Supplemental Online Content

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eTable 1. Patents Associated with mRNA COVID-19 Vaccines.

Year	Patent Number	Title
2003	US7901708B2	Liposomal apparatus and manufacturing methods
2004	US7803397B2	Polyethyleneglycol-modified lipid compounds and uses thereof
2005	US7745651B2	Cationic lipids and methods of use
2005	US7799565B2	Lipid encapsulated interfering RNA
2006	US7982027B2	Lipid encapsulated interfering RNA
2006	US9005654B2	Systems and methods for manufacturing liposomes
2006	US8278036B2	RNA containing modified nucleosides and methods of use thereof
2006	US7838658B2	siRNA silencing of filovirus gene expression
2006	US8101741B2	Modified siRNA molecules and uses thereof
2007	US7915399B2	Modified siRNA molecules and uses thereof
2008	WO2009086558A1	Improved compositions and methods for the delivery of nucleic acids
2009	US8188263B2	Modified siRNA molecules and uses thereof
2009	US8058069B2	Lipid formulations for nucleic acid delivery
2009	US9139554B2	Amino lipids and methods for the delivery of nucleic acids
2010	US8283333B2	Lipid formulations for nucleic acid delivery
2010	US8936942B2	Polyethyleneglycol-modified lipid compounds and uses thereof
2010	WO2011036557A1	Compositions and methods for enhancing cellular uptake and intracellular delivery of lipid particles
2010	US9012219B2	RNA preparations comprising purified modified RNA for reprogramming cells
2010	US8329070B2	Liposomal apparatus and manufacturing method
2011	US9006417B2	Non-liposomal systems for nucleic acid delivery
2011	US8492359B2	Lipid formulations for nucleic acid delivery
2011	US20140030808A1	Method for cellular RNA expression
2011	WO2013087083A1	Particles comprising single stranded RNA and double stranded RNA for immunomodulation
2012	US9758795B2	Nucleic acid-containing lipid particles and related methods
2012	US8691966B2	RNA containing modified nucleosides and methods of use thereof
2012	WO2013059922A1	Limit size lipid nanoparticles and related methods
2013	US9669089B2	Nucleic acid comprising or coding for a histone stem-loop and a poly(A) sequence or a polyadenylation signal for increasing the expression of an encoded pathogenic antigen
2013	US8835108B2	RNA containing modified nucleosides and methods of use thereof
2013	US8748089B2	RNA containing modified nucleosides and methods of use thereof
2013	US8822668B2	Lipid formulations for nucleic acid delivery
2013	US9074208B2	Modified siRNA molecules and uses thereof
2013	US9950065B2	Particles comprising a shell with RNA
2013	WO2015043613A1	Particles comprising a shell with RNA
2013	US9814777B2	Targeting lipids
2014	US9504651B2	Lipid compositions for nucleic acid delivery
2014	US20150017211A1	Delivery and formulation of engineered nucleic acids
2014	US9750824B2	RNA containing modified nucleosides and methods of use thereof
2014	US9364435B2	Lipid formulations for nucleic acid delivery
2014	US9694077B2	Lipid compositions

2014	US10159652B2	Device for formulating particles at small volumes
2015	US9404127B2	Non-liposomal systems for nucleic acid delivery
2015	US20150184123A1	RNA preparations comprising purified modified RNA for reprogramming cells
2015	US9163213B2	RNA preparations comprising purified modified RNA for reprogramming cells
2015	WO2015164674A1	Nucleic acid vaccines
2015	US9567296B2	Ionizable cationic lipid for RNA delivery
2015	US9371511B2	RNA preparations comprising purified modified RNA for reprogramming cells
2015	US10653780B2	Amino lipids and methods for the delivery of nucleic acids
2015	US20170273907A1	Stable formulations of lipids and liposomes
2016	US10385106B2	Modified polynucleotides for the production of secreted proteins
2016	WO2016118724A1	Lipid nanoparticle compositions
2016	WO2016118725A1	Lipid nanoparticle compositions
2016	US20180263907A1	Lipid particle formulations for delivery of RNA and water-soluble therapeutically effective compounds to a target cell
2016	WO2016156398A1	Lipid particle formulations for delivery of RNA and water-soluble therapeutically effective compounds to a target cell
2016	US9943846B2	Limit size lipid nanoparticles and related methods
2016	US10780054B2	Lyophilization of RNA
2016	US20180303925A1	Nucleoside-modified RNA for inducing an adaptive immune response
2016	US9580711B2	Lipid particles with asymmetric cationic lipids for RNA delivery
2016	US9518272B2	Non-liposomal systems for nucleic acid delivery
2016	US10006007B2	RNA preparations comprising purified modified RNA for reprogramming cells
2016	US20180296663A1	Vaccine composition
2016	US10221127B2	Lipids and lipid nanoparticle formulations for delivery of nucleic acids
2016	US20200085852A1	Epidermal mRNA vaccine
2016	US20190153428A1	Method for reducing immunogenicity of RNA
2016	US20190153425A1	Methods for providing single-stranded RNA
2016	US20190010485A1	Method of RNA in vitro transcription using a buffer containing a dicarboxylic acid or tricarboxylic acid or a salt thereof
2016	US10166298B2	Lipids and lipid nanoparticle formulations for delivery of nucleic acids
2016	US10232055B2	RNA containing modified nucleosides and methods of use thereof
2016	US20190083602A1	Method for producing RNA molecule compositions
2016	US20190022247A1	Lipids and lipid nanoparticle formulations for delivery of nucleic acids
2017	US9868692B2	Compounds and compositions for intracellular delivery of therapeutic agents
2017	US20170210697A1	Compounds and compositions for intracellular delivery of therapeutic agents
2017	US20200046838A1	Lipids for delivery of active agents
2017	US20170239374A1	Modified nucleosides, nucleotides, and nucleic acids, and uses thereof
2017	US10064959B2	Modified nucleosides, nucleotides, and nucleic acids, and uses thereof
2017	US20190336608A1	Cationic carriers for nucleic acid delivery
2017	US20200179526A1	Hybrid carriers for nucleic acid cargo
2017	US10106490B2	Lipids and lipid nanoparticle formulations for delivery of nucleic acids
2017	US20190321458A1	Formulation for administration of RNA
2017	US10041091B2	Nucleic acid-containing lipid particles and related methods

