

HOW mRNA VACCINES HIJACK OUR BODIES' FACTORIES

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How mRNA Vaccines Hijack



Our Bodies' Factories

RICHIE'S STORIES

HOW mRNA VACCINES HIJACK OUR BODIES' FACTORIES (AS TOLD BY RICHIE)



Hi, I'm Richie. I'm Neddy's friend. She invited me to join the Cosmic Explorers' team for *The Race to the Big Bang* contest. I'm the guy who tells the jokes, but I don't think the rest of the team likes my humor. Here is an example. Why did the chicken cross the road? . . . He was maintaining social distance from the chicken coming toward him.

I love being in the *Race to the Big Bang*. Meeting with the rest of the team online and at Neddy's house is the one thing that has kept me from killing my little brother, Leo. I love the time, space, and size-change travel adventures we have in the [Virtual World](#).

I am really glad that Neddy invited me to join with her, Jackson, and Johari to use the *Virtual World* to investigate the COVID-19 virus and the vaccine. My job is to tell the story of how the new mRNA vaccines *hijack our bodies' factories* to protect us from the COVID-19 virus. Each of our [cells](#), which are the building blocks for human bodies, have their own little factories. Each human has about 30 trillion cells, each with lots of factories.

What is cool is that the COVID-19 mRNA vaccine uses the same *hijack our bodies' factories* strategy used by the virus. The second cool thing is that the mRNA vaccines are the first vaccines to use [genetic engineering](#). That means it uses [genetic codes](#) to make it work.

The coolest thing is what Neddy's Grandpa texted us. It was about the fantastic prediction quoted in [Time](#) magazine made by the head of Moderna, which developed one of the mRNA vaccines. When this guy was told that their vaccine was 95% effective in defeating the virus in the clinical trials, he predicted, "It was a bad day for viruses. There was a sudden shift in the evolutionary balance between what human technology can do and what viruses can do. We may never have a pandemic again." Wow, fantastic. Right?

Our whole team believed we all should understand this amazing breakthrough technology which will be so important in our future. So, for my story, we need to know about two things. ONE-GENETIC CODES: what are genetic codes? TWO-OUR BODIES' CELL FACTORIES: how do our bodies' cell factories use genetic codes to make stuff?

Neddy covered both of those topics in her story on [How Covid-19 Hijacked our Bodies' Factories](#). So, Neddy let me modify that part from her story here. If you are already an expert on the genetic code and our bodies' factories, you can skip to the bottom of page 5.

