

Biodefense In The Age of Synthetic Biology and Precision Gene Editing

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Presentation:

**Global Security PLuS and New Approaches to Grey-Zone Threats:
Sydney, 11 September and Canberra 12 September 2018**

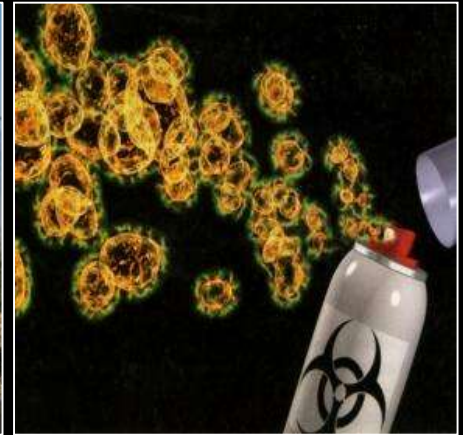
The Biosecurity Quartet

Infectious
Diseases
of
Natural
Origin

Urbanization
and
Environmental
Impacts on
Disease
Emergence
(EIDs)

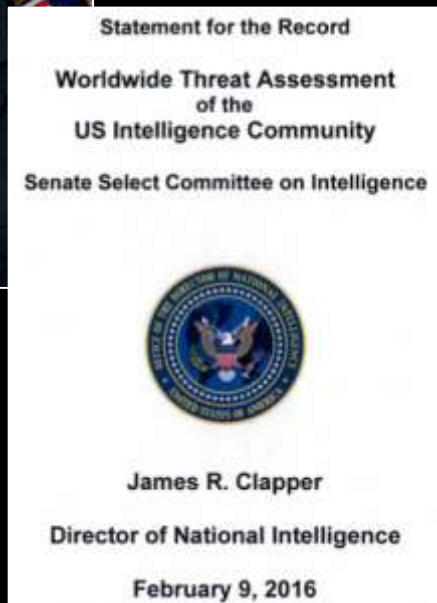
Military and/or
Humanitarian
Missions in
Dense Urban
Areas
and
'Hot Zones'

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

Synthetic Biology and National Security: The Ultimate Dual-Use Technology for Modification of Biological Systems?



**Technology Diffusion,
Automation,
Simplification and
Cost Reduction**



**New Oversight
Mechanisms and
International
Harmonization**

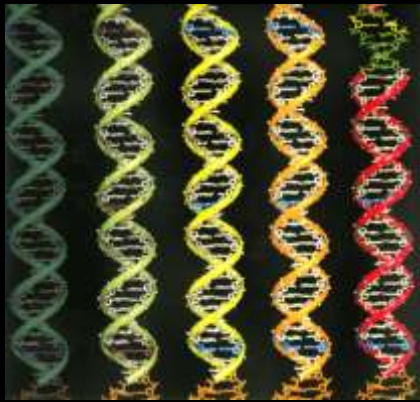
- **beneficent and maleficent applications of same knowledge**
- **potential to cause profound societal disruptions based on misuse, error or accident**

Biological Diversity and Variation: “Endless Forms Most Beautiful”



Synthetic Biology: Design-Build-Test

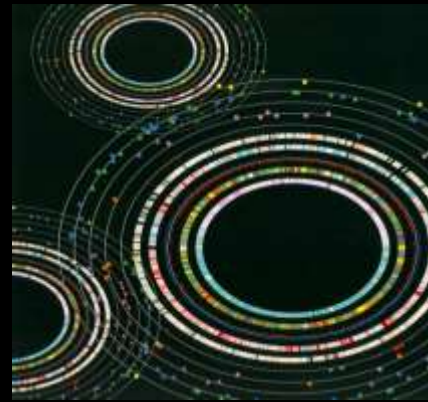
Code



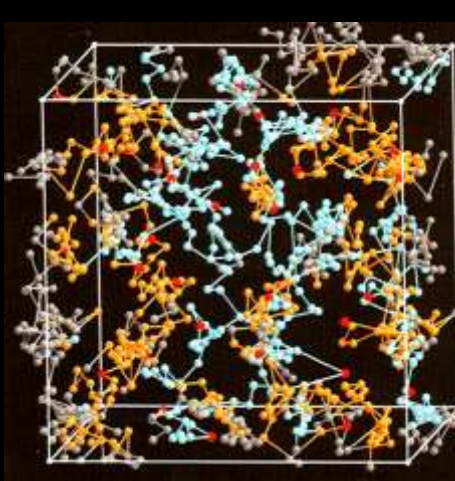
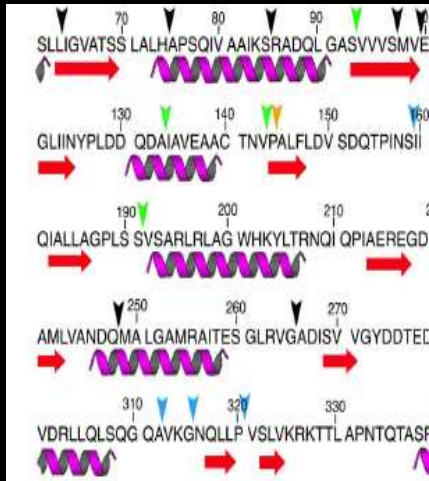
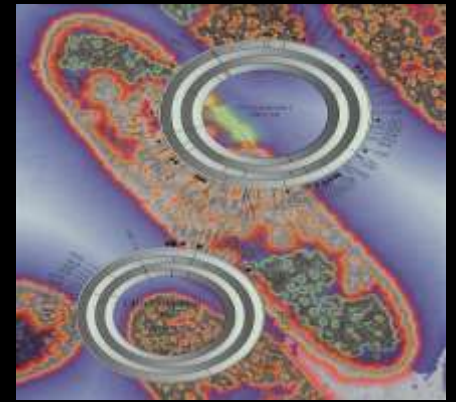
Parts



Genome Assembly



Recipient "Chassis"



Efficient Insertion

**Pathway: Network
Optimization**

**Scale Up and
Economic
Production**

**Oversight: Risk,
Regulation and
Responsibility**

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”**

The Key Technology Platforms for Genome Modification and New Capabilities in Synthetic Biology

- **read** (sequence)
- **write** (synthesize)
- **edit** (precision changes in known genomes)
- **design** (unique genomes with no natural counterpart)
- **xenobiology** (new genetic codes using non-natural DNA bases)
- **archive** (inventory of global genetic diversity)

Worldwide DNA Sequencing Capacity and Massive Data Flows



- doubling every 6 - 9 months
- 250K human genomes = 35 petabases
- Illumina X-10 sequencing instrument
 - one haploid genome every minute (3 Gbp/min)
 - 18,000 whole human genomes/year
- projected growth of global sequencing information to exabyte/zettabyte scale in a decade

