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

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BIOSECURITY AND BIOTERRORISM RESPONSE Winter 2020:
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Stanford University School of Medicine, Li Ka Shing Center (LKSC) room 130
22 January 2020

* WARNING: CONTAINS GRAPHIC BIOMEDICAL IMAGES
Infectious Diseases: A Powerful Force in Human Evolution
Wuhan, China Coronavirus (Dec 2019--?)
The Relentless Changing Dynamics of Infectious Diseases

- **Old foes resurgent:** Rx – resistance
- **Omnipresent pandemic threats**
- **New foes:** emerging infectious diseases
- **Global connectivities**
- **Bioterrorism and bioweapons**
- **Expansion of dual-use technological risks**
The Biosecurity Quartet

- Infectious Diseases of Natural Origin
- Urbanization and Environmental Impacts on Disease Emergence (EIDs)
- Military and/or Humanitarian Missions in Dense Urban Areas and ‘Hot Zones’
- New Dual-Use Technologies and the Expanded Threat Spectrum for Biowarfare/Bioterrorism

- shared dimensions in deterrence, prevention, detection, treatment and recovery
- additional requirements in forensics, attribution and retribution for bioattacks
Biosecurity
Shared Feature of Natural and Nefarious Threats

- surprise, stealth, spread and speed
- ‘all hazards’ and ‘resilience’ the foundations of response preparedness and planning
- cross-agency coordination (within government)
- cross-sector inter-dependencies (public, private, NGOs)
- local events can quickly become global
- global coordination (public health, diplomacy, media, law enforcement, intelligence communities, military, industry supply chains)
Fundamentally Different Threat Categories:

Bombings and Hazmat-Incidents: Immediate Damage Assessment

Bioincidents: An Unfolding (Rolling) Event - EDs and Farms Will Be the Front Line
Media Sensationalism, Public Fear and Irrational Decisions by Political Leadership
Ugly Realities

- media sensationalism fueling public panic
- pressure on governments to make illogical but politically expedient decisions
- in a severe outbreak the shock factor from any major level of fatalities will be unprecedented in modern peace times with unpredictable consequences for public responses and societal stability
- unpredictable unilateral decisions by other governments, restricting trade, travel and shipment of goods
- extended supply chains might break down completely
• SARS $ 30 billion
• Ebola W. Africa $ 53 billion
• Ebola U.S. $ 2.4 billion
• Amerithrax decontamination $320 million
• Projected cost of 1918 influenza – type pandemic
  - $683 billion US economy
  - $ 4 trillion global economy and 5% drop in GDP
Cost of US Response to 10 Cases of Ebola 2014

- $1.1 billion on domestic preparations, including $119 million on screening and quarantine
- $1.2 million cost to Univ. Nebraska Medical Center for care of three patients
- Nebraska patients generated 3,700 pounds of contaminated linens, gloves and biological waste
Supply Chain
The Daunting Logistics of Ebola Response

- DRC is 4x size of neighboring Rwanda
- Shipped over 900 metric tons of supplies from 8/18 to 11/19
- 17 million gloves
- 2 million surgical masks
- 909,000 gowns
- 200,000 doses of Ebola vaccine (new Arktek refrigeration technology)
- Rebuilt 15 miles of roads and four bridges to reduce travel time
Availability of Resources for Biocontainment and Epidemic Control
Ebola in West Africa (2014-15)
Ebola West Africa: 2014-15

The Logistics (and Risks) of Waste Disposal

Burial Practices
African Swine Fever Epizootic in the PRC (2018 - ?)

