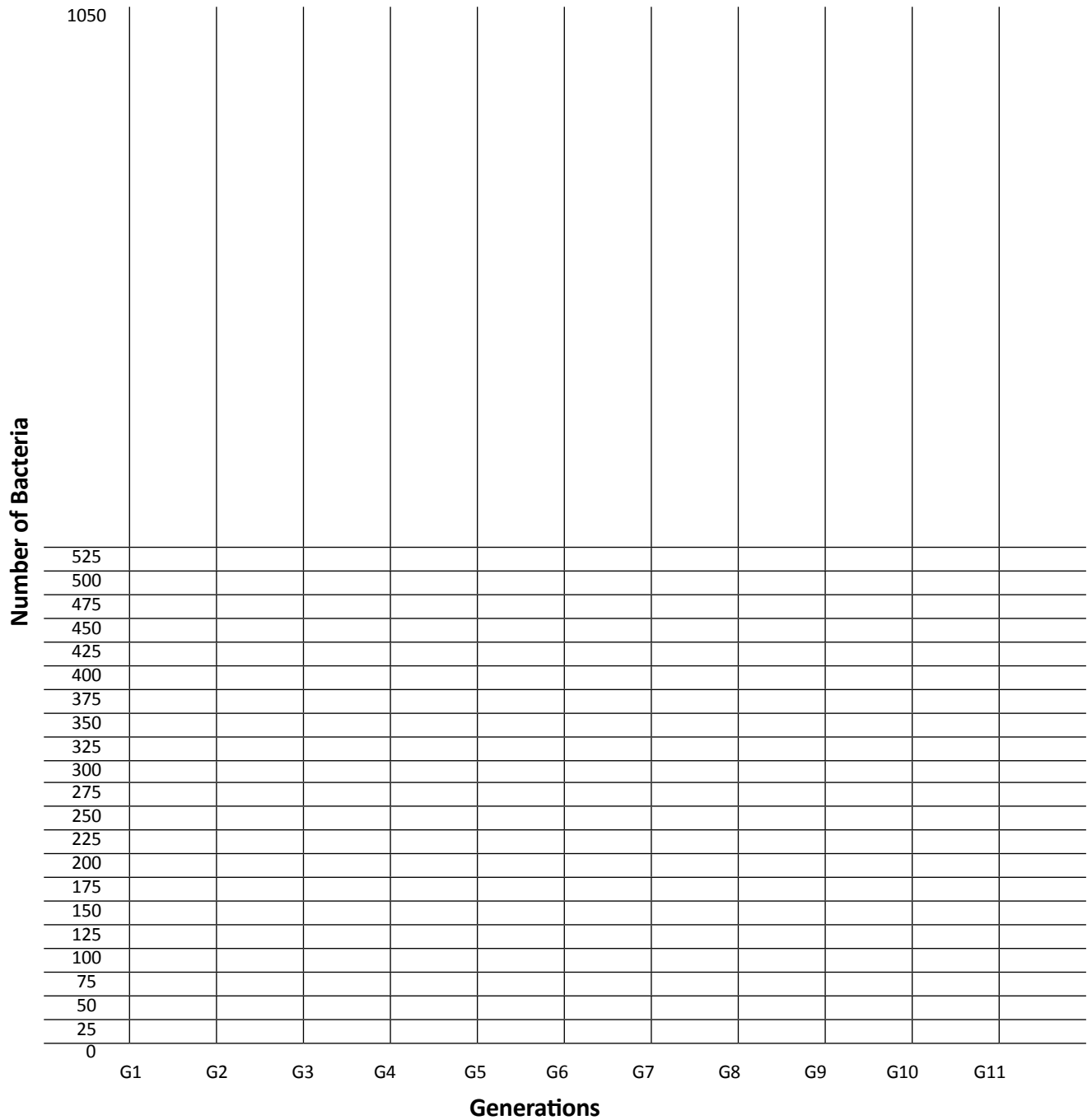
- Fold the paper in half, unfold it, and rip it in two pieces along the fold line. This is the second generation. Graph this point (G2, 2).
- Fold the two pieces of paper in half, unfold, and rip to make four *bacteria papericum*. This is the third generation. Graph this point (G2, 4).
- Fold, rip, and record four more times and graph up to the seventh generation.
- At this point you can stop folding and ripping the paper and use a calculator to determine the number of individuals in G8 through G11. To do this, multiply the number of organisms in the previous generation by 2, since they double every generation. Graph each generation.
- Connect the dots on the graph.
- Answer the questions on the lab sheet.



# Bacteria Out of Control

## Activity Sheet

### Bacteria Papericum Out of Control







## Protecting Yourself from Pathogens

by Blair H. Lee

With the discovery of the germ theory and the knowledge that pathogens cause many infectious diseases, scientists were able to begin working on ways to kill pathogens without harming patients. The first step is to stop people from getting infected. If you are careful, that is easier than you might think. You do this by not touching things, something people really like to do, and by avoiding coming in contact with people who are infected. You want to make sure you wash your hand regularly, because this washes away pathogens. You also want to use hand sanitizer, which kills many pathogens, on your clean hands. Even if you do all of these, you can still get sick. If you get sick from a bacterial pathogen, your doctor might prescribe antibiotics. Antibiotics are a medicine that kills bacterial pathogens. Antibiotics do not kill viruses. Antibiotics also do not prevent infections. They must be used sparingly or pathogens will develop resistance to them, called antibiotic resistance, and they will no longer be effective against the bacterial pathogen.

The word *antibiotic* means “against life” in Latin. Antibiotics are made from chemicals that keep bacteria from growing and reproducing. The chemicals that work against bacteria, do not work against viruses. Antibiotics are developed to target the cells of bacteria not your cells. When virus pathogens infect you, they hijack your cells and turn them into virus-making factories. From the standpoint of antibiotics, they are still your cells.

To combat viral infections, like polio, scientists develop medicines called vaccines. When a serious viral pathogen infects a population, it usually will not kill everyone. Some people will have a natural immunity to the pathogen. Some people will be strong enough that they survive, after which they will be immune to the disease. This is called acquired immunity. Some people will have a partial immunity, meaning they get sick but not as sick. Most of these people also survive. Mothers pass many of their immunities on to their children. A mother who is immune to a virus will usually have a baby who is immune to the same virus.

## Keeping Pathogens Out

The first line of defense in your war against pathogens is to not let them in! People touch things all the time without even thinking about it. Every time you touch something you risk picking up pathogens. They are microscopic so you won't be able to see them either! If you are out in public this is even more of a problem. At least at home, everyone shares the same germs. In public, there are germs no one in your family has. There are some things, like public toilets, we are taught to always wash our hands after touching. There are many studies, however, showing that there are dirtier things people touch all the time without washing their hands after touching. These include sinks in public restrooms, water fountain buttons, handrails, doorknobs, money, and elevator buttons. Scientists have found that elevator buttons have 40 times more pathogens on them than public toilet seats! YUCK! You cannot avoid touching many of these. What you can do is to be careful and wash your hands with soap and water before touching your face or touching someone else. You can also use hand sanitizer. Hand sanitizer works best on clean hands. Hand sanitizer does not kill every pathogen. When you wash your hands and use hand sanitizer together, that is the best way to keep pathogens from getting in.

