2020

What is a Virus?

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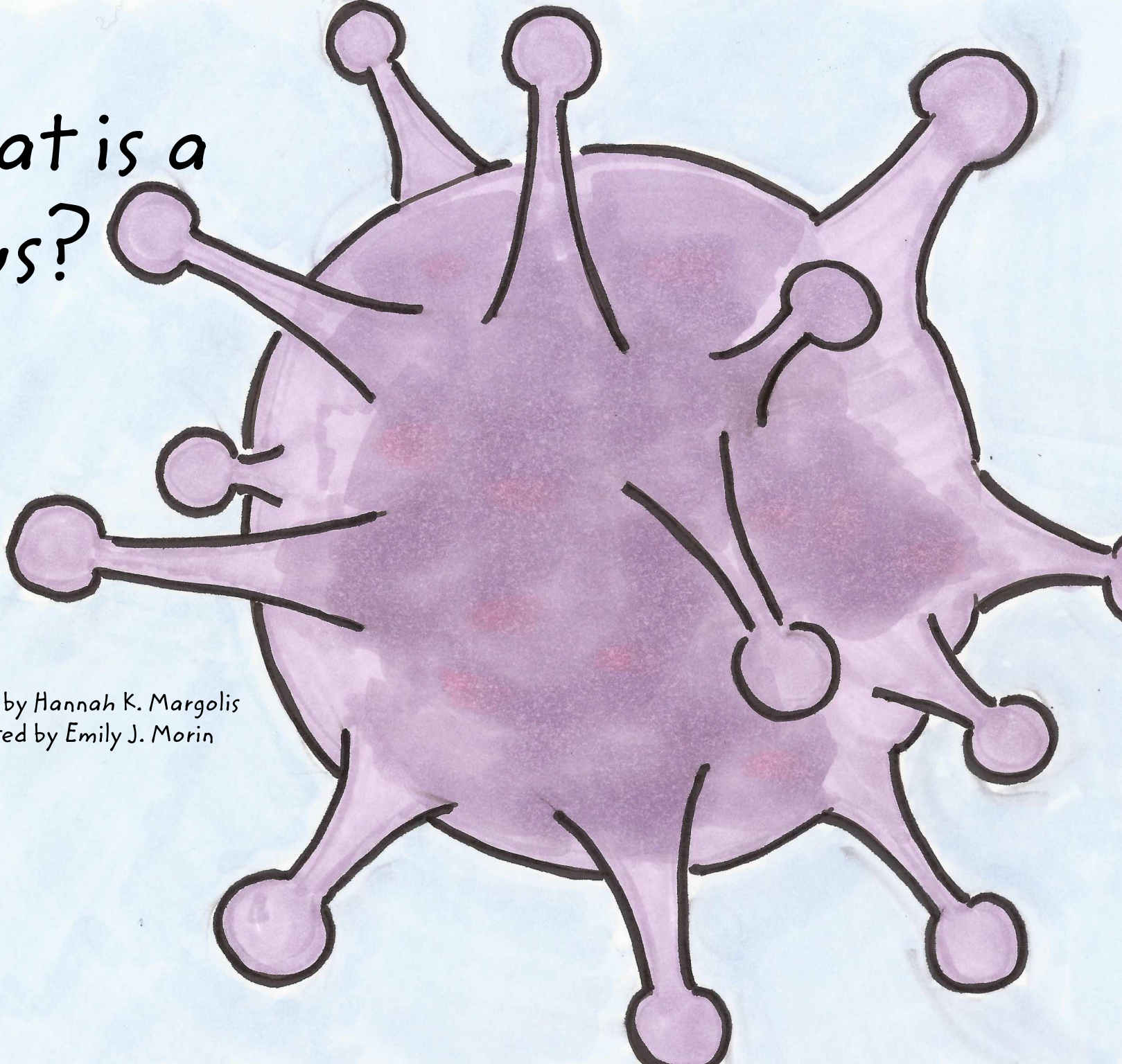

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Image References

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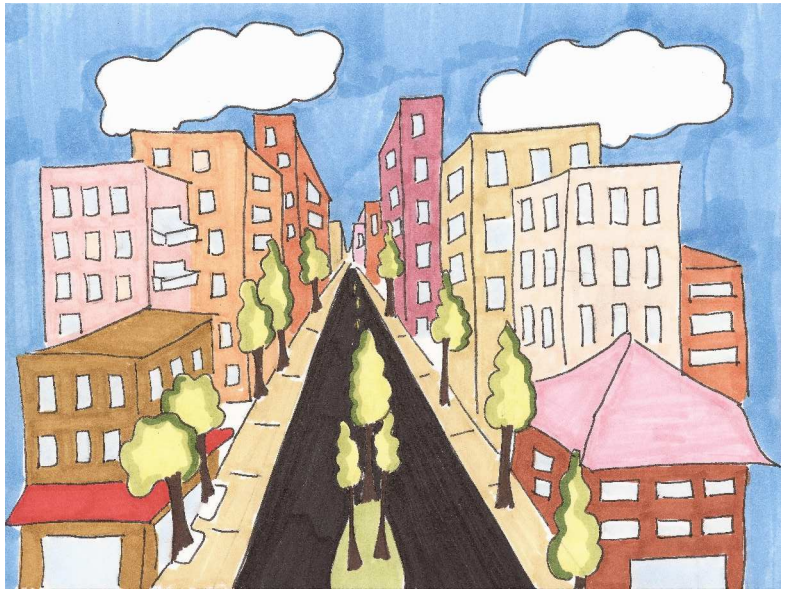
If you normally go to school during the day, you've probably noticed things have changed.

Kids aren't going to school



People aren't hanging out in groups.

