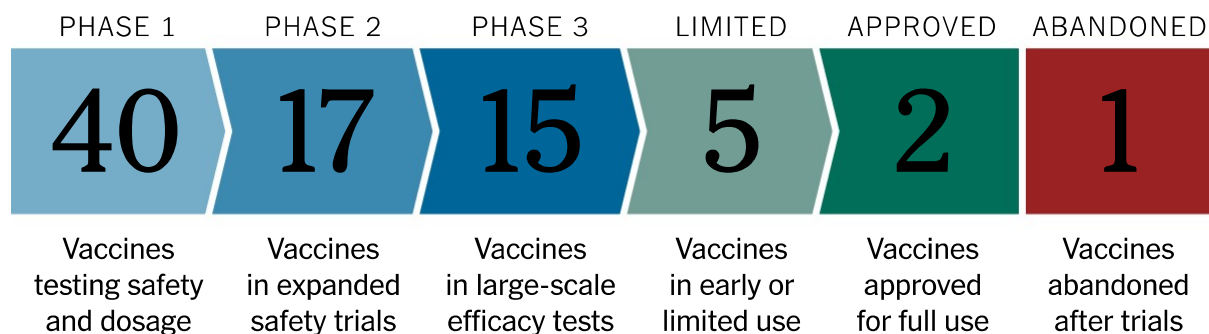


Coronavirus Vaccine Tracker

By Carl Zimmer, Jonathan Corum and Sui-Lee Wee Updated Dec. 13, 2020



Vaccines typically require years of research and testing before reaching the clinic, but in 2020, scientists embarked on a race to produce safe and effective coronavirus vaccines in record time. Researchers are currently testing **58 vaccines** in clinical trials on humans, and 15 have reached the final stages of testing. At least 85 preclinical vaccines are under active investigation in animals.

New additions and recent updates

- Dec. 12 **Genova Biopharmaceuticals** and **HDT Bio** enter Phase 1/2.
- Dec. 11 The F.D.A. authorizes the **Pfizer-BioNTech** vaccine for emergency use.
- Dec. 11 **AstraZeneca** joins forces with Russia's **Gamaleya Institute**.
- Dec. 11 The **Chinese Academy of Medical Sciences** moves to Phase 3.
- Dec. 11 **Sanofi** and **GSK** announce disappointing trial results in older adults.
- Dec. 10 A vaccine from Australia's **University of Queensland** is abandoned.

Leading vaccines

Developer	Type	Phase	Status
Pfizer-BioNTech	mRNA	2 3	Approved in Canada and other countries. Emergency use in U.S. and other countries.
Moderna	mRNA	3	Under F.D.A. review.

CanSino	Adenovirus	3	Limited use in China.
Gamaleya	Adenovirus	3	Early use in Russia.
Johnson & Johnson	Adenovirus	3	
Oxford-AstraZeneca	Adenovirus	2 3	
Novavax	Protein	3	
Vector Institute	Protein	1 2	Early use in Russia.
Sinopharm-Beijing	Inactivated	3	Approved in U.A.E.
Sinopharm-Wuhan	Inactivated	3	Limited use in U.A.E.
Sinovac	Inactivated	3	Limited use in China.

Below is a list of all vaccines that have reached trials in humans, along with a selection of promising vaccines being tested in animals. For an overview of treatments for Covid-19, see our [Coronavirus Drug and Treatment Tracker](#).

The Vaccine Testing Process

The development cycle of a vaccine, from lab to clinic.

PRECLINICAL TESTING : Scientists test a new vaccine on cells and then give it to **animals** such as mice or monkeys to see if it produces an immune response.

PHASE 1 SAFETY TRIALS : Scientists give the vaccine to a **small number of**

people to test safety and dosage, as well as to confirm that it stimulates the immune system.

PHASE 2 EXPANDED TRIALS : Scientists give the vaccine to **hundreds of people** split into groups, such as children and the elderly, to see if the vaccine acts differently in them. These trials further test the vaccine's safety.

PHASE 3 EFFICACY TRIALS : Scientists give the vaccine to **thousands of people** and wait to see how many become infected, compared with volunteers who received a placebo. These trials can determine if the vaccine protects against the coronavirus, measuring what's known as the efficacy rate. Phase 3 trials are also large enough to reveal evidence of relatively rare side effects.

EARLY OR LIMITED APPROVAL : Britain and other countries have begun giving emergency authorization to vaccines based on preliminary evidence that they are safe and effective. China and Russia, on the other hand, have authorized vaccines without waiting for the results of Phase 3 trials, which experts say has serious risks.

APPROVAL : Regulators review the complete trial results and plans for a vaccine's manufacturing, and decide whether to give it full approval.

COMBINED PHASES : One way to accelerate vaccine development is to combine phases. Some vaccines are now in Phase 1/2 trials, for example, which this tracker would count as both Phase 1 and Phase 2.

PAUSED or **ABANDONED** : If investigators observe worrying symptoms in volunteers, they can pause the trial. After an investigation, the trial may resume or be abandoned.

Filter the list of vaccines:

All vaccines

Preclinical

Phase 1

2

3

Approved

Abandoned

Genetic Vaccines

Vaccines that deliver one or more of the coronavirus's own genes into our cells to provoke an immune response.

RNA

DNA

PHASE 2 PHASE 3 COMBINED PHASES

APPROVED IN SEVERAL COUNTRIES EMERGENCY USE IN U.S., ELSEWHERE



VACCINE NAME: BNT162b2

EFFICACY: 95%

DOSE: 2 doses, 3 weeks apart

TYPE: Muscle injection

STORAGE: Freezer storage only at -94°F (-70°C)

On Nov. 9, New York-based **Pfizer** and the German company **BioNTech** made history by presenting preliminary data indicating that their coronavirus vaccine was over 90 percent effective. It was the first time anyone had found such evidence. Just over a month later, on Dec. 11, the Food and Drug Administration granted it the first emergency use authorization ever given by the United States to a coronavirus vaccine.

BioNTech researchers began designing the vaccine in January. They based it on a genetic molecule called messenger RNA (mRNA). The vaccine contains genetic instructions for building a coronavirus protein, known as spike. When injected into cells, the vaccine causes them to make spike proteins, which then get released into the body

and provoke a response from the immune system.

BioNTech partnered with Pfizer in March to scale up the research, launching a clinical trial in May. They found that the vaccine caused volunteers to produce antibodies against SARS-CoV-2, as well as immune cells called T cells that respond to the virus. On July 27, the companies announced the launch of a Phase 2/3 trial with 30,000 volunteers in the United States and other countries including Argentina, Brazil, and Germany. On Sept. 12, Pfizer and BioNTech announced that they would seek to expand their U.S. trial to 44,000 participants.

Through the summer and into the fall, the world focused more and more of its attention on the Pfizer-BioNTech trial. In September, Dr. Albert Bourla, the chief executive of Pfizer, said the Phase 3 trial would deliver enough results as soon as October to show if the vaccine worked or not. President Trump touted their progress, hinting that a vaccine would be available before the election. But on Oct. 27, Dr. Bourla announced that the volunteers in the trial had yet to experience enough cases of Covid-19 to determine if the vaccines work. Finally, on Nov. 8, Pfizer and BioNTech released preliminary analysis of the first 94 cases.

Over the next month, Pfizer and BioNTech released more data on more cases. On Dec. 8 the FDA released their independent analysis of the clinical trials. They determined that the vaccine has an efficacy rate of 95 percent. Less than two weeks after the first dose, the vaccine started protecting volunteers, and the second dose three weeks later boosted their immune response. The vaccine showed little difference in its protection of Black, Latino, and white volunteers; likewise, people with conditions such as obesity or diabetes enjoyed the same level of protection. The elderly also showed the same efficacy rate as people under 65. While the vaccine caused no serious side effects, it frequently caused short-lived fatigue, fever, and muscle aches.

