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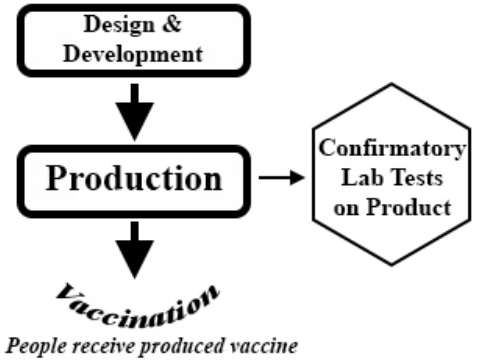
Update: COVID-19 Vaccine Candidates and Abortion-Derived Cell Lines

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 3 March 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"	**Phase 3**		Vero monkey cells	Vero monkey cells	Cytopathic test

		Given: Intramuscular 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** **Phase 3** **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 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*
Institute of Medical Biology, Chinese Academy of Medical Sciences	China	Inactivated virus "SARS-CoV-2 vaccine" Given: Intramuscular 2 doses (4 weeks apart)	**Phase 3** **Phase 1/2** **Phase 1/2**		Vero monkey cells Pu *et al.*, *medRxiv, 6Oct2020*	Vero monkey cells Pu *et al.*, *medRxiv, 6Oct2020*	Antibody ELISA Neutralizing antibody cytopathic effect Vero monkey cells Pu *et al.*, *medRxiv, 6Oct2020*; Supplement
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)	
Research Institute for Biological Safety Problems	Kazakhstan	Inactivated virus "QazCovid-in" Given: Intramuscular	**Phase 3** **Phase 1/2**				

		2 doses (3 weeks apart)					
Sinovac Biotech Co., Ltd.	China	Inactivated virus "CoronaVac" (formerly PiCoVacc) Given: Intramuscular 2 doses (2 weeks apart)	**Phase 4** *China granted conditional marketing authorization 8Feb2021* *Chile, Brazil, Turkey, Indonesia EUA granted* **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 2 doses (3 weeks apart)	**Phase 1/2**		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 1-2 doses	**Phase 1**		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**	*Operation Warp Speed* HHS-BARDA $1.2 Billion CEPI up to $384 Million	HEK293 cells	HEK293 cells van Doremalen *et al.*, *Nature*, 30July2020	HEK293 cells van Doremalen *et al.*, *Nature*, 30July2020 MRC-5 cells

			Phase 3 **Phase 2/3** **Phase 2/3** **Phase 1/2** **Phase 1/2**				Almuqrin *et al.*, *ResearchSquare* 20Oct2020
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) "Gam-COVID-Vac" "Sputnik V" Given: Intramuscular 2 doses (3 weeks apart)	**Phase 3** **Phase 3** *EUA in 30 countries as of Feb2021* *Early approval in Russia August 2020* **Phase 1/2** **Phase 1/2**		HEK293 cells	HEK293 cells Gamaleya has not published details on this vaccine, but has posted information on use of cell lines for their other adenoviral vaccines	
ImmunityBio and NantKwest	USA	Replication-deficient Adenovirus vector recombinant "hAd5 S-Fusion + N-ETSD" Given: Subcutaneous	**Phase 1** **Phase 1** **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	**Development Discontinued** **Phase 1/2** **Phase 1**	CEPI up to $4.9 Million	HEK293T Development and rescue of recombinant measles virus Hörner *et al.*, *PNAS* 22Dec2020	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

		1 or 2 doses (4 weeks apart)			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
Israel Institute for Biological Research (IIBR)	Israel	Replication-competent recombinant vesicular stomatitis virus (VSVΔG) "IIBR-100" Given: Intramuscular 1 dose	**Phase 1/2**		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 dose (some trials use 2 doses, 8 weeks apart)	**FDA Emergency Use Authorization Approved** **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	
Rega Institute, KU Leuven	Belgium	Replication-competent attenuated yellow fever vaccine (YF17D) vector "YF-S0" 1 dose	Pre-clinical		BHK-21J hamster cells Sanchez-Felipe *et al., Nature* 1Dec2020	BHK-21J hamster cells Sanchez-Felipe *et al., Nature* 1Dec2020	Antibody titer Pseudovirus HEK293T cells Immunoblot BHK-21J hamster cells Sanchez-Felipe *et al., Nature* 1Dec2020
Merck and IAVI	USA	Replication-competent recombinant vesicular stomatitis virus (VSVΔG) "V590" Given: Intramuscular	**Development Discontinued** **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 2 doses (3 weeks apart)	**Phase 2/3** **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
COVAXX and United Biomedical	USA Taiwan	Protein vaccine "UB-612" S1-RBD-protein; Multitope Peptide-Based Vaccine (MVP) Given: Intramuscular	**Phase 2/3** **Phase 1**		■ cDNA in expression vector; transfect CHO hamster cells Guirakhoo *et al., bioRxiv,* 30Nov2020	■ CHO hamster cells Guirakhoo *et al., bioRxiv,* 30Nov2020	■◆ Antibody-blocked binding to hACE2 HEK293