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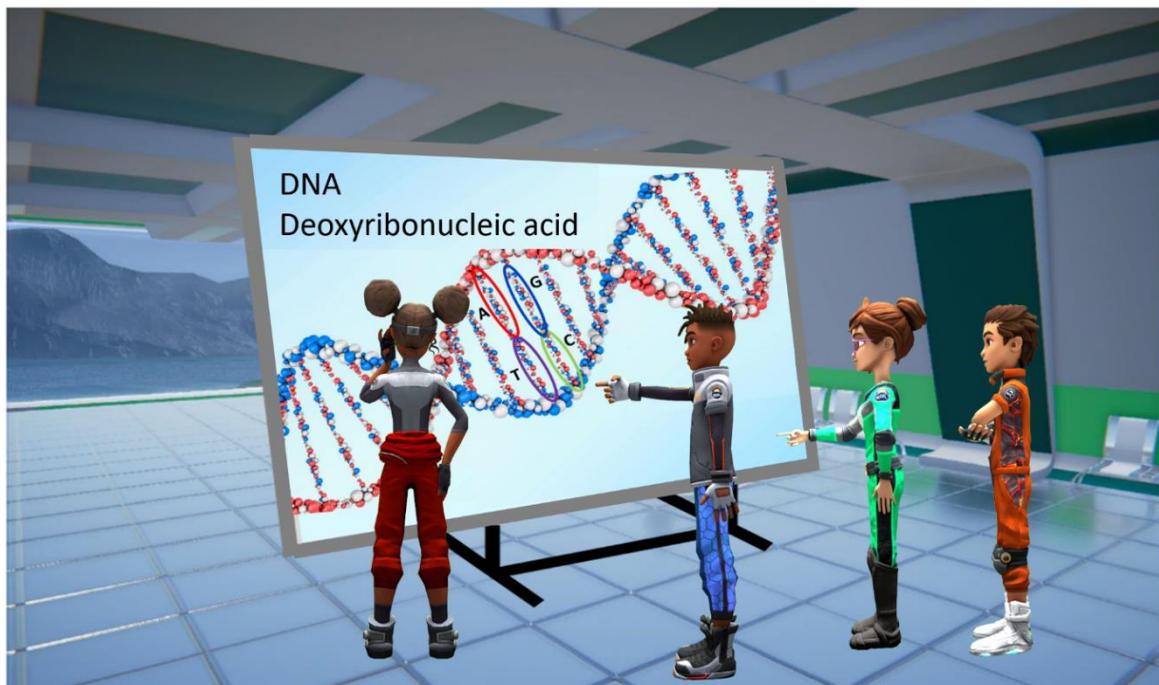
One cool thing we learned from Neddy is that viruses can't make baby viruses on their own. So, they have to hijack cells in living organisms to do it. They have been doing that for 3 billion years, starting with attacks on single-celled bacteria. Now they are hijacking the cells of human bodies. But us humans are smart. Our scientists figured out how to use the same *hijack our cell's factories* strategy to make amazing new [vaccines](#) to help us fight the virus. Johari wrote a story about the history of the wars of viruses and bacteria against the humans. The human's latest win is these new breakthrough mRNA vaccines, the first vaccines to be genetically engineered. Her story is called: [Breakthrough Covid-19 Vaccine in the Virus Wars](#).

Jackson has a good story about how our bodies' factories use [genetic codes](#) all the time for making products and substances. They make things the body needs like tears, mucus, hormones, hair, the juices your stomach needs for digesting food, and lots of other stuff. Jackson's story is called [My Body's Factories](#).

Neddy's story is about how the COVID-19 virus hijacks our bodies' factories, using its own genetic code to make lots of copies of itself. It is all those extra baby copies that make us sick. You can also find out how the virus makes people sick by playing the video on our [STARDUST MYSTERY](#) YouTube Channel called [Animated Coronavirus Story for Kids 1: How Grandpa Got COVID-19](#).

"So, guys," Neddy asked when we logged into the *Virtual World* for her story, "what is the genetic code? Where is the code stored, and how is it written?"

ONE- GENETIC CODES: Neddy started us off, "Our genetic code is the complete set of instructions for building our bodies plus all the things our body needs to operate. The Covid-19 coronavirus has its own genetic code too.



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Jackson brought up a diagram on the computer screen that he had used for his story and said, "We know about lots of codes. Our locker codes at school are made up of a series of 4 numbers from 0 to 9. Our English words are made up of strings of letters. Computer codes are written with just ones and zeros in different orders or sequences.

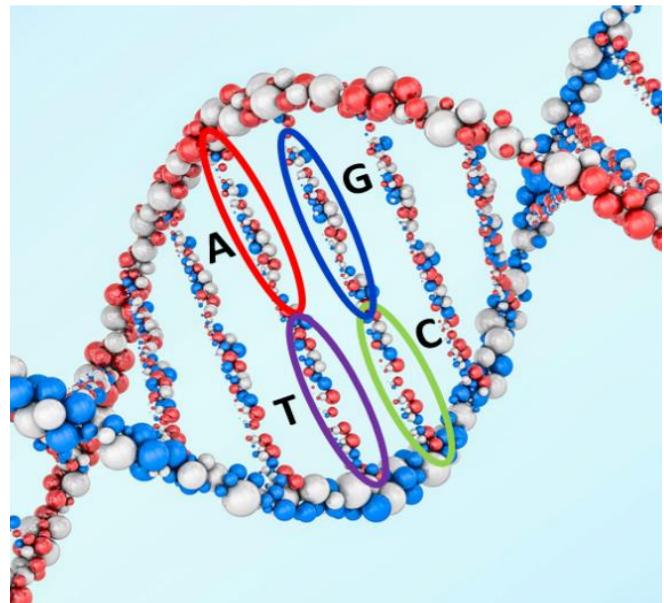
"So, how is our genetic code written? Instead of writing a code in sequences of letters or numbers, our genetic code is written in sequences of molecules."

