BOSTON TECH HUB FACULTY WORKING GROUP

# Annual Report

2019–2020

HARVARD Kennedy School
BELFER CENTER
for Science and International Affairs
TECHNOLOGY & PUBLIC PURPOSE PROJECT

Harvard John A. Paulson
School of Engineering
and Applied Sciences

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## Table of Contents


Foreword ..... 1

FWG Members and Guests ..... 5

Introduction ..... 13

Summary ..... 14

FWG Session Briefs: Fall 2019 ..... 19

FWG Session Briefs: Spring 2020 ..... 31



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**Carol Rose**, Executive Director of ACLU Massachusetts, discusses the public purpose implications of facial recognition and emotion artificial intelligence tools.

# Foreword

In 2017, we decided to convene some of the world's leading minds in the sciences, law, economics, and humanities to discuss the direction of technology and its unbounded opportunities. The decision rested on a key principle: **Boston provides the ideal environment to develop not only leading-edge technology, but also civically informed solutions for today's tech dilemmas.** Because rapid innovation in technology can circumvent the values of privacy, inclusion, transparency, and security, public purpose needs to be valued as a fundamental requisite of innovation. By recognizing its potential for both good and bad, technology can be guided toward the greater benefit of society.

With its rich history and vast resources, Boston is the perfect place to take the lead.

Throughout most of our nation's history, Boston has been at the epicenter of America's technological progress. The industrialization of New England—and the diversity of its sunrise industries—concurrently impacted the development of its universities. Beginning as early as the mid-1800s, Harvard and later MIT embarked on a mandate that stretched beyond the role of a traditional liberal arts institution and looked toward the development of practical innovations. The two universities became closely intertwined with commercial enterprise, and today's leaders in technology can often be traced back to these origins.

Boston's success and technological prowess are also predicated on a close relationship with government. Over the last century, federal research dollars have flooded into the city's basic science research, but particularly toward unprecedented advances in the applied sciences. In biotech, energy, materials, robotics, space, defense and other industries, both Harvard and MIT are well positioned to solve the country's most demanding technical and policy challenges. The invaluable connection between Boston and Washington D.C. aligns technologists with honorable work and a duty to secure a positive future for their inventions.

The Faculty Working Group set out to explore today's unique challenges. In the fall, we focused on new technologies, or their novel applications, including: **facial recognition and emotion artificial intelligence tools; asteroid mining and in-space manufacturing; gene drives; and life extension technologies**. In the spring, we put forward potential solutions for current dilemmas and discussed topics such as: how to keep public data secure with **differential privacy tools**; how policymakers should address **Chinese technology companies and China's state influence in American academia**; and how to **increase scientific and technological expertise in the federal government**.

Each session addressed a new frontier in technology that our society is only beginning to grapple with or struggling to adapt to. The participants included interdisciplinary faculty scholars, technologists, and other stakeholders from across Harvard and MIT, as well as government and industry. The discussions that arose from these sessions frame the key takeaways in this report.

A critical challenge of our time is making technological change positive for all. The fate of our collective future requires that experts—in academia, government, or industry—apply their knowledge in the service of civic duty and public purpose. The brightest and most creative problem solvers seek the hardest, most interesting problems. In Boston, this has been a tradition.

Sincerely,

Ash Carter
Frank Doyle

Members of the Faculty Working Group discuss the public purpose implications of life extension technologies.

# FWG Members and Guests

## CHAIRS

**Ash Carter** – *Director, Belfer Center, HKS; Faculty Director, Technology and Public Purpose Project, Belfer Center, HKS; Board Member and Innovation Fellow, MIT; Former U.S. Secretary of Defense*

**Frank Doyle** – *John A. Paulson Dean, John A. & Elizabeth S. Armstrong Professor of Engineering & Applied Sciences, Harvard John A. Paulson School of Engineering and Applied Sciences*

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| **Latanya Sweeney** | *Professor of Government and Technology in Residence* |
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## OTHER UNIVERSITY

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| **Steve Holtzman** | *Strategic Advisor, Decibel Therapeutics* |
| **Scott Kennedy** | *Senior Adviser and Trustee Chair in Chinese Business and Economics, Center for Strategic & International Studies* |
| **Eric Lander** | *President & Founding Director, Broad Institute* |
| **Chris Lynch** | *CEO and Co-Founder, Rebellion Defense* |
| **Travis McCready** | *Consultant and Advisor, Puddingstone Consulting* |
| **Jason Providakes** | *President & CEO, MITRE* |
| **Katie Rae** | *CEO & Managing Director, The Engine* |
| **Daisy Robinton** | *Scientist in Residence, Cambrian Biopharma* |
| **Carol Rose** | *Executive Director, ACLU Massachusetts* |
| **Eric Schmidt** | *Technical Advisor, Alphabet, Inc.* |
| **Jay Schnitzer** | *Vice President, Chief Technology Officer, Chief Medical Officer, MITRE Corporation* |
| **Kimberly Slater** | *Business Area Lead, Space Innovations, Draper* |
| **Bina Venkataraman** | *Editorial Page Editor, Boston Globe* |

*Please note: Many attendees have several affiliations across different schools, universities, and businesses.


**Daisy Robinton**, Scientist in Residence at Cambrian Biopharma, discusses the science behind life extension technologies.

# Introduction

A guiding principle for the Boston Tech Hub Faculty Working Group is that technological innovation is not pre-determined; individuals and societies shape how technologies are researched, developed, regulated, and used. Citizens, technologists, policymakers, and ethicists have an opportunity to embed public purpose in each step of the technology development process, ensuring that common values are suffused throughout new technologies and appropriate safeguards are put in place to manage their consequences.

Embedding public purpose values in the technological development process is not easy; it requires thoughtfulness and resolve from the public, private, and not-for-profit sectors, with input from local, national, and international leaders. This task is made more difficult when global leaders in innovation diverge on the values that they hold most dear.

Throughout its existence, the Boston Tech Hub Faculty Working Group has attempted to find opportunities for technologists and policymakers to work together to shape emerging technology in meaningful and measured ways. Participants have identified leverage points that technologists, policymakers, and advocates can use to inject public purpose considerations into the design and deployment of emerging technologies.

# Summary

## The development and application of novel surveillance technologies has profound implications for privacy, security, freedom, fairness, and other public purpose values

- While the public purpose values of security and privacy have been at odds throughout history, emerging technologies like facial recognition and emotion artificial intelligence tools allow surveillance to occur passively and at scale, impinging on an individual's reasonable expectation of privacy in public or semi-public spaces. Surveillance technologies can be used by law enforcement agencies to identify and monitor protestors, affecting freedom to peaceably assemble and to petition the government without fear of consequence. Additionally, authoritarian countries use surveillance technology to perpetrate human rights abuses, as China's Communist Party leadership is doing to its Uyghur population in Xinjiang province.
- Layered on top of questions of security and privacy is the bias currently built into surveillance tools, leading to false identifications that could cause unnecessary and intrusive interactions between innocent individuals and law enforcement officers. Today, facial recognition tools are less accurate when used to identify non-white individuals—largely a consequence of training systems with biased data. When coupled with existing societal inequities, such as structural racism in American society, bias inherent in surveillance tools could disproportionately harm marginalized communities.
- As with other emerging technologies, regulation has not kept pace with the development and deployment of surveillance tools; more must be done to ensure that the tools reduce harm. In America, a patchwork of regulations at the state and municipal levels prevents local law enforcement, commercial entities, or some combination thereof from using facial recognition tools; no federal legislation on the use of these tools has been passed. While several large technology companies have self-regulated their facial recognition tools by placing voluntary moratoriums on their sale and use,

experts remain concerned that once public attention on the issue of surveillance wanes, they will end this moratorium

## New biotechnologies are forcing society to reckon with longstanding questions of governance and access in new ways.

- Engineered gene drive systems enable humans to make temporary or permanent genetic alterations to an entire species over time; for example, engineered gene drives could be inserted into a mosquito population to prevent the spread of malaria to humans. However, gene drive systems cannot be guaranteed to stay within an intended impact zone and could lead to unintended ecological consequences.
- Life extension technologies hold the potential to slow down, halt, or reverse the aging process; in doing so, they could increase the 'health spans' or the lifespans of humans who have access to them. As with other classes of pharmaceuticals, life extension technologies would likely be expensive, preventing access to those who could not afford them.
- These novel biotechnologies, and others like them, bring to the fore longstanding questions of governance and access. How should gene drives and life extension technologies be governed and used? Are national and international governance frameworks capable of making and enforcing decisions on their appropriate use? If societies cannot guarantee affordable insulin, a life-saving technology for diabetics, can they be expected to ensure access to novel life-extending technologies?
- Additionally, these technologies ask new questions of society. What are the ecological consequences of purposefully pushing a species to extinction? Under what circumstances. If any, should engineered gene drives be used in human populations for the treatment of disease or for enhancement in the future? What are the unintended consequences of a human population that has a substantially longer

lifespan? There are no definitive, agreed-upon answers to these questions yet, and it is not clear that existing international institutions will be capable of addressing them in substantial ways.

