

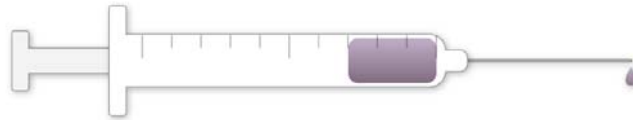
U.S.A.

World

Health

How the Pfizer-BioNTech Vaccine Works

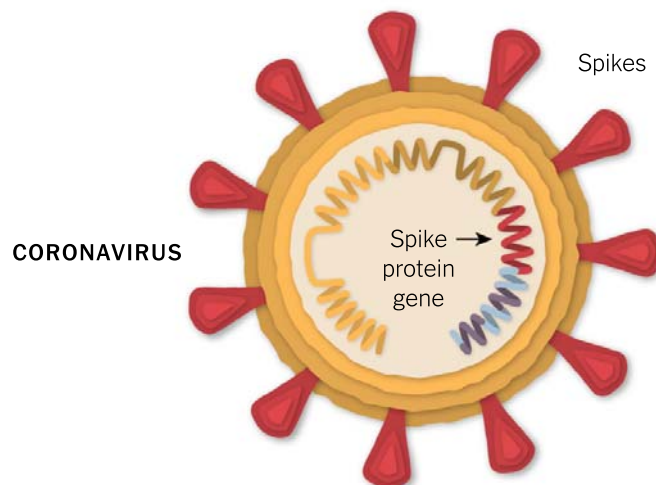
By [Jonathan Corum](#) and [Carl Zimmer](#) Updated Jan. 11, 2021



The German company BioNTech partnered with Pfizer to develop and test a coronavirus vaccine known as **BNT162b2**, the generic name **tozinameran** or the brand name **Comirnaty**. A clinical trial demonstrated that the vaccine has an efficacy rate of 95 percent in preventing Covid-19.

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.



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

mRNA Inside an Oily Shell

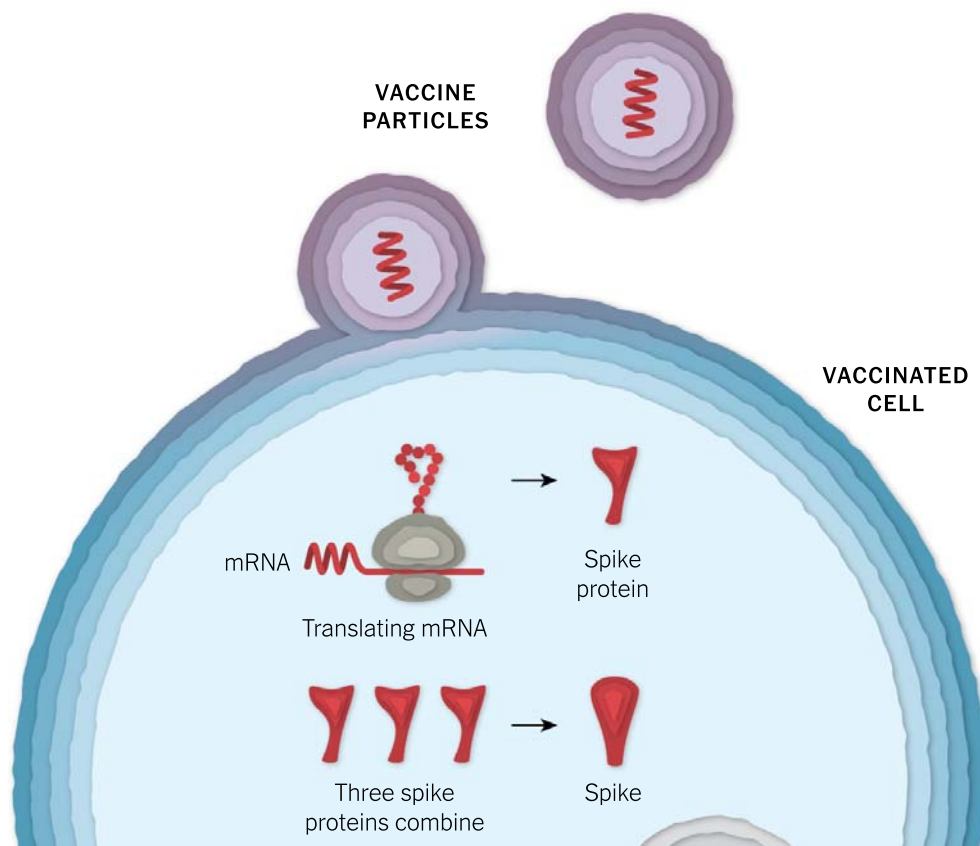
The vaccine uses messenger RNA, genetic material that our cells read to make proteins. The molecule — called mRNA for short — is fragile and would be chopped to pieces by our natural enzymes if it were injected directly into the body. To protect their vaccine, Pfizer and BioNTech wrap the mRNA in oily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

