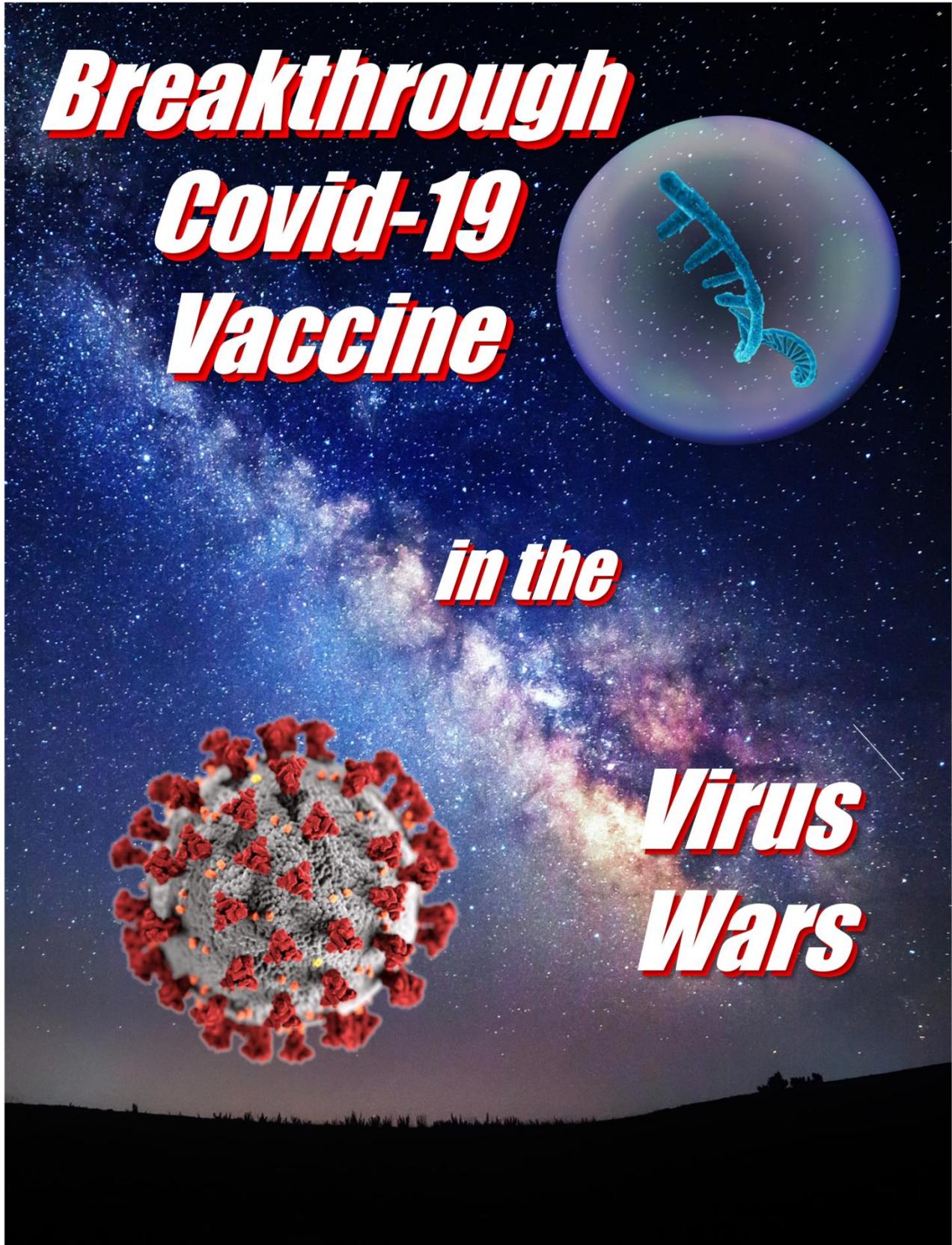


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JOHARI'S STORIES

BREAKTHROUGH COVID-19 VACCINE IN THE VIRUS WARS (AS TOLD BY JOHARI)



Hi, I'm Johari. I am the dim bulb twin sister of the *Boy Genius* Jackson. I am really not so dumb, but I am always compared to Jackson who started college at age 13. Oh, well, that's my life.