## America lacks a strong playbook of practical actions it can take in its economic and academic relationship with Chinese technology companies and Chinese funding of academic institutions in America.

- The United States and China have different views about public purpose values such as free speech, privacy, security, and inclusion. Despite their significant differences, the United States and China have little choice but to work together; they have close economic and academic relationships and must cooperate to address issues of international importance, like climate change and pandemics.
- Chinese businesses have close ties with the ruling Chinese Communist Party (CCP), and the country's National Intelligence Law compels the businesses to transfer data to the CCP if requested—even if the business does not wish to do so. As Chinese companies become global leaders in technologies like 5G wireless infrastructure—likely to be a vital engine of economic growth and prosperity—American and European policymakers must develop a playbook for how to respond.
- The United States and China have a significant academic research relationship; the countries are each other's top research collaborators. However, the Department of Education and the United States Congress are concerned that the CCP uses funding of American academic institutions and America-based researchers to gain access to intellectual property for its economic and military gain. America must balance its view of the significant value inherent in open academic collaboration with the public purpose implications of stolen technologies being used by the CCP in harmful ways.
- While American policymakers have developed several 'plays' for maintaining the country's national security and economic

competitiveness in the face of these challenges—from constraining Chinese firms' access to American-made products and customers to putting in place structures to prevent intellectual property theft—more must be done. America needs new plays to protect public purpose values like academic openness, trust, and transparency.

## As the pace of technological change increases, America must increase and augment its pathways to recruit scientific and technical talent to work for the federal government.

- In recent years, members of Congress have appeared unable to reckon with emerging technology issues through hearings and legislation. Similarly, high-profile executive branch projects, such as the botched initial development and rollout of Healthcare.gov, exposed a distinct need for technical talent within the White House and executive branch agencies.
- Compounding these issues, in recent decades, Congress has chronically underfunded itself, eliminated its in-house source of scientific expertise, and significantly reduced its committee staff. In the past several years, career scientists have left federal agencies in droves, feeling that their scientific expertise is disregarded and, in some cases, disdained.
- To remedy the issue of insufficient scientific and technical expertise within the legislative branch, several outside organizations have created or expanded congressional fellowship programs for scientists and technologists, and the Government Accountability Office established a Science, Technology Assessment, and Analytics team to provide expertise to Congress. The executive branch has created several programs to recruit technical talent to work on issues within the federal government—from 'tour of duty' roles in the Defense Digital Service and the United States Digital Service to prestigious fellowships for entrepreneurs through the Presidential Innovation Fellows program.

- Still, as the pace of technological change increases and both branches of government are tasked with increasingly sophisticated science and technology issues, they will need to consider additional pathways to recruit and retain technical talent and new institutions to house them in. The legislative branch will need to increase compensation and re-think its hiring model; the executive branch will once again need to value the expertise of its scientists.

Despite needing to hold several sessions virtually to ensure the health and safety of its members and prevent the spread of COVID-19, the Boston Tech Hub Faculty Working Group was still able to discuss, deliberate, and debate how emerging technologies can be shaped to ensure the public good. The diverse professional backgrounds of the membership allowed for the cross-fertilization of ideas and conversations that enriched the group's understanding of emerging technologies and their public purpose implications.

In the Fall 2020 semester, these virtual sessions will continue. A new set of technologies, both timely and forward-looking, will include **vaccine platforms, deepfakes, battery technologies, and brain-computer interfaces**. We look forward to further expanding our network in the Boston area and beyond, bringing together individuals dedicated to working on collective solutions to the most pressing issues of our time.

BOSTON TECH HUB FACULTY WORKING GROUP

# Session Briefs

Fall 2019

BOSTON TECH HUB FACULTY WORKING GROUP

FALL SESSION 1 • SEPTEMBER 17, 2019

# Facial Recognition and Emotion Artificial Intelligence


PREPARED BY:

**Joseph Fridman**
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HARVARD Kennedy School
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TECHNOLOGY & PUBLIC PURPOSE PROJECT

Harvard John A. Paulson
School of Engineering
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**The Boston Tech Hub Faculty Working Group**, hosted by former Secretary of Defense and Harvard Kennedy School Belfer Center Director Ash Carter and Harvard SEAS Dean Frank Doyle, will convene its first session of the fall semester on the topic of facial recognition and emotion artificial intelligence. This session will examine current applications, capabilities, limitations, and ongoing debates regarding acceptable use, regulation, and governance of the technologies.

# Context

## Facial Recognition

- **Facial Recognition (FR)** technologies are artificial intelligence algorithms that use machine vision techniques to analyze photographs or videos of faces to identify an individual. FR works by measuring distances between points on an image of a person's face to produce a unique 'faceprint' to each individual, which is then compared against a database of images to produce a list of likely matches. FR is sometimes combined with other forms of biometric data that are unique to an individual, such as iris patterns, fingerprints, and walking gait.

    - **Applications.** Uses of FR can be separated into two categories: authentication and surveillance. Authentication applications, such as Apple's FaceID feature for iPhones, allow someone to use their face as a key—to unlock a personal device, vehicle, or room, or to check-in at facilities such as airports, medical clinics, or hotels. Surveillance applications aim to identify individual persons within public settings by matching real-time facial scans with facial data stored in databases. Currently, surveillance applications are prevalent among law enforcement agencies and private security companies to identify suspects, locate missing people, cross-check against existing databases, or to identify individuals in high-risk venues (e.g., airports, stadiums, public squares). Private companies—including retailers like Walgreens—are also testing and deploying FR for commercial purposes, such as to identify individuals' shopping patterns in stores for targeted advertising.

    - **Concerns.** FR technology has reliability, bias, privacy, and human rights concerns. The reliability of FR identifications depends on the quality of the image. Some current FR technologies have been criticized for discriminating against non-male genders and non-white races, due to selection biases within datasets on which the algorithms are trained. The wide use of FR in public places has raised concerns over privacy, where individuals might be denied a reasonable expectation of privacy in semi-public spaces. For example, individuals entering substance abuse or abortion facilities could be identified without consent. Similar surveillance concerns surround FR enabling nation state human rights abuses, such as China's tracking of Muslim Uyghurs and political protesters in Hong Kong.

- **Regulatory proposals.** Regulations for FR include the development of privacy/data use frameworks, bans or moratoria, internal audits within law enforcement, civil society oversight, and the development of industry guidelines. There is currently no US federal legislation restricting the use of FR technology, though some cities have passed bans (e.g., San Francisco, Oakland, Somerville) and some states are considering statewide bans (e.g., Massachusetts, California) or requiring individual consent before companies can collect 'faceprints' and other biometric data (e.g., Illinois, Texas, Washington). In the European Union, the General Data Protection Regulation classifies facial images used for FR as a special category of personal data that requires explicit user consent.

## Emotion Artificial Intelligence (EAI)

- **Emotion Artificial Intelligence**, also called 'affective computing,' is an interdisciplinary field combining computer science, neuroscience, and physiology to create machines which can mimic human emotions (emotion synthesis) or analyze human emotions (emotion analysis). Synthetic emotions are constructed through algorithms that make robots, chatbots, and animations in videos more realistic. Emotion analytics, the focus of this session, uses algorithms to analyze the correlates of human emotions. These correlates can include the movements of facial muscles, as well as biosensing of other physiological or behavioral data (e.g., coloration, body temperature, heart rate, respiration) through wearable devices or cameras.

    - **Applications**. EAI is currently being built and used for commercial (e.g., advertisement effectiveness, consumer satisfaction, 'smart ads') and health applications (e.g., diagnostics, patient monitoring). Additionally, companies are building EAI applications tomonitor attention and productivity in the workplace and at school. Research Future (MRFR) forecasts that the global market for emotions analytics will reach $25 billion by 2023.