2017	US20200061185A1	Prefusion coronavirus spike proteins and their use
2017	US10960070B2	Prefusion coronavirus spike proteins and their use
2017	US20200163878A1	Lipid nanoparticle mRNA vaccines
2017	US20190274968A1	Nucleoside-modified RNA for inducing an adaptive immune response
2017	US10233148B2	Aromatic ionizable cationic lipid
2017	US10815463B2	Messenger UNA molecules and uses thereof
2017	US20180185516A1	Delivery of target specific nucleases
2017	US10442756B2	Compounds and compositions for intracellular delivery of therapeutic agents
2017	US20190351048A1	Mers coronavirus vaccine
2018	US10227302B2	Ionizable cationic lipid for RNA delivery
2018	US10576146B2	Particles comprising a shell with RNA
2018	US20200197508A1	Methods and compositions for stimulating immune response
2018	US20200046830A1	Nucleic acid vaccine composition comprising a lipid formulation, and method of increasing the potency of nucleic acid vaccines
2018	US20190002906A1	Synthesis and structure of high potency RNA therapeutics
2018	US10266485B2	Compounds and compositions for intracellular delivery of therapeutic agents
2018	US20190032087A1	Nucleic acid-containing lipid particles and related methods
2018	US20200172472A1	Lipids for use in lipid nanoparticle formulations
2018	US20190015501A1	Nucleic acid vaccines
2019	US10799602B2	Method for increasing expression of RNA-encoded proteins
2019	US20210137840A1	Lipid-based formulations for the delivery of RNA
2019	US10703789B2	Modified polynucleotides for the production of secreted proteins
2019	US10577403B2	Modified polynucleotides for the production of secreted proteins
2019	US20190314496A1	Polymeric carrier cargo complex for use as an immunostimulating agent or as an adjuvant
2019	WO2020002598A1	Bioreactor for RNA in vitro transcription
2019	US20200164038A1	Modified nucleoside, nucleotide, and nucleic acid compositions
2019	US20190388562A1	Ionizable cationic lipid for RNA delivery
2019	US20200206362A1	Compositions and methods for delivery of agents
2019	WO2020097540A1	Lipid nanoparticle formulations
2019	WO2020097548A1	Lipid nanoparticle formulations
2019	US20200109113A1	Ionizable cationic lipid for RNA delivery
2020	US20200283372A1	Lipids for lipid nanoparticle delivery of active agents
2020	US20200155671A1	Particles comprising a shell with RNA
2020	US10702600B1	Betacoronavirus mRNA vaccine
2020	US20200297634A1	Method of making lipid-encapsulated RNA nanoparticles
2020	US20200246451A1	Method for producing RNA compositions
2020	US20200282046A1	Betacoronavirus MRNA vaccine
2020	US20200345831A1	Nucleic acid comprising or coding for a histone stem-loop and a poly(a) sequence or a polyadenylation signal for increasing the expression of an encoded pathogenic antigen
2020	US20200399629A1	Method for reducing immunogenicity of RNA
2021	US20210275664A1	Prefusion coronavirus spike proteins and their use
2021	US10485884B2	RNA formulation for immunotherapy
2021	US20210292786A1	Purification and purity assessment of RNA molecules synthesized with modified nucleosides
2021	US20210340170A1	5'-cap compounds and their uses in stabilizing RNA, expressing proteins and in therapy

eTable 2. Scientists Associated with mRNA COVID-19 Vaccine Development.

