

Science and Innovation Leadership for the 21st Century: Challenges and Strategic Implications for the United States

Committee

Erica R. Fuchs

Co-Chair

Erica R. H. Fuchs is a Professor in the Department of Engineering and Public Policy at Carnegie Mellon University, and a Research Associate with the National Bureau of Economic Research. Her research focuses on the development, commercialization and global manufacturing of emerging technologies, and national policy in that context. She was the founding Faculty Director of Carnegie Mellon University's Manufacturing Futures Initiative, an initiative across six schools aimed to revolutionize the commercialization and local production of advanced manufactured products – and was one of 23 participants in the President's Council of Advisors on Science and Technology workshop that led to the creation of the Advanced Manufacturing Partnership. Dr. Fuchs served on the expert group that supported the White House in the 2016 Innovation Dialogue between the U.S. and China, and was selected as a World Economic Forum "Young Scientist" (top 40 under 40 globally) in 2012.

Dr. Fuchs is currently a member of NASEM's National Materials and Manufacturing Board, and previously served on three NASEM committees: the Committee on Harnessing Light (2011-2013); the U.S. Advisory Committee for the International Commission for Optics (2013-2015); and the Committee on the Study on the Evaluation of ARPA-e Mission and Goals (2015-2017).

Erica Fuchs earned a Ph.D. in engineering systems from the Massachusetts Institute of Technology.

Eric S. Lander

Co-Chair

Eric Lander (NAS/NAM) is the president and founding director of the Broad Institute, a biomedical research institution focused on genomic medicine founded by MIT and Harvard. He is also professor of biology at MIT and professor of systems biology at Harvard Medical School. A geneticist, molecular biologist, and mathematician, Dr. Lander has played a pioneering role in all major aspects of the reading, understanding, and medical application of the human genome—including being one of the principal leaders of the international Human Genome Project from 1990 to 2003. Dr. Lander has also played an active role in public policy, including serving as co-chair of the President’s Council of Advisors on Science and Technology from 2009 to 2017. Lander was previously on the faculty at Harvard Business School, where he served as assistant and associate professor from 1981 to 1990. He was subsequently appointed as a tenured professor in MIT’s Department of Biology (1990-present) and a member of the Whitehead Institute for Biomedical Research (1990-2008). He was later also appointed professor of systems biology at Harvard Medical School (2004-present).

Dr. Lander is a member of the National Academy of Sciences and of the National Academy of Medicine. Currently, he is a member of NASEM’s International Commission on the Clinical Use of Human Germline Genome Editing. He was previously a member of the International Summit on Human Gene Editing (2015-2016); the NAS Council Committee on Scientific Programs (2002-2003); the Committee on Science, Technology, and Law (2000-2003); the NAS Temporary Nominating Group for Computational Biology (2000-2003); and several other NASEM activities. His awards include the MacArthur Fellowship and the Breakthrough Prize in Life Sciences.

Eric Lander earned a D.Phil in mathematics from Oxford University, where he was a Rhodes Scholar.

Ajay Agrawal

Member

Ajay Agrawal is the Geoffrey Taber Chair in Entrepreneurship and Innovation and Professor of Entrepreneurship at the University of Toronto's Rotman School of Management and a research associate at the National Bureau of Economic Research in Cambridge, MA.

Dr. Agrawal conducts research on the economics of artificial intelligence, science policy, entrepreneurial finance, and geography of innovation. He is co-founder of NextAI, an accelerator and founder development program for early- or idea- stage AI-enabled startups; founder of the Creative Destruction Lab, a seed-stage program for science-based companies; and co-founder of an annual conference on the business of artificial intelligence, held at the University of Toronto. He is a co-author of the book, *Prediction Machines: The Simple Economics of Artificial Intelligence* (2018), and co-editor of *The Economics of Artificial Intelligence: An Agenda* (2019). Dr. Agrawal has presented this work at a variety of institutions, including Harvard, MIT, Stanford, London Business School, Wharton, London School of Economics, Carnegie Mellon, Berkeley, The Brookings Institution, the National Press Club in Washington, the World Intellectual Property Organization in Geneva, Industry Canada, and the Federal Reserve Bank, among others.