Synthetic Biology: Myriad Applications in Diverse Industrial Sectors

Healthcare



**Public
Health**



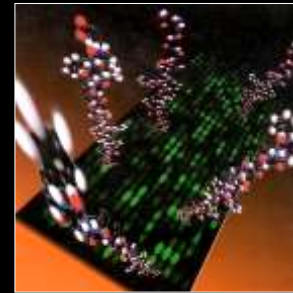
Agriculture



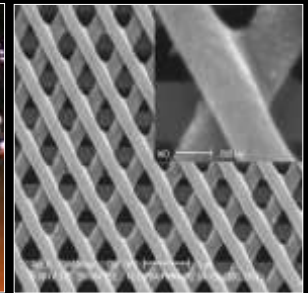
**Functional
Foods**



**Novel
Materials**



Textiles



**Bioenergy
and
Biofuels**



**Industrial
Enzymes**



**'Green'
Mfg**



**Bio-
Remediation**



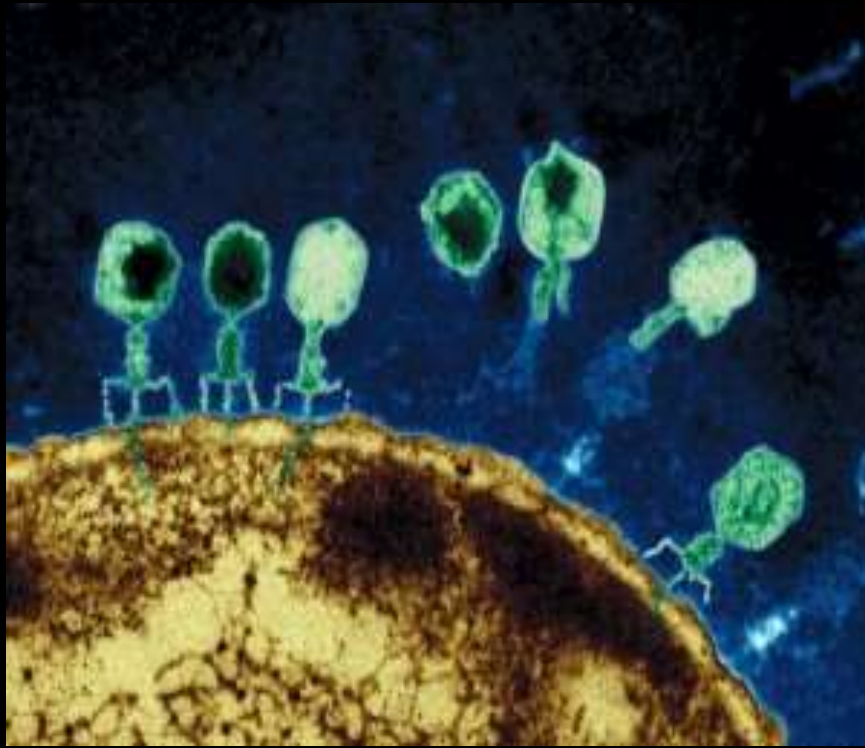
**Novel
Sensors**



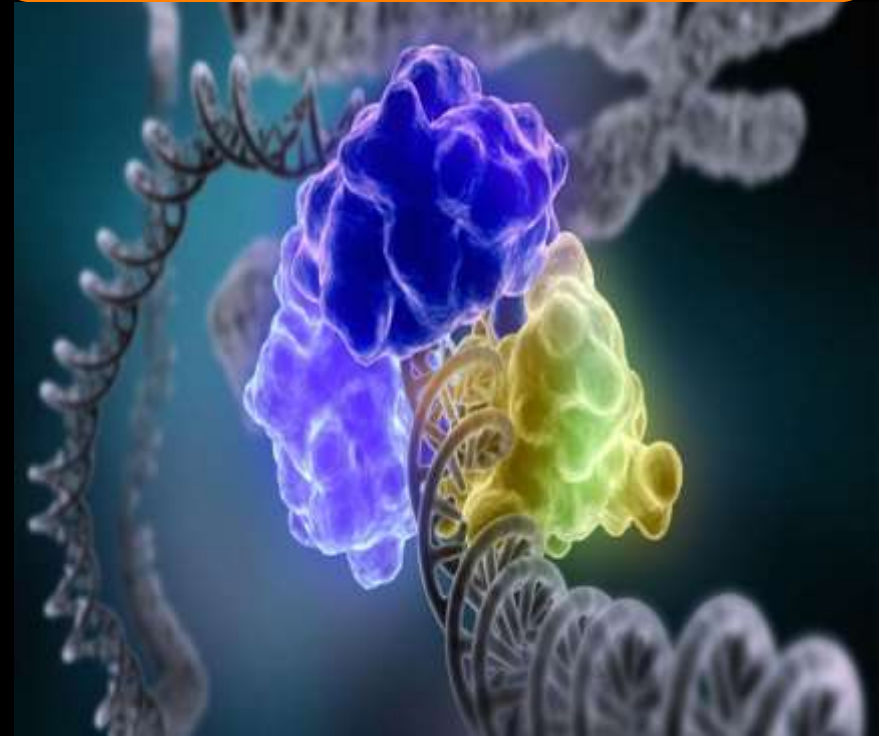
**DNA Data
Storage**

Programmable Nucleases and Genome Editing: The Game Changer in Synthetic Biology

Microbial CRISPR Defense System Against Viruses



CRISPR-Cas Guided Excision and Insertion of New Genes and Substitution of Individual DNA Bases

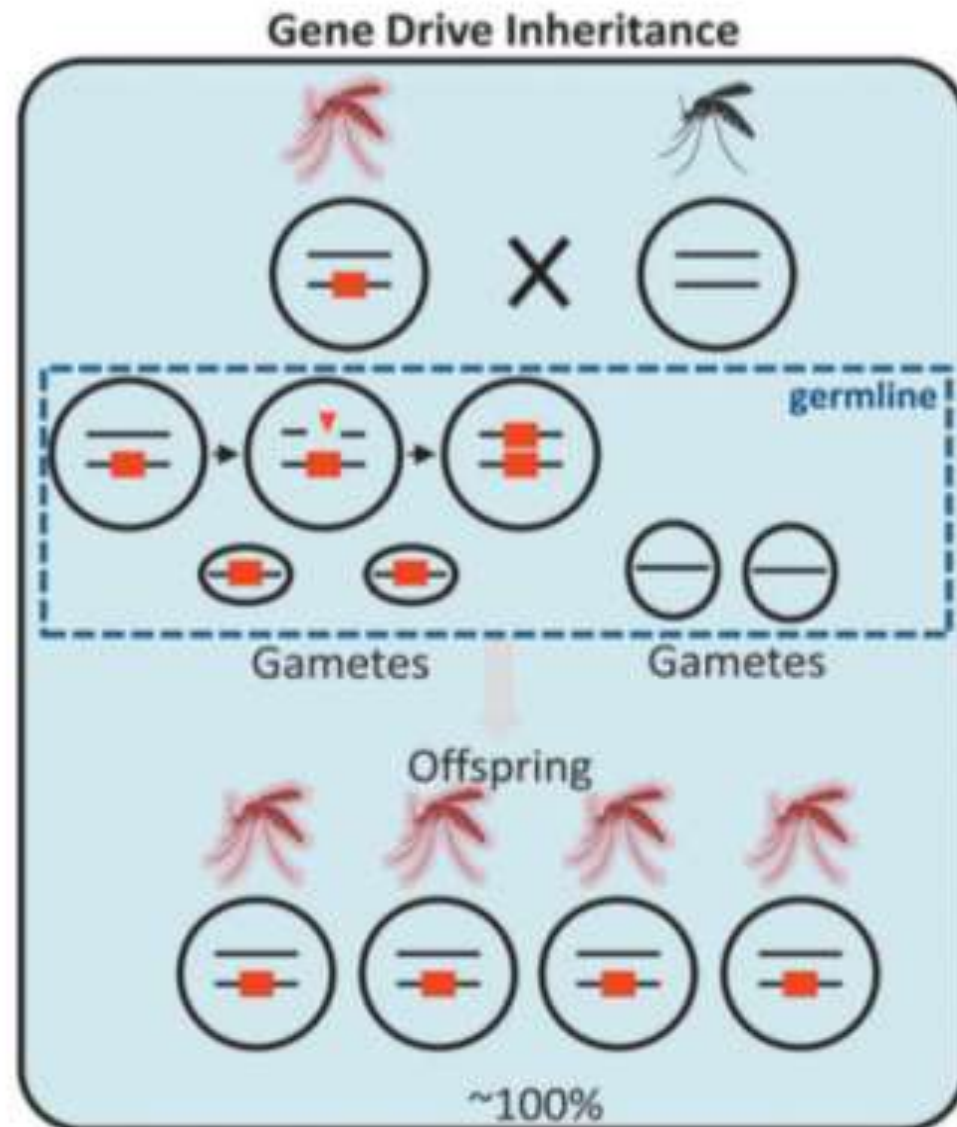
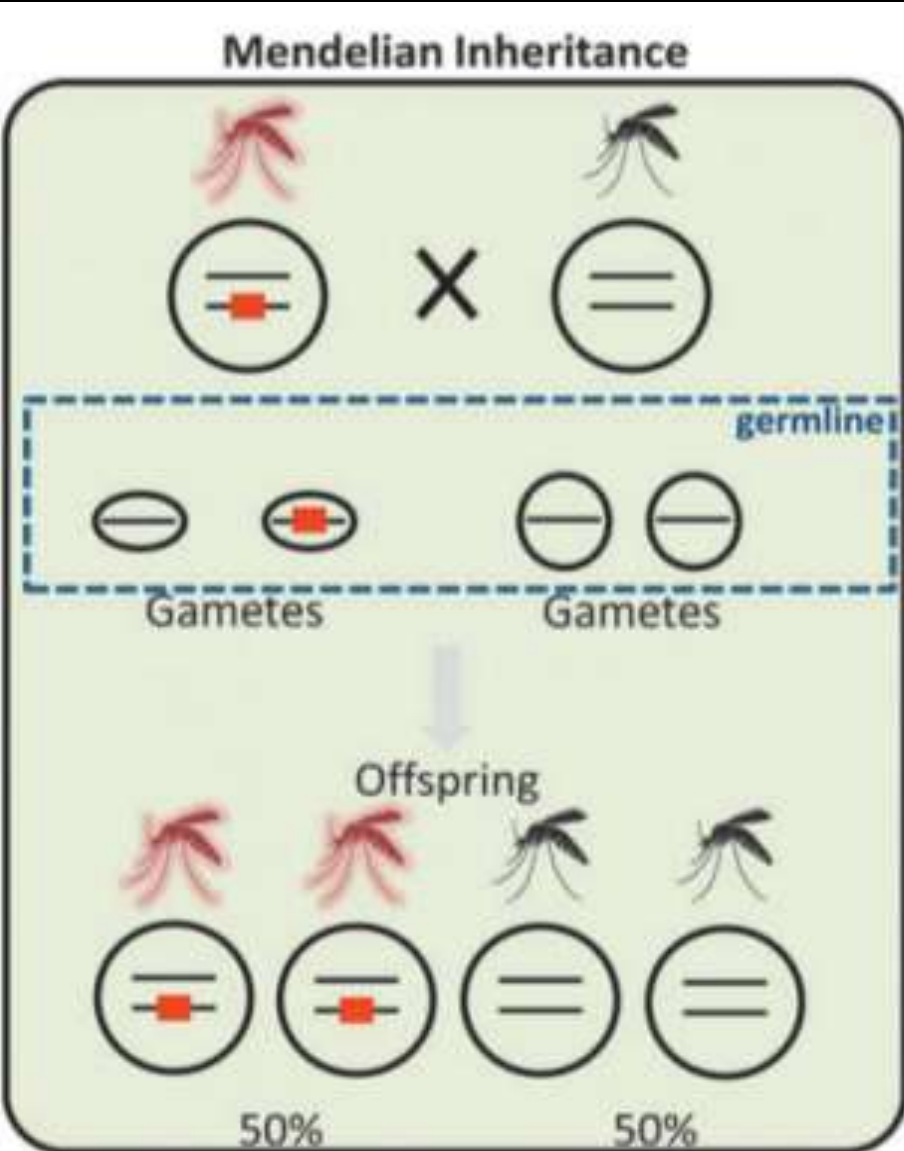


