

Synthetic Biology and National Security: Risks and Opportunities

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Key Points

- Rapid advances in the life sciences are converging with digital technologies to create a **Biorevolution**
- Biotechnologies, including synthetic biology, are foundational to the 21st century economy and a critical arena for global competition
- China is implementing an aggressive strategy to become the world leader in biotechnology & top competitor in the bioeconomy
- U.S. is the innovation engine of the biorevolution, but our weak translational capacity poses significant threats to US national security and economic competitiveness

Core Biotechnologies: Read, write, and edit the code of life

“Life is written in code. Biology is essentially programmable.” - Jason Kelly

- **DNA sequencing** - improving faster than Moore's Law
- **DNA synthesis** – slower, more expensive than sequencing, but improving
- **CRISPR** – the “Swiss Army Knife” of gene editing
 - Allows one to target and alter specific DNA sequences and modify gene function
 - Highly versatile, fast, cheap, and easy to use
- **Synthetic biology** – the manufacturing platform of the 21st century
 - Using the “parts and circuits” and “operating systems” of living organisms to build stuff we want
- **Artificial Intelligence methods**
 - Already broadly applied to improve sequencing accuracy, synthetic biology, drug discovery, clinical triage, diagnostic imaging, personalized medicine

What is synthetic biology?



Complex
functions



Engineering
principles

“Synthetic biology is the design and construction of new biological parts, devices, and systems...and the re-design of existing, natural biological systems for useful purposes.” – *Nature*, 2016

Catalogs of
standardized parts

Synthetic biology impacts many industries

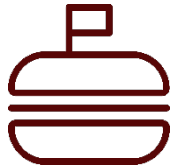
Fine Chemicals

Synthesis of fragrances at lower cost and more consistency than extraction from plant sources



Food

Cultured cells for higher quality meat replacements, lower cost sweeteners and other flavors



Materials

Engineering leather and fibers to improve quality and embed tech functionalities



Fuels

Ethanol from waste cellulose, biodiesel from photosynthetic algae



Therapeutics (Medicines)

Synthesis of complex medicinal compounds at high yields and purities



Therapeutics (Human Engineering)

Treatment of hereditary disease, engineering immunity to cancers, replacement organs for transplant, elimination of type 2 diabetes



Agriculture

Enhanced resistance to plants, pesticides, drought

National security implications of synthetic biology

- Essential to maintain U.S. economic competitiveness
- Needed to improve supply chain stability and resilience
- Critical to epidemic detection, management, and resolution
 - Vaccine discovery, production
 - Rapid diagnostics
- Military Applications
 - Materials development - Unique performance attributes
 - Distributed manufacturing
 - Rapid design and production of medical countermeasures
 - Human augmentation

National Security Implications of the Biorevolution

“Of all the things that could kill more than 10M people... the most likely are epidemics stemming from natural causes or bioterrorism.”

– Bill Gates, *New England Journal of Medicine*, 2016

Bioweapons

- Nuclear weapons equivalent in terms of lethality, large area coverage (using 1960s technology)
- Engineered bioweapons are feasible; potential targets broader than infectious disease; humans not the only targets – e.g., agriculture
- Know-how and materials are dual-use, cheap, hard to track, increasingly accessible, and automated

Epidemics of naturally occurring infectious diseases

- Becoming more frequent and impactful due to travel, trade, and intrusion into new ecosystems.
- Highly disruptive, costly, and potentially destabilizing
- U.S. must become more effective at epidemic management

National security implications: The Global Bioeconomy

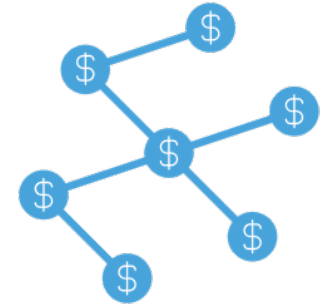
The U.S. is the innovation engine of the bioeconomy



NIH: trillion dollars invested since 1950; purchasing power peaked in 2003 then declined; FY19 budget is 9% < 2003



U.S. has top universities, holds most IP, patents, publications but China close behind



Largest biotech economy; strong revenue growth over past decade

National Security Implications: The Global Bio-economy

The U.S. is the creator and innovation engine of the biorevolution



Revenue growth over the past decade - largest biotech economy



Raised by life science companies across 1,547 deals in 2019 (a record high for deals)



U.S. holds the most, but China is close behind



FY19 budget - NIH purchasing power peaked in 2003 then declined for a decade

National security implications: The Global Bioeconomy

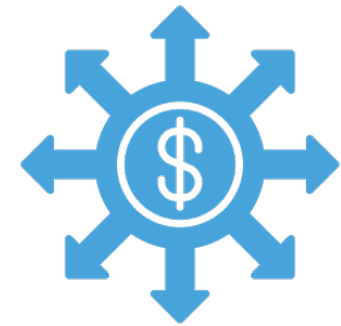
Federal support for mission-driven bio R&D very limited; contrast with physical sciences since WW2



Scant support for life sciences facilities, big bio projects beyond Human Genome Project



Translation of science to product highly dependent on private venture capital, Big Pharma



U.S. life sciences companies raised \$22B in VC across 1500 deals in 2109

National security implications: The Global Bioeconomy

China

- **Has urgent, compelling reasons to pursue biomed and biotech**
 - Ageing population in poor health; limited health care infrastructure; must feed billions in changing climate
 - Should find ways to cooperate on humanitarian goals
- **Sees biotech as way to expand global economic and geopolitical power**
 - Investing heavily in R&D, recruiting talent from abroad; regulatory reform, building new facilities
 - Establishing financial rules to favor Chinese firms
 - Linking AI skills and financial means of internet giants (Alibaba, Tencent) to AI/biotech

National Security Implications: The Global Bio-economy

China rising fast: dominating biotech is top political, economic, and scientific priority

- 2nd largest biopharma market
- Biotech top priority in 5-year plan (5% of GDP by 2020)
- \$14.4B in China VCPE life sciences investment in 2019, down from record-level \$17.6B in 2018. China healthcare-targeted funds raised \$23B in 2019, 45% lower than 2018.
- Chinese investment in U.S. biotech dropped 60% to \$725m in 1H 2019 vs \$1.65B in 1H 2018. Despite CFIUS/FIRRMA, 69% of outbound VC investment still targeted U.S.-based companies vs 16% to EU.
- Building biotech infrastructure at scale: large, public-private investments in genomics and AI, government funded incubators, primate research facilities, etc. Local innovative pipeline beginning to develop.
- China's giant internet firms (Tencent, Baidu, Alibaba) actively engaged in healthcare big data + AI R&D (top sector in 2019)
- War for talent: of 2M “sea turtle” returnees, 250K in life sciences; Thousand Talents Plan recruiting US scientists; 1/3 of foreign grad students in US are Chinese; Talent from large multinationals flowing to local biotechs.

What USG must do to maintain U.S. biotech competitiveness: a Sputnik moment

- Recognize national security implications of biotechnologies, including stakes involved in China's challenge
- Build and support U.S. translational infrastructure for bioscience/biotechnology
- Measure and track U.S. and global “bioeconomy”, including China's
- Create and execute a U.S. biotechnology strategy to include improved epidemic response, supply chain resilience
- Establish a life sciences/biotech talent pipeline for public and private sectors
- Proceed carefully with CFIUS reviews, bans on Chinese investing – do not crash the ambulance