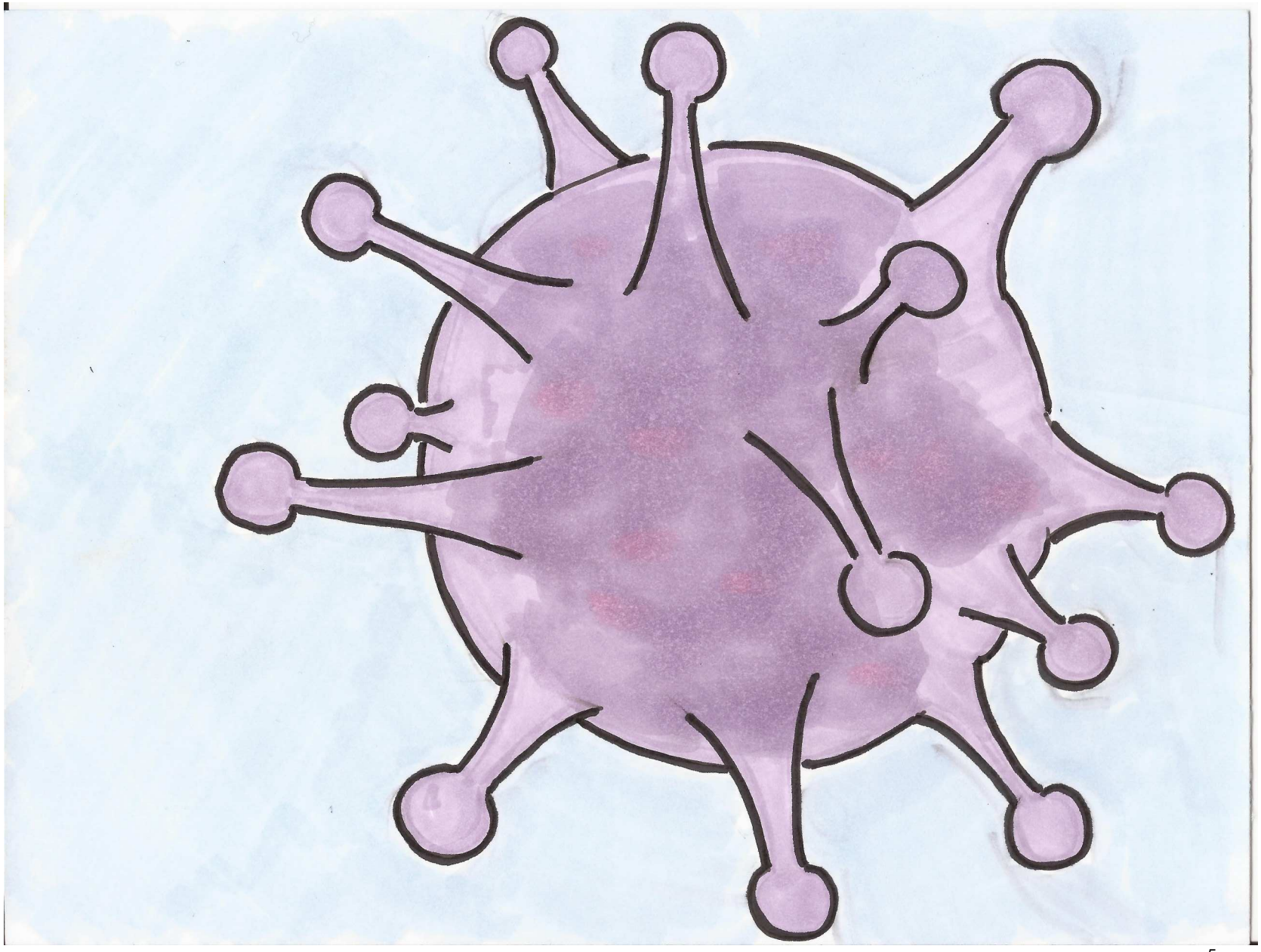
Your parents might be working from home.
You're probably trying to stay busy at home too!

You might wonder why.

The reason is that there is something new moving around...

It's just too small to see with your eyes.

The new thing is called a virus.



Viruses are all around us...

(We'd have to zoom in REALLY far to see the viruses!)

...just too small to see.

Just how small is a virus? A Question of Scale

When we say a virus is small, how small are we talking?

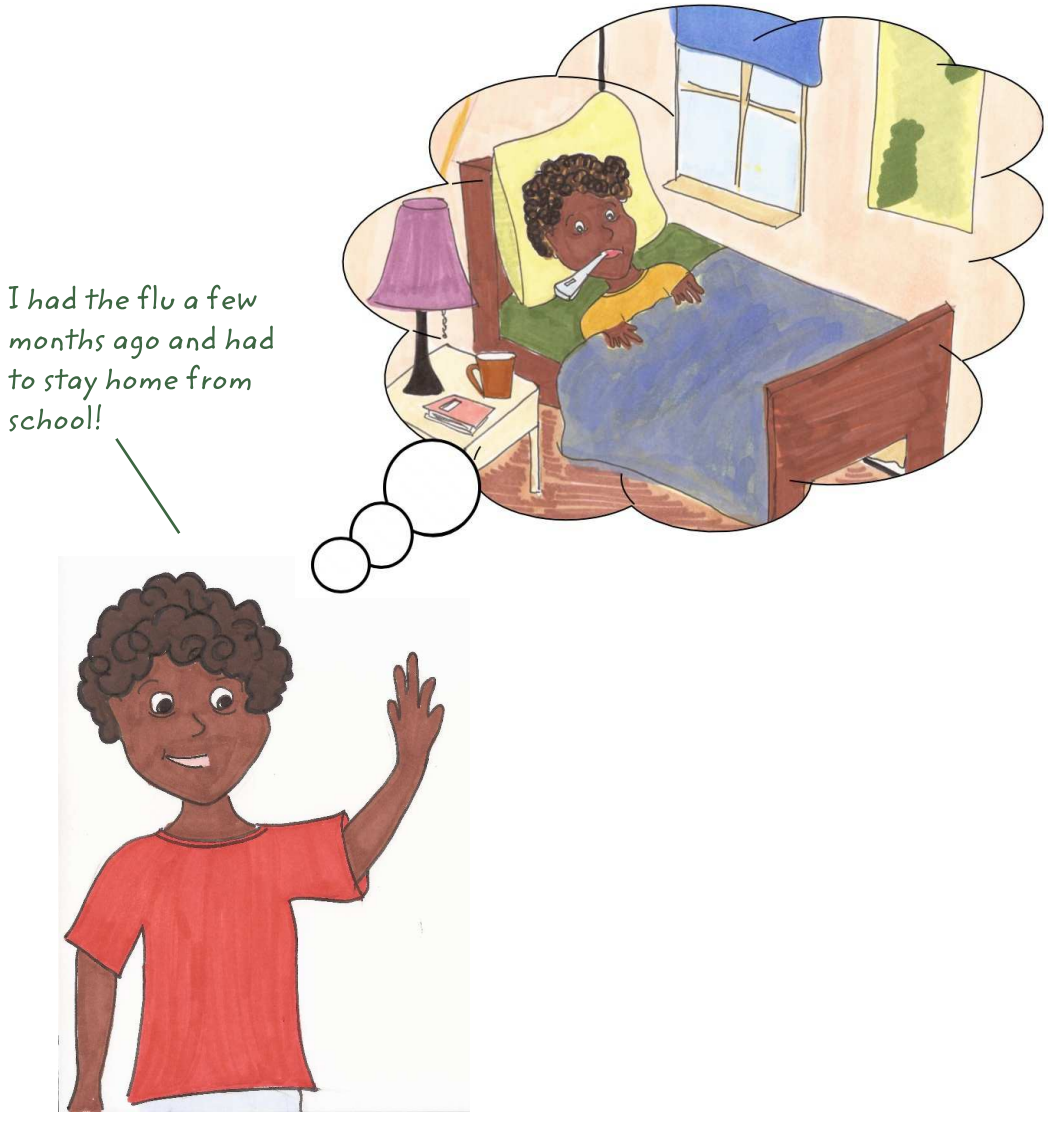
You're probably used to comparing the sizes of objects like a walnut to a watermelon.

