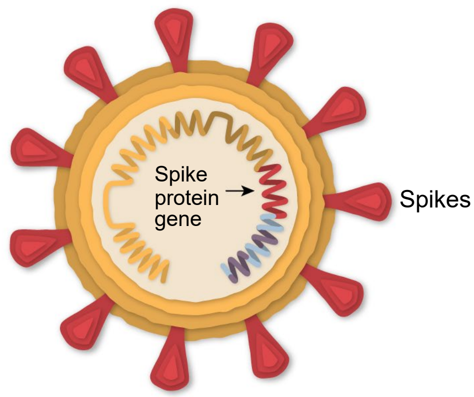
# COVID-19 MESSENGER RNA VACCINE

## A Piece of the Coronavirus

The SARS-CoV-2 virus is studded with proteins that it uses to enter human cells. These so-called spike proteins make a tempting target for potential vaccines and treatments.

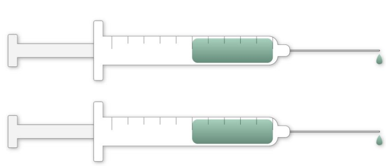
CORONAVIRUS

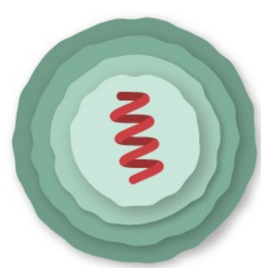



Like the Pfizer vaccine, Moderna's vaccine is based on the virus's genetic instructions for building the spike protein.

## mRNA Inside an Oily Shell

The vaccine uses messenger RNA, genetic material that our cells read to make proteins. The molecule — called mRNA for short — is fragile and would be chopped to pieces by our natural enzymes if it were injected directly into the body. To protect their vaccine, Pfizer and BioNTech wrap mRNA in oily bubbles made of lipid nanoparticles.

