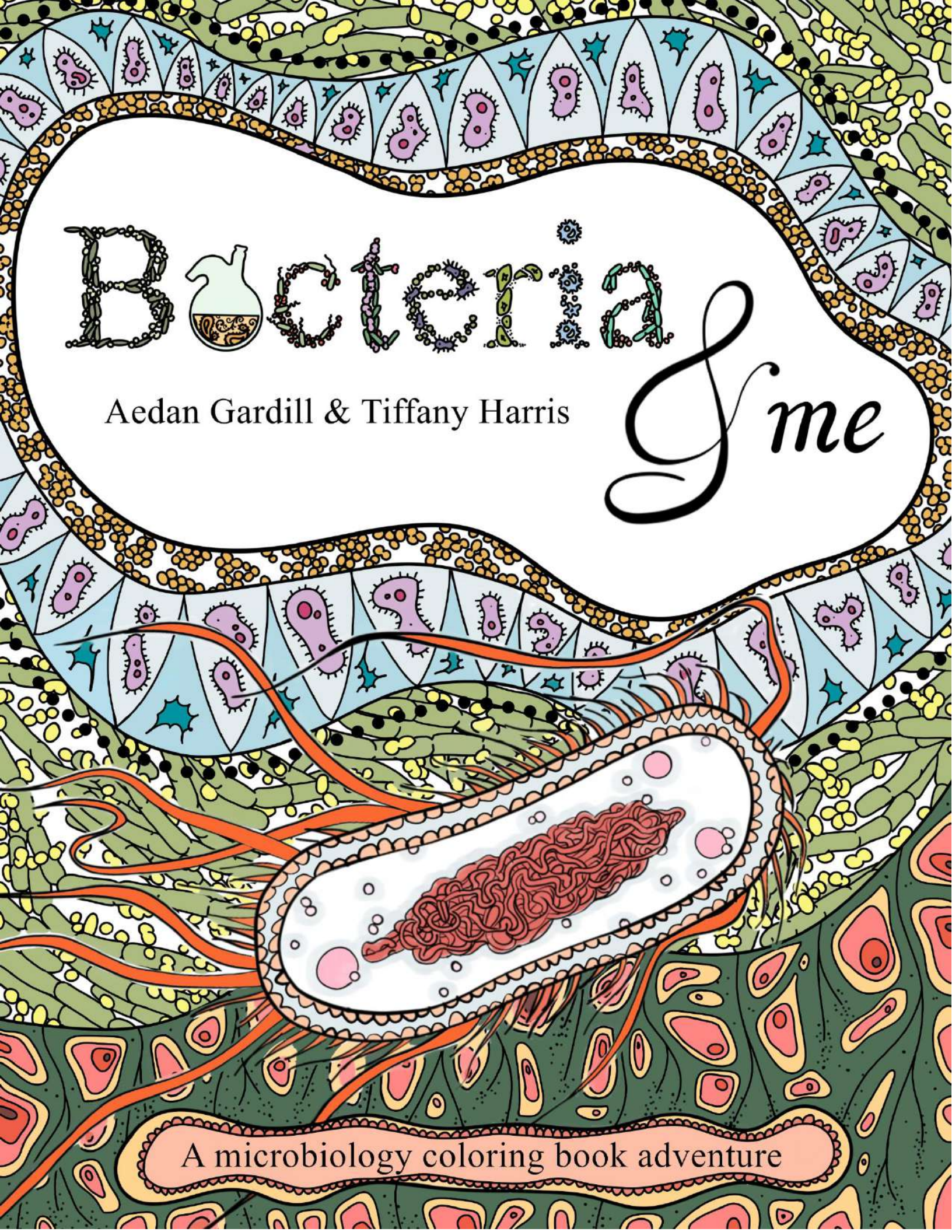
Bacteria & me
Aedan Gardill & Tiffany Harris
A microbiology coloring book adventure

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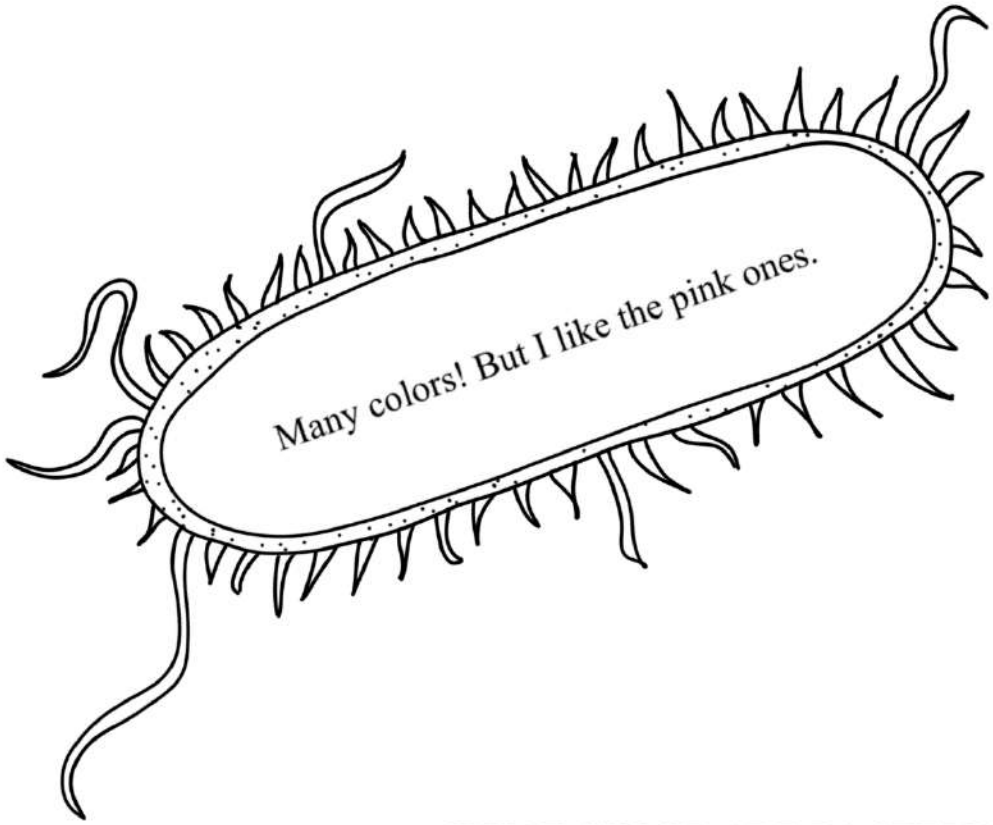
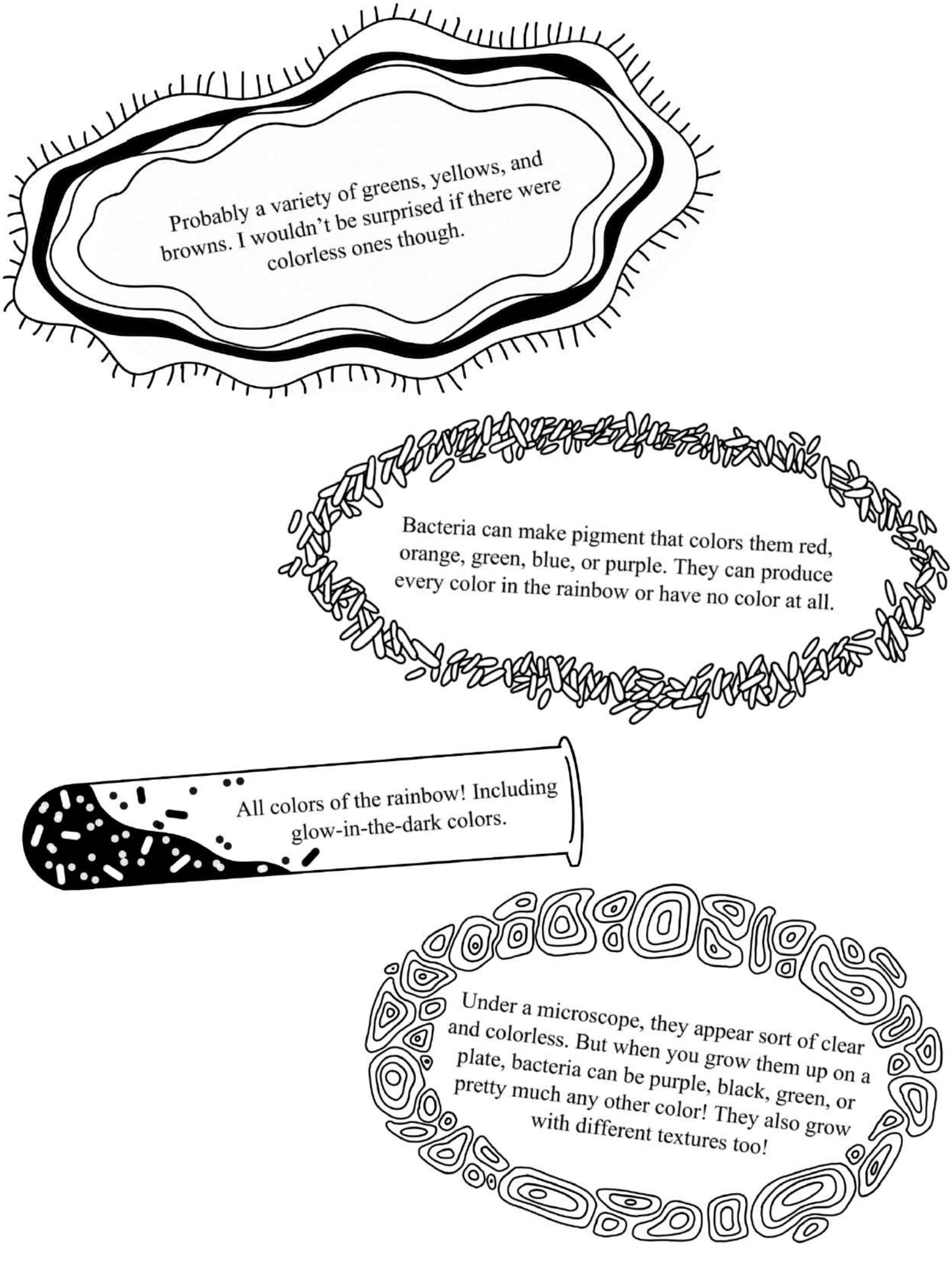
https://kohlerfellows.illuminatingdiscovery.wisc.edu/

March 2022



WHAT COLOR ARE BACTERIA?

What do you think?


Probably a variety of greens, yellows, and browns. I wouldn't be surprised if there were colorless ones though.
Bacteria can make pigment that colors them red, orange, green, blue, or purple. They can produce every color in the rainbow or have no color at all.
All colors of the rainbow! Including glow-in-the-dark colors.
Under a microscope, they appear sort of clear and colorless. But when you grow them up on a plate, bacteria can be purple, black, green, or pretty much any other color! They also grow with different textures too!

ANTONIE VAN LEEUWENHOEK

Antonie van Leeuwenhoek was a Dutch scientist who was the first to see bacteria under a microscope. He made over 500 lenses to use in a homemade microscope. His research laid the foundation for the field of bacteriology. The first representation of bacteria are his scientific drawings from a publication in 1683.


fig: A
D
fig: B
C


fig: E


Fig. I.
1
2

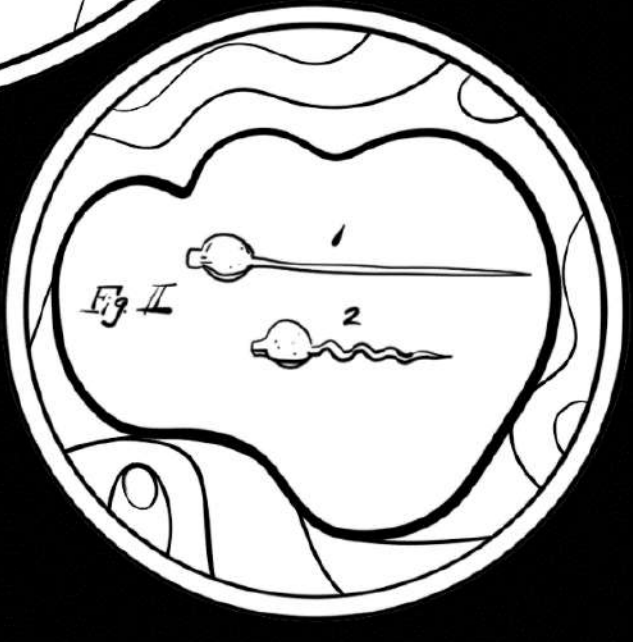
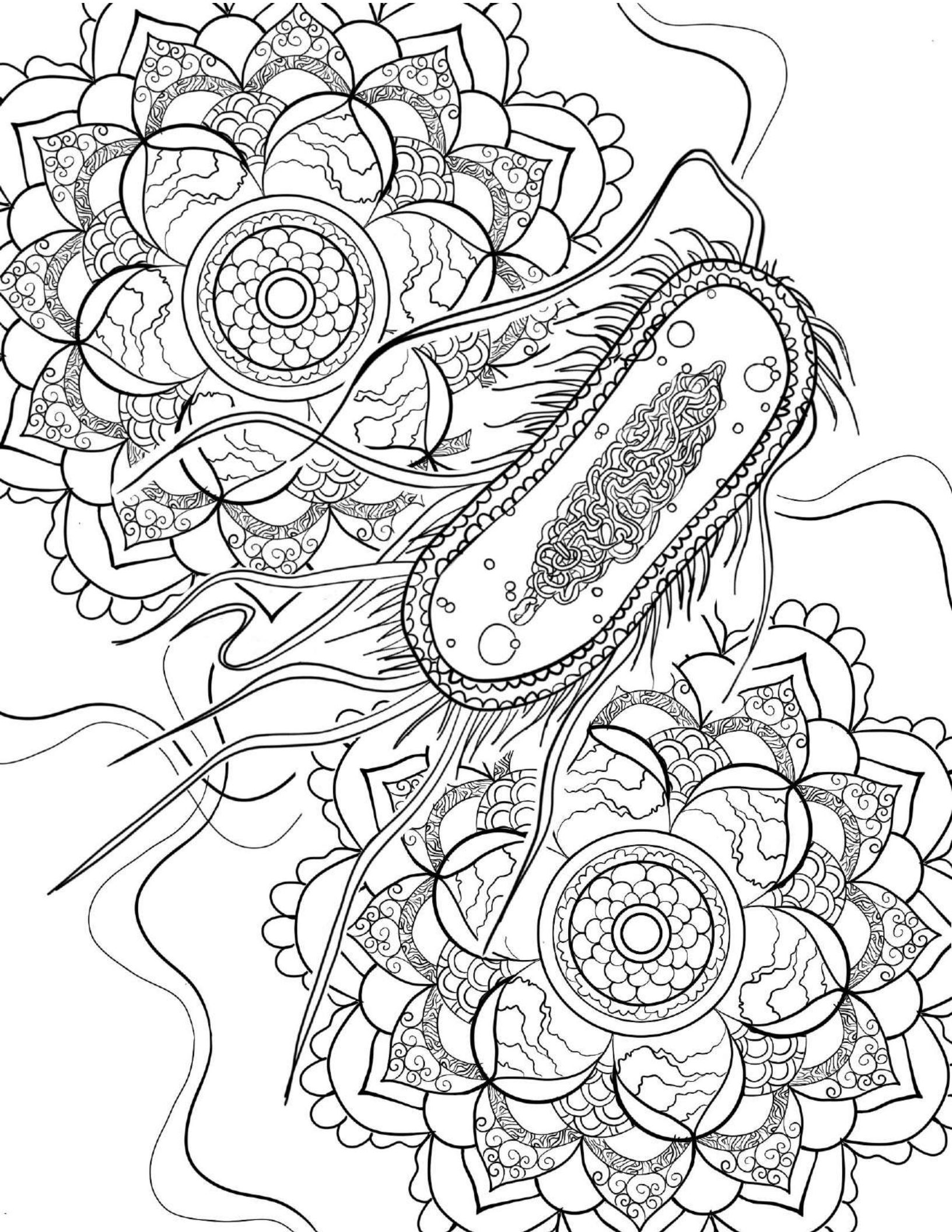


