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COVID-19 Vaccine Frontrunners

Stay up-to-date on the progress of dozens of vaccine candidates that are currently undergoing clinical testing.

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In early March, National Institutes of Allergy and Infectious Diseases Director Anthony Fauci stated that it would take at least a year to a year and a half to get a COVID-19 vaccine approved for use in the US, and that estimate may be optimistic, according to some experts. There are many unknowns this early in the game. How the early candidates will perform, which will be advanced to later stages of clinical development, what safety issues might arise, and how a successful vaccine will be mass produced are among the questions that are now getting attention and funding.

See "Newer Vaccine Technologies Deployed to Develop COVID-19 Shot"

The Coalition for Epidemic Preparedness Innovations (CEPI), a nonprofit dedicated to the development of vaccines against emerging infectious diseases, was one early source of cash for this endeavor, with a total of nearly $30 million invested in several candidates by April. Another bolus of funds came from the Biomedical Advanced Research and Development Authority (BARDA), part of the HHS Office of the Assistant Secretary for Preparedness and Response, which is contributing hundreds of millions of dollars to two top vaccine candidates: one made by Johnson & Johnson's Janssen division and another developed by Moderna in collaboration with the US government. More recently, the US government's Operation Warp Speed has invested heavily, giving more than $1 billion each to Novavax and to AstraZeneca, which is collaborating on a vaccine developed by the University of Oxford.

See "US Selects Two COVID-19 Vaccine Candidates for Huge Investments"

Below, *The Scientist* rounds up those vaccine candidates that appear to be furthest along. But there are many more in preclinical development. "Nobody knows which vaccines are going to work," Moderna CEO Stéphane Bancel told *Science* in March.

See "Clinical Trial of COVID-19 Vaccine Begins in Seattle"

Editor's note: This table was updated on July 20, 2020. New information in bold, red font.

DEVELOPER(S)	VACCINE METHOD	EVIDENCE	STATUS
Moderna and the US government *US*	Lipid nanoparticles containing mRNAs for the SARS-CoV-2 spike protein are injected into the arm.	Preliminary results from the early stage trials published in the *New England Journal of Medicine* in July suggest that the vaccine is safe and elicits higher levels of SARS-CoV-2 antibodies than infection with the virus. Moderna is developing similar vaccines against Zika and other viruses, and other companies have RNA vaccines in clinical trials as well, but to date, no vaccine of this type has been approved for use.	Phase 1 and Phase 2 clinical trials underway in Seattle
CanSino Biologics and the Academy of Military Medical Sciences *China and Canada*	Nonreplicating adenovirus 5 (Ad5) vector carrying the gene for the SARS-CoV-2 spike protein is injected into the arm.	**Preliminary results from the Phase 2 trial published in *The Lancet* in July suggest that the vaccine is safe and elicits an immune response, either a T cell response or an antibody response.** Adenoviruses are well-established vaccine vectors, and CanSino produced an Ebola	Phase 1 and Phase 2 clinical trials are underway in Wuhan, China. On June 25, following positive Phase 1 data published in *The Lancet* on May 22, China's Central

		vaccine (approved in China in 2017) using the same Ad5 platform.	Military Commission approved the vaccine's use by the country's military for a year. A Phase 1/2 trial has been approved to begin in Canada.
University of Oxford and AstraZeneca *UK, Brazil, and South Africa*	A chimpanzee adenovirus vaccine vector (ChAdOx1) carrying the gene for the SARS-CoV-2 spike protein is injected into the arm.	**Preliminary results from the Phase 1/2 trial published in *The Lancet* in July suggest that the vaccine is safe and elicits strong antibody and T cell immune responses.** Six macaques that had received a single dose of the vaccine candidate stayed healthy after being exposed to SARS-CoV-2. A Phase 1 trial using the same adenovirus vector to target MERS is ongoing in Saudi Arabia.	A Phase 1/2 clinical trial is underway in the UK, and enrollment has begun for a follow-up Phase 2/3 trial. Additionally, researchers began testing the vaccine in a trial in Brazil and another in South Africa in June. AstraZeneca aims to make 30 million doses available in the UK by September.
Inovio Pharmaceuticals *US*	A special device administers spike protein–encoding DNA molecules through the skin.	Mice and guinea pigs mounted immune responses against the virus, according to a recent preprint, and the company announced interim results from the Phase 1 trial at the end of June that suggested the vaccine was safe and spurred immune responses in 94 percent of the 36 participants analyzed.	Phase 1 clinical trial underway in Pennsylvania, Missouri, and Kentucky with plans to manufacture 1 million doses of its candidate this year
Sinovac Biotech *China, Brazil, and Bangladesh*	Inactivated SARS-CoV-2	In animal studies, the vaccine candidate provides protection against virus strains from different countries. Sinovac had used a similar platform to develop a vaccine against SARS in 2004 that showed promising results in early-stage human trials.	Phase 1/2 clinical trial is underway in China. In July, Phase 3 trials were approved to begin in Brazil and Bangladesh.
Group 42 (G42), the Abu Dhabi Department of Health, and China National Pharmaceutical Group (Sinopharm) *United Arab Emirates*	Inactivated SARS-CoV-2	The vaccine involves two doses given three weeks apart.	Phase 3 trial underway in UAE
Wuhan Institute of Biological Products	Inactivated SARS-CoV-2	In mid-June, Sinopharm announced that nearly all of the	Phase 1/2 clinical trial underway in