Inventor or Scientist	Associated Innovations	Method of Identification
Adam Judge	lipid nanoparticle, mRNA synthesis or modification	Patent review
Alan Martin	lipid nanoparticle	Patent review
Aleksandra Kowalcyzk	mRNA vaccine technology	Patent review
Alex Leung	lipid nanoparticle	Patent review
Alexander Bukreyev	lipid nanoparticle, mRNA synthesis or modification, mRNA vaccine technology	News reports
Amy Lee	mRNA synthesis or modification	Patent review
Andre Wild	lipid nanoparticle	Patent review
Andreas Funkner	mRNA synthesis or modification	Patent review
Andreas Kuhn	mRNA synthesis or modification	Patent review
Andreas Thess	mRNA synthesis or modification	Patent review
Andrew Geall	lipid nanoparticle	Literature review
Andrew Ward	prefusion spike protein	Patent review, Literature review, News reports
Angel I-Jou Leu	mRNA synthesis or modification	Patent review
Aniela Wochner	mRNA synthesis or modification	Patent review
Anna Blakney	mRNA synthesis or modification	Literature review
Anne Schlegel	mRNA synthesis or modification	Patent review
Annette Vogel	mRNA synthesis or modification	Patent review
Anthony Conway	lipid nanoparticle	Patent review
Anthony Person	mRNA synthesis or modification	Patent review
Antonin de Fougerolles	lipid nanoparticle, mRNA synthesis or modification	Patent review
Arisa Cale	mRNA synthesis or modification	Patent review
Axel Bouchon	mRNA vaccine technology	Patent review
Aysha Ansari	lipid nanoparticle	Patent review
Barbara Low Shoud Mui	lipid nanoparticle, mRNA synthesis or modification	Patent review
Barney Graham	prefusion spike protein	Patent review, Literature review, News reports
Benjamin Petsch	lipid nanoparticle	Patent review
Benyamin Yazdan Panah	mRNA synthesis or modification	Patent review
Bo Ying	mRNA synthesis or modification	Literature review
Carl Hansen	lipid nanoparticle	Patent review
Carlos G. Perez-Garcia	mRNA synthesis or modification	Patent review
Carolin Thiele	lipid nanoparticle	Patent review
Christian Dohmen	lipid nanoparticle	Patent review
Christopher Barbosa	lipid nanoparticle	Patent review
Christopher Cottrell	prefusion spike protein	Patent review
Ciaran Lawlor	lipid nanoparticle	Patent review
Colin Walsh	lipid nanoparticle	Patent review

Cory Giesbrecht	lipid nanoparticle, mRNA synthesis or modification	Patent review
Daniel Fritz	mRNA synthesis or modification	Patent review
Daniel Wrapp	prefusion spike protein	Patent review, News reports
Daniel Zucker	mRNA synthesis or modification	Patent review
David Butler	lipid nanoparticle	Patent review
David Curiel	mRNA synthesis or modification	Literature review
David Walker	lipid nanoparticle	Patent review
David Webb	lipid nanoparticle	Patent review
Derrick Rossi	mRNA synthesis or modification	Patent review, Literature review, News reports
Douglas Melton	mRNA synthesis or modification	Literature review
Drew Weissman	mRNA synthesis or modification	Patent review, Literature review, News reports
Edith Jasny	lipid nanoparticle	Patent review
Edward Yaworski	lipid nanoparticle	Patent review
Eli Gilboa	mRNA synthesis or modification	Literature review
Ellalahewage Sathyajith Kumarasinghe	lipid nanoparticle	Patent review
Ellen Frace Ambegia	lipid nanoparticle, mRNA synthesis or modification	Patent review
Elliot Kagan	mRNA synthesis or modification	Patent review
Eric Mucker	lipid nanoparticle	Patent review
Eric Yi-Chun Huang	mRNA vaccine technology	Patent review
Esparza Borquez	lipid nanoparticle	Patent review
Euan Ramsay	lipid nanoparticle	Patent review
Fabian Johannes Eber	mRNA synthesis or modification	Patent review
Felix Bertsch	mRNA synthesis or modification	Patent review
Florian Von Der Mulbe	mRNA vaccine technology	Patent review
Frank Schaubhut	mRNA vaccine technology	Patent review
Gary Dahl	mRNA synthesis or modification	Patent review
Gary Lee	lipid nanoparticle	Patent review
Gilles Besin	lipid nanoparticle	Patent review
Giuseppe Ciaramella	mRNA vaccine technology	Patent review
Hadi Yassine	prefusion spike protein	Patent review
Hannah Turner	prefusion spike protein	Patent review
Heinrich Haas	lipid nanoparticle, mRNA synthesis or modification	Patent review
Hiromi Muramatsu	mRNA synthesis or modification	Patent review
Hossam Hefesha	lipid nanoparticle, mRNA synthesis or modification	Patent review
Ian MacLachlan	lipid nanoparticle, mRNA synthesis or modification	Patent review, Literature review
Igor Jigaltsev	lipid nanoparticle	Patent review
Inder Verma	lipid nanoparticle	Literature review
Ingmar Hoerr	mRNA synthesis or modification	Literature review
Isaac Hernan	lipid nanoparticle	Patent review