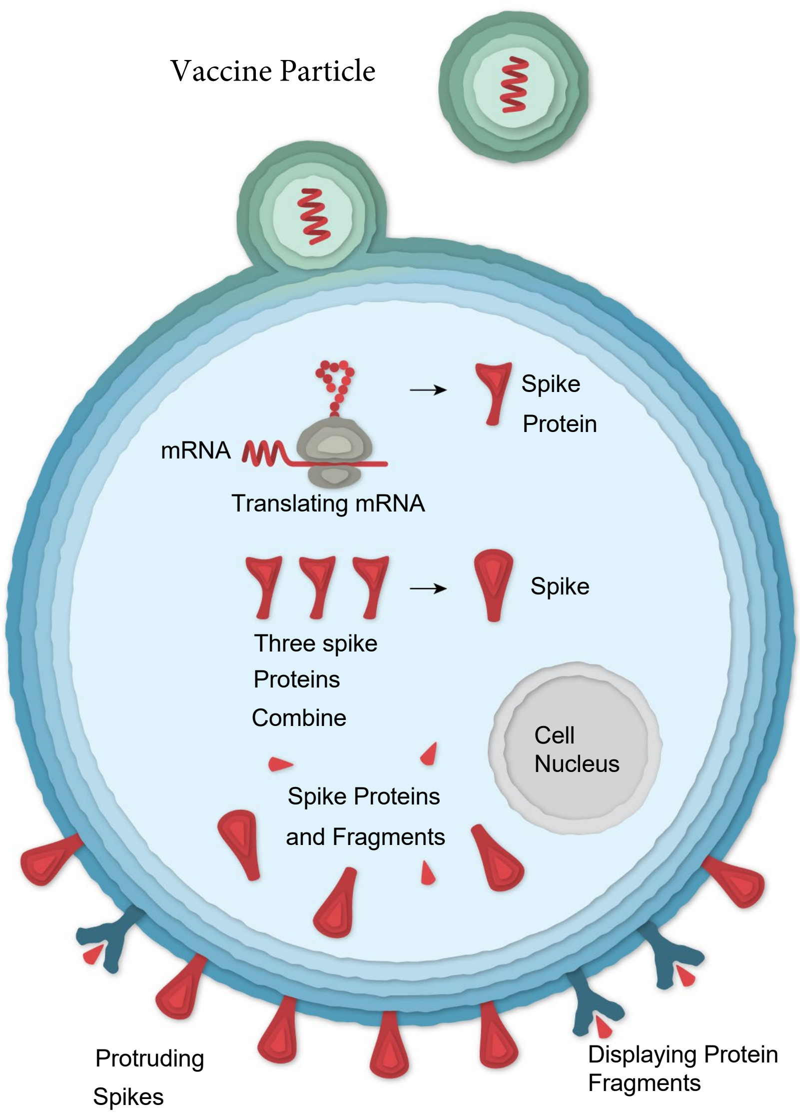




Lipid nanoparticles surrounding mRNA

## Entering a Cell

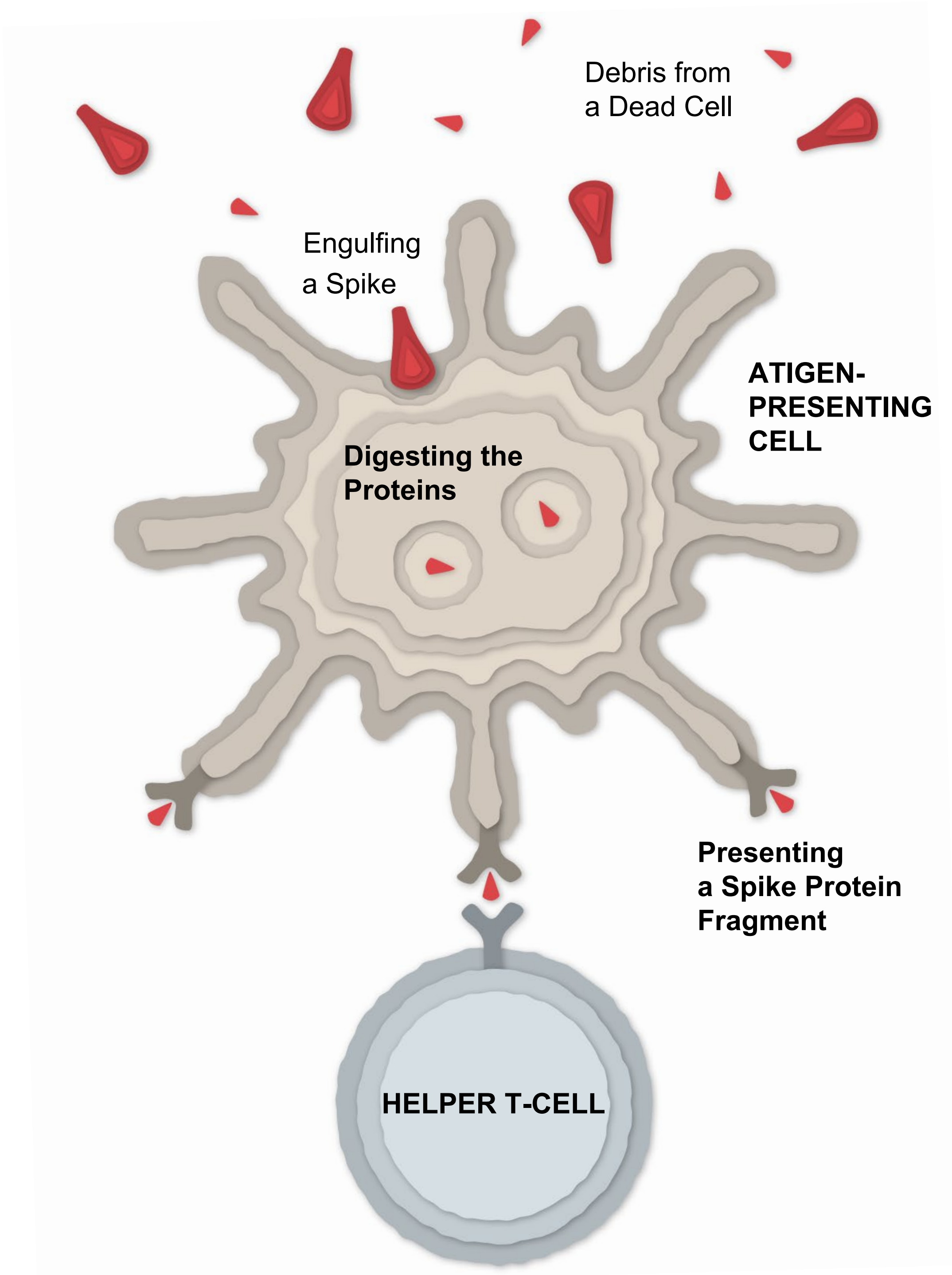
After injection, the vaccine particles bump into cells and fuse to them, releasing mRNA. The cell's molecules read its sequence and build spike proteins. The mRNA from the vaccine is eventually destroyed by the cell, leaving no permanent trace.