Fig. II
1
2

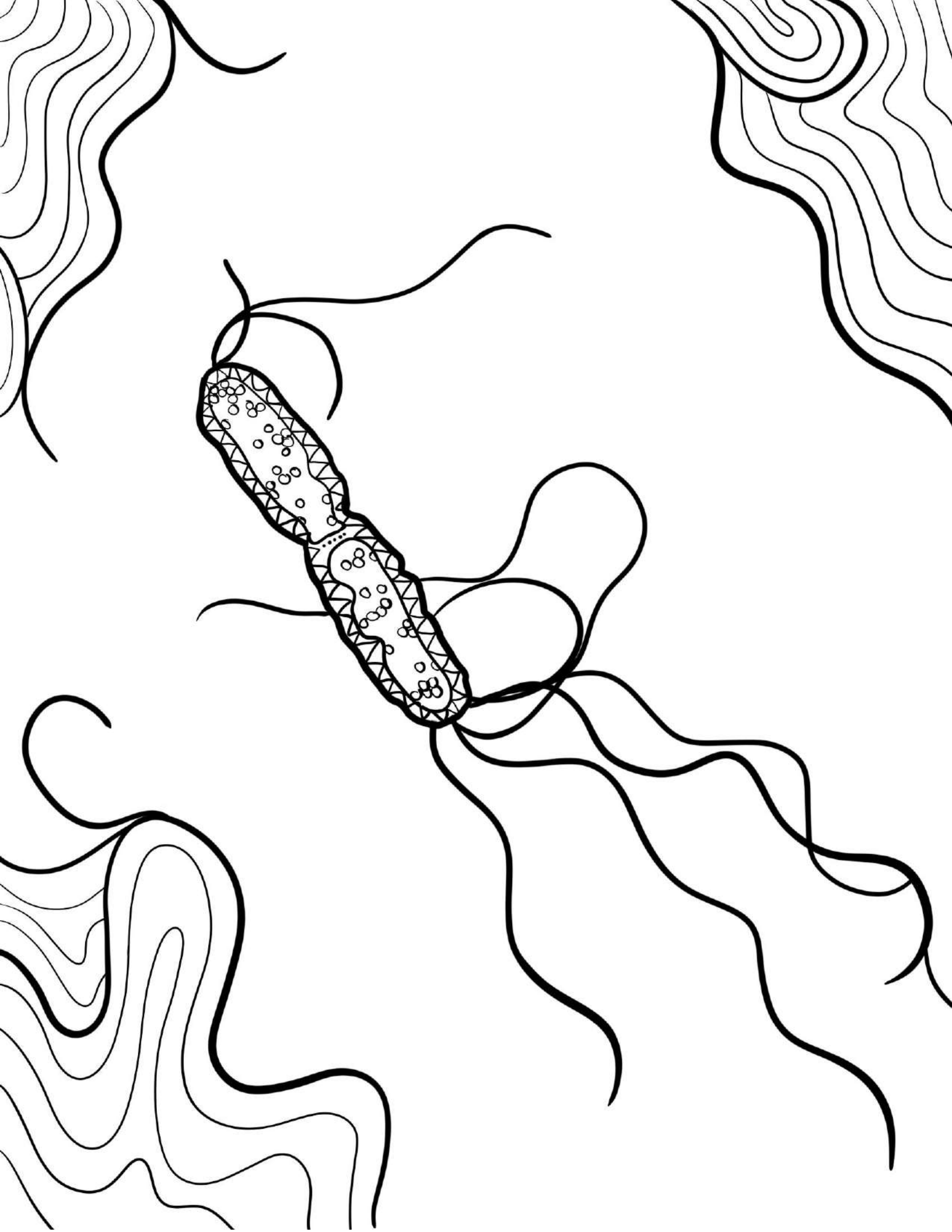
ESCHERICHIA COLI

Escherichia coli is a rod-shaped bacterium that is found in the environment, intestines, and can also be found in food, such as lettuce and meat products. These bacteria can cause illness, but most commonly exist without causing problems. Strains of *E. coli* are also used in the scientific laboratory for experiments involving bacterial genetics.



SALMONELLA ENTERICA

*Salmonella enteric*a is a rod-shaped bacterium that causes an illness known as salmonellosis, that often results in diarrhea, fever, and stomach cramps. Some infections with *Salmonella* are so severe they require hospitalization; however, most infections clear on their own without medical intervention. Infections are obtained from eating contaminated foods or by touching infected animals.

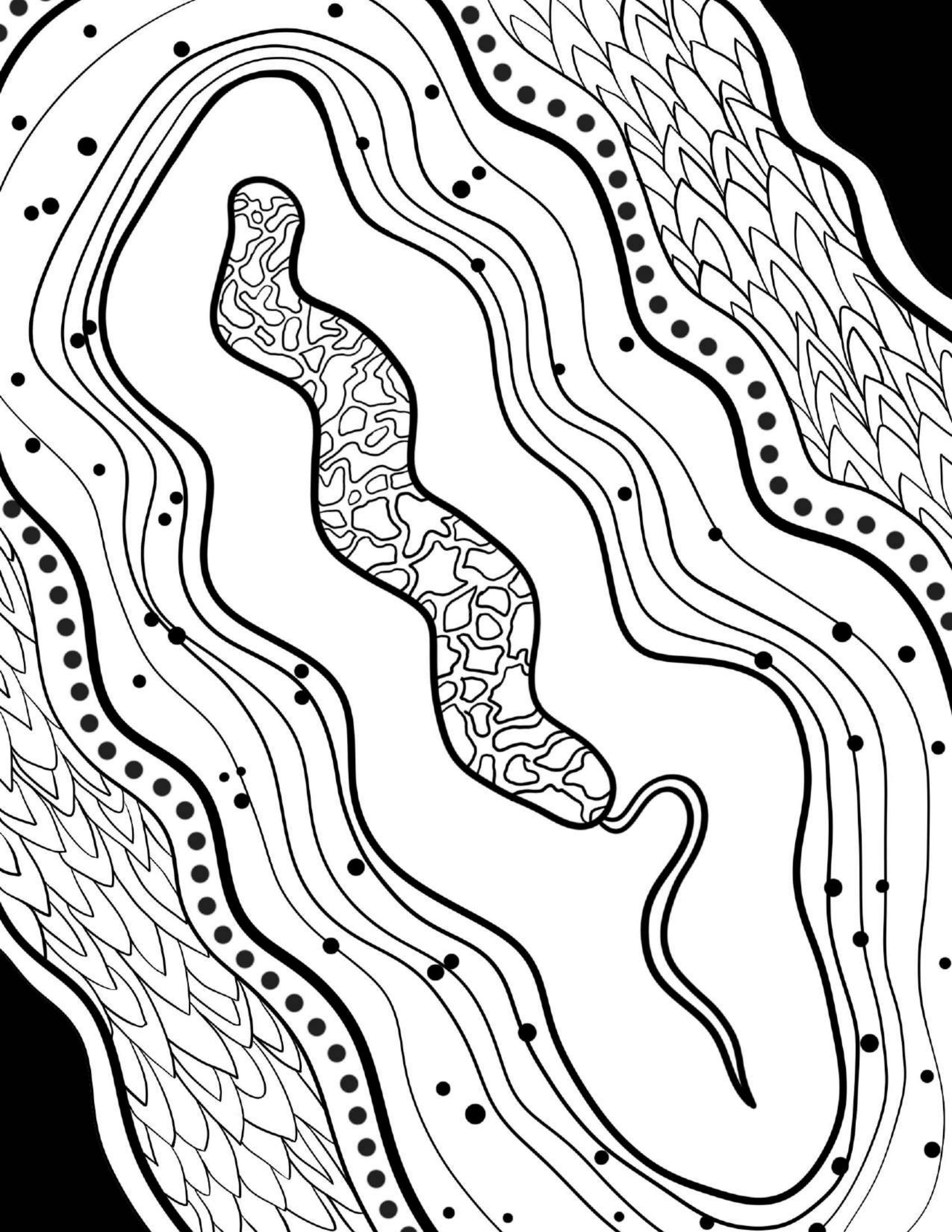


RUTH ELLA MOORE

Ruth Ella Moore, in 1933, became the first Black woman to receive a Ph.D. in the natural sciences. Her degree was in bacteriology from Ohio State University, and her work was on tuberculosis. She later went on to study African American blood types as well as the effect of antibiotics on gut bacteria as a professor at Howard University. At Howard University she was also the first woman to head a department. She was also the first Black member of the American Society of Microbiology.

CAMPYLOBACTER JEJUNI

Campylobacter jejuni causes the infection campylobacteriosis which is a type of diarrheal disease acquired by eating contaminated food. One common source of this bacteria is poultry. It is the most common diarrheal illness in the United States and is also 1 of 4 important causes of diarrheal disease in the world. *Campylobacter* can be easily killed by heat and so a main preventative measure against infection is to thoroughly cook food and follow basic hygienic practices during food preparation.

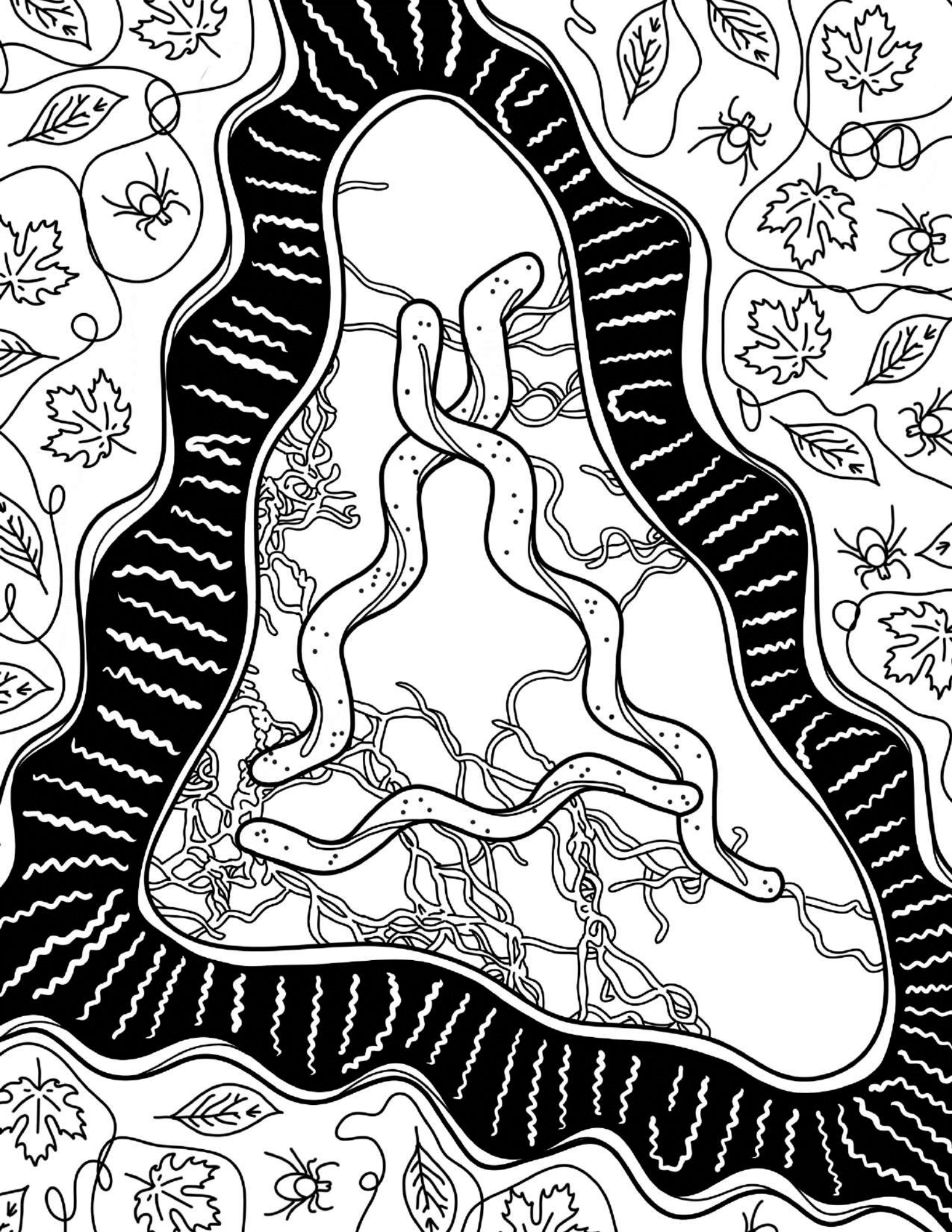


ROBERT KOCH

Robert Koch is perhaps most well known for Koch's Postulates which outline the requirements for identifying the causative agent of a disease. Additional work done by Koch, was isolating the causative agent of tuberculosis, *Mycobacterium tuberculosis*. His research on tuberculosis in the 1880s would lay the foundation for the development of the tuberculin skin test which identifies past or present tuberculosis infection. He also played a very important role in studying the bacterial source of anthrax and cholera which are *Bacillus anthracis* and *Vibrio cholerae* respectively.

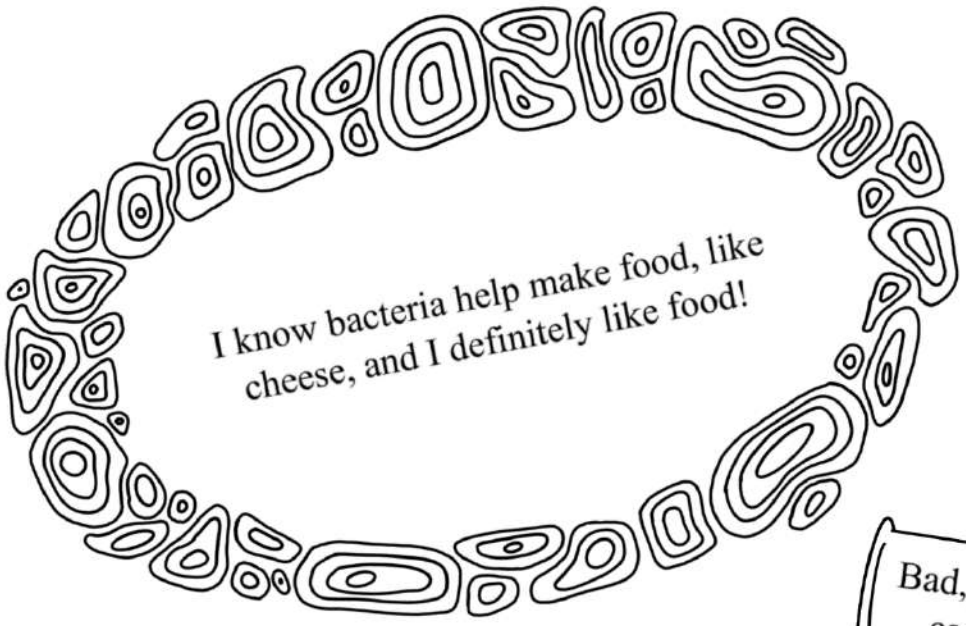
BORRELIA BURGDORFERI

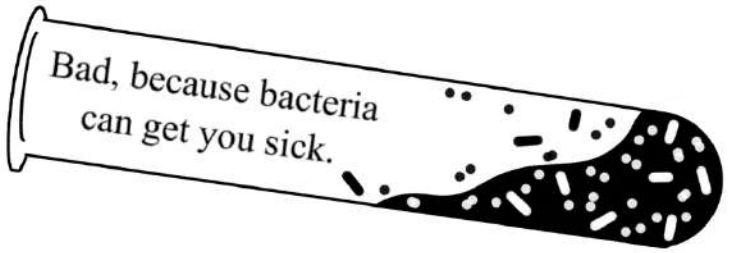
Borrelia burgdorferi is a spirochete bacterium that is the most common cause of Lyme disease. The bacteria are transmitted to humans via tick bites. This disease is the most common vector-borne disease in the United States. Symptoms of Lyme disease include fever, headache, fatigue, and a skin rash known as erythema migrans. This rash resembles a bullseye and is characteristic of Lyme disease. Most cases of Lyme disease can be treated with a course of antibiotics. The main steps of prevention are to wear insect repellent and immediately remove ticks.