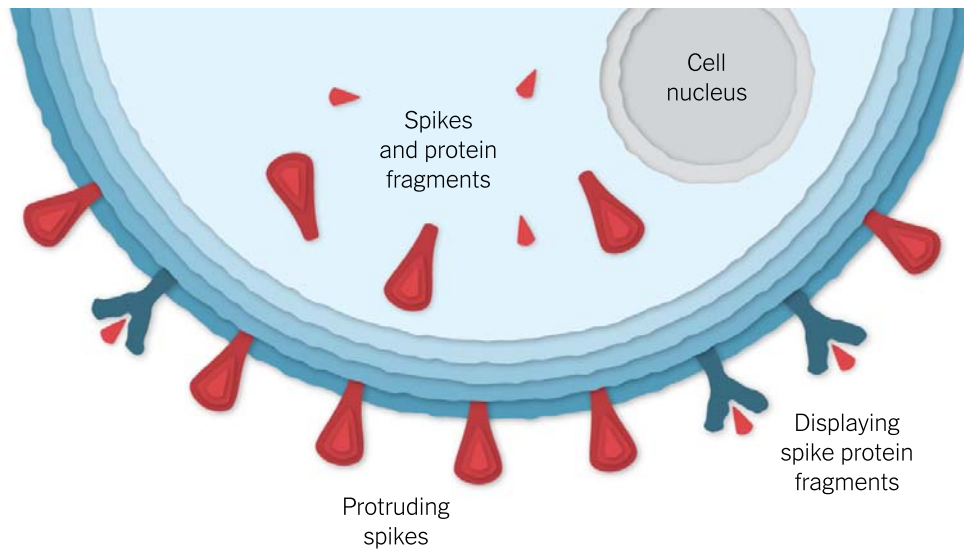


Because of their fragility, the mRNA molecules will quickly fall apart at room temperature. Pfizer is building special containers with dry ice, thermal sensors and GPS trackers to ensure the vaccines can be transported at -94°F (-70°C) to stay viable.

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.