Dr. Agrawal served as co-chair of the NASEM committee on Economic, Legal, and Regulatory Implications of Emerging Technologies: A Workshop Series (2018-2019).

Dr. Agrawal earned a Ph.D. in strategy and economics from the University of British Columbia, Vancouver.

Jeff Bingaman

Member

Jeff Bingaman is a former United States Senator from New Mexico, serving from 1983 to 2013. He served as Chairman of the Committee on Outreach for the Senate Democratic Caucus. Senator Bingaman held several committee assignments during his tenure in the U.S. Senate including: the Committee on Energy and Natural Resources, Committee on Finance, Joint Economic Committee, Committee on Armed Services, and the Committee on Health, Education, Labor, and Pensions. On the Senate Energy Committee, he contributed to every major piece of energy policy legislation over two decades. Prior to serving as a U.S. Senator, he worked as a private practice attorney, served as counsel to the New Mexico Constitutional Convention of 1969, and was Attorney General of New Mexico from 1979 to 1983, a position in which he focused mainly on environmental and antitrust issues.

For NASEM, Senator Bingaman is a member of the Board on Science, Technology, and Economic Policy and chairs the workshop planning committee on The Role of NIH in Drug Development Innovation and its Impact on Patient Access. He has also served as co-chair of the Committee on the Study of Education, Training, and Certification Pathways to a Skilled Technical US Workforce (2015-2017) and a member of the Committee on Ensuring Patient Access to Affordable Drug Therapies (2016-2017).

Senator Bingaman earned a J.D. from Stanford University.

Ashton B. Carter

Member

Ashton Carter is the Director of the Belfer Center for Science and International Affairs at Harvard University's John F. Kennedy School of Government. At the Harvard Kennedy School, he leads the Technology and Public Purpose project and serves as the Belfer Professor of Technology and Global Affairs. He is also an Innovation Fellow and member of the Corporation at the Massachusetts Institute of Technology.

Ashton Carter served as the 25th U.S. Secretary of Defense from 2015 to 2017, after serving as the number two ("COO") and number three ("weapons czar") positions in the Pentagon. For over 35 years inside government under presidents of both political parties as well as in the private sector, Secretary Carter leveraged his extraordinary experience in national security, technology, and innovation. He was awarded the Defense Distinguished Service Medal, the Department's highest civilian honor, on five separate occasions.

Secretary Carter has served on multiple NASEM committees, including the Committee on International Security and Arms Control (1989-1993; 2006-2009) and the Government-University-Industry Research Roundtable (Ex Officio Member, 2009-2014).

Ashton Carter earned a Ph.D. in theoretical physics from the University of Oxford.

James A. Evans

Member

James Evans is Professor of Sociology at the University of Chicago. He studies innovation and knowledge in science, technology and the digital economy with large-scale data and computational methods. He is also founding director of the university's Computational Social Science Program and Director of the Knowledge Lab, a center that uses big data, machine learning, high performance computing and intelligent crowdsourcing to understand and drive the changing nature of innovation and knowledge in a digital world. Before arriving at the University of Chicago, he served as a research associate in the Negotiation, Organizations, and Markets group at Harvard Business School.

James Evans earned a Ph.D. in sociology from Stanford University.

Edward W. Felten

Member

Edward W. Felten (NAE) is the Robert E. Kahn Professor of Computer Science and Public Affairs and the founding director of Princeton's Center for Information Technology Policy, a cross-disciplinary effort studying digital technologies in public life.

From 2011 to 2012 Dr. Felten served as the first chief technologist for the Federal Trade Commission. His research interests include computer security and privacy, especially relating to media and consumer products; and technology law and policy. He has published about 80 papers in the research literature and two books. His research on topics such as web security, copyright and copy protection, and electronic voting has been covered extensively in the popular press.

