

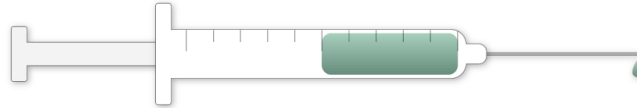
U.S.A.

World

Health

# How Moderna's Vaccine Works

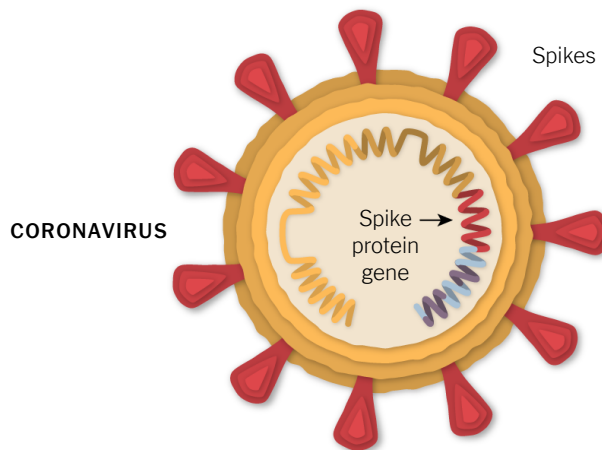
By [Jonathan Corum](#) and [Carl Zimmer](#) Updated Jan. 21, 2021



Moderna, a Massachusetts-based vaccine developer, partnered with the National Institutes of Health to develop and test a coronavirus vaccine known as **mRNA-1273**. A clinical trial demonstrated that the vaccine has an efficacy rate of 94.1 percent in preventing Covid-19.

## A Piece of the Coronavirus

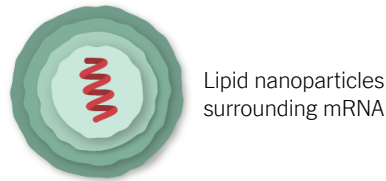
The SARS-CoV-2 virus is studded with proteins that it uses to enter human cells. These so-called spike proteins make a tempting target for potential vaccines and treatments.