- using an evolutionary mechanism from 3-4 billion years ago for twenty first century genome design
- delete, replace or change genes in any living species, including humans

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

Nuclease-Based Gene Drives: Genetic Modification of a Species to Eliminate Itself



Explosion of the Gene Editing and Gene Therapy Ecosystem

Gene Therapy (20+)



Gene Editing (8+)



CAR/TCR/T Cell (25+)



Synthetic biology companies raised over \$650 million in Q1 2018

Gene/Genome Synthesis

evonetix TWIST BIOSCIENCE

Genome/Protein Engineering

DMC
INSCRIPTA

Organism Engineering

INTREXON
AMYRIS

Food and Agriculture

BOOST
BIOMES

PAIRWISE



inocucor
THE PHYTO-MICROBIOME COMPANY



Yield10
BIOSCIENCE

SuperMeat
Real meat, without harming animals

HEXAFLY

Perfect Day

Tools and Automation

opentrons

Materials

Bolt
Threads

CustoMem
CAPTURE INNOVATION

Environment

FRED
sense
Technologies

Biopharma and Health

AMPLIPHI
BIOSCIENCES CORPORATION

OxSyBio

synlogic

SENTI BIO

engine
BIOSCIENCES

inovio

Atomwise
Better medicines faster.

Prokarium

Chemicals

bioamber

synbiobeta

Rapid Growth of a New Industry Supply Chain for CRISPR-Cas Gene Editing Services

Mirus The Transfection Experts

X2 for CRISPR

Use the X2[®] CRISPR/Cas9 Transfection Vectors

TransIT-X2[®] Dynamic Delivery System

Now you can use the same transfection reagent for your lentivirus, transposon or expression experiments. The TransIT-X2[®] Dynamic Delivery System takes CRISPR/Cas9 genes editing a step further with an advanced proprietary technology that efficiently delivers plasmid DNA, small RNAs such as gRNAs and CRISPR/Cas9 guide RNAs in HEK293T cells.

The TransIT-X2[®] Dynamic Delivery System delivers CRISPR/Cas9 components in multiple formats:

- 1. DNA: deliver plasmid DNA encoding Cas9 or guide RNA
- 2. RNA: deliver gRNA or siRNA in RNA
- 3. Protein: deliver Cas9/gRNA or Cas9/siRNA

20 Years of Excellence

Providing gene delivery reagents since 1993

CRISPR Plasmids
KNOCKOUT & ACTIVATION

CRISPR/Cas9
Endonuclease Plasmids
Homology Directed
Repair Plasmids
Double Endonuclease
Endonuclease Plasmids
CRISPR/Cas9
Activation Plasmids
Inverted Activation
Plasmids

EXCLUSIVELY AVAILABLE AT
SCBT.COM

BioLabs

Programmable Nucleases

Purified, recombinant proteins for genome editing applications

CRISPR/Cas9, the genome editing tool, has revolutionized the field. These Cas nucleases target the production of proteins from DNA. This system, CRISPR/Cas9, is used for genome editing, cloning, transduction and other complex manipulations.

Download our Cas9 Editing Protocol at www.bio.com/cas9editing

How does it work?
CRISPR/Cas9 system, Cas9 nuclease (CRISPR/Cas9) and Cas9 (CRISPR/Cas9)

GE

Specific, functional, and scalable CRISPR-Cas9 gene editing

Simplify CRISPR-Cas9 gene editing with Dharmacon **predesigned CRISPR guide RNA reagents**. Selected by the proprietary Dharmacon CRISPR RNA algorithm, these genome-wide products are designed with unparalleled specificity checking, plus selection criteria trained and validated on functional knockout data. Now you can easily order specific, functional, predesigned CRISPR guide RNAs – without any time-consuming design steps or tedious cloning – for editing one gene or thousands.

Optimized tools for confident CRISPR-Cas9 genome engineering

JUST IMAGINE

THE POSSIBILITIES WITH AUTOMATED CRISPR ANALYSIS

Fragment Analyzer is the only automated instrument for the analysis of CRISPR/Cas9 gene-editing events. Accelerate your scientific discovery using a streamlined process for deep identification of both individual and pooled gene mutations.

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ANALYTICAL

CELLECTA

Gene functional analysis. CRISPR and RNAi. Simplified.

Custom and off-the-shelf knockouts and knockdown reagents.

- Ready-to-use knockouts / knockdown reagents
- Custom knockouts and knockdown reagents, knockdown reagents
- CRISPR/Cas9 and RNAi reagents
- Knockout and knockdown reagents

Find out how Cellecta can help with all your gene editing needs. Visit www.cellecta.com today.