Ismail Hafez	lipid nanoparticle	Patent review
James Heyes	lipid nanoparticle, mRNA synthesis or modification	Patent review
Jared Davis	mRNA synthesis or modification	Patent review
Jason McLellan	prefusion spike protein	Patent review, Literature review, News reports
Jason Schrum	mRNA synthesis or modification	Patent review
Jay Hooper	lipid nanoparticle	Patent review
Jayaprakash Nair	lipid nanoparticle	Patent review
Jeffrey Ulmer	lipid nanoparticle	Literature review
Jens Huft	lipid nanoparticle	Patent review
Jerome Jendrisak	mRNA synthesis or modification	Patent review
Jesper Pallesen	prefusion spike protein	Patent review
Jianxin Chen	lipid nanoparticle, mRNA synthesis or modification	Patent review
Jochen Probst	mRNA synthesis or modification	Patent review
Johannes Lutz	lipid nanoparticle, mRNA vaccine technology	Patent review
John Mascola	prefusion spike protein	Patent review, News reports
Jorge Moreno Herrero	mRNA synthesis or modification	Patent review
Joseph Payne	lipid nanoparticle, mRNA synthesis or modification	Patent review
Joseph Senn	lipid nanoparticle	Patent review
Judith Meis	mRNA synthesis or modification	Patent review
Justin Guild	mRNA synthesis or modification	Patent review
Kallanthottathil Rajeev	lipid nanoparticle, mRNA synthesis or modification	Patent review
Katalin Kariko	mRNA synthesis or modification	Patent review, Literature review, News reports
Katharina Kolland	mRNA synthesis or modification	Patent review
Kenechi Ejebe	mRNA synthesis or modification	Patent review
Kerry Benenato	lipid nanoparticle	Patent review
Kerstin Reuter	lipid nanoparticle, mRNA synthesis or modification	Patent review
Kevin Ou	lipid nanoparticle	Patent review
Kieu Lam	lipid nanoparticle	Patent review
Kim Ellen Schwendt	lipid nanoparticle	Patent review
Kim Wong	lipid nanoparticle, mRNA synthesis or modification	Patent review
Kiyoshi Tachikawa	mRNA synthesis or modification	Patent review
Kizzmekia Corbett	prefusion spike protein	Patent review, News reports
Kristy Wood	mRNA synthesis or modification	Patent review
Larry Lawrence Corey	mRNA vaccine technology	Patent review, News reports
Lena Mareen Kranz	mRNA synthesis or modification	Patent review
Lisa Hensley	mRNA synthesis or modification	Patent review
Lloyd Jeffs	lipid nanoparticle, mRNA synthesis or modification	Patent review
Lorne Palmer	lipid nanoparticle, mRNA synthesis or modification	Patent review
Luigi Warren	mRNA synthesis or modification	Patent review

Madeleine Hipp	mRNA vaccine technology	Patent review
Mahjoub Bihi	mRNA synthesis or modification	Patent review
Marco Ciufolini	lipid nanoparticle, mRNA synthesis or modification	Patent review
Marco Poleganov	mRNA synthesis or modification	Patent review
Mariola Fotin-Mleczek	lipid nanoparticle, mRNA synthesis or modification, mRNA vaccine technology	Patent review
Mark Cornebise	lipid nanoparticle	Patent review
Markus Baiersdorfer	mRNA synthesis or modification	Patent review
Markus Conzelmann	mRNA synthesis or modification	Patent review
Markus Kreuz	mRNA synthesis or modification	Patent review
Martin Kunze	mRNA synthesis or modification	Patent review
Martin Meng	mRNA synthesis or modification	Patent review
Masaru Kanekiyo	prefusion spike protein	Patent review
Matthew Winkler	mRNA synthesis or modification	Literature review
Michael Gordon Joyce	prefusion spike protein	Patent review
Michael Green	mRNA synthesis or modification	Literature review
Michael Heartlein	mRNA synthesis or modification	Literature review
Michael Holmes	lipid nanoparticle	Patent review
Michael Hope	lipid nanoparticle, mRNA synthesis or modification	Patent review
Michael Jung	lipid nanoparticle	Patent review
Michael Rauen	mRNA synthesis or modification	Patent review
Michael Sonntag	mRNA synthesis or modification	Patent review
Michael Wiggenhorn	mRNA synthesis or modification, mRNA vaccine technology	Patent review
Michel Roberge	lipid nanoparticle	Patent review
Mustafa Diken	lipid nanoparticle, mRNA synthesis or modification	Patent review
Muthiah Manoharan	lipid nanoparticle, mRNA synthesis or modification	Patent review
Muthusamy Jayaraman	lipid nanoparticle	Patent review
Nathan Belliveau	lipid nanoparticle	Patent review
Nianshuang Wang	prefusion spike protein	Patent review, News reports
Norbert Pardi	mRNA synthesis or modification	Patent review, News reports
Noubar Afeyan	mRNA synthesis or modification	Patent review, News reports
Olga Mykhaliyk	lipid nanoparticle	Patent review
Orn Almarsson	lipid nanoparticle	Patent review
Ozlem Tureci	mRNA synthesis or modification	Literature review
Padmanabh Chivukula	lipid nanoparticle, mRNA synthesis or modification	Patent review
Patrick Baumhof	lipid nanoparticle, mRNA vaccine technology	Patent review
Pattraranee Limphong	mRNA synthesis or modification	Patent review
Paul Krieg	mRNA synthesis or modification	Literature review
Paulo Jia Ching Lin	lipid nanoparticle	Patent review
Pedro Valencia	mRNA synthesis or modification	Patent review
Peter Kwong	prefusion spike protein	Patent review, News reports