These impressive results led rapidly to authorizations across the world. On Dec. 2, the United Kingdom gave emergency authorization

to Pfizer and BioNTech's vaccine, becoming the first Western country to give such an approval to a coronavirus vaccine. Injections began on Dec. 8, with William Shakespeare, age 81, among the first to receive a dose. On Dec. 13, workers at a Pfizer plant in Kalamazoo, Mich., loaded the vaccines onto trucks for the first deliveries across the United States. The first vaccinations were planned for the next day. Pfizer and BioNTech will deliver an initial shipment of 2.9 million doses to the United States in the first week after the vaccine's authorization.

A growing number of other countries across the world have also given emergency authorization for the Pfizer-BioNTech vaccine, including Kuwait and Mexico. Meanwhile, Bahrain, Canada, and Saudi Arabia gave the vaccine full approval.

The distribution of the vaccine worldwide will be determined in part by deals that the companies made starting in the summer with countries around the world. The Trump administration awarded a \$1.9 billion contract in July for 100 million doses. The New York Times reported in December that the administration passed up the chance to secure another 100 million doses. It will be difficult for the United States to obtain more of the vaccine quickly, because other countries have made deals for the next few month's production. Japan made a deal for 120 million doses, for example, while the European Union arranged to purchase 200 million doses.

Pfizer and BioNTech expect to manufacture over 1.3 billion doses worldwide by the end of 2021.

For more details, see **[How the Pfizer-BioNTech Vaccine Works.](#)**

Updated Dec. 13

PHASE 3

moderna



National Institutes of Health
Turning Discovery Into Health

VACCINE NAME: mRNA-1273

EFFICACY: 94.5%

DOSE: 2 doses, 4 weeks apart

TYPE: Muscle injection

STORAGE: 30 days with refrigeration, 6 months at -4°F (-20°C)

On Nov. 30, the Boston-based company **Moderna** announced it was applying to the Food and Drug Administration for an emergency use authorization, less than a year after it launched the first clinical trial for a coronavirus vaccine. It is the second application, coming just two weeks after Pfizer and BioNTech. If Moderna receives the authorization, the first injections of its vaccine could start on Dec. 21.

Like Pfizer and BioNTech, Moderna makes its vaccine from mRNA. In recent years, the company has tested mRNA vaccines for a number of diseases, but they have yet to bring one to market. In January, they began developing a vaccine for the coronavirus.

The United States government bankrolled Moderna's efforts, providing nearly \$1 billion in support. In partnership with **National Institutes of Health**, they found that the vaccine protects monkeys from the coronavirus. In March, the scientists were the first to put a Covid-19 vaccine into human trials. After those studies yielded promising results, Phase 3 testing on 30,000 volunteers began on July 27.

On Nov. 16, Moderna announced the first preliminary data from the trial, followed by the complete data on Nov. 30. Out of 196 cases of Covid-19 among trial volunteers, 185 were in people who received the placebo. And of the 11 vaccinated volunteers who got Covid-19, none suffered from severe disease. The researchers estimated that the vaccine had an efficacy rate of 94.1 percent, far higher than experts had expected when vaccine testing began. While it's not clear how long this efficacy will last, Moderna has found that after three months the trial participants still have a strong immune defense against the coronavirus. On Dec. 2, Moderna registered a trial to test the vaccine on adolescents between 12 and 18 years of age.

On the business side, Moderna lost a patent dispute in July over some of their vaccine technology. The following month, the company stated that it could not be certain it was the first to make the inventions claimed in their patents, including its coronavirus vaccine. Meanwhile, the company has entered deals with several countries to supply the vaccine if it's approved. On Aug. 11, the United States government awarded the company an additional \$1.5 billion in exchange for 100 million doses if the vaccine proves safe and effective, following up in December with a deal for another 100 million doses in the second quarter of 2021. On Nov. 25, the company reached an agreement with the European Commission to supply up to 160 million doses. Moderna has made similar deals with other countries including Canada, Japan and Qatar.

For more details, see **How Moderna's Vaccine Works**.

Updated Dec. 12

PHASE 2 PHASE 3 COMBINED PHASES



大阪大学
OSAKA UNIVERSITY



VACCINE NAME: AG0302-COVID19

EFFICACY: **Unknown**

DOSE: **2 doses, 2 weeks apart**

TYPE: **Skin injection**

STORAGE: **Over a year at room temperature**

On June 30, the Japanese biotechnology company **AnGes** launched a Phase 1 trial to test a DNA-based vaccine, developed in partnership with **Osaka University** and **Takara Bio**. The company moved on to a Phase 2/3 trial in December.

Updated Dec. 8

PHASE 2



In July, the Indian vaccine-maker **Zydus Cadila** began testing a DNA-based vaccine delivered by a skin patch. They launched a Phase 2 trial on Aug. 6 and are planning a Phase 3 trial to begin in December. In a Dec. 11 interview, company's chairman Pankaj Patel, the company's chairman, said the company expects to have their vaccine ready for distribution by March 2021.

Updated Dec. 12

PHASE 2



VACCINE NAME: **INO-4800**

EFFICACY: **Unknown**

DOSE: **To be determined**

TYPE: **Skin injection**

STORAGE: **Over a year at room temperature**

The American company **Inovio** has developed DNA-based vaccines which are delivered into the skin with electric pulses from a hand-held device. They have vaccines in clinical trials for a number of diseases, and in June they announced interim data from a Phase 1 trial on Covid-19. They found no serious adverse effects, and measured an immune response in 34 out of 36 volunteers. Inovio has yet to publish detailed results of these studies, however, and it is embroiled in several lawsuits with stockholders and a company partner. On Sept. 28, the F.D.A. put the vaccine on a partial hold due to questions about the delivery device. On Nov. 16, Inovio said that the F.D.A. had given them permission to move forward with their Phase 2/3 trial. They are also running a Phase 2 trial in China.

Updated Dec. 10

PHASE 2

VACCINE NAME: CVnCoV

EFFICACY: **Unknown**

DOSE: **2 doses, four weeks apart**

TYPE: **Muscle injection**

STORAGE: **Stable at least 3 months at 36–46°F (2–8°C)**

In March, the Trump administration unsuccessfully tried to entice **CureVac** to move its research on a mRNA vaccine from Germany to the United States. The company moved ahead with its work in Germany and found promising responses in mice. In July, they launched a Phase 1 clinical trial, in which they saw an encouraging response in the immune systems of volunteers. In September, the company started a Phase 2 study. They expect to follow that with a Phase 3 trial in December, which should yield preliminary data in the first quarter of 2021.

In November, CureVac negotiated a deal to provide the European Union with up to 225 million doses of their vaccine. They project manufacturing up to 300 million doses in 2021 and up to 600 million doses the following year. CureVac has collaborated with Elon Musk's company Tesla on creating mRNA "micro-factories," which could potentially be deployed around the world to make billions of doses of the vaccine. On Nov. 12, the company announced that its vaccine could be kept in a refrigerator at 41 degrees. Other RNA vaccines made by Pfizer and Moderna have to be kept frozen at chillier temperatures.

Updated Nov. 30

PHASE 1 **PHASE 2** **COMBINED PHASES**

**Imperial College
London**

MORNINGSIDE

Imperial College London researchers have developed a “self-amplifying” RNA vaccine, which boosts production of a viral protein to stimulate the immune system. They began Phase 1/2 trials on June 15 and have partnered with **Morningside Ventures** to manufacture and distribute the vaccine through a new company called VacEquity Global Health. The researchers expect to know if the vaccine is effective by the end of the year.