*An article with excellent advice for keeping pathogens out: "I had no immune system for months after my bone marrow transplant. Here's how I avoided viral illness, and how you can, too. It's easier than you think."*

<https://medium.com/@amcarter/i-had-no-immune-system-for-months-after-my-bone-marrow-transplant-1b097f16040c>



## How Dirty Can They Really Be?

An Investigation Lab by Blair H. Lee



Look at your hands. How dirty can they really be? Smell them. Do they smell clean or dirty? If they look clean and have a smell, what is giving them a scent? Whether you can see them or not, your hands are literally covered in foreign particles, bacteria, and maybe even viruses. In this lab, you will investigate how dirty your hands can really be.

### Materials

- 3 thick slices of white bread that contains as few preservatives as possible (don't choose the loaf's end slices). Homemade or bakery-made bread with no preservatives is best.
- 3 baggies
- Permanent marker
- Soap
- Warm water
- Tongs that have been sterilized in boiling water
- Your unwashed hands (at least two active hours since you last washed them)

### Procedure

1. Label the three baggies, *Control*, *Dirty*, and *Clean*—one word on each.
2. Use the tongs to place one bread slice in the bag that is labeled *Control*.
3. Pick up a bread slice with your unwashed hands and lightly squeeze and rub it on both sides. Put this this piece of bread in the bag labeled *Dirty*.
4. Wash your hands using the handwashing procedure found on the next page.
5. Pick up a bread slice with your now superclean hands and lightly squeeze it on both sides. Put this in the bag that is labeled *Clean*.
6. Every day, for a week or more, look at the three bags and monitor what happens.

# Winning the War on Pathogens!

An Activity by Blair H. Lee



For most of human history people have been battling pathogens and losing. It hasn't even been 200 years since scientists discovered pathogens cause disease (the germ theory). And it was many more years until handwashing after using the bathroom became the norm. EW! These days, we all know to wash our hands, but did you know that there is a proper handwashing technique?

Pathogens

they like it on your hands

they want to get inside you

they want to make millions of copies

they **don't** want to go down the drain!

Germs are harder to wash off than many of us give them credit for. In this activity, you will learn the best technique for getting rid of pathogens on your hands as recommended by the Centers for Disease Control and Prevention.

## Materials

- A sink with running water
- Soap (it does not have to be antibacterial)
- Your hands

## Procedure

1. Wet your hands with water. Turn off the water.
2. Squirt or rub soap on your hands creating a lather. Make sure you rub it everywhere including between your fingers. Rub your hands for 20 seconds. Either use a timer to do this or sing the Happy Birthday song twice through.
3. Rinse your hands of all soap with clean running water.
4. Dry your hands with a clean towel or air-dry them.

# A Winning Weapon: Hand Sanitizer

A Recipe by Blair H. Lee

Hand sanitizer is another weapon against pathogens. Hand sanitizer contains rubbing alcohol. There are other ingredients in hand sanitizer, but rubbing alcohol is the active ingredient. The active ingredient in a substance is the one that is responsible for the substance's activity. The alcohol in hand sanitizer is the ingredient that kills most, but not all, types of bacteria and viruses. Hand sanitizer is a good way to kill the germs on your hands, unless they are too grimy. Your hands have to be fairly clean for it to work. Hand sanitizer is a great choice when you aren't near soap and a sink, but it does not take the place of washing your hands. This activity has a recipe for making your own hand sanitizer. I bet you never guessed you would be making your own weapons!

## Materials

- $\frac{3}{4}$  cup of 99% isopropyl or rubbing alcohol
- $\frac{1}{4}$  cup of aloe vera gel
- 10 drops of tea tree oil, lavender oil, or lemon juice
- Funnel (optional)
- Bottle with a cap. A clean, empty hand sanitizer bottle will work well.
- Permanent marker

## Procedure

1. If you are using one, put the funnel in the bottle.
2. Measure each ingredient into the bottle. Put the cap on the bottle and shake well but carefully.
3. Label the bottle as hand sanitizer.

Learn

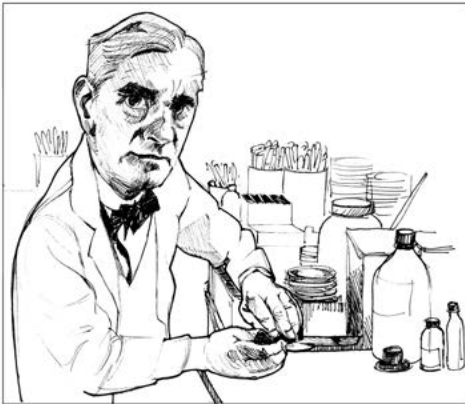


# Alexander Fleming

## Research

*This is a research activity. Use your computer to find the answers to the following questions. Suggested answers can be found at the end of this unit study.*

### Infection, Antibiotics, and War



Alexander Fleming

You're out shopping. Without thinking, you put your hand on the checkout counter and then spread lip balm on without washing your hands. There were live bacteria on the counter and now they are on your lips. You lick your lips, and now they are inside you. You are going to be sick. It will take a couple of days before you know it, but you are. First, your throat will hurt. Then, you will start sneezing. Next, your whole body will start hurting and you will have a fever. Your parent will take you to the doctor, and the doctor might prescribe antibiotics. Think about it: no more bacteria than would fit on the tip of your finger got inside you and made your whole body sick.

1. When were antibiotics discovered? Who discovered them? What was the name of the first antibiotic?
  
  
  
  
  
  
  
  
  
  
2. This scientist fought in what war? What did he see in that war that caused him to dedicate his life to finding an antibacterial agent?

## Research *continued*



3. For much of human history, there has been a war going on somewhere. What happened to wounded soldiers in the time before there were antibiotics? We can look at data from the Civil War to help answer this question. The Surgeon General of the United States at the time, William A. Hammond of the Union Medical Corps, kept detailed records of the causes of deaths of Union soldiers. Based on these records:

A. What percentage of Union soldiers who died, died from infectious disease?

B. What is the estimated percentage of Confederate soldiers who died from infectious disease?

C. Of the 620,000 soldiers who died in the Civil War, approximately how many died from infectious disease?

Think of all the wars in history that occurred before World War II and the discovery of penicillin. Think of all the people in all the wars that died from infections that could have been cured with antibiotics. That is a lot of people! Isn't it?

Learn



# Smallpox

## Research

*This is a research activity. Use your computer to find the answers to the following questions. Suggested answers can be found at the end of this unit study.*

### Smallpox: What Columbus Brought



Have you gotten your shots? Most children in the world today are immunized against several different diseases with vaccines. Vaccines contain a neutralized form of the pathogen. They expose your immune system to the pathogen. After that, your body recognizes that pathogen and you are immune to the disease it causes. That means if you are exposed to the pathogen causing that disease, you will not get sick from it.