"There is a copy of the code in every [cell](#) in our bodies," continued Johari. "It is written in several giant molecules called [DNA](#) which stands for Deoxyribonucleic acid. Every living thing has its own unique DNA code. The DNA molecules are stored in a part of the cell called the [cell nucleus](#)."

Neddy added what she knew from reading a book called *The Double Helix*. "DNA has two chains of atoms made up of carbon, hydrogen, oxygen, nitrogen and phosphorous. The two chains coil around each other in a long rope like you see on our screen. That is the double helix."

"The most important feature of DNA is how the code is written," Jackson stated. "The genetic code is written in sequences of just four molecules. The molecules have names, but we identify them by their first letters A, T, G and C. The four molecules connect the twisted pairs of chains. They always are paired, A with T and G with C but they can be connected to the chains in either direction. The order of those four molecules in the DNA is the genetic code. It is the recipe for everything in our bodies. When scientists figured out our whole DNA code, they wrote it as a sequence of letters like A, G, C, C, C, T, A, A, G, C, and on for 3 billion more letters. It would take 100 years and 750,000 pieces of paper for a person to type the whole sequence working 8 hours a day and 5 days a week.

Neddy added, "The code has the instructions for my eye and hair color, my height, my brain, my spit, my tears, and everything else about my body. And the bits of code for specific things like eye color are called [genes](#). Genes for different characteristics vary in size from a few hundred to 2 million letters."



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Now, we need to see where the DNA is located. Milo had built a cell playground for the *Virtual World* that showed the different parts of a cell. We changed our size to be a hundred thousand times smaller and teleported to the playground.



When we got there, Jackson pointed and said, "The cell nucleus is the yellow sphere in the center. The DNA is located in the X-shaped structures called [chromosomes](#)."

We jumped over the cell parts to the cell nucleus to get a better look at them.

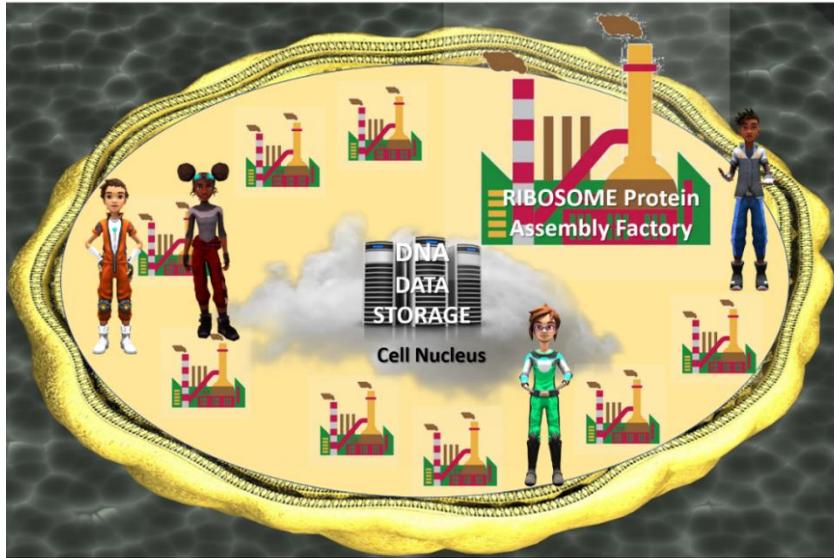
Jackson said, "There were 23 of the chromosome pairs for a total of 46. That's where all our bodies instructions are stored."



