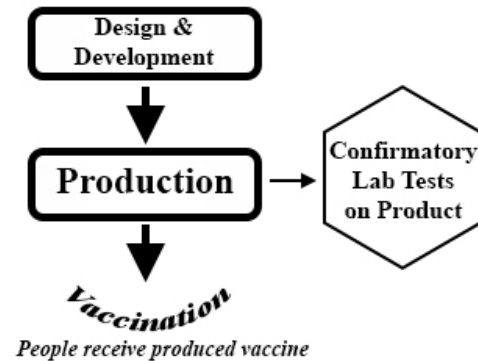


Update: COVID-19 Vaccine Candidates and Abortion-Derived Cell Lines

Accurate information about the development and production of COVID-19 vaccines is essential, especially because many proposed candidates use newer molecular technologies for production of a viral vaccine. One concern regarding the ethical assessment of viral vaccine candidates is the potential use of abortion-derived cell lines in the development, production or testing of a vaccine. This analysis utilizes data from the primary scientific literature when available, along with data from clinical trial documents, reputable vaccine tracking websites, and published commercial information.¹ It is the hope that by providing accurate data, recipients can make well-informed decisions regarding vaccine choices.

For additional background and guidance, please see:

- * [A Visual Aid to Viral Infection and Vaccine Production](#) for a visual primer on the various strategies for viral vaccine production.
- * [COVID-19 Vaccines & Fetal Cell Lines](#) for an infographic description of how fetal cell lines are sometimes used to produce vaccines.
- * [Chart of Operation Warp Speed Vaccines](#) streamlined view of the leading vaccine candidates.



Flow Chart for Creation and Testing of Vaccines
















Design & Development: conceptualization, preparatory experiments, and specification for how vaccine will be constructed and produced.

Production: process used to manufacture final vaccine to be given to people.













Confirmatory Lab Tests on Product: tests to analyze quality, nucleic acid or protein sequence, protein confirmation, antibody reactivity, etc. of final vaccine product.













Vaccination: giving final produced vaccine to people.



















<u>Analysis of SARS-CoV-2 (COVID-19) Vaccine Candidates</u>							
<i>Last Updated 4 January 2021</i>							
					DOES NOT USE abortion-derived cell line		
					DOES USE abortion-derived cell line		
					SOME tests DO NOT use abortion-derived cells, SOME DO.		
					Currently undetermined		
Sponsor(s) ¹	Country	Strategy ²	Clinical Trial Status ³	Public Funding ⁴	Design & Development	Production	Confirmatory Lab Tests
WHOLE VIRUS VACCINE – LIVE ATTENUATED or INACTIVATED							
Beijing Institute of Biological Products/ Sinopharm	China	Inactivated virus “BBIBP-CorV” Given: Intramuscular	Phase 3		Vero monkey cells	Vero monkey cells	Cytopathic test










		2 doses (2 weeks apart)	<i>Early approval in China</i> Phase 3 Phase 1/2		Wang et al., Cell 182, P713, 6Aug2020	Wang et al., Cell 182, P713, 6Aug2020	Vero monkey cells Wang et al., Cell 182, P713, 6Aug2020
Wuhan Institute of Biological Products/ Sinopharm	China	Inactivated virus “New Crown COVID-19” Given: Intramuscular 2 doses (2 weeks apart)	Phase 3 <i>Early approval in China</i> Phase 1/2		 Vero monkey cells Xia et al., JAMA 324, 951, 13Aug2020	 Vero monkey cells Xia et al., JAMA 324, 951, 13Aug2020	 Plaque reduction neutralization test Vero monkey cells Xia et al., JAMA 324, 951, 13Aug2020
Bharat Biotech/Indian Council of Medical Research	India	Inactivated virus “COVAXIN” “BBV152” Given: Intramuscular 2 doses (2 weeks apart)	<i>India EUA granted</i> Phase 3 Phase 1/2 Phase 1/2		 Vero monkey cells Yadav et al., ResearchSquare 10Sept2020	 Vero monkey cells Yadav et al., ResearchSquare 10Sept2020	 Antibody ELISA Plaque reduction Vero monkey cells Yadav et al., ResearchSquare 10Sept2020
John Paul II Medical Research Institute	USA	Live attenuated virus	Pre-clinical		 Ethical cell lines as a matter of policy	 Perinatal human cells (term umbilical cord and placental)	
Sinovac Biotech Co., Ltd.	China	Inactivated virus “PiCoVacc” Given: Intramuscular 2 doses (2 weeks apart)	Phase 3 <i>Early approval in China</i> Phase 3 Phase 1/2 Phase 1/2		 Vero monkey cells	 Vero monkey cells Gao et al., Science 369, 77, 3July2020	 protein test HEK293 cells Supplement Gao et al., Science 369, 77, 3July2020
Valneva and Dynavax	France USA UK	Inactivated Virus “VLA2001” plus adjuvant CpG1018 Given: Intramuscular	Pre-clinical		 Vero monkey cells	 Vero monkey cells Same platform as IXIARO, Valneva press release, 22April2020	