CELLECTA

SBA

SYNTHETIC BIOLOGY
AUSTRALASIA

SYNTHETIC BIOLOGY

IN AUSTRALIA
AN OUTLOOK TO 2030

ACOLA
Australian Council of
Organic Life Scientists



SynBio FSP

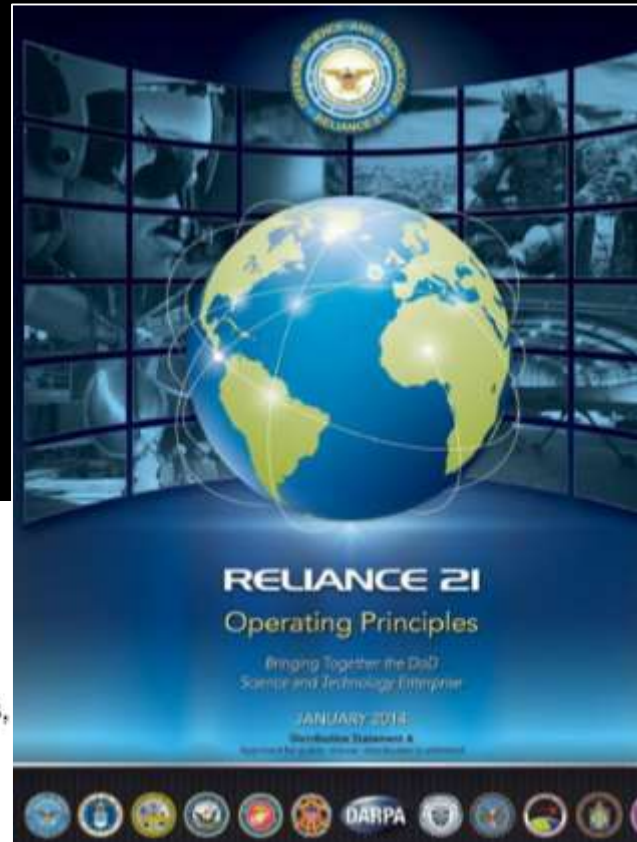
Our Synthetic Biology Future Science Platform is positioning Australia to play a role in one of the fastest growing areas of modern science so that we can understand global developments and, where appropriate, contribute to advances in areas including manufacturing, industrial biotechnology, environmental remediation, biosecurity, agriculture and healthcare research.

Synthetic Biology and US Military Science and Technology



www.darpa.mil

- 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 Nanoplatfroms for diagnostics and therapeutics
- Living Foundries – create engineering framework for synthetic biology



www.dtra.mil

- Reduce, eliminate, counter, mitigate weapons of mass destruction
 - WMD sensing and recognition
 - Threat containment, filtering, shielding
 - Decontamination
 - Forensics
 - Neutralization of CBRNE materials



Synthetic Biology: applications in Defence



[dstl]

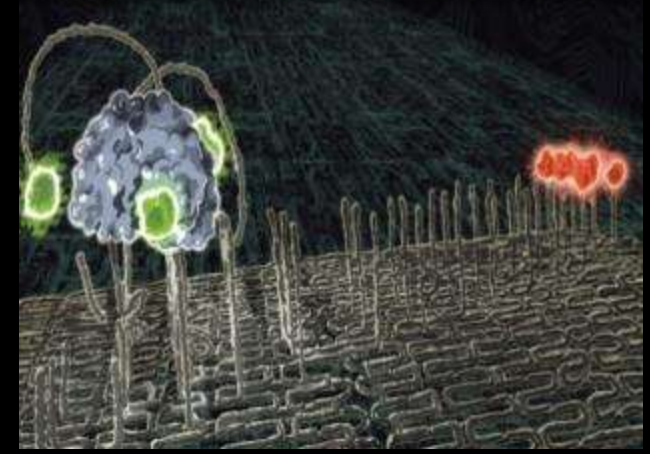
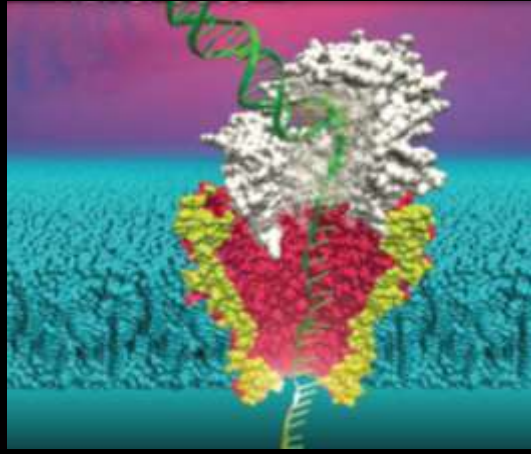
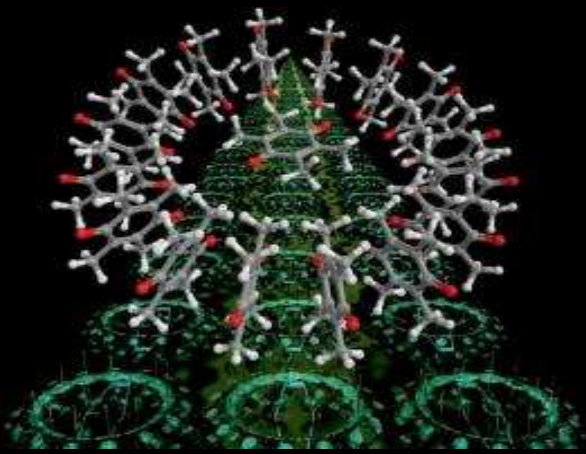
01 October 2014
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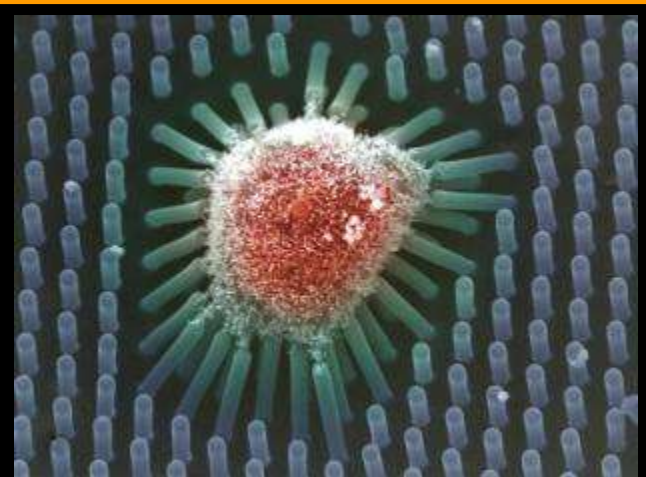
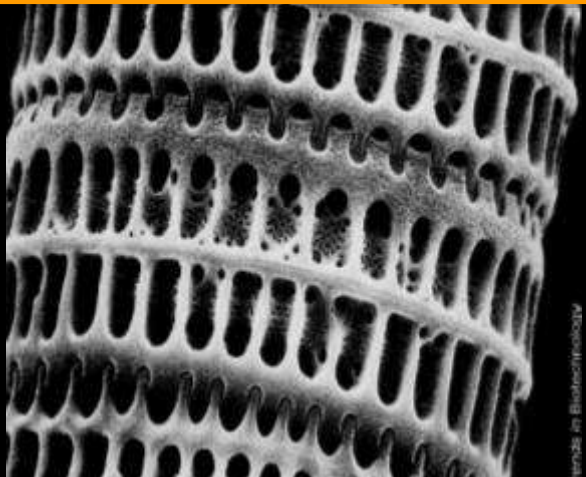

Ministry
of Defence

Ångstrom Level Design: Directed Molecular Assembly of Novel Materials and Sensor Displays

Sensors and Molecular Machines



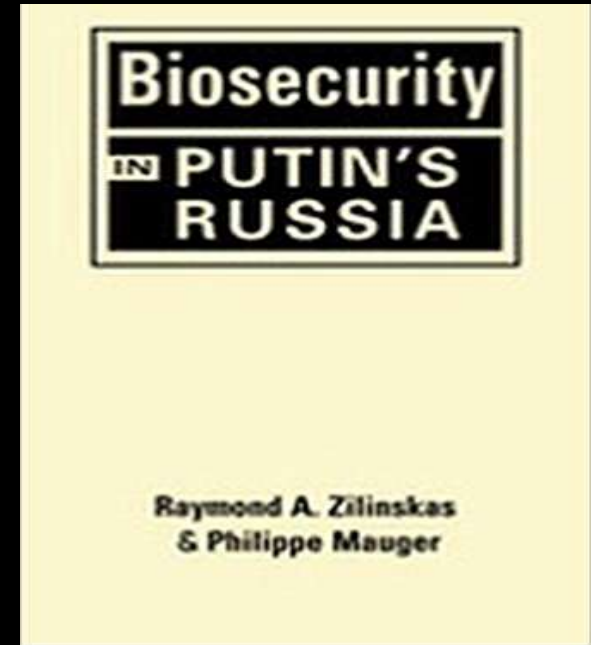
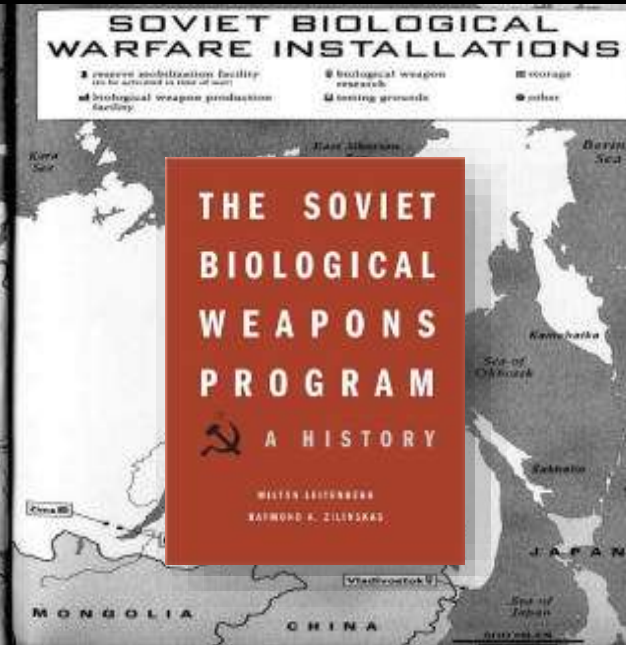
Biomimetic Design: Organic-Inorganic Hybrids



