COVID-19 Vaccines- How Do They Work? Will I Get Vaccinated?

After a year of illness, social disruption, and economic pain, Americans finally have a chance to regain control over a virus that has claimed hundreds of thousands of lives. Vaccines were once viewed by Americans as saviors over diseases that inflicted suffering and death across all corners of our country. But with the rise of social media, some people have become leery of vaccines. Let's take a step back before discussing the current COVID-19 vaccines.

Through the mid-20th century, parents feared paralysis and death each summer as polio epidemics spiked, and at all times of the year pregnant women dreaded the horrific birth defects caused by rubella (German measles) including brain damage, deafness, blindness, and stillbirth. These are just two of the many infectious diseases (whooping cough, meningitis, measles, etc.) that caused serious illness and death across the U.S. on a regular basis. When vaccines were developed to prevent these diseases, it was seen as patriotic to voluntarily step up and receive inoculation. Americans were not only protecting their families, but their entire communities.

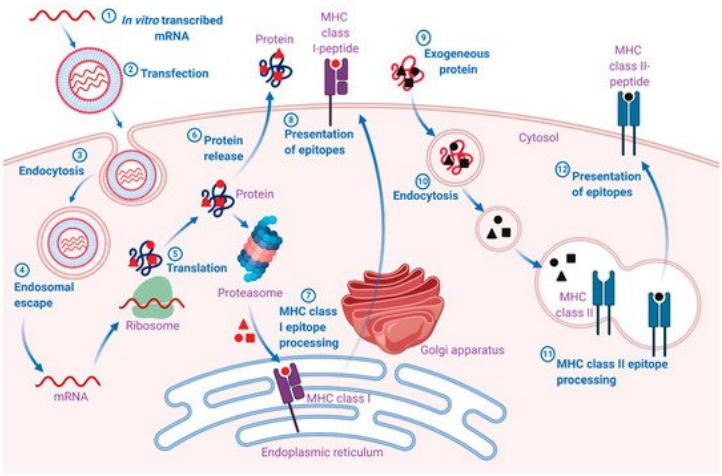
Vaccines traditionally worked by introducing dead or inactivated virus or bacteria into the body so the germ could be recognized by the body's immune system with little risk of causing harm. During a natural infection, it typically takes a week or more for the body to fully mount a response to a new pathogen. By that time, severe illness can develop. A vaccine allows the body the opportunity to develop an immune response prior to the threat of actual infection. The vaccine stimulates the production of antibodies and cytotoxic ("killer") T cells that can be quickly summoned by our bodies if we are infected by the live virus or bacteria later on. The antibodies and killer T cells prompted by the vaccine will activate within hours after exposure to an actual infection. This quick immune response prevents both illness and the potential that vaccinated people will spread the disease to others.

The two vaccines approved by the FDA use a newer technology to produce a robust immune response to the virus responsible for COVID-19. Although these are the first mRNA vaccines approved, this technology has been undergoing steady research and development for the past 30 years. Recent advances have provided the means of stabilizing the lipid nanoparticle coating that delivers the key piece of antigenic material to our cells. If that sounds like too many technical terms and you want more understanding, please read the next three paragraphs. Otherwise, feel free to skip past the second diagram.

Messenger RNA (mRNA) is a molecule produced by our cells to translate inherited genetic information from our DNA into actual proteins our bodies need to function. You couldn't digest your food, read this article, or breathe without DNA being transcribed to mRNA which is then translated into the proteins we need to survive. The COVID vaccines use this mRNA-to-protein translational process to eliminate the need to inject whole viruses that were necessary in older generations of vaccines. Based on the genetic code of the COVID virus, researchers were able to identify the genes that code for a key protein on the virus's surface (spike protein). This specific segment of genetic material, and only this specific segment, was transcribed into a piece of mRNA to be used for vaccination. Because the vaccine only contains this one portion of mRNA, **there is no risk of COVID infection from either vaccine**.

The final technical barrier to produce a successful vaccine has been to protect the fragile segments of mRNA until they can be delivered inside cells to ribosomes. Ribosomes are tiny assembly factories in our cells' cytoplasm that translate the instructions encoded in mRNA into protein (see diagram below). Recent scientific breakthroughs have led to the development of protective envelopes (lipid nanoparticles) that transport mRNA through cell membranes and release it into the cytoplasm. Lipid nanoparticles also have a very short half-life, so within a few days of administration, all of the vaccine mRNA is gone.

The left side of the following diagram corresponds to the mRNA vaccine process (the right side is for a different type of vaccine that is still under development):