- estimated loss of 50% of farm pig population
- pork is 70% of meat consumption in PRC
- impact on global prices, protein source shifts and import costs
- global epizootic risk
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The Strategic Environment for Biosecurity

- Risk Assessment and Mitigation
- Expanded Threat Spectrum
- Technology Convergence
- Strategic Surprises and Dislocations
- Disruptive Technologies
- Rapid Technology Diffusion and New Global Competitors
- Proliferation of Dual-Use Risks
- Technology Acceleration
- Dual-Use Technologies
Dual-Use Applications of Synthetic Biology and the Expanded Threat Spectrum

- beneficent and maleficent applications of same knowledge
- potential to cause profound societal disruptions based on deliberate misuse, error or accident
“Exploring Biospace”

Understanding the Principles of Biological Design

Synthetic Biology and Digital Biology

De Novo Construction of Unique Biological Structures, Functions and Modified Organisms With No Known Evolutionary Precedents
“Endless Forms Most Beautiful”: Synthetic Biology and Exploring Biospace

Form and Function (diversity)

Instructional Information (code)

Assembly (design sets)

Design of Novel Biological Systems (exploring biospace)
Mapping the Design Principles of Biological Systems: The Construction of Increasing Hierarchical Complexity

- common genetic (digital) code in all life forms
- toolbox of protein motifs for combinatorial assembly (“molecular lego”)
- assembly of structurally and functionally diverse proteins
- protein interactions and nanoscale intracellular structures

- molecular signaling networks
- cells and tissues
- organs
- organism
Digital Biology (Code) and Synthetic Biology (Construction): “It from Bits”

- program and assemble new biological functions and organisms based on knowledge of the instructional ‘rules’ for synthesis and assembly
- reprogramming existing biological systems
- expanding “biospace”
  - design, simulation and construction of novel functions/organisms with no known natural evolutionary counterpart
  - novel biotic: abiotic combinations
- “directed evolution” and “accelerated evolution”
“Exploring Biospace”: The Power of Combinatorial Interactions and Molecular Assembly

- estimated 22,000 genes in human genome
- two genes cooperate to create a function $=(22,000 \times 21,999)/2 = 241,989,000$ potential combinations
- 100 genes generate a complex function $=10^{65794}$ potential combinations
- number of theoretical possibilities for synthetic assembly (biospace) far exceed the narrow molecular space sampled in 4 billion years of evolution
Synthetic Biology Mirrors Engineering Principles: Design-Build-Test

- **Code ("blueprint")**
- **Parts**
- **Genome–Encoded Assembly**
- **Recipient "Chassis"**

Efficient Insertion of Design Code
Pathway and Network Optimization
Scale Up and Economic Production
Oversight: Risk, Regulation and Responsibility
Synthetic Biology: Myriad Applications in Diverse Industrial Sectors

- Healthcare
- Public Health
- Agriculture
- Functional Foods
- Novel Materials
- Textiles

- Bioenergy and Biofuels
- Industrial Enzymes
- ‘Green’ Mfg
- Bio-remediation
- Clean Water
- Sensor Networks
CRISPR-Cas guided excision and insertion of new genes and substitution of individual DNA bases.

- Microbial CRISPR Defense System Against Viruses
- CRISPR-Cas guided excision and insertion of new genes and substitution of individual DNA bases.

- Using an evolutionary mechanism from 3-4 billion years ago for twenty-first-century genome design.
- Delete, replace, or change genes in any living species, including humans.
Explosion of the Gene Editing and Gene Therapy Ecosystem
Worldwide DNA Sequencing Capacity and Massive Data Flows

- doubling every 6 - 9 months
- 250K human genomes = 35 petabytes
- projected growth of global sequencing information to exabyte/zettabyte scale in 5 years
Gene Editing and Base Editing

- ‘knockout’
  - delete or render non-functional
- ‘silence’
  - switch off expression but DNA code unchanged
- ‘activate’
  - switch on expression of silent genes
- somatic modification (augmentation)
  - changes in non-germ line cells with no inheritance by progeny
- germ line modification (enhancement)
  - changes in gametes (sperm/egg) with inheritance by progeny
Genetic Modification

- trial and error
- precise and programmable
- non-heritable change of somatic cells (augmentation)
- heritable change of germ line cells (enhancement)
- gene drives (widespread insertion of a trait)

- any organism, including humans
- any cell type
- any biological function
Digital Biology

- DNA is a digital code
- biology at internet speed
  - transmission of digital instruction code to any location
  - geographic uncoupling of design (code) from manufacture (synthesis and assembly)
- technology diffusion and ‘democratization’ of technology
- dramatic expansion of dual-use risks
  - monitoring, control, legal and ethical issues
Synthetic Biology and US Military Science and Technology