HAROLD AMOS

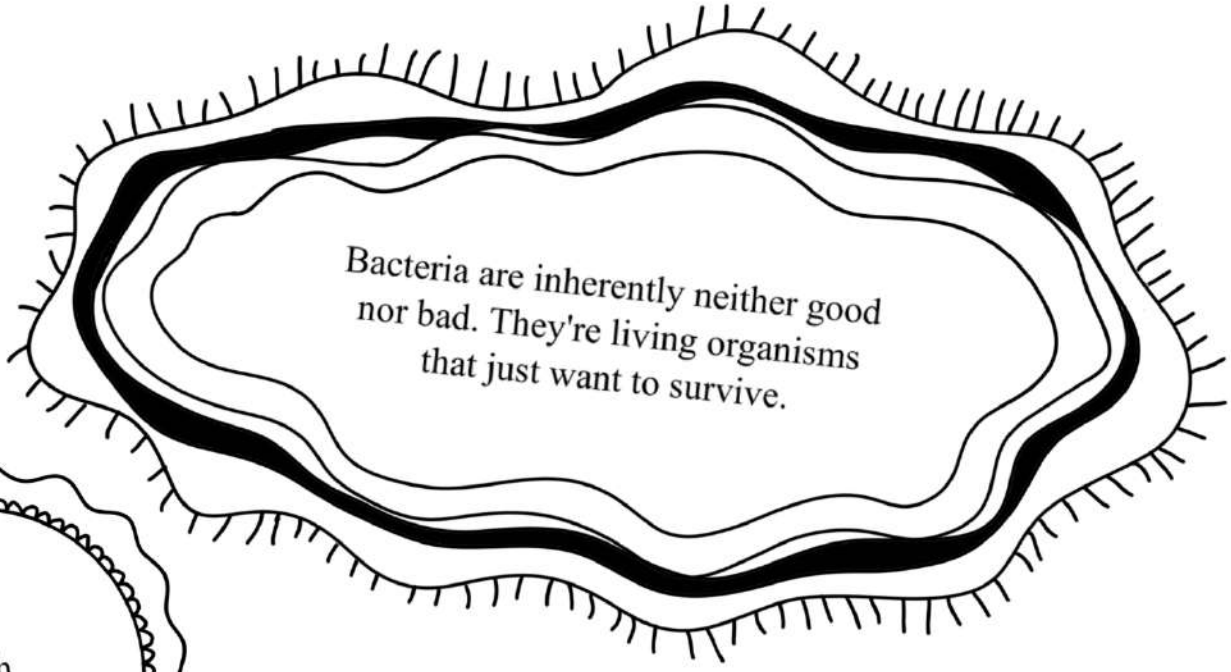
Harold Amos was an African American microbiologist that studied bacterial metabolism and virology (the study of viruses). In 1952, Amos was the first African American to earn a doctoral degree from the Division of Medical Sciences at Harvard Medical School. He was also the first African American to chair a department, which is now the Department of Microbiology and Immunobiology at Harvard Medical School. Amos' interest in microbiology started at a young age from reading a biography of Louis Pasteur.

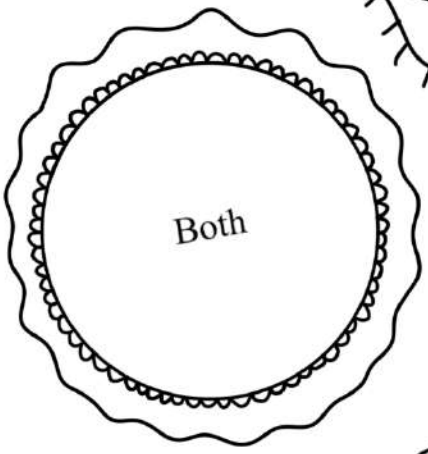


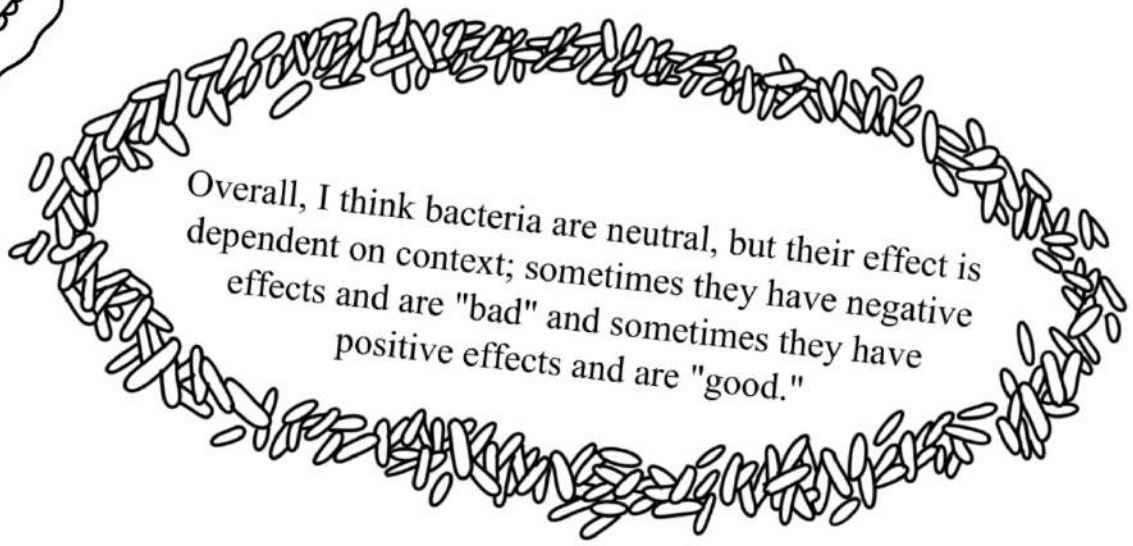


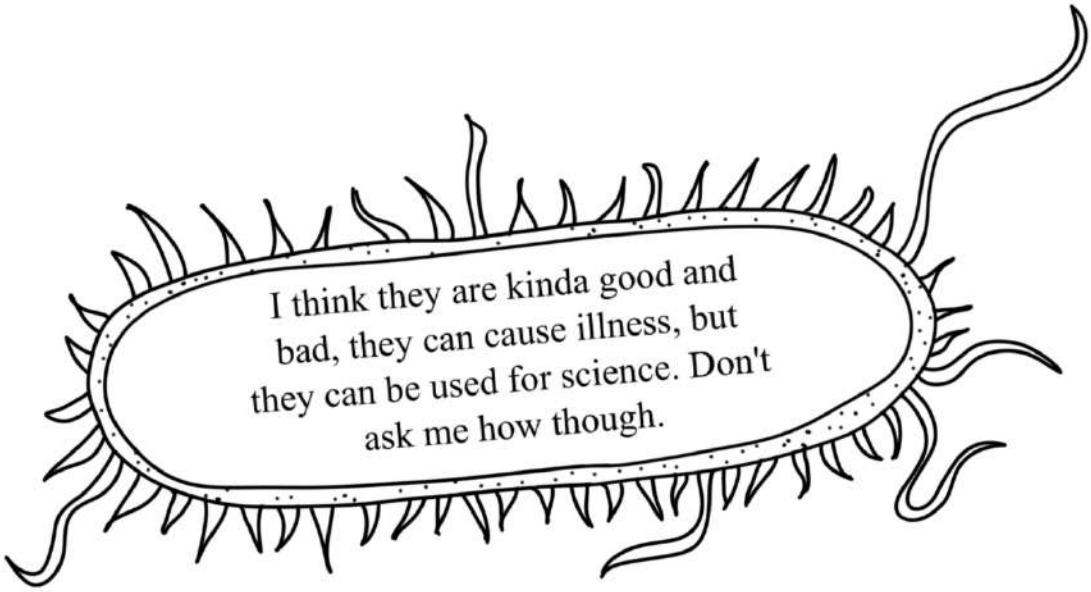
ARE BACTERIA GOOD OR BAD?

What do you think?


Bacteria are inherently neither good nor bad. They're living organisms that just want to survive.

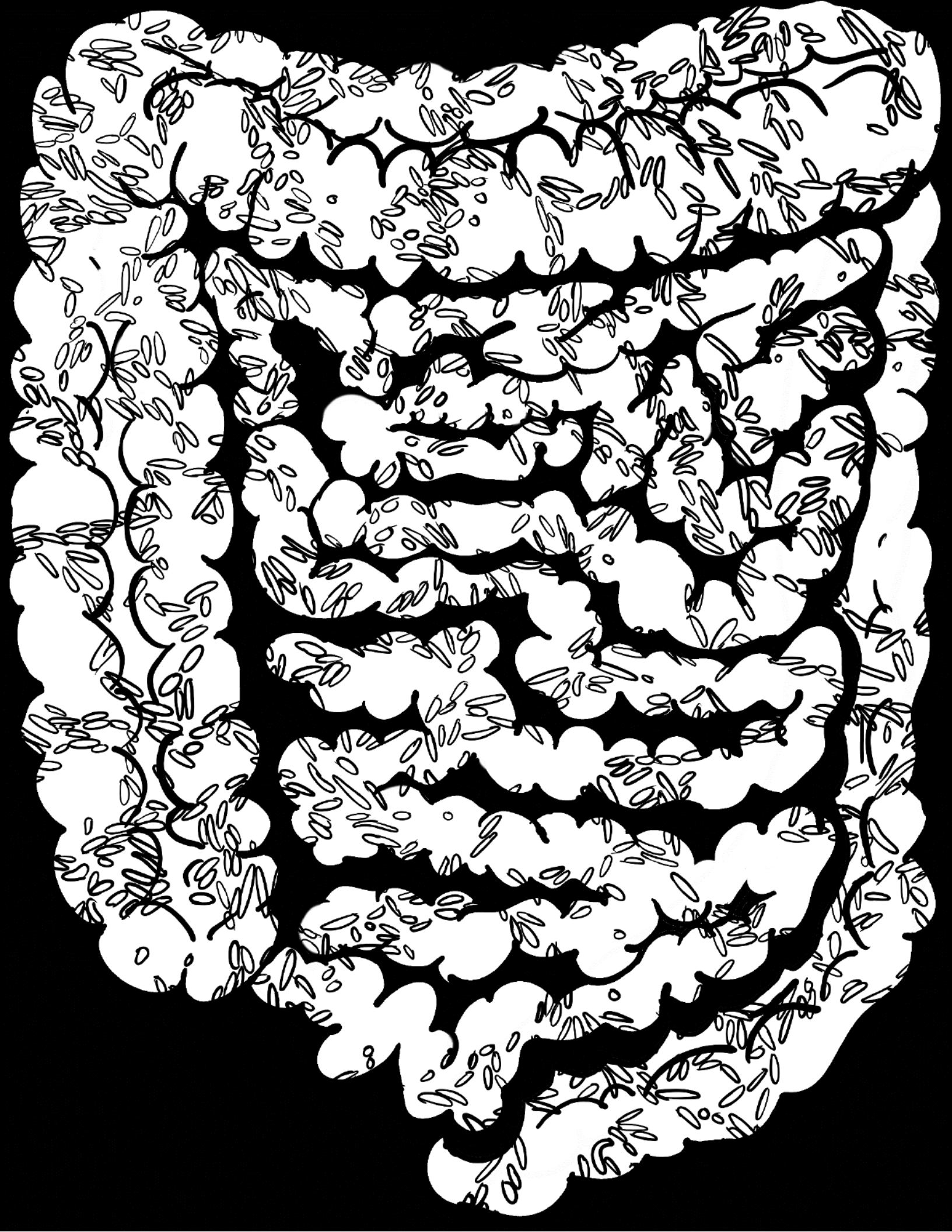

Both


Overall, I think bacteria are neutral, but their effect is dependent on context; sometimes they have negative effects and are "bad" and sometimes they have positive effects and are "good."


I think they are kinda good and bad, they can cause illness, but they can be used for science. Don't ask me how though.

GUT MICROBIOTA

We all have a thriving collection of bacteria, viruses, and fungi found in our guts, often called the microbiota. While many types of bacteria, viruses, and fungi are harmful to humans, our microbiota is critical to a healthy life and has many functions in the human body. Specifically, gut bacteria interact with the human immune system as well as play an important role in the metabolism of food.

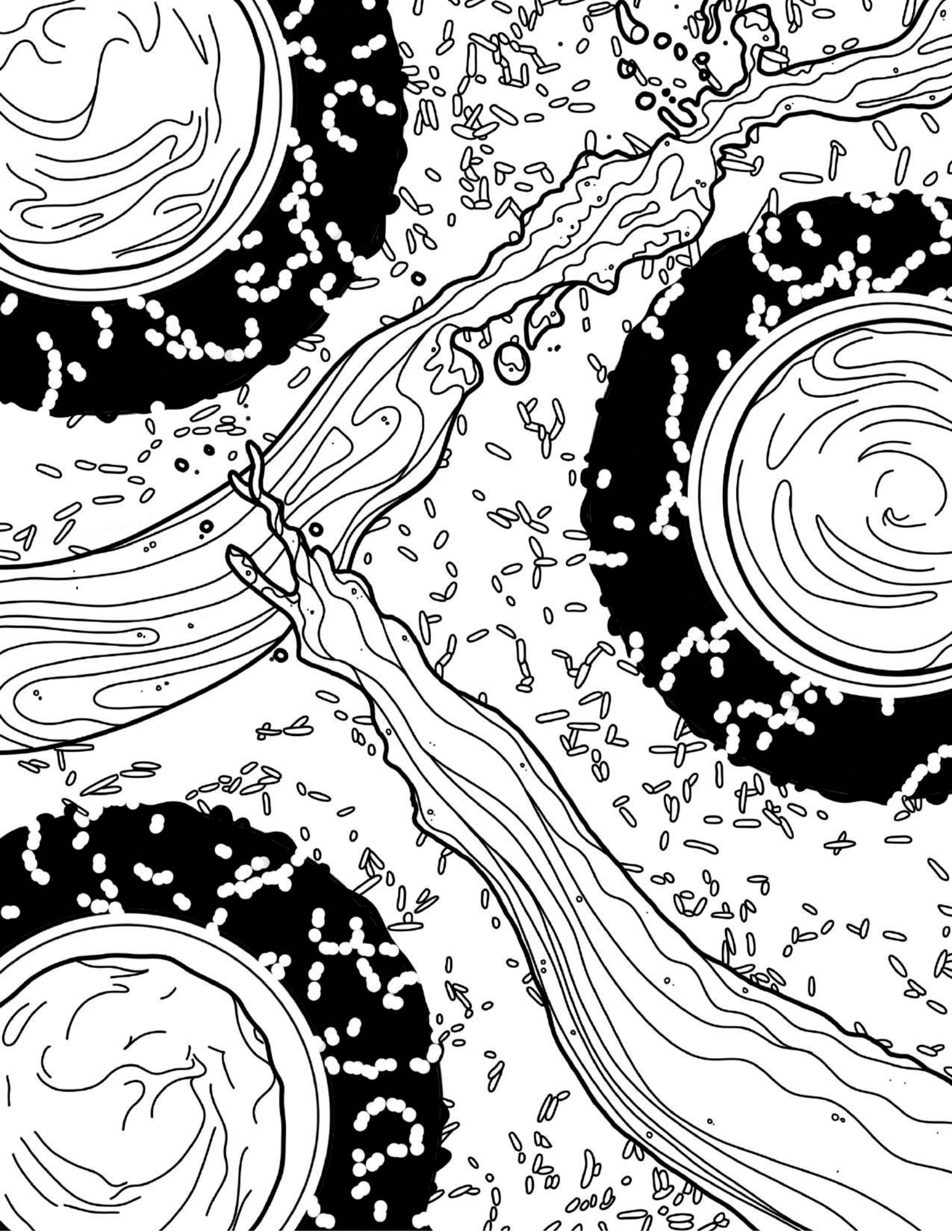


ABIGAIL A. SALYERS

Abigail A. Salyers was a microbiologist that is most well known for her work on the microbiome of the gut. She was the first female tenured professor at the University of Illinois where she studied the interactions between gut bacteria and their host as well as antibiotic resistance gene transfer. In 2001, during the anthrax mailing attacks, she was the president of the American Society of Microbiology. Despite the push to devote overwhelming resources into anthrax and bioterrorism research, she stressed the importance of still balancing other research on diseases that threaten the population annually, such as influenza.