But what if we want to compare the sizes of two very different things, like the size of the moon to the size of that walnut? That's a pretty big difference!

Scientists explain these differences in powers of ten. For instance, a watermelon (around 40 cm long) is about 10 times larger than a walnut (4.5 cm long) and the moon (3474 km in diameter) is 10 million times larger than that walnut (that's 1 with seven zeroes: 10,000,000!)

This is the level of scale we need to describe viruses. On average, a virus (100 nm) is 1 million (1,000,000) times smaller than the watermelon. In other words, a virus is so small compared to a watermelon, it is similar to comparing a watermelon to the moon!

In fact, you've probably been in contact with a virus before.



But what are viruses, and how do they make us sick?

What makes something alive?

This might seem like a silly question. But believe it or not, many scientists disagree on what exactly makes something alive!

While some things, like a fish or flower, are definitely alive, what about parts of living things? Is your foot alive? A bone from dinner?

In general, scientists do agree that to be alive, something must:

•Be able to move

•Take in energy from food

•Notice and respond when something around you changes

•Grow

•Reproduce

•Maintain **homeostasis**- a fancy term meaning you can keep things in your body constant, like your body temperature even if it's cold outside.

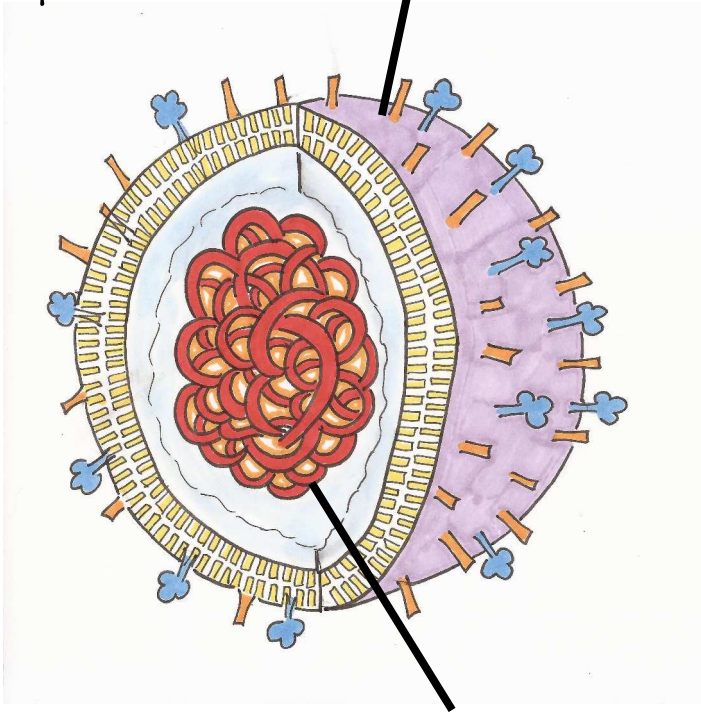
Think about something living- like a tree, a dog, or yourself. Do you meet all of these categories? What about something like **fire?** (This one is tricky! Hint: can fires maintain homeostasis?)

Although some scientists debate it, viruses are normally not considered alive because they cannot reproduce on their own and do not take in energy from food.

This might sound weird, but most scientists believe viruses aren't alive

Viruses are just containers

The outside is made of two materials called protein and lipids.



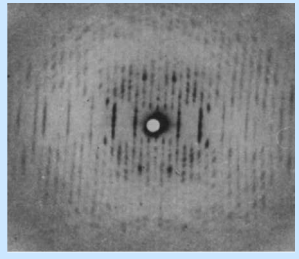
The inside holds genetic material: either DNA or RNA.

How do we know what viruses look like? Rosalind Franklin and Tobacco Mosaic Virus

We said earlier that viruses are really small – thousands of times smaller than a pin. So how do we know what they look like?

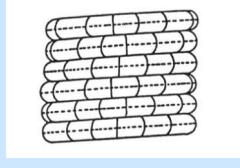
In the 1950s, a chemist named Rosalind Franklin collected some of the first data on the structure of viruses. She studied TMV, a virus that infects plants.

Dr. Franklin at work

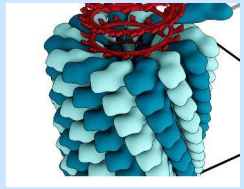


Franklin used a complex method called x-ray crystallography to get diffraction images like this one.

With these images, she figured out that the virus had protein on the outside and DNA on the inside. She even made sketches of the structure that are very close to the structure of the virus we have today!

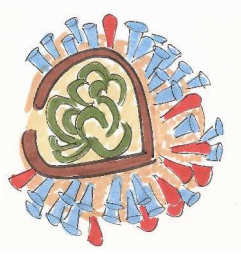


Franklin's sketch

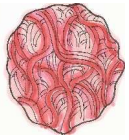


Current TMV Structure

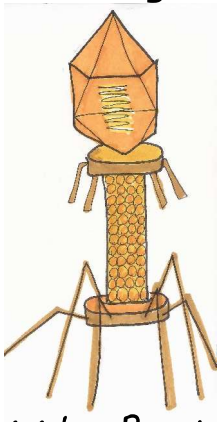
Viruses come in many varieties with



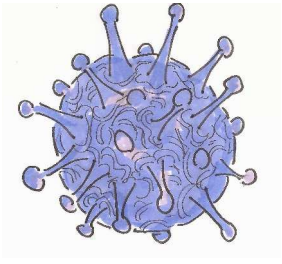
Alphainfluenzavirus
Common Flu
80-120 nanometers (nm)



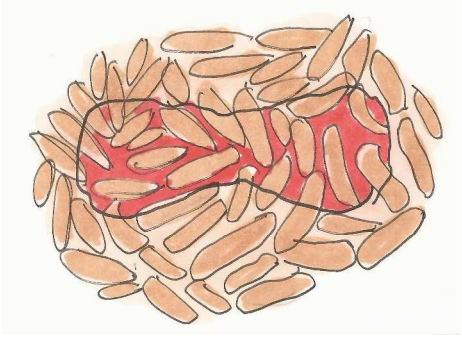
Rhinovirus
Common Cold
30 nm



Myoviridae Bacteriaphage
Infect bacteria!
Approx 200 nm



Lentivirus
HIV/AIDS
120 nm

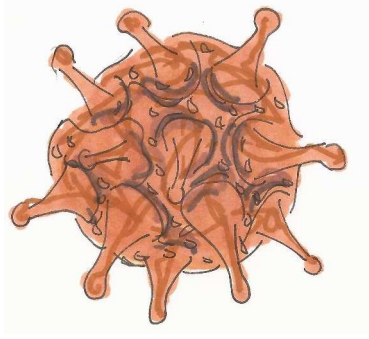


Variola major and minor
Small pox (eradicated)
250 x 300 nm

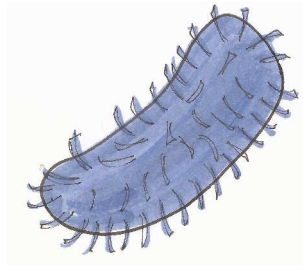
Zaire ebolavirus
Ebola
800-1000 nm long!