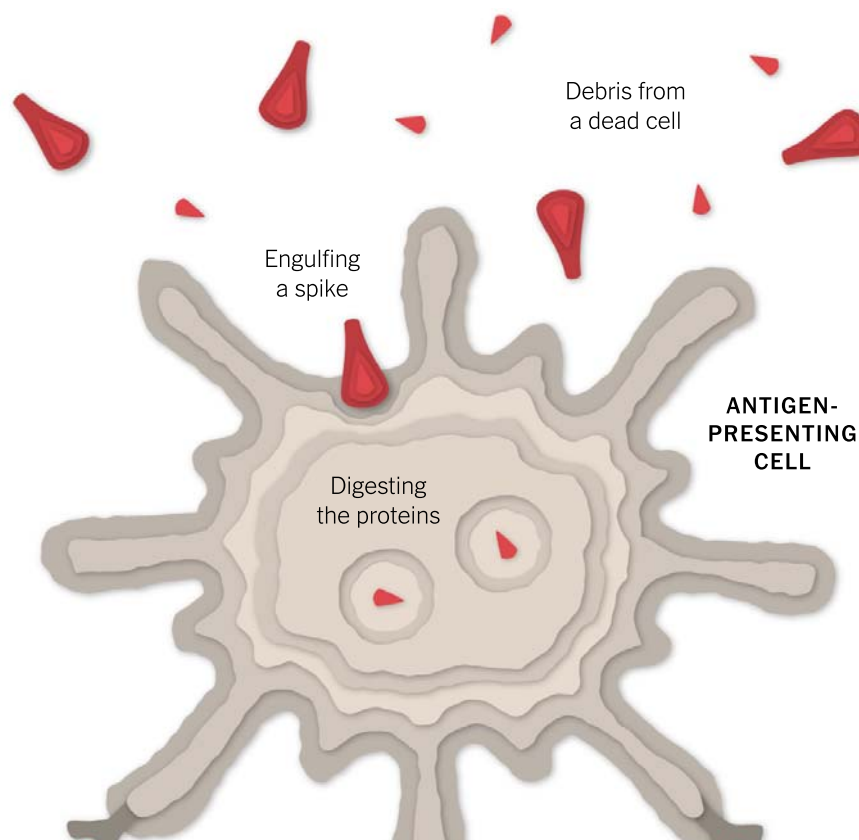


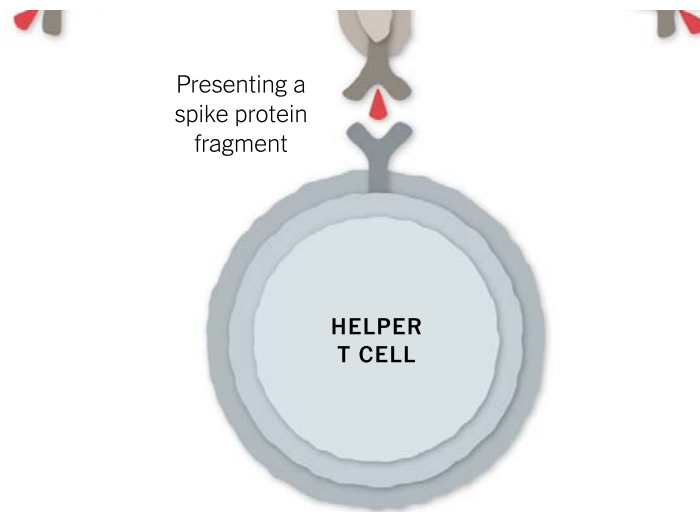


Some of the spike proteins form spikes that migrate to the surface of the cell and stick out their tips. The vaccinated cells also break up some of the proteins into fragments, which they present on their surface. These protruding spikes and spike protein fragments can then be recognized by the immune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