Some of the spike proteins form spikes that migrate to the surface of the cell and stick out their tips. The vaccinated cells also break up some of the proteins into fragments, which they present on their surface. These protruding spikes and spike protein fragments can then be recognized by the immune system.

# Spotting the Intruder

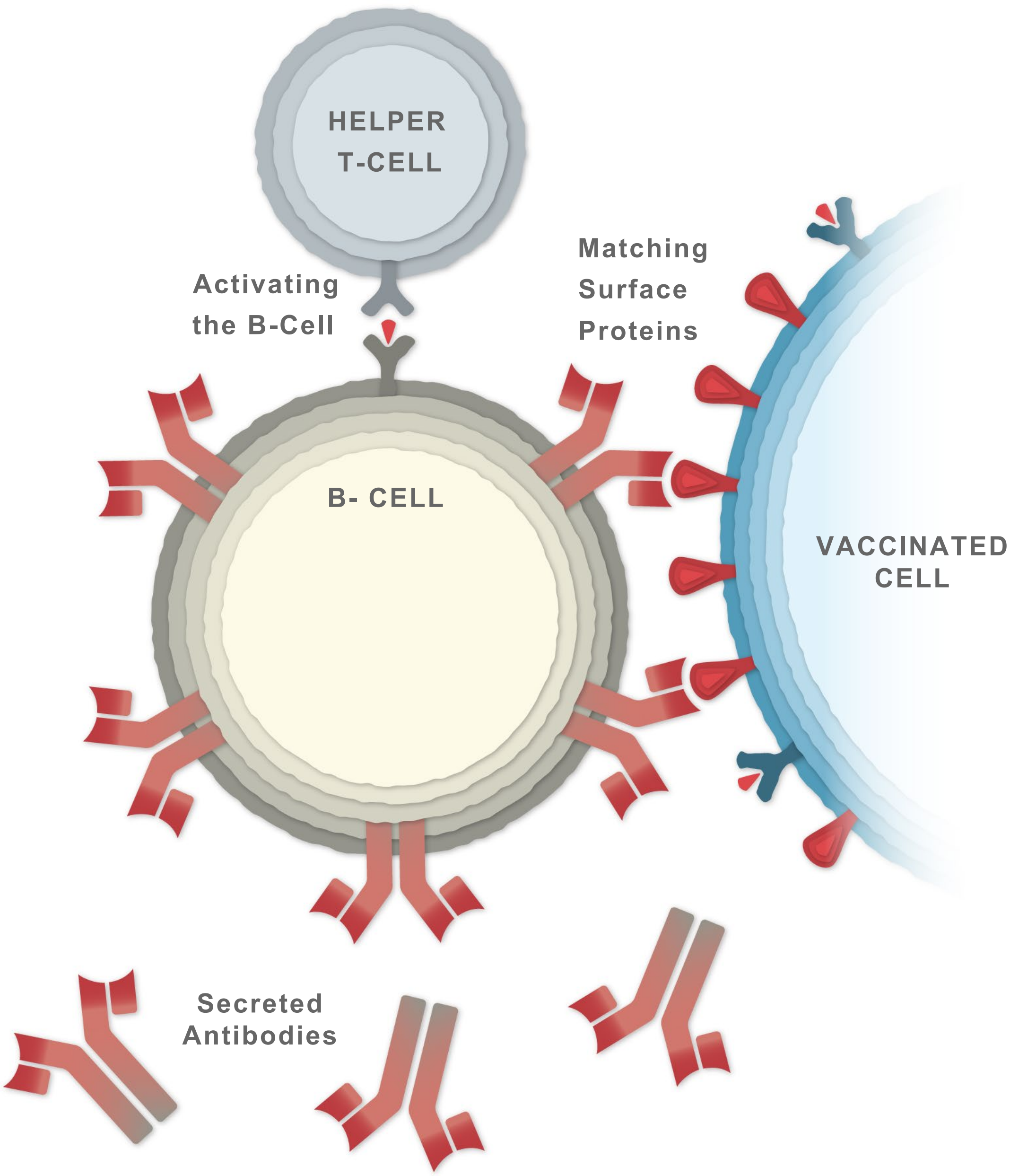
When a vaccinated cell dies, the debris will contain many spike proteins and protein fragments, which can then be taken up by a type of immune cell called an antigen-presenting cell.




