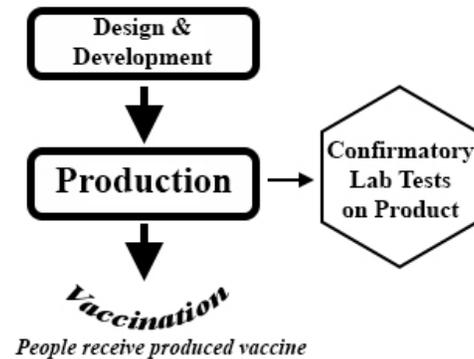


Update: COVID-19 Vaccine Candidates and Abortion-Derived Cell Lines

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 3 December 2020</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 Phase 3		Vero monkey cells	Vero monkey cells	Cytopathic test

			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	Phase 3 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 “BBV152” Given: Intramuscular	Phase 3 Phase 1/2 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	Phase 3 Phase 3 Phase 1/2 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	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	Phase 3 Phase 3 Phase 2 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	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 “TMV-083” Given: Intramuscular	Phase 1	CEPI up to \$4.9 Million		 Vero monkey cells	
Israel Institute for Biological Research (IIBR)	Israel	Replication-competent recombinant vesicular stomatitis virus (VSVΔG) “IIBR-100” Given: Intramuscular	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.COV2-S” Given: Intramuscular	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”	Phase 1		 HEK293 cells	 HEK293 cells	

		plus dsRNA adjuvant Given: Oral				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	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 SARS-CoV-2, conjugated to a carrier protein adsorbed on an aluminum-containing adjuvant Given: Intramuscular	<i>Early approval in Russia Oct 2020</i> Phase 1 Phase 1			 chemically synthesized peptide antigens	
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	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	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	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	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 "T-VIVA-19" SARS-Cov-2 spike protein S1 domain fused with human IgG-Fc Given: Intramuscular	Pre-clinical		 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"	Pre-clinical		 HEK293 cells	 HEK293 cells Kim et al., EBioMedicine, 2April2020	

		Given: Microneedle arrays					
University of Queensland and CSL Ltd.	Australia	Protein vaccine “V451” Recombinant protein with proprietary molecular clamp Given: Intramuscular	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	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	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	<i>FDA Emergency Use Authorization Requested</i> 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	<i>FDA Emergency Use Authorization Requested 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 LNP (lipid nanoparticle) encapsulated Given: Intramuscular	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
DNA VACCINE							
Genexine	Korea	DNA vaccine “GX-19” DNA synthesized <i>in vitro</i> , placed in plasmid vector Given: Intramuscular and Electroporation	Phase 1/2		 Sequence designed on computer	 No cells used Seo et al., bioRxiv 10Oct2020	
Inovio Pharmaceuticals	USA	DNA vaccine “INO-4800” DNA synthesized <i>in vitro</i> , placed in plasmid vector Given: Intradermal Electroporation	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>	Phase 1			 No cells used	

		“bacTRL-spike” Given: Oral, bacteria bind to gut lining					
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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>

NOTE that patents are not considered because they are unreliable sources; even the most relevant patents are prospective documents that provide examples of potential use, but do not provide information about actual, current application of an invention or technology.

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/>