"Thanks for the tour, Jackson," said Neddy.

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"Ok," continued Neddy, "now let's learn about TWO - OUR BODIES' CELL FACTORIES. How are our factories normally used and how do they get hijacked by the vaccines? Our



body's factories are called [ribosomes](#) and each cell contains many of them. They are the dozens of tiny yellow spheres attached to the pink structures near the nucleus in the cell playground."

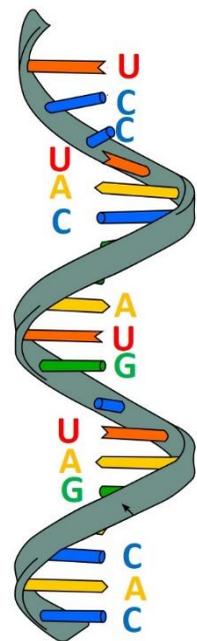
Jackson wrote a story called [My Body's Factories](#) that explains how the manufacturing system normally works. Jackson used a simplified cell playground

that Milo built in the *Virtual World* with just the cell nucleus DNA data storage and the ribosome factories.

Neddy summarized Jackson's story. "When the body needs a molecule like pepsin for digestion in the stomach, the nucleus takes the gene for pepsin and makes a short copy of the instructions with four molecules attached to a single chain called messenger RNA or mRNA. The pepsin mRNA goes to the ribosomes. The ribosomes read the mRNA code and make pepsin molecules which exit the cell into the stomach. The ribosomes do not control what they make. They just churn out the product described by any mRNA or RNA code that is delivered to them. You can read Jackson's story if you want more information about how our factories normally work.

"What exactly is messenger RNA?" I asked Neddy.

She answered, "All living organisms use mRNA to transcribe the code in the DNA to the portable special code that instructs our ribosome factories to produce specific substances. RNA is a molecule similar to DNA. But it has just a single helix, not a double, and instead of the code molecule T, it has a molecule labeled U. The nucleus transcribes a part of the DNA code to make the special short messenger RNA molecule with a sequence of the single, unpaired code molecules A, U, G, and C.

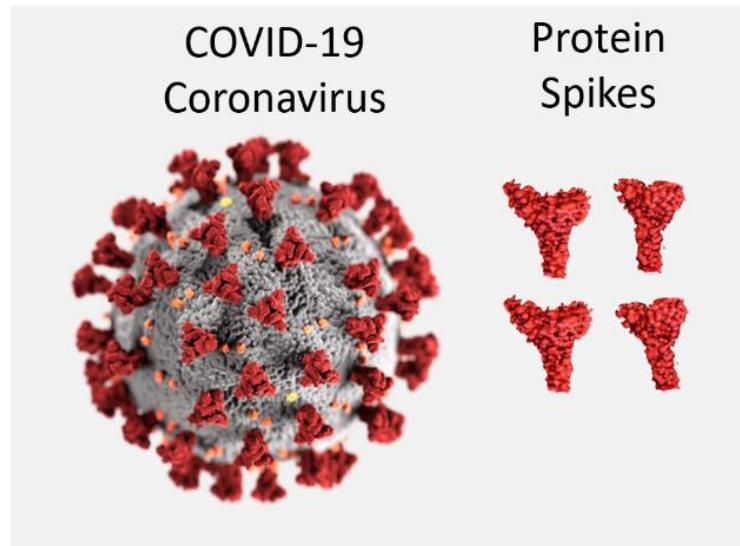


THE mRNA VACCINES: The genetic code for the whole coronavirus is a strand of RNA with around 30,000 letters that provide the instructions to penetrate a cell, hijack its factories and make thousands of copies of itself. The mRNA vaccine uses just that part of the virus code