- Biowarfare defense – advanced diagnostics, decontamination, medical therapies
- Tactical Biomedical Technologies – mobile trauma stabilization, novel therapeutics, generation and storage of blood products
- Restorative Biomedical Technologies – restore complex tissues after traumatic injury, neural-controlled prostheses
- Bio-inspired Platforms and Systems – mimic locomotion and chemical/visual/aural sensing
- Microphysiological Systems – organs-on-chip to mimic human physiological systems
- In Vivo Nanoplatforms for diagnostics and therapeutics
- Living Foundries – create engineering framework for synthetic biology

• Reduce, eliminate, counter, mitigate weapons of mass destruction
  • WMD sensing and recognition
  • Threat containment, filtering, shielding
  • Decontamination
  • Forensics
  • Neutralization of CBRNE materials
Advanced Manufacturing Digital Programming of New 3-D Fabrication and Assembly Technologies
Biodefense in an Era of Synthetic Biology and Precision Gene Editing

- what are the implications for the future biothreat spectrum?
- what are the timeframes that particular novel threat categories are likely to evolve?
- what new surveillance and counter-measures will be needed?
- how do current international agreements regarding WMD/CBW need to be updated to address the changing threat spectrum?
Strategic and Operational Objectives of Purposeful Bioattacks

• civilian and military targets
• evade or confuse diagnosis
• treatment resistance
• circumvent vaccine immunization protections
• overload healthcare and other incident response capacities
• economic disruption of supply chains of essential goods
• spread public panic and erode trust in authorities
• deception to hide attribution
• multi-focal strikes with different agents and/or combinations of agents
The Appeal of CBW for Asymmetric Warfare and Terrorism
The FSU Covert Biopreparat Program: Violation of 1972 BWC
Domestic Activists, Lone Wolf and Biohackers

“Win McCormack has put a penetrating spotlight on Indian guru Bhagwan Rajneesh and his bizarre and very dangerous cult. An utterly fascinating work.”
—VINCENT BUGLIOSI, author of *Helter Skelter*

THE RAJNEESH CHRONICLES
The True Story of the Cult That Unleashed the First Act of Bioterrorism on U.S. Soil
WIN McCORMACK

ODYSSEY OF A Mad Genius
PLUS: OKLAHOMA CITY, A YEAR LATER
- The Survivors’ Tales
- Interview with McVeigh

BIOHACKERS
The Politics of Open Science
ALESSANDRO DELFANTI
“Amerithrax” October 2001

“I will show you fear in a handful of dust”
-T. S. Elliot
The Need for Stringent Forensics and Robust Evidence for Event Attribution
A dramatic increase in the number of threats, incidents, and incursions by drones at NFL stadiums. We are all very fortunate that the drone over Levi’s Stadium dropped only leaflets.

CATHY LANIER
Senior VP of Security, NFL
Drone Swarms with Ordinance or CBW Payloads and Facial Recognition Homing
Mapping the Global Inventory of Natural Microbial Threats to Humans and Vital Agriculture/Ecological Resources

Natural Pathogens as Convenient Substrates for Engineering New Vectors for Bioterrorism and Biowarfare
The #1 Global Pandemic Threat?
The Omnipresent Risk of Pandemic Influenza
Global Disease Surveillance

Quarantine Activity Reporting System (QARS).

Public Health Department’s Surveillance

GeoSentinel
The Global Surveillance Network of the ISTM and CDC
a worldwide communications & data collection network of travel/tropical medicine clinics
Ground Zero Biosurveillance Data

Comprehensive Front Line Sampling of Sentinel Species

Real-time Intelligence and Faster Preparedness
‘One Health’ Biosurveillance

Natural reservoirs and ecological niches of emerging viruses

- range and physical contact
- environmental factors

Susceptible human host

- demographics
- cultural, political and economic factors
- health system capacity to detect/respond

Global Biosurveillance (BSV)