VIRAL VECTOR-BASED VACCINE							
Altimmune	USA	Replication-deficient Adenovirus vector “AdCOVID” Given: Intranasal	Pre-clinical		◆ PER.C6 cells	◆ PER.C6 cells Same platform as NasoVAX NasoVAX uses PER.C6 Licensed PER.C6 from Janssen	◆
AstraZeneca University of Oxford	USA UK	Replication-deficient Adenovirus vector “AZD1222” “ChAdOX1nCoV-19” Given: Intramuscular 2 doses (4 weeks apart)	UK EUA granted India EUA granted Phase 3 Phase 3 Phase 3 Phase 2/3 Phase 2/3 Phase 1/2 Phase 1/2	<i>Operation Warp Speed</i> HHS-BARDA \$1.2 Billion CEPI up to \$384 Million	◆ HEK293 cells	◆ HEK293 cells van Doremalen et al., Nature preprint, 30July2020	◆
CanSino Biologics, Inc. Beijing Institute of Biotechnology, Academy of Military Medical Sciences, PLA of China	China	Replication-deficient Adenovirus vector “Ad5-nCoV” Given: Intramuscular 1 dose	Phase 3 Phase 3 Phase 2 Phase 2 Phase 1 Phase 1		◆ HEK293 cells	◆ HEK293 cells Biospace, 12May2020	◆
Gamaleya Research Institute	Russia	Replication-deficient Adenovirus vectors (rAd26-S+rAd5-S) “Sputnik V” Given: Intramuscular 2 doses (3 weeks apart)	Phase 3 <i>Early approval in Russia</i> <i>August 2020</i> Phase 1/2 Phase 1/2		◆ HEK293 cells	◆ HEK293 cells	◆
ImmunityBio and NantKwest	USA	Replication-deficient Adenovirus vector recombinant “hAd5 S-Fusion + N-ETSD” Given: Subcutaneous	Phase 1		◆ E.C7 cells (derivative of HEK293 cells) Rice et al., bioRxiv 30July2020	◆ E.C7 cells (derivative of HEK293 cells) Rice et al., bioRxiv 30July2020	◆ Protein and antibody tests HEK293T cells