I am going to tell you the awesome story of the breakthrough [Messenger RNA vaccine](#) for COVID-19. Messenger RNA is also called mRNA. It is the latest, and probably the greatest chapter in the epic battle between humans and disease-causing [viruses](#). You can read about how it works in Milo's Story, *The Cosmic Kids Explain Covid-19 Expedition 2: Vaccine*.

But mRNA is also the messenger in the routine way in which our bodies make products and substances that we need, like the protein pepsin for digestion in the stomach. You can read Richie's story called *Our Body's Cell Factories* to find out more about that. You can read Jackson's Story called *The Coronavirus Hijacks Our Cell Factories* to find out how the cell factories are used by the virus to make copies of itself.

The viruses aren't the only things smart enough to hijack our cell factories. The scientists that invented the mRNA vaccine use that strategy too. You can read Neddy's Story *The mRNA Vaccine Hijacks Our Cell Factories* to find out how are factories are used by the mRNA vaccines.

Before we get to the mRNA vaccine, I want to tell you what I learned about the history of the wars between humans and viruses and [bacteria](#). Viruses and bacteria have always been attacking us humans causing local [epidemics](#) and global [pandemics](#). The first recorded major epidemic took place in 429 BC. There have been lots more epidemics and pandemics since then:

- 1200 B.C. Babylon Flu Epidemic
- 429-427 BC. Plague of Athens. (Typhoid or Typhus)
- 165-180. Antonine Plague.
- 541-542. Plague of Justinian.
- 1347. Black Death.
- 1509-1529. Smallpox & Measles in the New World.
- 1618-1648. Typhus in the Thirty Years War.

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- 1656. Plague of Italy
- 1775-1782. Smallpox
- 1852-1860. Cholera.
- 1918-1919. Influenza
- 1960-Present. HIV / AIDS
- 2003. SARS
- 2014-Present. Zika
- 2014-2016. Ebola
- 2019-Present. Covid-19

The bacteria's biggest wins the Plague of Justinian in 541 that killed 50 million people and the Plague of 1347 called the Black Death that killed almost half the people in Europe and as many as 200 Million between Europe and Asia. In 1656 in Italy there were special plague doctors that wore bird masks and protective clothing. They believed that the sickness came from breathing bad air, so the long beak was packed with herbs and spices that made the inhaled air smell fresh.



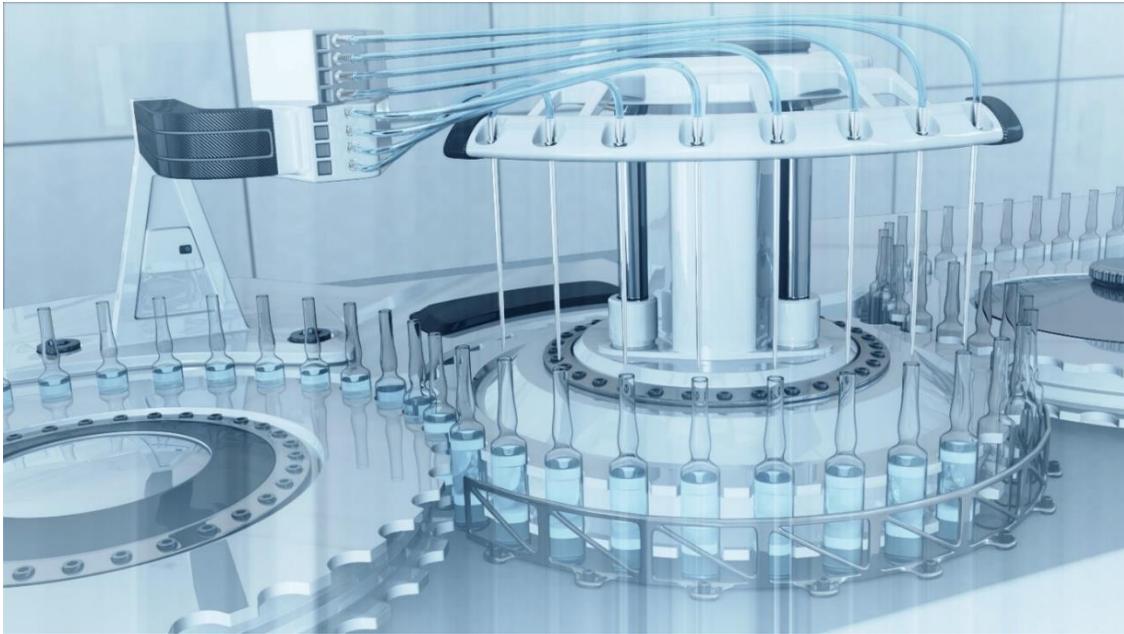
A big win for us humans came in 1796 when Edward Jenner created the vaccine to combat the virus that causes smallpox. Jenner observed that milkmaids who previously had caught a similar but less severe disease called cowpox did not catch smallpox. Did having cowpox make them immune to smallpox? To test this idea, he infected his