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

## mRNA Inside an Oily Shell

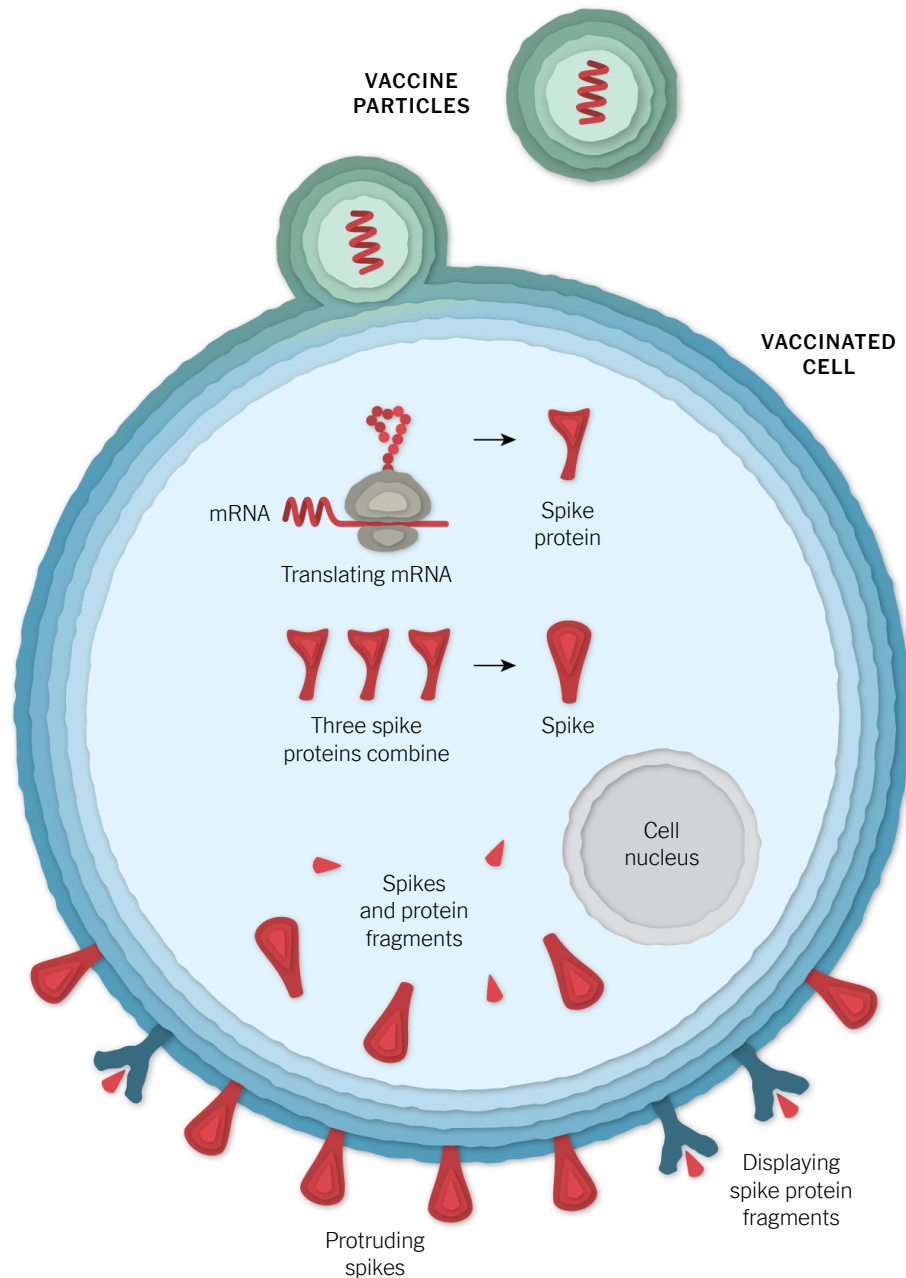
The vaccine uses messenger RNA, genetic material that our cells read to make proteins. The molecule — called mRNA for short — is fragile and would be chopped to pieces by our natural enzymes if it were injected directly into the body. To protect the vaccine, Moderna wraps the mRNA in oily bubbles made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



Because of their fragility, the mRNA molecules will quickly fall apart at room temperature. Moderna's vaccine will need to be refrigerated, and should be stable for up to six months when shipped and stored at  $-4^{\circ}\text{F}$  ( $-20^{\circ}\text{C}$ ).