							Rice et al., bioRxiv 30July2020 Seiling et al., medRxiv 6Nov2020
Institut Pasteur and Themis and Merck	USA France	Replication-competent recombinant measles virus “V591” (formerly “TMV-083”) Given: Intramuscular 1 or 2 doses (4 weeks apart)	Phase 1/2 Phase 1	CEPI up to \$4.9 Million	 HEK293T Development and rescue of recombinant measles virus Hörner et al., PNAS 22Dec2020 Hörner et al. Supplement “SARS-CoV-2 S-encoding vaccine candidates... were generated as described previously”	 Vero monkey cells Hörner et al., PNAS 22Dec2020 Hörner et al. Supplement	 Lentiviral vectors for antigenic DC Fusogenic test HEK293T Fusogenic test S protein expression Vero monkey cells Hörner et al., PNAS 22Dec2020 Hörner et al. Supplement
Israel Institute for Biological Research (IIBR)	Israel	Replication-competent recombinant vesicular stomatitis virus (VSVΔG) “IIBR-100” Given: Intramuscular 1 dose	Phase 1		 BHK hamster cells Vero monkey cells Yahalom-Ronen et al., bioRxiv 19June2020	 Vero monkey cells Yahalom-Ronen et al., bioRxiv 19June2020	 Plaque reduction; immunofluorescence Vero monkey cells Yahalom-Ronen et al., bioRxiv 19June2020
Janssen Research & Development, Inc. Johnson & Johnson	USA	Replication-deficient Adenovirus vector “Ad26.COVS-2-S” Given: Intramuscular 1 or 2 doses (8 weeks apart)	Phase 3 Phase 3 Phase 1/2	<i>Operation Warp Speed</i> HHS-BARDA \$1,457,887,081 total	 PER.C6 cells	 PER.C6 cells Tostanoski et al., Nature Medicine, 3Sept2020; Mercado et al., Nature 30July2020 J&J, 30March2020; Janssen Vaccine Technologies	
Merck and IAVI	USA	Replication-competent recombinant vesicular stomatitis virus (VSVΔG) “V590” Given: Intramuscular	Phase 1	<i>Operation Warp Speed</i> HHS-BARDA \$38,033,570	 Vero monkey cells	 Vero monkey cells Use rVSV Ervebo platform	

						Ervebo uses Vero cell culture-11 Description	
Shenzhen Geno-immune Medical Institute	China	Lentivirus minigenes + Adult human APC (antigen-presenting cells)	Phase 1		?		?
Shenzhen Geno-immune Medical Institute	China	Lentivirus minigenes + Adult human CD/T cells (dendritic cells and T cells) "LV-SMENP-DC"	Phase 1/2		?		?
Vaxart	USA	Replication-deficient Adenovirus vector "VXA-CoV2-1" plus dsRNA adjuvant Given: Oral	Phase 1		 HEK293 cells	 HEK293 cells Moore et al., bioRxiv 6Sept2020	
PROTEIN-BASED VACCINE							
Anhui Zhifei Longcom Biopharmaceutical/Institute of Microbiology, Chinese Academy of Sciences	China	Protein vaccine Recombinant RBD dimer plus adjuvant Given: Intramuscular 2 or 3 doses (30 days apart)	Phase 3 Phase 2 Phase 1/2 Phase 1		 HEK293T cells Dai et al., Cell 6Aug2020	 CHO hamster cells Dai et al., Cell 6Aug2020	 Pseudovirus HEK293T cells Dai et al., Cell 6Aug2020
Clover Biopharmaceuticals, Inc.	China	Protein vaccine "SCB-2019" plus adjuvant CpG 1018 Given: Intramuscular	Phase 1	CEPI up to \$69.5 Million	 cDNA in expression vector; transfect CHO hamster cells Liang et al., bioRxiv, 24Sept2020 Trimer-Tag system; Liu et al., Scientific Reports 2017	 CHO hamster cells Liang et al., bioRxiv, 24Sept2020	 Pseudovirus HEK293 cells Ref'd: Nie et al., Emerging Microbes & Infections 24Mar2020 Cytopathic effect Vero monkey cells Liang et al., bioRxiv, 24Sept2020
Federal Budgetary Research Institution State Research Center of Virology and Biotechnology "Vektor"	Russia	Protein vaccine "EpiVacCorona" chemically synthesized peptide antigens of	<i>Early approval in Russia Oct 2020</i>		?	 chemically synthesized peptide antigens	?