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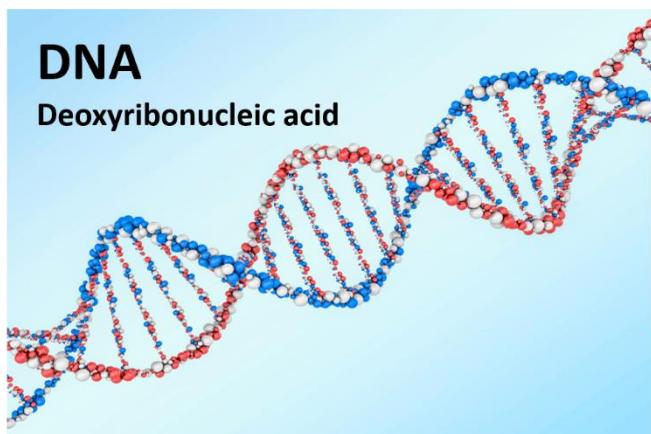
gardener's son, who was 8 years old, with cowpox and later exposed him to smallpox. Fortunately, the experiment worked. The boy was [immune](#) to smallpox. The vaccine prepared people's [immune system](#) to fight smallpox by exposing them to a weaker form of the disease.

In the 225 years since Jenner's discovery, vaccines for both virus and bacterial infections using Jenner's concept were successfully developed to fight diseases. The not-so-good news is that these vaccines, that typically use a dead or weakened form of the virus or bacteria, would take up to 8 years to develop.



My brother Jackson read the history of the virus and bacteria wars that I had written and asked, "So why is the mRNA vaccine so special?"

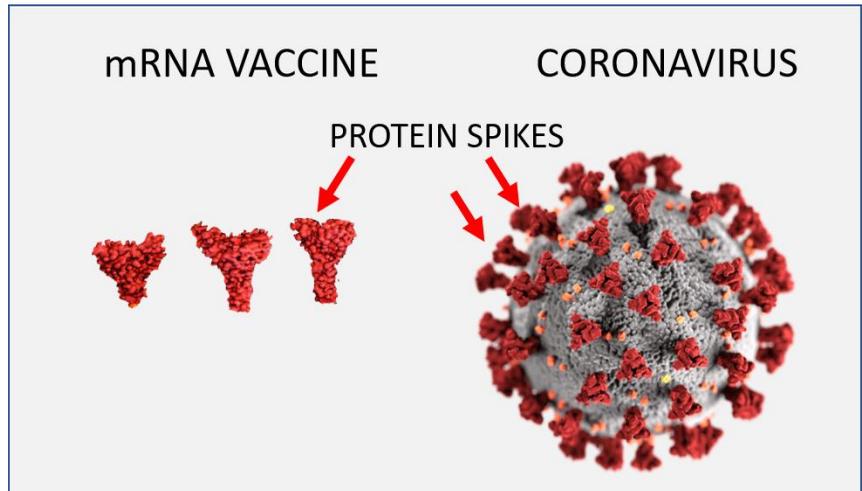
"There are four reasons," I answered. "First, the mRNA vaccines use an awesome breakthrough technology that is making drastic changes in medicine. They are the first genetically engineered vaccines."