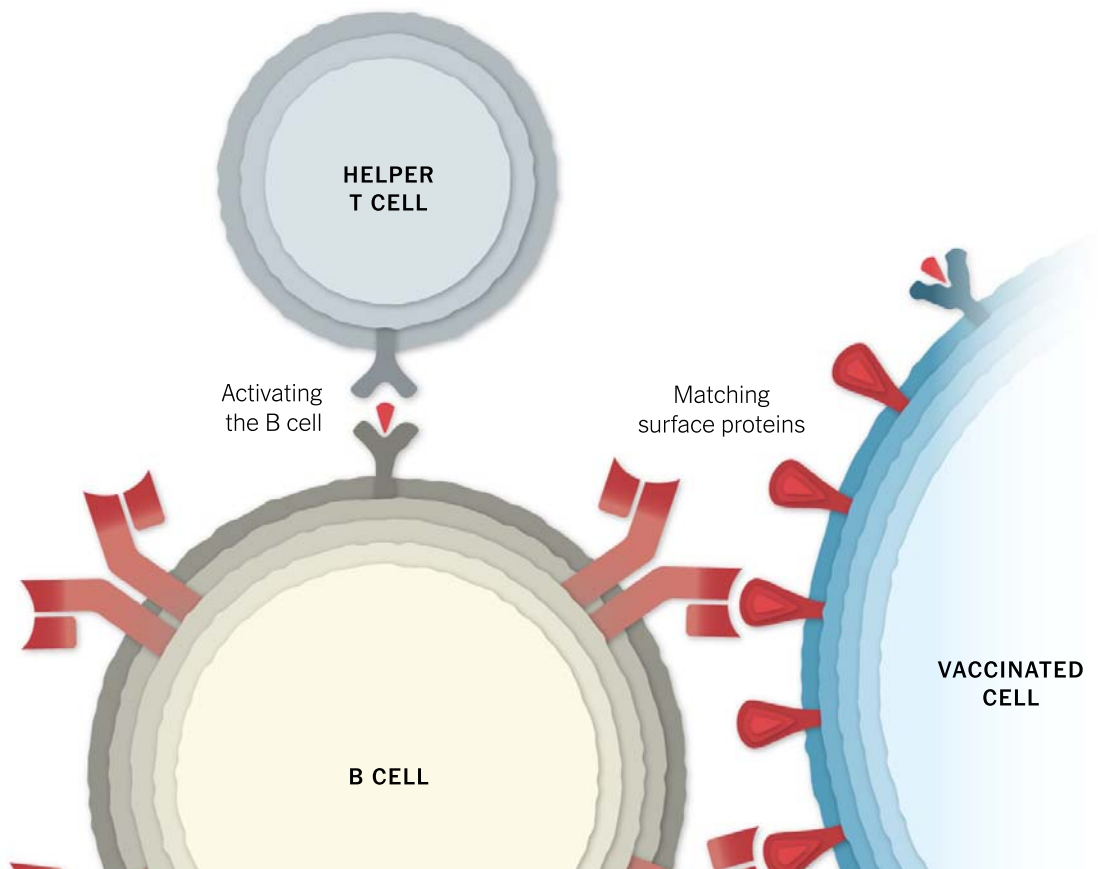


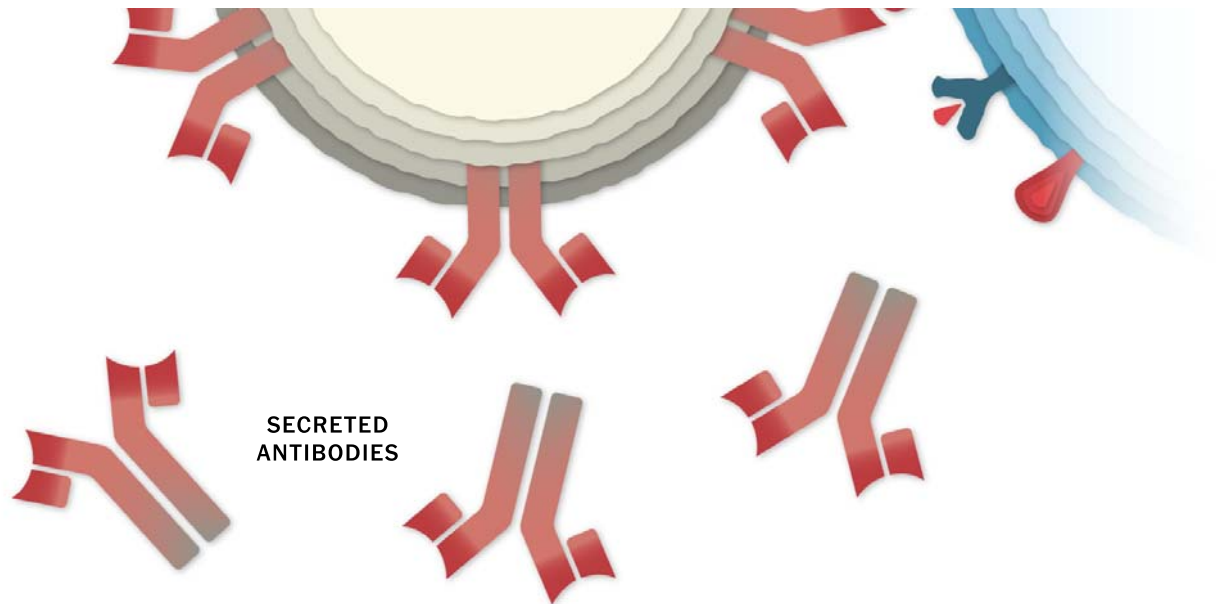


The cell presents fragments of the spike protein on its surface. When other cells called helper T cells detect these fragments, the helper T cells can raise the alarm and help marshal other immune cells to fight the infection.

Making Antibodies

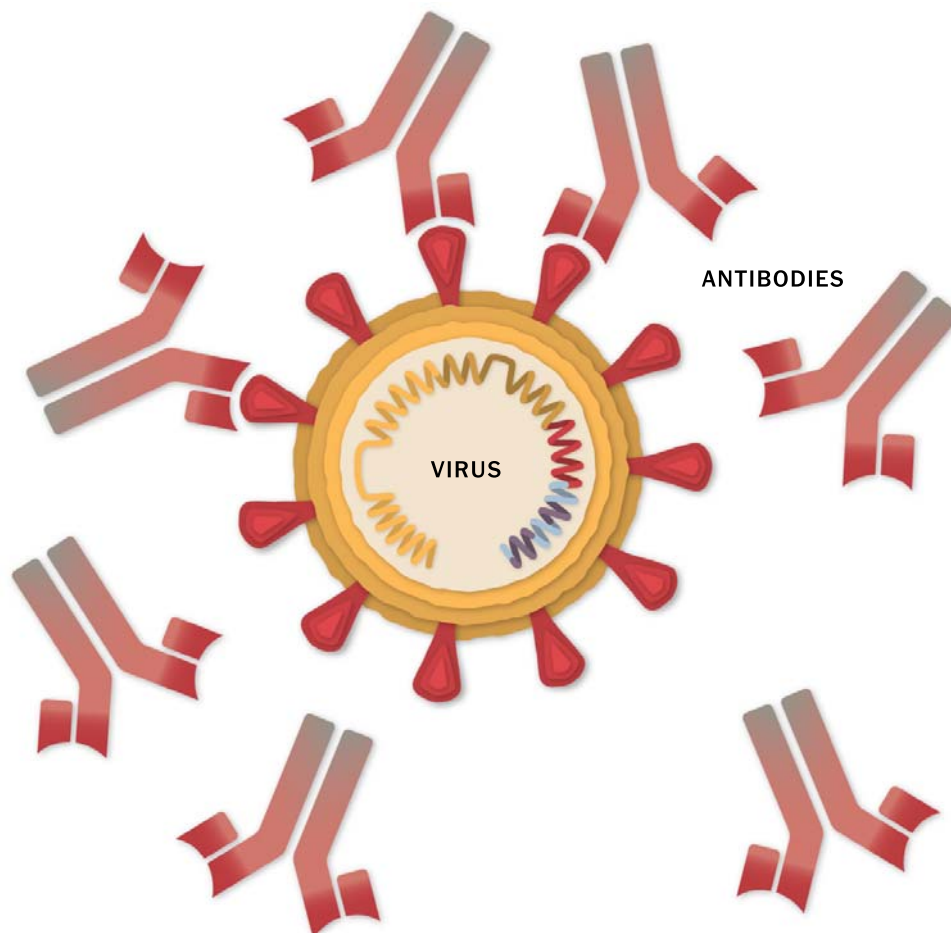
Other immune cells, called B cells, may bump into the coronavirus spikes on the surface of vaccinated cells, or free-floating spike protein fragments. A few of the B cells may be able to lock onto the spike proteins. If these B cells are then activated by helper T cells, they will start to proliferate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