		SARS-CoV-2, conjugated to a carrier protein adsorbed on an aluminum-containing adjuvant Given: Intramuscular 2 doses (3 weeks apart)	Phase 1 Phase 1				
John Paul II Medical Research Institute	USA	Recombinant Protein Perinatal human cells (term umbilical cord and placental)	Pre-clinical		 Ethical cell lines as a matter of policy	 Perinatal human cells (term umbilical cord and placental)	
Kentucky BioProcessing, Inc. (British American Tobacco)	USA	Protein vaccine "KBP-201" Plant-expressed RBD Given: Intramuscular 2 doses (3 weeks apart)	Phase 1/2		 Recombinant DNA sequence for RBD of SARS-CoV-2	 Plant expression of RBD peptide	
Medicago	Canada	Protein on Virus-Like Particle "CoVLP" Plant-expressed spike protein particle with adjuvant, CpG1018 or AS03 Given: Intramuscular 2 doses (3 weeks apart)	Phase 2/3 Phase 2 Phase 1		 Recombinant DNA sequence in <i>Agrobacterium</i> , transformation of plant cells	 Plant expression of protein and VLP Ward et al., medRxiv 6Nov2020	 Pseudovirus HEK293 cells Ward et al., medRxiv 6Nov2020
Novavax	USA	Protein vaccine "NVX-CoV2373" Baculovirus expression plus Matrix M adjuvant Given: Intramuscular 2 doses (3 weeks apart)	Phase 3 Phase 3 Phase 2 Phase 1	<i>Operation Warp Speed</i> HHS-BARDA \$1,600,434,523 CEPI up to \$388 Million		 Sf9 insect cells Bangaru et al., bioRxiv preprint, 6Aug2020; Graphical view	 Pseudovirus HEK293 cells Bangaru et al., bioRxiv preprint, 6Aug2020
Sanofi and GSK Protein Sciences	USA France	Protein vaccine Baculovirus expression plus AS03 adjuvant Given: Intramuscular 2 doses (3 weeks apart)	Phase 1/2	<i>Operation Warp Speed</i> HHS-BARDA \$2,072,775,336 total		 Sf9 insect cells Baculovirus expressed recombinant protein ;	
Sorrento	USA	Protein vaccine	Pre-clinical				

		“T-VIVA-19” SARS-Cov-2 spike protein S1 domain fused with human IgG-Fc Given: Intramuscular			DNA fragment developed in lab Herrmann et al., bioRxiv preprint, 30June2020	CHO cells Herrmann et al., bioRxiv preprint, 30June2020	Antibody ELISA; Neutralization assays Vero monkey cells Herrmann et al., bioRxiv preprint, 30June2020
Sorrento	USA	Protein vaccine “STI-6991” SARS-Cov-2 spike protein expressed on K562 cells	Pre-clinical		?	 K562 cells Concept: Ji et al., Medicine in Drug Discovery, March2020	?
University of Pittsburgh	USA	Protein vaccine Adenovirus-expressed recombinant proteins “PittCoVacc” Given: Microneedle arrays	Pre-clinical		 HEK293 cells	 HEK293 cells Kim et al., EBioMedicine, 2April2020	
University of Queensland and CSL Ltd.	Australia	Protein vaccine “V451” Recombinant protein with proprietary molecular clamp Given: Intramuscular	HALTED Phase 1 Phase 1 Phase 1	CEPI up to \$4.5 Million		 expiCHO hamster cells	?
RNA VACCINE							
Arcturus Therapeutics	USA	mRNA vaccine self-transcribing, replicating “LUNAR-CoV19” (“ARCT-021”) <i>in vitro</i> transcription reaction with T7 RNA polymerase from STARR plasmid template LUNAR proprietary lipid nanoparticle encapsulated Given: Intramuscular 1 dose	Phase 2 Phase 1/2		 Sequence designed on computer	 No cells used de Alwis et al., bioRxiv 3Sept2020	 protein test HEK293 de Alwis et al., bioRxiv 3Sept2020

