Biosecurity:
A Multi-Dimensional Challenge of Escalating Complexity and Urgency

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Pressing Threats II
New and Emerging Bioweapons
Drivers of Technological Change

- automation
- large scale data and analytics
- entrepreneurial innovation

acceleration

- biology, medicine, engineering and computing
- new cross-sector corporate alliances

convergence

faster global diffusion

- industrial and military competitiveness
- trade policies
- supply chains
Drivers of Technological Change

- **acceleration**
  - espionage and corporate competitiveness
  - cybersecurity

- **convergence**
  - expanded dual-use threats
  - gray warfare and social manipulation

- **faster global diffusion**
National Leadership in Advanced Technologies: The Quest for Corporate and Military Superiority

- biotechnology
- genomics
- synthetic biology
- artificial intelligence
- quantum computing
- control of low earth orbits
  - commercial
  - military
National Leadership in Advanced Technologies: The Quest for Corporate and Military Superiority

A New Cold War Begins?

'bio'

'cyber'

'space'

A New Cold War Begins?

[China flag] [Russia flag]
The Dual-Use Dilemma

- advances in science and technology with simultaneous potential for beneficent and maleficent applications
- omnipresent in the history of technical progress and weapons development
- every technology that can confer military superiority is always developed

- metallurgy: swords, spears, stirrup, armor
- ordinance: bullets, bombs
- aviation: planes, missiles, drones
- electronics: GPS, guidance systems
- computing: cyberwarfare
- nuclear
- robotics and autonomous systems
- space exploration
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‘BIO’ joins the club!
Advances in the Biosciences and the Expanded Dual-Use Dilemma

**genomics (and multiOmics)**
- mapping the functional properties of living organisms (phenotype) at the molecular level based on encoded genetic information (genotype)
- understanding the molecular signaling information networks (biocircuits) that control specific biological functions - cells, tissues, organs, whole organisms

**synthetic biology**
- new technologies to alter the properties of existing organisms
- design of biological functions/organisms for which there is no known evolutionary precedent
- powerful new tools for genome modification - read, write, edit
Dual-Use Technologies:
De Novo Synthesis of Pathogens

Chemical Synthesis of Poliovirus cDNA: Generation of Infectious Virus in the Absence of Natural Template
Jeronimo Cello, Aniko V. Paul, Eckard Wimmer

Construction of an infectious horsepox virus vaccine from chemically synthesized DNA fragments
Ryan S. Noyce, Seth Lederman, David H. Evans
1 Department of Medical Microbiology & Immunology and Li Ka Shing Institute of Virology, University of Alberta, Edmonton, Alberta, Canada, 2 Tonix Pharmaceuticals, Inc., New York, New York, United States of America

Rapid reconstruction of SARS-CoV-2 using a synthetic genomics platform
T.T.N. Thao et al. (2020) Nature 582, 561
Dual-Use Technologies and Expansion of the Biothreat Spectrum

deliberate engineering of microorganisms for biowarfare/ bioterrorism

- evade detection and circumvent therapeutic countermeasures
- new virulence features to alter target organs attacked
- induce high levels of chronic disease and unsustainable economic burden to healthcare systems
- expand the spectrum of vulnerable host species (animals, crops, ecosystem disruption)
Mapping Genetic Control Circuits in Human Organs and Cells: New Dual-Risk Challenges

GTex Consortium
Synthetic Biology and Dual –Use Research: Thinking ‘Beyond Bugs’

- Precision medicine: mapping molecular networks - (circuit diagrams) of every cell type in the body and the circuit disruptions that cause disease
- Roadmap for next-generation CBW agents to target specific molecular circuits (★, ✴, ⭐)
Dual-Use Technologies and Expansion of the Biothreat Spectrum

‘beyond bugs’

- new biothreats that do not involve microorganisms
- potential to target any lifeform or biological functions based on knowledge of the underlying molecular control systems
  - “biocircuit modulators”
- although viruses could theoretically be designed to attack specific biocircuits the more likely scenario will be to design chemical molecules to hit the circuit of interest
Next Generation Chemical Threat Agents: ‘Inspired by Biology’

- design of next-generation chemical weapons targeted to specific biocircuits
- acute versus chronic effects
- altered immune functions
  - activation: autoimmune disease
  - immunosuppression: vulnerability to multiple infections
- neuromodulation
  - trigger fear, panic, hallucinations, aberrant memories
  - reduce thresholds for violence, addictive behavior
China’s Export of Fentanyl and Derivatives: A New Biosecurity Threat

Evolution of the U.S. Overdose Crisis
Understanding China’s Role in the Production and Supply of Synthetic Opioids

Bryce Pardo

Testimony presented before the House Foreign Affairs Subcommittee on Africa, Global Health, Global Human Rights, and International Organizations on September 6, 2018
Next Generation Chemical Threat Agents: ‘Inspired by Biology’

- extravagant diversity of biological circuits involved in human physiology and the perturbations causing disease (acute and chronic)
  - millions of potential targets
- major obstacle to robust defense planning for threat assessment, monitoring and mitigation
- ‘all hazards’ biopreparedness for diverse microbial threats is challenging but protection against biocircuit modulation presents a quantally more complex problem
- solutions not easily identifiable
  - higher level of complexity than any previous dual-use dilemma in national security
Dual-Use Technologies and Expansion of the Biothreat Spectrum

Gray Warfare

- targeted psychological manipulation of cognition and beliefs
- undermine societal trust in political leadership and institutions
- promote social division, tension and civil unrest
- ‘fake news’ and self-reinforcing ‘echo chamber’ propaganda
- parallel dimension to cyberwarfare but more subtle, insidious and longer-term impact
  - use of social media, gaming
Darker Shades of Gray: The Emerging Dimension of Hybrid Warfare

- lawfare: exploiting loopholes to seed confusion and dissent
- deception, disinformation and propaganda
- weaponized narratives ("fake news")
- plausible deniability
Gray Zone Tweets and Biosecurity: Russian Trolls and Twitter Bots

• purposeful social media disinformation campaigns
• weaponized disinformation in health communications
  - anti-vaccination campaigns
  - anti-GMO movements
  - exploit health disparities and racial tensions
• compromise health care computer systems and or other critical computing capabilities in bioincidents
• Russian FSB Novochok chemical attack on Sergei and Yulia Skripal in UK (3/4/2018)
  - Salisbury UK hospital computers hacked
  - thwarted hack of Organization for Prohibition of Chemical Weapons (The Hague) conducting forensic analysis of incident samples
Targeted Neuromodulation – The Ultimate Technological Triad: From Commerce to Control

social media profiling

mechanistic neuroscience and mapping cognitive pathways

big data and artificial intelligence
Dual-Use Technologies and the Expanding Biothreat Spectrum

- rate of technology progress and risk expansion outpacing current national and international oversight mechanisms
- new classes of dual-use biothreats will arise from intensifying national competitiveness for commercial domination of advanced technologies
  - synthetic biology, neuroscience and AI (among others)
- CBW Convention and national export controls were designed to address far narrower, well-defined risks
Week Seven
Planning for the Future

- the present continued: navigating the post-COVID-19 world
- anticipated future technology trajectories and their impact
- guaranteed certainties
  - escalating technological complexity
  - intensified international competition for commercial and military dominance of advanced technologies
  - decision-making in the face of greater uncertainty
  - new governance challenges and more demanding legislative competencies