- huge gaps in our understanding of infectious disease ecology and zoonotic risk
- 1400 human pathogens, 335 new EIDs since 1940
- increasing number of EID events each decade
- Project PREDICT, Global Virome Project and DARPA PRE-EMPT have identified over 1000 viral species with the potential to infect humans with rodents, bats and primates as major reservoirs of future zoonotic risks
- target BSV capability to ‘hot spots’ for zoonotic ‘spillover’
  - defined by specific environmental, ecological and socio-economic characteristics
  - urbanization-megapoli-push into virgin ecoterrain
  - breakdown/inadequate public health infrastructure/sanitation/hygiene
- eastern and southeastern Asia, India and equatorial Africa
Metagenomic Profiling of Pathogens and Their Evolution

**Influenza Virus**

**Zika Virus**
Faster Detection Saves Lives: The Primacy of Diagnostics in Biosurveillance and Preparedness Mobilization

Profile: signatures of infectious agents

Detect: rapid automated PON/POC diagnostics

Act: real-time situation awareness, decisions

surveillance sans frontières

pathogen evolution

dual-use research and engineered biothreats
Remote Monitoring of Health Status: Faster Detection of Prodromal Infections Saves Lives
Beyond Select Agents: The Expanded Threat Spectrum

AGENT X

- exotic natural EID/zoonose?
- deliberately engineered bioterror agent?
- Bioerror?
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*

PLOS ONE https://doi.org/10.1371/journal.pone.0188453
January 19, 2018

Construction of an infectious horsepox virus vaccine from chemically synthesized DNA fragments

Ryan S. Noyce¹, Seth Lederman², David H. Evans¹*

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
Therapeutic Oncolytic Viruses Designed to Circumvent Immune Detection

- Onco-Vex-GM-CSF (Amgen)
- Reolysin (Oncolytics Biotech)
- JX-594-Jennerex (Biotherapeutics)
Risk, Restraint and Responsibility: Claims By Some In The Academic Community for Unconstrained Publication

- ‘academic freedom’ and intrinsic value of “knowledge”
- scientists are not responsible for harmful uses of their research (the gunmaker’s defense)
- individual scientists cannot affect the overall trajectory of a research field
- publication is a deterrent to misuse and critical vehicle to inform countermeasure development

  - so who really needs to have access to this information to develop countermeasures?
Engineering Microbial Pathogens: Shifting the Disruption Impact from Acute to Chronic

- cause delayed but inevitable mortality (4-6 weeks) to overwhelm preparedness resources and paralyze healthcare delivery systems
- high chronic morbidity in survivors and resulting clinical burden (human) or economic loss (agriculture and disruption trade supply chains)
- racial and ethnic selectivity (human) and genetic bottlenecks (agricultural crops)
- acute panic and progressive erosion of trust in government
- long term psychological effects on exposed societies
Latent, Activatable Agents

- ‘silent’ integration into host genome
  - targeted insertion in specific organs/cell types
- co-infection and co-insertion of activation trigger (gene enhancers)
- activation on demand by exposure to enhancer triggers
  - from targeted effects on individuals/groups to widespread population effects
  - silent insertion into germ line (sperm, eggs) and trans-generational vulnerabilities
Synthetic Biology and DURC: Thinking ‘Beyond Bugs’

- Precision medicine is mapping the molecular networks (circuit diagrams) of every cell type in the body and circuit disruptions in disease.
- Roadmap for next-generation chemical warfare agents to target specific molecular circuits.
Mapping Biological Information Pathways and New Dual-Use Threats

- identification of genetic coding (information) and molecular pathways (wiring circuits) for every cell type in the human body
- disease-induced circuit changes
  - improved diagnosis and treatment (precision medicine)
- same information provides ‘targets’ for disruption by biological (infectious) and chemical (non-infectious) agents
  - direct targeting
  - indirect effect by targeting the target’s control system(s)
- epigenetic ‘gene silencing’
  - turning silent genes on and active genes off
“Armies of the future will need weapons based on new physical principles, including genetic and psychophysical science.”