    - **Concerns.** Concerns about EAI are similar to those of FR regarding privacy, algorithmic bias, and potential human rights abuses. Additionally, some are concerned about the accuracy of inferring emotional states from facial expressions and other biosensed data. A recent consensus panel convened by the Association for Psychological Science concluded that facial movements often do not reliably map to specific emotional states; there can also be significant differences across cultures and individuals in the degree of expression of emotions.

    - **Regulatory proposals.** There are no current regulations for EAI technologies. Some EAI applications**,** like in automobiles and health care products, are regulated by existing state or federal laws for safety and efficacy; additionally, the FTC can act on claims of fraud and mislabeling of emotions in EAI products. GDPR does not treat emotion data as a special class of data requiring opt-in consent, so long as it is not uniquely identifiable.

## Discussion Questions

- What are the trade-offs that society makes when implementing facial recognition technology?
- Whose primary responsibility is it to manage risks of facial recognition and EAI technology? Legislatures? Courts? Developers? Operators? What are the separate responsibilities ofeach?
- What characteristics define a 'surveillance state'? What policies should guide lawenforcement use of FR and EAI? What responsibility do private companies have to follow similar rules?
- The use of FR technology has already run into issues of racial bias and the use of EAI will need to differentiate emotions across cultures. What domestic and international safeguards could exist to protect against algorithmic bias?

## Readings

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Elaine Sedenberg and John Chuang. "Smile for the Camera: Privacy and Policy Implications of Emotion AI," UC Berkeley School of Information. 2019.

Tim Lewis. "AI Can Read Your Emotions. Should it?" *The Guardian.* 2019.

Jay Stanley. "Experts Say 'Emotion Recognition' Lacks Scientific Foundation," American Civil Liberties Union. 2019.

BOSTON TECH HUB FACULTY WORKING GROUP

FALL SESSION 2 • OCTOBER 8, 2019

# Asteroid Mining and In-Space Manufacturing


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**The Boston Tech Hub Faculty Working Group**, hosted by former Secretary of Defense and Harvard Kennedy School Belfer Center Director Ash Carter and Harvard SEAS Dean Frank Doyle, will convene its second session of the fall semester on the topic of asteroid mining and in-space manufacturing. This session will examine current applications, capabilities, limitations, and ongoing debates regarding acceptable use, regulation, and governance of the two technologies.

# Context

- **Asteroid mining**[1] is the process of harvesting natural resources—including water (as ice), metals, and minerals—from near-earth asteroids. Asteroid mining is a subset of a obtaining resources from space generally, which includes, among other things: asteroids, Earth's Moon, and other planets and their moons.

    - **Applications.** Resources obtained from asteroids (or space generally) could either be processed on a lunar base or space station or brought back to earth to be processed. Importantly, asteroid ice could be used as a propellant (either as steam or as combustible fuel), substantially reducing the fuel required for rockets launching from earth. Vast quantities of iron, nickel, platinum, and palladium would have many uses in space and on Earth. Taken together, some researchers argue that asteroid mining applications could lower greenhouse gas emissions from spacecraft launches, spacecraft re-entries, and terrestrial mining operations.[2]

    - **Concerns.** There are three broad concerns with asteroid mining: feasibility/cost, sovereignty, and equity.

      *Feasibility/Cost.* The two most notable asteroid mining companies, Planetary Resources and Deep Space Industries, could not maintain investor funding, and were acquired by other companies in 2018, as business model concerns mounted. Once thought of as a near-term possibility, asteroid mining now appears to be a longer- term enterprise, with existing companies developing enabling tools and technologies, such as asteroid databases and propulsion systems.[3]

      *Sovereignty.* Like past discussions on who is able to use Earth's international waters, there are sovereignty concerns about space and who can use it. A patchwork of international, regional, and national treaties, laws, and regulations has started, but not finished, answering sovereignty concerns.[4]

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1 Because this is the popular term for obtaining resources from asteroids, we use it here. Some argue that the term is misleading, as 'mining' is a term that may not apply for obtaining resources from asteroids or, more broadly, from space.

2 There is disagreement as to whether obtaining space resources would have benefits for Earth's environment. For more, see Hein, Saidani, and Tollu: https://arxiv.org/ftp/arxiv/papers/1810/1810.04749.pdf

3 Abrahamian, Atossa Araxia. "How the Asteroid-Mining Bubble Burst." *MIT Technology Review.* June 26th, 2019. https://www.technologyreview.com/s/613758/asteroid-mining- bubble-burst-history/

4 Christensen, Ian et al. "New Policies Needed to Advance Space Mining." *Issues in Space and Technology.* Winter 2019. https://issues.org/new-policies-needed-to-advance-space-mining/

*Equity.* Few countries and companies have the resources and expertise to build space programs, creating concerns that the benefits of space resources will not be available to all. As with other industries, what is fair is an ongoing discussion.

- **Regulatory Proposals.** The Outer Space Treaty, which entered into force in 1967 and is ratified by 109 nations, stipulates that, among other things: (1) states cannot claim sovereignty over outer space, (2) the Moon and other celestial bodies can only be used for peaceful purposes, (3) states are responsible for all national space activities regardless if they are conducted by non-governmental entities and shall be held liable for damages, and (4) states "shall avoid harmful contamination of space and celestial bodies."[5]

  In 2015, the US Congress passed the SPACE Act, which gave American companies the rights to everything extracted from asteroids, despite not having property rights to them.[6] Luxembourg created a similar legal framework in 2017.[7]

- **In-Space Manufacturing** is the process of creating products outside of earth, whether with items brought from earth or with items mined created from materials mined and processed outside of earth. In-space manufacturing encompasses everything from 3D printing parts on the International Space Station to creating living environments for humans on a moon or planet.

  - **Applications.** Manufacturing in space can take advantage of microgravity, the vacuum of space, and other properties of non-earth environments to create objects that would be infeasible or impossible to manufacture on earth. It can also substantially reduce the weight of materials flown off earth, which has practical and environmental benefits.[8] [vi]

  - **Concerns.** Given its nascency, in-space manufacturing carries with it a host of practical unknowns (e.g., failure modes, process parameter unknowns) that will need to be further studied. Additionally, there is little governance of the field, creating legal and regulatory risk.

  - **Regulatory Proposals.** The regulatory proposals described on page 1 apply to in-space manufacturing as well. Aside from those broad regulations, there is little regulation of in-space manufacturing so far.

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5 "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies." United Nations Office for Outer Space Affairs. http://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introouterspacetreaty.html

6 H.R.2262 - U.S. Commercial Space Launch Competitiveness Act. November 25th, 2015. https://www.congress.gov/bill/114th-congress/house-bill/2262

7 "A Legal Framework for Space Exploration." The Grand Duchy of Luxembourg. July 13th, 2017. http://luxembourg.public.lu/en/actualites/2017/07/21-spaceresources/index.html

8 O'Connell, Cathal. "The Future of In-Space Manufacturing." *Cosmos.* February 1st, 2019. https://cosmosmagazine.com/space/the-future-of-in-space-manufacturing

## Discussion Questions

- What is/are the proper governance mechanism(s) to regulate the use of space for commercial purposes?

- Is the Outer Space Treaty enough to properly regulate asteroid mining, in-space manufacturing, and other pursuits? What other global governance frameworks are needed?

- How much should governments spend on space-related technological development versus the private sector? What are the upsides and downsides of a private sector-led model?

- Should global governance mechanisms consider equity when crafting future legal and regulatory frameworks? Why or why not?

## Readings

Atossa Araxia Abrahamian. "How the Asteroid-Mining Bubble Burst." *MIT Technology Review.* June 26th, 2019.

Ian Christensen et al. "New Policies Needed to Advance Space Mining." *Issues in Science and Technology,* Winter 2019.

Cathal O'Connell. "The Future of In-Space Manufacturing." *Cosmos Magazine,* February 2019.

BOSTON TECH HUB FACULTY WORKING GROUP

FALL SESSION 3 • NOVEMBER 19, 2019

# Gene Drives


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**The Boston Tech Hub Faculty Working Group**, hosted by former Secretary of Defense and Harvard Kennedy School Belfer Center Director Ash Carter and Harvard SEAS Dean Frank Doyle, will convene its third session of the fall semester on the topic of gene drives. The session will examine current applications, capabilities, limitations, and ongoing debates regarding acceptable use, regulation, and governance of the technology.

