

# *Science You Can Use*

Jack K. Horner

**Dear Science:** My sister-in-law is a licensed physician's assistant (PA) and refuses to be vaccinated against COVID because she believes that the Pfizer and Moderna vaccines "change your DNA." About two months ago, she and her husband got COVID. She recovered quickly, but he almost died. Do the Pfizer or Moderna vaccines change your DNA? -- Buck R.

**Dear Buck:** Here is the short answer. Let's call the Pfizer and Moderna COVID vaccines "mRNA COVID" vaccines. None of the mRNA COVID vaccines could change your DNA.

Here are some details.

*A birds-eye view of how mRNA vaccines work.* DNA is the molecule that "encodes" how our bodies develop and function in the environment they encounter. Beyond doubt, changing DNA without profound knowledge and control of the consequences of such a change, would be disastrous. Therapies that attempt to change DNA, called *gene-editing* therapies, are in their infancy, highly experimental, and in the US at least, highly controlled. That aspect of your sister-in-law's concern is spot on.

mRNA COVID vaccination, however, does *not* change your DNA. Here's why.

Under normal conditions, the information contained in your DNA is first copied to a separate kind of molecule called "messenger RNA", or "mRNA" for short. mRNA is called "messenger" RNA because in normal conditions, it literally transports a chemical "message" (specifically, information that is encoded in your DNA) to special-purpose regions of your cells that use the information from the mRNA to assemble *proteins*. Proteins participate in the regulation of essentially all the functions of our bodies.

Notice that if we could safely insert "designer" mRNA into a cell, and if the cell recognized that designer mRNA as a legitimate order to assemble a protein, the mRNA would direct the protein-assembling machinery of the cell to build the protein whose "assembly" code is in that mRNA. mRNA COVID vaccines exploit this "messenger" behavior.

The mRNA COVID vaccines are dilute suspensions of specially-designed mRNA molecules encapsulated in a protective lipid ("fatty") coat. These particles are called "lipid nanoparticles" (LNPs). When the LNPs are injected during vaccination, various cells incorporate the LNPs (containing the mRNA). As an LNP enters a cell, the lipid coat falls away, and the freed mRNA "tells" the receiving cell to generate a protein that looks very much like a part of a unique spike protein on the coat of the SARS-CoV-2 virus (the virus that causes COVID). In response, the cell generates many copies of this part of the spike protein. The spike-protein copies produced by the cells are then sensed by our immune system, which mounts a defense against anything (including the SARS-CoV-2 virus) that "looks like" the spike protein. In effect, mRNA COVID vaccines provoke our own cells to become "factories" of specially designed, harmless proteins that cause our immune system to "recognize" any virus that has such proteins on its coat. By

carefully designing mRNA to order our cells to produce proteins that occur only in the coat of specific pathogenic viruses, we can tailor an mRNA vaccine to target specific, or small closely related families, of viruses. mRNA vaccines do not change DNA.

*Are mRNA COVID vaccines safe?* Over the last 18 months, about 4.5 billion people worldwide have been *partially* vaccinated with (i.e., have received at least one shot of) mRNA COVID vaccines; about half that number have been fully vaccinated (in the case of the Pfizer and Moderna vaccines, this requires two shots). During that time neither vaccine has produced an adverse reaction that is any more severe than those experienced by recipients of flu vaccines. Most recipients have experienced a little soreness at the injection site, but nothing more. A few have experienced mild flu-like symptoms for one or two days.

*Are mRNA COVID vaccines effective and safe for more than a few months?* The only way to answer questions like these with the depth of understanding we have in vaccines that have been used for years (such as the measles or tetanus vaccines) is to administer the candidate vaccines to millions of people and monitor the health of those recipients for at least five years, comparing those results with the health of people who did not receive the vaccines.

*What happens if you remain unvaccinated?* If you are not vaccinated for COVID, you are 20 times more likely to die from COVID than if you have been fully vaccinated with an mRNA COVID vaccine and have had a booster shot (see Texas Department of State, Health Services, <https://www.dshs.texas.gov/immunize/covid19/data/vaccination-status.aspx>). Think of a 20-fold difference in risk of death this way. Suppose you knew that one of your driving habits – say, turning left against traffic at the beginning of a red light -- was 20 times more likely to kill you than if you did not have that behavior. It would only make sense to stop turning left against traffic at the beginning of a red light.

For further information, see Florian Krammer, “SARS-CoV-2 vaccines in development”, *Nature* 586 (22 October 2020), pp. 516-527. Worldwide vaccination rates can be found on <https://www.nytimes.com/interactive/2021/world/covid-vaccinations-tracker.html>.

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*Jack Horner is a systems engineer.*