President Vladimir Putin
Essay, Rossiyskaya Gazeta, 2012
Chemical or Electronic Modulation of Specific Neural Circuity: New Warfare Capabilities and Societal Vulnerabilities

- fear, depression, suicidal ideation
- aggression
- disruption of sleep patterns
- memory modulation
- lethargy
- addiction
Cyborg Soldier 2050: Human/Machine Fusion and the Implications for the Future of the DOD

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Approved for public release: distribution unlimited.
Purposeful Societal and Economic Disruptions Via Rapid Design of Ever-Changing Addiction Drugs Generated by Synthetic Biology
China’s Export of Fentanyl and Derivatives: A New Biosecurity Threat

U.S.-China Economic and Security Review Commission

February 3, 2017

Fentanyl: China’s Deadly Export to the United States

Sean O’Connor, Policy Analyst, Economics and Trade

Acknowledgments: The author thanks Barry Carfagno, Research Fellow, Economics and Trade, for his research assistance. The author also thanks officials at the U.S. Drug Enforcement Administration and U.S. Department of Justice for their helpful insights. Their assistance does not imply any endorsement of this report’s contents, and any errors should be attributed solely to the author.

Key Findings

- China remains the largest source of illicit fentanyl and fentanyl-like substances in the United States.
- Since the publication of the Commission’s 2017 Staff Report, "Fentanyl: China’s Deadly Export to the United States," which detailed how illicit fentanyl and other synthetic opioids (SSO) from China are finding their way into the United States. The 2017 report’s conclusion remains accurate, including that: China remains the largest source of illicit fentanyl and fentanyl-like substances in the United States.
- Fentanyl, a synthetically produced opioid, is shipped from China either directly to the United States or to drug traffickers.

Overview of Chinese Fentanyl and Other Illicit Synthetic Opioid Flows to the United States

In February 2017, the Commission published a staff report titled "Fentanyl: China’s Deadly Export to the United States," which detailed how illicit fentanyl and other synthetic opioids (SSO) from China are finding their way into the United States. The 2017 report’s conclusion remains accurate, including that:

- China remains the largest source of illicit fentanyl and fentanyl-like substances in the United States.
- Fentanyl, a synthetically produced opioid, is shipped from China either directly to the United States or to drug traffickers.

Evolution of the U.S. Overdose Crisis

Understanding China’s Role in the Production and Supply of Synthetic Opioids

Bryce Pardo
China Has Withheld Samples of a Dangerous Flu Virus

Despite an international agreement, U.S. health authorities still have not received H7N9 avian flu specimens from their Chinese counterparts.

Health workers attending to an H7N9 avian flu patient in Wuhan, China, in 2017.
Agence France-Presse -- Getty Images
• major R.& D. investments and sophisticated biotechnology/computing expertise
• purposeful creation of large diaspora for training in US/EU universities
• relentless industrial espionage and relentless cyber-exfiltration efforts
• mapping the genetic diversity of human populations
National Security Implications of Genome Data on Populations

Population Databanks

Individual Profiles

Foreign Access to Data

Data Security

iCarbonX

华大基因

BGI
MEMORANDUM FOR: SEE DISTRIBUTION

DEC 20 2019

SUBJECT: Direct-to-Consumer Genetic Testing Advisory for Military Members

It has come to the attention of the DoD that some direct-to-consumer (DTC) genetic testing companies are encouraging DoD personnel to purchase genetic ancestry and health information through the offering of military discounts or other incentives. These DTC genetic tests are largely unregulated and could expose personal and genetic information, and potentially create unintended security consequences and increased risk to the joint force and mission.

Exposing sensitive genetic information to outside parties poses personal and operational risks to Service members. DTC genetic tests that provide health information have varying levels of validity, and many are not reviewed by the Food and Drug Administration before they are offered, meaning they may be sold without independent analysis to verify the claims of the seller. Possible inaccuracies pose more risk to DoD military personnel than the public due to Service member requirements to disclose medical information that affects readiness (see DoD Instruction 6025.19, “Individual Medical Readiness”). Testing outside the Military Health System is unlikely to include a clear description of this risk.

Moreover, there is increased concern in the scientific community that outside parties are exploiting the use of genetic data for questionable purposes, including mass surveillance and the ability to track individuals without their authorization or awareness.

Until notified otherwise, DoD military personnel are advised to refrain from the purchase and/or use of DTC genetic services.