The cell presents fragments of the spike protein on its surface. When other cells called helper T-cells detect these fragments, the helper T-cells can raise the alarm and help marshal other immune cells to fight the infection.

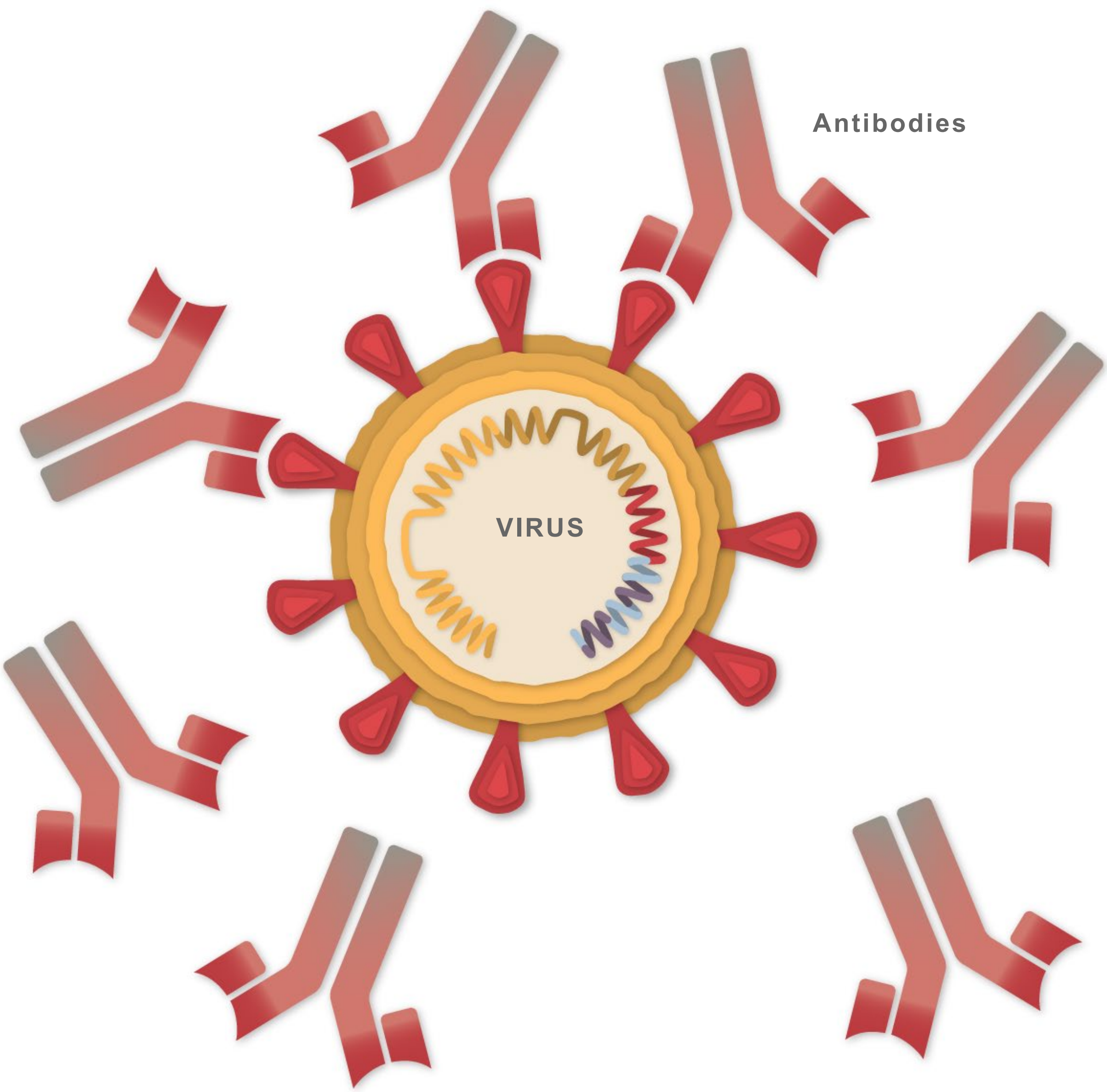
## Making Antibodies

Other immune cells, called B-cells, may bump into the coronavirus spikes and protein fragments on the surface of vaccinated cells. A few of the B-cells may be able to lock onto the spike proteins. If these B-cells are then activated by helper T-cells, they will start to proliferate and pour out antibodies that target the spike protein.