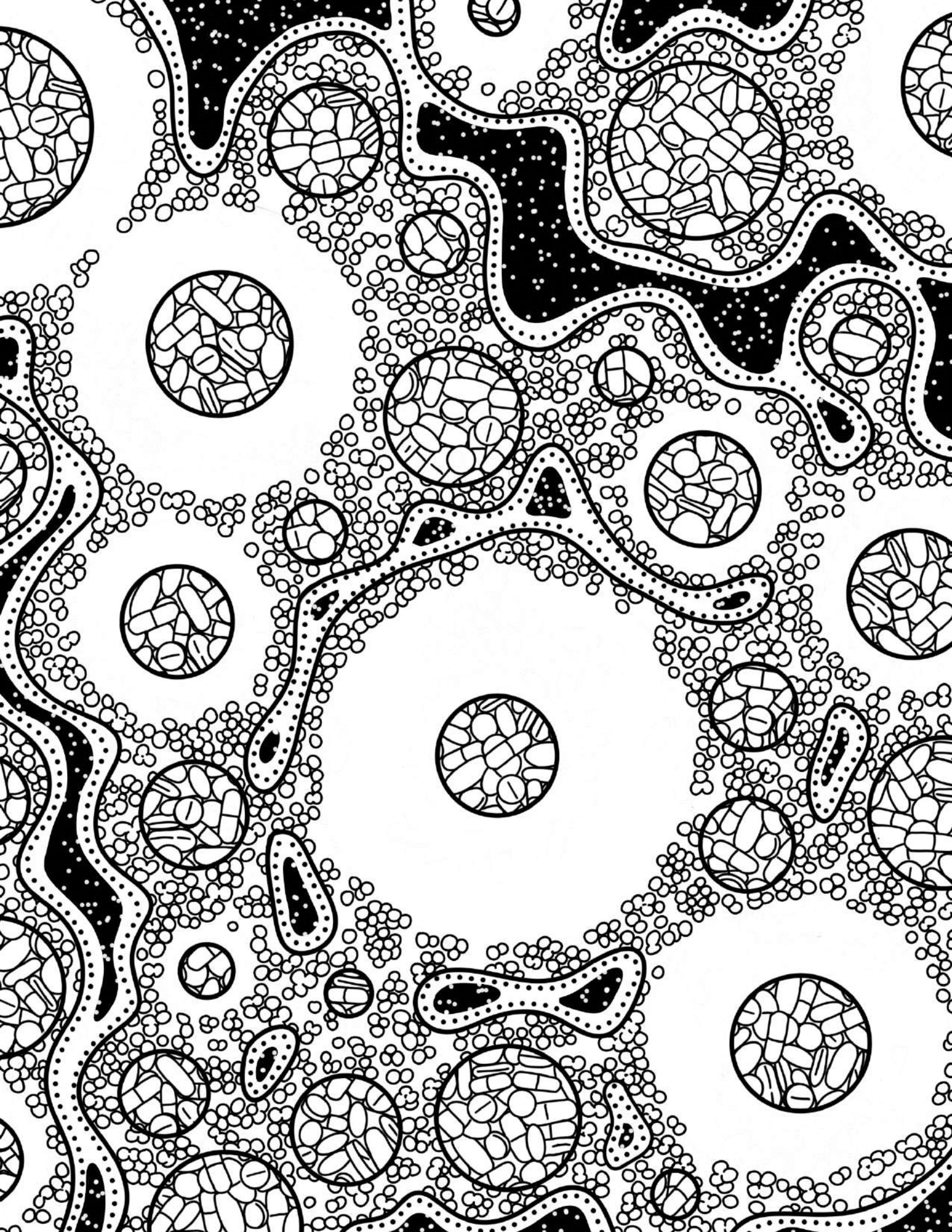
PROBIOTICS

Probiotics consist of a variety of bacterial species that may improve the bacterial environment of your gut. Probiotics and bacteria cultures, such as *Lactobacillus,* can be found in many different foods like yogurt, kombucha, and pickles, but can also be in a pill form. Perhaps the most common use for probiotics is to help with diarrhea; however, they may also help prevent over-colonization of potentially harmful bacteria and improve digestion.



ANTIBIOTICS

Antibiotics are medicines that are used to treat bacterial infections. They are not effective against viral infections because viruses are not living and will not complete the processes targeted by antibiotics. Antibiotics are classified based upon the structure of the drug. Different antibiotics will target different processes in bacteria that are necessary for growth and survival. These include things like making proteins, replicating DNA, and constructing the cell wall (which surrounds the cell and is necessary to maintain cell shape). Antibiotics can be bacteriostatic, where they simply stop the growth of the bacteria to allow the immune system to act against the bacteria, or they can also be bactericidal, where they kill the bacteria and then rely on the body to clear the debris.



ALEXANDER FLEMING

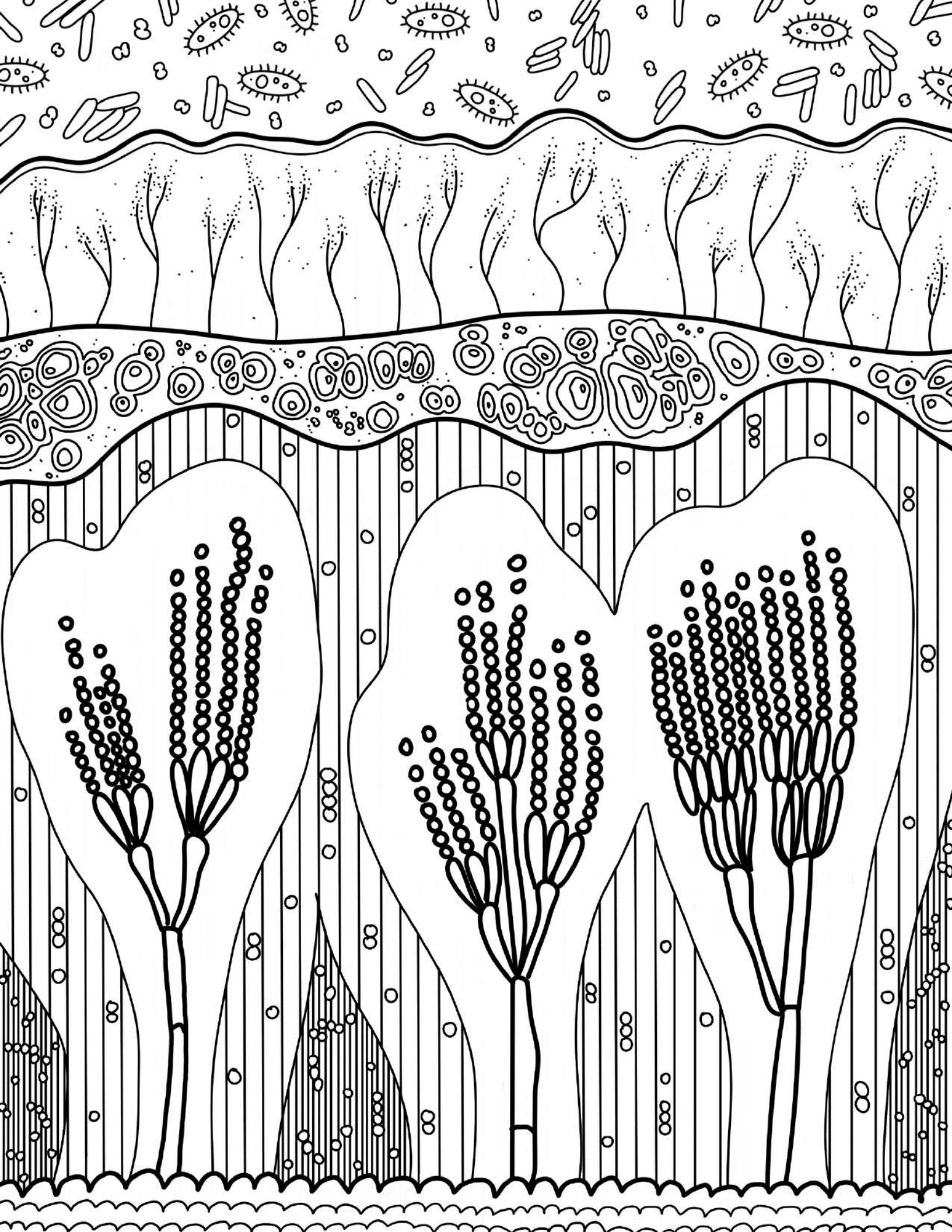
Alexander Fleming is a bacteriologist that discovered penicillin. In 1928, after returning from holiday, he discovered that he had contamination on his bacterial cultures. He showed that this contamination could prevent growth of bacteria known to cause illness. Penicillin would go on to become a very important antibiotic, however, Fleming was unable to isolate penicillin for therapeutic use, but is still credited for its discovery.

MARY HUNT

Mary Hunt was a laboratory technician who worked at the USDA Northern Regional Research Laboratory in 1943. After the initial discovery of penicillin by Alexander Fleming, the great task became to isolate the drug and mass produce it. Laboratory workers were tasked with finding a strain of *Penicillium* that would allow mass production of the penicillin drug. Several accounts claim that Hunt found a "pretty, golden" moldy cantaloupe that was later found to be infected with *Penicillium chrysogenum.* This strain was able to produce more penicillin than the previous identified strain by Alexander Fleming. This key discovery allowed the mass production of penicillin that became important for treating soldiers in World War II.

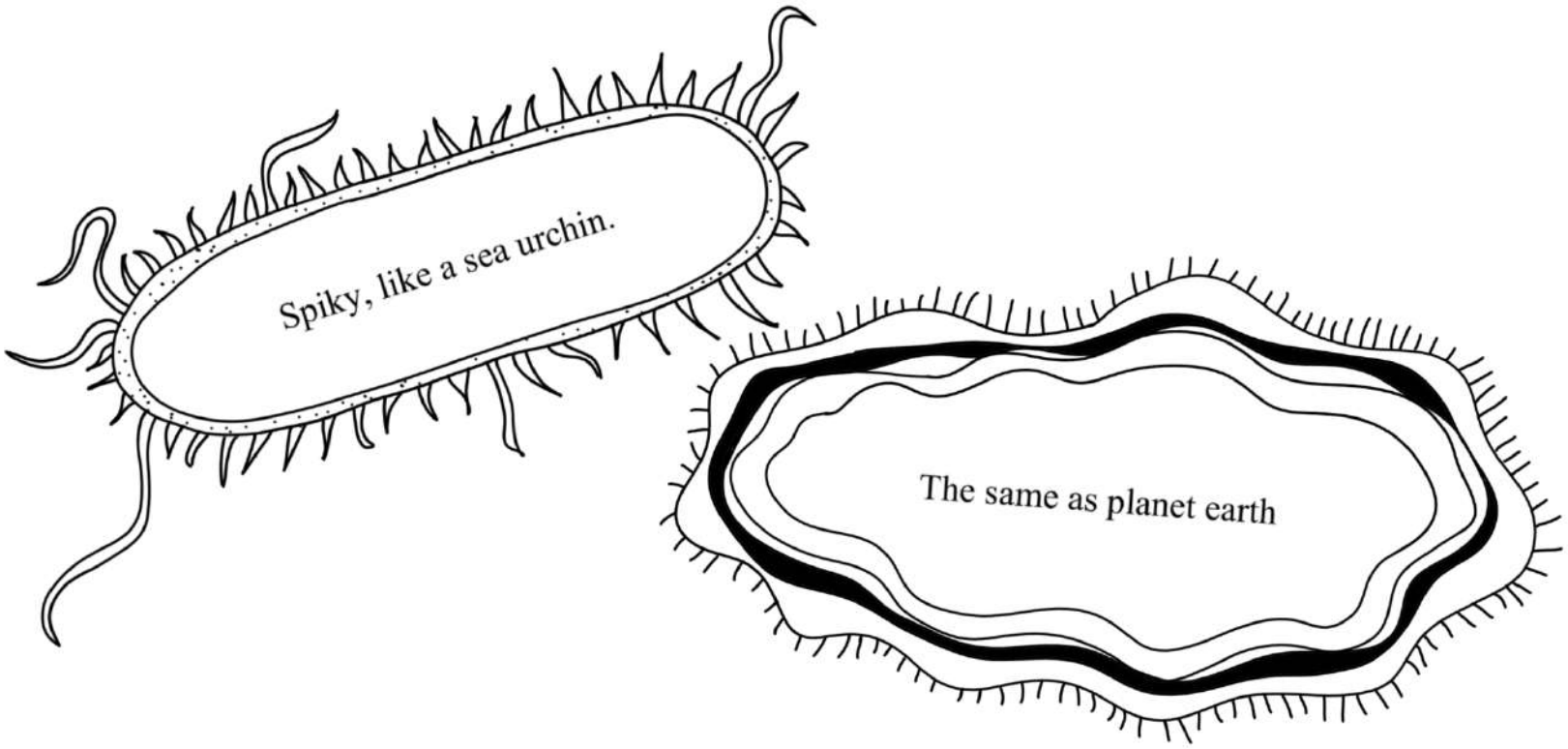
PENICILLIUM

Penicillin is an antibiotic that was initially discovered by Alexander Fleming in 1928 after he determined that the mold, *Penicillium*, produced a substance that could kill bacteria. It wasn't until 1941 when the drug was available for medical use. Prior to its discovery, many bacterial infections were untreatable as penicillin was one of the first antibiotics to be discovered. Even today it is still one of the most widely used antibiotic drugs.



ELIZABETH BUGIE

Elizabeth Bugie was a biochemist who participated in the discovery of streptomycin in the 1940s, which is an antibiotic that is isolated from the soil bacterium *Streptomyces griseus*. She was a part of a team of scientists in the lab of Selman Waksman at Rutgers University. Streptomycin was one of the first broad spectrum antibiotics that could treat a wide range of different infections, most notably tuberculosis. While Bugie's name is on the original scientific paper for the isolation of streptomycin, she was unfortunately not included on the patent for the drug or acknowledged for the Nobel prize for the discovery, despite being an important member of Waksman's lab.



IF BACTERIA WERE FOUND ON ANOTHER PLANET, WHAT WOULD THEY LOOK LIKE?

What do you think?

I think it will look like fast movement.

I think they would look pretty similar but with different metabolic abilities. It's possible they would be different colors and shapes based on the planet's environment!

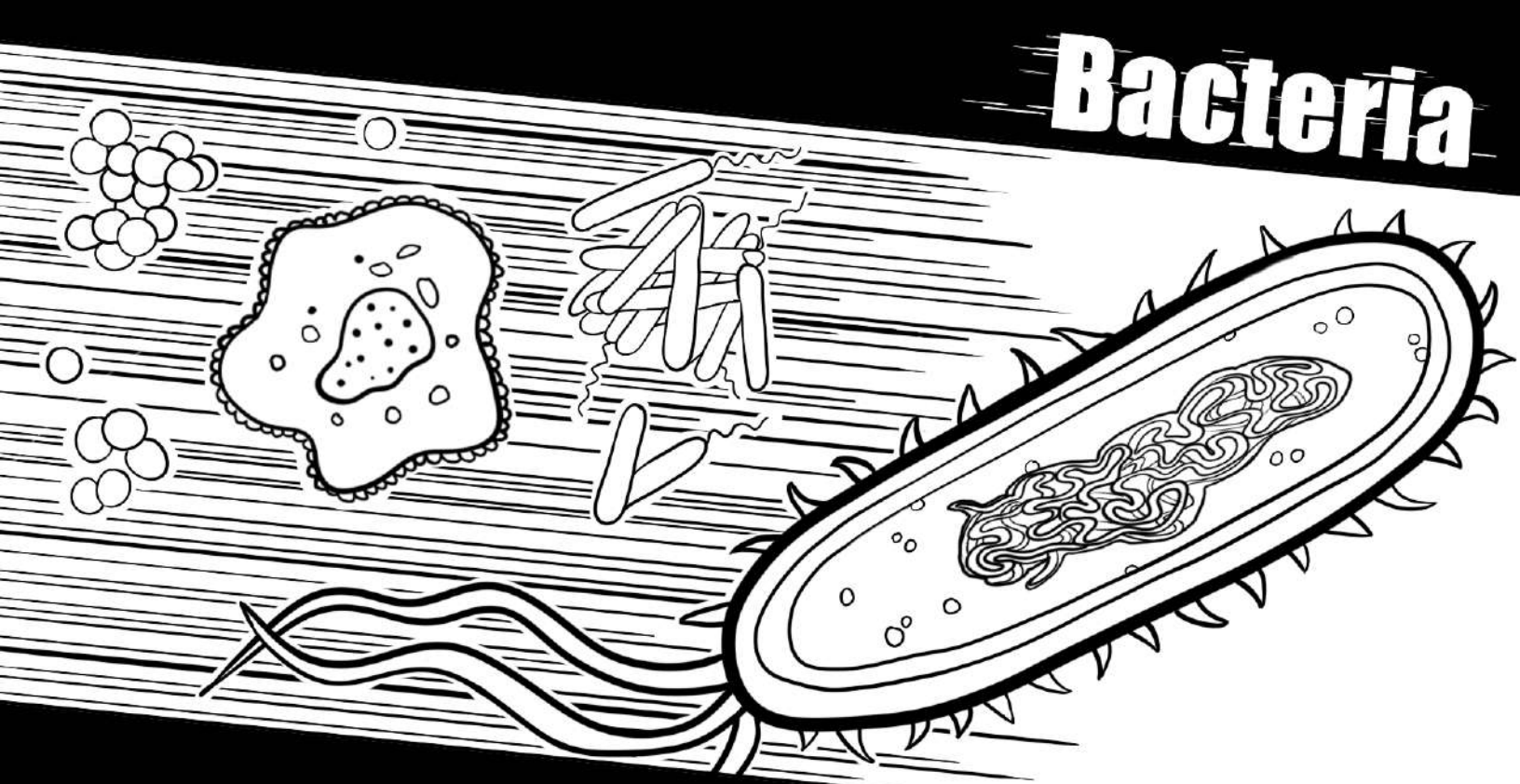
Weird and slimy.

I think it would look like triangles.