Joseph D. Kernan
Under Secretary of Defense for Intelligence

James N. Stewart
Assistant Secretary of Defense for Manpower and Reserve Affairs, Performing the Duties of the Under Secretary of Defense for Personnel and Readiness
Editing the Human Germ Line: No Longer An Abstract Question

- editing humanity: moral and legal constraints or hubris and irresistible inevitability?
- long standing science fiction scenarios and philosophical, religious, ethical, legal debates on the societal implications
- no longer a theoretical debate
The Governance and Oversight of Synthetic Biology

Growing Gap Between Technological Acceleration and Timely Development of National Policies and International Harmonization
US Policy Landscape for Bioweapons and Bioterrorism

- Biological and Toxin Weapons Convention
- Biological Weapons Anti-Terrorism Act (Public Law 101-298, 1990)
- Antiterrorism and Effective Death Penalty Act (Public Laws 104-132, 1996)
- USA Patriot Act (Public Law 107-56, 2001)
- Public Health and Bioterrorism Preparedness and Response Act (Public Law 107-188, 2002)
- Federal and institutional policies for oversight of dual-use research of concern (White House, 2012, 2015)
Export Controls on Technologies for WMD Threats and CBW Weaponization

The U.S. Export Control System and the Export Control Reform Initiative

Jan F. Ferguson
Specialist in International Trade and Finance

Paul K. Kerr
Specialist in Nonproliferation

August 9, 2018

Dual-Use Technologies and Export Control in the Post-Cold War Era

Documents from a Joint Program of the National Academy of Sciences and the Russian Academy of Sciences

The Defence Export Control Office

DECO

Australian Government
Department of Defence

DECO

Australian Government
Department of Defence

Detecting Suspicious Procurement Attempts

Regrettably, not all buyers approach Australian industry with a legitimate commercial purpose. The following information is designed to assist industry identity authorities that may indicate an attempt to illegally acquire conventional arms or procure goods, services, and technologies for weapon of mass destruction (WMD) programs.

Bilateral WMD programs and proliferation of conventional arms pose significant threats to the safety of all Australians, and to regional and global security. It is in Australia’s interest to ensure that all sales to conventional weapons and items that could contribute to WMD programs are appropriately controlled.

The Defence Export Control Office works closely with other government agencies to ensure that accredited industrial organisations are aware of conventional weapons and, in turn, protect Australia’s reputation as a responsible member of the global exporting community.

To this end, Industry should ensure that all exports are conducted in compliance with all statutory and regulatory requirements. Companies selling exported defence and dual-use goods, and items that could contribute to WMD programs, must be licenced by DECO.

Australian industry can help prevent the proliferation of WMD and conventional weapons by reporting all suspicious approaches to DECO.

Australia Group

Common Control List Handbook

Volume I: Chemical Weapons-Related Common Control Lists

Volume II: Biological Weapons-Related Common Control Lists

Intergovernmental Agreement on Biosecurity Review

July 2016

Submission by the Export Council of Australia
Policy Frameworks for Dual-Use Research of Concern (DURC): Primary Focus on Pathogenic Microorganisms
Current Regulatory and Oversights Frameworks are Outdated

- historical narrow focus on small list of select pathogens
- major gaps in USG experience, knowledge and agility to interpret and regulate emerging industrial ecosystems
  - inter-agency communication and decision authorities
  - monitoring global supply chains and multiple intermediaries
  - internet crime
  - digital biology and data security
- poor coupling and integration of global public, health frameworks (natural infections) and biodefence efforts (nefarious assaults)
Screening of Gene Sequences of Concern

- screening orders to synthesize potentially dangerous sequences
  - focus on select agents
- likely increasing irrelevance as a biosafety/surveillance tool
  - low cost of synthesis machines
  - digital genome computer codes bypass screening and surveillance tools
  - new gene editing tools makes any gene a target
Biosecurity Innovation and Risk Reduction: A Global Framework for Accessible, Safe and Secure DNA Synthesis

In collaboration with the Nuclear Threat Initiative (NTI)

January 2020
new class of potential signatures to predict lab-of-origin in engineered DNA sequences

Automated Remote Monitoring of Bioprocess Equipment to Ensure Integrity of Synthetic Program as Declared
Gray Zone Threats