The Appeal of CBW for Asymmetric Warfare and Terrorism



FSU and Russian CBW Programs



“Armies of the future will need weapons based on new physical principles, including genetic and psychophysical science.”

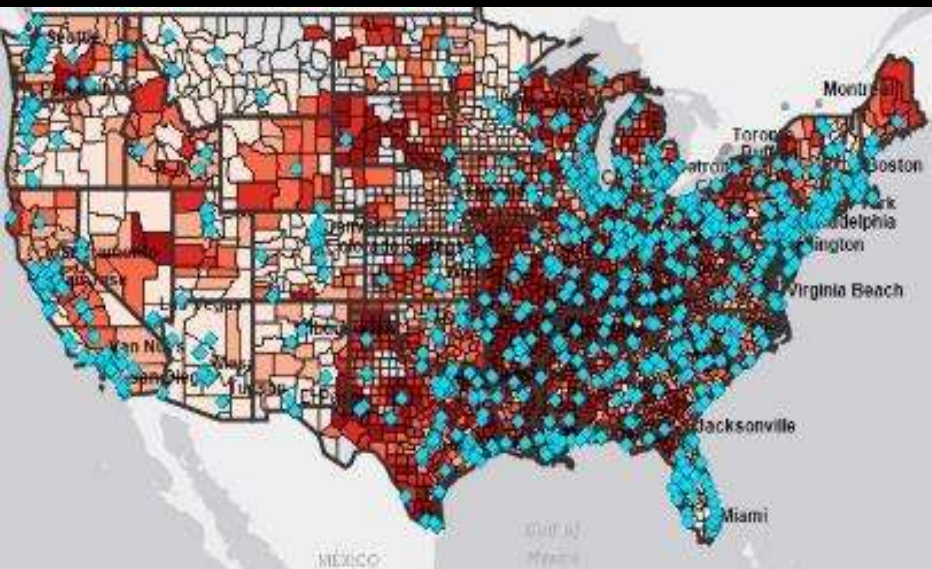
**President Vladimir Putin
essay, Rossiyskaya Gazeta, 2012**



- **major R&D investments and sophisticated expertise in biotechnology and artificial intelligence**
- **purposeful creation of large diaspora for training in US/EU universities**
- **relentless industrial espionage and 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



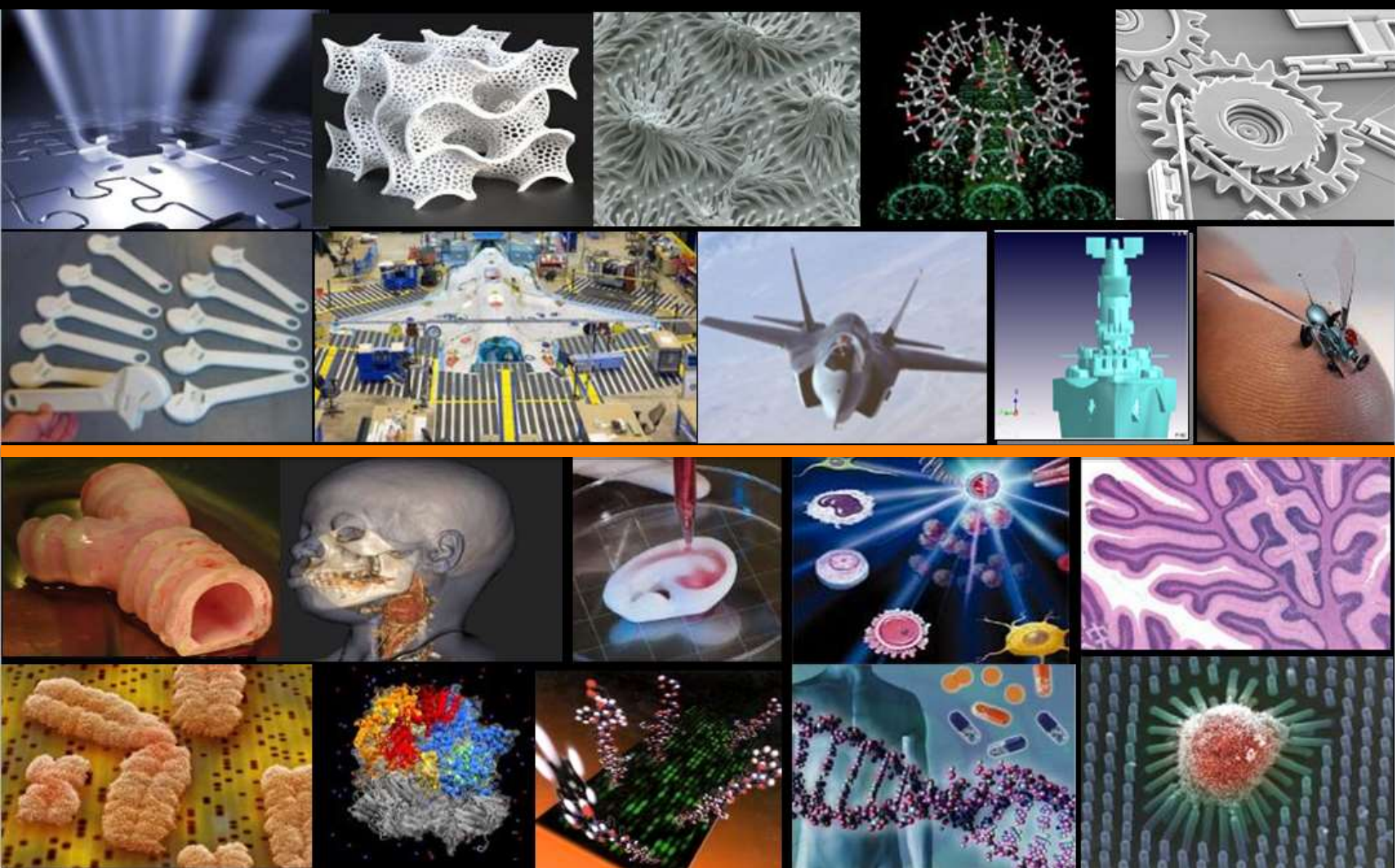
Data Security



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)