and China National Pharmaceutical Group (Sinopharm) *China*		more than 1,000 participants who had received two injections of the mid-dose vaccine tested positive for antibodies against SARS-CoV-2. The organization did not report results for volunteers receiving the low or high dose, nor did it provide data on antibody levels, *FiercePharma* noted.	China
Beijing Institute of Biological Products and China National Pharmaceutical Group (Sinopharm) *China*	Inactivated SARS-CoV-2	The two-dose vaccine protects rhesus macaques against SARS-CoV-2, according to a paper published in *Cell* in early June. In late June, Sinopharm announced results from the early trials that the vaccine was safe and that participants receiving the vaccine had high titers of antibodies.	Phase 1/2 clinical trial underway in China
Symvivo *Canada*	Orally administered *Bifidobacterium* probiotic engineered to carry DNA encoding the SARS-CoV-2 spike protein	In addition to this vaccine currently in human testing, two other candidates for COVID-19 are being developed by Symvivo.	Phase 1 clinical trial underway in British Columbia and Nova Scotia
BioNTech and Pfizer *Germany and the US*	Four RNA vaccine candidates are being tested in parallel.	Preliminary results from the early stage trial suggest that the vaccine is safe and, in the 24 patients analyzed, elicits higher levels of SARS-CoV-2 antibodies than infection with the virus, according to a preprint posted by the companies on July 1. Similar results were seen in an ongoing trial in Germany, according another preprint posted later in the month.	Phase 1/2 clinical trial underway in Germany and in Ohio, New York, and Maryland in the US, while China has approved a Phase 1 trial to begin. The companies plan to supply millions of vaccines by year end.
Shenzhen Geno-Immune Medical Institute *China*	Immune cells (human dendritic cells and T cells, or artificial antigen presenting cells) are engineered to express a synthetic minigene based on SARS-CoV-2 proteins and injected or infused into the patient.	The research institute modifies cells using lentivirus vectors that it has used to develop CAR T cell therapies as well as gene therapies.	A Phase 1/2 clinical trial is underway in China for the dendritic cell and T cell–based vaccines, and a Phase 1 trial is underway for a vaccine using artificial antigen presenting cells.
Clover Biopharmaceuticals *Australia*	The vaccine delivers pieces of the SARS-CoV-2 spike protein.	The Trimer-Tag platform used is the basis for other viral vaccines in development.	Phase 1 clinical trial underway clinical in Australia
Novavax *Australia*	Nanoparticles carrying antigens derived from the SARS-CoV-2 spike protein (with Matrix-M adjuvant)	In 2012, the company started development on a SARS vaccine that served as the basis for its new SARS-CoV-2 vaccine candidate.	Phase 1 clinical trial underway in Australia