# Context

- **Gene Drives** are pieces of DNA that are inherited by offspring more frequently than 50% of the time. While gene drives exist in nature, this session will focus on engineered gene drives inserted into a species, with the intent of spreading a specified change through a specified population.[1]

- Currently, gene drive systems use CRISPR-cas9 (Clustered Regularly Interspaced Short Palindromic Repeats), a tool to precisely identify a section of DNA, make a cut, and insert desired DNA.[2] The CRISPR system can also be included in inserted DNA, so that any offspring—which inherit one chromosome from the edited parent and one from a 'wild' unedited parent[3]—will be 'self-edited' and therefore will pass the gene drive system on to their own offspring. In this way, a gene drive "allows humans to change the genetic makeup of a species by changing the DNA of a few individuals that then spread the modification throughout an entire population."[4]

- Engineered gene drives could be made to be endlessly reproducible or temporary. Endlessly reproducible gene drives would, if successful, transmit through each subsequent generation of a species, because "they carry everything they need to copy themselves."[5] Temporary gene drives—sometimes referred to as '**daisy drives**'—would theoretically cause a gene drive system to fail after a certain number of reproductions;[6] the change would be self-limiting. Certain non-driving technologies can also affect wild populations and shared environments, but because they do not increase in frequency in the wild, they can only affect much smaller areas.

# Applications

1 We are grateful to Naomi Silverstein for research assistance with this brief.

2 Researchers discovered CRISPR as a simple immune system in bacteria meant to identify and disrupt viral 'attackers.'

3 Assuming that the other parent has not also been genetically modified.

4 Matthews, Dylan. "A genetically modified organism could end malaria and save millions of lives — if we decide to use it." Vox. September 26, 2018. https://www.vox.com/science-and-health/2018/5/31/17344406/crispr-mosquito-malaria-gene-drive-editing-target-africa-regulation-gmo

5 "Daisy Drive Systems." Sculpting Evolution. MIT. http://www.sculptingevolution.org/daisydrives

6 Ibid. Theoretically, this same system could be used to restore a target species to its original state.

- In **agriculture**, gene drives could be developed to control pest populations without pesticides or to eliminate parasites like the New World Screwworm that cause economic losses and animal suffering in cattle (and other non-livestock animals). In **human health**, gene drives could be developed to reduce the spread of diseases like malaria, schistosomiasis, and Lyme. In **ecosystems**, gene drives could be used to remove invasive species from a geography or to add beneficial traits to threatened species, like coral. In **animal welfare**, gene drives could reduce the fecundity of rodent pests currently controlled through inhumane poisons.

- Gene drives could be used to **disrupt transmission of certain diseases** by either *making a vector or reservoir species immune* or by *suppressing* the population. For example, mosquitoes that transmit malaria could either be engineered to pass on immunity to the parasite or engineered to produce disproportionately sterile male offspring, crashing the population and disrupting transmission of the disease.[7] In either case, the mosquito would be unable to act as a vector of disease, reducing transmission and potentially eradicating a disease from a given area.

## Public Purpose Concerns and Considerations

- **Ecological Impact.** Self-propagating gene drive systems cannot be tested in the field due to their extreme invasiveness; any trials would require a daisy drive or equivalent. If a gene drive is used to reduce or eliminate a species, the full ecological impact throughout the range is unlikely to be known prior to use. This concern is somewhat tempered by the ability to precisely target certain species; three species of mosquito (out of 3,500) are mostly responsible for transmitting malaria, for example.[8] However, ecological impacts remain an important consideration for scientists, advocates, and governments.

- **Improper Use.** Gene drive systems can be created and released unilaterally. An unsanctioned use of an engineered gene drive could cause harm to a geographic area and could set back the use of engineered gene drives for other purposes— effectively 'scaring off' society from using the technology. This concern is compounded by the troubling history of the "Global North" testing medicines and treatments on the "Global South" and the inherent power imbalance between organizations like Target Malaria, which is based in London, and the communities it seeks to work in, often in sub-Saharan Africa.

7 There are other ways to suppress a population, like spreading a gene that causes female sterility.

8 Matthews, Dylan. "A genetically modified organism could end malaria and save millions of lives — if we decide to use it." *Vox*. September 26, 2018. https://www.vox.com/science-and- health/2018/5/31/17344406/crispr-mosquito-malaria-gene-drive-editing-target-africa-regulation- gmo

- **Security**. Because they are slow, obvious to sequencing, and can be reliably overwritten, gene drive technology inherently favors defense. However, adequate defense requires monitoring at-risk species and/or environments, which will be challenging for most nations, and the technology could be used as a social weapon to deepen societal divisions and incite trade wars and border controls.[9]

- **Resistance.** Organisms may become resistant to one or more aspects of engineered gene drives, rendering them less useful and potentially making it more difficult to use gene drives in the future. While resistance can likely be engineered around, gaining approval or multiple drives in a given locality may be difficult.

## Regulatory Proposals

- **Self-Governance.** Most scientists, researchers, and organizations working on engineered gene drives approach their use cautiously. For example, Target Malaria—which seeks to use gene drives to eliminate malaria-carrying mosquitoes in endemic areas—created an ethics advisory committee and works closely with civil society organizations and governments in the four countries where it seeks to eventually release edited mosquitoes.

- **Local, National, and Regional Governance.** Many countries have prohibitions in place against the use or sale of genetically modified organisms. Some researchers argue for an interdisciplinary task force to create a deliberative framework that can help local communities decide whether and how to allow the use of engineered gene drives in their geographies.[10][10]

- **International Governance.** In a 2018 meeting of the United Nations Convention on Biological Diversity, nations rejected a moratorium on the release of species engineered with gene drive systems. The nations did, however, include language about informed consent and local involvement. Various protocols (e.g., Cartagena Protocol on Biosafety, Nagoya Protocol) exist to regulate the movement of living organisms produced by genetic editing and the access to genetic resources.

  Many individuals (including Kevin Esvelt, an inventor of CRISPR-based gene drive) and organizations have called for all proposed experiments involving gene drive to be made public, allowing those affected to have a voice in critical early- stage decisions that will determine the form of the eventual application. They have advocated for the World Health Organization or another international

9 Esvelt, Kevin. "The thing to fear is fear itself." http://mars.gmu.edu/handle/1920/11337

10 Kofler, Natalie and Kevin Esvelt et al. Editing nature: Local roots of global governance." Policy Forum. American Association for the Advancement of Science. November 2018. https://research.ncsu.edu/ges/files/2018/11/Editing-nature_Local-roots-of-global- governance_Science_Kuzma_11.2.18.pdf

organization to host a registry that would require sponsorship of proposals by an interested local community.

## Discussion Questions

- Should gene drive technology be reserved for only certain issues afflicting humanity? What is the threshold of severity that warrants gene drive use?

- At what level should governance be considered? (i.e., should a local village have the ability to consent to gene drive use, or should an international treaty govern its use?)

- Are existing governance frameworks appropriate for regulating the use of engineered gene drives? If not, what else is needed?

## Readings

"Gene Drive FAQ." Sculpting Evolution, *MIT Media Lab.* 2019.

Natalie Kofler, Kevin Esvelt et al. "Editing nature: Local roots of global governance." *Policy Forum. American Association for the Advancement of Science.* November 2018.

Winterberg, Susan, Carmel Shachar, Jeantine Lunshof, and Joshua Grolman. "Genome Editing." *Technology Fact Sheet Series. Technology and Public Purpose Project*. 2019.

BOSTON TECH HUB FACULTY WORKING GROUP

FALL SESSION 4 • JANUARY 28, 2020

# Life Extension Technologies

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**The Boston Tech Hub Faculty Working Group**, hosted by former Secretary of Defense and Harvard Kennedy School Belfer Center Director Ash Carter and Harvard SEAS Dean Frank Doyle, will convene its fourth and final session of the fall semester on the topic of life extension technologies. The session will examine current applications, capabilities, limitations, and ongoing debates regarding acceptable use, regulation, and governance of the technology.

# Context

- **Life-extension technologies (LETs)** are a broad class of technologies meant to slow down, halt, or reverse aging.[1, 2] Several foundational aspects are worth noting:

    - There is disagreement about whether aging is a disease or a naturally-occurring biological process associated with a higher incidence of other diseases (e.g., heart disease, Alzheimer's). To date, the Food and Drug Administration and the World Health Organization have declined to classify aging as a disease.

    - Similarly, it is difficult to define what in aging is 'normal' vs. 'abnormal'—whether someone's body is 'older' or 'younger' than their age. Among other things, this makes it difficult to classify an intervention as 'therapy' or 'enhancement', which may complicate how the technologies are viewed. There are several companies that claim to be able to tell consumers their 'true' age based on biomarkers, along with applications for how to optimize those biomarkers.