(Eradicated means the virus is now gone thanks to medical efforts.)

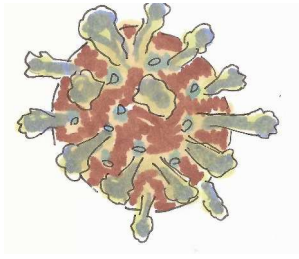
different protein coats.



Human alphaherpesvirus 3
Chickenpox
200 nm



Rabies lyssavirus
Rabies
180 nm long



SARS-CoV-2
Coronavirus
120 nm

These different protein coats allow viruses to make us sick.
How?

SARS-CoV-2
The 2020 Coronavirus outbreak

You might have heard about something called the Coronavirus recently.

The Coronavirus is a sickness, like a flu or the cold. But unlike the flu or the cold, coronavirus is a **respiratory illness.** This means it affects how well your lungs can help you breathe.

The virus can be spread when someone who is sick coughs or touches their mouth or nose.

Coronavirus is caused by a virus that didn't exist before, called SARS-CoV-2. It is related to other viruses that also cause respiratory illness.

Signs that you're sick (called symptoms) include shortness of breath, a dry cough, fever, and chills.

SARS-CoV-2 has caused a pandemic, meaning it has infected many people all around the world.

Part of the reason it is so successful is that many people who get coronavirus don't feel that sick and spread it when they go about their daily plans.

Scientists are working hard to find ways to treat and prevent Coronavirus, but everyone must help prevent the spread of the virus so life can return to normal.

To answer that, we need to imagine being on the scale of a virus, because viruses are

very, very, very, very tiny

Take a closeup look at your hands- what do you see?

'Resolution' is a fancy word for the smallest thing something can see. Our eyes have a resolution of about 0.1 mm. That's a bit smaller than the width of your fingernail.

Even with a magnifying glass I can't see the cells that make up my hand.

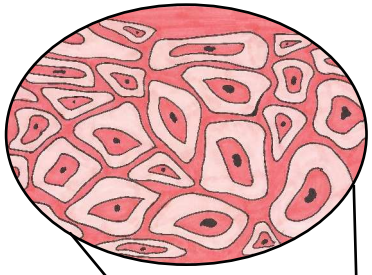
Take a look at your hand in a magnifying glass- you can see more than with your eyes alone!

But what if we zoomed in to a higher resolution than your eyes can see?

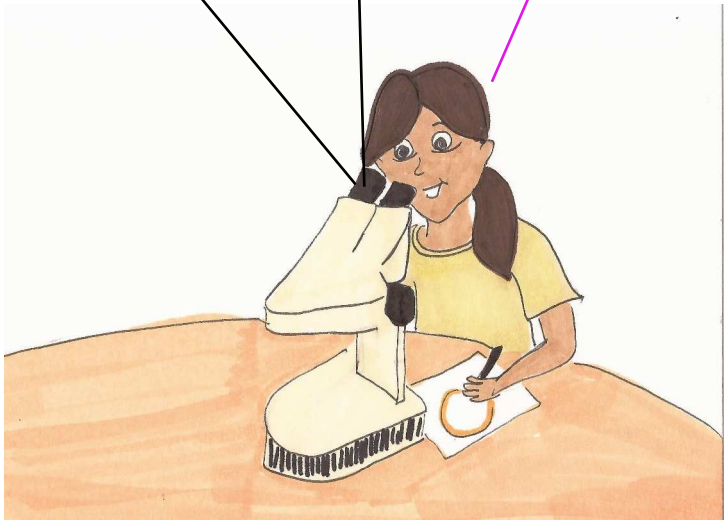
We can do this with a very powerful **microscope**

Now you can see that your hand is made up of many smaller parts, called **cells**

A view of cells in the microscope



Did you know your body is made up of over 30 trillion cells? That's more than 8000 times the number of stars in our galaxy!



Seeing Cells-the pioneers of microscopes

In 1665, Robert Hooke was the first person to use the term "cells" to describe the tiny components of a plant under the microscope. He compared them to arranged pieces of a honeycomb from a bee hive in his famous book *Micrographia.*

Hooke was a naturalist from England with interests ranging from map making to the planets, fossils, and living things. Later in life, Hooke worried other scientists would take his ideas, and started recording his work in code.