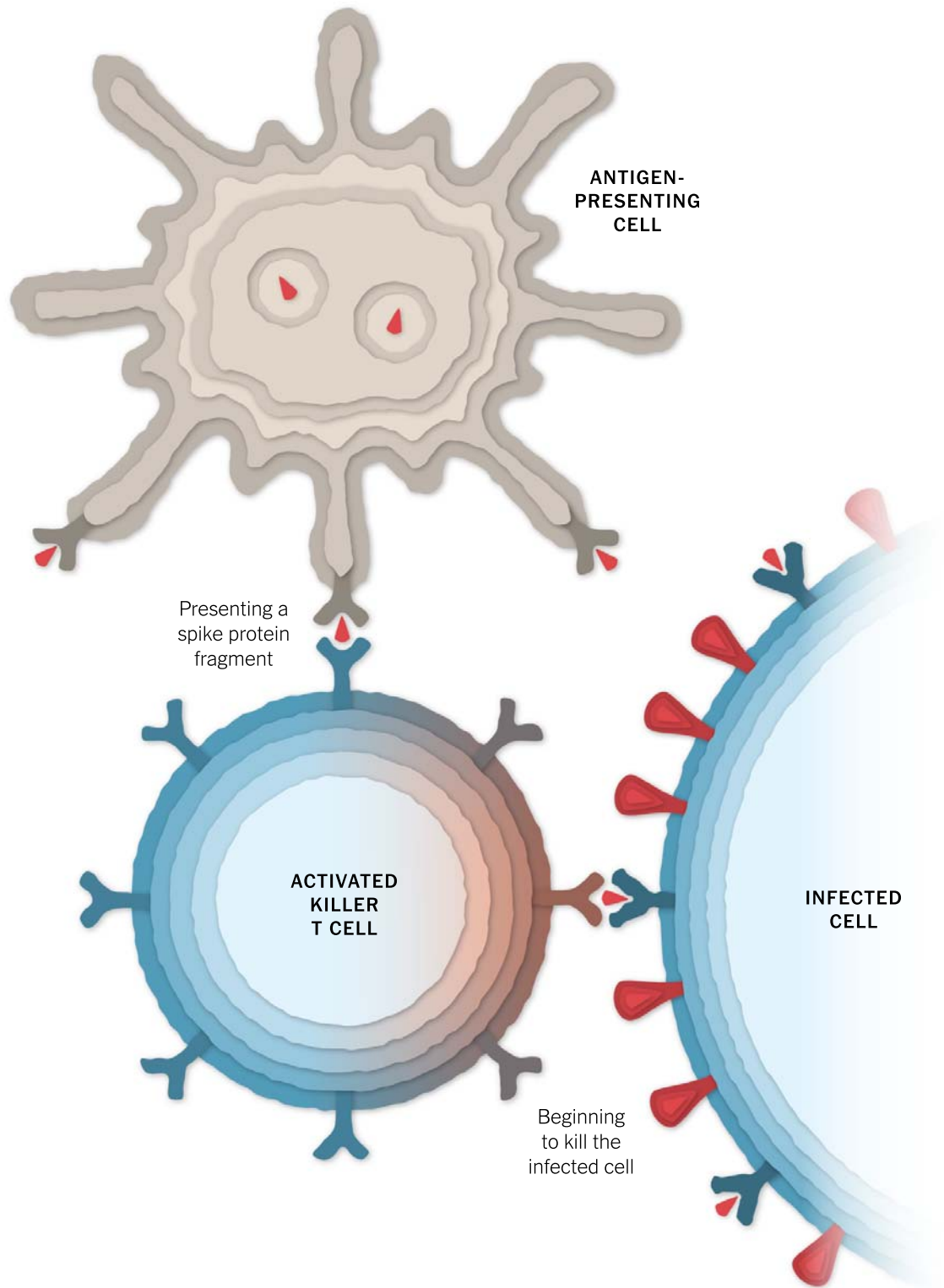
Stopping the Virus

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



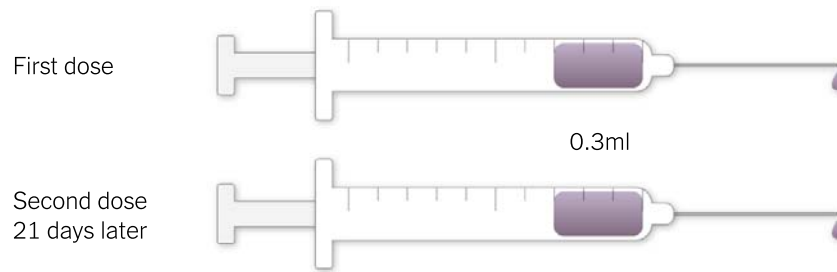
Killing Infected Cells

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.

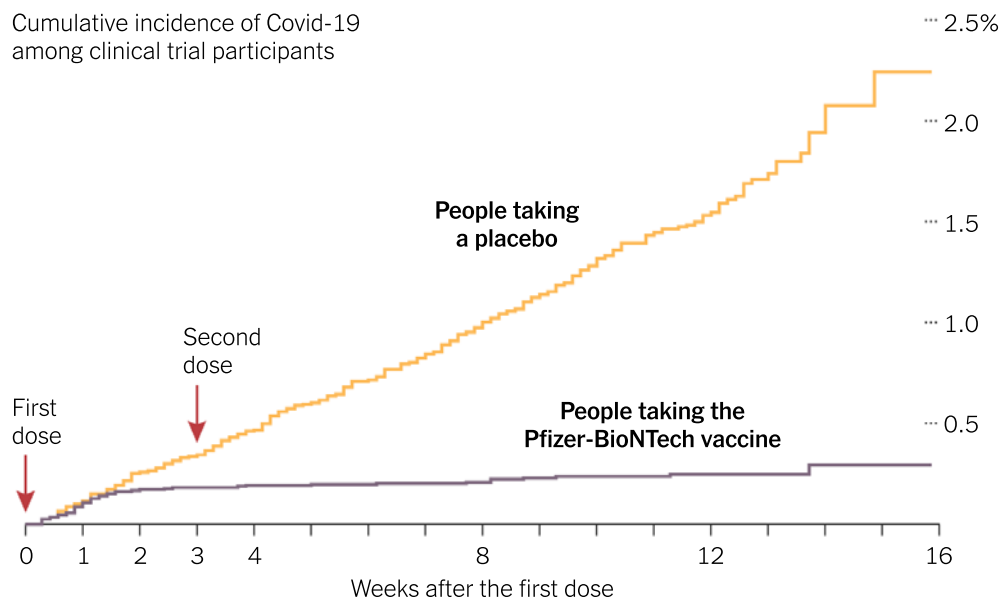


Remembering the Virus

The Pfizer-BioNTech vaccine requires two injections, given 21 days apart, to prime the immune system well enough to fight off the coronavirus. But because the vaccine is so new, researchers don't know how long its protection might last.



A preliminary study found that the vaccine seems to offer strong protection about 10 days after the first dose, compared with people taking a placebo:



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.

For more about the vaccine, see Pfizer's Covid Vaccine: 11 Things You Need to Know.