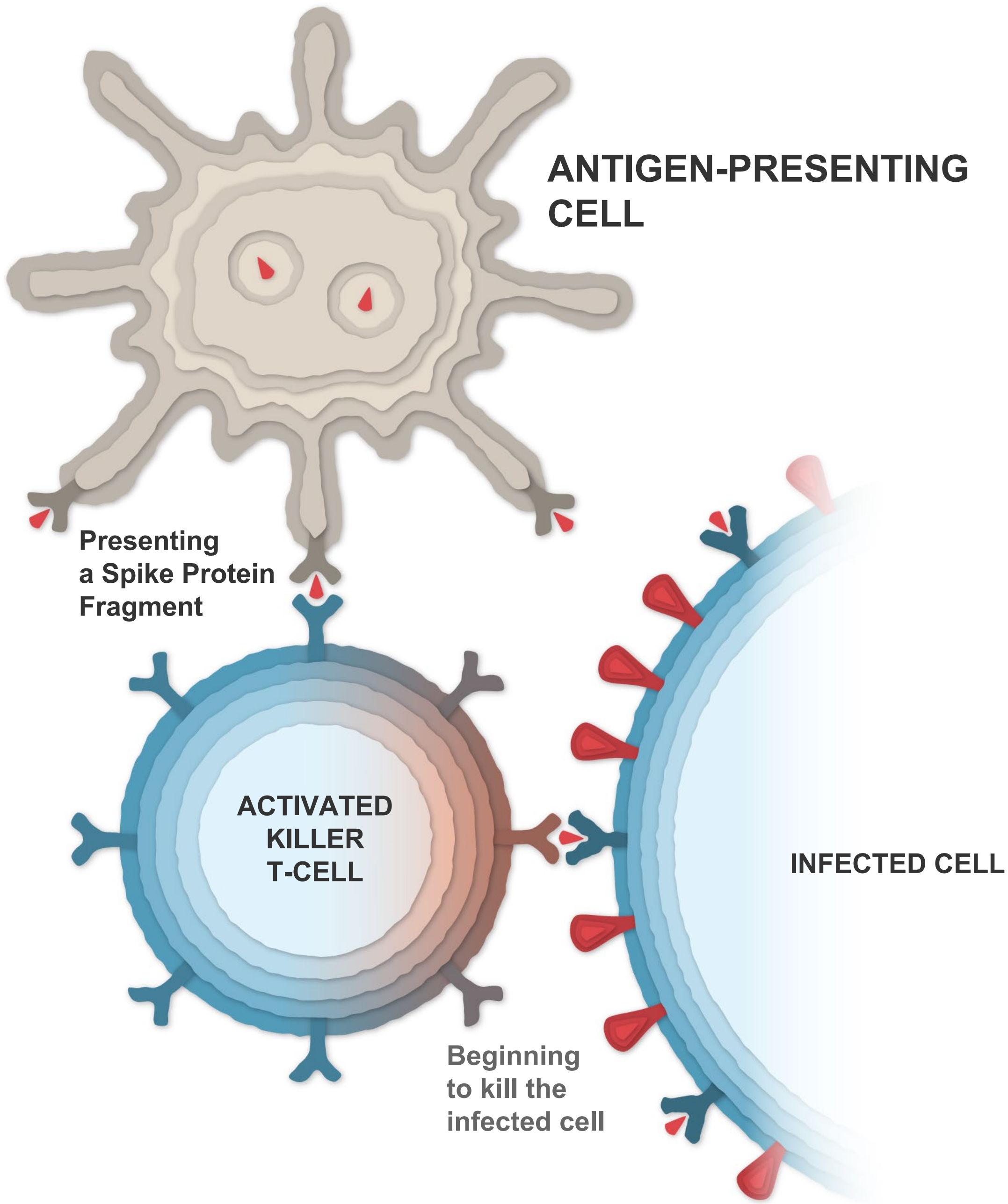
## Stopping the Virus

The antibodies can latch onto coronavirus spikes, mark the virus for destruction and prevent infection by blocking the spikes from attaching to other cells.



## KILLING INFECTED CELLS

The antigen-presenting cells can also activate another type of immune cell called a killer T-cell to seek out and destroy any **coronavirus-infected cells** that display the spike protein fragments on their surfaces.




It's possible that in the months after vaccination, the number of antibodies and killer T-cells will drop. But the immune system also contains special cells called memory B-cells and memory T-cells that might retain information about the coronavirus for years or even decades.

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