		2 doses (4 weeks apart)					Guirakhoo *et al., bioRxiv,* 30Nov2020
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 2 doses (3 weeks apart)	*Early approval in Russia Oct 2020* **Phase 1/2**		?	chemically synthesized peptide antigens	?
Instituto Finlay de Vacunas	Cuba	Protein vaccine "Finlay-FR-1" Receptor-Binding Domain (RBD) SARS-CoV-2 spike + adjuvant Given: Intramuscular 2 doses (4 weeks apart)	**Phase 1/2** **Phase 1**		? RBD produced in mammalian cells Garcia-Rivera, *MEDICC Review,* 30Oct2020	? RBD produced in mammalian cells Garcia-Rivera, *MEDICC Review,* 30Oct2020	?
Instituto Finlay de Vacunas	Cuba	Protein vaccine "Finlay-FR-2" Receptor-Binding Domain (RBD) SARS-CoV-2 spike chemically bound tetanus toxoid + adjuvant Given: Intramuscular 2 doses (4 weeks apart)	**Phase 2** **Phase 1**		? RBD produced in mammalian cells Garcia-Rivera, *MEDICC Review,* 30Oct2020	? RBD produced in mammalian cells Garcia-Rivera, *MEDICC Review,* 30Oct2020	?
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.*, *Science*, 27Nov2020 Bangaru *et al.*, Supplement Bangaru *et al.*, *bioRxiv* preprint, 6Aug2020; Graphical view	Pseudovirus HEK293 cells Bangaru *et al.*, *Science*, 27Nov2020 Bangaru *et al.*, Supplement 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 2** **Phase 1/2**	*Operation Warp Speed* 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" 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 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 3** **Phase 2/3** **Phase 2** **Phase 1**	CEPI up to $15.3 Million	 Sequence designed on computer	 No cells used Rauch *et al.*, *bioRxiv* 9Feb2021	 Protein test Reticulocyte lysate, HeLa cells Rauch *et al.*, *bioRxiv* 9Feb2021
Moderna, Inc. with National Institutes of Health	USA	mRNA vaccine non-replicating "mRNA-1273"	***FDA Emergency Use Authorization Approved***	*Operation Warp Speed* HHS-BARDA	 Sequence designed on computer	 No cells used Corbett *et al.*, *Nature* , 5Aug2020	 protein test & pseudovirus HEK293 cells

		T7 RNA polymerase-mediated transcription from DNA plasmid template LNP (lipid nanoparticle) encapsulated Given: Intramuscular 2 doses (4 weeks apart)	**Phase 3** **Phase 2** **Phase 1**	$2,479,894,979 total CEPI up to $1 Million			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
Providence Therapeutics	Canada	mRNA vaccine "PTX-COVID19-B" Synthesized mRNA LNP (lipid nanoparticle) encapsulated Given: Intramuscular 2 doses (4 weeks apart)	**Phase 1**		?	No cells used *Cision*, 5Aug2020 Providence Therapeutics	?
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 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

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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** **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 2** **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
Osaka University, AnGes, Takara Bio	Japan	DNA vaccine "AG0301-COVID19" "AG0302-COVID19" Chemically synthesized plasmid vector grown in *E. coli* Pressure injector Given: Intramuscular 2 doses (2 weeks apart)	**Phase 2/3** **Phase 1/2** **Phase 1/2**		Sequence designed on computer	No cells used *E. coli* Nishikawa *et al.*, *bioRxiv*, 14Jan2021	Virus neutralization Vero E6 monkey cells Nishikawa *et al.*, *bioRxiv*, 14Jan2021
Symvivo Corporation	Canada	DNA vaccine "bacTRL-spike" Genetically engineered *Bifidobacterium longum* Given: Oral, bacteria bind to gut lining 1 dose	**Phase 1**		?	No cells used	?
Zydus Cadila	India	DNA vaccine "ZyCov-D" Chemically synthesized plasmid vector grown in *E. coli* Given: Intradermal 3 doses (4 weeks apart)	**Phase 3** **Phase 1/2**		Sequence designed on computer	No eukaryotic cells used *E. coli* Dey *et al.*, *bioRxiv* 26Jan2021	Expression analysis Plaque reduction Vero monkey cells Dey *et al.*, *bioRxiv* 26Jan2021

							Yadav *et al.*, *bioRxiv* 3Feb2021

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/