## 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.

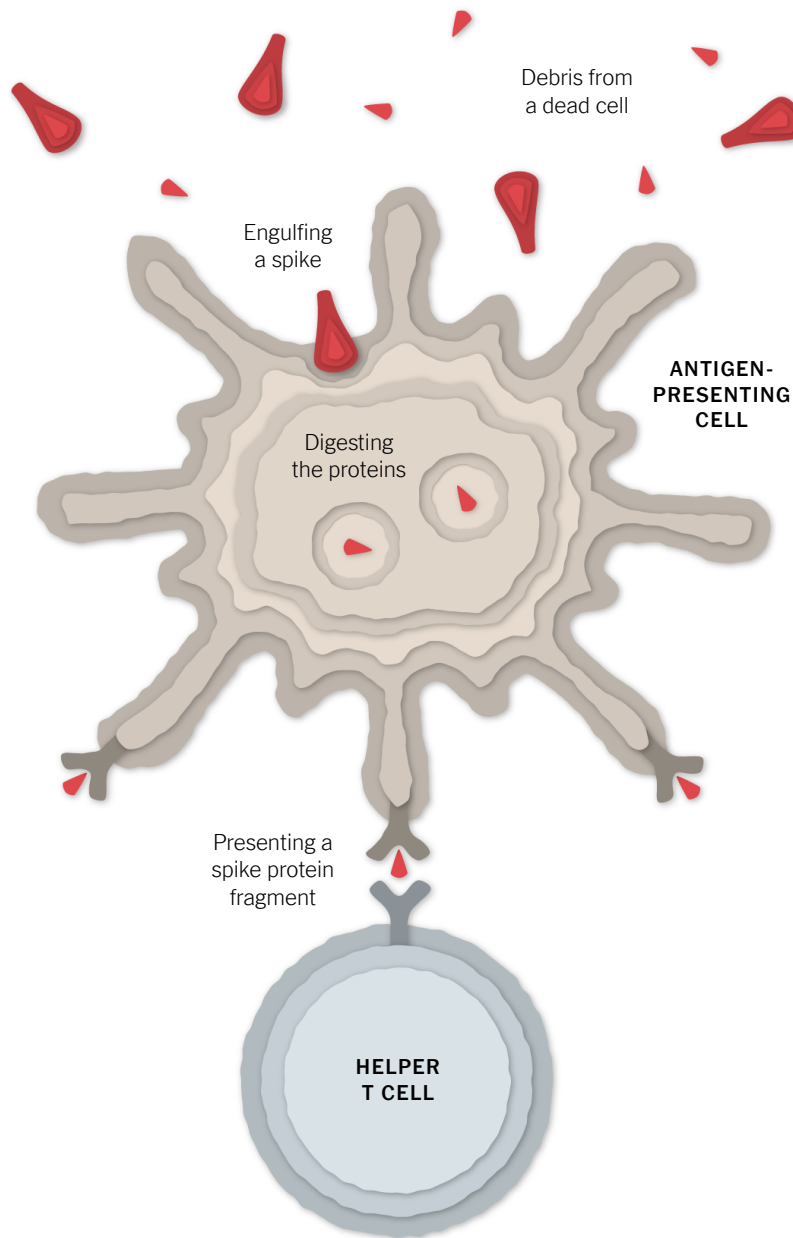


Some of the spike proteins form spikes that migrate to the surface of the cell and stick out their tips. The vaccinated cells also break up some of the proteins into fragments, which they present on their surface. These protruding spikes and spike protein fragments can then be recognized by the immune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

