How Do mRNA Vaccines Protect You from COVID-19?

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Vaccines help protect us from a variety of infections. During the COVID-19 pandemic, we've all heard a lot about a type of vaccine called an mRNA vaccine, which stands for messenger ribonucleic acid.

While mRNA vaccines may seem very new, researchers have been working on them for a long time.

In this article, we'll take a closer look at mRNA vaccines, how they work, and their safety and effectiveness.

How do vaccines work?

Your immune system protects you from external threats, such as disease-causing germs called pathogens. Immune cells become activated when they recognize something in your body as foreign, like pathogens.

Your immune system is activated by what's known as an antigen. Antigens are often proteins present on the outside of pathogens like viruses or bacteria.

Once activated, the various parts of your immune system work together to generate an immune response to the antigen, which can include antibodies and killer T cells.

Your immune system also has a memory. That means it can remember its response to antigens should it encounter them again in the future.

Vaccines harness the power of your immune system's memory. They work by introducing noninfectious parts of a pathogen to your body, so your body can learn to recognize the invader and kill it before it causes disease.

However, unlike an actual infection, vaccines don't make you sick.

In a vaccine, a pathogen has been weakened or inactivated to prevent it from causing disease. Sometimes, only a part of a pathogen is used, such as a single protein.

When you’re vaccinated, your immune system generates a response to the antigens present in the vaccine. That way, your body already has the tools to better protect you should you encounter the actual pathogen in the future.

How do mRNA vaccines work?

MRNA vaccines introduce your immune system to an antigen in a unique way. Instead of using a weakened or inactivated form of a pathogen, they work by teaching your body’s cells how to temporarily produce an antigen themselves.

This is done through the use of mRNA, which is a type of nucleic acid that tells your body how to make proteins. Your own cells use mRNA every day to make the proteins that are vital for your body to function properly.

As of publication, the only mRNA vaccines currently in use are the Pfizer-BioNTech and Moderna COVID-19 vaccines.

How mRNA vaccines work

1. After being injected into the muscle of the upper arm, the mRNA, which is protected by a layer of lipids (fats), enters nearby cells.
2. Inside the cell, the mRNA sheds its protective fat layer and gives instructions on how to make a spike protein. This is a protein found

on the outside of the novel coronavirus. The virus uses it to attach to and enter host cells.
3. Once the spike protein is made, the mRNA is destroyed and the cell displays the spike protein on its surface.
4. Cells of your immune system notice the spike protein on the cell surface and recognize it as foreign. They become activated and begin to work with other parts of the immune system to generate an immune response to it.

The immune response to the Pfizer-BioNTech and Moderna COVID-19 vaccines after one dose wasn't very high. Because of this, both vaccines require at least two doses to be effective.

How effective are mRNA vaccines at preventing COVID-19 and protecting against severe symptoms?

Initial large-scale clinical trials found that, after two doses, effectiveness against disease for the Pfizer-BioNTech and Moderna vaccines was 95 percent and 94.1 percent, respectively.

Since then, more studies have been done on the effectiveness of these vaccines.

A 2021 study

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of the Pfizer-BioNTech vaccine included data from more than 3 million people from December 2020 to August 2021. It found that, compared with unvaccinated people, after two doses the vaccine:

- was 73 percent effective at protecting against disease
- was 90 percent effective at protecting against hospitalization
- had decreased effectiveness against COVID-19 in the 6 months after the second dose, but still remained high against hospitalization

A 2022 study compared 352,878 people who had received two doses of the Moderna vaccine with the same number of unvaccinated people in June 2021.

Compared with unvaccinated people, researchers found the vaccine was:

- 87.4 percent effective at protecting against disease
- 95.8 percent effective at protecting against hospitalization
- 97.9 percent effective at protecting against COVID-19-related-death

mRNA vaccines, boosters, and Omicron

The recommendation

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for boosters from the Centers for Disease Control and Prevention (CDC) and the emergence of the highly transmissible Omicron variant has led to further findings on mRNA vaccine effectiveness.

Overall, it appears the two vaccines have decreased effectiveness against Omicron. However, research shows that getting a booster can raise levels of protection against the Omicron variant.

A 2022 study

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specifically examined the effectiveness of the Moderna COVID-19 vaccine against the Omicron variant. Researchers found that:

- Two-dose vaccine effectiveness against infection with Omicron was 44 percent in the 14 to 90 days after the second dose.
- Three-dose vaccine effectiveness against infection with Omicron was 71.6 percent in the 14 to 60 days after the booster, but dropped to 47.4 percent after 60 days.

- Despite decreased effectiveness at preventing against infection with Omicron, three doses of the Moderna vaccine were still more than 99 percent effective against hospitalization with Omicron.

A 2021 study, currently in preprint, had similar findings for the Pfizer-BioNTech vaccine. This study found that:

- Two-dose vaccine effectiveness was 88 percent in the 2 to 9 weeks after the second dose.
- However, this protection dropped to 34 to 37 percent after 15 weeks.
- Following a booster dose, vaccine effectiveness increased to 75.5 percent. Researchers didn't determine how long protection from the booster lasted.

How safe are mRNA vaccines?