There have been a few types of pathogens that over the course of human history have caused much death and suffering. The smallpox virus is one of those. What happens to people infected with it?

## Research *continued*

When and where did smallpox originate?

Was smallpox a problem in Europe too?

Scientists believe smallpox originated in India or Egypt over 3,000 years ago. It was a devastating disease that killed an average of 30 percent of the people who got it. Explorers and settlers brought it with them to the Americas. Indigenous people in the Americas had never been exposed to the virus before, and had little or no immunity to it.

How and when did smallpox come to the Americas?

What percentage of Native Americans are thought to have been killed by the virus?

How did this virus help bring down the Aztec Empire?

Worldwide, smallpox is considered to be an eradicated virus. What does that mean?

How was smallpox eradicated?

## Contributors

The educators, historians, and scientists that made contributions to the Pandemic Unit Study also create curriculum and write books for Pandia Press. Many of the lessons and activities found in this guide are adapted from *History Quest* and *REAL Science Odyssey*, both published by Pandia Press. Visit [www.pandiapress.com](http://www.pandiapress.com) to learn more.



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Lindsey is the editor of *History Quest: Early Times* and the co-author of the *History Quest: Early Times Study Guide*. She is currently hard at work on the next book in the series.



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Amy Sharony is the founder and editor of *home/school/life* magazine. She studied physics, philosophy, and literature in college, completing her Ph.D. in English and comparative literature at Columbia University. She lives in Atlanta with her husband, her two happily homeschooled children, and one very spoiled dog.

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Blair is the primary author of Pandia Press's critically acclaimed *R.E.A.L. Science Odyssey* Series, and she is the author of *The Science of Climate Change: A Hands-On Course*. She is also the co-author of *Project-Based Learning: Creating a Modern Education of Curiosity, Innovation, and Impact*.

# Teacher Guides and Answer Keys

## Pandemic History

### Teacher's Guide for Pandemics and Progress: The Spanish Flu of 1918 and COVID-19 of 2020

This lesson is designed to be flexible for students in middle school through high school. For students on the younger end of this range, you may need to help with the reading. At this age, I believe students should be tackling primary sources and articles written by scientists and historians, so I have introduced a few in this lesson, but development can be asynchronous and you know your student best and should assist them when needed to scaffold new skills. Older students should be expected to answer with more complexity and thoughtfulness. In terms of schedule, I recommend doing a section a day to absorb and reflect, but do what works best for your student and schedule.

If you have a sensitive teen, this lesson may be emotionally challenging. I've intentionally written it to focus on the facts and provoke critical thinking, but the subject matter is, by nature, difficult for some. For others, studying the past and analyzing data can be comforting and help one feel in control. The two most important outcomes I hope for students is to understand how studying history is relevant and useful in solving current problems, and how our actions today write the history of tomorrow.

Below are sample answers for the questions posed. Answers, of course, will vary, but this section will help you to guide your student. I encourage you to pause and go on tangents if your student is interested in diving deeper on a particular topic.

#### Pandemic vs. Endemic vs. Outbreak

Possible Answers:

1. Define these terms.

*Outbreak: An outbreak is when the number of cases of a particular disease is more than what is normally expected.*

*Endemic: An endemic is when there is a disease that exists constantly or naturally in a specific region.*

*Pandemic: A pandemic is when a disease has spread over several countries or continents and affected large numbers of people.*

2. Infectious disease specialist Dr. Pritish Tosh gives an example of dengue fever on the Big Island of Hawaii. How were these cases different than dengue fever cases in other parts of the world? Why were the cases on the Big Island considered an outbreak? How did they stop the outbreak?

*Dengue fever does not usually occur on the Big Island of Hawaii, so it is not endemic in Hawaii, like it is in other places in the world. It is assumed that a traveler, already infected with dengue fever, brought it to Hawaii, where they were likely bitten by a mosquito, which then bit and infected other people, causing an outbreak. Once the infected people were identified and treated, the transmission was stopped and the outbreak was controlled and eliminated.*

3. Why are the Spanish Flu of 1918 and the current COVID-19 virus considered pandemics?

*Both the Spanish Flu of 1918 and the current COVID-19 virus are considered pandemics because they affected/are affecting many countries and continents, and large numbers of people contracted the illness.*

4. Look at the visual graphic and/or chart of pandemics.

The Scientific Revolution of the 16th and 17th centuries saw the emergence of modern science, changing how society viewed nature through advancements in math, physics, chemistry, astronomy, and biology (including human anatomy and medicine). How many of the deadliest pandemics on this list happened before the 16th century?

*There are four pandemics before the 16th century: The Antonine Plague, Japanese smallpox epidemic, Plague of Justinian, and the Black Death.*

The Golden Age of Science in the 19th century promoted the rapid expansion of scientific knowledge, application, and invention. Many scientific discoveries based on experimentation and the analysis of other scientists improved many people's way of life and began to move society toward a holistic understanding of science and the way things work. How many of the deadliest pandemics on this list happened before the 19th century?

*There are eight pandemics before the 19th century, those listed above plus: The "New World" smallpox outbreak, Great Plague of London, Italian Plague, and some of the Cholera pandemics.*

The Golden Age of Medicine is considered to have started in the 1930s through the 1950s, when the way healthcare was structured changed dramatically and new advancements in research, treatment, and prevention benefitted every level of society. How many of the deadliest pandemics on this list happened before the 1930s?

*There are thirteen pandemics before the 1930s, those listed above plus: the rest of the Cholera pandemics, Third Plague, Yellow Fever, Russian Flu, and Spanish Flu.*

The Age of Modern Medicine generally began in the 1980s, with the integration of modern technology into research and healthcare. How many of the deadliest pandemics on this list happened before the 1980s?

*There are fifteen pandemics before the 1980s, those listed above plus: The Asian Flu and the Hong Kong Flu.*

What effect do you think the historical events listed above had on the outcomes of the pandemics that happened during that time?

*Answers will vary. Students may research and answer for each time period, or they may give a general answer. Those answers may include the advancement of science and its positive effect on medical understanding and treatment, and the changing view on healthcare, which has helped improve survival rates in pandemics (and overall).*

How many pandemics have happened after 1980?

*There are six pandemics listed as occurring after 1980: HIV/AIDS, Swine Flu, SARS, Ebola, MERS, and COVID-19.*

Looking back on this information, how many of the 20 pandemics listed occurred before 1980? What percentage is this? Is the death rate higher or lower after 1980? Why do you think this is?

*Fourteen (fifteen if students counted the Cholera pandemics twice) of the pandemics listed happened before the 1980s, or 70 percent. With the exception of HIV/AIDS, the death rate is lower. Answers will vary, but student answers may include that research, treatment, and prevention have all improved, and technology has advanced the way our healthcare systems predict and respond to pandemics.*

What has changed over time in the way we respond to pandemics? What has not changed in the spread of disease?