PHASE 1 PHASE 2 COMBINED PHASES



The California-based company **Arcturus Therapeutics** and **Duke-NUS Medical School** in Singapore have developed an mRNA vaccine. It has a “self-replicating” design that leads to a greater production of viral proteins. Tests on animals showed that it protected them against infection. In August, Arcturus launched a Phase 1/2 trial at Singapore General Hospital. On Nov. 9, the company announced that an interim analysis of the trial showed that the vaccine produced an immune response that’s in the range of responses seen in people who recovered from Covid-19. Singapore reached an agreement with Arcturus to spend up to \$175 million to acquire vaccines when they’re ready.

Updated Nov. 12

PHASE 1



The Korean company **Genexine** started testing the safety of a DNA-based vaccine in June. They anticipate moving to Phase 2 trials in the fall.

Updated June 24

PHASE 1



ABOGEN

WALVAX 沃森生物
WALVAX BIOTECHNOLOGY CO., LTD.

In June, Chinese researchers at the **Academy of Military Medical Sciences**, **Suzhou Abogen Biosciences** and **Walvax Biotechnology** announced they would start their country's first safety trials on a mRNA-based vaccine, called ARCoV. Earlier studies on monkeys reportedly showed protective effects.

Updated June 26

PHASE 1

Chula
Chulalongkorn University

Chula VRC

Chula Vaccine Research Center

ศูนย์เชี่ยวชาญเฉพาะทางกาวิจัยและพัฒนาวัคซีน จุฬาลงกรณ์มหาวิทยาลัย

Researchers at Thailand's **Chulalongkorn University** have been developing several potential vaccines for the coronavirus. The furthest along is an mRNA-based vaccine known as ChulaCov19. On Sept. 29, the **Chula Vaccine Research Center** registered a Phase 1 trial to test it in humans. In an interview with the Bangkok Post, the leader of the project said that up to 30 million doses might be produced for Thailand and six other Asian countries if the vaccine proved to be safe and effective.

Updated Sept. 30

PHASE 1

entos 

The Canadian company **Entos Pharmaceuticals** has created a DNA vaccine for the coronavirus. Most other genetic vaccines carry the gene for the spike protein on the surface of the virus. Entos instead chose the gene for nucleocapsid, a protein that sits inside the virus's membrane. They are betting it can offer long-lasting immunity. In October, Entos launched a Phase 1 trial in Canada for their vaccine,

called Covigenix VAX-001.

Updated Oct. 20

PHASE 1



On Nov. 2, the Canadian company **Symvivo** announced they had administered a DNA vaccine to their first volunteer in a Phase 1 trial. The DNA is inserted into harmless bacteria, which volunteers swallow in a frozen liquid (the company is working on putting the bacteria into a pill). When the bacteria reach the intestines, the DNA slips into cells in the gut lining, which then make viral proteins.

Updated Nov. 3

PHASE 1



New Jersey-based **OncoSec Immunotherapies** has developed experimental cancer treatments that deliver genes into tumors. There, the injected genes produce a natural signalling molecule called IL-12, which attracts the attention of immune cells that attack the cancer. In the spring, OncoSec began adapting their technology to make a vaccine for the coronavirus. The vaccine, called CORVax12, consists of a loop of DNA that encodes both the spike protein and IL-12. Causing the body to make extra IL-12 could potentially enhance the immune system's ability to make antibodies to the spike protein. On Nov. 13, the company registered a Phase 1 trial to test the safety of the CORVax12.

Updated Nov. 13

PHASE 1 PHASE 2 COMBINED PHASES



Gennova Biopharmaceuticals in India and Seattle-based **HDT Bio** partnered to develop a vaccine based on self-amplifying RNA. The vaccine, known as HGC019, was able to safely provoke animals to make antibodies to the coronavirus, leading India to grant the companies approval in December to start Phase 1/2 trials.

Updated Dec. 12

PRECLINICAL



The French pharmaceutical company **Sanofi** is developing an mRNA vaccine in partnership with **Translate Bio**. They have found that it produces a strong antibody response in mice and monkeys and are planning on starting Phase 1 trials by December. It would become Sanofi's second Covid-19 vaccine candidate in clinical trials, along with their protein-based vaccine.

Updated Oct. 15

PRECLINICAL

Other genetic vaccines in active preclinical development include vaccines from: Applied DNA Sciences, EvviVax and Takis Biotech; DIOSynVax; Elixirgen Therapeutics; ETheRNA; Infectious Disease Research Institute and Amyris; Mediphage Bioceuticals; the OPENCORONA Consortia; Scancell; the Spanish National Center for Biotechnology and the Spanish National Research Council.

Updated Sept. 30

Viral Vector Vaccines

Vaccines that contain viruses engineered to carry coronavirus genes. Some viral vector vaccines enter cells and cause them to make viral proteins. Other viral vectors slowly replicate, carrying coronavirus proteins on their surface.

PHASE 3 LIMITED USE IN CHINA



VACCINE NAME: **Ad5-nCoV**

EFFICACY: **Unknown**

DOSE: **Single dose**

TYPE: **Muscle injection**

STORAGE: **Refrigerated**

The Chinese company **CanSino Biologics** developed a vaccine based on an adenovirus called Ad5, in partnership with the Institute of Biology at the country's **Academy of Military Medical Sciences**. In May, they published promising results from a Phase 1 safety trial, and in July they reported that their Phase 2 trials demonstrated the vaccine produced a strong immune response. In an unprecedented move, the Chinese military approved the vaccine on June 25 for a year

as a “specially needed drug.” CanSino would not say whether vaccination would be mandatory or optional for soldiers. Starting in August, CanSino began running Phase 3 trials in a number of countries, including Saudi Arabia, Pakistan and Russia.

Updated Sept. 24

PHASE 3 EARLY USE IN RUSSIA



МИНИСТЕРСТВО
ЗДРАВООХРАНЕНИЯ
РОССИЙСКОЙ ФЕДЕРАЦИИ

VACCINE NAME: Sputnik 5 (formerly Gam-Covid-Vac)

EFFICACY: 92%

DOSE: 2 doses, 3 weeks apart

TYPE: Muscle injection

STORAGE: Freezer storage. Developing an alternative formulation that can be refrigerated.

The **Gamaleya Research Institute**, part of Russia’s Ministry of Health, has created a vaccine based on two adenoviruses. Preliminary results announced in November indicate that the vaccine has a high efficacy rate in Phase 3 trials.

Gamaleya produced the vaccine, initially called Gam-Covid-Vac, from adenoviruses called Ad5 and Ad26. Both kinds have been tested as vaccines over the years. By combining them, the Russian researchers hoped to avoid a situation in which the immune system could learn to recognize the vaccine as a foreign object that needed to be destroyed.

The researchers launched clinical trials in June. On Aug. 11, President Vladimir V. Putin announced that a Russian health care regulator had approved the vaccine, renamed Sputnik V, before Phase 3 trials had even begun. Vaccine experts decried the move as risky, and Russia later walked back the announcement, saying that the approval was a “conditional registration certificate,” which would depend on positive results from Phase 3 trials. Those trials, initially planned for just 2,000 volunteers, were expanded to 40,000. In addition to Russia, volunteers

were recruited in Belarus, the United Arab Emirates, and Venezuela. On Oct. 17, a Phase 2/3 trial was launched in India.

On Sept. 4, three weeks after Putin's announcement, Gamaleya researchers published the results of their Phase 1/2 trial. In a small study, they found that Sputnik yielded antibodies to the coronavirus and mild side effects. Meanwhile, Russia negotiated agreements to supply the vaccine to countries including Argentina, Brazil, India, Mexico, and Venezuela.

On Nov. 11, the Russian Direct Investment Fund announced preliminary evidence from their Phase 3 trial indicating that the vaccine is effective. Based on 20 cases of Covid-19 among the trial participants, Russian scientists estimated that the vaccine demonstrated 92 percent efficacy. On Nov. 24, the vaccine makers followed up with an analysis on 39 cases that pointed to the same efficacy rate. They also claimed that a preliminary analysis on some volunteers who had the vaccine for a longer period of time showed a 95 percent efficacy rate, but outside experts questioned that conclusion. As with Moderna and Pfizer, the Gamaleya Research Institute has yet to follow up on their announcement with a detailed study in a peer-reviewed scientific journal.