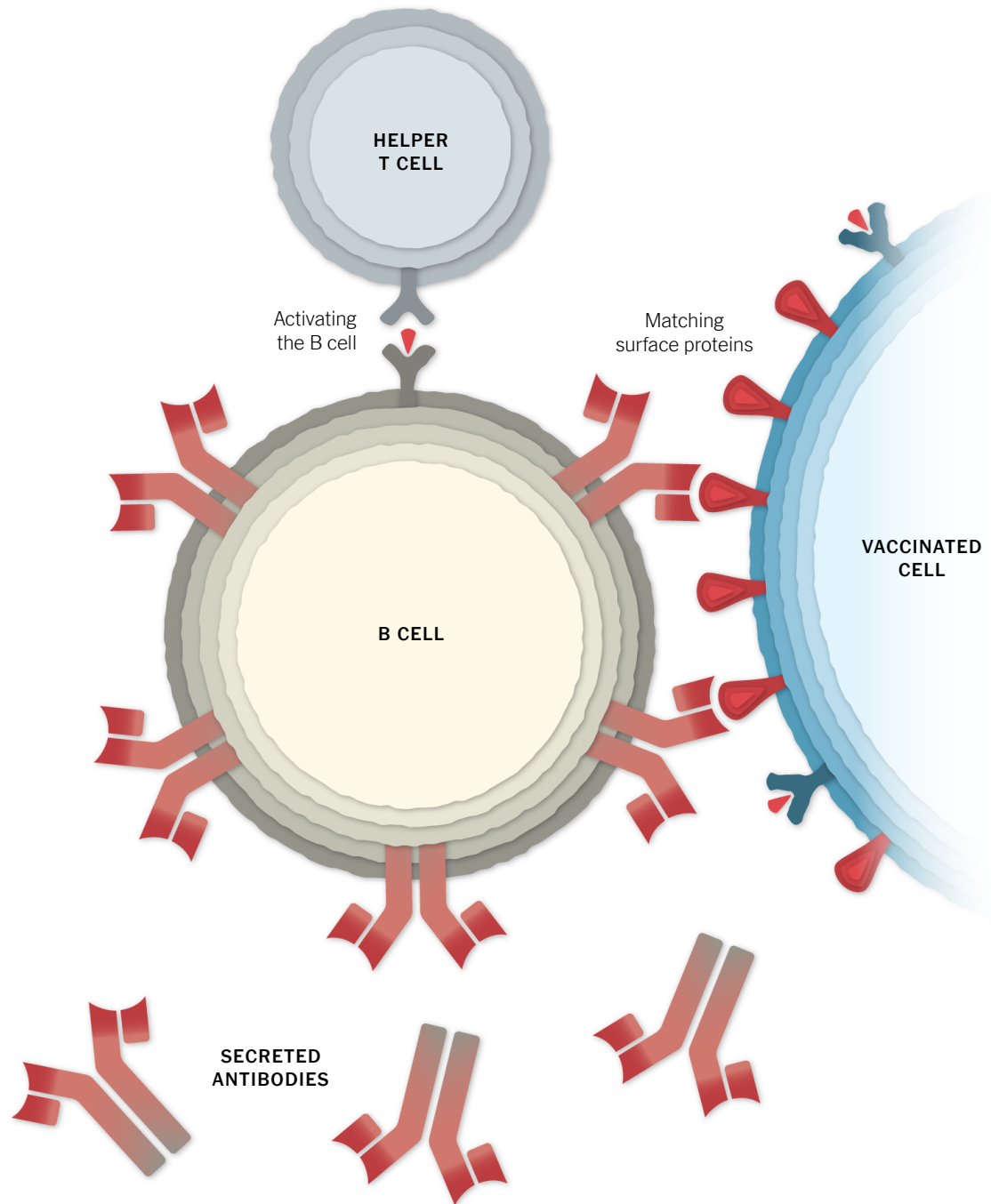


The cell presents fragments of the spike protein on its surface. When other cells called helper T cells detect these fragments, the helper T cells can raise the alarm and help marshal other immune cells to fight the infection.

## Making Antibodies

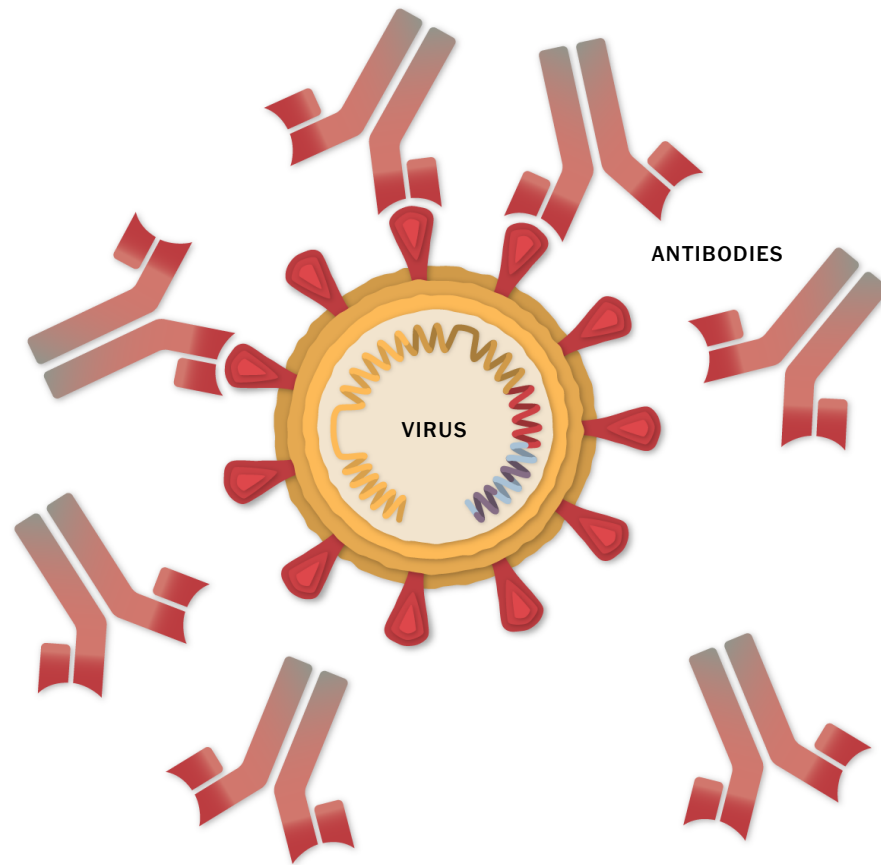
Other immune cells, called B cells, may bump into the coronavirus

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.