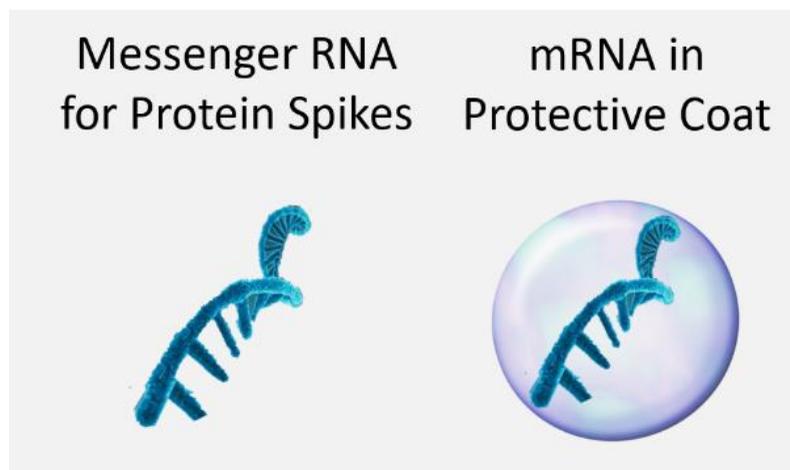
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for the knobs on the surface called protein spikes. The mRNA vaccine hijacks the cell to have it make protein spikes. The spikes migrate to the cell's surface and the bodies' [immune system](#) makes [antibodies](#) to attack the spikes. If the real virus should invade that body, the immune system will remember the spikes and attack those on the virus. That is enough to keep the virus from invading the bodies' cells and making copies. The vaccine has trained the body to be [immune](#) to the virus.

Here is a picture of the COVID-19 Coronavirus. The knobs on the surface picture in a reddish color are its protein spikes. The protein spikes are needed for the virus to make its attack on a cell. In order to get its RNA into a cell to make copies of itself, one of these knobs must attach to a part of a cell called a receptor. If a body's immune system prevents the knob from attaching to the cell, it will not be able to make copies of itself, and the person will be immune to the infection.



The genetic code for the COVID-19 coronavirus is written in RNA not DNA. To make the vaccine, the gene for the protein spikes, that is the section of the virus RNA that is the code for