Gamaleya Research Institute of Epidemiology and Microbiology, Health Ministry of the Russian Federation, Acellena Contract Drug Research and Development *Russia*	Adenovirus vector displaying the SARS-CoV-2 spike protein on its surface	Gamaleya Research Institute Director Alexander Gintsburg announced in May that he and other staff researchers had gotten the vaccine themselves, the AP reports.	Phase 1/2 clinical trials are underway in Russia to test liquid and powder forms of the vaccine.
Immunitor *Canada and Mongolia*	Heat-inactivated plasma from donors with COVID-19 taken as a pill daily for a month	The initial safety test will give volunteers the pill for 15 days.	Phase 1/2 clinical trial underway in British Columbia and Mongolia
Institute of Medical Biology at Chinese Academy of Medical Sciences, West China Second University Hospital, Yunnan Center for Disease Control and Prevention *China*	Inactivated SARS-CoV-2	Trial organizers announced that the study is moving into its second phase, which will include three dose groups and a placebo group.	Phase 1/2 clinical trial underway in China
Imperial College London	Self-amplifying RNA molecules are injected into the muscle.	The vaccine platform, which is designed to allow researchers to respond quickly to emerging pathogens, received $8.4 million from CEPI last December. “We cannot predict where or when Disease X will strike, but by developing these kinds of innovative vaccine technologies we can be ready for it,” CEPI CEO Richard Hatchett said at the time.	Phase 1 trial underway in the UK
CureVac *Belgium and Germany*	RNA vaccine; details not disclosed	CureVac reported in January that a Phase 1 trial of a comparable vaccine for rabies induced immune responses with just 1 microgram of mRNA, meaning it could be easy to scale up to produce mass quantities.	Phase 1 trial underway in Belgium and Germany; company says it could manufacture 10 million doses by that time.
Medicago	Virus-like particles that resemble SARS-CoV-2 are produced in a close relative of tobacco.	The company has a rotavirus vaccine in clinical trials that is based on virus-like particles, and another for norovirus in preclinical studies.	A Phase 1 trial has been approved
Altimmune	Undisclosed vaccination	The company is using the same	A Phase 2 trial has

Altimmune	Undisclosed vaccination delivered intranasally	The company is using the same technology to develop a flu vaccine that is in clinical trials.	A Phase 2 trial has been approved
AnGes, Japan Agency for Medical Research and Development *Japan*	Engineered circular DNA encoding the SARS-CoV-2 spike protein	The vaccine consists of two intramuscular injections.	Phase 1/2 trial underway in Japan
Aivita Biomedical *US*	A patient's own dendritic cells are modified to carry SARS-CoV-2 antigens and then reinfused.	Antigen-carrying dendritic cells triggered a response in the same patient's lymphocytes in vitro.	A Phase 1/2 trial has been approved to begin in California.
Genexine *South Korea*	DNA encoding the SARS-CoV-2 spike protein	The vaccine was shown to produce neutralizing antibodies in nonhuman primates.	Phase 1/2 trial underway in South Korea
Vaxine, Medytox *Australia*	Recombinant SARS-CoV-2 spike protein plus a polysaccharide adjuvant	Vaxine developed an experimental swine flu vaccine during the 2009 pandemic.	Phase 1 trial approved to begin in Australia
Zydus Cadila *India*	Engineered DNA plasmid encoding a SARS-CoV-2 antigen	In a preclinical study, the vaccine neutralized SARS-CoV-2 in a virus neutralization assay.	Phase 1/2 trial underway in India
Bharat Biotech *India*	Inactivated SARS-CoV-2	In guinea pigs and mice, the vaccine was safe and elicited an immune response.	Phase 1/2 trial underway in India
University of Pittsburgh School of Medicine	Microneedle patch delivers pieces of the spike protein through the skin.	Vaccinated mice produced antibodies specific to SARS-CoV-2 at levels that would likely neutralize the virus, according to a study published in *EBioMedicine* on April 2.	Expected to start clinical testing in the next few months
Janssen	Nonreplicating adenovirus 26 (Ad26) vector carrying undisclosed genetic material of SARS-CoV-2 is delivered via intramuscular injection.	Janssen is also developing other Ad26-based vaccine candidates, including its Ebola vaccine that was deployed in the Democratic Republic of Congo in November 2019.	Expected to start clinical testing in July; with BARDA's support, the company will scale up to produce up to 300 million doses of vaccine in the US each year
Generex Biotechnology	Undisclosed synthetic viral peptides are combined with proprietary Ii-Key immune system activation	The company has had success with the Ii-Key technology for other infectious diseases and for cancer in clinical trials.	Expected to start clinical testing "within 90 days," the company announced on February 27