Peter Liljestrom	mRNA synthesis or modification	Literature review
Petra Schreiner	lipid nanoparticle	Patent review
Philip Felgner	lipid nanoparticle	Literature review
Philipp Hoffmann	mRNA synthesis or modification	Patent review
Pieter Cullis	lipid nanoparticle, mRNA synthesis or modification	Patent review, Literature review
Priya Karmali	lipid nanoparticle	Patent review
Regina Heidenreich	lipid nanoparticle, mRNA synthesis or modification, mRNA vaccine technology	Patent review
Robert James Taylor	lipid nanoparticle	Patent review
Robert Kirchdoerfer	prefusion spike protein	Patent review
Robert Langer	lipid nanoparticle, mRNA synthesis or modification	Patent review, News reports
Robert Malone	lipid nanoparticle	Literature review
Salih Yimaz	mRNA synthesis or modification	Patent review
Sandra Lazzaro	lipid nanoparticle	Patent review
Sayda Elbashir	mRNA synthesis or modification	Patent review
Sean Semple	lipid nanoparticle, mRNA synthesis or modification	Patent review
Sebastian Horner	mRNA synthesis or modification	Patent review
Sebastian Kreiter	lipid nanoparticle, mRNA synthesis or modification	Patent review
Srinivasulu Masuna	lipid nanoparticle	Patent review
Staci Sabnis	lipid nanoparticle	Patent review
Stefanie Sewing	mRNA synthesis or modification	Patent review
Stephanie Erbar	mRNA synthesis or modification	Patent review
Stephanie Fesser	mRNA synthesis or modification	Patent review
Stephanie Herz	mRNA synthesis or modification	Patent review
Stephen Hoge	lipid nanoparticle	Patent review
Stephen Reid	lipid nanoparticle	Patent review
Steve Pascolo	mRNA synthesis or modification	Patent review, Literature review
Steven Ansell	lipid nanoparticle	Patent review
Steven Tanis	lipid nanoparticle	Patent review
Stuart Malcolm	lipid nanoparticle	Patent review
Suhaib Siddiqi	mRNA synthesis or modification	Patent review
Sunny Himansu	mRNA vaccine technology	Patent review
Susanne Rauch	lipid nanoparticle, mRNA synthesis or modification, mRNA vaccine technology	Patent review
Thomas Geisbert	mRNA synthesis or modification	Patent review
Thomas Ketterer	mRNA vaccine technology	Patent review
Thomas Madden	lipid nanoparticle	Patent review, Literature review
Thomas Schlake	mRNA synthesis or modification	Patent review
Thorsten Klamp	mRNA synthesis or modification	Patent review
Thorsten Mutzke	mRNA synthesis or modification, mRNA vaccine technology	Patent review
Tilmann Roos	mRNA synthesis or modification	Patent review

Tim Beissert	mRNA synthesis or modification	Patent review
Timothy Leaver	lipid nanoparticle	Patent review
Tom Maniatis	mRNA synthesis or modification	Literature review
Ugur Sahin	lipid nanoparticle, mRNA synthesis or modification	Patent review, Literature review, News reports
Vandana Sood	mRNA synthesis or modification	Patent review
Wenke Wagner	mRNA synthesis or modification	Patent review
Xinyao Du	lipid nanoparticle	Patent review
Yanjie Bao	lipid nanoparticle	Patent review
Ying K. Tam	lipid nanoparticle, mRNA synthesis or modification	Patent review
Yuen Yi C. Tam	lipid nanoparticle	Patent review
Yves Husemann	lipid nanoparticle, mRNA synthesis or modification	Patent review

eTable 3. National Institute of Health Grants Directly Related to mRNA Covid-19 Vaccines.

NIH-Funded Grant	Funding Agency	NIH-Funded Grant at Fiscal Year Level	Principal Investigator or Project Leader	Organization Name	Fiscal Year	Fiscal Cost (2022 USD)
Epitope-Based Design and Modified RNA Platform for Bivalent Marburgvirus Vaccine	NIAID	5R01AI141661-04	BUKREYEV, ALEXANDER	UNIVERSITY OF TEXAS MED BR GALVESTON	2022	756,658
		5R01AI141661-03			2021	815,777
		5R01AI141661-02			2020	838,401
		1R01AI141661-01			2019	922,478
CoVPN 3005 - Efficacy, Immunogenicity, and Safety of SARS-CoV-2 Recombinant Protein Vaccine with Adjuvant in Adults 18 Years of Age and Older	NIAID	3UM1AI068614-15S2	COREY, LAWRENCE	FRED HUTCHINSON CANCER RESEARCH CENTER	2021	66,036,292
HVTN 405/HPTN 1901 Characterizing SARS-CoV-2-specific immunity in convalescent individuals	NIAID	3UM1AI068614-14S1	COREY, LAWRENCE	FRED HUTCHINSON CANCER RESEARCH CENTER	2020	393,953,859
Investigating the mechanism of mRNA cleavage in the ribosomal A-site	NIGMS	5F32GM087070-02	DAVIS, JARED HENRY	YALE UNIVERSITY	2010	65,465
		1F32GM087070-01			2009	62,884
Advancement of Vaccines and Treatments for Ebola and Marburg Virus Infections	NIAID	5U19AI142785-04	GEISBERT, THOMAS WILLIAM	UNIVERSITY OF TEXAS MED BR GALVESTON	2022	7,043,167
		5U19AI142785-03			2021	7,571,405
		5U19AI142785-02			2020	7,999,982
		1U19AI142785-01			2019	7,867,218
RNA Interference for the Treatment of Ebola and Marburg Hemorrhagic Fever	NIAID	5R01AI089454-04	GEISBERT, THOMAS WILLIAM	UNIVERSITY OF TEXAS MED BR GALVESTON	2013	649,731
		5R01AI089454-03			2012	708,545
		5R01AI089454-02			2011	747,210
		1R01AI089454-01			2010	775,200
Enhancing Immunological Memory Using Aptamer targeted siRNA Delivery to T Cells	NCI	3R01CA181598-03S1	GILBOA, ELI	UNIVERSITY OF MIAMI SCHOOL OF MEDICINE	2016	119,665
Enhancing Immunological Memory Using Aptamertargeted siRNA Delivery to T Cells	NCI	3R01CA181598-05S1	GILBOA, ELI	UNIVERSITY OF MIAMI SCHOOL OF MEDICINE	2018	114,322
		5R01CA181598-05			2018	361,194
		3R01CA181598-04S1			2017	116,742
		5R01CA181598-04			2017	368,838
		5R01CA181598-03			2016	378,075
		5R01CA181598-02			2015	383,171
		1R01CA181598-01A1			2014	382,853
Expressing New Tumor Antigens by Inhibition of Nonsense Mediated mRNA Decay	NCI	5R01CA151857-05	GILBOA, ELI	UNIVERSITY OF MIAMI SCHOOL OF MEDICINE	2015	381,922
		5R01CA151857-04			2014	370,157
		5R01CA151857-03			2013	361,097
		5R01CA151857-02			2012	393,669
		1R01CA151857-01A1			2011	405,416
Antigenicity and Immunogenicity of Stabilized prefusion F protein	NIAID	1ZIAAI005129-06	GRAHAM, BARNEY	NATIONAL INSTITUTE OF ALLERGY AND INFECTIOUS DISEASES	2021	1,555,860
		1ZIAAI005129-05			2020	1,426,968
		1ZIAAI005129-04			2019	2,125,700
		1ZIAAI005129-03			2018	988,696
		1ZIAAI005129-02			2017	1,289,255
		1ZIAAI005129-01			2016	1,462,985
Biodefense/Emerging Infection Vaccine Studies	NIAID	1ZIAAI005047-11	GRAHAM, BARNEY	NATIONAL INSTITUTE OF ALLERGY AND INFECTIOUS DISEASES	2013	1,030,852
		1ZIAAI005047-10			2012	1,056,411
		1ZIAAI005047-09			2011	5,429,733