In an unprecedented move in the coronavirus vaccine field, the Gamaleya Institute joined forces in December with the drugmaker AstraZeneca, which makes a vaccine with human adenoviruses. The two teams will combine their vaccines to see if they deliver stronger protection together than either does on its own. The trial is expected to start by the end of 2020.

In early December, the Russian government began a mass vaccination campaign with the Sputnik V vaccine. But worry that the vaccine was rushed has led to widespread hesitancy in the country.

Updated Dec. 11

PHASE 3



Beth Israel Lahey Health 
Beth Israel Deaconess Medical Center

VACCINE NAME: **Ad26.COV2.S**

EFFICACY: **Unknown**

DOSE: **1 dose**

TYPE: **Muscle injection**

STORAGE: **Stable in refrigerator**

A decade ago, researchers at **Beth Israel Deaconess Medical Center** in Boston developed a method for making vaccines out of a virus called Adenovirus 26, or Ad26 for short. **Johnson & Johnson** developed vaccines for Ebola and other diseases with Ad26 and have now made one for the coronavirus. In March they received \$456 million from the United States government to support their move towards production. The vaccine has provided protection in experiments on monkeys. Johnson & Johnson began Phase 1/2 trials in July. Unlike other leading vaccines in clinical trials, the company gave one dose, not two.

Johnson & Johnson launched a Phase 3 trial in September. On Oct. 12, the company announced it was pausing the trial to investigate an adverse reaction in a volunteer. The trial resumed eleven days later. Although Johnson & Johnson initially set out to recruit 60,000 volunteers for their Phase 3 trial, it was capped at 40,000 in December. Results are expected in January.

In August, the federal government agreed to pay Johnson & Johnson \$1 billion for 100 million doses if the vaccine is approved. The European Union reached a similar deal on Oct. 8 for 200 million doses. The company is aiming for production of at least a billion doses in 2021.

On Nov. 16, Johnson & Johnson announced that they were also launching a second Phase 3 trial to observe the effects of two doses of their vaccine, instead of just one.

Updated Dec. 10

PHASE 2 PHASE 3 COMBINED PHASES**UNIVERSITY OF
OXFORD****AstraZeneca** VACCINE NAME: **AZD1222**EFFICACY: **Up to 90%**DOSE: **2 doses, 4 weeks apart**TYPE: **Muscle injection**STORAGE: **Stable in refrigerator for at least 6 months**

On Dec. 8, researchers with the **University of Oxford** and the British-Swedish company **AstraZeneca** published the first scientific paper on a Phase 3 clinical trial of a coronavirus vaccine. The trial demonstrated that the vaccine can protect people from Covid-19, but it left many questions unresolved about the results.

Early in the pandemic, Oxford researchers developed the vaccine by genetically engineering an adenovirus that normally infects chimpanzees. When they gave the vaccine to monkeys, they found that it protected the animals from the disease. In April they followed up with a Phase 1/2 trial. The vaccine developers did not detect any severe side effects in the trial, while observing that the vaccine raised antibodies against the coronavirus as well as other immune defenses. The vaccine began Phase 2/3 trials in the United Kingdom and India (where it's known as Covishield). In addition, AstraZeneca launched Phase 3 trials in Brazil, South Africa, and the United States.

On Sept. 6, AstraZeneca halted global trials of the vaccine to investigate one volunteer, who developed a form of inflammation called transverse myelitis. Within a week, the trials began in all countries except the United States. Meanwhile, a newspaper in Brazil reported on Oct. 21 that a volunteer in the trial there died of Covid-19. While AstraZeneca did not comment, the Brazil trial was not paused, suggesting that the volunteer received a placebo. On Oct. 23, the F.D.A. authorized the restart of the U.S. trial.

On Nov. 19, researchers published the first findings from the Phase 2/3

trials in the United Kingdom. They looked in particular at how people at different ages responded to the vaccine, studying 160 people aged 18 to 55 years old, 160 between 56 and 69, and 240 70 years or older. They didn't observe any serious side effects at any age. Encouragingly, the older volunteers produced about as many antibodies against the coronavirus as the younger ones.

On Nov. 23, AstraZeneca and Oxford announced that the vaccine had good efficacy, based on a study of the first 131 cases of Covid-19 in the trials in the United Kingdom and Brazil. The volunteers all got two doses, but in some cases the first dose was only half strength. Surprisingly, an initial half-strength dose led to 90 percent efficacy, while two standard-dose shots led only to 62 percent efficacy. The researchers speculated that the lower first dose did a better job of mimicking the experience of an infection, promoting a stronger immune response. But only after the initial announcement did it become clear that the low dose version was the result of a mistake in how the vaccines were measured out, not part of the original plan for the trial. It also emerged that the low dose was only tried out on volunteers under 55, raising more questions about how strong the preliminary results were.

In an unprecedented move in the coronavirus vaccine field, AstraZeneca announced on Dec. 11 that it would collaborate with the Russian creators of the Sputnik V vaccine, which is also made from adenoviruses. The two teams will combine their vaccines to see if they deliver stronger protection together than either does on its own. The trial is expected to start by the end of 2020.

Starting in May, AstraZeneca secured a series of agreements to provide vaccines to governments should they prove effective. The United States awarded the project \$1.2 billion in support for 300 million doses. In August the European Union reached an agreement for AstraZeneca to deliver 400 million doses if the trials yield positive results. The company has said their total annual manufacturing capacity for the vaccine, if approved, stands at two billion doses.

On Dec. 7, the Serum Institute of India announced it was applying to the Indian government for emergency use authorization of the ChAdOx1 vaccine. In India, the vaccine is known as Covishield.

Updated Dec. 11

PHASE 1



The Italian biotechnology company **ReiThera** has developed a Covid-19 vaccine, called GRAd-COV2, that is based on an adenovirus that infects gorillas. Working in collaboration with the **Lazzaro Spallanzani National Institute for Infectious Diseases** in Rome, they launched a Phase 1 trial at the end of July. In November, they announced that the vaccine was well tolerated and produced antibodies, opening the way to a Phase 2/3 trial in the coming months.

Updated Nov. 24

PHASE 1



While many vaccines are given as injections, some vaccines can be taken as a pill. Oral vaccines have been approved for diseases including polio, cholera, and typhoid fever. The small San Francisco company **Vaxart** specializes in developing oral vaccines. They have created and tested pills for influenza and other diseases. Earlier this year, Vaxart began work on an oral vaccine for Covid-19. It contains an adenovirus called Ad5 (the same viral vector in CanSinoBio's vaccine and in Russia's Sputnik V).

When Vaxart gave the pill to mice, they produced antibodies against the coronavirus. Mice don't suffer symptoms of Covid-19, however, so the researchers then switched to hamsters, which do. In an

unpublished study, they found that the vaccine pill not only dramatically reduced the amount of coronavirus in sick hamsters, but also protected them from two important symptoms of the disease: weight loss and swollen lungs. In October, the company began giving the pill to volunteers in a Phase 1 clinical trial.

Although none of Vaxart's vaccines have yet been licensed, the company's stock price increased 3,600 percent in the first half of 2020. In June, The New York Times reported, a hedge fund that partly controlled the company sold off most of its shares, netting over \$200 million in profits. In the wake of that reporting, the Department of Justice began investigating the company, while a number of shareholder lawsuits were brought against Vaxart, its executives and its board.

Updated Nov. 12

PHASE 1



The American company **Merck** acquired the Austrian firm **Themis Bioscience** in June and is working on a vaccine originally developed at **Institut Pasteur**. The vaccine uses a weakened measles virus that carries a gene for the coronavirus spike protein. Researchers launched a Phase 1 trial in August.