    - Finally, there is disagreement as to whether LETs, if found to be effective, should be used, for a variety of reasons. (see Public Purpose Considerations for more)

- Researchers are exploring several mechanisms to slow down or reverse the aging process. Among others:

    - **Affecting Sirtuins.** Sirtuins are proteins that affect metabolic regulation and may influence aging; humans have seven of them.[3] Research with mouse models "suggests that protection of genome stability is among the most important roles of sirtuins during stress response." Some believe that mildly stressing the body (e.g., calorie restriction, exposure to cold temperatures) activates sirtuins, which may improve cell health. Supplements that increase nicotinamide adenine dinucleotide (NAD+), an enzyme that sirtuins need to function.

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1 We thank Naomi Silverstein for her assistance with this brief.

2 This is obvious but worth noting for clarity's sake: LETs meant to slow down, halt, or reverse the aging process are distinct from treatments that extend the lives of individuals with specific ailments. Insulin is a life extension technology for individuals with diabetes; antibiotics are life extension technologies for individuals with infections. This session will focus on aging-oriented LETs.

3 Sirtuins are 'highly conserved', meaning that they serve similar functions in many species, indicating that they are an important component of life.

- **Using 'Young Blood' to Rejuvenate Cells.** Research using mouse models showed that injecting blood plasma from young mice into old mice caused the older mice to perform better in spatial-memory tests,[4] and connecting the circulatory systems of a young and old mouse can "reverse age-related impairments in neural stem cell function in the old brain."[5, 6]

- **Targeting 'Old' Cells with Senolytics.** Senolytics are compounds that "encourage the aged cells to selectively self-destruct so the immune system can clean them out."[7] This may improve organ function and reduce the incidence of age-related disease, though human trials are currently small and nascent.

- **Gene Therapy/Editing.** In the nematode model *c. elegans,* researchers such as Cynthia Kenyon showed that altering a single gene could double its lifespan.[8] More speculatively, Harvard biologist George Church cofounded a company that seeks to use gene therapy to increase the lifespan of dogs.[9]

# Applications

- **Increasing Longevity.** LETs may increase the lifespans of those who have access to the technologies, whether by reducing the incidence of age-related diseases or by 'rejuvenating' the body's cells, thereby reducing cellular age.

- **Improving Quality of Life.** Along similar lines, LETs may improve quality of life for individuals who reach a certain age, even if they do not substantially increase lifespan. Researchers refer to this as increasing the "health span" of human beings.[10]

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4 Goldman, Bruce. "Infusion of young blood recharges brains of old mice, study finds." Stanford Medicine. May 4th, 2014. http://med.stanford.edu/news/all-news/2014/05/infusion-of-young-blood- recharges-brains-of-old-mice-study-finds.html.

5 Villeda Lab. University of California-San Francisco. http://villedalab.ucsf.edu/rejuvenation

6 Researchers stress that these studies have only been done in mice, and human trials are needed to know about using similar methods on humans. At least one company, Ambrosia, began offering 'young plasma' infusions to humans, though it has stopped doing so after an FDA advisory cautioned against it.

7 Adam, David. "What if Aging Weren't Inevitable, but a Curable Disease?" *MIT Technology Review*. August 19th, 2019. https://www.technologyreview.com/s/614080/what-if-aging-werent-inevitable-but-a-curable-disease/

8 Kenyon, Cynthia et al. "A C. elegans mutant that lives twice as long as wild type." *Nature*. December 2nd, 1993. https://www.ncbi.nlm.nih.gov/pubmed/8247153

9 Regalado, Antonio. "A stealthy Harvard startup wants to reverse aging in dogs, and humans could be next." MIT Technology Review. May 9, 2018. https://www.technologyreview.com/s/611018/a-stealthy- harvard-startup-wants-to-reverse-aging-in-dogs-and-humans-could-be-next/.

10 Weintraub, Karen. "Aging is Reversible—at Least in Human Cells and Live Mice." *Scientific American*. December 15th, 2016, https://www.scientificamerican.com/article/aging-is-reversible-at-least-in- human-cells-and-live-mice/.

## Public Purpose Concerns and Considerations

- **Inequity**. If one or more classes of LETs do in fact increase average lifespan, it is probable that they will be restricted to those who can afford them. This concern is true for both inequities within and between countries. In practice, inequity in LETs may be not substantively different than with many other products—and even other life-saving pharmaceuticals—but LETs may be viewed differently.

- **Ecological Impacts**. Some worry that extending lifespans will cause negative externalities from greater use of resources in a planet with a growing population and limited resources.

- **Hype.** For many, LET hype and hope currently outpace the science. Companies can sell non-Food and Drug Administration (FDA)-approved pharmaceuticals as supplements rather than medical treatments, potentially offering false hope and negative consequences to users. This could have both immediate negative effects and longer-term consequences to the industry.

## Governance and Regulation

- The FDA does not classify aging as a disease, meaning that it will not approve explicitly anti-aging therapies for that use. Therapies meant for use to treat age-related diseases, on the other hand, are regulated by the FDA.

- The World Health Organization's International Classification of Diseases (ICD-11) includes an ageing-related extension code that can be applied to diseases—"ageing- related means 'caused by pathological processes which persistently lead to the loss of organism's adaptation and progress in older ages"—but not as a disease itself.[11]

- Many researchers spin out biotechnology companies from their work, but classify their products as supplements, rather than treatments. Classifying the product as a supplement allows companies to sell it without FDA review or approval.

- In February 2019, the FDA released a safety alert advisory urging against the use of plasma infusions of 'young' blood, causing a controversial company doing so to haltall patient treatments.[12]

11 "ICD-11 for Mortality and Morbidity Statistics." World Health Organization. April 2019. https://icd.who.int/browse11/l-m/en#/http://id.who.int/icd/entity/459275392

12 Edney, Anna. "Beware of Using Young People's Blood to Halt Aging, FDA Says." *Bloomberg News*. February 19th, 2019. https://www.bloomberg.com/news/articles/2019-02-19/beware-of-buying- young-people-s-blood-to-prevent-aging-fda-says

## Discussion Questions

- Should aging be classified as a disease? Why or why not?
- How different are LETs from other technologies? Is the 'treatment vs. enhancement' framework viable for LETs?
- If LETs are effective, do governments have a responsibility to make sure they are broadly accessible? How would governments do that?
- Should academics and researchers profit from the sale of non-proven supplements making potentially-exaggerated claims?

## Readings

Marisa Taylor. "A Fountain of Youth Pill? Sure, If You're A Mouse." *Kaiser Health News*. February 2019.

David Adam. "What if Aging Weren't Inevitable, But a Curable Disease?" *MIT Technology Review*. August 2019.

Jayne C. Lucke et al. "Anticipating the Use of Life Extension Technologies." *European Molecular Biology Organization, Science and Society*. 2010.

BOSTON TECH HUB FACULTY WORKING GROUP

# Session Briefs

Spring 2020

BOSTON TECH HUB FACULTY WORKING GROUP

SPRING SESSION 1 • APRIL 21, 2020

# Differential Privacy


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**The Boston Tech Hub Faculty Working Group**, hosted by former Secretary of Defense and Harvard Kennedy School Belfer Center Director Ash Carter and Harvard SEAS Dean Frank Doyle, will convene its first session of the spring semester on the topic of differential privacy. The session will examine data privacy issues, current applications of differential privacy tools, capabilities, limitations, and more.

### PROBLEM TO BE ADDRESSED

Governments, businesses, and academics rely on aggregated data to understand problems, test hypotheses, and improve operations. However, even aggregated, de-identified personal data can be individually re-identified through myriad known and currently-unknown methods, which erodes individual security and privacy. **Striking an appropriate balance between societal value stemming from the use of data with individual privacy and security is of paramount concern**.

## Context

- **Differential privacy** is a "formal mathematical framework for quantifying and managing privacy risks."[1] and "a general framework for reasoning about the increased risk that is incurred when an individual's information is included in a data analysis."[2]

- Tactically, differential privacy tools add a calibrated amount of statistical noise to datasets, depending on the value of a privacy loss parameter (epsilon, or the "privacy budget"). Small values of epsilon denote high amounts of added statistical noise, limiting the usefulness of the analysis but increasing privacy protection. As a result, differential privacy tools create analyses that are approximations of "real-world" analyses, trading off perfectly-accurate analyses for increased individual privacy protection.