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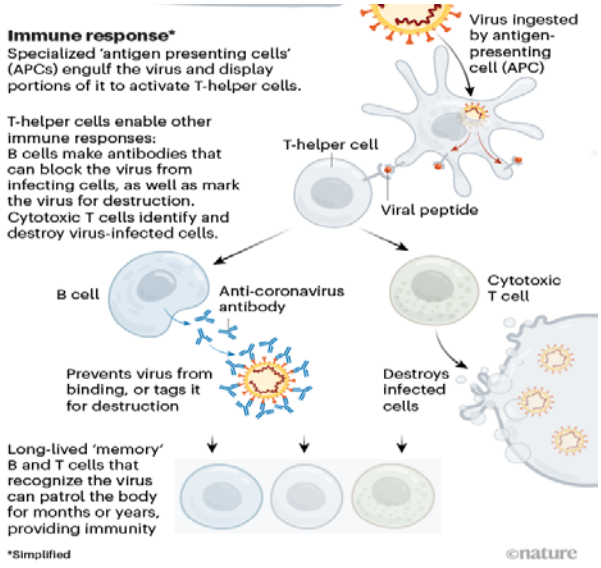
From there, the vaccine-driven cells (via antigen presenting cells and T-helper cells) deliver COVID spike proteins to the B cells and cytotoxic T cells of our immune system (see diagram below). B cells are then produced to generate specific antibodies against the COVID virus, and cytotoxic T cells are programmed to destroy any cells that are initially infected with COVID virus before the virus can spread throughout our bodies. This combination of antibody and T cell protection has shown to be 95% effective in preventing COVID infections in those who have received the recommended 2-dose mRNA inoculation.



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Because the COVID vaccines only contain two critical components (mRNA and lipid nanoparticles), the potential for side effects is likely lower than for traditional vaccines. The independent panel of experts who reviewed the most recent vaccine for the FDA voted 20-0 that the benefits of the mRNA vaccine clearly outweighed risks. However, these are new products and it would be disingenuous to suggest there

is no potential for adverse reactions. Each vaccine was administered to 15,000 people, along with 15,000 people receiving placebo injections, starting in July. In addition, over 200,000 frontline healthcare workers have thus far received the Pfizer vaccine. Overall, three cases of anaphylactic allergic reaction have occurred with the Pfizer vaccine. Allergic reactions have not been seen yet with the Moderna vaccine. There are no preservatives in either vaccine and neither were made with any egg products. As a precaution, people with a history of anaphylactic reactions should make sure they receive vaccination at a location that is prepared to treat a serious allergic reaction in the small chance it should occur.

A condition called Bell's palsy developed in 4 people in the Pfizer trial and 3 people in the Moderna trial. One person who received a placebo developed Bell's palsy. It is unclear whether the cases of Bell's palsy are directly related to the vaccines or if those cases are coincidental since numerous infections (common cold viruses, influenza, mononucleosis, etc.) can cause this condition. Bell's palsy results in a temporary weakening of the facial muscles that typically improves with a few weeks and resolves in a few months.

About 2% of people had significant pain at the injection site after vaccination, and 5-7% had significant fatigue and/or general muscle aches for about two days. These body-wide symptoms are due to the vaccine's activation of the immune system, but are not the result of an actual infection. Again, it is not possible to get a COVID infection from either vaccine because neither contain any virus particles.

There is a chance that we may learn of other side effects over time, but this must be weighed against the clear harms that continue to result from ongoing COVID infections. 300 Marylanders died from COVID infections in the past week and more than 1,600 people are currently hospitalized. Leaving oneself vulnerable to the virus places you and those around you at a clear risk of chronic respiratory problems, heart muscle damage, blood clots, stroke, and death.

Studies to this point have also shown that antibody production after natural COVID infections weaken at a much faster rate than after mRNA vaccination. We need to keep in mind that the COVID virus is in the same family as many common cold viruses (adenovirus), and humans are susceptible to recurrent infections from colds year-after-year. Although we won't know until late in 2021, it seems possible that those who are depending on their natural immunity to prevent reinfection may be at greater risk than those who receive vaccination.

The Pfizer vaccine is approved for everyone 16 and over. The Moderna vaccine is approved for those 18 and over. The difference in ages is a result of the inclusion criteria each manufacturer set during the study trials. Pfizer allowed enrollment at age 16, Moderna at 18. Neither vaccine was intentionally tested in pregnant women. Some women in both trials became pregnant shortly after vaccination. To this point, there have been no indications of miscarriages or birth defects. These women and their babies are being closely monitored. Theoretically, there is no reason to expect additional risk during pregnancy. We have decades of extensive experience with vaccines during pregnancy. Other than a few older vaccines containing live virus (not an issue for COVID vaccines), inoculations have proven safe for both mothers and developing fetuses.

We all take risks on a daily basis. Every encounter with other people brings potential exposure to infectious diseases, possible acts of violence, etc. Every car ride we take places us and our children at risk of severe injuries from crashes. Playing sports risks concussions and other injuries. Every antibiotic we take carries some risk of allergic reaction. Receiving a vaccine also carries a small, but possible risk. But seldom do our actions lead to as much potential good, with such small risk, as receiving a vaccination to protect against COVID-19. Nothing else holds as much potential to end the physical, emotional, and social harms that have been inflicted on our community and our country over this past year.

As we each consider our option to be vaccinated against COVID-19, we are doing so in the context of the time we live. 2020 has been a very difficult year for all of us. We have also seen our country become more divided. We have a chance to make 2021 much safer and to take a major step in restoring normalcy to our lives. We also have a chance to come together as a nation in a common cause of patriotic selflessness.

Yes, there is an element of risk in getting a new vaccine. But the early evidence is very reassuring, and let's face it, life rarely provides guarantees. When my opportunity arrives in the next week or two, I feel a responsibility to my family, my patients, my coworkers, and my community to get vaccinated. When my family members have their choice, I will encourage them to do likewise. I often hear people call themselves patriotic. Here is each person's chance to make a small personal sacrifice for the good of our community and our nation.

I wish you all a very healthy and happy New Year.
Dr. Polsky