		1ZIAAI005047-08			2010	5,514,771
		1ZIAAI005047-07			2009	3,157,177
Coronavirus vaccine development	NIAID	1ZIAAI005125-08	GRAHAM, BARNEY	NATIONAL INSTITUTE OF ALLERGY AND INFECTIOUS DISEASES	2021	561,645
		1ZIAAI005125-07			2020	1,519,760
		1ZIAAI005125-06			2019	1,062,850
		1ZIAAI005125-05			2018	494,348
		1ZIAAI005125-04			2017	973,824
		1ZIAAI005125-03			2016	1,149,177
		1ZIAAI005125-02			2015	322,568
		1ZIAAI005125-01			2014	454,814
Influenza Vaccine Development	NIAID	1ZIAAI005003-19	GRAHAM, BARNEY	NATIONAL INSTITUTE OF ALLERGY AND INFECTIOUS DISEASES	2020	3,311,822
		1ZIAAI005003-18			2019	4,251,399
		1ZIAAI005003-17			2018	2,316,745
		1ZIAAI005003-16			2017	2,754,244
		1ZIAAI005003-15			2016	1,664,414
		1ZIAAI005003-14			2015	1,686,849
Rapid Development of Vaccines for Emerging Viruses	NIAID	1ZIAAI005128-06	GRAHAM, BARNEY	NATIONAL INSTITUTE OF ALLERGY AND INFECTIOUS DISEASES	2021	1,725,221
		1ZIAAI005128-05			2020	1,426,968
		1ZIAAI005128-04			2019	2,125,700
		1ZIAAI005128-03			2018	2,268,871
Vectors and Methods to Increase Immunogenicity during DNA Vaccination	NIAID	1ZIAAI005061-15	GRAHAM, BARNEY	NATIONAL INSTITUTE OF ALLERGY AND INFECTIOUS DISEASES	2017	831,881
		1ZIAAI005061-14			2016	612,630
		1ZIAAI005061-13			2015	1,320,851
		1ZIAAI005061-12			2014	1,333,379
		1ZIAAI005061-11			2013	1,637,967
		1ZIAAI005061-10			2012	1,761,176
		1ZIAAI005061-09			2011	983,534
Alternative Splicing and mRNA 3' End Formation in Normal Gene Regulation and Cancer Development	NIGMS	5R01GM035490-32	GREEN, MICHAEL R	UNIV OF MASSACHUSETTS MED SCH WORCESTER	2021	351,122
		5R01GM035490-31			2020	356,021
		5R01GM035490-30			2019	364,840
		2R01GM035490-29A1			2018	370,393
Splicing of mRNA Precursors	NIGMS	5R01GM035490-28	GREEN, MICHAEL R	UNIV OF MASSACHUSETTS MED SCH WORCESTER	2013	380,315
		5R01GM035490-27			2012	403,880
		5R01GM035490-26			2011	415,932
		2R01GM035490-25A1			2010	426,389
		5R01GM035490-24			2008	369,421
		5R01GM035490-23			2007	385,229
		5R01GM035490-22			2006	405,018
		2R01GM035490-21			2005	429,818
		5R01GM035490-20			2004	318,598
		5R01GM035490-19			2003	324,684
		5R01GM035490-18			2002	333,289
		2R01GM035490-17			2001	332,827
		5R01GM035490-16			2000	260,238
		5R01GM035490-15			1999	259,737
		5R01GM035490-14			1998	256,707