The clinical trials for the Pfizer-BioNTech and Moderna vaccines found both to be safe overall. When serious side effects did occur, they happened at comparable rates between people who had received the vaccine and those who had received a placebo injection.

A 2021 study

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analyzed over 11.8 million mRNA vaccine doses between December 2020 and June 2021 for 23 serious outcomes, paying particular attention to:

- anaphylaxis, a serious allergic reaction that can happen following vaccination
- myocarditis and pericarditis, two types of heart inflammation that have been reported with mRNA vaccines
- Bell's palsy, a temporary facial paralysis that had been observed more commonly, but still rarely, in the vaccine group in the clinical trials of the mRNA vaccines

Researchers found that:

- Overall, none of the 23 outcomes occurred at a level that met the study's criteria to signal a concern.
- The estimated rates of anaphylaxis in the study were similar to those reported by other studies.
- An elevated risk of myocarditis or pericarditis was observed for younger people, particularly males.
- No evidence was found that linked Bell's palsy to mRNA vaccines.

Common side effects of mRNA vaccines

Common side effects of the mRNA vaccines include:

- pain, redness, or swelling at the injection site
- fatigue
- muscle pain
- headache
- fever, with or without chills
- nausea

Side effects like muscle pain, headache, and fever are generally more common after the second dose. They typically go away on their own within a few days and can be eased with rest and over-the-counter medications.

How was it possible that mRNA vaccines were created so quickly?

While mRNA vaccines may seem new, researchers have actually been studying them for a long time. In fact, the first delivery of mRNA into a cell to make proteins happened in 1978

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Since then, researchers have advanced mRNA vaccine technology. They've improved the synthesis of RNA as well as the layer of fats that deliver it into cells.

Examples of other mRNA vaccines that have been studied include those for:

- flu
- rabies
- Zika
- cytomegalovirus (CMV)

When the COVID-19 pandemic began, researchers used this existing body of research to develop the mRNA COVID-19 vaccines. Other factors that helped these vaccines be made so rapidly included:

- additional funding from both public and private sources
- accelerated timelines for clinical trials
- high levels of collaboration within scientific communities around the world

Despite being developed quickly, the safety and effectiveness of these vaccines still needed to be demonstrated in clinical trials. Accelerated timelines didn't mean corners were cut when it came to testing standards or scientific integrity.

Common myths about mRNA vaccines

You may have heard a lot of different things about the COVID-19 mRNA vaccines. Some of these things may be true while others aren't.

Let's take a moment to debunk some of the common myths about these vaccines.

Myth: Natural immunity is better than a vaccine

We still don't understand much about how long natural immunity to the coronavirus lasts. Overall, getting vaccinated is a safer way to build immunity, as getting COVID-19 can lead to:

- long COVID after your acute illness has passed
- severe illness that can include complications like respiratory distress or failure, blood clots, and organ damage
- death

Vaccination is still important, even if you've already had COVID-19.

In fact, new research shows that people who have been vaccinated *and* have had COVID-19 have higher levels of neutralizing antibodies. This is called super immunity.

Myth: The vaccine ingredients are dangerous

In addition to mRNA, these vaccines also contain fats, sugars, and salts. If you'd like more information, the CDC has a list of each ingredient in the Pfizer-BioNTech

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and Moderna

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vaccines and what they do.

If you have a history of allergic reactions to any of the ingredients included in the mRNA vaccines, you'll want to talk with your doctor before getting vaccinated.

The mRNA vaccines *do not* contain ingredients like:

- tissues from humans or other animals
- preservatives
- antibiotics
- latex
- metals

Myth: The COVID-19 vaccine can give you COVID-19

The mRNA vaccines for COVID-19 don't contain whole virus. They only contain a piece of mRNA that instructs your cells on how to make the spike protein. As such, they cannot cause you to become sick with COVID-19.

It's possible you'll feel a little sick after getting your COVID-19 vaccine. This is completely normal and a sign that your body is building an immune response. Side effects generally go away within 1 to 2 days.

Myth: Vaccinated people can shed the vaccine

Vaccine shedding happens when a vaccinated person releases vaccine components into the environment. This can only happen with vaccines that contain a live, weakened form of a virus.

The mRNA vaccines don't contain whole virus in any form. Because of this, they cannot be shed.

Myth: The mRNA vaccines alter your DNA

Your DNA is contained in the nucleus of each cell. The mRNA from the vaccine never enters the nucleus of a cell. Because of this, it cannot alter or affect your DNA.

Additionally, vaccine mRNA only stays in your cells for a short time. It's destroyed after a cell has used it to make the spike protein.

The bottom line

The mRNA vaccines instruct your cells on how to temporarily make a protein from a disease-causing pathogen. Your immune system can then see this protein and generate an immune response against it that can protect you against disease in the future.

As of publication, the only mRNA vaccines in use are those for COVID-19. They are made by the pharmaceutical companies Pfizer, BioNTech, and Moderna.

Large-scale clinical trials and subsequent studies have found both vaccines to be safe and effective against the coronavirus that causes COVID-19.

MRNA vaccine technology holds a wealth of promise for the future. Building off what's known from previous research and COVID-19 vaccine development, researchers can move forward to develop mRNA vaccines for other pathogens.

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