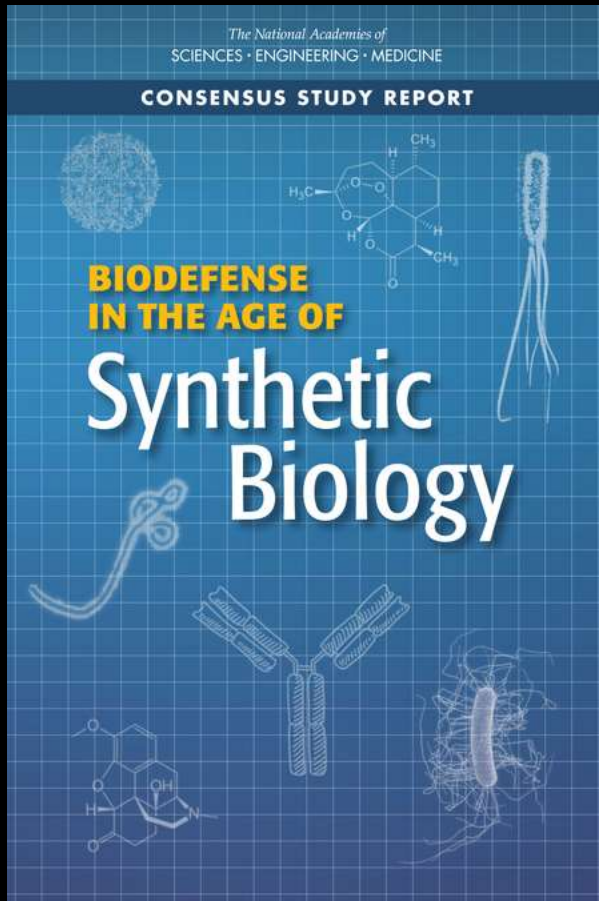
Advanced Manufacturing Digital Programming of New 3-D Fabrication and Assembly Technologies



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?**
- **gray-zone complexity**

A Risk Scale for Synthetic Biology: Dual-Risk Research of Concern (DURC)



high

- alterations of known pathogens
- engineering of pathogenic microbes with entirely novel properties
- modification of microbial metabolic pathways and synthesis of novel materials

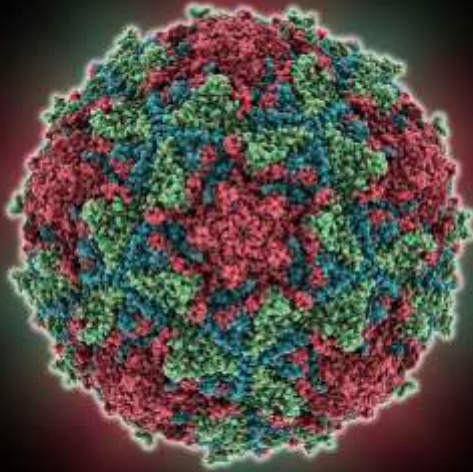
high to medium

- modification of human organ systems
 - microbiome, immune defenses
 - brain

medium to low

- gene drives and ecosystem disruption
- large scale eugenics

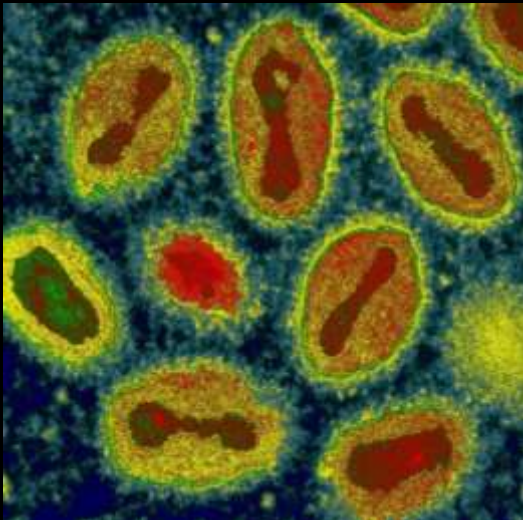
De Novo Synthesis of Pathogens



Science (2002) 297, 1016

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. Evans^{1*}

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

DURC With Pathogenic Microorganisms

known pathogens

- **increase virulence/transmissibility/dissemination/persistence**
- **evasion of detection/diagnosis**
- **engineer resistance to countermeasures**
- **compromise host immunity**
- **alter host range and/or tissue tropism**

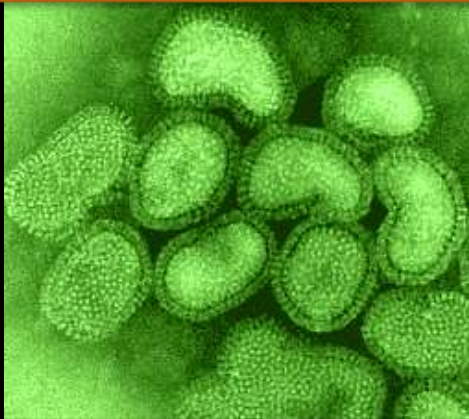
novel threats

- **reconstitute eradicated or extinct microorganisms**
- **de novo design of synthetic organisms with these virulence traits**
- **immunologically naive populations**

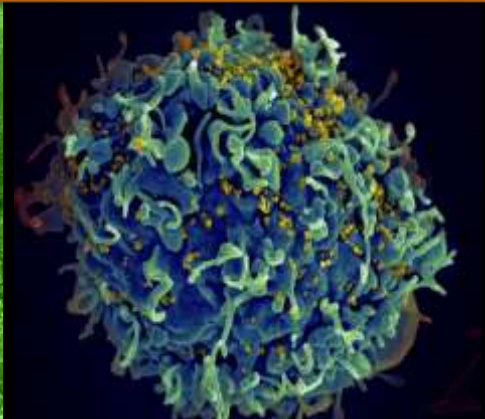
“One Health”

Zoonotic Diseases as Major Human Health Threats: A Rich Reservoir for Microbial Manipulation

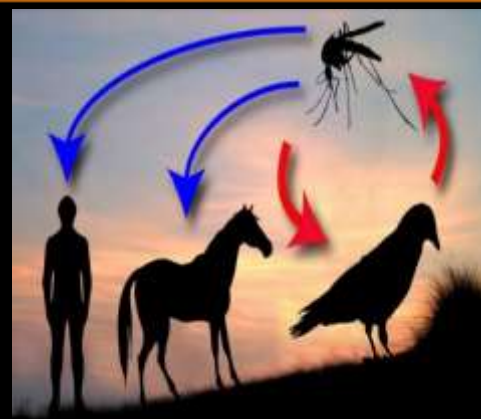
**pandemic (avian)
influenza**



HIV



**West Nile
virus**



MERS- CoV



**Ebola
virus**



**bush meat
food chain**



**Zika
virus**



**what's
out there?**

Thinking Beyond Select Agents: The Impact of 'Agent X' (Natural or Nefarious)

atypical disease clusters and novel features



quarantine logistics



incident management



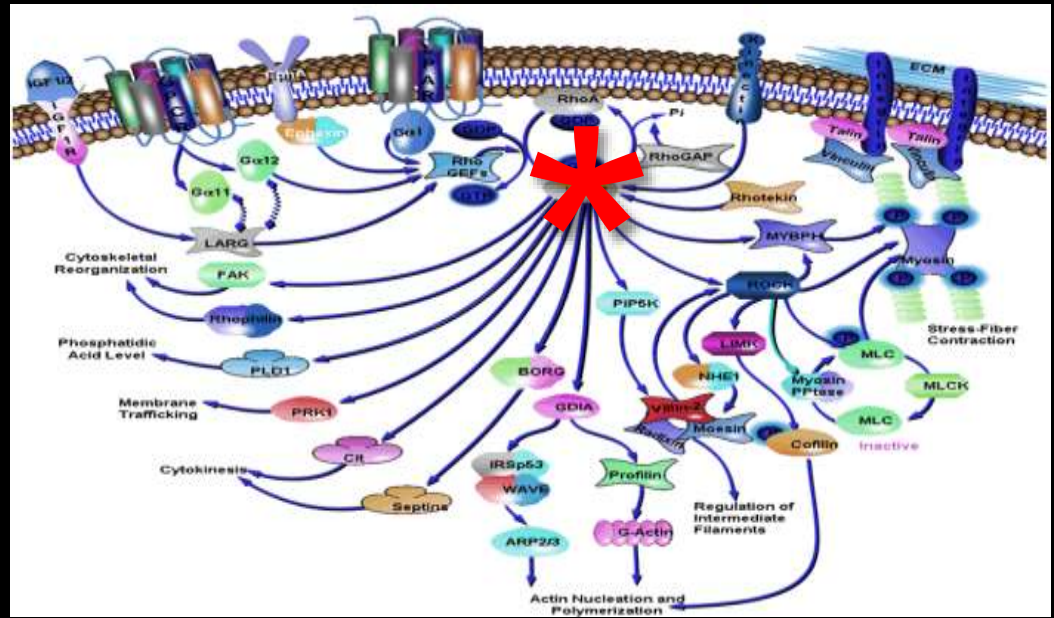
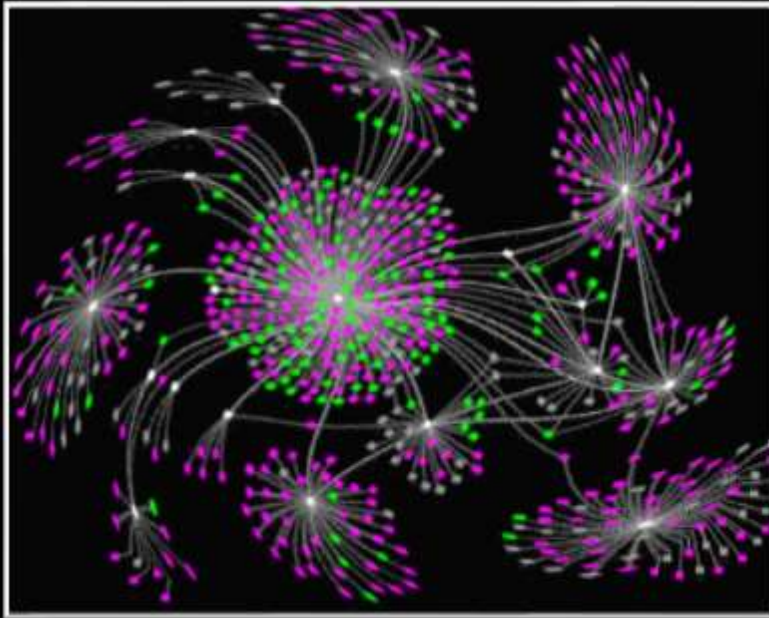
Engineering Microbial Pathogens: Shifting the Disruption Impact from Acute to Chronic