Updated Aug. 12

PHASE 1



In 2019, researchers at the **University of Hong Kong** and **Xiamen University** created a nasal-spray vaccine for the flu based on a genetically weakened form of the influenza virus. Earlier this year, they engineered the vaccine to produce part of the coronavirus spike protein as well. On Sept. 9, they received approval to start clinical trials in partnership with **Beijing Wantai Biological Pharmacy**.

Updated Sept. 9

PHASE 1



Three decades ago, the **German Center for Infection Research** developed a smallpox vaccine from a harmless virus called Modified Vaccinia Ankara, or MVA for short. In recent years, they adapted it to create a vaccine for MERS, a disease caused by another coronavirus. This spring, they made an MVA-based vaccine for SARS-CoV-2, the coronavirus that is causing the Covid-19 pandemic. It carries the gene for the spike protein, which is produced inside cells that it invades. On Sept. 29, the center and a consortium of German universities registered a Phase 1 trial. The vaccine is expected to be ready for approval by the end of 2021.

Updated Sept. 29

PHASE 1



In addition to its project with Themis, **Merck** is partnering with **IAVI** on a second viral vector vaccine. It is based on vesicular stomatitis viruses, the same approach Merck successfully used to produce the first approved vaccine for Ebola. They have designed their coronavirus vaccine as a pill, which could potentially make it easier to

distribute than syringes for injections. Merck and IAVI received \$38 million from the United States government to support their research, and on September 30 they registered a Phase 1 trial.

Updated Aug. 27

PHASE 1



The California-based company **ImmunityBio** launched a Phase 1 trial of a Covid-19 vaccine in October. The vaccine uses the Ad5 adenovirus, the same one used by CanSinBio and the Gamaleya Institute in Russia. ImmunityBio has engineered the Ad5 virus to carry genes for two genes from the coronavirus. In addition to the spike protein, it also carries the gene for a protein called nucleocapsid. The company hopes that this combination will provoke a strong immune response. On Dec. 10, the company announced that the vaccine protects monkeys from the coronavirus. The chairman and C.E.O. of ImmunityBio is billionaire Patrick Soon-Shiong, the owner of the Los Angeles Times.

Updated Dec. 11

PHASE 1



In the spring, the **Israel Institute for Biological Research** started work on a coronavirus vaccine based on vesicular stomatitis viruses. They engineered the viruses to carry the gene for the coronavirus spike protein. On Oct. 25, the Israeli government announced that the vaccine, called Brilife, would be going into Phase 1 trials. If the vaccine is successful in Phase 1 and Phase 2 trials, researchers hope to start Phase 3 trials in spring 2021.

Updated Oct. 26

PHASE 1



Researchers at **City of Hope**, a California biomedical research institute, created a vaccine based on a weakened form of a virus called Modified Vaccinia Ankara, or MVA for short. They added two coronavirus genes to the virus — one for the spike protein, and one for another protein called nucleocapsid. They hope the combination will enable the vaccine to produce immunity that's both fast and long-lasting. On Nov. 24 they announced the start of a Phase 1 trial, with hopes for a Phase 2 trial to start in the second quarter of 2021.

Updated Nov. 24

PRECLINICAL



The Swiss company **Novartis** will manufacture a vaccine based on a gene therapy treatment developed by the Massachusetts Eye and Ear Hospital, Massachusetts General Hospital and the Gene Therapy Program at the University of Pennsylvania. A virus called an adeno-associated virus delivers coronavirus gene fragments into cells. Phase 1 trials are set to begin in late 2020.

Updated Aug. 24

PRECLINICAL

Other viral vector vaccines in active preclinical development include vaccines from: Altimmune; Icahn School of Medicine at Mount Sinai; Intravacc; KU Leuven; Meissa Vaccines; the Spanish National Center for Biotechnology and the Spanish National Research Council; Thomas Jefferson University and Bharat Biotechnology; Tonix Pharmaceuticals; University of Pittsburgh; Vivaldi Biosciences; Washington University.

Updated Oct. 20

Protein-Based Vaccines

Vaccines that contain coronavirus proteins but no genetic material. Some vaccines contain whole proteins, and some contain fragments of them. Some pack many of these molecules on nanoparticles.

PHASE 3



VACCINE NAME: **NVX-CoV2373**

EFFICACY: **Unknown**

DOSE: **2 doses, 3 weeks apart**

TYPE: **Muscle injection**

STORAGE: **Stable in refrigerator**

Maryland-based **Novavax** makes vaccines by sticking proteins onto microscopic particles. They've taken on a number of different diseases this way; their flu vaccine finished Phase 3 clinical trials in March. The company launched trials for a Covid-19 vaccine in May, and the Coalition for Epidemic Preparedness Innovations has invested \$384

million in the vaccine. In July the U.S. government awarded Novavax another \$1.6 billion to support the vaccine's clinical trials and manufacturing.

After getting promising results from preliminary studies in monkeys and humans, Novavax launched a Phase 2 trial in South Africa in August. The blinded, placebo-controlled trial on 2,900 people will measure not just the safety of the vaccine but its efficacy. The following month, Novavax launched a Phase 3 trial enrolling up to 15,000 volunteers in the United Kingdom. It is expected to deliver results in early 2021. A larger Phase 3 trial in the United States is expected to launch by the end of December.

In September Novavax reached an agreement with the Serum Institute of India, a major vaccine manufacturer, that they said would enable them to produce as many as 2 billion doses a year. If the trials succeed, Novavax expects to deliver 100 million doses for use in the United States by the first quarter of 2021. On Nov. 4 they announced another agreement to deliver 40 million doses to Australia.

Updated Nov. 30

PHASE 2 PHASE 3 COMBINED PHASES



VACCINE NAME: **CoVLP**

EFFICACY: **Unknown**

DOSE: **2 doses, 3 weeks apart**

TYPE: **Muscle injection**

STORAGE: **Stable in refrigerator**

Canada-based **Medicago**, partly funded by the cigarette maker Philip Morris, grow vaccines in a plant called *Nicotiana benthamiana*, a wild species related to tobacco. They deliver virus genes into leaves, and the plant cells then create protein shells that mimic viruses.

In July, Medicago launched Phase 1 trials on a plant-based Covid-19 vaccine in combination with adjuvants to boost the immune system's response to the viral proteins. In that study, they found that an adjuvant made by GSK produced promising levels of antibodies in volunteers. On Oct. 23, the company announced it had reached an agreement with the government of Canada to supply 76 million doses. A Phase 2/3 trial of the vaccine began on Nov. 12.

Updated Nov. 24

PHASE 3



INSTITUTE OF MEDICAL BIOLOGY
CHINESE ACADEMY OF MEDICAL SCIENCES

VACCINE NAME: ZF2001

EFFICACY: Unknown

DOSE: 3 doses, 4 weeks apart

TYPE: Muscle injection

The Chinese company **Anhui Zhifei Longcom** and the **Chinese Academy of Medical Sciences** partnered to make a vaccine. Their candidate is composed of an adjuvant, along with a section of the spike protein called the receptor-binding domain. They launched Phase 2 trials in July, followed by a Phase 3 trial with 29,000 volunteers in December.

Updated Dec. 2

PHASE 2



West China School of Medicine
West China Hospital of Sichuan University

In July, researchers at **West China Hospital of Sichuan University** published a study in *Nature* describing a vaccine made from the RBD region of the spike protein that could protect mice and monkeys from the coronavirus. To make the vaccine, researchers encode the RBD

region in a gene, which they insert into a virus. They then infect insect cells with the virus, causing them to make the molecule in huge amounts. On Aug. 24, they launched a Phase 1 trial, and on Nov. 16 they moved to Phase 2.