		2R01GM035490-13			1997	253,358
		5R01GM035490-12			1996	428,693
		5R01GM035490-11			1995	430,803
		5R01GM035490-10			1994	426,141
		2R01GM035490-09			1993	510,452
		5R01GM035490-08			1992	467,060
		5R01GM035490-07			1991	492,885
		7R01GM035490-06			1990	502,338
		5R01GM035490-05		HARVARD UNIVERSITY	1989	484,079
		2R01GM035490-04			1988	575,796
		5R01GM035490-03			1987	450,684
		5R01GM035490-02			1986	383,970
		1R01GM035490-01			1985	394,430
Influenza Vaccine Development	NIAID	1ZIAAI005003-20	KANEKIYO, MASARU	NATIONAL INSTITUTE OF ALLERGY AND INFECTIOUS DISEASES	2021	23,808,946
Erythropoietin-encoding mRNA for treatment of anemia	NHLBI	5R42HL087688-03	KARIKO, KATALIN	RNARX	2010	518,956
		4R42HL087688-02			2009	531,874
		1R42HL087688-01			2007	135,283
Structural Studies of the Corona Virus Life Cycle	NIAID	3R00AI123498-03S1	KIRCHDOERFER, ROBERT N	UNIVERSITY OF WISCONSIN-MADISON	2020	140,741
Structural Studies of the Coronavirus Life Cycle	NIAID	3R00AI123498-04S1	KIRCHDOERFER, ROBERT N	UNIVERSITY OF WISCONSIN-MADISON	2021	99,142
		5R00AI123498-04			2021	267,669
		4R00AI123498-03			2020	271,405
		5K99AI123498-02		SCRIPPS RESEARCH INSTITUTE	2018	117,344
		1K99AI123498-01A1			2017	119,828
Computational Algorithms, Methods, and Tools for Structure-Based Vaccine and Antibody Design	NIAID	1ZICAI005113-09	KWONG, PETER D	NATIONAL INSTITUTE OF ALLERGY AND INFECTIOUS DISEASES	2018	280,754
		1ZICAI005113-10			2019	602,919
		1ZICAI005113-08			2017	1,148,586
		1ZICAI005113-07			2016	182,288
		1ZICAI005113-06			2015	122,670
		1ZICAI005113-05			2014	118,998
		1ZICAI005113-04			2013	119,790
		1ZICAI005113-03			2012	122,760
		1ZICAI005113-02			2011	126,423
		1ZICAI005113-01			2010	129,700
Design Of Immunogens	NIAID	1ZIAAI005024-20	KWONG, PETER D	NATIONAL INSTITUTE OF ALLERGY AND INFECTIOUS DISEASES	2021	2,286,825
		1ZIAAI005024-19			2020	1,998,663
		1ZIAAI005024-18			2019	3,818,774
		1ZIAAI005024-17			2018	1,296,982
		1ZIAAI005024-16			2017	2,973,519
		1ZIAAI005024-15			2016	717,604
		1ZIAAI005024-14			2015	967,877
		1ZIAAI005024-13			2014	967,073
		1ZIAAI005024-12			2013	973,509

		1ZIAAI005024-11			2012	997,646
		1ZIAAI005024-10			2011	1,023,998
		1ZIAAI005024-09			2010	1,046,575
		1ZIAAI005024-08			2009	225,913
Immunogen Design for SARS-CoV-2	NIAID	1ZIAAI005149-02	KWONG, PETER D	NATIONAL INSTITUTE OF ALLERGY AND INFECTIOUS DISEASES	2021	652,166
		1ZIAAI005149-01			2020	277,663
Dityrosine Locked Prefusion F Protein: A Path To A Protective RSV Vaccine	NIAID	1R43AI112124-01A1	MARIANI, ROBERTO	AVATAR MEDICAL, LLC	2014	359,220
Pre-clinical Vaccine and Antibody Development for Coronavirus Disease 2019 (COVID-19)	NIAID	1ZIAAI005152-02	MASCOLA, JOHN	NATIONAL INSTITUTE OF ALLERGY AND INFECTIOUS DISEASES	2021	422,545
		1ZIAAI005152-01			2020	276,290
Pre-clinical Vaccine Development for Emerging and Re-emerging Infectious Diseases	NIAID	1ZICAI005134-03	MASCOLA, JOHN	NATIONAL INSTITUTE OF ALLERGY AND INFECTIOUS DISEASES	2021	4,229,211
		1ZICAI005134-02		NATIONAL INSTITUTE OF ALLERGY AND INFECTIOUS DISEASES	2020	4,493,907
		1ZICAI005134-01		NATIONAL INSTITUTE OF ALLERGY AND INFECTIOUS DISEASES	2019	4,065,354
Structure, Function and Antigenicity of Coronavirus Spike Proteins	NIAID	5R01AI127521-05	MCLELLAN, JASON SCOTT	UNIVERSITY OF TEXAS, AUSTIN	2021	659,009
		5R01AI127521-04			2020	668,205
		5R01AI127521-03			2019	684,757
		7R01AI127521-02			2018	711,196
		1R01AI127521-01A1		DARTMOUTH COLLEGE	2017	737,264
Development of Universal Influenza Virus Vaccines Using Nucleoside-Modified Messenger RNA	NIAID	5R01AI146101-03	PARDI, NORBERT	UNIVERSITY OF PENNSYLVANIA	2021	656,203
		5R01AI146101-02			2020	664,635
		1R01AI146101-01			2019	715,794
Lipid nanoparticles as novel adjuvants inducing effective T follicular helper cell and humoral immune responses	NIAID	5R01AI153064-02			2021	680,666
		1R01AI153064-01			2020	678,092
Nucleoside modified mRNA based HIV vaccine	NIAID	5R01AI124429-04	WEISSMAN, DREW	UNIVERSITY OF PENNSYLVANIA	2019	934,047
		5R01AI124429-03			2018	951,673
		5R01AI124429-02			2017	975,199
		1R01AI124429-01			2016	1,020,789
Oral Delivery of RNA Encoded Antigen	NIDCR	5R21DE019059-02	WEISSMAN, DREW	UNIVERSITY OF PENNSYLVANIA	2009	243,881
		1R21DE019059-01			2008	292,658
RNA delivery for dendritic cell HIV antigen presentation	NIAID	5R01AI050484-09	WEISSMAN, DREW	UNIVERSITY OF PENNSYLVANIA	2011	492,812
		5R01AI050484-08			2010	505,588
		5R01AI050484-07			2009	524,475
		2R01AI050484-06A2			2008	524,475
		3R01AI050484-05S1			2007	104,119
		5R01AI050484-05			2006	548,678
		5R01AI050484-04			2005	584,073
		5R01AI050484-03			2004	601,508
		5R01AI050484-02			2003	612,999
		1R01AI050484-01A2			2002	629,245
Dityrosine Locked Prefusion F Protein: A Path To A Protective RSV Vaccine	NIAID	5R43AI112124-02	YONDOLA, MARK	AVATAR MEDICAL, LLC	2015	357,072