An Emerging Dimension of Hybrid Warfare

New Risks in the Gray Zone Between Peace and Major Conflict

Implications for Biosecurity
Gray Zone Threats

- between peace (zero) and major military conflicts between nations (five)
- are we already facing level one/two – level escalation?
Darker Shades of Gray: The Emerging Dimension of Hybrid Warfare

- deception, disinformation and propaganda
- weaponized narratives ("fake news")
- lawfare; exploiting loopholes and seeding ambiguity
- plausible deniability
- exploit Western public reluctance for military deployments
Gray Zone Tweets and Biosecurity: Russian Trolls and Twitter Bots

• weaponized health communications
  – anti-vaxxer campaigns
  – anti-GMO movements

• compromise health care computer systems and or other critical computing capabilities in bioincidents

• Novochok chemical attack UK 2018
  – Salisbury UK hospital computers hacked
  – thwarted hack of Organization for Prohibition of Chemical Weapons (The Hague) conducting forensic analysis of incident samples
New Technologies and Public Trust

- “techlash”
  - fast and loose approach of Silicon Valley to consumer data protection and privacy
- ‘anti-science’ suspicion and resentment of elitism
- “fake news”
- autonomous vehicles/smart robots
- gene editing/synthetic biology
- machine learning/artificial intelligence
Out of Sight: Out of Mind!

The Cocoon of Protection: How Quickly We Forget Past Epidemics and Their Toll

Reduced Investment in Public Health and Biosecurity: Myopic and Flawed Policy
Comfort and Complacency: The Enemies of Vigilance and Preparedness
Tackling antimicrobial resistance 2019–2024

The UK’s five-year national action plan

Published 24 January 2019

Encouraging Vaccine Innovation: Promoting the Development of Vaccines that Minimize the Burden of Infectious Diseases in the 21st Century

Report to Congress

December 2017

Vaccine Platforms: State of the Field and Looming Challenges
“Fits and Starts: Reactionary Biodefense”

October 2018
U.S. Funding for Global Health Security

- Zika appropriations
- Ebola appropriations
- Global health security

2006: $390
2007: $321
2008: $376
2009: $417
2010: $486
2011: $397
2012: $390
2013: $366
2014: $499
2015: $909
2016: $146
2017: $407
2018: $402
2019: $353

The Joint External Evaluation Exercise (JEE): January 2016*

- major deficits in 89% of the 55 countries evaluated to date
- surveillance for highly antibiotic resistant pathogens and antimicrobial stewardship
- biosecurity and surveillance for zoonotic diseases, food poisoning and water-borne illness
- insufficient personnel and training
- investment levels
- major risks to cross-border disease spread

*V. Gupta et al. (2018) J. Global Health 8, e.020416
The Curse of Contemporary Governance: ‘Quick Fixes’ and the Retreat from Complexity

- false comfort and complacency
  - society increasingly “cocooned” from complexity and risk

- pervasive and dangerous scientific illiteracy among legislative and policy makers about biosecurity

- “quick fixes” unidimensional, short term policies that
  - do not address long term, multidimensional complexity

- public policy defined increasingly by length of legislative terms

- influence of media in shaping public policy priorities and potential compromise of operational preparedness
The Imperative for Proactive Actions for Robust Biosecurity

- need for higher priority of biosecurity in national security strategy and international engagement
- development of more sophisticated threat assessment capabilities
- strengthen surveillance, analysis deterrence capabilities in national security, IC, law enforcement
- greater investment in robust threat mitigation capabilities
  - obligate private sector engagement
  - logistics and operational integration (and training) for complex bioincident management
- agile oversight mechanisms and international harmonization
Escalating Complexities in Biosecurity

All Hazards Analysis

Synthetic Biology, Digital Biology

Biosurveillance and Diagnostics

Meta–Data, Advanced Computing, AI

Agent X and Proliferation of Dual-Use Risks

“Threat Space”

“Design Space”

“Detection Space”

“Analysis Space”

“Preparedness Space”
“Politics is the art of the possible, the calculated science of survival”

Prince Otto von Bismarck

“Survival owes little to the art of politics, but everything to the calculated application of science”.

Professor Rudolph Virchow (in reply)
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