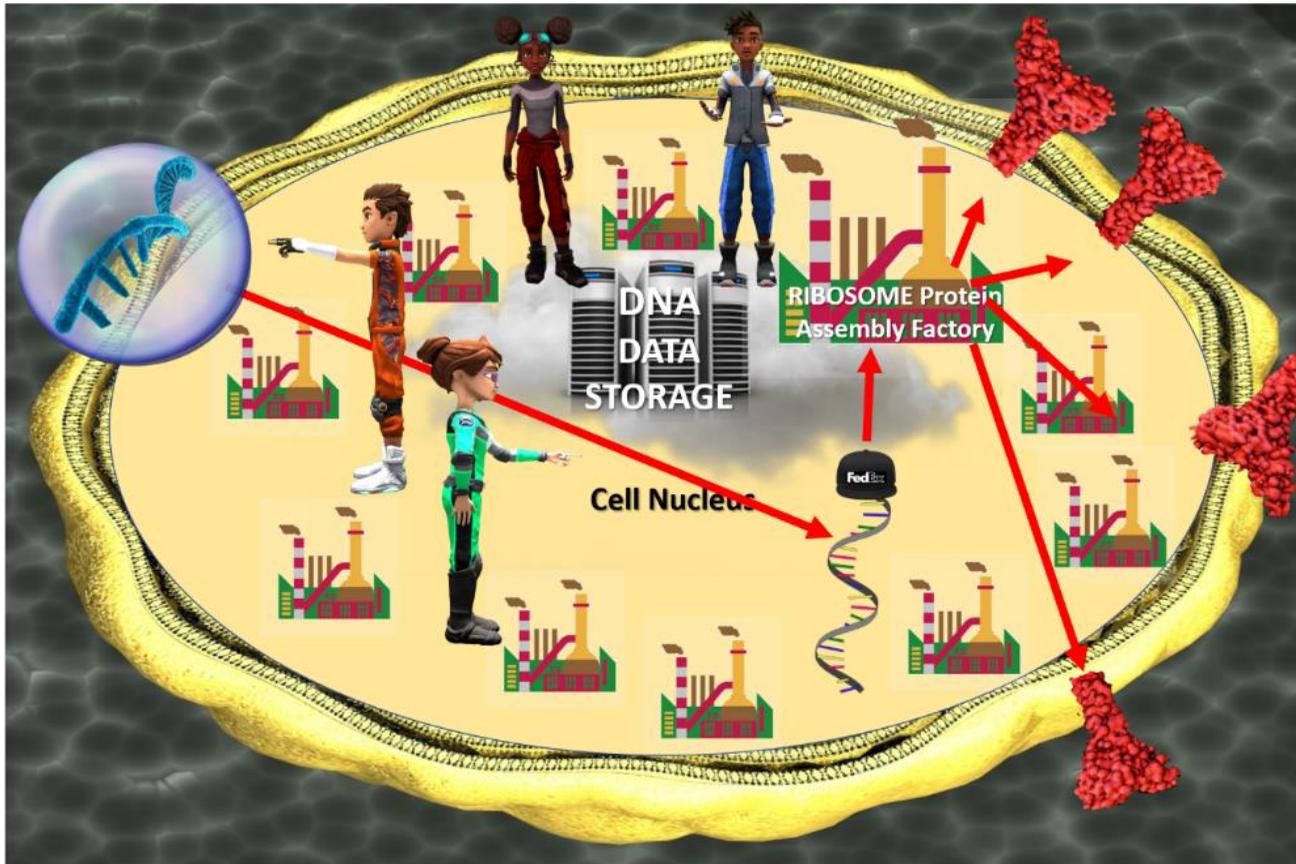


the protein spikes, is copied. That is the mRNA. That was the easy part of the vaccine development. The hard part was delivering the mRNA to the cell's ribosomes. For that job, the mRNA was enclosed in a protective coat. That allows the vaccine mRNA to get to a cell's surface and penetrate into the cell.

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So, the vaccine arrives at a cell surface. The vaccine gets its mRNA genetic code for the spikes into the cell and directly to the ribosomes, bypassing the cell nucleus.

"I get it," said Neddy. "The ribosome factories know what to do with mRNA. When mRNA is delivered, it does its job and makes products according to the mRNA instructions. It doesn't matter that the mRNA did not come from the nucleus. So, the ribosome factories churn out copies of the virus' protein spikes which then poke out on the cell surface."



"So, you see," I concluded, "humans are at least as smart as the viruses. We used the viruses *hijack the cell's factories* strategy."

"You might like to read my story too," added Johari. My story is about the history of the war between humans and the [Viruses](#) and [bacteria](#). We have historical records of that war in [epidemics](#) going back 3000 years. In our worst battle, the black death plague [pandemic](#), bacteria killed 200 million people in the year 1347. But there was a big win for us humans in 1796 when Edward Jenner created the [vaccine](#) to combat the virus that causes smallpox. His vaccine made people [immune](#) to the disease by exposing them to a similar but weaker form of the infection. Vaccines have been used for the last 225 years, but the latest vaccine based on mRNA technology is the greatest breakthrough ever. My story is called: [Breakthrough Covid-19 Vaccine in the Virus Wars.](#)"

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Neddy's Grandpa has a story to tell too. It's about some amazing new genetic engineering technology that we learned by studying the 3 billion year long battle between viruses and bacteria. He says it has the funny name CRISPR. CRISPR can guide molecules that work like scissors to eliminate or edit specific sequences of DNA or RNA. This technique has already been used in trials to cure sickle cell anemia. It is also being used in the war against COVID-19 as a rapid infection test. Two women scientists, Jennifer Doudna and Emmanuelle Charpentier, won the 2020 Nobel Prize in Chemistry for developing CRISPR. Grandpa's story is called: [*CRISPR: the Genetic Engineering Breakthrough*](#).