Hooke's microscope

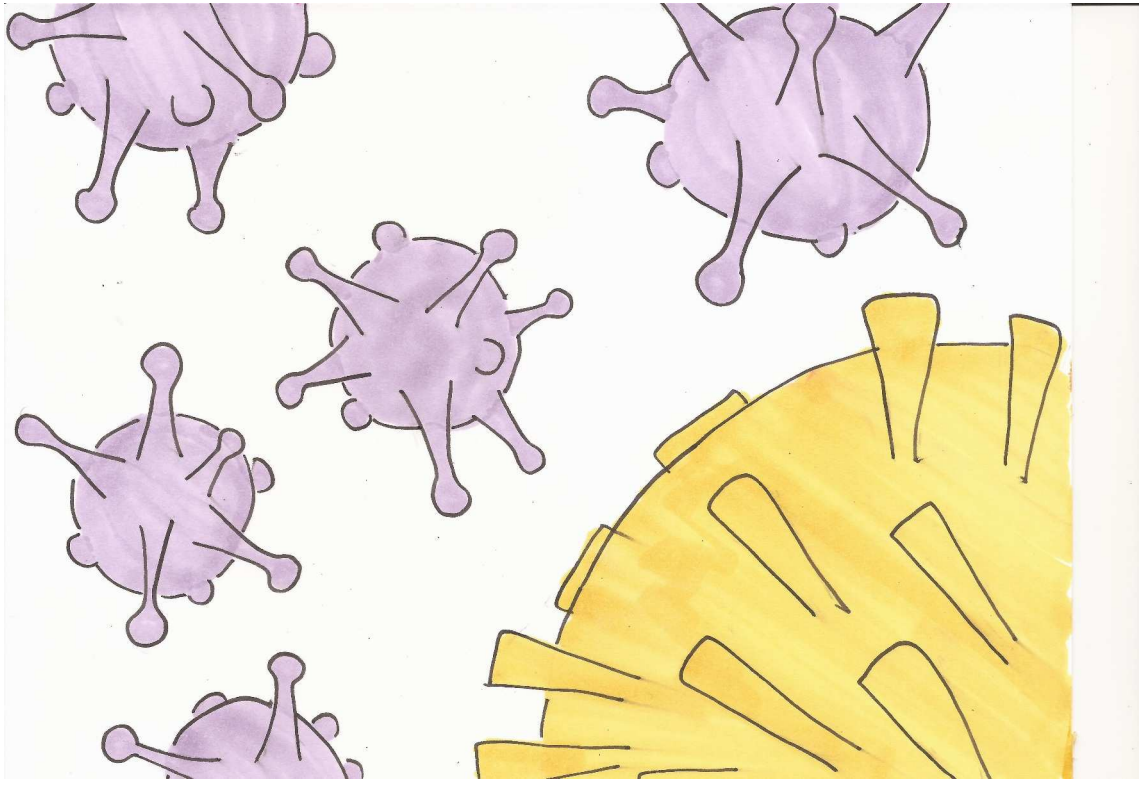
A sketch of plant cells Hooke made.

Antony Van Leeuwenhoek is called the "Father of Microbiology". In the 1670s, he made new microscope lenses that could magnify much better. He discovered single celled organisms including bacteria and protists (which he called "wee beasties") by examining things such as the plaque he scraped off of his teeth.

Anthony Van Leuwenhoek

Now that we are seeing at the level of a cell, we can imagine what a virus would "see."

Viruses have one big goal.

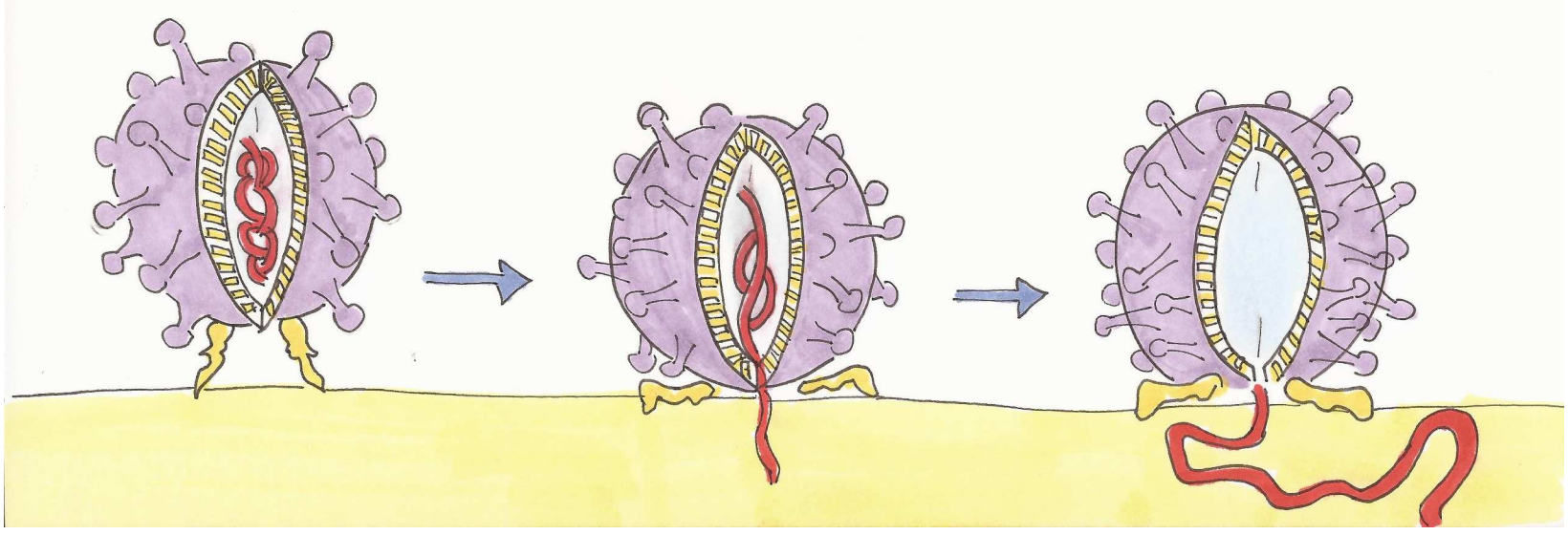


Viruses want to make more copies of themselves, but they don't have the tools to do this alone.

The virus needs to use the machinery inside of your cells.

Viruses have a sneaky way of gaining access to your cells.

The different proteins on the coat allow the virus to virus to dock onto receptors on your cells.

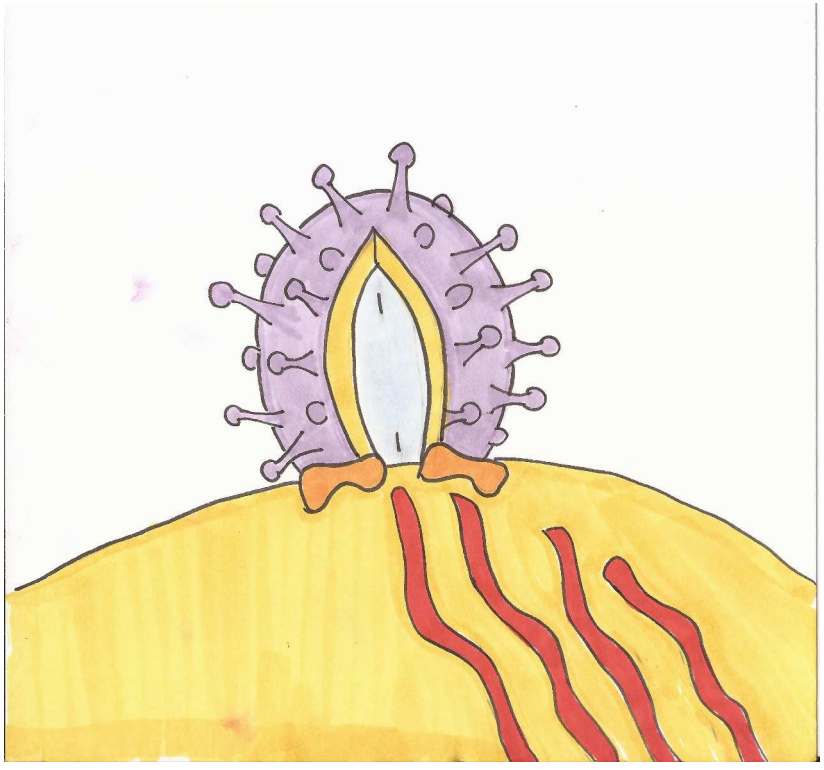


The virus docks onto the receptor.