*Answers will vary, but student answers may include that our scientific knowledge, healthcare systems, technology, and treatment options have all contributed to the way we are able to predict and respond to pandemics faster. The world is also increasingly more urban, creating denser living situations, which increases the likelihood of spreading disease quickly. The global trade, travel, and military movements (though not like in World War I) around the world have not changed, and continue to spread disease in the same way it always has.*

## **The Spanish Flu of 1918**

Possible Answers:

1. The picture below is of an emergency hospital at Camp Funston in Kansas in 1918, where one of the first established cases of this pandemic was found. This picture is considered a primary source. A primary source is any source of information (photograph, art, manuscript, letter, diary, recording, artifact, etc.) that was created during the time you are studying. Look carefully at the picture.

What do you see? *Answers will vary. Students might describe the setting, the people, the details, etc.*

What is happening in this photograph? *Answers will vary. Students may describe the patients tended by doctors, patients sleeping, people having conversations.*

Who is caring for the patients? *Answers will vary. Students may say doctors and other healthcare workers.*

Where was this photograph taken? Is the place important? *Camp Funston in Kansas. It was an important site since it was where one of the first established cases of this pandemic was found.*

How does fresh air get in? *Answers may vary, but point out the open windows.*

How do you think it feels to be a patient in this emergency hospital? *Answers will vary.*

What do you wonder about this picture? *Answers will vary.*

How does this picture make you feel? *Answers will vary.*

What can we learn from this picture as a primary source? *Answers will vary. Primary sources provide a window into historic events, places, and people. This photograph shows us many things from 1918: how emergency hospitals were set up, the proximity of the patients with contagious disease, the conditions in which doctors cared for patients, building details, clothing preferences, and more.*

2. How did World War I contribute to the spread of the Spanish Flu?

*The movement of soldiers, as well as supply convoys, across countries and continents spread the flu quickly.*

3. Describe the first, second, and third wave of the Spanish Flu.

*The first wave of the Spanish Flu was in the spring of 1918 and was relatively mild and short-lasting. The second wave began around August 1918 and was deadly, most likely because the virus had mutated, causing majority of illness and death worldwide during this pandemic. The third wave hit the world after the quarantine was lifted in late 1918, finally ending in May 1919 for most countries.*

4. What did scientists think caused influenza? Who presented the hypothesis that influenza is caused by a virus and when? When was it officially recognized that influenza was caused by a virus? When were scientists able to isolate the first human virus?

*Scientists believed that influenza was caused by Pfeiffer's bacillus (*Haemophilus influenzae* bacterium). Scientists from the Pasteur Institute, Nicolle and Lebailly, presented the hypothesis that influenza is caused by a virus in October 1918. It wasn't until 1930 that the flu was recognized as being caused by a virus, and not until 1933 that scientists were able to isolate the first human influenza virus.*

5. Name three public health measures from 1918 that are similar to what we are currently doing to curb the spread of COVID-19. Are there any that are no longer relevant?

*Answers will vary, but may include suspending public meetings, social distancing, quarantine, closure of businesses and public meeting places, and limiting people in essential shops and public transportation. Answers will vary, but students may think that forbidding spitting in the street or services for the removal of human waste may no longer be considered as we have modern systems and laws for those in place.*

6. Why was this pandemic called the “Spanish Flu”? What problems might be caused by calling an international pandemic after a specific country? Have we seen this problem with COVID-19?

*It was called the Spanish Flu because during World War I, Spain was neutral and Spanish newspapers were free to report on the devastation that the flu was having on their country. This made people think that the illness had originated in Spain, especially since other countries were purposely not reporting the spread of the disease in order to avoid public alarm during wartime. Eventually, other countries could no longer deny what was happening but the name stuck. Naming an international pandemic after a specific country can cause many problems, such as inaccurate science and racism. We can see this problem today with COVID-19, in which some have dubbed it “The Chinese Virus,” causing incidences of assault and racism toward Asian people in several different countries.*

7. How many people were infected and how many died of the Spanish Flu of 1918? What percentage of those infected died? What was the overwhelming cause of death?

*About 500 million people were infected and 50 million died, or 10 percent. The overwhelming cause of death was bacterial pneumonia, a secondary infection caused by the conditions of influenza on the body. (As a side note: Today bacterial pneumonia is treated with antibiotics. In 1918, antibiotics had not yet been invented.)*

8. According to this article, what improvements to public health were a result of the 1918 pandemic?

*Answers will vary, but may include health education, isolation and social distancing, sanitation, record-keeping, surveillance, and scientific knowledge.*

	Before the 1918 Pandemic	After the 1918 Pandemic
<b>What did healthcare look like?</b>	<i>Doctors worked for themselves or were funded by charity. The poor and working class had limited access to healthcare.</i>	<i>Many countries adopted a centralized national healthcare system. The United States installed employer-based insurance schemes.</i>
<b>What were the medical treatments available for the virus?</b>	<i>Almost none.</i>	<i>As a scientific understanding of influenza developed, flu vaccines, antiviral medications, and, in 1928, the first antibiotics became available.</i>
<b>How was the study of epidemiology approached?</b>	<i>It wasn't a funded, specific branch of science until after 1918.</i>	<i>Epidemiology is now an important branch of science, helping to collect data, understand the patterns and consequences of disease, and assist in the planning and prevention of disease spread.</i>
<b>What public health measures helped prevent the spread of disease?</b>	<i>Closing public meeting places and quarantine, but because there was no data to predict pandemics, often these were imposed too late.</i>	<i>Closing public meeting places, quarantine, data reporting, global communication, uncensored media, scientific advancements.</i>

9. How were public healthcare policies influenced by the idea of eugenics before 1918? How did people justify this viewpoint? Do we see any examples of this attitude today?

*Since it was common for the wealthy and privileged to view the poor and working class as lazy and pre-disposed to disease and lack of hygiene, and that their inability to improve their lives was their own fault, there was little effort made to provide even the most basic healthcare. Answers will vary, but there are many examples still in the world in which the poor and working class are blamed for their circumstance, the United States included.*

10. The World Health Organization's (WHO) constitution states (as it was written in 1946) "The enjoyment of the highest attainable standard of health is one of the fundamental rights of every human being without distinction of race, religion, political belief, economic or social condition." How did this idea and assertion influence the way future pandemics were approached?

*Answers will vary, but may include: The adoption on an egalitarian approach to health, or the belief that people are equal and should have the same rights and opportunities, discouraged the viewpoint that individuals are to blame for disease. It encouraged countries to ensure their citizens have access to healthcare, and promoted the prevention and treatment of disease as a worldwide responsibility.*

### **COVID-19: Learning from the Past and Preparing for the Future**

1. What are the four main lessons this article points out as similarities between the two pandemics, and that we should learn from in order to protect as much of our population as possible?