- Importantly, researchers believe differential privacy tools can "future-proof" statistical analyses; that is, they can give researchers and individuals confidence that future technologies—advanced computing power, new algorithms, and the like—will not re-identify individuals' data in what is known as a *privacy attack*.

1 Alexandra Wood et al. "Differential Privacy: A Primer for a Non-Technical Audience." February 2019. Berkman Klein Center for Internet and Society at Harvard University. Page 209

2 Ibid, 240.

# Applications

- **2020 United States Census.** The 2020 US Census will incorporate differential privacy tools to protect public information. As the Census Bureau notes, "There are many variants of differential privacy. The one selected for the 2020 Census introduces controlled noise into the data in a manner that preserves the accuracy at higher levels of geography…Our differential privacy methods will be designed to preserve the utility of our legally mandated data products while also ensuring that every respondents' personal information is fully protected."[3]

- **Private Sector.** Companies use differential privacy tools to gather aggregated user activity data to improve their services for users. Apple, for example, uses differential privacy techniques to collect and analyze data on emoji use "to help design better ways to find and use our favorite emoji."[4]

# Public Purpose Concerns and Considerations

- **Data Privacy.** With increasing processing power and available data, reidentifyingdata that has been deidentified will become easier over time.

  For example, in 2006, Netflix released deidentified user data as part of its 'Netflix Prize' competition, which researchers were able to reidentify using other public data.[5] US Census Bureau researchers were able to conduct successful 'privacy attacks' on previous census data, too: "when Census Bureau researchers accounted for modern algorithms and computing power, they discovered the inadequacy of these measures. Like with Netflix, security through obscurity collapsed when other public data sources were combined with the last census."[6]

  Differential privacy tools quantify the potential risk of data privacy loss for individuals, creating an upper-bound on potential privacy loss.

- **Data Accuracy & Sample Size.** While all statistical analyses have inherent inaccuracies—stemming from, among other things, sampling error—differentially private analyses add another type of error: "Analyses performed with differential privacy differ from standard statistical analyses—such as the

3 Jarmin, Ron. "Census Bureau Adopts Cutting Edge Privacy Protections for 2020 Census." United States Census Bureau. February 15th, 2019. https://www.census.gov/newsroom/blogs/random-samplings/2019/02/census_bureau_adopts.html

4 "Differential Privacy." Apple. Page 3. https://www.apple.com/privacy/docs/Differential_Privacy_Overview.pdf

5 Francis, Matthew. "Using Differential Privacy to Protect the United States Census." *Siam News*. Society for Industrial and Applied Mathematics. October 1st, 2019. https://sinews.siam.org/Details-Page/using-differential-privacy-to-protect-the-united-states-census

6 Ibid.

calculation of averages, medians, and linear regression equations—in that random noise is added in the computation."[7]

## Governance and Regulation

- Domestically and internationally, several laws mandate that governments, organizations, and researchers to protect data privacy (e.g., Federal Policy for the Protection of Human Subjects, General Data Protection Regulations), with additional protection for certain sensitive data (e.g., health, education).[8] As Wood et al put it: Taken together, the safeguards required by these legal and ethical frameworks are designed to protect the privacy of individuals and ensure they fully understand both the scope of personal information to be collected and the associated privacy risks. They also help data holders avoid administrative, civil, and criminal penalties, as well as maintain the public's trust and confidence in commercial, government, and research activities involving personal data."[9]

- Differential privacy is viewed as a tool that can help satisfy legal requirements: "Interest in the concept is growing among potential users of the tools, as well as within legal and policy communities, as it holds promise as a potential approach to satisfying legal requirements for privacy protection when handling personal information. In particular, differential privacy may be seen as a technical solution for analyzing and sharing data while protecting the privacy of individuals in accordance with existing legal or policy requirements for de-identification or disclosure limitation."[10]

7 Alexandra Wood et al. "Differential Privacy: A Primer for a Non-Technical Audience." February 2019. Berkman Klein Center for Internet and Society at Harvard University. Page 220.

8 Ibid.

9 Ibid, 216.

10 Ibid, 210.

## Discussion Questions

- How does differential privacy compare as a solution to other means of protecting data privacy (e.g., homomorphic encryption, k-anonymization)
- What are the tradeoffs of using differential privacy tools to protect data privacy?
- How can differential privacy tools scale beyond traditional/anticipated use cases, if at all?

## Readings

Alexandra Wood, Salil Vadhan et al. "Differential Privacy: A Primer for a Non-Technical Audience." 2019.

Mark Bun. "A Teaser for Differential Privacy." Princeton. December 2017.

Michael Hawes. "Differential Privacy, and the 2020 Decennial Census." United States Census Bureau. March 2020.

BOSTON TECH HUB FACULTY WORKING GROUP

SPRING SESSION 2 • APRIL 28, 2020

# Chinese Technology Companies and China's Influence on Academia: Protecting America's National Security


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and Applied Sciences

**The Boston Tech Hub Faculty Working Group**, hosted by former Secretary of Defense and Harvard Kennedy School Belfer Center Director Ash Carter and Harvard SEAS Dean Frank Doyle, will convene its second session of the spring semester on the topic of Chinese technology companies and state funding of American academic institutions, and their effects on American national security. The session will examine the issues around the relationships between the Chinese Communist Party and the country's private sector; China's influence and actions on American academic institutions; how these efforts may negatively affect America's national security; and what should be done to mitigate national security risks.

### PROBLEM TO BE ADDRESSED:

Through Chinese companies like Huawei and ZTE, China's government could potentially access sensitive data that the companies have. This could create a security risk to Huawei and ZTE components for technologies like 5G, the wireless communications infrastructure.

Separately, China's government may be taking advantage of the spirit of openness and collaboration that academia in democratic countries strives for, potentially accessing ideas and technologies in ways that hinder American economic competitiveness and national security, as well as democratic values around the world.

**What should American policymakers do to address these concerns in the short term? In the long term?**

# Context

## Chinese Technology Companies

- Huawei and ZTE are private companies based in China that produce foundational equipment for, among other things, telecommunications infrastructure—including for 5G, the next generation of wireless infrastructure. Theoretically, these companies could steal information sent through networks using their foundational and enabling technologies, or could embed concealed 'kill switches' into vital infrastructure.[1]

- Private companies in China have unusually close ties with the governing Chinese Communist Party (CCP). Additionally, companies are required to comply with the Chinese National Intelligence Law, which compels private companies to transfer sensitive data to the CCP, if requested—even if the companies do not want to give this data.[2]

- In a recent report, the Defense Innovation Board argued that being a leader in 5G infrastructure and uses will be vital for American economic competitiveness, and that the first-mover advantage for 5G

1 Gorman, Lindsay. "5G Is Where China and the West Finally Diverge." *The Atlantic*. January 5th, 2020. https://www.theatlantic.com/ideas/archive/2020/01/5g-where-china-and-west-finally-diverge/604309/

2 Ibid.

infrastructure and the capabilities it enables (e.g., autonomous vehicles, remote sensing) is very high.[3] However, there are no American companies capable of quickly bringing to market 5G infrastructure. In the marketplace, Huawei equipment is typically cheaper than its competitors based in democratic countries, like Sweden's Ericsson, Finland's Nokia, and South Korea's Samsung.[4]

- Therefore, there are concerns about America—or its allies—using Huawei or ZTE components in their wireless infrastructure; tradeoffs appear to exist between installation cost, installation speed, component sophistication, and security. Additionally, many in America and Europe view this decision primarily through a trade lens, not a security lens, making a comprehensive discussion more difficult.[5]

## Academic Funding and Collaboration

- In recent years, the United States and China have been each other's top research collaborators.[6] Open, collaborative basic research is viewed in the academic community as vital.