The DNA (or RNA) is pushed into your cell!

The viruses can then push the DNA or RNA into your cell

The virus forces your cell to make more copies of its DNA or RNA.



The DNA (or RNA) is copied, or replicated, in your cell!

But the virus doesn't stop there,

DNA, proteins, RNA, and lipids
Cell (and virus) building blocks

We've been throwing these words around a lot to describe viruses. But what exactly are they?

DNA: if you think of cells as little living factories, you can think of DNA as the instruction manual. It is a very long string of individual units called nucleotides. When read out, it tells the cell how to produce what it needs to survive.

Proteins: proteins are the extremely tiny machines inside of cells. DNA tells the cells what proteins to make when. Proteins do almost all of the work that keeps us alive, from forming highways in our cells to transport things to acting as molecular scissors to untangle DNA. There are proteins that look and act like keyboards, recycling bins, and even wheels. Proteins are made up of very long strings of units called amino acids.

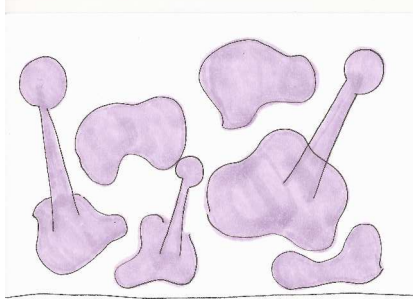
RNA: as the name suggests, RNA is very similar to DNA. It is often used as a disposable copy of certain parts of the DNA manual, but some viruses carry all of their instructions as RNA rather than DNA.

Lipids: lipids are fats. They include things like oils and wax. Lipids play important structural roles, helping to make up the coat that holds cells and viruses together.

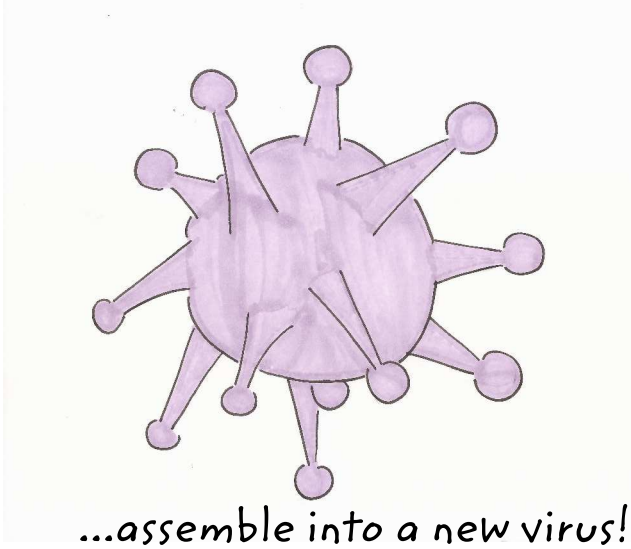
There is a more great information on these building blocks in online educational resources. Check them out!

The DNA (or RNA) your cell has just made for the virus is like an instruction manual.

When read by your cell, it tells your cell to make the proteins that make up the viral coat.



Viral proteins...

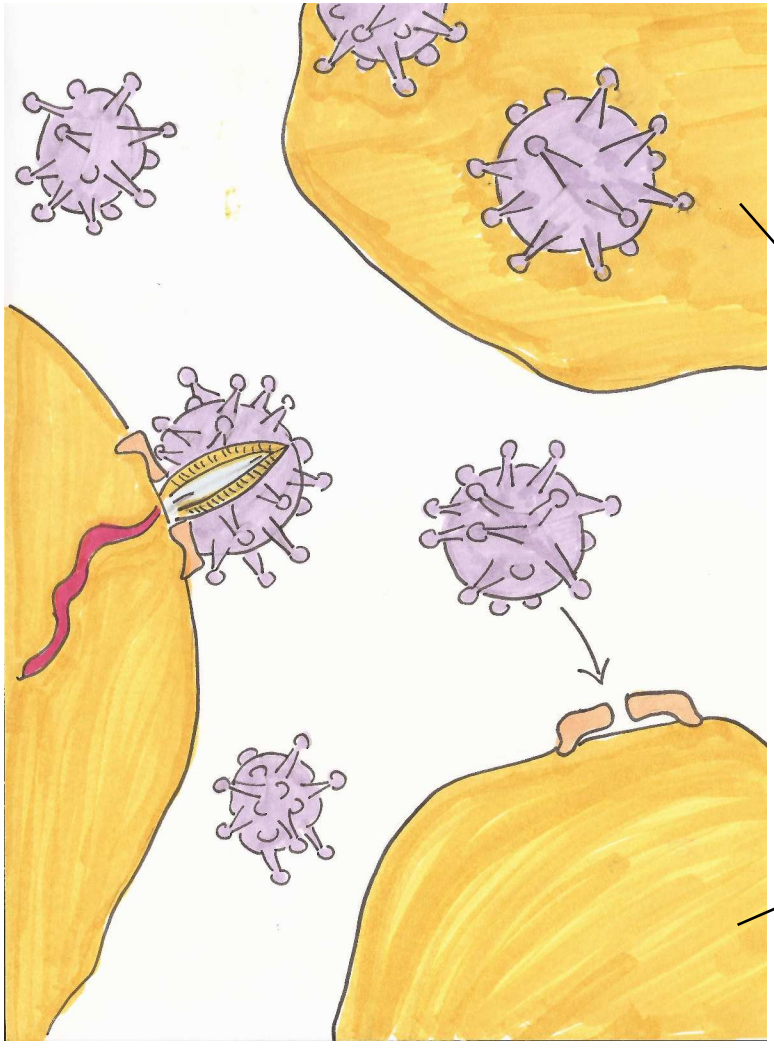


...assemble into a new virus!

The virus has turned your cell into a little factory to duplicate itself!

Once made, the new viruses burst out of your cells, which can hurt your cells.

The viruses can then infect nearby cells.



This process repeats again...

and again...

and again...

Duplicated viruses ready to leave the cell.