Professor Felten is a member of the National Academy of Engineering and of the American Academy of Arts and Sciences and is a fellow of the Association for Computing Machinery. He has testified at House and Senate committee hearings on privacy, electronic voting, and digital television. In 2004, Scientific American magazine named him to its list of 50 worldwide science and technology leaders. Among his committee service at NASEM, he served on the committees on Study on Directions for the AFOSR Mathematics and Space Sciences Directorate Related to Information Science and Technology (2005) and Fundamentals of Computer Science: Challenges and Opportunities (2000-2005). He served as a member of the NASEM Committee for the Study on Directions for the AFOSR Mathematics and Space Sciences Directorate Related to Information Science and Technology (2005) and the Committee on Fundamentals of Computer Science - Challenges and Opportunities (2000-2005).

Dr. Felten earned a Ph.D. in computer science and engineering from the University of Washington.

John L. Hennessy

Member

John L. Hennessy (NAS/NAE) is the Chair of Alphabet, Inc.; Professor of Electrical Engineering and Computer Science at Stanford University; and Director of Stanford's Knight-Hennessy Scholars Program. Dr. Hennessy served as President of Stanford University from September 2000 until August 2016.

Dr. Hennessy, a pioneer in computer architecture, joined Stanford's faculty in 1977 as an assistant professor of electrical engineering. In 1981, he drew together researchers to focus on a technology known as RISC (Reduced Instruction Set Computer), which revolutionized computing by increasing performance while reducing costs. Dr. Hennessy helped transfer this technology to industry cofounding MIPS Computer Systems in 1984. His subsequent research focused on multiprocessor systems, including the DASH and FLASH projects, both of which pioneered concepts now used in industry. He is the co-author (with David Patterson) of two internationally used textbooks in computer architecture.

His honors include the 2012 Medal of Honor of the Institute of Electrical and Electronics Engineers, the 2017 ACM Turing Award (jointly with David Patterson), the 2001 Eckert-Mauchly Award of the Association for Computing Machinery, the 2001 Seymour Cray Computer Engineering Award, and the 2004 NEC C&C Prize for lifetime achievement in computer science and engineering. He is an elected member of the National Academy of Engineering, the National Academy of Sciences, the American Academy of Arts and Sciences, The Royal Academy of Engineering, and the American Philosophical Society and has served on number NASEM board and committees.

John Hennessy earned a Ph.D. in computer science from the Stony Brook University.

Arunava Majumdar

Member

Arun Majumdar is the Jay Precourt Provostial Chair Professor at Stanford University, a faculty member of the Departments of Mechanical Engineering and Materials Science and Engineering (by courtesy) and co-Director of the Precourt Institute for Energy. He is also a faculty in Department of Photon Science at SLAC.

Dr. Majumdar's research in the past has involved the science and engineering of nanoscale materials and devices, especially in the areas of energy conversion, transport and storage as well as biomolecular analysis. His current research focuses on electrochemical and thermochemical redox reactions that are fundamental to a sustainable energy future, multidimensional nanoscale imaging and microscopy, and a new effort to re-engineer the electricity grid using data science, including deep learning techniques.

In October 2009, Dr. Majumdar was nominated by President Obama and confirmed by the Senate to become the Founding Director of the Advanced Research Projects Agency - Energy (ARPA-E), where he served until June 2012 and helped ARPA-E become a model of excellence and innovation for the government with bipartisan support from Congress and other stakeholders. Between March 2011 and June 2012, he also served as the Acting Under Secretary of Energy. Furthermore, he was a Senior Advisor to the Secretary of Energy, Dr. Steven Chu, on a variety of matters related to management, personnel, budget, and policy.

After leaving Washington, DC and before joining Stanford, Dr. Majumdar was the Vice President for Energy at Google, where he created several energy technology initiatives, especially at the intersection of data, computing and electricity grid.

Prior to joining the Department of Energy, Dr. Majumdar was the Almy & Agnes Maynard Chair Professor of Mechanical Engineering and Materials Science & Engineering at University of California-Berkeley and the Associate Laboratory Director for energy and environment at Lawrence Berkeley National Laboratory.