Possible answers include:

*The primary cause of infection was viral. However, pneumonia, a bacterial disease, was often the cause of death in 1918, and COVID-19 is following the same pattern in affecting the body and making people, especially the elderly and immune-compromised, susceptible to secondary infections.*

*There are few places that could escape the disease spread. In 1918, there wasn't much air travel but steamships and trains helped carry the disease around the world aided by the intense travel and interaction of soldiers fighting in World War I. Nowadays, the world is so interconnected with all kinds of travel, but especially air travel, that there is no way to prevent the spread of disease without restricting or shutting down travel entirely.*

*Different viruses target different populations, and in 1918 the young and healthy were the most at risk for complications and death, while the elderly and immune-compromised seem most at risk with COVID-19, but the data is still coming in. This means we have to be prepared for anything when we don't know how a new virus will act or spread.*

*Public health is the best defense. Many people did not have access to healthcare in 1918, and what was available could not offer reliable treatment. Supporting scientific advancement and funding medical studies will allow us to protect all of society with medicine and vaccines, and having consistent, proven public measures like quarantines and government-based resource assistance will allow us to contain disease and survive pandemics, socially and economically.*

2. Why does Joe Hanson (the man in the video) call pandemics a paradox?

*Answers will vary, but might include: A paradox is something that seems illogical or absurd, but through evidence or explanation turns out to be true. He calls pandemics a paradox because they go from just a few people being sick to many people being sick in a very short time frame, in an almost impossible way that makes people doubt the seriousness or reality of the situation.*

3. Sketch a graph of what an outbreak or pandemic looks like with rapid spread versus slow spread. Include a line to represent the capacity of the healthcare system. Why is a slow spread better?

*Students should be able to sketch a graph that looks like the one in the video. The rapid spread rises quickly, well above the line for healthcare capacity, and then falls quickly, while the slow growth takes more time, but stays below the healthcare capacity line.*

4. Summarize the example the video gave of exponential growth using lily pads.

*Answers may include: Using the lily pads in a pond as an example, if the growth rate doubles every day, then at first it won't seem like that much, but on day 54 out of 60, 1 percent of the pond will be covered, and on day 59, 50 percent of the pond will be covered, and on day 60, 100 percent of the pond will be covered. That is a rapid increase all at once!*

5. Why is it important to slow the spread of disease in a pandemic?

*Answers may include: Slowing the spread of disease in a pandemic allows us to protect the most vulnerable in our community, prevent our healthcare system from becoming overwhelmed, gives us time to research and find new treatments, and increases the survival rate.*

6. Compare how the two cities of Philadelphia and St. Louis responded to the 1918 pandemic, referencing both the video and the chart below. What was the outcome for each city? Now compare it to the graph you created for in question 3. What do you notice?

*Answers may include: Philadelphia ignored all warnings and held a parade attended by 200,000 people. Within three days, every hospital bed was full and 4,500 people died within a week. On the other hand, St. Louis heeded all the warnings and shut down all public places including schools, canceled events, and changed work schedules just two days after the first cases were detected in the city. As a result, more people survived in St. Louis.*

*Students should notice that the graph they made closely matches the graph of these two cities.*



7. What is this a map of?

*This map tracks the number of confirmed COVID-19 cases throughout the world.*

8. What is GIS and how does it work? (You may need to research this.)

*GIS stands for “Geographic Information System.” It is capable of gathering, managing, and analyzing data. It is capable of looking at data, both independently and in context with multiple sets of information. It looks at location specific information, and can layer analysis in different kinds of visualizations, from heat maps to 3D views and more. GIS can provide deeper, more meaningful insights into patterns and relationships, helping us to understand and analyze situations and events.*

9. Where does this map get its data from?

*This map gets its data from the World Health Organization (WHO), the Centers for Disease Control (CDC), the European Centre for Disease Prevention and Control (ECDC), the National Health Commission of the People’s Republic of China (NHC), DXY (an online community for Chinese physicians and other healthcare professionals), and 1Point3Acres (a group of Chinese immigrants in the US who built a real-time COVID-19 tracker for public awareness and transparency). These organizations are listed at the bottom of the map.*

10. Describe all the information this map tells us. What does it not tell us?

*Answers will vary, and may include: total number of confirmed cases of COVID-19 worldwide, by country, and by city; total number of deaths from COVID-19 worldwide, by country and by city; total number of active cases of COVID-19 worldwide, by country and by city; total number of people recovered from COVID-19 worldwide, by country, and by city; a graph showing the overall increase in cases of COVID-19; a graph showing the daily increase in cases of COVID-19.*

*Answers will vary, and may include: The map does not show us any personal data on those who contracted COVID-19 (age, health, sex, etc.), how severe the cases were, how many people had to go to the hospital, how the virus responded to treatment, what public health measures were put into place in any given area, any localized graphs of increase or decrease of disease, etc.*

11. How many ways could this map be used, and by whom?

*Answers will vary, but may include: epidemiologists using data to track and understand virus for research, healthcare professionals to prepare for cases in their region, government officials making decisions on public health measures and resource planning and distribution, school administrators planning for closures and online learning, businesses making decisions for the company and their employees, curious learners tracking the virus.*

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# Pandemic Science

## Are Viruses Alive?

This lesson explains the nine characteristics that define life and introduces the intriguing and thought-provoking example of viruses. The debate about viruses is a real-world application of the characteristics defining life. As students think through the debate about how viruses should be categorized, living or not, they will have to think through the characteristics used to define an organism as living. This will help reinforce these defining characteristics. Students are asked to come to their own conclusion about whether viruses should be reclassified as organisms. There is no right or wrong answer. Viruses are what they are. The argument is really just a matter of definition, but definitions are very important when classifying organisms, so maybe the definition is not so trivial after all. If you want a topic to debate over dinner, this would be a good one.

## Polio (Poliomyelitis virus)

What is polio? How is it transmitted?

*Poliomyelitis or polio is a virus that infects people. Polio is transmitted through polio-contaminated feces. The route of transmission is usually from a person's hands to their mouth. You can also get polio from sharing eating utensils with an infected person.*

What does it do to a person who is infected with it? What is paralytic polio?

*Ninety percent of the people who get polio recover from it with no ill effects. The other ten percent develop symptoms. One percent of these people develop paralytic polio. Paralytic polio causes paralysis. This in turn can lead to deformities of the hips, ankles, and/or feet. Polio can also cause breathing problems. People who suffered from these breathing problems sometimes had to use an iron lung to help them breathe in order to stay alive. In severe cases, people infected with polio died.*

How long has polio been infecting people?

*Polio has been infecting people for thousands of years. A stone carving from Egypt dated to about 1500 B.C.E. shows a boy with shrunken legs caused by the virus. Tiny Tim in Charles Dickens's A Christmas Carol was probably a victim of polio. Polio mainly infects children.*

Which U.S. president had polio? When did he serve as president? How old was he when he contracted polio?

*Franklin Delano Roosevelt, FDR, was 39 years old when he contracted polio on August 10, 1921. He was the 32nd president. "Once you've spent two years trying to wiggle one toe, everything is in proportion," Roosevelt said in 1945.*

*FDR had paralytic polio, which caused him to be paralyzed from the waist down. He was the only disabled president. He served as president from 1933 to 1945. He was the only U.S. president to serve three terms. He died less than three months after he was elected to his fourth term. The United States Constitution has since been changed, so that no one can be elected for more than two terms as president.*

Who discovered the polio vaccine?