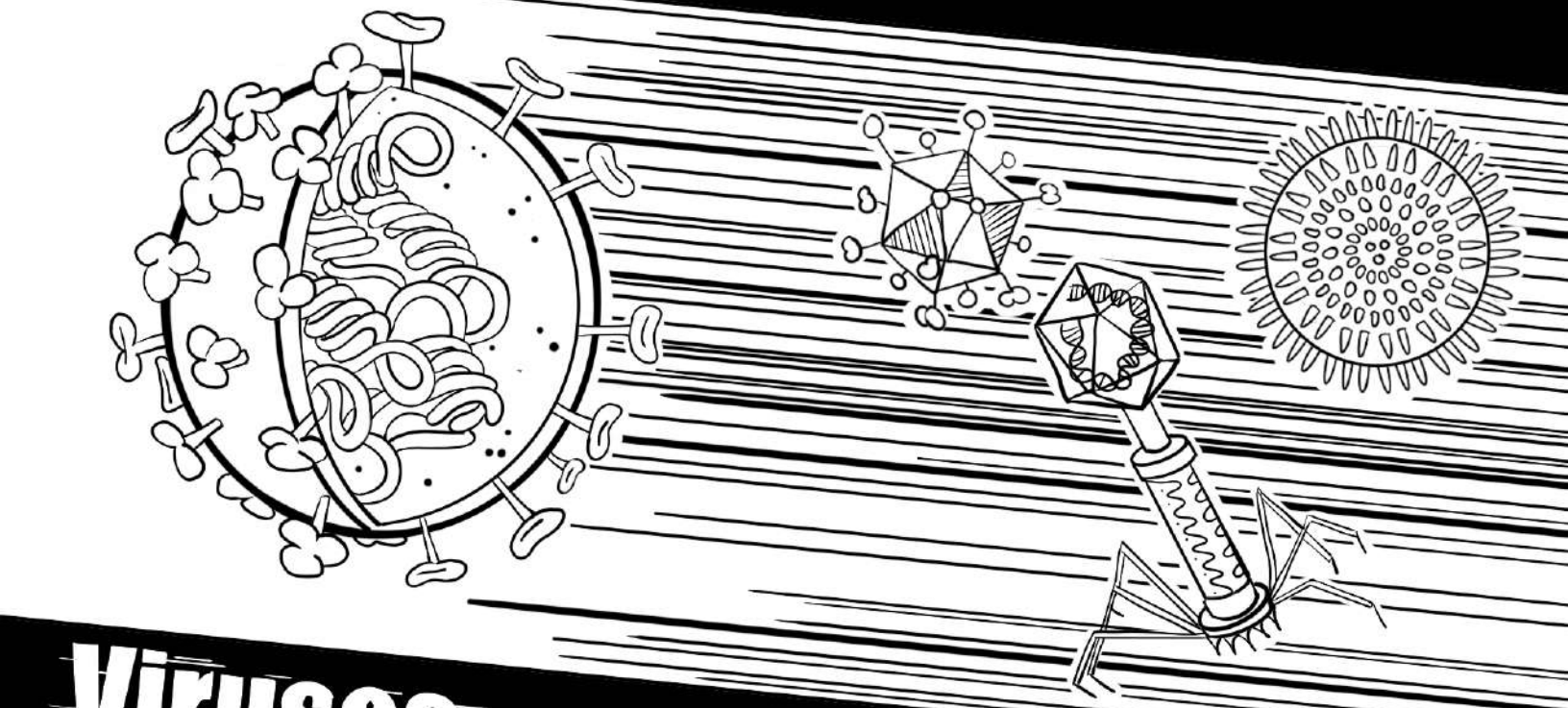
BACTERIA VS. VIRUSES

What's the difference between bacteria and viruses? Bacteria are microscopic single celled organisms that have a cell wall and do not have any membrane-bound organelles. This is different from, say, the cells in our body which have organelles, such as mitochondria or a nucleus. Viruses are also microscopic; however they are not living organisms and must rely on a living host to facilitate their replication. There is much debate over the classification of viruses as non-living, but the general consensus is that since the virus cannot perform basic functions necessary for life on their own, like metabolism and reproduction, they are non-living. In order for viruses to reproduce, they must insert part of their genetic material into a living host cell, and then the cell will end up creating more viruses.

Bacteria



Vs



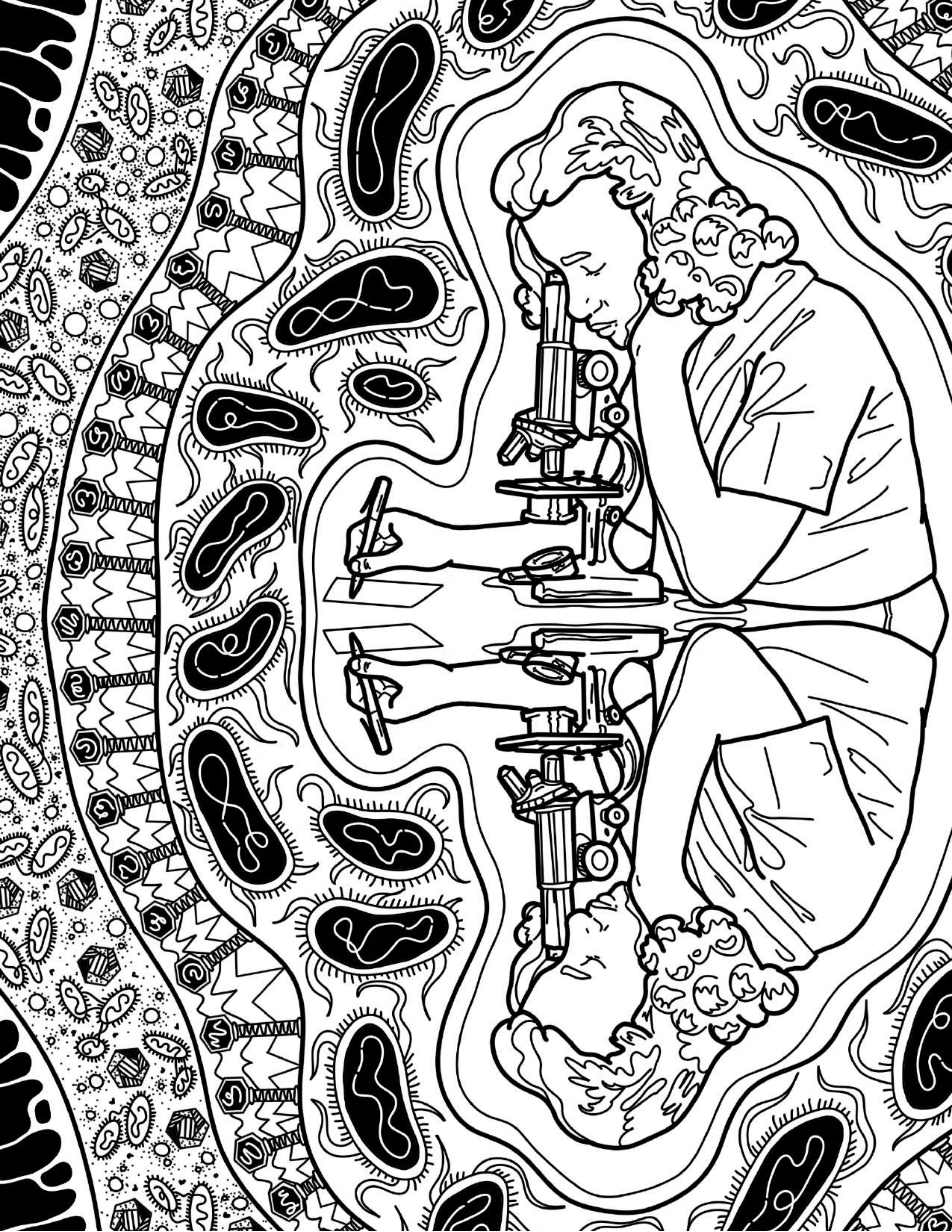
Viruses

JUNE ALMEIDA

June Almeida was the first person to identify coronavirus under the microscope in 1964. While COVID-19 is a new illness, it is part of a type of a broader class of viruses called “coronavirus”. She became an expert in using an electron microscope, which is a powerful microscope that can allow scientists to view incredibly small microbes at high resolution. She identified and imaged many other viruses and was also the first to see rubella virus (which causes German measles) and provided important information on HIV and Hepatitis B (other viruses). She developed many new methods for imaging and diagnosing viruses.

ESTHER LEDERBERG

Esther Lederberg was a microbiologist that made major contributions to the field of microbial genetics. Her most well known discovery was lambda phage, in 1950, which is a bacterial virus in *E. coli*. This phage is used widely for studying the regulation of genes and how DNA rearranges. While studying the lambda phage, she also discovered the fertility factor F which plays a role in transferring genetic material between bacteria. She also developed a useful method to replicate bacteria colonies onto additional petri dishes called replica plating.

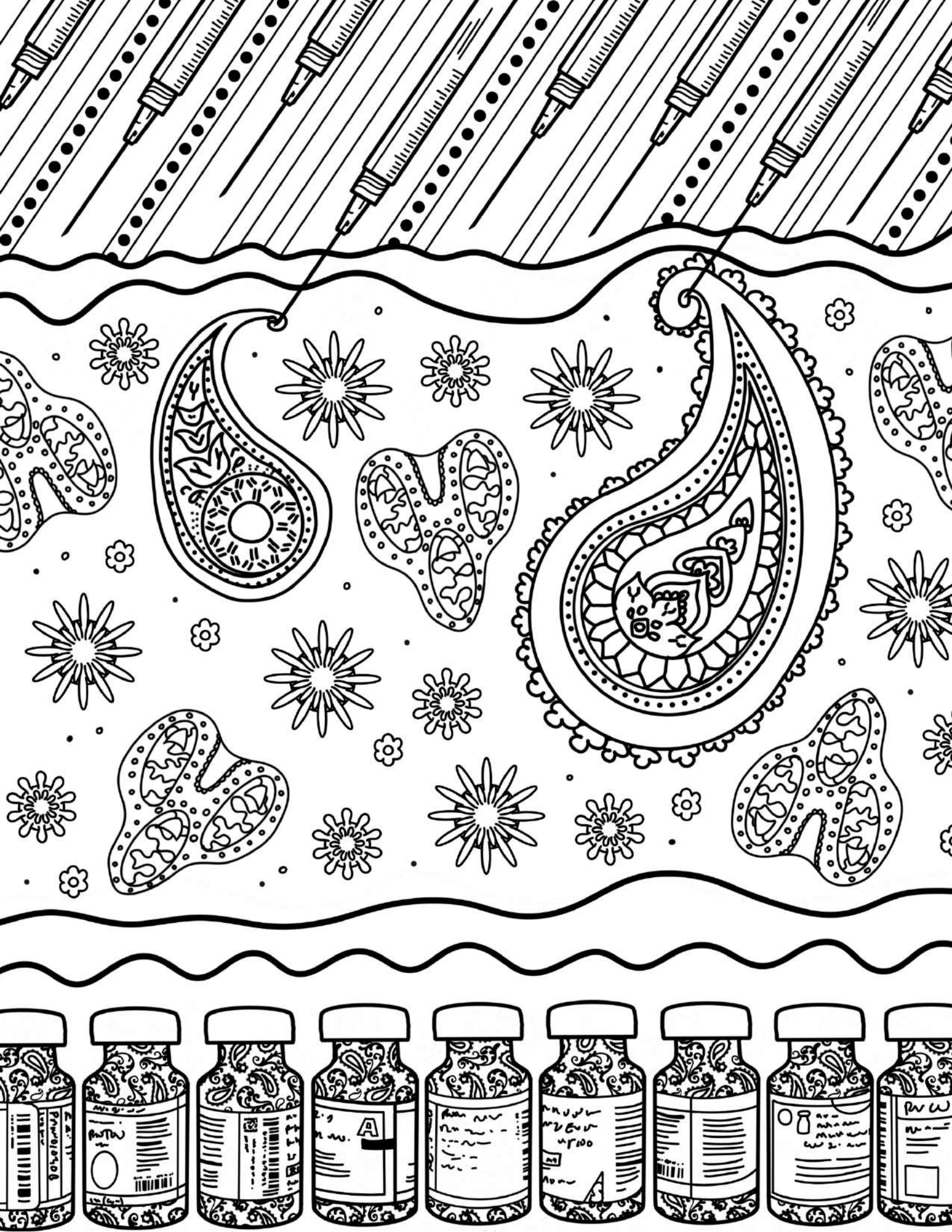


EDWARD JENNER

Edward Jenner was an English physician that discovered vaccination for the prevention of smallpox near the end of the 18th century. During that time smallpox was very prevalent and killed many people. Jenner noticed that milkmaids, after getting another disease called cowpox, did not catch smallpox. It was because of this observation that Jenner found that inoculation with material from lesions of cowpox could protect a person from smallpox. In fact, the word *vaccination* comes from the Latin word *vacca* for cow.

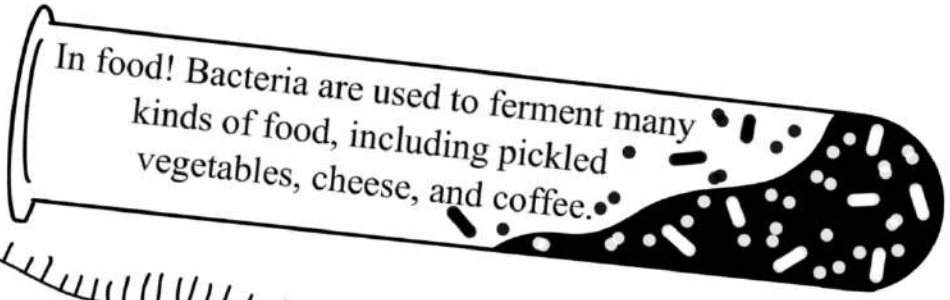
VACCINATION

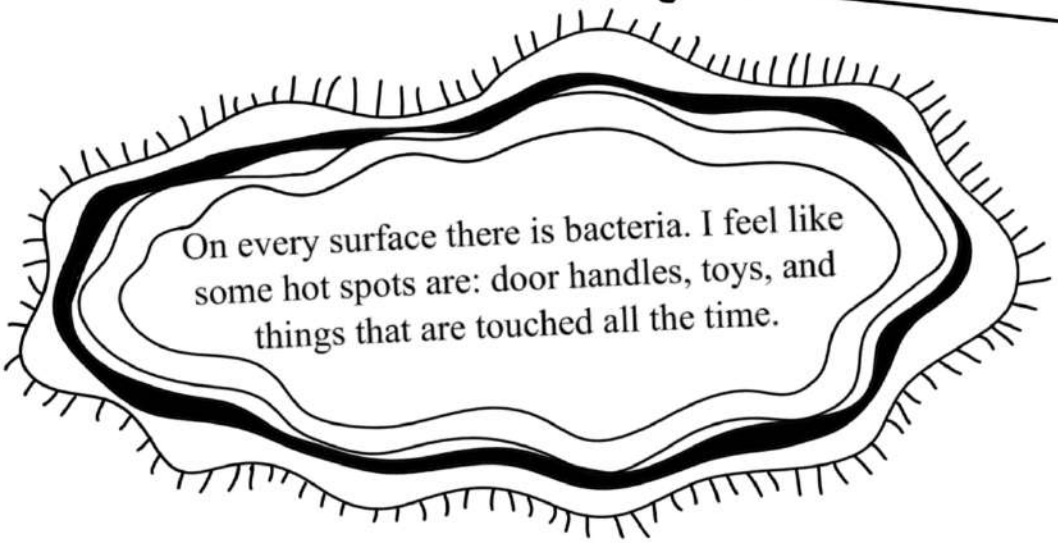
A vaccine contains materials that will stimulate the immune system against a disease. The act of administering a vaccine is known as vaccination. Vaccines work by introducing the disease-causing microbe to the body, so the next time that person encounters the same microbe the body will be prepared to fight it off. When the vaccine enters the body, the cells of the immune system will recognize the antigen, which is the component of the vaccine that is from the infectious microbe. Some of these cells, known as B cells, will then create antibodies, other cells, known as T cells, will learn to recognize the antigen to kill it. When you are exposed to the infectious microbe after vaccination, antibodies will attach to the microbe to inactivate it and alert other immune cells of the infectious microbe's presence. T cells will then attack the organism to kill it.