Updated Nov. 20

PHASE 1 PHASE 2 COMBINED PHASES



On Aug. 18, the head of epidemiology at Cuba's public health ministry announced that the **Finlay Vaccine Institute** in Havana would start a clinical trial on a vaccine for Covid-19. The vaccine, called Soberana 1, contains a part of the spike protein, called RBD, along with two extra ingredients: proteins from a bacteria and aluminum hydroxide. These ingredients, known as adjuvants, boost the immune system's response to the coronavirus RBD.

Updated Oct. 28

PHASE 1 PHASE 2 COMBINED PHASES EARLY USE IN RUSSIA



On Aug. 26, the **Vector Institute**, a Russian biological research center, registered a Phase 1/2 trial for a coronavirus vaccine they call EpiVacCorona. The vaccine contains small portions of viral proteins, known as peptides. According to newspaper reports, the EpiVacCorona trials had already begun by then. On October 14, Vladimir Putin announced that Russia has granted regulatory approval to EpiVacCorona, making it the second vaccine to receive that designation after the Gamaleya Institute's Sputnik V vaccine. Like the Sputnik vaccine, EpiVacCorona received approval before a Phase 3 trial to demonstrate that it was safe and effective. That trial is expected to start later this year.

Updated Oct. 14

PHASE 1 PHASE 2 COMBINED PHASES



In addition to their mRNA vaccine, **Sanofi** developed a Covid-19 vaccine based on viral proteins. They produced the proteins with engineered viruses that grow inside insect cells. **GSK** supplemented these proteins with adjuvants that stimulate the immune system. The vaccine is based on the same design Sanofi used to create Flublok, an approved vaccine for influenza. The companies launched a Phase 1/2 clinical trial in September.

Sanofi's vaccine was widely expected to play a major role in tackling the pandemic. In the United States, Operation Warp Speed selected it as one of six vaccines to secure in large quantities, reaching a \$2.1 billion agreement for 100 million doses. On Sept. 18 Sanofi closed another deal with the European Union for 300 million doses for an unspecified amount, and later reached an agreement with Canada for up to 72 million doses. In addition, Sanofi agreed to provide 200 million doses to COVAX, an international collaboration to deliver the vaccine equitably across the world. The company expected to move to a Phase 3 trial in December and potentially seek emergency use authorization in the United States by spring. The company announced plans to make up to one billion doses in 2021.

But on Dec. 11, Sanofi and GSK announced that their vaccine was proving disappointing. While it provided promising levels of antibodies in people under 50, older people did not respond as strongly as they had hoped. They will start a new Phase 2 trial in February with a different formulation. If they can get sufficiently high antibodies with the new vaccine, they will move on to Phase 3 studies. That could be a challenge, because they may not be able to test it against a placebo. Instead, they may have to test against one of the vaccines expected to receive emergency use authorization by then. Sanofi and GSK do not expect the vaccine to become available before the end of 2021.

Updated Dec. 11

PHASE 1 PHASE 2 COMBINED PHASES



SpyBiotech, a company spun off from the University of Oxford, announced in September that the first volunteers in an Australian Phase 1/2 trial were receiving their Covid-19 vaccine. The researchers created the vaccine from a mixture of proteins. Some of the proteins, from hepatitis B viruses, assemble themselves into hollow shells. The researchers decorated these shells with part of the coronavirus spike protein. The Serum Institute of India, which licensed the technology from SpyBiotech, is running the trials.

Updated Sept. 24

PHASE 1 PHASE 2 COMBINED PHASES



Biological E. Limited
Celebrating Life Every Day



After the SARS epidemic in 2002, **Baylor College of Medicine** researchers began developing a vaccine that could prevent a new outbreak. Despite promising early results, support for the research disappeared. Because the coronaviruses that cause SARS and Covid-19 are very similar, the researchers revived the project in partnership with the **Texas Children's Hospital**. The researchers have found that the Covid-19 vaccine produces antibodies in mice. The Indian company **Biological E** licensed it in August and launched a Phase 1/2 trial in November, combining the viral proteins with an adjuvant made by **Dynavax**. If trials confirm that the vaccine works, they hope to potentially make a billion doses a year.

Updated Nov. 16

PHASE 1

Clover Biopharmaceuticals has developed a vaccine containing the spike protein from coronaviruses. To further stimulate the immune system, the company is testing so-called adjuvants made by British drugmaker **GSK** and the American company **Dynavax**. Investments from CEPI will support the development of manufacturing that could lead to the production of a billion doses a year. Clover's formula looks to be especially durable; the vaccine can sit out at room temperature for a month and remain viable.

Clover launched a Phase 1 trial in June, and in December they announced that the vaccine triggered a high level of antibodies. The company is following up on the promising results by launching a Phase 2 / 3 trial with the GSK adjuvant by the end of 2020.

Updated Dec. 5

PHASE 1

The Australian company **Vaxine** developed a vaccine that combines viral proteins with an adjuvant that stimulates the immune system. A Phase 1 trial began over the summer, and Phase 2 trials are expected to commence by the end of the year.

Updated Sept. 29

PHASE 1



A second plant-based vaccine is in development at **Kentucky BioProcessing**, an American subsidiary of British American Tobacco, the maker of Lucky Strike and other cigarettes. Like Medicago, Kentucky BioProcessing engineers a wild relative of tobacco called *Nicotiana benthamiana* to make viral proteins. The company previously used this technique to make a drug called Zmapp for Ebola. After preclinical testing in the spring, they registered a Phase 1 trial for their coronavirus vaccine in July. The trial is scheduled to start in December.

Updated Dec. 2

PHASE 1



高端疫苗生物製劑股份有限公司
MEDIGEN VACCINE BIOLOGICS CORP

DYNAVAX
INNOVATING IMMUNOLOGY

Taiwan-based vaccine maker **Medigen** is making a vaccine made of a combination of spike proteins and an adjuvant from **Dynavax**. After a series of promising experiments on animals, they began injecting volunteers for a Phase 1 trial in early October.

Updated Oct. 13

PHASE 1



Taiwan-based vaccine manufacturer **Adimmune** got permission to launch a Phase 1 trial on Aug. 20. The vaccine contains the RBD section of the virus's spike protein.

Updated Aug. 20

PHASE 1



New York-based **COVAXX**, a subsidiary of United Biomedical, has created a vaccine containing parts of several viral proteins. On Sept. 11 they registered a Phase 1 trial in Taiwan. They have reached an agreement with authorities in Brazil to run their Phase 2/3 trial there. On Nov. 25, Covaxx announced agreements with countries including Brazil, Ecuador, and Peru to deliver more than 140 million doses for \$2.8 billion.

Updated Nov. 25

PHASE 1



In the spring, researchers at the **University of Tübingen** in Germany created a vaccine made of eight parts of two viral proteins, along with an immune-stimulating adjuvant. In September they launched a Phase 1 trial.

Updated Sept. 15

PHASE 1



In October, Cuba's **Finlay Vaccine Institute** launched clinical trials on their second experimental vaccine for the coronavirus. Known as Sovereign 2, it contains the RBD part of the coronavirus spike protein. The RBD fragment is fused to a standard tetanus vaccine, which makes it stable. It also uses aluminum hydroxide.

Updated Oct. 28

PHASE 1



The **Center for Genetic Engineering and Biotechnology of Cuba** announced on Nov. 26 that it was beginning a Phase 1 trial of a vaccine delivered as a nasal spray. Known as Mambisa, the vaccine contains a piece of the coronavirus spike protein called the receptor-binding domain, along with a protein from the hepatitis B virus that stimulates the immune system. The name refers to women who fought in Cuba's nineteenth-century wars of independence.

Updated Nov. 30

PHASE 1



In addition to their nasal spray vaccine, the **Center for Genetic Engineering and Biotechnology of Cuba** also launched a separate trial at the end of November on a vaccine injected into the muscle. It contains a piece of the coronavirus spike protein called the receptor-binding domain. The vaccine is called Abadala, named after a poem by the nineteenth-century poet José Martí.