- The Department of Education and Congress believe that the CCP seeks to use funding of American academic institutions to gain access to valuable intellectual property—which increases the competitiveness of Chinese companies—and to increase its soft power. According to a November 2019 Senate Permanent Subcommittee on Investigations report, "China unfairly uses the American research and expertise it obtains for its own economic and military gain."[7]

    - In some cases, research funding from Chinese public and private institutions could lead to the development of technologies that will be used in ways that reduce privacy and potentially infringe on human rights. For example, according to an official at the Department of Education, an American university "received research funding from a Chinese multinational conglomerate to develop new algorithms and advance biometric security techniques for crowd surveillance capabilities."[8] In others cases, individuals recruited through China's Thousand Talents

3 Defense Innovation Board. "The 5G Ecosystem: Risks & Opportunities for DoD." April 2019. https://media.defense.gov/2019/Apr/04/2002109654/-1/-1/0/DIB_5G_STUDY_04.04.19.PDF

4 Gorman.

5 Ibid.

6 Ellis, Lindsay and Nell Gluckman. "How University Labs Landed on the Front Lines of the Fight with China." *Chronicle of Higher Education*. May 31, 2019. https://www.chronicle.com/interactives/20190531ChinaResearch?cid=rclink

7 "Threats to the U.S. Research Enterprise: China's Talent Recruitment Plans." United States Senate Permanent Subcommittee on Investigations. November 2019. https://www.hsgac.senate.gov/imo/media/doc/2019-11-18%20PSI%20Staff%20Report%20-%20China's%20Talent%20Recruitment%20Plans%20Updated.pdf

8 Rubinstein, Reed. "Letter to Permanent Subcommittee on Investigations. United States Department of Education, Office of the General Counsel. November 27th, 2019. https://www2.ed.gov/policy/highered/leg/psi-nov27-2019.pdf

Plan have allegedly stolen sensitive information from American universities and laboratories before returning to China.[9]

- As a result, universities are "discouraging their faculty members from participating in Chinese talent-recruitment programs, part- and full-time visiting appointments some see as an honor. The FBI has said these programs are part of a Chinese strategy "luring" expertise to their universities. Scholars who participate, the agency warned, could be violating export-control and espionage laws."[10] Additionally, "[American] universities are also rejecting Chinese money for research. Heavyweights like Cornell and Stanford Universities and MIT have halted new research agreements with Huawei, a Chinese telecommunications company under scrutiny by the U.S. government."[11]

- This complicates the existing beliefs of American academia, which generally holds that global collaboration is a means of producing the most progress in scientific and technological realms.

## Public Purpose Concerns and Considerations

- **Data Security.** Experts are concerned that if Huawei or ZTE components are used to build 5G infrastructure in the United States or in allied countries, data security could be hindered by those companies' relationships to the CCP and its National Intelligence Law. According to a Defense Innovation Board report, "If China leads the field in 5G infrastructure and systems, then the future 5G ecosystem will likely have Chinese components embedded throughout…This would pose a serious threat to the security of D.O.D. operations and networks going forward."[12]

- **Openness, Collaboration, and Transparency.** Action taken to place limits on academic collaboration may have a negative effect on research quality, innovation, and cross-border relationships. Further, even the perception that Chinese-born researchers may not be trustworthy could have a chilling effect on research partnerships and on the ability of the United States to retain top global talent.

- **Equality and Fairness.** Skepticism about Thousand Talent Plan recruits working in America—or about ethnically Chinese researchers, American-born or otherwise—could unfairly harm innocent individuals and affect the United States' ability to recruit and retain talent at research universities and in the private sector.

9 "Threats to the U.S. Research Enterprise: China's Talent Recruitment Plans." United States Senate Permanent Subcommittee on Investigations. November 2019.

10 Ellis and Gluckman.

11 Ellis and Gluckman.

12 Defense Innovation Board. "The 5G Ecosystem: Risks & Opportunities for DoD."

# Governance and Regulation

- There have been several attempts to constrain Huawei's access to the American market and to American products, and the Department of Justice indicted Huawei, alleging that it stole trade secrets.
    - In May 2019, President Trump "issued an executive order barring US companies from using information and communications technology from anyone considered a national security threat," including Huawei.[13]
    - In August 2019, "the [American] Commerce Department has put Huawei on a so-called entity list, which bans American corporations from supplying foreign companies deemed potential security threats."[14]
    - In January 2020, the Department of Justice indicted Huawei, alleging that, among other things, the company attempted to steal trade secrets and "misappropriate sophisticated technology from U.S. counterparts."[15]
- Government agencies, including the NIH, are attempting to crack down on researchers who fail to be transparent and disclose all foreign funding they receive.
- In the FY2020 National Defense Authorization Act, Congress created two bodies "aimed at preventing foreign governments from unfairly exploiting the US research enterprise."[16]
    - A White House-driven effort will coordinate government agencies to "protect federally funded research projects from cyberattacks, theft, and other foreign threats."[17]
    - Separately, the National Academies of Sciences, Engineering, and Medicine will convene a roundtable with "officials from academia, government, and industry to advise the government on ways to achieve national security without undermining valuable international collaborations."[18]

13 Stewart, Emily. "The US government's battle with Chinese telecom giant Huawei, explained." *Vox*. August 2019. https://www.vox.com/technology/2018/12/11/18134440/huawei-executive-order-entity-list-china-trump

14 Lohr, Steve. "U.S. Moves to Ban Huawei From Government Contracts." *The New York Times*. 7 Aug. 2019. www.nytimes.com/2019/08/07/business/huawei-us-ban.html?login=email&auth=login-email

15 "Chinese Telecommunications Conglomerate Huawei and Subsidiaries Charged in Racketeering Conspiracy and Conspiracy to Steal Trade Secrets." United States Department of Justice. February 13, 2020. https://www.justice.gov/opa/pr/chinese-telecommunications-conglomerate-huawei-and-subsidiaries-charged-racketeering

16 Malakoff, David. "Congress creates two new bodies to tackle foreign influence on U.S. research." *Science*, American Association for the Advancement of Science. December 10, 2019. https://www.sciencemag.org/news/2019/12/congress-creates-two-new-bodies-tackle-foreign-influence-us-research

17 Ibid.

18 Ibid.

# Discussion Questions

## Technology

- How significant a threat to American national security is Huawei components in 5G infrastructure, in America and abroad?

- What potential solutions exist to mitigate potential threats to American national security? Should the United States purchase components from European or South Korean companies? Subsidize American companies? What are the drawbacks of the potential solutions?

## Academia

- How significant a threat to American national security and economic competitiveness are programs like the Thousand Talents Plan?

- What potential solutions exist to mitigate potential threats to American national security? What are the drawbacks of the solutions?

- How can academic freedom and cross-border collaboration be protected?

# Readings

Lindsay Gorman. "5G is Where China and the West Finally Diverge." *The Atlantic.* January 5, 2020.

John Deutch and Condoleezza Rice. "Maintaining America's Lead in Creating and Applying New Technology." Chapter 7. *The World Turned Upside Down: Maintaining American Leadership in a Dangerous Age.* Aspen Strategy Group. November 2017.

"Threats to the U.S. Research Enterprise: China's Talent Recruitment Plans." (Executive Summary). United States Senate Permanent Subcommittee on Investigations. November 2019.

Aruna Viswanatha and Kate O'Keeffe. "U.S. Struggles to Stem Chinese Efforts to Recruit Scientists." *Wall Street Journal.* November 17, 2019.

BOSTON TECH HUB FACULTY WORKING GROUP

SPRING SESSION 3 • MAY 26, 2020

# Increasing STEM Expertise in Government


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**The Boston Tech Hub Faculty Working Group**, hosted by former Secretary of Defense and Harvard Kennedy School Belfer Center Director Ash Carter and Harvard SEAS Dean Frank Doyle, will convene its third and final session of the spring semester on the topic of increasing STEM expertise in the federal government. The session will examine the problem with insufficient scientific and technological expertise in the American federal legislative and executive branches, the types of expertise each body needs to be effective, and potential solutions to mitigate the problem.

**PROBLEM TO BE ADDRESSED:**

In recent years, high-profile legislative hearings and executive branch product rollouts have underlined a gap between the technical knowledge the federal government has and what it needs to be effective.

While there are several potential ways to increase the federal government's scientific and technical expertise from the outside, this session will consider: **What should the federal government do to increase its internal scientific and technical expertise, in order to address some of the nation's most pressing issues?**[1]

# Context

## Legislative Branch

- While Congress is often described as one of the most advised bodies in the world—with unparalleled access to external expertise—in recent hearings, members of Congress have appeared unable to reckon with technology issues. A September 2019 Technology and Public Purpose Project report, *Building a 21st Century Congress,* found that this gap—between Congress's access to scientific and technical expertise and its use of that information—can be explained by a lack of internal capacity, driven by several factors:[2]

    - Congress's decision to de-fund the Office of Technology Assessment (OTA), a nonpartisan research organization at Congress that produced original research on emerging technologies, in the 1990s. Without an in-house, unbiased, and credible source of technology assessment within Congress, the body loses a sustained repository of scientific and technical knowledge to be consistently drawn on; personal offices and committees must seek out information from other sources.