JOSEPH LISTER

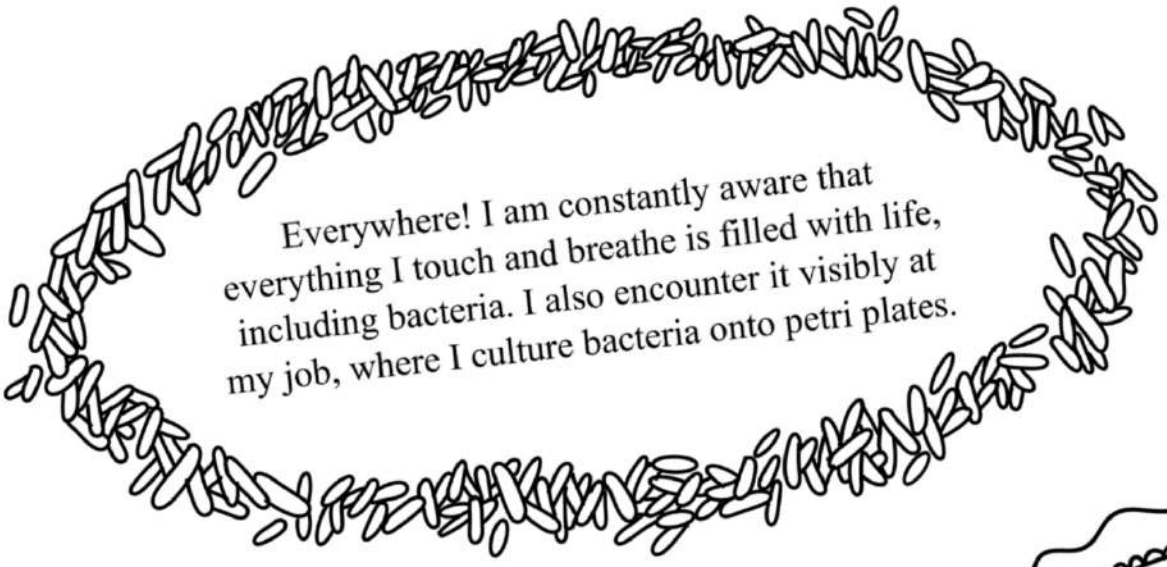
Joseph Lister was a British physician who is deemed the father of modern surgery. In the 19th century, infections of surgical wounds were quite common and often resulted in death of the patient. Using Louis Pasteur's Germ Theory of Disease, which was the idea that microorganisms in the body resulted in infectious disease, Lister postulated that this theory could explain how surgical wounds become infected. As a method to prevent infection during operations, Lister applied a chemical, termed antiseptic, through both washes and sprays that would kill the microorganism, preventing infection of the surgical wound. This practice would soon become standard in surgical procedures and laid the foundation for many of the antiseptic practices adopted in the modern operating room.



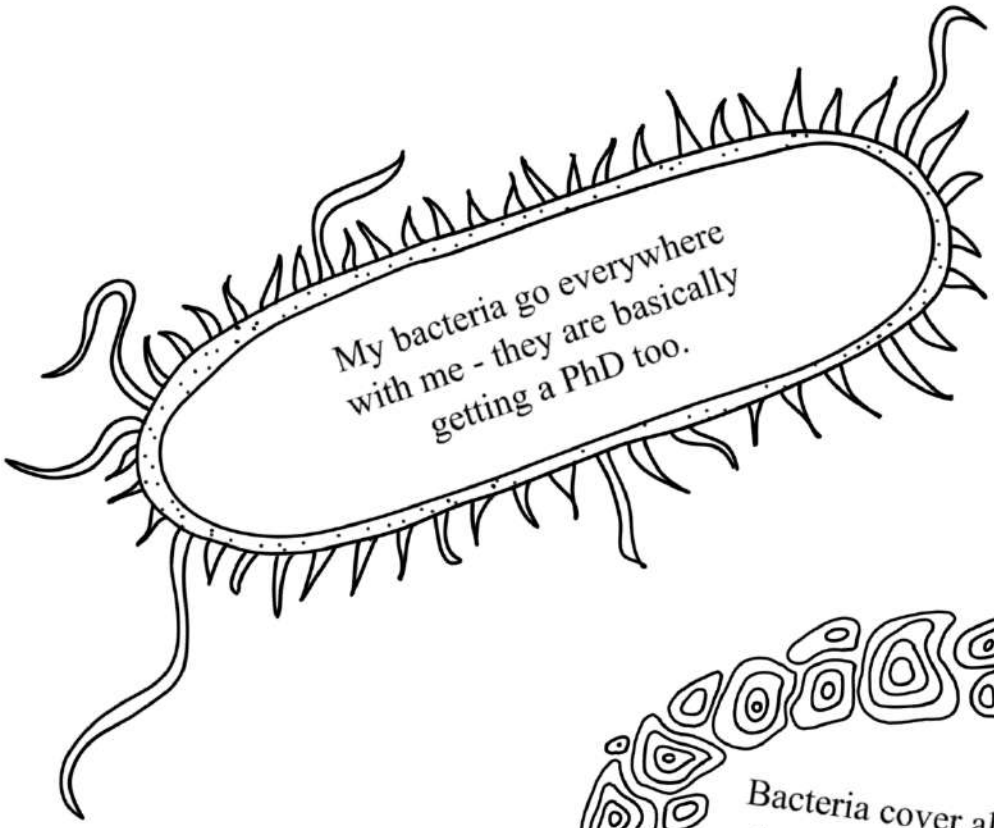


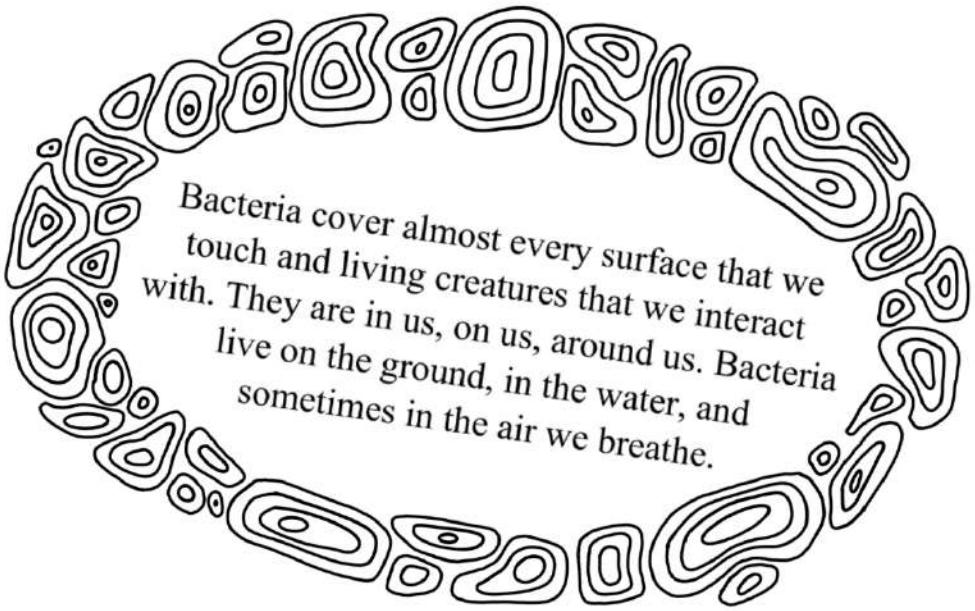
WHERE ARE BACTERIA ENCOUNTERED IN EVERYDAY LIFE?

What do you think?


Everywhere! I am constantly aware that
everything I touch and breathe is filled with life,
including bacteria. I also encounter it visibly at
my job, where I culture bacteria onto petri plates.


Everywhere, especially
in yucky places.


My bacteria go everywhere
with me - they are basically
getting a PhD too.


Bacteria cover almost every surface that we
touch and living creatures that we interact
with. They are in us, on us, around us. Bacteria
live on the ground, in the water, and
sometimes in the air we breathe.

LOUIS PASTEUR

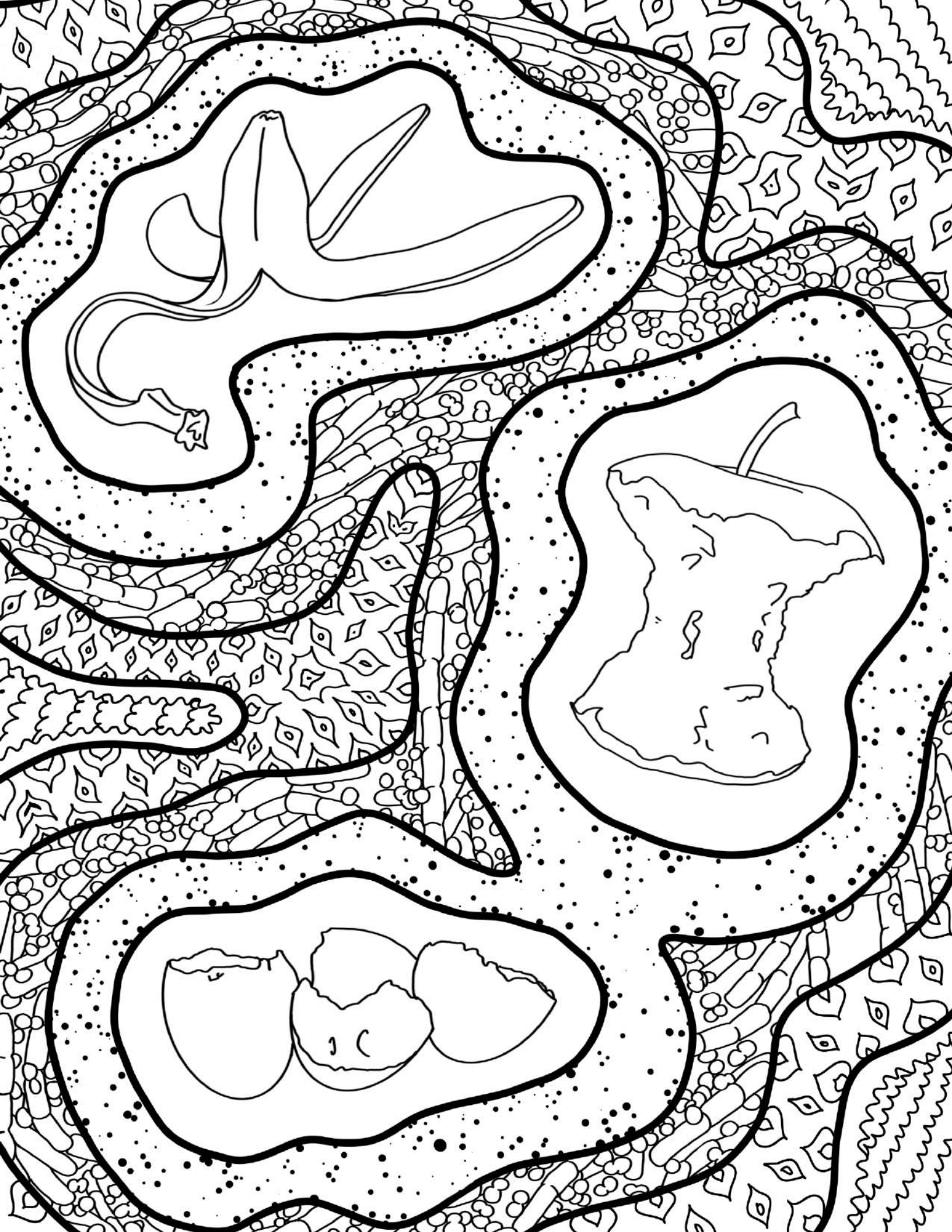
Louis Pasteur was a French chemist and microbiologist who is considered one of the important scientists in founding medical microbiology. Pasteur made many different scientific discoveries but is perhaps most well known for developing the process of pasteurization in the 1860s. This process involves heating foods or beverages to kill microbes responsible for contamination. Milk is a common product that undergoes the process of pasteurization to prevent spoilage.

FERMENTATION

Several foods and beverages we consume are produced through the process of fermentation. Fermentation is the process by which bacteria or fungi breakdown sugars. Foods such as cheese and yogurt undergo fermentation from *Lactobacillus* which are rod-shaped bacteria that create lactic acid from sugar. Beverages such as beer, wine, and kombucha are fermented from *Saccharomyces*, a sphere-shaped fungus that creates ethanol from sugar. In the case of beer, these sugars are broken down into alcohol; however, many other breakdown products can be produced.

COMPOSTING

Composting is the process of recycling organic material into fertilizer that can be used for soil for plants. This process relies on microbes to complete the decomposition of the material. There are three main components of composting: browns, greens, and water. Browns are plant material that contain carbon which is the food source for the microbes that decompose the material. Greens are fresh organic material that contain high amounts of nitrogen which allows the decomposers to grow and reproduce rapidly. Water is also necessary for the survival of the decomposers as it provides moisture that helps break down the organic material. Fruits and vegetables, coffee grounds, shredded newspaper, and grass clippings are some materials that can be composted. Benefits of composting include reducing the need for chemical fertilizers, enriching the soil, and reducing methane emissions from landfills.

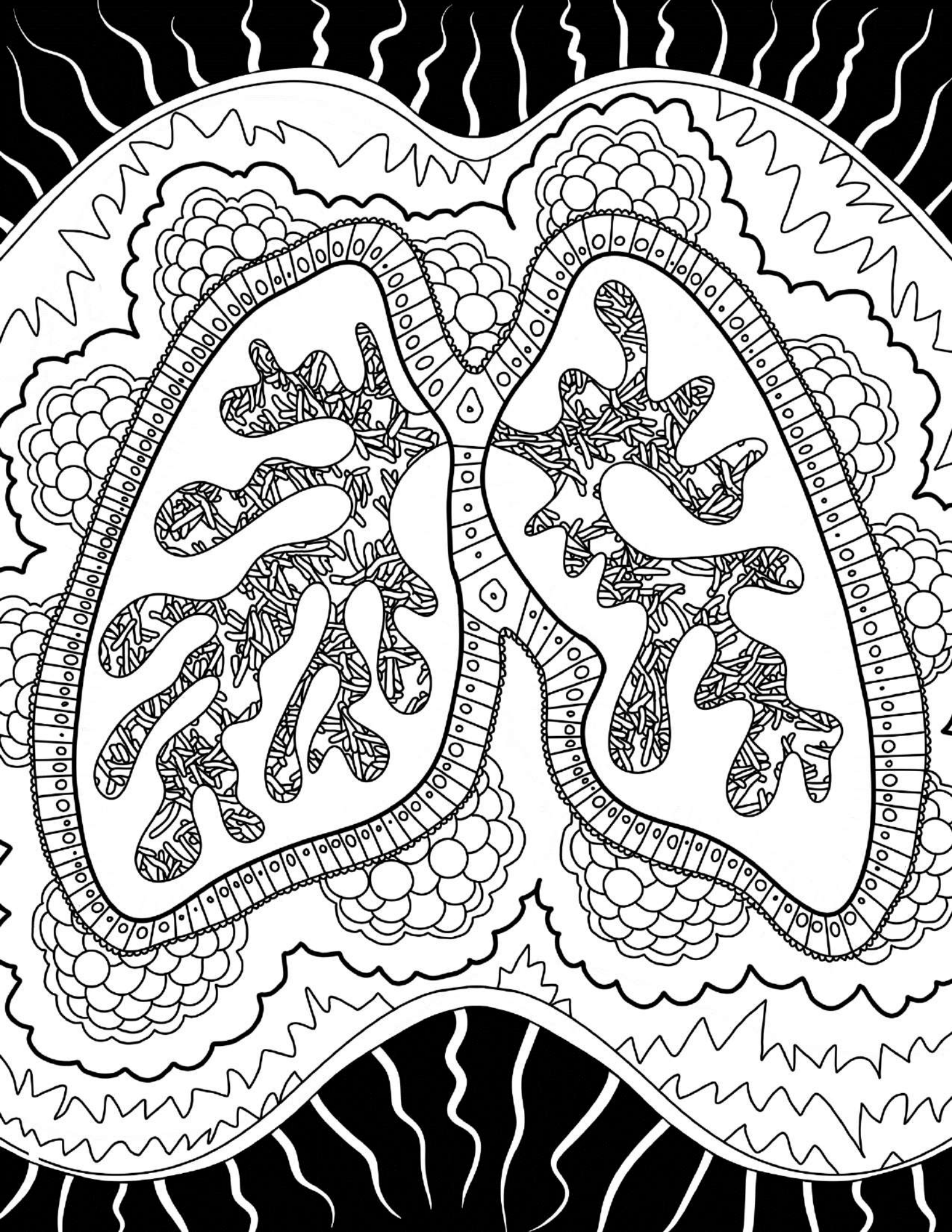


JESSIE ISABELLE PRICE

Jessie Isabelle Price was an African American veterinary microbiologist that isolated *Pasteurella anatipestifer* which is the cause of New Duck disease. In the 1950s, New Duck disease was a big problem for the duck industry. She also worked on other diseases affecting ducks and waterfowl, such as avian cholera, developing important vaccines against some of them. Price was heavily involved in the advancement of African American scientists as well as women in science and served on various committees of several different organizations, such as the American Association for the Advancement of Science and the American Society for Microbiology.