Preparation and Injection

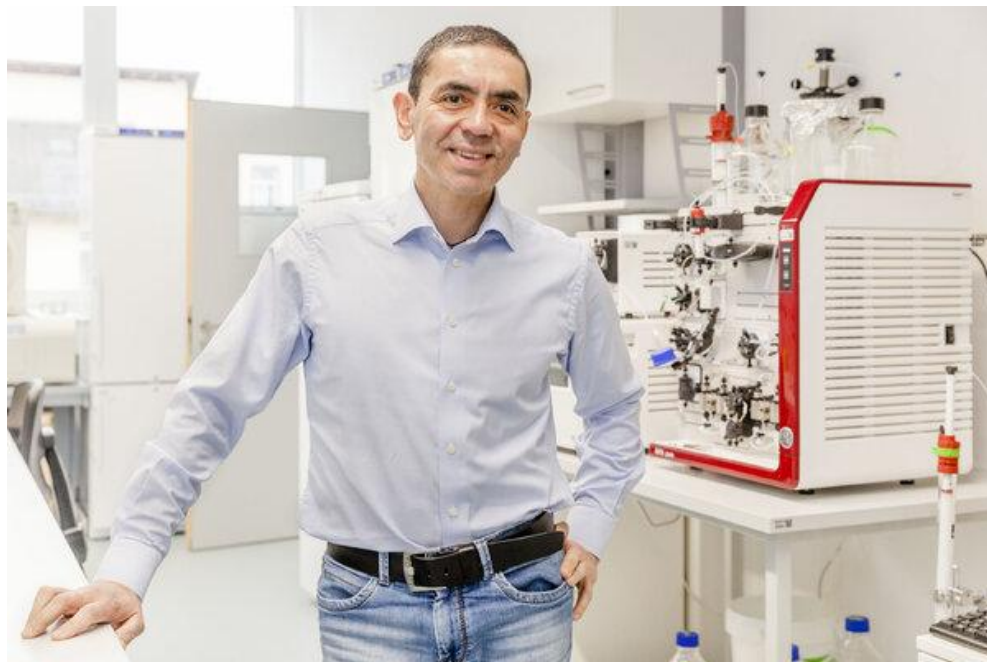
Each vial of the vaccine contains 5 doses of 0.3 milliliters. The vaccine must be thawed before injection and diluted with saline. After dilution the vial must be used within six hours.



A diluted vial of the vaccine at Royal Free Hospital in London. Jack Hill/Agence France-Presse

Vaccine Timeline

January, 2020 BioNTech begins work on a vaccine after Dr. Ugur Sahin, one of the company's founders, becomes convinced that the coronavirus will spread from China into a pandemic.



Dr. Ugur Sahin of BioNTech. BioNTech

March BioNTech and Pfizer agree to collaborate.

May The companies launch a Phase 1/2 trial on two versions of a mRNA vaccine. One version, known as BNT162b2, had fewer side effects.