Vaxart	A pill containing different SARS-CoV-2 antigens	After testing five different vaccine candidates in animals, the company chose its lead candidate, which generated immune responses after a single dose, for clinical testing. The company has other oral recombinant vaccine candidates that have shown success in clinical trials.	Expected to start clinical testing early in the second half of 2020
Takis Biotech and Applied DNA Sciences	The company is exploring five DNA-based candidates based on the SARS-CoV-2 spike protein.	The vaccine candidates contain PCR-produced pieces of linear DNA, as opposed to the more traditional circular plasmids, which could have several advantages including quick production. No vaccines using this approach have yet been tested in humans.	Expected to start clinical testing in the fall
Sanofi and GSK	Antigen based on SARS-CoV-2 spike protein (with adjuvant)	Sanofi uses the same recombinant DNA technology in a flu vaccine and in a SARS vaccine candidate that never entered clinical trials. Meanwhile, GSK's adjuvant, AS03, was used in vaccines the company made against the H1N1 and H5N1 pandemic flu viruses.	Expected to start clinical testing in September
Merck	A weakened measles virus vector carries undisclosed viral components	Merck is purchasing Vienna-based Themis, which has an existing measles vaccine, to develop the COVID-19 vaccine.	Expected to start clinical testing later this year
Merck	A vesicular stomatitis virus (VSV) carries undisclosed viral components	The VSV vector is used for Merck's existing Ebola vaccine.	Expected to start clinical testing later this year
Arcturus Therapeutics	Self-replicating mRNA encoding coronavirus proteins	The self-replicating mRNA platform is not the basis of any approved medicines, but preclinical results announced in April suggest the vaccine candidate triggers an immune response.	Expected to start clinical testing this summer

In addition to vaccine candidates specific to SARS-CoV-2, several trials are underway testing vaccines against different pathogens as well as nonspecific formulations designed to stimulate an innate immune response.

DEVELOPER(S)	VACCINE METHOD	EVIDENCE	STATUS
Multiple organizations *International*	The Bacille Calmette-Guerin (BCG) vaccine for tuberculosis consists of live attenuated *Mycobacterium bovis*.	Lower rates of COVID-19–related deaths in countries with mandatory BCG vaccination prompted the launch of several clinical trials to test whether the immune response triggered by the vaccine may protect against SARS-CoV-2.	Several Phase 3 and 4 trials are underway.
Kasr El Aini Hospital *Egypt*	The measles-mumps-rubella (MMR) vaccine consists of live-attenuated strains of the three viruses.	Epidemiological data have revealed that places where the MMR vaccine is given as standard medical care have lower COVID-19 death rates than areas where MMR vaccination is not standard. Additionally, sailors aboard the *U.S.S. Roosevelt* who tested positive for COVID-19 had mostly mild symptoms, which some researchers suspect may have been due to administration of the MMR vaccine to all US Navy recruits.	Phase 3 trial underway in Egypt
Immunovative Therapies, Mirror Biologics *US*	An off-the-shelf living immune cell	The affiliated companies are currently testing the formulation as a therapeutic vaccine for chemotherapy-refractory metastatic cancers.	A Phase 1/2 trial for healthy older adults has been approved to begin in New York.
Canadian Cancer Trials Group, others *Canada*	Heat-killed *Mycobacterium obuense*	The vaccine is intended to stimulate nonspecific innate immunity. The company is also testing the vaccine in clinical trials for cancer.	A Phase 3 trial has been approved to begin in Canada.
Bandim Health Project *Guinea-Bissau*	Oral polio vaccine, an attenuated strain of the poliovirus	Researchers argue that the vaccine is safer and available in greater quantities than the BCG vaccine against tuberculosis, which is also being tested as a possible COVID-19 preventive.	A Phase 4 trial has been approved to begin in Guinea-Bissau in West Africa.
Inmunotek, BioClever *Mexico*	A mixture of inactivated bacteria	The vaccine is intended to stimulate nonspecific innate immunity.	A Phase 3 trial for healthcare workers has been approved to begin in Mexico.
Pulmotect *US*	An inhaled combination of two synthetic Toll-like receptor agonists	The vaccine was originally developed as a potential therapeutic for cancer and has undergone early stage clinical testing. In mice, it provided protection against a range of respiratory pathogens, including MERS and SARS.	A Phase 2 trial for people with known SARS-CoV-2 exposure is underway in several US states.

Correction (June 11, 2020): An earlier version of this table stated that Janssen's adenovirus-based COVID-19 vaccine candidate is administered intranasally. In fact, the vaccine is administered via intramuscular injection. The Scientist *regrets the error.*

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coronavirus, COVID-19, disease & medicine, drug development, epidemic, infectious disease, outbreak, pandemic, SARS-CoV-2, vaccine, vaccine design, vaccine trials