CureVac	Germany	mRNA vaccine non-replicating “CVnCoV” <i>in vitro</i> transcription lipid nanoparticle encapsulated Given: Intramuscular 2 doses (4 weeks apart)	Phase 2/3 Phase 2 Phase 1	CEPI up to \$15.3 Million	 Sequence designed on computer	 No cells used Rauch et al., bioRxiv 23Oct2020	 Protein test Reticulocyte lysate, HeLa cells Rauch et al., bioRxiv 23Oct2020
Moderna, Inc. with National Institutes of Health	USA	mRNA vaccine non-replicating “mRNA-1273” T7 RNA polymerase-mediated transcription from DNA plasmid template LNP (lipid nanoparticle) encapsulated Given: Intramuscular 2 doses (4 weeks apart)	FDA Emergency Use Authorization Approved Phase 3 Phase 2 Phase 1	<i>Operation Warp Speed</i> HHS-BARDA \$2,479,894,979 total CEPI up to \$1 Million	 Sequence designed on computer	 No cells used Corbett et al., Nature, 5Aug2020	 protein test & pseudovirus HEK293 cells Corbett et al., Nature, 5Aug2020
Pfizer and BioNTech	USA Germany	mRNA vaccine non-replicating “BNT-162a1,b1,b2,b3,c2” nucleoside-modified mRNA <i>in vitro</i> transcribed by T7 polymerase from a plasmid DNA template LNP (lipid nanoparticle) encapsulated Given: Intramuscular 2 doses (3 weeks apart)	FDA Emergency Use Authorization Approved <i>UK EUA granted</i> Phase 2/3 Phase 1/2 Phase 1/2 Phase 1 Phase 1	<i>Operation Warp Speed</i> HHS-BARDA \$1.95 Billion	 Sequence designed on computer	 No cells used Vogel et al., bioRxiv 8Sept2020	 protein test & pseudovirus HEK293 cells Vogel et al., bioRxiv 8Sept2020
Sanofi Pasteur and Translate Bio	USA France	mRNA vaccine non-replicating “MRT5500” synthesized by <i>in vitro</i> transcription employing RNA polymerase with a plasmid DNA template	Pre-clinical		 Sequence designed on computer	 No cells used Kalnin et al., bioRxiv 14Oct2020 mRNA production in the lab ; Translate Bio scientific platform	 protein test & pseudovirus HEK293 cells Kalnin et al., bioRxiv 14Oct2020

		LNP (lipid nanoparticle) encapsulated Given: Intramuscular					
DNA VACCINE							
Genexine	Korea	DNA vaccine “GX-19” DNA synthesized in vitro, placed in plasmid vector Given: Intramuscular and Electroporation 2 doses (4 weeks apart)	Phase 1/2		 Sequence designed on computer	 No cells used Seo et al., bioRxiv 10Oct2020	
Inovio Pharmaceuticals	USA	DNA vaccine “INO-4800” DNA synthesized in vitro, placed in plasmid vector Given: Intradermal Electroporation 2 doses (4 weeks apart)	Phase 2/3 Phase 1/2 Phase 1	<i>Operation Warp Speed</i> CEPI up to \$22.5 Million	 Sequence designed on computer	 No cells used Smith et al., Nature 20May2020	 protein test & pseudovirus HEK293 cells Smith et al., Nature 20May2020
Symvivo Corporation	Canada	DNA vaccine Genetically engineered <i>Bifidobacterium longum</i> “bacTRL-spike” Given: Oral, bacteria bind to gut lining 1 dose	Phase 1			 No cells used	

1. Data accumulated from primary literature as referenced in the Chart; AND “COVID-19 Treatment and Vaccine Tracker,” Milken Institute, <https://covid-19tracker.milkeninstitute.org/> ; AND “Draft landscape of COVID-19 candidate vaccines,” World Health Organization (WHO), <https://www.who.int/publications/m/item/draft-landscape-of-covid-19-candidate-vaccines>
2. Prentice, DA and Sander Lee, T. June 15, 2020. A Visual Aid to Viral Infection and Vaccine Production. *On Science Series 1*. Accessed 19 June 2020 at: <https://lozierinstitute.org/a-visual-aid-to-viral-infection-and-vaccine-production/>
3. Phases of Clinical Trials: Pre-clinical- laboratory and animal studies; Phase I- 10-100 people, study safety and dosage; Phase II- tens to hundreds of people, study efficacy, dosage, side effects; Phase III- hundreds to thousands of people, study efficacy and adverse reactions.
4. HHS-BARDA = U.S. Health and Human Services-Biomedical Advanced Research and Development Authority; CEPI = Coalition of Epidemic Preparedness Innovations; BARDA’s rapidly-expanding COVID-19 medical countermeasure portfolio. Accessed 29 Sept 2020 at <https://www.medicalcountermeasures.gov/app/barda/coronavirus/COVID19.aspx>; CEPI’s COVID-19 Vaccine Portfolio, Accessed 29 Sept 2020 at <https://cepi.net/COVAX/>