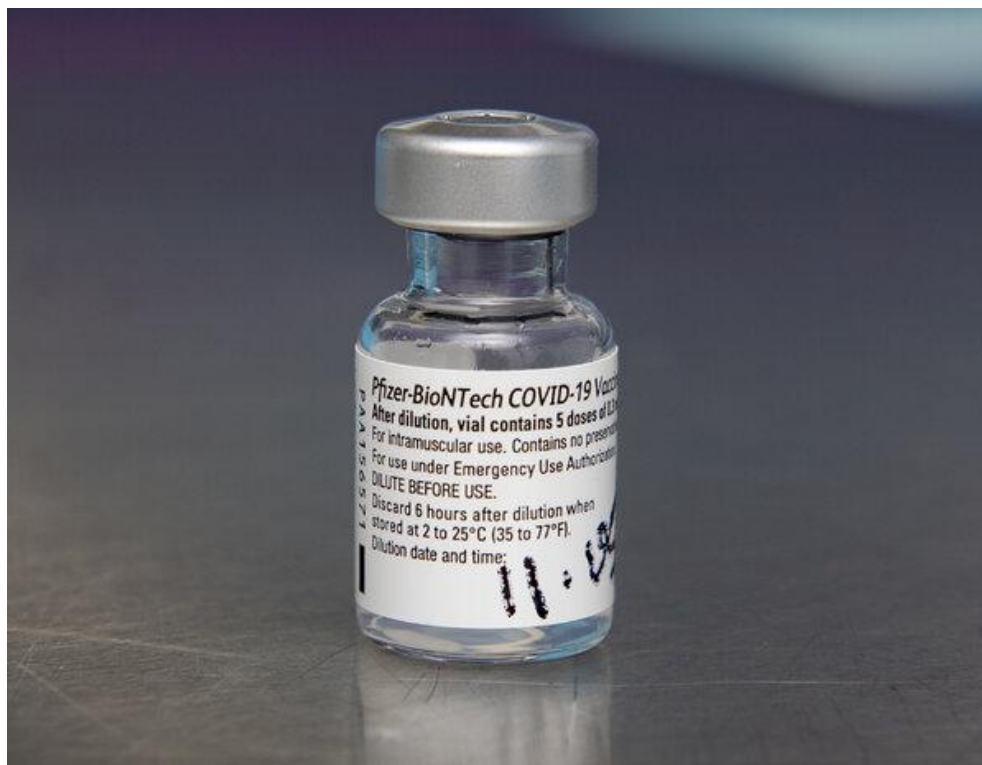


The first trial participant being vaccinated in Germany. BioNTech

July 22 The Trump administration awards a \$1.9 billion contract for 100 million doses to be delivered by December, with an option to acquire 500 million more doses, if the vaccine is authorized by the Food and Drug Administration.

July 27 The companies launch a Phase 2/3 trial with 30,000 volunteers in the United States and other countries, including Argentina, Brazil and Germany.

Sept. 12 Pfizer and BioNTech announce they will seek to expand their U.S. trial to 44,000 participants.



A vial of the Pfizer-BioNTech vaccine. Pool photo by Andy Stenning

Nov. 9 Preliminary data indicates the Pfizer vaccine is over 90 percent effective, with no serious side effects. The final data from the trial shows the efficacy rate is 95 percent.

Nov. 20 Pfizer requests an emergency use authorization from the F.D.A.

Dec. 2 Britain gives emergency authorization to Pfizer and BioNTech's vaccine, becoming the first Western country to give such an approval to a coronavirus vaccine.

Dec. 8 William Shakespeare, age 81, is among the first people to receive a shot of the vaccine in Britain, on the first day of vaccinations for at-risk health care workers and people over 80.

Dec. 9 Canada authorizes the Pfizer-BioNTech vaccine.

Dec. 10 Saudi Arabia approves the vaccine.

Dec. 11 The F.D.A. grants Pfizer-BioNTech vaccine the first emergency use authorization for a coronavirus vaccine in the United States. Mexico also approves the vaccine for emergency use.

Dec. 14 Vaccination begins in the United States.

Dec. 21 The European Union authorizes the vaccine.

Dec. 31 Pfizer expects to produce up to 50 million doses by the end of the year, and up to 1.3 billion doses in 2021. Each vaccinated person will require two doses.

Spring 2021 Vaccines by Pfizer and Moderna are expected to reach large-scale distribution in the spring.

Sources: National Center for Biotechnology Information; Nature; Florian Krammer, Icahn School of Medicine at Mount Sinai.

Tracking the Coronavirus

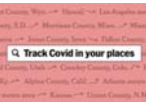
United States



Latest Maps and Data
Cases and deaths for every county



Vaccine Distribution
Where shots have been given



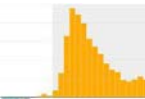
Your Places
Build your own dashboard to track cases



Hospitals Near You
Patients hospitalized and I.C.U. beds remaining



Restrictions
What is open and closed in each state



Deaths Above Normal
The true toll of the pandemic in the U.S.



Cities and Metro Areas
Where it is getting better and worse



Nursing Homes
The hardest-hit states and facilities

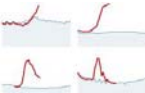


Colleges and Universities
Cases at more than 1,700 schools

World

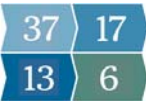


Latest Maps and Data
Cases and deaths for every country

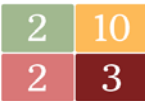


Deaths Above Normal
The true toll of coronavirus around the world

Health



Vaccines
Track their development



Treatments
Rated by effectiveness and safety

Countries

Brazil	India	U.K.
Canada	Italy	United States
France	Mexico	
Germany	Spain	

States, Territories and Cities

Alabama	Alaska	Arizona
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Arkansas	Massachusetts	Oregon
California	Michigan	Pennsylvania
Colorado	Minnesota	Puerto Rico
Connecticut	Mississippi	Rhode Island
Delaware	Missouri	South Carolina
Florida	Montana	South Dakota
Georgia	Nebraska	Tennessee
Hawaii	Nevada	Texas
Idaho	New Hampshire	Utah
Illinois	New Jersey	Vermont
Indiana	New Mexico	Virginia
Iowa	New York	Washington
Kansas	New York City	Washington, D.C.
Kentucky	North Carolina	West Virginia
Louisiana	North Dakota	Wisconsin
Maine	Ohio	Wyoming
Maryland	Oklahoma	

Data

[Frequently Asked Questions About the Covid Data](#)

[Access the Open Source Covid Data](#)