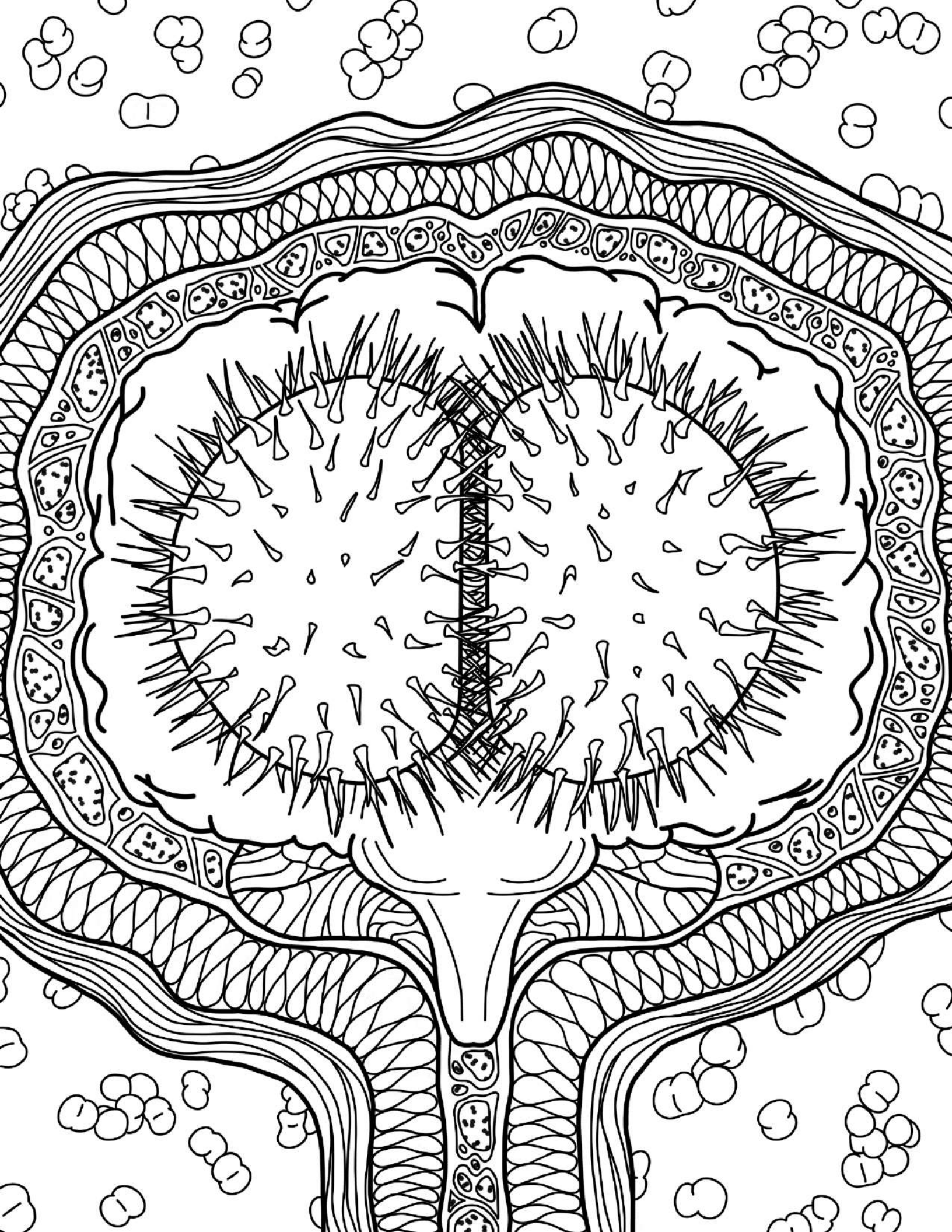
MYCOBACTERIUM TUBERCULOSIS

Mycobacterium tuberculosis is a bacteria that causes the disease tuberculosis which is most commonly an infection of the lungs. Symptoms of the disease include coughing, chest pain, and coughing up blood. Tuberculosis has plagued humans for centuries, with evidence of the disease existing in mummies of ancient Egyptians. The disease is spread through the air where people breathe in the bacteria which may initiate an infection in the lungs; however tuberculosis can infect other parts of the body by spreading from the lungs.



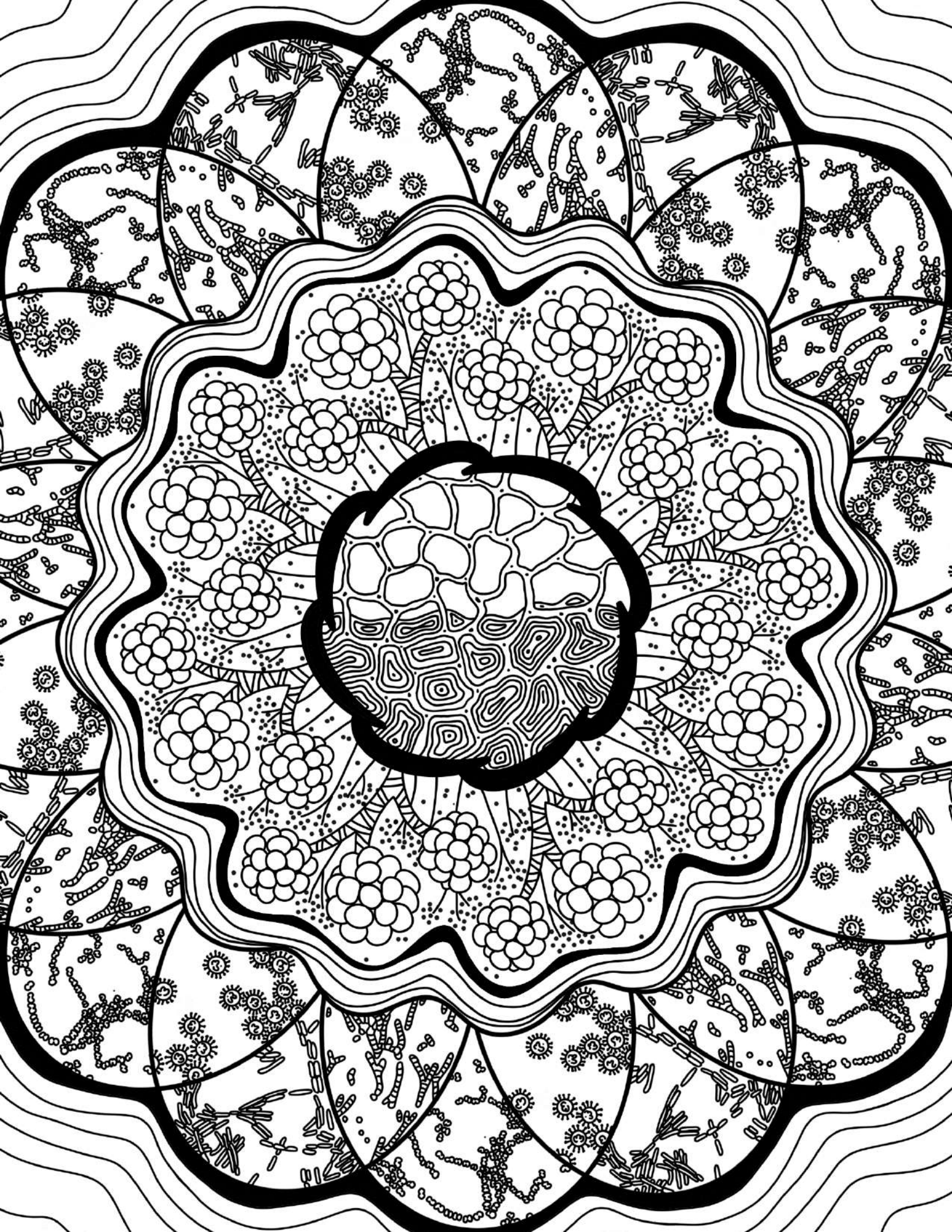
NEISSERIA MENINGITIDIS

Neisseria meningitidis is a coccus shaped bacterium that exists in pairs and can cause bacterial meningitis. Meningitis is an inflammation of the membranes surrounding the brain and spinal cord. Fever, headache, and a stiff neck are the most common symptoms of the infection. *N. meningitidis* can also cause an infection of the blood, known as meningococcemia.



PNEUMONIA

Pneumonia is an inflammation of the lungs due to infection. Some symptoms of pneumonia include cough, fever, shortness of breath, chest pain, nausea, vomiting, and confusion. Pneumonia can be caused by a number of microbes: from fungi to viruses to bacteria. The most common bacterial infection for adults is from *Streptococcus pneumoniae*, and bacterial pneumonia is often very serious and may require medical intervention.



DEINOCOCCUS RADIODURANS

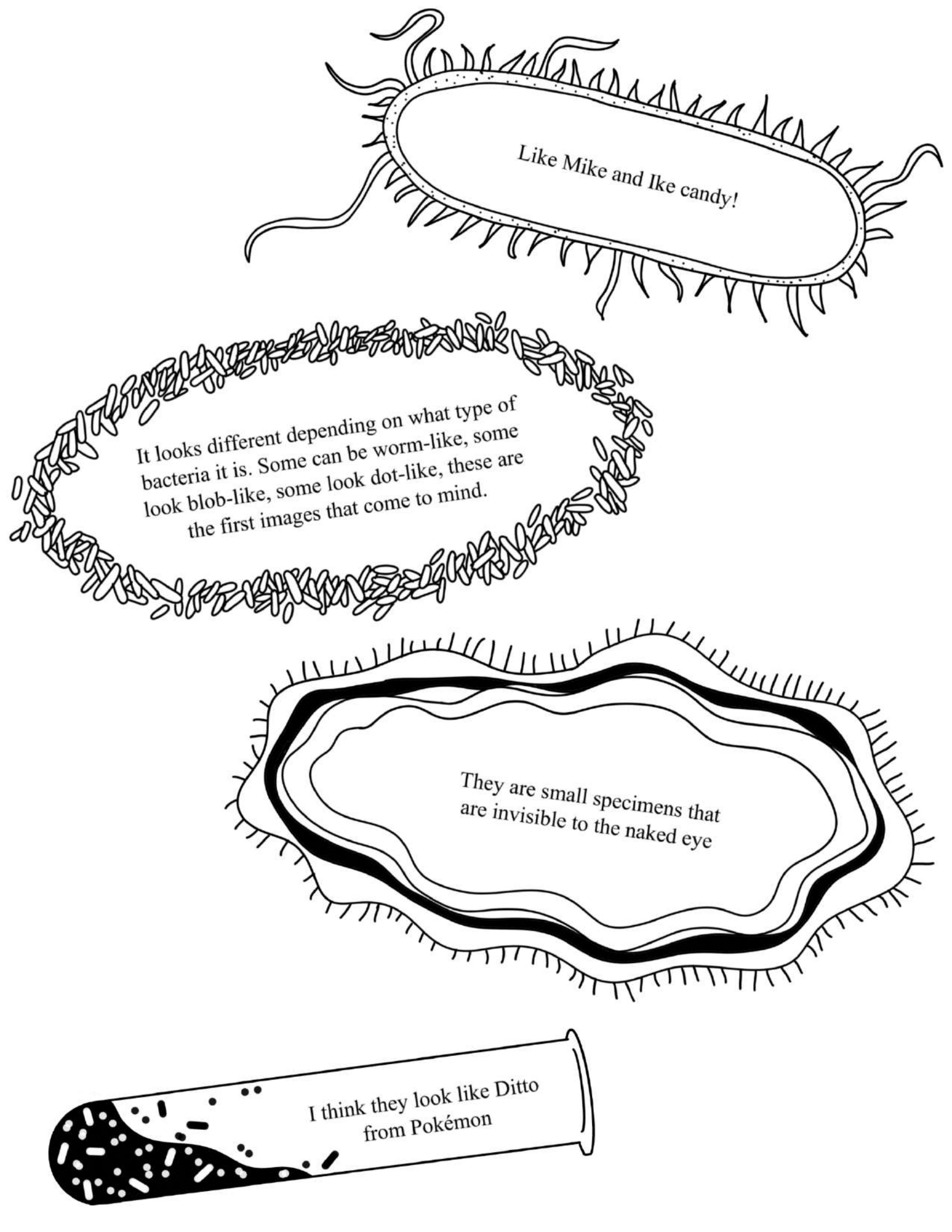
Deinococcus radiodurans are bacteria that can survive extremely high levels of radiation. In 1956, these bacteria were isolated from a can of ground meat that had been irradiated at high levels. It was soon named *Deinococcus* after the greek adjective that means strange or unusual. The cells are spherical and exist in tetrads (or groups of four). Typically high levels of radiation will damage a cell's DNA resulting in death; however, *D. radiodurans* have mechanisms to resist this damage. There is a lot of research investigating what those specific mechanisms are.

Like little microscopic peanuts and fuzzy gumdrops

Green and squishy

WHAT DO BACTERIA LOOK LIKE?

What do you think?


Like Mike and Ike candy!
It looks different depending on what type of bacteria it is. Some can be worm-like, some look blob-like, some look dot-like, these are the first images that come to mind.
They are small specimens that are invisible to the naked eye
I think they look like Ditto from Pokémon

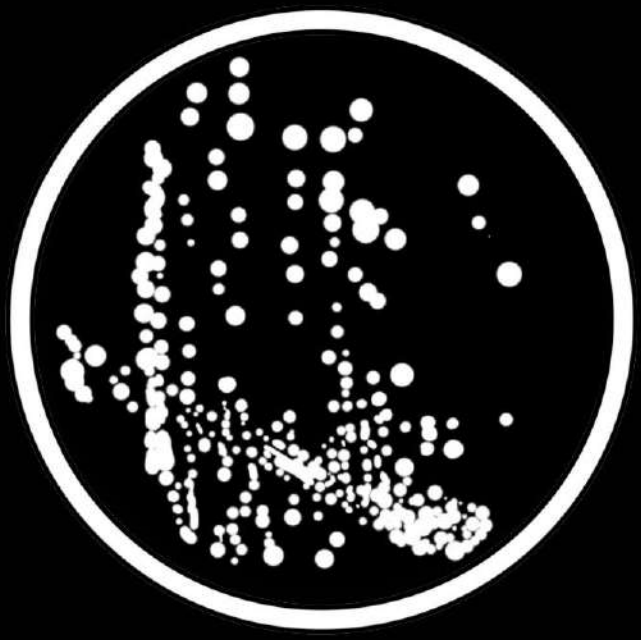
BASIC BACTERIAL SHAPES

Bacteria come in all shapes and sizes, but there are three basic shapes that bacteria take. Those three shapes are coccus, bacillus, and spirochete. A coccus is a round shaped bacterium. An example of a coccus shaped bacterium is *Staphylococcus aureus*. A bacillus is a rod shaped bacterium. An example of a bacterium that is a bacillus is *Escherichia coli*. A spirochete bacterium is a bacterium in the shape of a spiral. An example of a spirochete is *Borrelia burgdorferi*, which is one causative species of Lyme disease.