All these stories about the Covid-19 virus and the mRNA vaccines are fantastic," I concluded. "I think that genetic engineering is going to make major advances in medicine for the rest of our lives."

GRANDPA'S GLOSSARY

Virtual World: Virtual worlds, also known as virtual environments, use computer technology to create a simulated world that a user can explore and interact with, while creating a feeling as if he or she were in that world. The representation of the user in that world is called an avatar. The user can even wear goggles to make it appear that he or she is surrounded by the 3-D virtual world. That is called virtual reality.

Genetic Code: The genetic code is the molecular system used by living cells to translate information encoded within genetic material into the products and substances required by the organisms. For living cellular organisms the code is created by the sequence of four molecules designated by the letters A, C, G, and T strung together in the DNA. The code for any molecular substance can be transcribed into messenger RNA in a way that the cellular factories, the ribosomes, can read them and turn them into protein molecules. In some viruses, the genetic code is written in single stranded RNA rather than the double stranded DNA.

Genetic Engineering: Genetic engineering is the process of using DNA and RNA in technology to alter the genetic makeup of an organism. Genetic engineering involves the direct manipulation of one or more genes. Sometimes, a gene from another species is added to an organism's genome to give it a desired feature.

Time Magazine: *mRNA Technology Gave Us the First COVID-19 Vaccines. It Could Also Upend the Drug Industry* by WALTER ISAACSON, JANUARY 11, 2021. <https://time.com/5927342/mrna-covid-vaccine/>

Cell Nucleus: The cell nucleus is a highly specialized structure of every cell that serves as the information processing and administrative center of the cell. This structure has two major functions: it stores the cell's hereditary material (the information on your body's characteristics; the blueprint and instructions for building your body) in the genes, and it coordinates the cell's activities, which include growth, metabolism, protein synthesis, and reproduction (cell division).

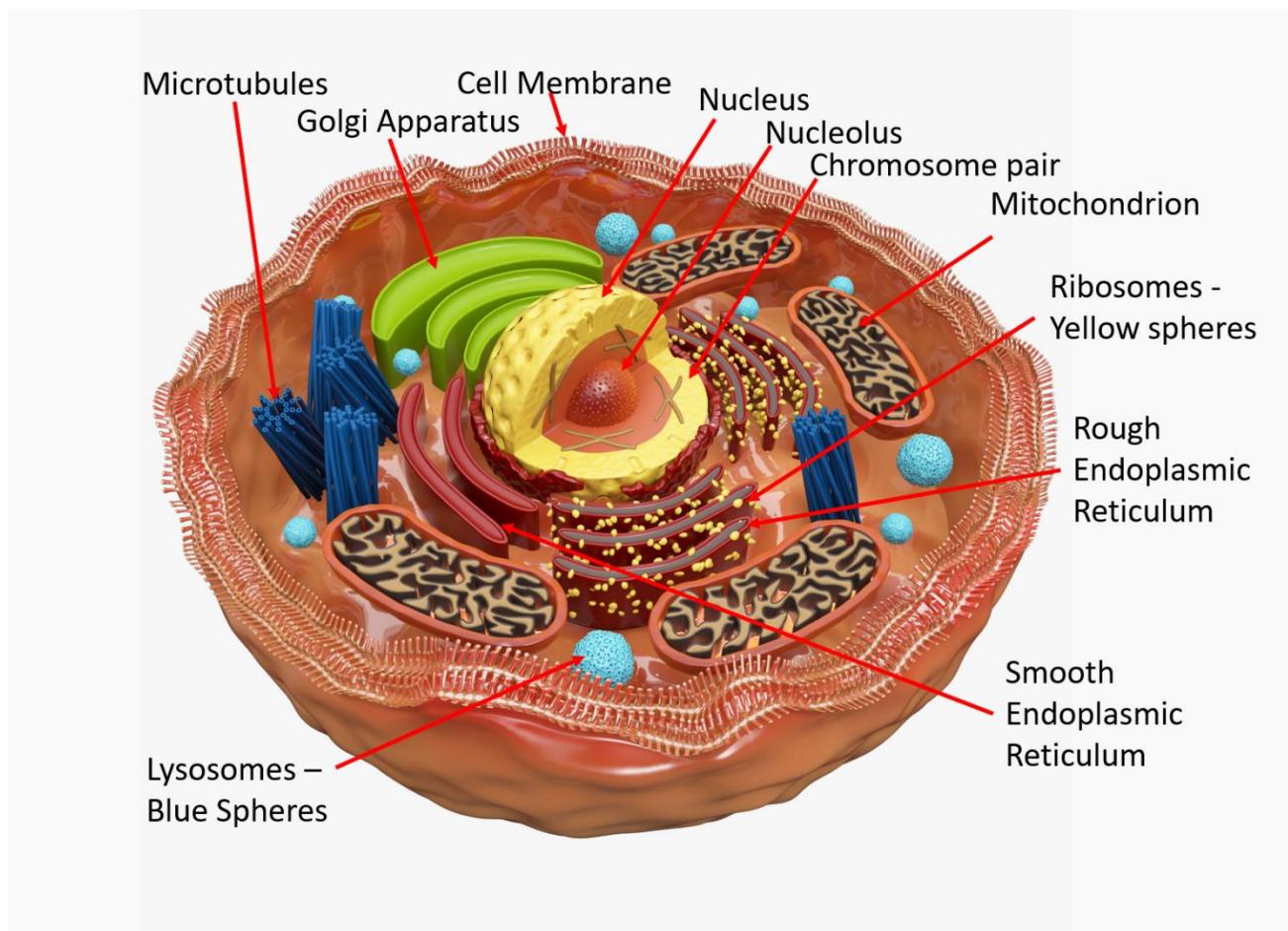
Chromosomes: These are the threadlike bodies in the cell nucleus that carry the genes (your body's building instructions) in a linear order: the human species has twenty-three pairs, designated one to twenty-two in order of decreasing size and the X and Y female and male sex chromosomes respectively.