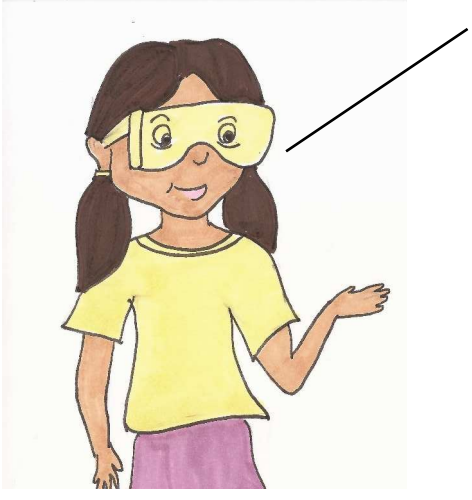
This healthy cell is about to be infected by one of the duplicated viruses!

...until it makes you sick!

When a virus has infected you, you might get:

- A runny nose
- A sore throat
- Fever or chills
- A cough
- Body aches

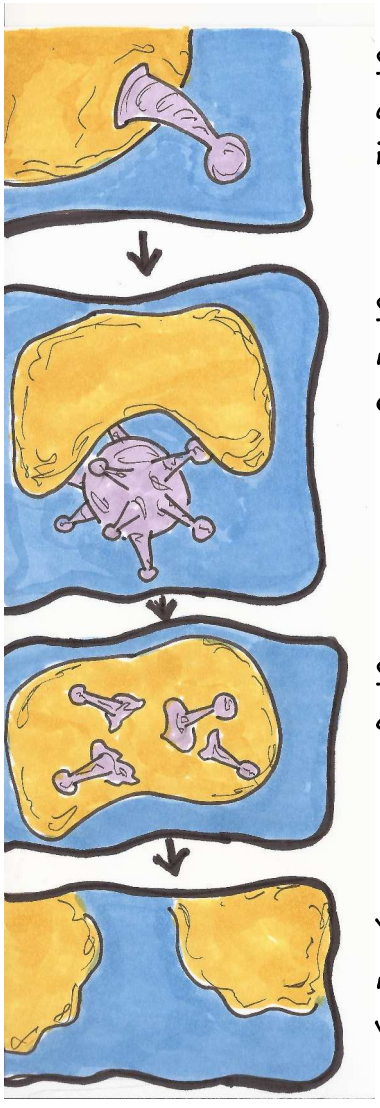
All of these feelings, called symptoms, are caused by the virus infecting your cells.



Even though viruses don't mean to make you sick, symptoms are caused by the viruses using your cells to copy themselves.

This all might seem scary, but your body is ready to fight back for you.

Different types of cells in your body can recognize the virus and help destroy it.



Step 1: an infected cell displays part of the virus on its surface. This tells cells that make up your immune system that there is an invader!

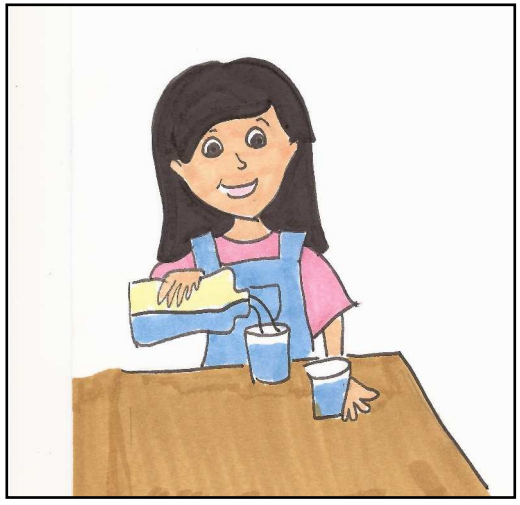
Step 2: Special cells that circulate in your blood now know what the invader looks like. They can eat the viruses trying to infect you!

Step 3: These cells can destroy the virus.

Your other cells are now safe from the virus!

Your immune system is made up by special cells and structures in your body that help you when you are sick or could be infected by something.

You can help your body by taking care of yourself when you're sick.



Drink lots of water.

Get plenty of rest.

Keep things clean.

Doing these things can help you get better soon and help prevent family and friends that live with you from getting sick too.

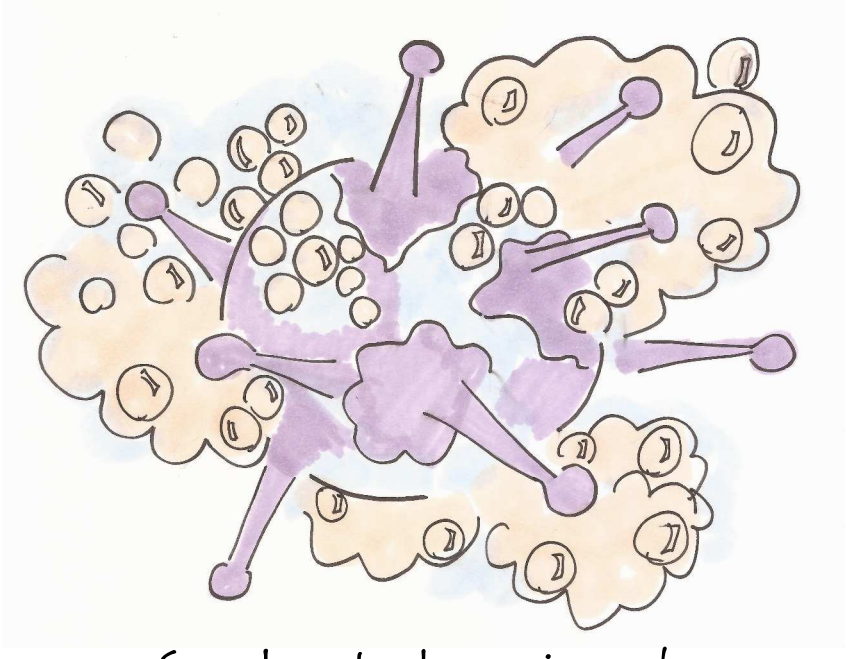
And the good news is you can stop a virus using only two things found in your bathroom- soap and water!

But alcohol based hand sanitizer works too if you aren't near a sink.

How does this work?