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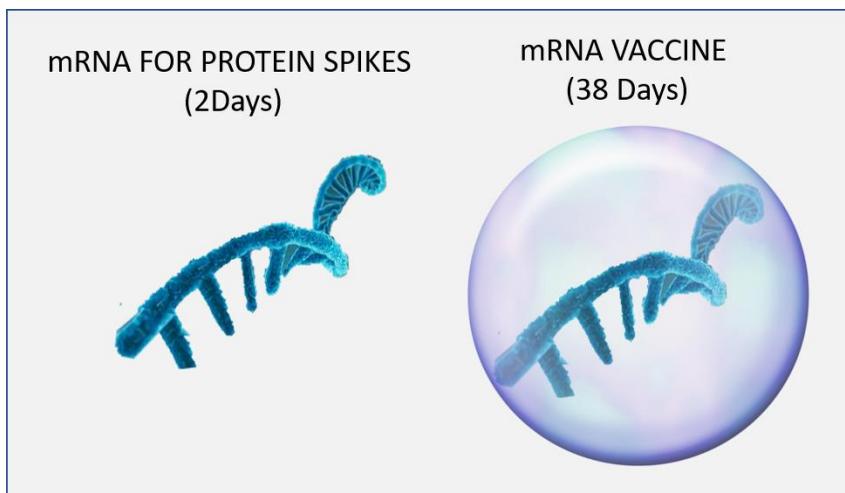
"I know what that means," said Jackson. "It means they use the genetic codes in [DNA](#) and [RNA](#). These large molecules contain all the information for the construction and operation of your body and for the virus. So, the vaccine somehow uses genetic codes."

"Right," I continued. "The second important feature of the mRNA vaccines is that they are safe. They only use small pieces of the virus that can't make you sick. The new technology uses just a piece of the coronavirus to prepare your immune system. It uses the little knobs on the surface of the coronavirus called protein spikes. The picture shows what the protein spikes look like."



"I get it," said Jackson. "That is cool. Instead of a dead or weakened virus the mRNA vaccine uses a small virus piece. Without the rest of the virus, they won't make you sick, but they will get your immune system ready to fight the whole Covid-19 virus should it appear."

"Right again," I said. "You're actually pretty smart after all."



"The third important feature," I continued, "is that the mRNA vaccines were super-fast to develop compared to the years required for previous vaccines. The mRNA piece of the Covid-19 virus genetic code for building the protein spikes took just two days to create. The complete vaccine with the

mRNA in protective oily droplets was ready to test in just 38 days."

"Wow, amazing. So, how does it all work in your body?" asked Jackson.

"That is the fourth piece of the story," I answered. "The vaccine is injected into your arm muscle. It transports the mRNA code for the protein spikes into your muscle cells. The cells have little factories where they routinely produce proteins needed by your body based on the protein's mRNA. So, when the cell's factories get the vaccines mRNA, they start to produce the virus protein spikes which eventually get to the cell's surface. The protein spikes on the cell

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surface get the body's immune system to produce antibodies that attack the spikes. Then, your immune system goes into action to destroy the infected cell, spikes and attached antibodies. But some antibodies are left. Those left-over antibodies and other parts of your vaccine-trained immune system will be in your body and ready to defend it if the whole virus tries to attack."

"I agree," said Jackson. "The messenger RNA vaccine is really breakthrough technology. I'll bet lots of future vaccines will be made this way. They will probably make new flu vaccines with the mRNA technology too."

"Maybe scientists will even be able to make mRNA vaccines for cancer." I added.

GRANDPA'S GLOSSARY

Messenger RNA: Messenger RNA, or mRNA, is a single-stranded molecule of RNA that contains the genetic sequence of a gene, a part of the genetic code for a specific functional product. For example, the protein spikes on the coronavirus are such functional products. The mRNA is read by a ribosome in the process of synthesizing the product. The pepsin molecule described in Epilogue 2 is another example of a functional product created by a cell's ribosomes using mRNA. The process of copying a gene from DNA into mRNA is called transcription.

Viruses: A virus is an infectious particle that is too small to be seen, even under a microscope. It cannot replicate itself but can hijack living cells of an organism to produce virus copies. Viruses infect all types of life forms: animals, plants, bacteria, and other microorganisms. There are millions of types of viruses in every place on Earth. There are more viruses than any other type of biological entity. The war between viruses and bacteria has been going on for 3 billion years, with each entity developing sophisticated attack and defense strategies. Most biologists say that viruses are not living organisms. They are not made out of cells, they don't grow, they are not stable, and they can't reproduce by themselves.

Vaccine: A vaccine is a medicine that can provide immunity to an infectious disease caused by a virus or bacterium. A vaccine uses a weakened, dead, or partial form of the virus or bacterium. When exposed to the vaccine, the body's immune system reacts to destroy the foreign substance. Because the active ingredient resembles the disease-causing agent, the immune system is prepared to defend against the active agent in the future. The treatment using a vaccine is called vaccination.