eTable 4. Biomedical Advanced Research and Development Authority and Department of Defense Grants Directly Related to mRNA COVID-19 Development.

Date	Funding Agency	Grant Recipient	Original Cost (USD)	Cost (2022 USD)*	Funding Category	Description
11/15/11	DOD	CureVac	33,100,000	42,268,700	Vaccine development, clinical trials	Given to support the pre-clinical development of mRNA vaccine technology, especially against rabies.
9/7/16	BARDA	Moderna	125,000,000	148,375,000	Vaccine development	Given to support the development of mRNA vaccines against infectious diseases broadly, then Chikungunya
10/2/13	DOD	Moderna	24,600,000	29,766,000	Vaccine development, clinical trials	Given to support the pre-clinical development of mRNA vaccines against Zika.
4/16/20	BARDA	Moderna	430,298,520	469,025,386	Clinical trials	Given to support late-stage development of mRNA vaccines against COVID-19
5/24/20	BARDA	Moderna	53,000,000	57,770,000	Manufacturing	Given to boost manufacturing capacity of mRNA vaccines against COVID-19
7/21/20	BARDA	Pfizer	1,950,000,000	2,125,500,000	Vaccine supply	Used to purchase 100,000,000 vaccine doses ($21.26/dose)
7/25/20	BARDA	Moderna	471,596,459	514,040,140	Clinical trials	Given to fund late-stage clinical trials of mRNA vaccines against COVID-19
8/11/20	BARDA	Moderna	1,525,000,000	1,662,250,000	Vaccine supply	Used to purchase 100,000,000 vaccine doses ($16.62/dose)
9/1/20	DOD	Pfizer	48,683,161	53,064,645	Vaccine supply	For procurement and delivery of pharmaceutical products
12/11/20	BARDA	Moderna	1,666,598,000	1,816,591,820	Vaccine supply	Used to purchase 100,000,000 vaccine doses ($18.17/dose)
12/22/20	BARDA	Pfizer	2,011,282,500	2,192,297,925	Vaccine supply	Used to purchase 100,000,000 vaccine doses ($21.92/dose)

2/11/21	BARDA	Moderna	1,650,000,000	1,773,750,000	Vaccine supply	Used to purchase 100,000,000 vaccine doses ($17.74/dose)
2/11/21	BARDA	Pfizer	2,011,282,500	2,162,128,687	Vaccine supply	Used to purchase 100,000,000 vaccine doses ($21.62/dose)
3/12/21	BARDA	Moderna	62,705,357	67,408,259	Clinical trials	Used to fund clinical trials in adolescents, with crossover doses
4/18/21	BARDA	Moderna	236,364,615	254,091,961	Clinical trials	Moderna was given more money to cover the costs of various clinical trials, other costs associated with the studies.
6/15/21	BARDA	Moderna	3,303,993,662	3,551,793,187	Vaccine supply	Used to purchase 200,000,000 vaccine doses ($17.76/dose)
6/15/21	BARDA	Moderna	144,140,941	154,951,512	Clinical trials	Used to fund clinical trials of the vaccine in children
7/21/21	BARDA	Pfizer	4,869,750,000	5,234,981,250	Vaccine supply	Used to purchase 200,000,000 vaccine doses ($26.17/dose)
7/30/21	DOD	Pfizer	3,500,000,001	3,762,500,001	Vaccine supply	Used to purchase 500,000,000 vaccine doses for international donation ($7.53/dose)
10/22/21	BARDA	Pfizer	1,230,000,000	1,322,250,000	Vaccine supply	Used to purchase 50,000,000 vaccine doses ($26.45/dose)
11/19/21	DOD	Pfizer	1,400,000,001	1,505,000,001	Vaccine supply	Used to purchase 200,000,000 vaccine doses for international donation ($7.53/dose)
1/19/22	DOD	Pfizer	2,047,500,000	2,047,500,000	Vaccine supply	Used to purchase 300,000,000 vaccine doses for international donation ($6.83/dose)
3/22/22	BARDA	Moderna	308,000,000	308,000,000	Clinical trials	Given to fund clinical trials of mRNA vaccines against COVID-19 in children

*Inflation-adjusted to 2022 USD using the CPI for all Urban consumers (CPI-U).