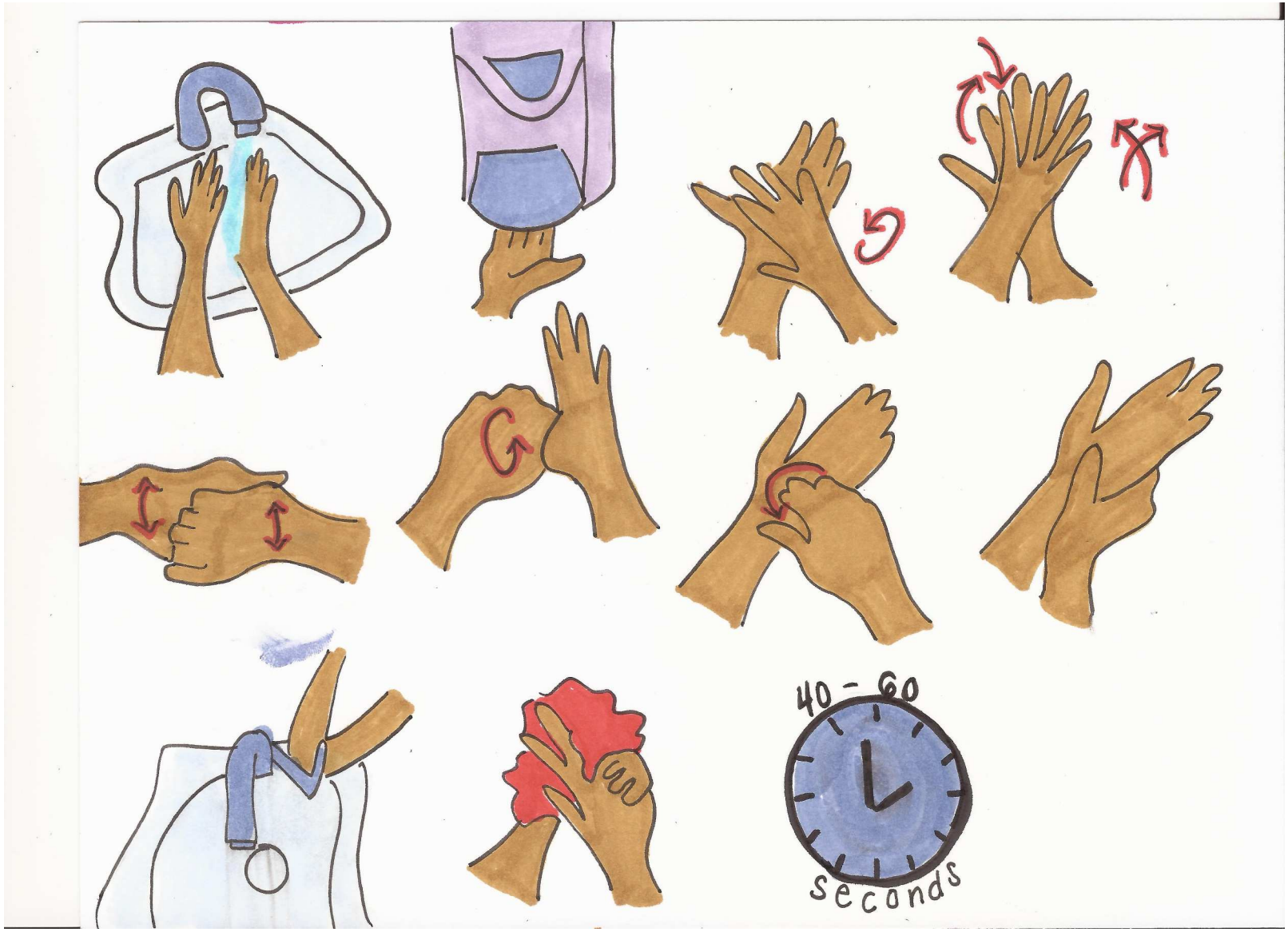
Soap destroys the protein and fat coat of the virus.

Without the coat, the virus can't infect your cells anymore.



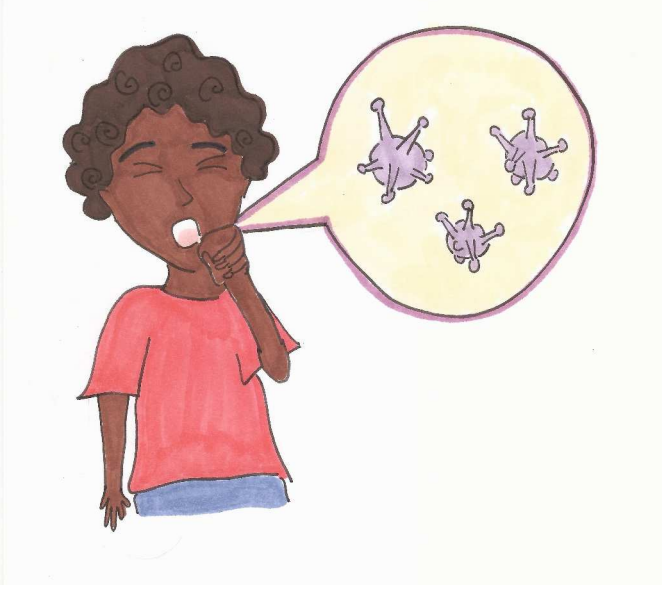
Soap breaks down viruses!

The Centers for Disease Control (CDC) recommends washing your hands for twenty seconds.



And because viruses need our cells to make more copies, you can stop a virus by making sure you don't share it with someone else when you're sick.

Many types of viruses can be spread when you cough or sneeze.



You can help prevent the spread of viruses by:

Covering your cough and sneeze with your elbow

Staying home when sick

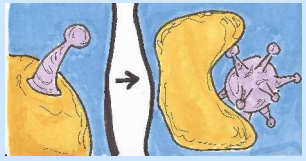
Listening to the advice of health professionals

Getting vaccinated against common viruses (it's not fun but it really helps!)

Wearing a mask when recommended by scientists (like for covid-19).

The Value of Vaccination: How shots keep us safe.

On page 21 we saw that your cells can help get rid of viruses by showing your immune system what the virus looks like.



The part of a virus recognized by your immune system is called an antigen.

This is a lot like helping the police find a burglar or thief by hanging up wanted posters. The problem is, it can take a while for police to identify a burglar, and it can take your cells a while to display the virus.

But what if there was a way for your body to know what a specific virus looked like before it could infect you and make you sick?

This is exactly how vaccination protects you. Shots contain broken down parts of viruses that can't make you sick but can train your body what to look for in the future. This way, if a real virus gets into your body, your immune system is ready to get rid of it right away.

Once a new virus is discovered, it can take scientists a while to make a new vaccine that is safe. Vaccination is one very good way to eradicate (get rid of) viruses like poliovirus on page 10.

Even though shots aren't fun to get, they can keep you and your family from getting sick.

Doing these things can help reduce the spread of viruses, like SARS-CoV-2, and help life get back to normal. All of us can help to end coronavirus and other sicknesses by understanding what viruses are and how to best protect ourselves against them.

About the author: Hannah Margolis is a recent graduate from Dartmouth College where she studied biochemistry and global health. She currently works at the National Institutes of Health and plans to pursue a career in science research.

About the illustrator: Emily Morin is a recent graduate from Dartmouth College where she studied geography and economics. She plans on pursuing a career in urban planning and design.