Dr. Majumdar is a member of the National Academy of Engineering and the American Academy of Arts and Sciences. He served as the Vice Chairman of the Advisory Board of US Secretary of Energy, Dr. Ernest Moniz, and was also a Science Envoy for the US Department of State with focus on energy and technology innovation in the Baltics and Poland. He is a member of the International Advisory Panel for Energy of the Singapore Ministry of Trade and Industry. He serves as an advisor to Envision Energy, Breakthrough Energy Ventures, First Light Fusion, the New Energy Group of Royal Dutch Shell and Lime Rock New Energy. He is a member of the Board of Directors of Cyclotron Road and the Electric Power Research Institute.

Dr. Majumdar received his bachelor's degree in Mechanical Engineering at the Indian Institute of Technology, Bombay in 1985 and his Ph.D. from the University of California, Berkeley in 1989.

Dr. Majumdar also serves on the National Academies' LabX Advisory Board.

Jason Matheny

Member

Jason Matheny is founding director of the Center for Security and Emerging Technology at Georgetown University. Previously he was Assistant Director of National Intelligence and Director of IARPA, responsible for the development of breakthrough technologies for the U.S. intelligence community. Before IARPA, he worked at Oxford University, the World Bank, the Applied Physics Laboratory, the Center for Biosecurity, and Princeton University, and was the co-founder of two biotechnology companies. He is a member of the National Security Commission on Artificial Intelligence and is a recipient of the Intelligence Community's Award for Individual Achievement in Science and Technology, the National Intelligence Superior Service Medal, and the Presidential Early Career Award for Scientists and Engineers.

He has served on various White House committees related to artificial intelligence, biosecurity, high-performance computing, and quantum information science. He co-led the National AI R&D Strategic Plan released by the White House in 2016 and was a member of the White House Select Committee on AI, created in 2018.

Dr. Matheny currently serves on the NASEM Intelligence Community Studies Board.

Jason Matheny earned a Ph.D. in applied economics from Johns Hopkins University.

J. Michael McQuade

Member

J. Michael McQuade is Carnegie Mellon University's vice president for research.

From 2006 to 2018 Dr. McQuade served as senior vice president for Science & Technology at United Technologies Corporation (UTC). At UTC, Dr. McQuade's responsibilities included providing strategic oversight and guidance for research, engineering and development activities throughout the business units of the corporation and at the United Technologies Research Center, focused on a broad range of high-technology products and services for the global aerospace and building systems industries. Dr. McQuade also held senior positions with technology development and business oversight at 3M, Imation and Eastman Kodak. He served as vice president of 3M's Medical Division and president of Eastman Kodak's Health Imaging Business. His early career at 3M was focused on research and development of high-end acquisition, processing and display systems for health care, industrial imaging and remote sensing. He has broad experience managing basic technology development and the conversion of early-stage research into business growth.

Dr. McQuade has served as a member of the President's Council of Advisors on Science and Technology and of the Secretary of Energy Advisory Board and is a member of the Defense Innovation Board.

Dr. McQuade earned a Ph.D. in physics from Carnegie Mellon University.

Judith A. Miller

Member

Judith A. Miller is Chair of the ABA Cybersecurity Legal Task Force and is also a member of the Defense Science Board's Task Force on Cyber Deterrence. She is active in a variety of public service and professional activities. She was Senior Vice President, General Counsel and a member of the Board of Directors of the Bechtel Group from January 2006 to January 2010. Prior to joining the Bechtel Group, she was a partner with Williams & Connolly LLP in Washington, DC. Her practice included a wide range of complex civil litigation and business-related criminal litigation, corporate and individual officer counseling, internal investigations, as well as issues affecting the defense industry. She returned to the firm in January 2000, after having been the then longest serving General Counsel of the U.S. Department of Defense (1994-1999). She clerked for Associate Justice Potter Stewart and U.S. Court of Appeals Judge Harold Leventhal. Ms. Miller is a past chair (2007-2008) of the American Bar Association's Section of Litigation and served on its Executive Committee and Council. She is a member of the Defense Science Board, the Council of the American Law Institute, the Executive Committee of the Atlantic Council of the United States, and the International Senior Lawyers Project Board. She is also a trustee of Beloit College (from which she also received an honorary Doctor of Laws degree); and served as a member of the American Bar Association's Commission on Ethics 20/20, the Standing Committee on Law and National Security; and the Markle Foundation Task Force on National Security in the Information Age. Ms. Miller is a recipient of the U.S. Department of Defense Medal for Distinguished Public Service and the Bronze Palm to that Medal. She was the Women's Bar Association of the District of Columbia 2006 Woman Lawyer of the Year.