Bacteria: Bacteria are single celled organisms that can't be seen with the naked eye but can be seen under a microscope. Bacteria can cause disease such as strep throat and pneumonia. But bacteria also have beneficial uses such as in the production of yogurt, cheese, and vinegar. Bacteria occur in the shape of spheres, rods and spirals. They were among the first life forms to appear on Earth over 3 billion years ago and are present almost everywhere on Earth.

Epidemics: An epidemic is the rapid spread of a disease to a community or region within a short period of time. It is the sudden increase in the number of cases of a disease above what is normally expected in that population in that area.

Pandemics: A pandemic is an epidemic of an infectious disease that has spread across a large region such as several continents or the whole world. A pandemic affects a large population.

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Immune: An organism is immune to an infection if it has resistance to that infection due to the presence of specific antibodies or white blood cells. Such immunity may be naturally occurring or may be acquired from a prior infection or from a vaccine.

immune system: In a living organism, the immune system is the organisms' mechanisms for fighting disease. In bacteria, the immune system is part of the organism's DNA capable of remembering, identifying and destroying an invading virus. In multi-celled organisms the immune system can be a network of specialized cells, tissues, organs, and substances that help the body fight infections and other diseases. Such systems can produce antibodies and specialized cells which attack an infectious substance as well as cells capable of remembering (sometimes for decades) the infection and producing new antibodies and attack cells should the infection reappear.

DNA (Deoxyribonucleic Acid): Let's say you wanted to build a robot. You look online and find a set of instructions. It would have to contain lots of things: a list of parts; specifications and drawings for each part (for size, shape, color, function, etc.); and instructions for how the parts are connected. If your friend is going to build one too, you need to copy the instructions. If you are building a complicated robot, the list could be very long, requiring a whole book full of instructions. The instructions for building you and all living things are contained in the DNA, which is reproduced in every cell. Each living thing has its own unique DNA code. The double-helix structure of DNA was identified by James Watson, Francis Crick, Maurice Wilkins, and Rosalind Franklin in separate papers in the journal *Nature* in 1953. Watson, Crick, and Wilson (but not Franklin, who died in 1958) received the 1962 Nobel Prize in Physiology or Medicine. You can see a picture of the double helix in Epilogue 2. It is two long chains of molecules that are twisted around each other, like a long rope. The molecules are built of mainly five atoms: carbon, hydrogen, oxygen, nitrogen (CHON), and phosphorus. The links between the two twisted backbones of the DNA are made up of 4 protein molecules in pairs. They are designated by the letters A paired with T, and G paired with C. The building instructions are determined by the order or sequence in which the four molecules are arranged. This is like thousands of words created with different sequences of the twenty-six letters of the English alphabet, or computer codes created with different sequences of ones and zeros.

Each cell in your body contains a complete twisted pair of chains in the form of DNA. When you started life as a single cell, one of your DNA chains came from your mother and the other from your father. As your cells multiplied, the DNA was copied so that each cell had an identical copy of your first DNA molecule. The instructions on whether you are a girl or boy, the color of your eyes and hair, how tall you will be, and every other physical thing about you are coded in your DNA. A single double strand of a human's DNA if stretched out straight would be 2 meters long. If all the DNA in a human body were stretched out and connected end to end it would be 60 billion kilometers long, long enough to extend to Pluto and back to Earth 4 times.

RNA Ribonucleic acid (RNA) is a large molecule that is similar to DNA but is only a single chain rather than a double helix. The complete genetic code for the coronavirus is written in its RNA. In humans and other animals, the code for making protein substances and products needed by the body is written in RNA. These special purpose RNA molecules are copied from sections of DNA in a process

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called transcription. RNA consists of a single backbone chain with protruding pairs of four molecules designated by the letters A paired with U, and G paired with C. So, three of the molecules are the same as those in the connecting chains in DNA. The building instructions are determined by the order or sequence in which the four molecules are arranged. This is like thousands of words created with different sequences of the twenty-six letters of the English alphabet, or computer codes created with different sequences of ones and zeros. Messenger RNA or mRNA is used by cellular organisms to convey the information (genetic code) required for the cells to produce specific products.

THE STARDUST MYSTERY PROJECT

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