*Polio used to be widespread until Dr. Jonas Salk, a true American hero, discovered the polio vaccine. The polio vaccine was made available to the public in 1955. He did not patent his polio vaccine discovery, because it would have drastically increased the medicine's price. He freely distributed the polio vaccine so every child could be saved from contracting this potentially crippling disease. In addition to polio, Dr. Salk dedicated his life to researching the causes, preventions, and cures of influenza, cancer, and AIDS.*

The vaccine for polio was invented by a true American hero, Jonas Salk. Salk spent his life trying to find cures for deadly diseases like AIDS and polio. When he did find a vaccine that worked, he refused to patent it. Vaccines that are not patented are cheaper to produce and therefore available to more people. How did the U.S. president in the image above help in the fight against polio?

*FDR helped create the organization the March of Dimes, which raised more than \$20 million to fund Salk's research into finding a vaccine that worked.*

## The Good Guys

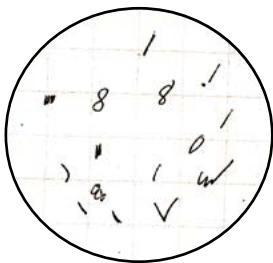
This lab takes two days with yogurt sitting at room temperature overnight between Day 1 and Day 2. You could complete the lab in one day if you divide the yogurt into two parts; keep one part refrigerated, and place the other on the counter 24 hours before the lab.

Bacteria are smaller than eukaryotic cells; even so, you can see them easily at 100x and 400x magnification. Be careful not to get yogurt that has fillers added like fruit or sugar or (perish the thought), M&M's. Make sure, also, that you get yogurt with live active culture; this is the good bacteria your students will be looking at.

Three of the types of bacteria in the samples I looked at were rod-shaped. I could see slight differences in them, but there was no obvious way to tell them apart. The streptococcus looked like little balls chained together; they were easy to see.

You might be surprised to see the bacteria stop moving after you add stain. Adding stain kills the bacteria. I would suggest staining, though; there is better definition of the organisms with the stain.

### Day 1



Read the label of the yogurt container. Write the names of the types of bacteria in the list of ingredients.

*Lactobacillus acidophilus*

*Lactobacillus bulgaricus*

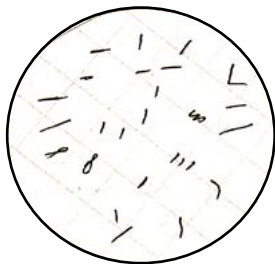
*Streptococcus thermophilus*

*Bifidus = Bifidobacterium*

The bacteria in yogurt can be recognized by their shape or grouping arrangement. Search the names of the bacteria on your computer, ask, "What shape are (*bacteria name*)?" Record the types of bacteria you see with your microscope. Which bacteria are most abundant? Which bacteria are least abundant?

*Answers will vary. Lactobacillus acidophilus = rod-shaped, Lactobacillus bulgaricus = rod-shaped, Streptococcus thermophilus = spheres connected as a chain, Bifidus = Bifidobacterium = rod-shaped*

*I saw lots of rod-shaped bacteria; some looked different from others and some of the rods seemed linked at their ends. There were several chains of spheres. I saw as few as two spheres linked and as many as six linked together. The rods were more abundant than the spheres.*

**Day 2**

Did you see anything new? Did the abundance of any type of bacteria change more than others? Give explanations with your answers.

*Answers will vary. I didn't see anything new, but there were about twice as many bacteria. I think the bacteria increased in number overnight using asexual reproduction.*

We have a symbiotic relationship with the good bacteria found in yogurt. These bacteria help us digest food and fight pathogens that get inside us. What benefit do we provide to the bacteria?

*We provide a nice, safe, warm place to live with plenty of food and water.*

**Death to the Prokaryotes!**

Most people take it for granted that the food we eat is safe. Canning is an important method of preserving food. In this lab, students will learn how food is canned and how harmful pathogens in food are killed. They will also learn the interesting history of canning. The process of canning food was invented so that Napoleon could better feed his troops during wartime.

**Lab Sheet Suggested Answers**

If old or rotting apples were used . . . *Rotting is caused by bacteria and other microorganisms. The more bacteria on the fruit, the harder it is to get rid of. The whole point is to eat non-rotten food.*

If bruises were not cut from the apples . . . *Bruised apples are damaged. Bruised sites can have small tears in them, which increases the threat that bacteria might get inside.*

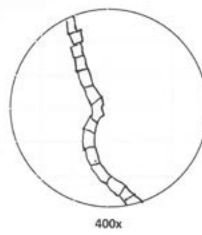
If the jars, rims, and lids were not clean . . . *You are washing away things that might spoil your food and make it unsafe to eat.*

If the seal between the jar and rim was not tight . . . *Microorganisms can get into the jars and spoil the food.*

If the applesauce was not cooked as long as it should have been . . . *You might not have killed all the microorganisms.*

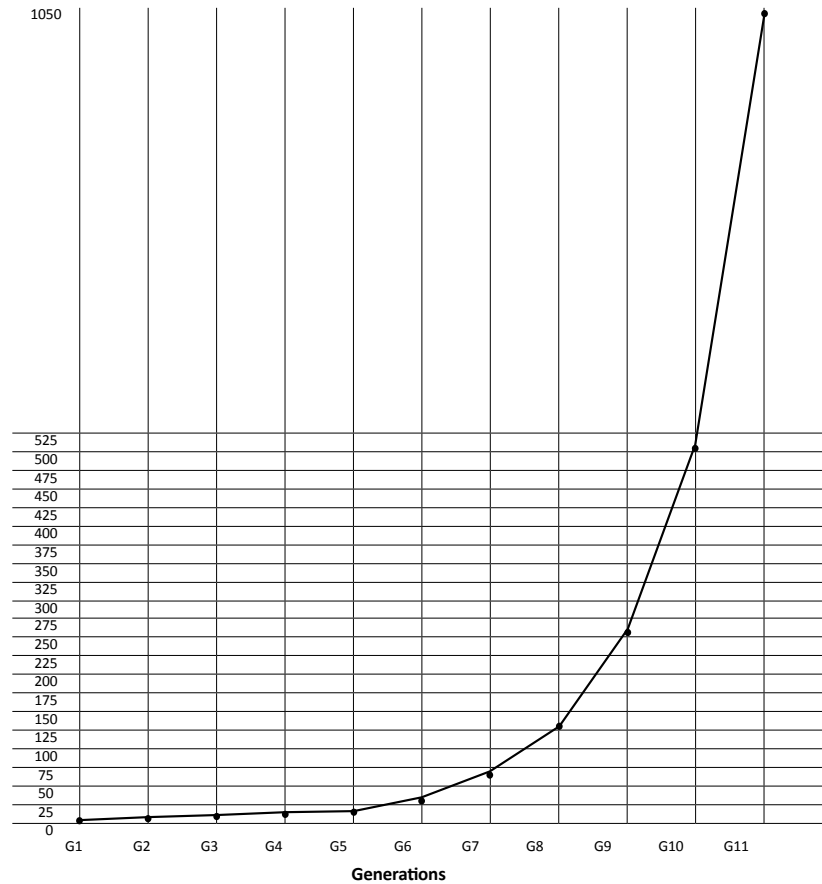
**Discovering Cells**

This lab recreates the historically important lab in which Robert Hooke documented the first microscopic view of a cell. The cells Hooke saw were cork cells. Cork is made from dead tree bark. Unlike cells that are alive, dead cells are "empty." Students will only see the cell walls of cork. During this lab, students will learn the important microscope technique of making wet mount slides. Note: If the cork is sliced too thick, you will not have a clear view of each cell.