Judith Miller is a member of the NASEM Committee on Science, Technology, and Law. She has also served as a member of the NASEM Committee on Scientific Communication and National Security (2005-2010), Committee on Science, Security and Prosperity in a Changing World (2008-2010), and Roundtable on Scientific Communication and National Security (2003-2005).

Judith Miller earned a J.D. from Yale Law School.

David C. Mowery

Member

David C. Mowery is the William A. & Betty H. Hasler Professor Emeritus of New Enterprise Development at the Haas School of Business at University of California, Berkeley. He began his teaching career as an assistant professor in the Social and Decision Sciences Department at Carnegie-Mellon University in 1982, being promoted to associate professor prior to moving to UC Berkeley in 1988. He has also served as Assistant to the Counselor in the Office of the United States Trade Representative and as a Fellow at the Council on Foreign Relations. His research interests include the impact of technological change on economic growth and employment, the management of technological change, and international trade policy and U.S. technology policy, especially high-technology joint ventures.

He has served on a number of NASEM committees, among them the Committee on Human Spaceflight (2012-2014); Committee on Assessing the Value of Research in Advancing National Goals (2012-2014); Committee on Harnessing Light: Capitalizing on Optical Science Trends and Challenges for Future Research (2011-2013).

David Mowery earned a Ph.D. in economics from Stanford University.

Catherine A. Novelli

Member

Catherine A. Novelli is the President of Listening for America, a non-partisan, non-profit organization dedicated to forging a new vision of U.S. international trade engagement. She previously served as Under Secretary of State for Economic Growth, Energy, and the Environment (2014-2017) where she promoted economic reform and open markets for U.S. products and services. Secretary Novelli spent seven years as Vice President, Worldwide Government Affairs at Apple Inc, and, previously, was a partner in the law firm of Mayer Brown International. She had a long career at the Office of the U.S. Trade Representative, rising to Assistant U.S. Trade Representative for Europe & the Mediterranean, where she coordinated U.S. trade and investment policy for Europe, Russia, Central Asia, the Middle East and Northern Africa. She took a leading role in many of the most important U.S. trade negotiations in those regions, including free trade agreements with Jordan, Morocco and Bahrain, and Oman. Secretary Novelli has received the State Department Distinguished Service Award and the International Trade Woman of the Year Award.

Catherine Novelli is a member of the NASEM Policy and Global Affairs Committee.

She earned a J.D. from the University of Michigan and a Master of Laws from University of London.

Martine A. Rothblatt

Member

Martine A. Rothblatt is Chairman and Chief Executive Officer of United Therapeutics. Dr. Rothblatt founded United Therapeutics in 1996 and has served as Chairman and Chief Executive Officer since the inception of the company. Prior to creating United Therapeutics, Dr. Rothblatt founded and served as chairman and chief executive officer of Sirius Satellite Radio and was principally responsible for several other unique applications of satellite communications technology. She also represented the radio astronomy interests of the National Academy of Sciences' Committee on Radio Frequencies before the Federal Communications Commission. On behalf of the International Bar Association, she led efforts to present the United Nations with a draft Human Genome Treaty. She moved to biotechnology from satellite technology and started United Therapeutics to find a cure or better treatment for the pulmonary hypertension that affects one of her daughters.

Dr. Rothblatt received a combined law and Master of Business Administration degree from the University of California, Los Angeles. She earned her Ph.D. in medical ethics from the Royal London School of Medicine and Dentistry, Queen Mary College, University of London. Her book, "Your Life or Mine: How Geoethics Can Resolve the Conflict Between Public and Private Interests in Xenotransplantation," was published by Ashgate in 2004. Dr. Rothblatt is a member of the International Institute of Space Law, the International Academy of Astronautics and the International Bar Association. She was elected a member of the American Philosophical Society in 2008.