    - Congress's decision to underfund itself, particularly in recent decades. For example, between 1979 and 2015, congressional committee staff and legislative support body staff was reduced by 38% and

1 A lack of scientific expertise is also an issue at the international and state levels of government. We chose to focus on the American federal government solely to narrow the conversation.

2 Miesen, Mike, Laura Manley et al. *Building a 21st Century Congress: Increasing Congress's Science and Technology Expertise.* The Technology and Public Purpose Project. Belfer Center for Science and International Affairs. September 2019. https://www.belfercenter.org/publication/building-21st-century-congress-improving-congresss-science-and-technology-expertise

41%, respectively.[3] Adjusted for inflation, members of Congress in the House of Representatives are allotted about the same amount of money to staff their offices as they were in 1996, even as the average number of constituents per representative has increased by nearly 16%.[4] Taken together, members of Congress are asked to do more work with less, and their staff members are tasked with serving as both generalists and subject matter experts on myriad topics.

- Congress's relative lack of scientists and technologists serving in policy advising roles.[5] In many cases, scientists and technologists simply do not know that policy advising is a possible career path; in others, they may be concerned that they do not have the policy skills necessary to thrive as an adviser in Congress.

- In recent years, several organizations have created programs and offices meant to close Congress's STEM expertise gap.

    - In 2019, the Government Accountability Office created a Science, Technology Assessment, and Analytics (STAA) division, which drafts technology assessment and provides technology advice to Congress.

    - Several organizations, like the American Association for the Advancement of Science and TechCongress, place highly-regarded fellows with a STEM background in congressional personal offices and committees. Demand for fellows outpaces the funding available to support them; according to AAAS, for example, during the last placement cycle there was congressional demand for 100 AAAS fellows, but funding for only 33.[6] While these are time-limited fellowships, fellows do have the opportunity to find full-time positions in Congress or an executive branch agency.

## Executive Branch

- The botched initial development and rollout of Healthcare.gov in 2013 highlighted the executive branch's difficulties with technology development and deployment.

    - In response, Silicon Valley veterans were brought on for temporary 'tour of duty' deployments to fix the website far more quickly than was typical of large government information technology projects.[7]

3 Ibid, page 70.

4 Ibid, page 89.

5 Of course, there are many scientists and technologists who do serve in policy advising roles in Congress. By the estimations of most stakeholders interviewed as part of the September 2019 TAPP report on congressional STEM capacity, though, there are not enough relative to what is needed.

6 Interview with AAAS Representative. February 2020.

7 Brill, Steven. "Obama's Trauma Team." *Time.* February 27, 2014. https://time.com/10228/obamas-trauma-team/

- The initial failure, paired with the success of the Healthcare.gov recovery operation, showed both the need for, and usefulness of, top technology talent working in the executive branch.

- In recent years, the White House, Department of Defense, and other executive branch entities have created programs to recruit technologists to work on technical issues within their organizations.

  - Between 2012 and 2014, three programs—the United States Digital Service, 18F, and the Presidential Innovation Fellows—were created to increase the federal government's technology competency.[8] While each program has different missions and processes, all recruit technologists and entrepreneurs to work on technical problems faced by executive branch agencies.

  - In 2015, former Secretary of Defense Ash Carter launched the Defense Digital Service to bring top technology talent to help solve technology-related defense issues at the Department of Defense.[9] Among other programs, the DDS hosts a bug-bounty program called Hack the Pentagon, incentivizing computer scientists to find and point out vulnerabilities that could lead to security issues in DoD systems.

- Finally, the executive branch broadly relies on scientific and technical expertise to craft thoughtful regulations and administer programs. In the past three years, however, feeling that scientific expertise is disregarded at this time, many career scientists have left their agency positions.[10] This hollowing out of scientific expertise in the executive branch could have a deleterious effect on agency performance for a significant period of time.

## Public Purpose Concerns and Considerations

- **Effective Government.** As shown through the Healthcare.gov development process, lacking technology expertise in government leads to suboptimal products, which adversely affect constituents, wastes tax dollars, and imperils future policies.

8 Anastasoff, Jennifer and Jennifer Smith. "Mobilizing Tech Talent: Hiring Technologists to Power Better Government." Partnership for Public Service. September 2018. https://ourpublicservice.org/wp-content/uploads/2018/09/Mobilizing_Tech_Talent-2018.09.26.pdf

9 Ash Carter. "Building the First Link to the Force of the Future." Remarks at the George Washington University Elliot School of International Affairs. November 18, 2015. https://www.defense.gov/Newsroom/Transcripts/Transcript/Article/630419/building-the-first-link-to-the-force-of-the-future-remarks-by-secretary-of-defe/

10 Plumer, Brad and Coral Davenport. "Science Under Attack: How Trump is Sidelining Researchers and Their Work." *The New York Times.* December 28, 2019. https://www.nytimes.com/2019/12/28/climate/trump-administration-war-on-science.html

- **Inclusive Policymaking.** Absent STEM expertise in the policymaking process, Congress risks crafting policies that are technologically ignorant, cause unintended consequences, or fail to solve a problem—or all three.

  Absent internal STEM expertise, the legislative and executive branches may become beholden to self-interested parties, like technology companies and lobbyists, for advice and assistance.

- **Potential Bias/Conflict of Interest.** Large technology companies are potential sources of STEM talent for the legislative and executive branches; they often do business with the government, creating an actual or perceived potential conflict of interest.

  When considering tours of duty in the legislative or executive branches, then, it is important to create strictures that prevent an actual or perceived conflict of interest.

## Governance and Regulation

- The Intergovernmental Personnel Act of 1970 allows "the temporary assignment of employees between the Federal Government and State, local, and Indian tribal governments, institutions of higher education," federally funded research and development centers (FFDRC), and more.[11] For example, Congress or a federal agency could bring on university or FFRDC talent on a specific technology topic for a temporary assignment.

- Federal agencies have several hiring authorities available to them to create tours of duty for private sector talent. The Fellowships and Industry Exchange Program Hiring Authority (Schedule A(r)), for example, allows agencies to hire fellows and to create positions for private sector talent.[12] The AAAS Science and Technology Policy Fellows program, for example, uses Schedule A hiring authority.[13]

- In July 2016, the Office of Management and Budget released a memo, "Federal Cybersecurity Workforce Strategy," that outlined government-wide strategies to augment the federal government's cyber workforce.[14]

11 5 CFR § 334.101 - Purpose. *Federal Register*. Cornell Law School Legal Information Institute. https://www.law.cornell.edu/cfr/text/5/334.101

12 Pena, Vanessa, and Chelsea Stokes. "Tour of Duty Hiring in the Federal Government." Institute for Defense Analyses Science & Technology Policy Institute. 2019. https://www.ida.org/-/media/feature/publications/t/to/tour-of-duty-hiring-in-the-federal-government/d10700final.ashx

13 2300-212-1 – Interns and Fellows Appointed Through Schedule A. *NIH Policy Manual*. September 22, 2017. https://policymanual.nih.gov/2300-213-1

14 Donovan, Sean, Beth Colbert, and Tony Scott. "Federal Cybersecurity Workforce Strategy." Office of Management and Budget, Executive Office of the President. July 12, 2016. https://www.chcoc.gov/content/federal-cybersecurity-workforce-strategy

- Following that memo, the Office of Personnel Management (OPM) released guidelines on "Compensation Flexibilities to Recruit and Retain Cybersecurity Professionals," outlining several ways that agencies could increase compensation to attract and keep technical talent.[15]
- Strategies to recruit and retain technical talent in the executive branch included, but were not limited to, recruitment, relocation, and retention incentives; special compensation rates for certain employees; a special needs pay-setting authority.

## Discussion Questions

- Is there a need for additional STEM expertise in the federal legislative and executive branches, as opposed to seeking expertise from outside the government? If so, what else should be done?
- To improve STEM expertise in government what can the United States learn from other countries?
- What role should universities play in increasing STEM expertise in government? Non-profit organizations? The government itself?
- How can government service be better viewed as a boon to a scientist's or technologist's career, as opposed to, at worst, a detriment to it?

## Readings

Ash Carter. "Building the First Link to the Force of the Future." Remarks at the George Washington University Elliot School of International Affairs. November 18, 2015.

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15 "Compensation Flexibilities to Recruit and Retain Cybersecurity Professionals." Office of Personnel Management. 2016. https://www.opm.gov/policy-data-oversight/pay-leave/reference-materials/handbooks/compensation-flexibilities-to-recruit-and-retain-cybersecurity-professionals.pdf

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