## Bacteria Out of Control

This is a very short lab demonstrating how quickly a pathogen can go from one individual to many. This might be the first time your student hears about things growing exponentially. Other examples of exponential growth you could discuss are human population and compound interest.



- If it takes bacteria 15 minutes to divide, how long would it take for 11 generations to go from G1 to G11?  
*Going from G1 to G11 the bacteria divides 10 times.  $10 \times 15 = 150$  minutes, which is  $2\frac{1}{2}$  hours.*
- One bacterium can become one million bacteria in seven hours. How does that make it hard for your immune system to respond?  
*You have to make enough white blood cells to kill all those bacteria. That can overwhelm your system. That is a lot of white blood cells.*
- This type of growth is called exponential growth. Look up *exponential growth* in the dictionary and write the definition here.  
*Exponential growth is where the rate of growth becomes ever more rapid in proportion to the growing total number.*

## Alexander Fleming

1. When were antibiotics discovered? Who discovered them? What was the name of the first antibiotic?

*The first antibiotic to be discovered was penicillin in 1928, by Alexander Fleming.*

2. This scientist fought in what war? What did he see in that war that caused him to dedicate his life to finding an antibacterial agent?

*Fleming served as a captain in the Army Medical Corps throughout World War I. During the war, he witnessed many soldiers die from infected wounds. When the war was over, he dedicated himself to finding an antibacterial agent.*

3. For much of human history, there has been a war going on somewhere. What happened to wounded soldiers in the time before there were antibiotics? We can look at data from the Civil War to help answer this question. The Surgeon General of the United States, William A. Hammond of the Union Medical Corps, kept detailed records of the causes of deaths of Union soldiers. Based on these records:

A. What percentage of Union soldiers who died, died from infectious disease? *70 percent*

B. What is the estimated percentage of Confederate soldiers who died from infectious disease? *75 percent*

C. Of the 620,000 soldiers who died in the Civil War, approximately how many died from infectious disease? *414,000*

## Smallpox: What Columbus Brought

Vaccines are a controversial subject, but the death toll from some diseases was staggering. Smallpox is one example. In David McCullough's book *1776*, he relates that colonists feared the British abandoning Boston and leaving behind people infected with smallpox, who would infect the Continental Army. Because of this concern, the first group of Continental soldiers General George Washington sent into Boston were all men who had contracted and survived smallpox and were therefore immune to the disease.

I think this is a very interesting area of history. For a great adult book on the subject of plague I recommend *Justinian's Flea: Plague, Empire, and the Birth of Europe* by William Rosen. It gives you a real idea of how random and capricious killer diseases have been over the course of history, where a fluke of an individual's immune system, not merit, determines who survives and who does not.

### Possible Answers

There have been a few types of pathogens that over the course of human history have caused much death and suffering. The smallpox virus is one of those. What happens to people infected with it?

*People infected with it get small bumps, about the size of grains of rice, filled with pus all over their body. They also get a fever; and they can die.*

When and where did smallpox originate?

*In Africa more than 12,000 years ago. The smallpox virus has been found on Egyptian mummies that are 3,000 years old.*

Was smallpox a problem in Europe too?

*In Europe during the 18th century, smallpox killed about 400,000 people a year.*

How and when did smallpox come to the Americas?

*In 1495, slaves imported by Columbus brought the smallpox virus to the West Indies.*

What percentage of Native Americans are thought to have been killed by the virus?

*The virus killed 60 to 80 percent of Native Americans.*

How did this virus help bring down the Aztec Empire?

*In 1520, Hernan Cortes fought and lost to the Aztec Indians. One of Cortes's men had smallpox. Cortes and his army left in defeat; the virus did not. When Cortes came back one year later, many of the Aztecs were already dead from the disease and he was able to defeat the sick, dying, and weakened people who were left.*

Worldwide, smallpox is considered to be an eradicated virus. What does that mean?

*The smallpox virus was eliminated.*

How was smallpox eradicated?