Updated Nov. 30

PHASE 1



SK Bioscience, a South Korean vaccine maker, designed a Covid-19 vaccine based on pieces of the spike protein of the coronavirus. In August they found that the vaccine triggers a strong production of antibodies in monkeys. They launched a Phase 1 trial at the end of November.

Updated Dec. 2

PHASE 1 ?



On July 18, **North Korea's** State Commission of Science and Technology announced on their web site that they had started clinical trials on a vaccine based on part of the coronavirus spike protein. It's hard to independently evaluate the claim from the isolated dictatorship. The commission claimed to have tested the vaccine on animals, but provided no data. Four months after their announcement, South Korean lawmakers said they had foiled an attempt by North Korea to hack South Korean companies developing coronavirus vaccines. So far, North Korea has not released any further information about the trials they supposedly are running.

Updated Dec. 2

ABANDONED



On Dec. 10, a vaccine from Australia's **University of Queensland** was the first to be abandoned after entering a clinical trial. Cancelling the vaccine meant the collapse of a \$1 billion deal with the Australian government for 51 million doses.

The vaccine studies offered great promise at first. Experiments on hamsters showed that the vaccine protected them from the coronavirus. The university launched Phase 1 trials in July, combining coronavirus spike proteins with an adjuvant made by **CSL**. They were on track to move on to late-stage trials when they made an unwelcome discovery: some volunteers were getting positive tests for HIV, even though they were not actually infected with that virus.

According to early reports, the trouble appears to lie in the way the

researchers designed the vaccine. If spike proteins are not anchored to a coronavirus, they can unfold. Antibodies to the unfolded spike protein may not work against folded proteins on real viruses. So the researchers made a small change to the protein, creating a little clamp at one end to hold the molecule in its proper shape. Unfortunately, the clamp is similar to a protein on HIV, which can lead the immune system to make HIV-like antibodies. People who volunteered for the vaccine trial tested positive on HIV antibody tests, even though they were perfectly healthy. That discovery was enough to cause the Australian government to scrap the trial. “It will no longer feature in Australia’s vaccine plan,” said Prime Minister Scott Morrison at a press conference to announce the cancellation.

Updated Dec. 10

PRECLINICAL



A vaccine in development by the **University of Pittsburgh**, called PittCoVacc, is a skin patch tipped with 400 tiny needles made of sugar. When placed on the skin, the needles dissolve and deliver virus proteins into the body. Its creators are planning to start clinical trials in late 2020.

Updated Aug. 27

PRECLINICAL

Other protein-based vaccines in active preclinical development include vaccines from: Adaptive Phage Therapeutics; AdaptVac and Bavarian Nordic; Applied Biotechnology Institute; Artes Biotech; Axon Neuroscience; BiOMVis and University of Trento; City College of New York and TechnoVax; EpiVax; GeoVax; Heat Biologics; IBio and CC-Pharming; Icosavax and University of Washington; ImmunoPrecise Antibodies; IMV; Instituto Butantan; Intravacc; IrsiCaixa; Izmir Biomedicine and Genome Center; National Autonomous University of Mexico; Navarrabiomed; NidoVax; OncoGen; Oragenics; OSE Immunotherapeutics; Osivax; PDS Biotechnology; Pontifical Catholic University of Chile; Saiba; SK Bioscience; University of Alberta; University of Amsterdam; University of Georgia and EpiVax; University of Saskatchewan and VIDO-InterVac; University of

Virginia; UNSAM-CONICET; Vaxform; Vaxil-Bio; VBI Vaccines; Verndari; VIDO-InterVac; Voltron Therapeutics; Walter Reed Army Institute of Research; Wyss Institute and Harvard University; Yisheng Biopharma.

Updated Sept. 25

Inactivated or Attenuated Coronavirus Vaccines

Vaccines created from weakened coronaviruses or coronaviruses that have been killed with chemicals.

Inactivated
virus

PHASE 3

APPROVED IN U.A.E.



VACCINE NAME: **BBIBP-CorV**

EFFICACY: **86%**

DOSE: **2 doses, 3 weeks apart**

TYPE: **Muscle injection**

The state-owned Chinese company **Sinopharm** is currently testing two vaccines based on inactivated coronaviruses. One of them was created by the **Beijing Institute of Biological Products**. A Phase 1/2 trial showed that the vaccine didn't cause any serious side effects and cause people to make antibodies against the coronavirus. In July a Phase 3 trial began in the United Arab Emirates in July, and in Morocco and Peru the following month.

On Sept. 14, the U.A.E. gave emergency approval for Sinopharm's vaccine to use on health care workers, and soon government officials and others were also receiving it. Less than two months later, on Dec. 9, the U.A.E. gave full approval to the Beijing Institute vaccine, announcing it had an efficacy rate of 86 percent. The government rapidly set up clinics across the country where anyone could receive the vaccine. But the government did not release any details with their announcement, leaving it unclear how they had come to their conclusions. The neighboring country of Bahrain, which also participated in the Sinopharm trials, also gave full approval to the vaccine on Dec. 13, based on the same data. Tellingly, Sinopharm did not offer any comment on either announcement.

In China, meanwhile, the government gave Sinopharm emergency approval over the summer to inject both vaccine candidates into government officials, health care workers, and other select groups. By November, the chairman of Sinopharm said, almost a million people in China had received the vaccines. On Nov. 25, Sinopharm announced it had filed an application to market its vaccines in China — despite the fact that it has not yet offered results of its Phase 3 trials to show that the vaccines are safe and effective.

Updated Dec. 13

PHASE 3 LIMITED USE IN U.A.E.



武汉生物制品研究所有限责任公司
WUHAN INSTITUTE OF BIOLOGICAL PRODUCTS CO.,LTD.

In addition to their Beijing Institute vaccine, **Sinopharm** also began testing an inactivated virus vaccine developed by the **Wuhan Institute of Biological Products**. The Phase 1/2 trial showed that the vaccine produced antibodies in volunteers, some of whom experienced fevers and other side effects. The Wuhan version of the vaccine is undergoing Phase 3 trials in several countries. On Dec. 12, Peru announced that it had paused their vaccine trial to investigate neurological problems in one volunteer. It was not clear which of the two Sinopharm vaccines was involved.

Updated Dec. 13

PHASE 3 LIMITED USE IN CHINA



VACCINE NAME: **CoronaVac**

EFFICACY: **Unknown**

DOSE: **2 doses, 2 weeks apart**

TYPE: **Muscle injection**

STORAGE: **Refrigerated**

Sinovac Biotech, a private Chinese company, developed an inactivated vaccine called CoronaVac. In June the company announced that Phase 1/2 trials on 743 volunteers found no severe adverse effects and produced an immune response. Sinovac published the details of the trial in November in a medical journal, showing a comparatively modest production of antibodies. Only a Phase 3 trial would demonstrate if that was enough to protect people from Covid-19.

In July, Sinovac launched a Phase 3 trial in Brazil, followed by others in Indonesia and Turkey. While Sinovac has yet to release late-stage trial data, on Oct. 19 officials in Brazil said that it was the safest of five

vaccines they were testing in Phase 3 trials.

Reuters reported that the Chinese government gave the Sinovac vaccine an emergency approval for limited use in July. In October, authorities in the eastern Chinese city of Jiaxing announced they were giving CoronVac to people in relatively high-risk jobs, including medical workers, port inspectors and public service personnel.

Meanwhile, Sinovac has been preparing to manufacture the vaccine for global distribution, reaching an agreement to supply Indonesia with at least 40 million doses by March 2021. In September, Yin Weidong, the CEO of Sinovac, said the company planned on worldwide distribution of the vaccine in early 2021 — including the United States. In December Sinovac said it expected to manufacture 300 million doses in 2020 and increase their capacity to an annual production of 600 million doses.