- **overwhelm preparedness resources and paralyze healthcare delivery systems**
- **high chronic morbidity in survivors and resulting clinical burden (human) or economic loss (agriculture and trade)**
- **racial and ethnic selectivity (human) and genetic bottlenecks (agricultural livestock and crops)**
- **acute (panic) and enduring long term psychological impact (erosion of trust in government)**

Latent Agents: Activation on Demand

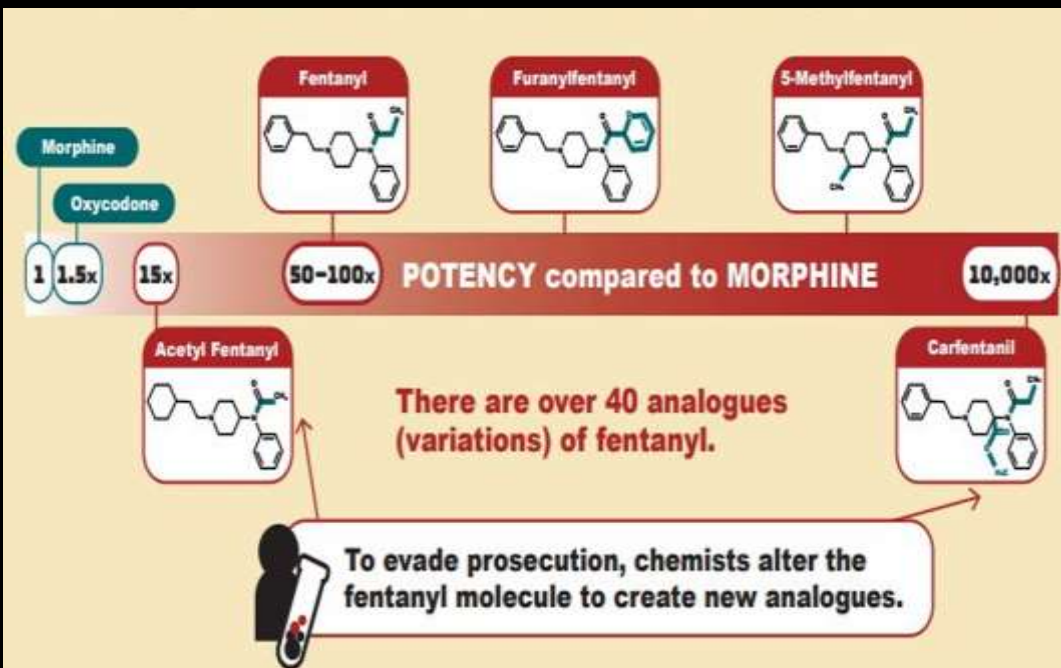
- **‘silent’ integration into host genome**
 - **targeted insertion in specific organs/cell types**
- **co-infection and co-insertion of activation trigger (gene enhancers)**
- **activation on demand by exposure to enhancer triggers**
 - **from targeted effects on individuals/groups to widespread population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

Synthetic Biology and DURC: “Thinking Beyond Bugs”



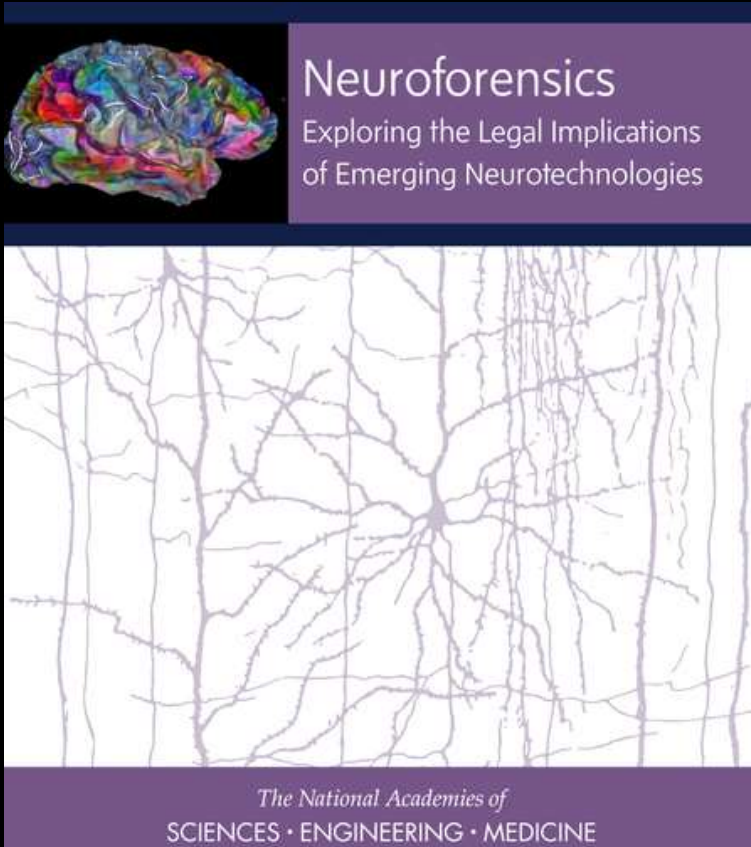
- **precision medicine**
 - mapping the molecular networks (circuit diagrams) of every cell type in the body and circuit disruptions in disease
- **creates roadmap for next-generation chemical warfare agents to target specific molecular circuits**





Dual-Use Implications of Advances in Brain Science

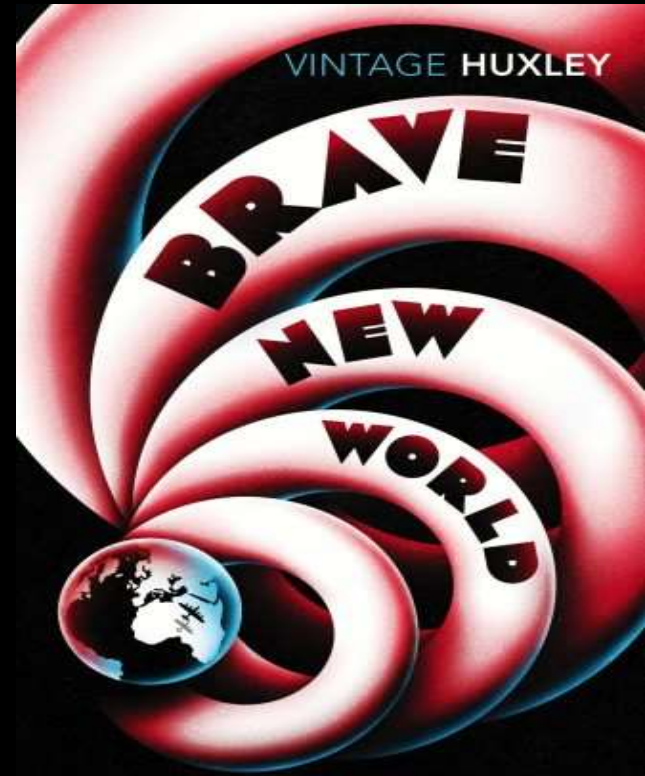
Chemical or Electronic Modulation of Specific Neural Circuitry: New Warfare Capabilities and Societal Vulnerabilities



