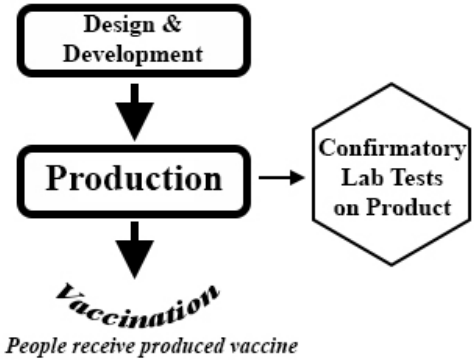
Update: COVID-19 Vaccine Candidates and Abortion-Derived Cell Lines

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.

Analysis of SARS-CoV-2 (COVID-19) Vaccine Candidates

Last Updated 4 January 2021

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	Confirm-atory 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)	*Early approval in China* **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** *Early approval in China* **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)	*India EUA granted* **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 2 doses (2 weeks apart)	**Phase 3** *Early approval in China* **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 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**	*Operation Warp Speed* 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 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** *Early approval in Russia August 2020* **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.COV2-S" Given: Intramuscular 1 or 2 doses (8 weeks apart)	**Phase 3** **Phase 3** **Phase 1/2**	*Operation Warp Speed* 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**	*Operation Warp Speed* 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	*Early approval in Russia Oct 2020*		?	 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 *Agrobacterium*, 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**	*Operation Warp Speed* 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**	*Operation Warp Speed* 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") *in vitro* 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" *in vitro* 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**	*Operation Warp Speed* 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 *in vitro* 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*** *UK EUA granted* **Phase 2/3** **Phase 1/2** **Phase 1/2** **Phase 1** **Phase 1**	*Operation Warp Speed* 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 in vitro 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**	*Operation Warp Speed* 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 *Bifidobacterium longum* "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
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/