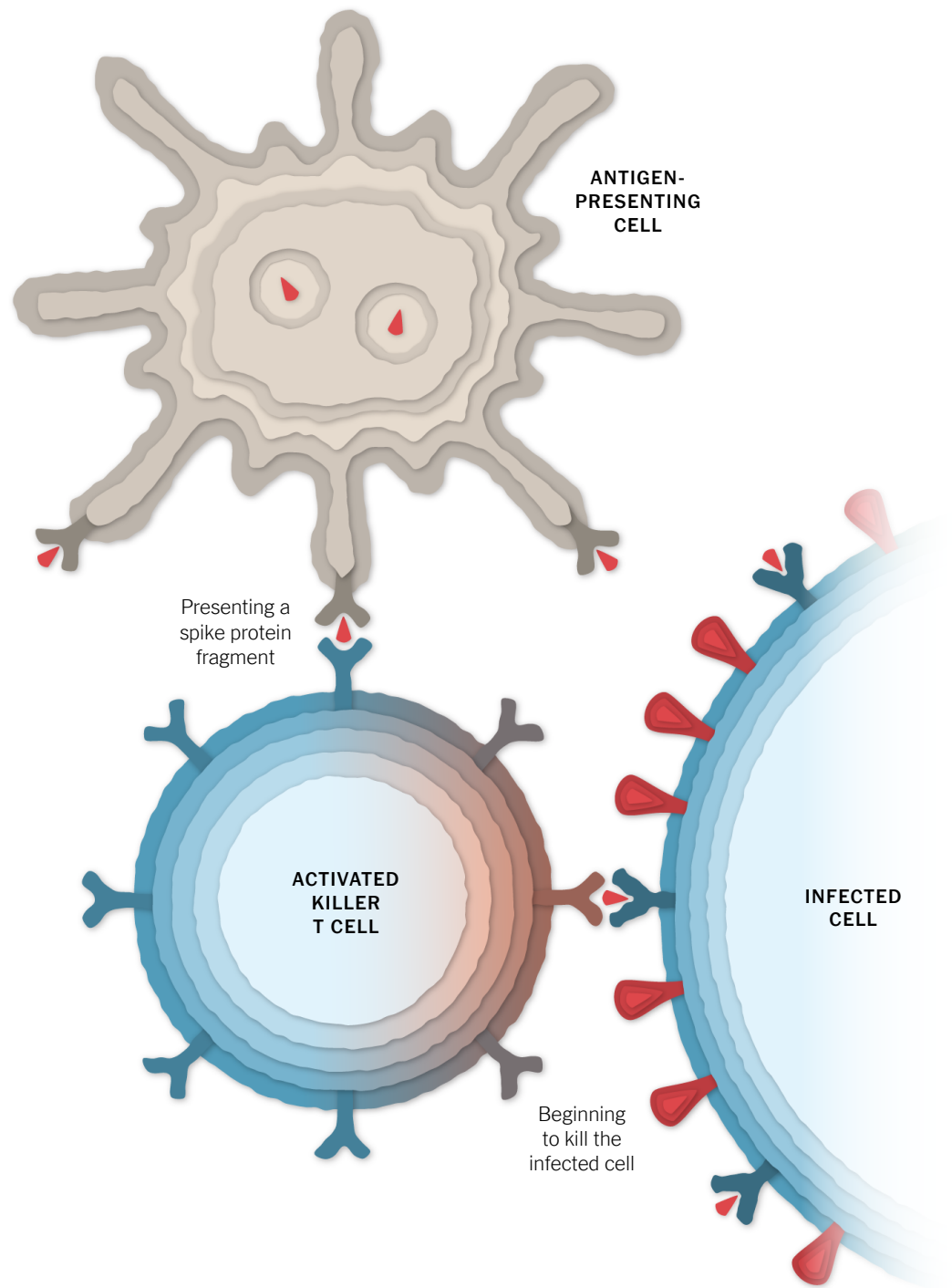
### Stopping the Virus

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



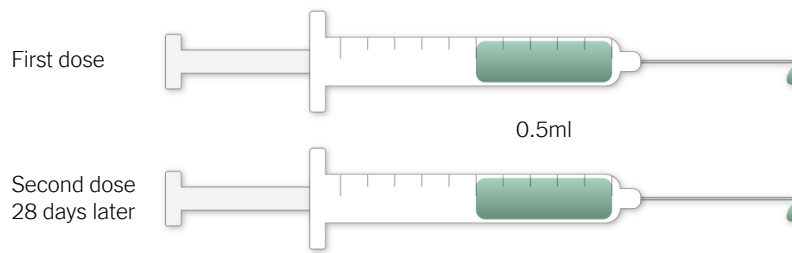
### **Killing Infected Cells**

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

Moderna's vaccine requires two injections, given 28 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.



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.

An early study found that Moderna's vaccine provides protection for at least three months.

For more about the vaccine, see [Moderna's Covid Vaccine: What You Need to Know](#).

## Preparation and Injection

Each vial of the vaccine contains 10 doses of 0.5 milliliters. The vials need to be warmed to room temperature before injection. No dilution with saline is required.



A nurse prepares a shot of the Moderna vaccine. Hans Pennink/Associated Press



## Vaccine Timeline

**January, 2020** Moderna begins work on a coronavirus vaccine.

**March 16** Moderna scientists are the first to put a Covid-19 vaccine into human trials.

**April 16** Moderna announces that the United States government will provide \$483 million in support for the design and testing of Moderna's vaccine. Researchers at the National Institutes of Health will oversee much of the research, including the clinical trials.

**July 27** After initial studies yield promising results, Moderna and the N.I.H. begin Phase 3 testing on 30,000 volunteers across the United States. A quarter of the participants are 65 years or older.

**July 28** Moderna finds that the vaccine protects monkeys from the coronavirus.

**Aug. 11** The United States government awards the company an additional \$1.5 billion in exchange for 100 million doses, if the vaccine is authorized by the Food and Drug Administration.

**Nov. 16** Moderna announces preliminary data from its Phase 3 trial. Researchers estimate that the vaccine has an efficacy rate of 94.1 percent, far higher than experts had expected when vaccine testing began.