Dr. Rothblatt also serves on the National Academies' Committee on Science, Technology, and Law.

Denis F. Simon

Member

Dr. Denis Fred Simon is executive vice chancellor at Duke Kunshan University and Professor of China Business and Technology at Duke's Fuqua School of Business.

Fluent in Mandarin Chinese, Dr. Simon has more than four decades of experience studying business, competition, innovation and technology strategy in China. In 2006, he was awarded the China National Friendship Award by Premier Wen Jiabao in Beijing. Prior to Duke, Dr. Simon's career included spells as senior adviser on China and global affairs in the Office of the President at Arizona State University; vice-provost for international affairs at the University of Oregon; and professor of international affairs at Penn State University's School of International Affairs. He was founding provost and vice-president for academic affairs of the Levin Graduate Institute of International Relations and Commerce under the State University of New York in New York City.

Dr. Simon is the author of several books including *Corporate Strategies Towards the Pacific Rim*; *Techno-Security in an Age of Globalization*; and *China's Emerging Technological Edge: Assessing the Role of High-End Talent*.

Dr. Simon served as a member of NASEM's Committee on Competitiveness and Workforce Needs of United States Industry (2006-2009) and as a member of the National Academies' Transfer of Technology Seminar (1985).

Dr. Simon earned a Ph.D. in political science from the University of California, Berkeley.

Christina D. Smolke

Member

Christina D. Smolke is CEO of Antheia, Inc. and Professor (Research) of Bioengineering and, by courtesy, of Chemical Engineering at Stanford University. She earned her B.S. in Chemical Engineering at the University of Southern California in 1997, and her Ph.D. in Chemical Engineering at UC Berkeley in 2001.

Dr. Smolke, a pioneer in the fields of synthetic biology and metabolic engineering, joined Caltech's faculty in 2003 as an Assistant Professor of Chemical Engineering and joined Stanford's faculty in 2009. Dr. Smolke's early work pioneered the design and application of a broad class of RNA molecules, called RNA switches, that process and transmit user-specified input signals to targeted protein activities, providing programmable platforms for building biological sensors and control systems. Dr. Smolke's recent work has pioneered the development of yeast biosynthesis platforms for complex plant-based alkaloids, leading to efficient, sustainable, rapid-response fermentation processes for producing essential plant-based medicines.

Dr. Smolke's impact in advancing the frontiers of biotechnology has been recognized with numerous awards, including Chan Zuckerberg Biohub Investigator, Nature's 10, AIMBE College of Fellows, NIH Director's Pioneer Award, WTN Award in Biotechnology, and TR35 Award.

Jeannette M. Wing

Member

Jeannette M. Wing is Avaneessians Director of the Data Science Institute and Professor of Computer Science at Columbia University. She went to Columbia in July 2017 from Microsoft, where she served as Corporate Vice President of Microsoft Research, overseeing a global network of research labs. She is widely recognized for her intellectual leadership in computer science, particularly in trustworthy computing. Dr. Wing's seminal essay, titled "Computational Thinking," was published more than a decade ago and is credited with helping to establish the centrality of computer science to problem-solving in fields where previously it had not been embraced.

Before joining Microsoft, Dr. Wing held positions at Carnegie Mellon University and at the National Science Foundation. At Carnegie Mellon, she served as Head of the Department of Computer Science and as Associate Dean for Academic Affairs of the School of Computer Science. At the National Science Foundation, she was Assistant Director of the Computer and Information Science and Engineering Directorate, where she oversaw the federal government's funding of academic computer science research. Her areas of research expertise include security and privacy; formal methods; programming languages; and distributed and concurrent systems.

Dr. Wing is currently a member of the NASEM Committee on National Statistics; previously, she served on the Computer Science and Telecommunications Board (2001-2007), the Committee on Innovation in Information Technology (2002-2003), and Science and Technology for Countering Terrorism: Panel for Information Technology (2001-2003).

Dr. Wing earned a Ph.D. in computer science from the Massachusetts Institute of Technology.

Gail Cohen

Staff Officer