*Smallpox was eradicated through a global vaccination program.*

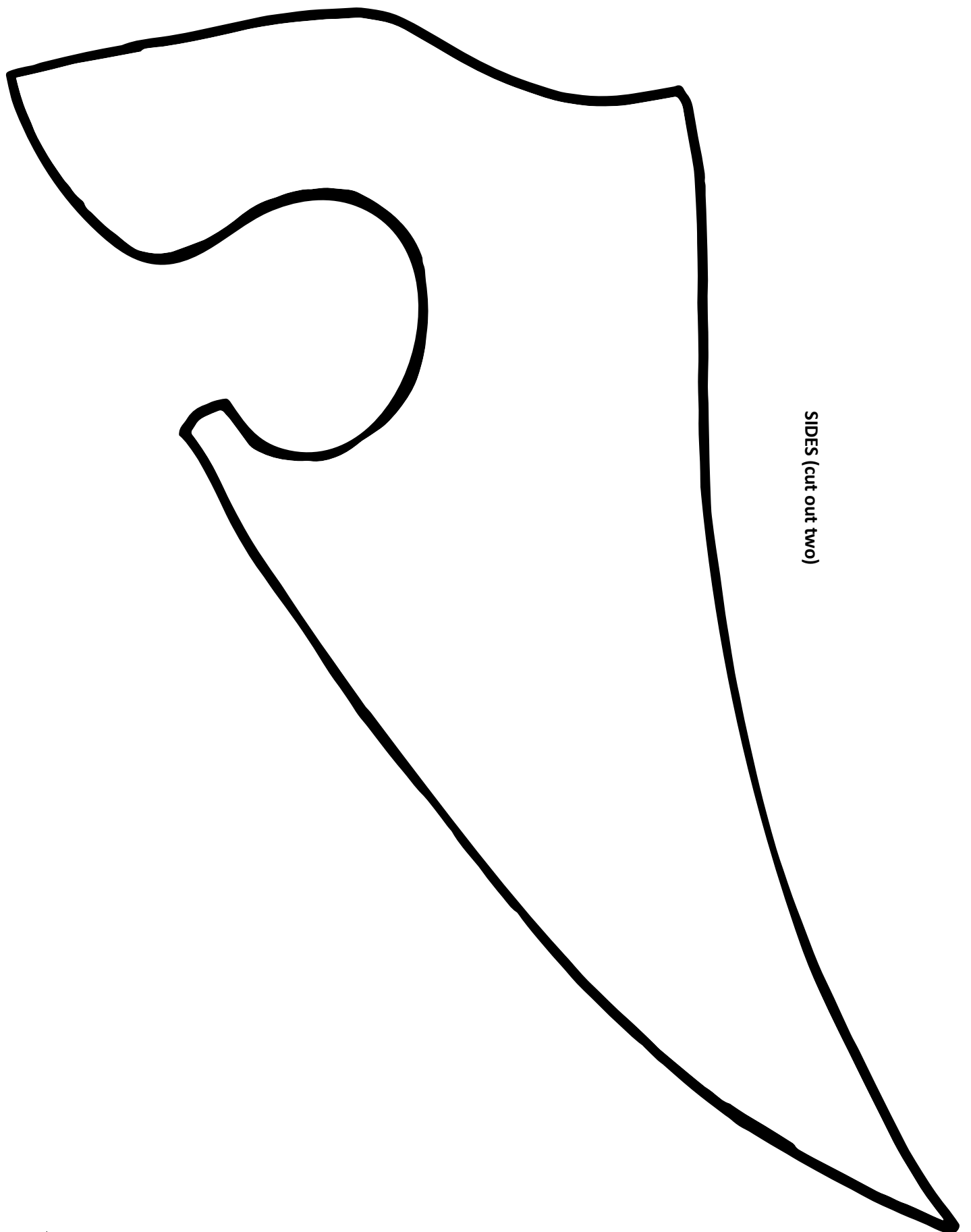
### **Recommended Books**

*The Immune System: Your Magic Doctor*, Garvy, Helen

*Dr. Jenner and the Speckled Monster: The Discovery of the Smallpox Vaccine*, Marrin, Albert

*Smallpox in the New World (Epidemic!)*, True Peters, Stephanie

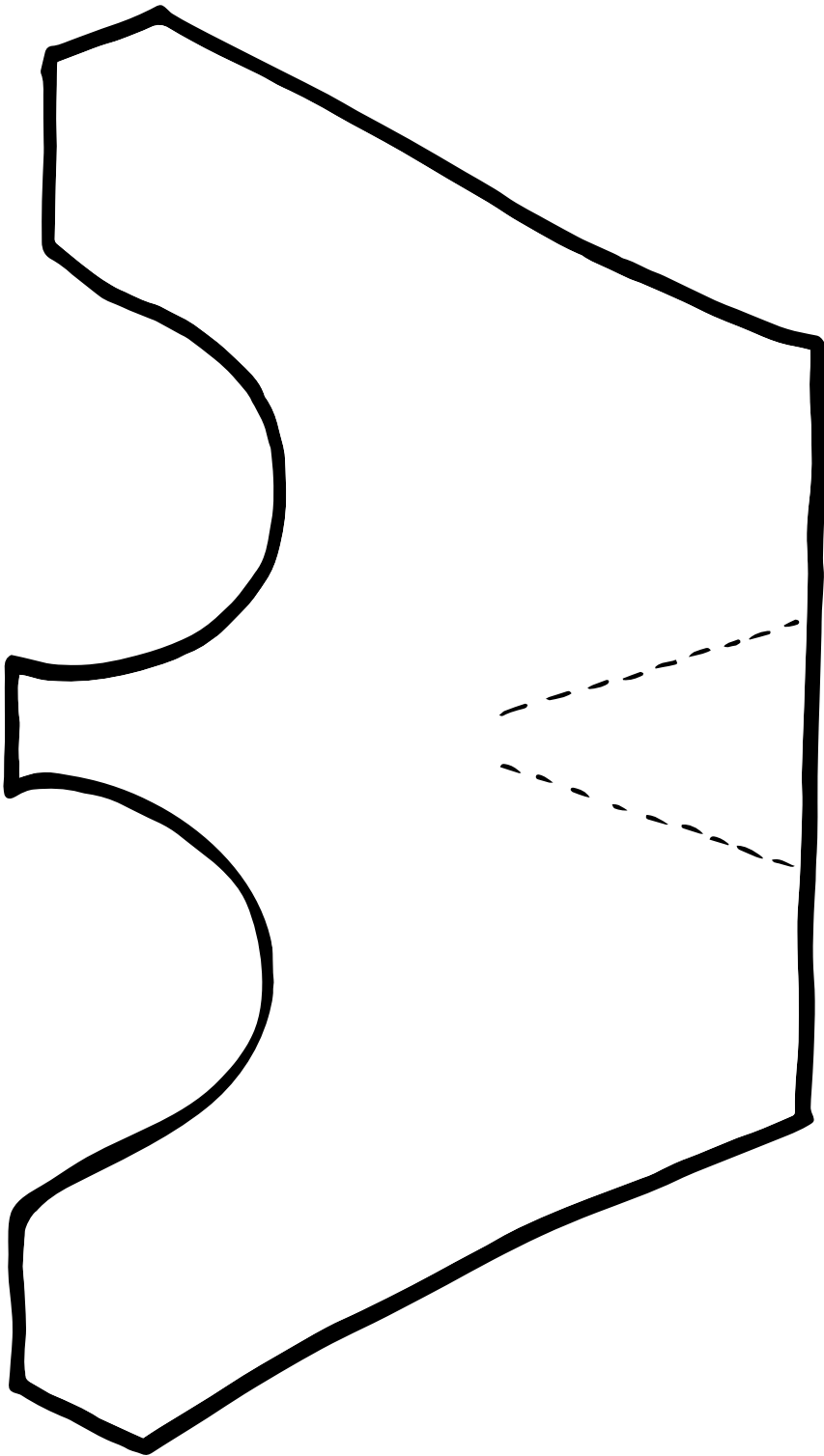




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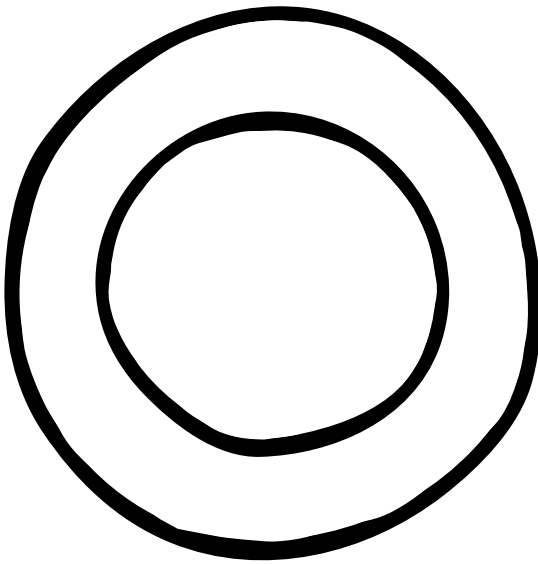


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