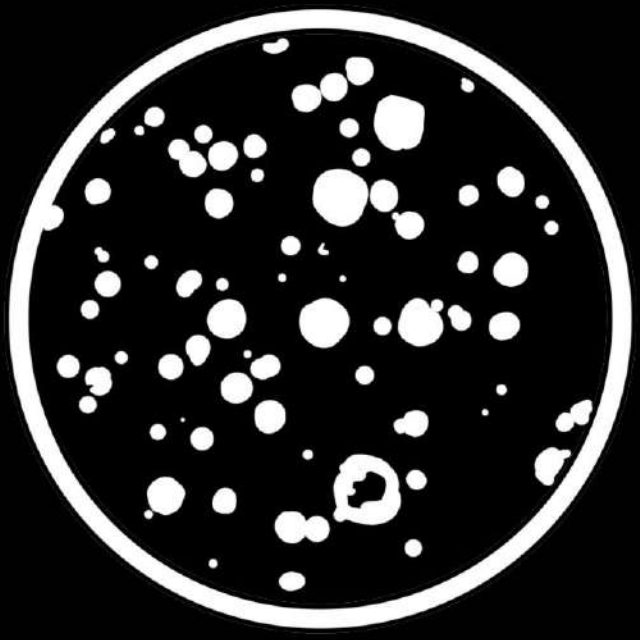

Spirochete
Bacilla
Coccus

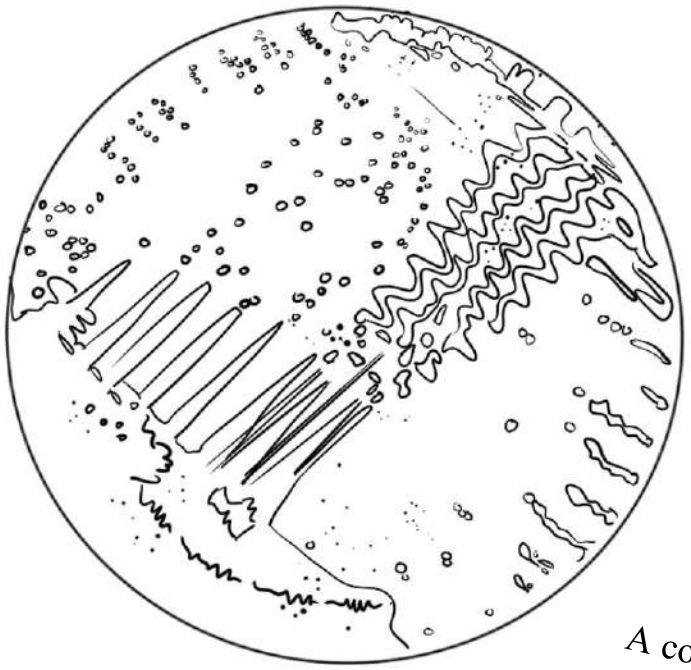
FANNY HESSE

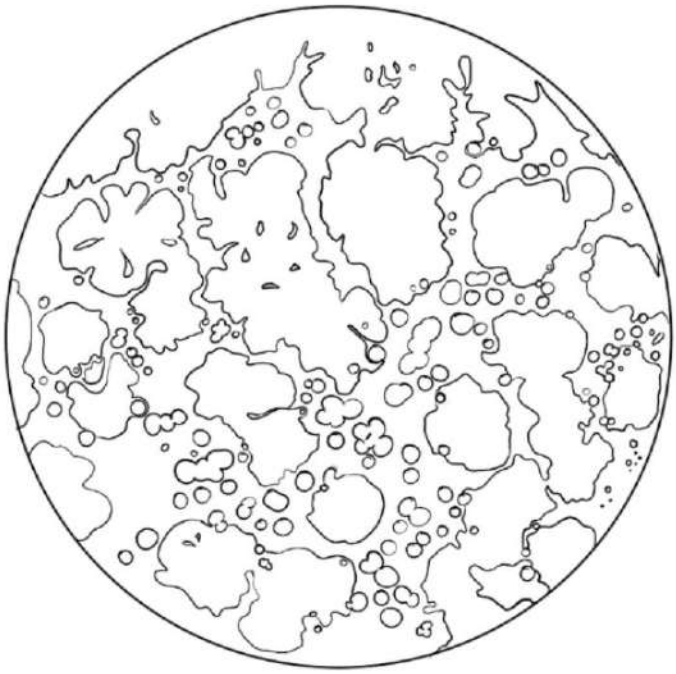
Angelina Fanny Hesse, in the 1880s, was the first person to suggest that agar should be used as a media for growing and isolating bacteria. Hesse was a scientific illustrator and technical assistant for her husband, who was a member of Robert Koch's lab. She learned of agar from a neighbor when she was a child living in New York. Agar works best for bacterial cultures because it doesn't melt when the plates are incubated at higher temperatures, which are required to grow some bacteria. After observing this, her husband brought the idea to Koch. Although her discovery was crucial, neither she nor her husband were credited for this discovery.



Nutrient agar media is commonly used in the laboratory to grow bacteria. There are many different types of agar that have different ingredients that help to grow specific species of bacteria. Agar is derived from red algae and after preparation it becomes a solid. Agar is typically put into a petri dish, which is a round glass or plastic container.

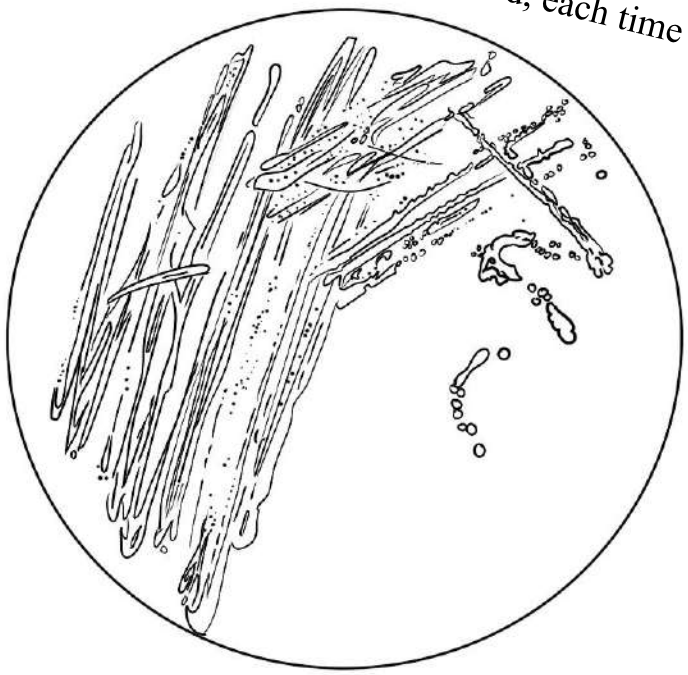


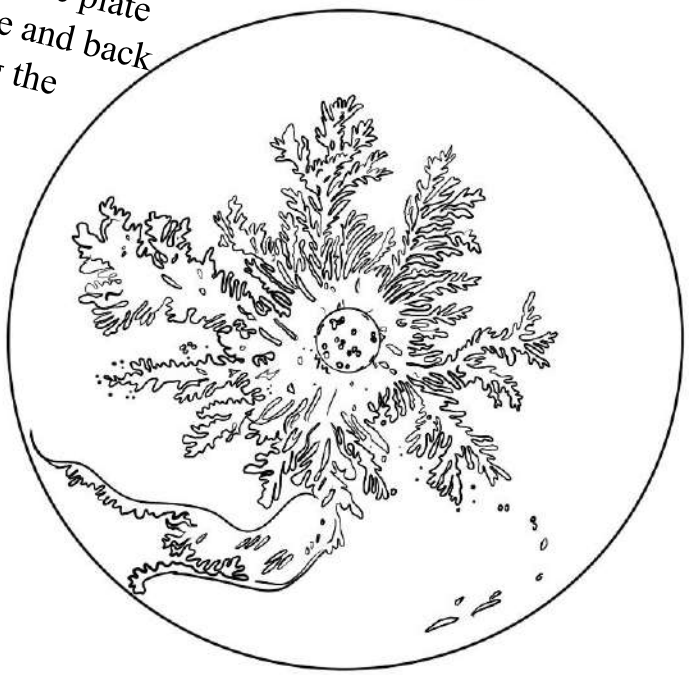




A common way to isolate individual colonies of bacteria on petri dishes is using a bacterial streak. A colony of bacteria is a group of bacterial cells that originate from a single bacterial cell. This means they are genetically identical.

To streak the plate, a swab with bacteria is initially swabbed onto one side of the plate. Then a sterile stick is drawn across the plate from the initial swab out into another section of the plate and back again many times. This is repeated, each time decreasing the number of streaks

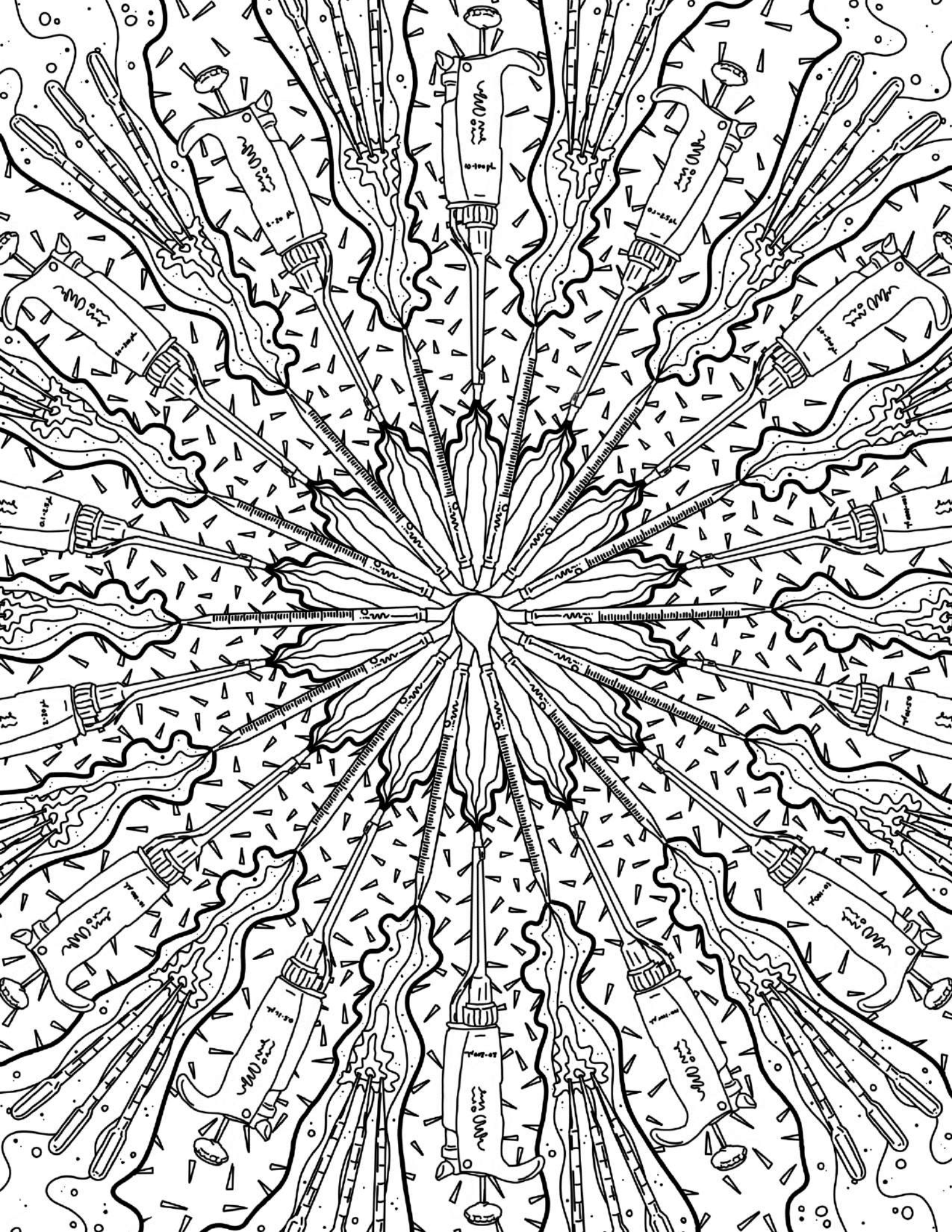




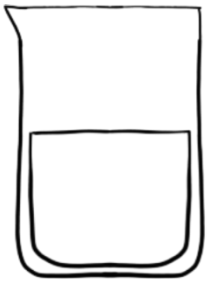
This process gives you individual colonies growing in one region of the agar.

PIPETTE

Pipettes are common lab equipment that are used to transfer liquids. There are several different types of pipettes including volumetric pipettes, disposable pipettes (or transfer pipettes), and variable volume pipettes. Volumetric pipettes are used to accurately transfer a specific volume of liquid. These pipettes have narrow tips and a bulb-like structure in the middle and can only transfer a specific volume of liquid that the pipette was designed to transfer. Disposable or transfer pipettes are used to transfer small amounts of liquid. These pipettes have a bulb at one end that is pressed and released to pull the liquid into the pipette and pressed again to release the liquid. With a variable volume pipette you can adjust the exact volume of the liquid that is being transferred. These pipettes use sterilizable tips to hold the liquid that is being transferred. Each variable volume pipette has a range of volumes of liquid that can be transferred, so there are several different sizes available. Variable volume pipettes allow the transfer of liquids easily using one hand.



GLASSWARE



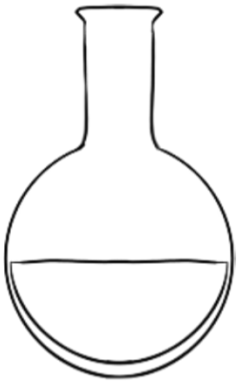
BEAKER

BUCHNER FLASK

ERLENMEYER FLASK

VOLUMETRIC FLASK

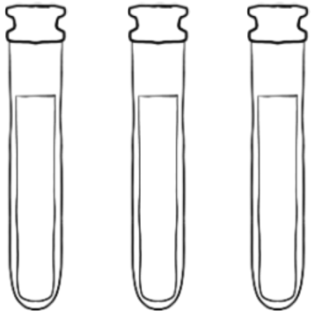
SCHLENK FLASK



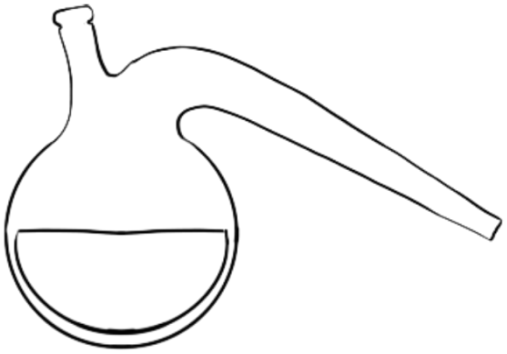
ROUND-BOTTOM FLASK

FLORENCE FLASK

KJELDAHL FLASK



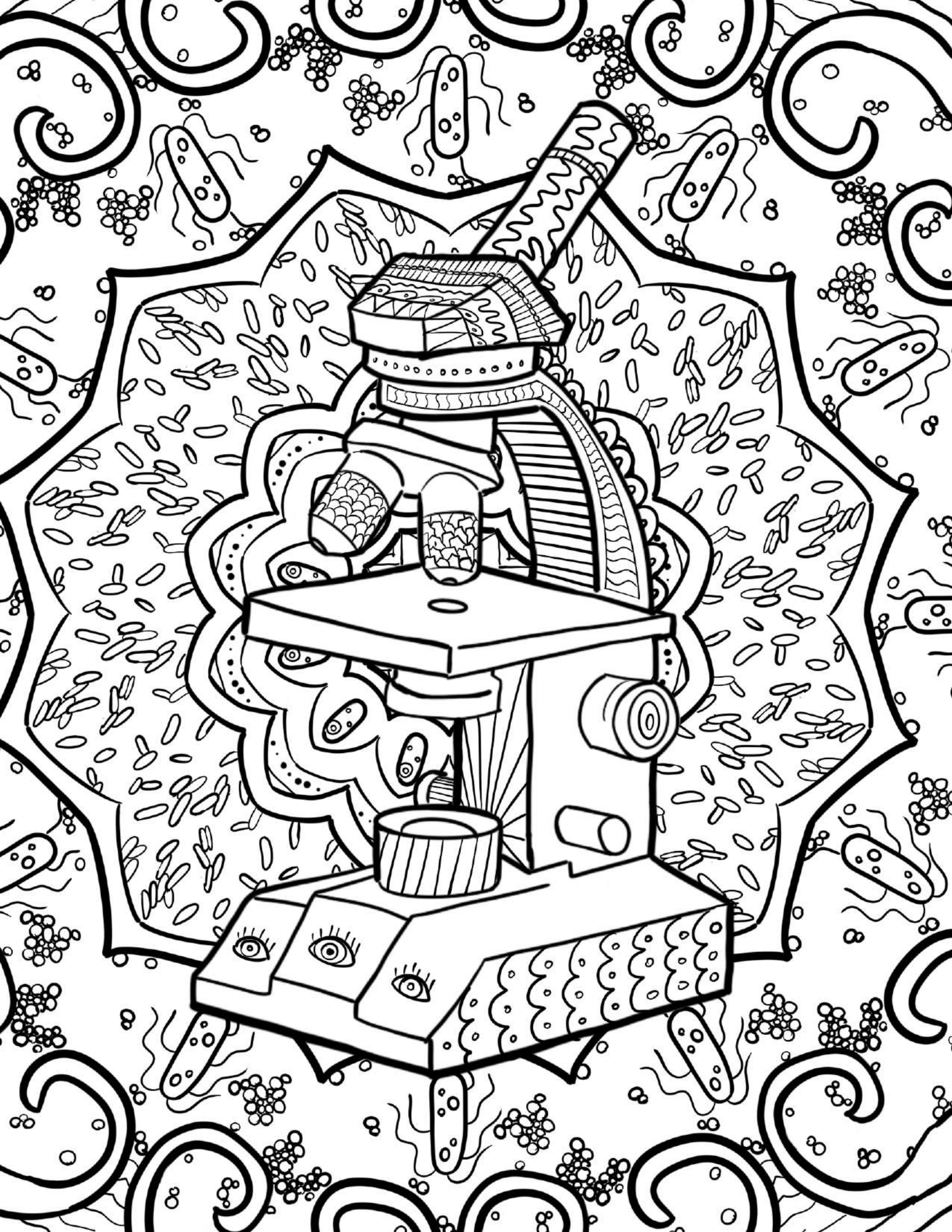
TEST TUBES



RETORT FLASK

MICROSCOPE

A microscope is a piece of equipment used in the laboratory to visualize very small organisms such as bacteria. The microscope uses a series of lenses to magnify the organism to allow it to be visualized by the naked eye, magnifying the image sometimes up to 1000 times. Without them, we wouldn’t be able to see the amazing world of bacteria!



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