**Nov. 30** Moderna applies for emergency use authorization from the F.D.A.

**Dec. 2** Moderna registers a trial to test the vaccine on children between 12 and 18 years of age.

**Dec. 18** The F.D.A. authorizes the Moderna vaccine for emergency use. The first injections of its vaccine could start on Dec. 21.

**Dec. 23** Canada authorizes the vaccine.

**Dec. 31** The company expects to produce 20 million doses by the end of this year, and up to a billion doses in 2021. Each vaccinated person will require two doses.

**Jan. 4** Israel authorizes the vaccine for emergency use.

**Spring 2021** Vaccines by Moderna and Pfizer-BioNTech 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

	<p><b>Latest Maps and Data</b> Cases and deaths for every county</p>		<p><b>Vaccinations</b> Where shots have been given</p>
	<p><b>Your Places</b> Build your own dashboard to track cases</p>		<p><b>Hospitals Near You</b> Patients hospitalized and I.C.U. beds remaining</p>
	<p><b>Restrictions</b> What is open and closed in each state</p>		<p><b>Deaths Above Normal</b> The true toll of the pandemic in the U.S.</p>
	<p><b>Cities and Metro Areas</b> Where it is getting better and worse</p>		<p><b>Nursing Homes</b> The hardest-hit states and facilities</p>
	<p><b>Colleges and Universities</b> Cases at more than 1,700 schools</p>		

### World

	<p><b>Latest Maps and Data</b> Cases and deaths for every country</p>		<p><b>Deaths Above Normal</b> The true toll of coronavirus around the world</p>
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### Health

	<p><b>Vaccines</b> Track their development</p>		<p><b>Treatments</b> Rated by effectiveness and safety</p>
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### Countries

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

### States, Territories and Cities

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

## Data

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

[Access the Open Source Covid Data](#)