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mRNA Vaccines: What you need to know

How do mRNA vaccines work? How are they different from other, currently available vaccines?

mRNA vaccines give your cells instructions on how to make a protein (like the spike protein against SARS-CoV-2, the virus that causes COVID-19). If you are exposed to the pathogen targeted by the vaccine after vaccination, your body will recognize it and know how to mount a protective immune response.

Depending on the pathogen that is being targeted, different vaccine platforms are used to generate effective vaccines. Some use weakened or inactivated (killed) pathogens. Other vaccines target a piece of a pathogen to teach your immune system how to fight off future disease. The process for making many of these traditional (i.e., established technologies) vaccines is generally lengthy and costly. Modifying traditional vaccines quickly, if needed, can be difficult. In contrast, mRNA vaccines are less costly and can be developed more quickly. Lastly, mRNA vaccines can be considered a safer vaccine platform for certain populations, as they do not contain live viruses.

What is mRNA?

Messenger RNA (mRNA) is genetic material within cells that contains the instructions needed to make proteins. Our DNA, or genetic code, contains all the genes we will express in our lifetime. Within genes are instructions that code for different proteins, and mRNA is the "middleman" between cellular DNA and proteins. Cellular function is dependent on the availability of specific proteins, and mRNA is critical to protein synthesis and an essential component of all living organisms. Right now, your body is using millions of proteins for its regular functions just to stay alive and healthy.

Every vaccine, no matter what platform is used, must undergo a clinical trial and be tested extensively by its manufacturer. Safety is a priority throughout the vaccine development process. Further, the U.S. Food and Drug Administration (FDA) must license or authorize a vaccine before it can be used. FDA scientists and medical professionals carefully evaluate all available information about the vaccine to determine its safety and effectiveness during this process. Even after vaccines are approved and recommended for public use in the U.S., the Centers for Disease Control and Prevention (CDC) and FDA use multiple systems to monitor their safety. These systems ensure that vaccines continue to be safe, effective, and their benefits continue to outweigh the risks throughout time.

mRNA vaccines do not alter our DNA.

mRNA vaccines cannot alter our DNA because the mRNA from the vaccine cannot enter the nucleus of the cell, which is where our DNA is located. mRNA vaccines also lack the enzymes necessary to convert the mRNA into DNA and integrate into the host's genome. This makes it biologically impossible for mRNA vaccines to modify human DNA.

Was the development of mRNA vaccines rushed?

mRNA vaccines had been in development for nearly two decades before the onset of the COVID-19 pandemic. Decades of scientific research and key breakthroughs laid the foundation for the development of the mRNA vaccines currently in use today (e.g., Moderna and Pfizer's mRNA COVID-19 vaccines, Moderna's RSV vaccine).

The development of these vaccines involved hundreds of people all over the world who have worked in both fundamental and applied areas of research.

mRNA was discovered in the early 1960s. The early years of mRNA research were marked by a lot of enthusiasm for the technology, but some difficult technical challenges took a great deal of innovation to overcome.

The biggest challenge was that mRNA would be taken up by the body and quickly degraded (destroyed) before it could "deliver" its instructions and be translated into proteins by the cell. The solution to this problem came from advances in nanotechnology: the development of fatty droplets (lipid nanoparticles) that wrapped the mRNA like a bubble, which allowed entry into the cells. Once inside the cell, the mRNA message could be translated into proteins, like the spike protein of SARS-CoV-2, and the immune system would then be primed to recognize the foreign protein.

Thanks to decades of research and innovation, mRNA vaccine technology was ready to be put into use when the World Health Organization declared COVID-19 a pandemic in 2020. With an unprecedented pooling of knowledge, funding, and an extreme need, this technology was used to develop COVID-19 vaccines that haven been proven to be extremely safe and effective. mRNA vaccines contributed to saving more than 2.4 million lives from SARS-CoV-2 (the virus that causes COVID-19) in the first eight months of the pandemic. Since 2020, an mRNA vaccine against respiratory syncytial virus (RSV) for older adults has also been approved by the FDA.

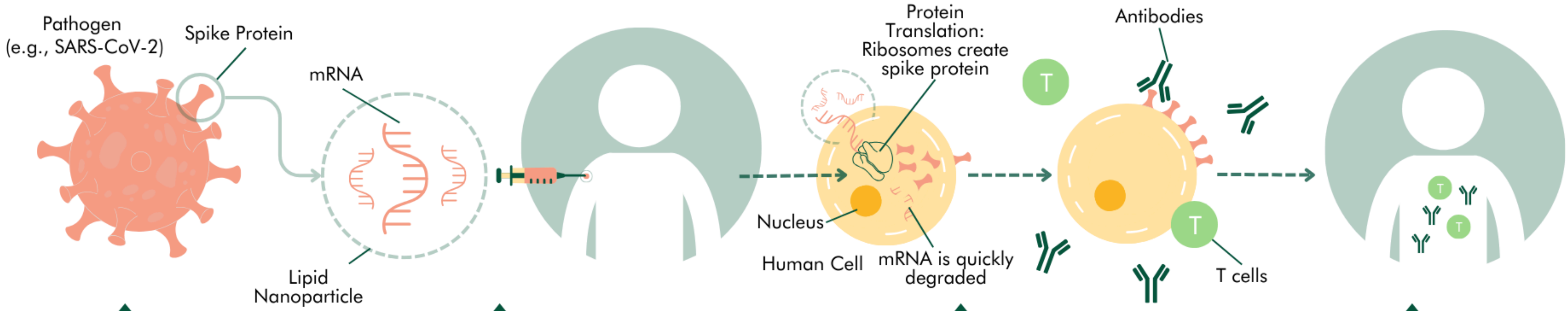
The future of mRNA vaccines.

Vaccine manufacturers are developing mRNA vaccines to protect against other respiratory viruses, such as the flu. Researchers and scientists are also exploring applications of the technology to protect against HIV and to treat cancer. It's a new era for vaccine technology and production, and a testament to scientific progress and decades of research.

See the step-by-step process of how mRNA vaccines work

HOW MRNA VACCINES WORK

mRNA vaccines help the body's immune system build protection against a specific pathogen so that if a person is ever exposed to that pathogen following vaccination, the immune system can quickly recognize and respond to it before it can cause serious illness.



mRNA vaccines give genetic instructions to cells in the body on how to make a piece of a pathogen, usually a protein found on the outer membrane of the pathogen (e.g., the spike protein of SARS-CoV-2, the virus that causes COVID-19.)

The mRNA vaccine is injected into a muscle, usually on the upper arm or thigh. The vaccine contains mRNA surrounded by a lipid nanoparticle (fatty bubble). Once the vaccine is inside the body, the lipid nanoparticle acts as a vehicle to deliver the instructions (aka the mRNA) to our cells. Without the lipid nanoparticle, the mRNA in the vaccine would degrade quickly and would have difficulty crossing into cells.

Once inside the cell, the mRNA is translated by ribosomes, which make the targeted protein or parts of the targeted protein (e.g., spike protein). After the mRNA is read, it is broken down by the cell. The cell displays the newly made proteins on their surface. As part of a normal immune response, the immune system produces specialized proteins called antibodies and other defenses against the pathogen (ex. T cells).

Vaccination primes the immune system, so if an individual encounters the pathogen in the future, the body is able to recognize and destroy it. mRNA vaccines may prevent disease entirely or it may help to reduce severity of disease if an individual is infected.

References

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