Genes: These are the basic arrangement of DNA molecules in the chromosomes of the cell nucleus that determines the body's individual characteristics like hair color, eye color, and height. Genes are linear sequences of nucleotide molecules along a segment of DNA that provides the coded instructions for hereditary characteristics (your body's building

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instructions. A gene is a basic unit of heredity. During gene expression, the DNA is first copied into RNA which transmits the instructions to the cells of the organism.

Cells: The cell is the basic building block for all living things. The cell was discovered by Robert Hooke in 1665 from studies of living material in which he observed very small repeating structures using a microscope. He called the structures cells because they resembled cells of a honeycomb. The first living things on Earth were single-celled organisms. Each cell was able to perform all the functions necessary for life. They could feed themselves and reproduce. Multicell creatures like humans have highly specialized cells that perform specific functions, such as nerve cells which are long and can transmit signals, muscle cells which contract to move arms and legs, and killer T-cells which can attack foreign objects to protect the body. Most cells are between 1 micron (1/1,000,000 of a meter) and 100 microns in size. The human body contains about 30 trillion cells whose size is like the thickness of a hair.



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

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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.

Ribosomes: Ribosomes are complex structures found inside living cells. Their purpose is to produce functional products (proteins) required by the organism according to the instructions contained in messenger RNA created by the organism. Viruses have the ability to hijack a cell's ribosomes to have it make copies of itself from its RNA. The ribosomes are also used by mRNA vaccines to have it make copies of the protein spikes seen on the outside of a coronavirus. The spikes stimulate the body's immune system to prepare it to fight off the virus should it appear.

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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Antibodies: An antibody is a large, Y-shaped molecule used by a body's immune system to fight foreign objects like bacteria and viruses. The antibody can attach to the foreign object to prevent it from being dangerous as it does with the Covid-19 coronavirus. Or it can attach to the foreign object to identify it for destruction by other parts of the immune system.

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

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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 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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