On Nov. 9, the Brazilian government announced they had paused the country's Sinovac trial the previous month because of an adverse event. The details of the pause were murky, raising suspicions that politics were involved. Two days after the announcement, the trial was allowed to resume. The Brazilian trial has recorded enough cases of Covid-19 to let researchers determine Sinovac's efficacy. They expect to release their results by Dec. 15.

Updated Dec. 9

PHASE 3



VACCINE NAME: **Covaxin** (also known as BBV152 A, B, C)

EFFICACY: **Unknown**

DOSE: **2 doses, 3 weeks apart**

STORAGE: **At least a week at room temperature**

In collaboration with the **Indian Council of Medical Research** and the **National Institute of Virology**, the Indian company **Bharat Biotech** designed Covaxin, a vaccine based on an inactivated form of the coronavirus. Studies on monkeys and hamsters found that it provided protection against infection. In June, Bharat's coronavirus vaccine became the first created in India to go into clinical trials. While the results of the Phase 1/2 trials have yet to be published, an executive at Bharat told India Today that about 85 to 90 percent of the 1,000 volunteers produced antibodies to the coronavirus and experienced no serious adverse effects due to Covaxin. On Oct. 23, the company announced they were initiating a Phase 3 trial. Bharat expects results in early 2021 and anticipates distributing the vaccine next June.

Updated Nov. 23

PHASE 3



INSTITUTE OF MEDICAL BIOLOGY
CHINESE ACADEMY OF MEDICAL SCIENCES

Researchers at the **Institute of Medical Biology at the Chinese Academy of Medical Sciences**, which has invented vaccines for polio and hepatitis A, created an inactivated coronavirus vaccine. In May, they launched a Phase 1 trial on 192 volunteers which indicated the vaccine was safe and produced an immune response. A Phase 2 trial followed on 750 volunteers, which led the researchers to select a two-week spacing between the two doses of the vaccine. In December the researchers launched a Phase 3 trial on up to 34,020 volunteers in Brazil and Malaysia.

Updated June 23

PHASE 1 PHASE 2 COMBINED PHASES



Russian Academy of Sciences

The **Chumakov Center** at the **Russian Academy of Sciences** has developed an inactivated coronavirus vaccine. On Oct. 14, the TASS news agency reported that clinical trials of the vaccine would begin in Kirov and St. Petersburg on Oct. 19. On its web site, the center stated that it would finish the first phase of trials the following month.

Updated Oct. 14

PHASE 1



RIBSP
Research Institute for
Biological Safety Problems

The central Asian nation of Kazakhstan began research on a vaccine made from inactivated coronaviruses over the summer. On August 28, their **Research Institute for Biological Safety Problems** registered a Phase 1 trial on the vaccine, known as QazCovid.

Updated Aug. 28

PHASE 1



康泰生物
BIOKANGTAI

Shenzhen Kangtai Biological Products is a Chinese company that makes vaccines for diseases such as hepatitis B and measles. In August, AstraZeneca reached an agreement with them to supply China with their mRNA vaccine. In October Shenzhen Kangtai launched a Phase 1 trial on 180 volunteers of its own vaccine, based on inactivated coronaviruses. The company, which is also manufacturing AstraZeneca, has been dogged by reports of corruption and scandals.

Updated Dec. 9

PHASE 1



On Nov. 5, Turkey's **Erciyes University** announced they had begun injecting volunteers with an inactivated coronavirus vaccine. It is the first clinical trial of a coronavirus vaccine developed in Turkey.

Updated Nov. 16

PHASE 1

CODAGENIX  INC.

New York-based **Codagenix** develops vaccines based on live attenuated viruses, but with a twist: they create the viruses from scratch. Researchers rewrite the genome of viruses, introducing hundreds of mutations. Then they manufacture RNA molecules encoding the rewritten genes. In special host cells, the molecules can give rise to full-blown viruses. But thanks to their numerous mutations, they are too weak to cause Covid-19 when they're delivered in a vaccine. After successful experiments in animals, a Phase 1 trial of their coronavirus vaccine was registered on Nov. 6.

Updated Nov. 10

PRECLINICAL

Other inactivated or attenuated coronavirus vaccines in active preclinical development include vaccines from: Valneva; Vivaldi Biosciences; Washington University; Western University.

Updated Nov. 7

Repurposed Vaccines

Vaccines already in use for other diseases that may also protect against Covid-19. Repurposed vaccines are not included in our vaccine count.

PHASE 3



The Bacillus Calmette-Guerin vaccine was developed in the early 1900s as a protection against tuberculosis. The **Murdoch Children's Research Institute** in Australia is conducting a Phase 3 trial called the BRACE to see if the vaccine partly protects against the coronavirus.

OTHER CLINICAL TRIALS

Other repurposed vaccines are in clinical trials being conducted by: the Bandim Health Project; Crown Coronation (Washington University and partner universities); Hôpitaux de Paris; Louisiana State University Health Sciences Center New Orleans; the BADAS Study (Texas A&M University, Baylor College of Medicine, M.D. Anderson Cancer Center and Cedars-Sinai Medical Center); India's National Institute for Research in Tuberculosis; BCG-CORONA (UMC Utrecht and Radboud University); University of Campinas; University Health Network, the Serum Institute of India, the Max Planck Institute for Infection Biology and Verity Pharmaceuticals; Oklahoma Medical Research Foundation and the University of Oklahoma; Vakzine Projekt Management.

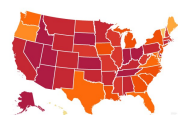
Updated Sept. 25

Note: Vaccines will be added to the tracker when they reach **Phase 1**, and tracked until they succeed or fail.

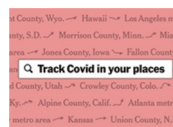
Did we miss something? To notify The Times of new developments, send updates to vaccinetracker@nytimes.com.

Tracking the Coronavirus

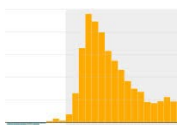
United States



Latest Maps and Data
Cases and deaths for every county



Your Places
Build your own dashboard to track cases



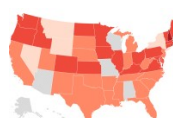
Deaths Above Normal
The true toll of the pandemic in the U.S.

City	Population	Cases	Deaths
Lake City, Fla.	1,065	1247	1
Bakersfield, Calif.	11,188	1247	1
Miami	66,711	1138	1
Lake Charles, La.	2,204	1101	1
Shenandoah Valley, Va.	4,652	1088	1
San Antonio, Texas	1,434	1045	1
El Paso, Texas	654	1030	1
Victoria, Texas	1,007	1011	1
Grand Central Station	4,302	1002	1
Orlando, Fla.	792	938	1

Cities and Metro Areas
Where it is getting better and worse



Restrictions
What is open and closed in each state

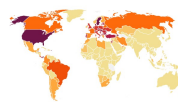


Nursing Homes
The hardest-hit states and facilities

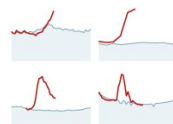


Colleges and Universities
Cases at more than 1,700 schools

World



Latest Maps and Data
Cases and deaths for every country

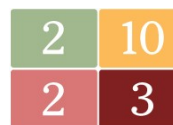


Deaths Above Normal
The true toll of coronavirus around the world

Health



Vaccines
Track their development



Treatments
Rated by effectiveness and safety

Countries

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

States, Territories and Cities

- Alabama
- Alaska
- Arizona

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](#)

Additional reporting by Denise Grady, Andrew E. Kramer, Hari Kumar, Cao Li and Carlos Tejada.

Note: Early versions of the tracker combined two vaccines by **Sinopharm** into one entry. Subsequent reporting confirmed they are two different vaccines. A previous version of the tracker stated that Pfizer had reached a deal with the EU, when in fact the deal was made by AstraZeneca.

Sources: World Health Organization, National Institute of Allergy and Infectious Diseases, National Center for Biotechnology Information, New England Journal of Medicine, Rollins School of Public Health at Emory University.