- **fear, paranoia depression, suicidal ideation**
- **aggression**
- **disruption of sleep patterns**
- **memory modulation**
- **addiction**
- **lethargy**
- **hallucinations**

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
- previous luxury of theoretical debate because the technology was not available

WORLD

China, Unhampered by Rules, Races Ahead in Gene-Editing Trials

U.S. scientists helped devise the Crispr biotechnology tool. First to test it in humans are Chinese doctors



A cancer patient at Hangzhou Cancer Hospital goes through a procedure that includes infusing his own cells after genetic editing using Crispr.
PHOTO: QILAI SHEN FOR THE WALL STREET JOURNAL

By *Preetika Rana, Amy Dockser Marcus and Wenxin Fan*

Jan. 21, 2018 2:19 p.m. ET

Editing the Human Germ Line: No Longer An Abstract Question

Research article

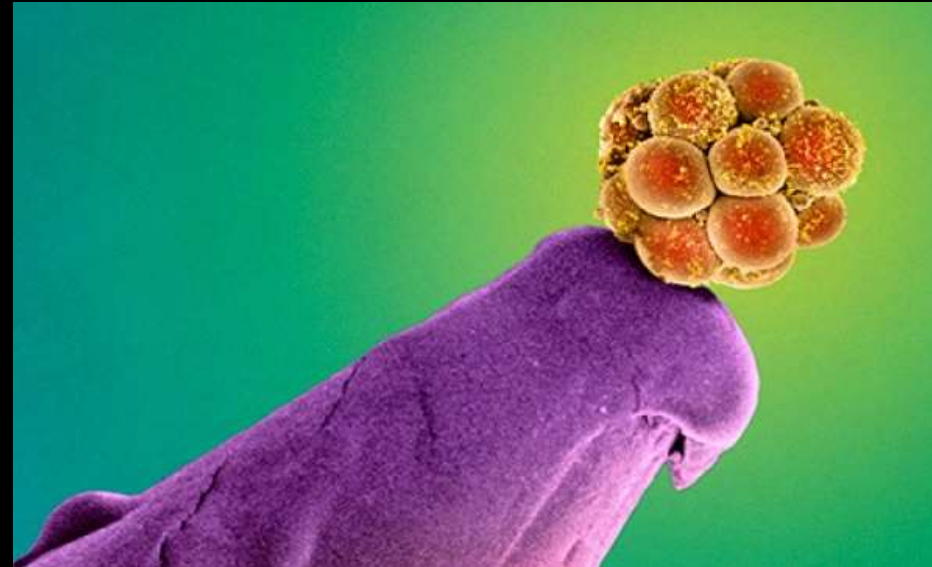
CRISPR/Cas9-mediated gene editing in human tripronuclear zygotes

Puping Liang¹, Yanwen Xu¹, Xiya Zhang¹, Chenhui Ding¹, Rui Huang¹, Zhen Zhang¹, Jie Lv¹, Xiaowei Xie¹, Yuxi Chen¹, Yujing Li¹, Ying Sun¹, Yaofu Bai¹, Zhou Songyang¹, Wen Ma¹, Canquan Zhou¹ and Junjiu Huang¹

- (1) Guangdong Province Key Laboratory of Reproductive Medicine, the First Affiliated Hospital, and Key Laboratory of Gene Engineering of the Ministry of Education, School of Life Sciences, Sun Yat-sen University, Guangzhou, 510275, China

✉ Canquan Zhou (Corresponding author)
Email: zhoucanquan@hotmail.com

✉ Junjiu Huang (Corresponding author)
Email: hjunjiu@mail.sysu.edu.cn



“Today, we sense that we are close to being able to alter human heredity. Now we must face the questions that arise. How, if at all, do we as a society want to use this capability?”

Dr. David Baltimore



Biohackers and DIY Bio



STRATEGIC SECURITY ANALYSIS

Synthetic Biology and 'Amateur Science': Dual-use and Challenges of Regulation

by Ioana Puscas



The Governance and Oversight of Synthetic Biology

**Growing Gap Between Technological Acceleration
and Timely Development of National Policies
and International Harmonization**

Design	Build	Test	Synthetic Biology Technologies and Applications	Factors to Assess Capability for Malicious Use			Factors to Assess Capability for Mitigation			
				Use of Technology	Use as a Weapon	Attributes of Actors	Deterrence and Prevention Capabilities	Capability to Recognize an Attack	Attribution Capabilities	Consequence Management Capabilities
			Automated Biological Design							
			Metabolic Engineering							
			Phenotype Engineering							
			Horizontal Transfer and Transmissibility							
			Xenobiology							
			Human Modulation							
			DNA Construction							
			Editing of Genes or Genomes							
			Library Construction							
			Bootstrapping of Engineered Constructs							
			High-Throughput Screening							
			Directed Evolution							



Current Frameworks for Technology Oversight and Bioincident Preparedness Response are Outdated

- **historical focus on “one purpose” industries**
- **biothreat focus on ‘select agents’**
- **major gaps in governmental expertise to interpret and regulate accelerating technological change**
- **inter-agency communication and decision authorities**
 - **monitoring global supply chains and multiple intermediaries**
 - **internet crime**
 - **digital biology and data security**
- **poor linkage and integration of global public, health frameworks (natural infections) and biodefence efforts (nefarious assaults)**

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

Export Controls on Technologies for WMD Threats and CBW Weaponization



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

Ian F. Fergusson
Specialist in International Trade and Finance

Paul K. Kerr
Specialist in Nonproliferation

August 9, 2018

Congressional Research Service
7-5750
www.crs.gov
RS2018-016

CRS REPORT
Prepared for Members and
Committees of Congress



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

National Research Council



DETECTING SUSPICIOUS PROCUREMENT ATTEMPTS

Reportable, not all buyers approach Australia's industries with a legitimate commercial purpose. The following information is designed to assist industry identify activities that may indicate an attempt to illegally acquire conventional arms or procure goods, services and technologies for weapons of mass destruction (WMD) programs.

Most 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 would-be proliferators are denied access to conventional weapons and items that may contribute to WMD activities are appropriately restricted.

The Strategic Export Control Office works closely with other government agencies to prevent the proliferation of WMD and 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 compliant with all statutory and regulatory requirements. Applications to export regulated defence and dual-use goods, and goods and services that could contribute to a WMD program, must be subject with DECO.

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

IDENTIFYING SUSPICIOUS APPROACHES

- There are several red flags that may contribute to an attempt to acquire WMD items:
- Acquisition from persons or entities on the Department of Foreign Affairs and Trade's Consolidated List
 - Approaches from countries subject to sanctions, or with a WMD program
 - Unusual or inappropriate requests for goods to be manufactured to military, or unusually high specifications
 - Unusually favourable, or non-standard payment terms
 - Unusual requests regarding the shipment route, or loading on the goods

If you have encountered any of these red flags, you may have had a suspicious approach. Please call your nearest Australian embassy.

WHAT NOW?

Members of industry who have information that could identify a suspicious approach, or purchase are encouraged to contact DECO via:

Phone - 1800 66 10 66

Online - access our 'Reporting A Suspicious Approach' form at www.defence.gov.au/sitdeco/decos
Mail - mark of letters 'to: Confidential' and post to:
Defence Export Control Office
Department of Defence
W11 1AA, Canberra
Canberra, ACT 2600
For further information on DECO's Privacy Policy click on the link to the 'Reporting A Suspicious Approach' form above.

Australia Group Common Control List Handbook

Volume I: Chemical Weapons-Related Common Control Lists



Australia Group Common Control List Handbook

Volume II: Biological Weapons-Related Common Control Lists



Intergovernmental Agreement on Biosecurity Review

July 2018

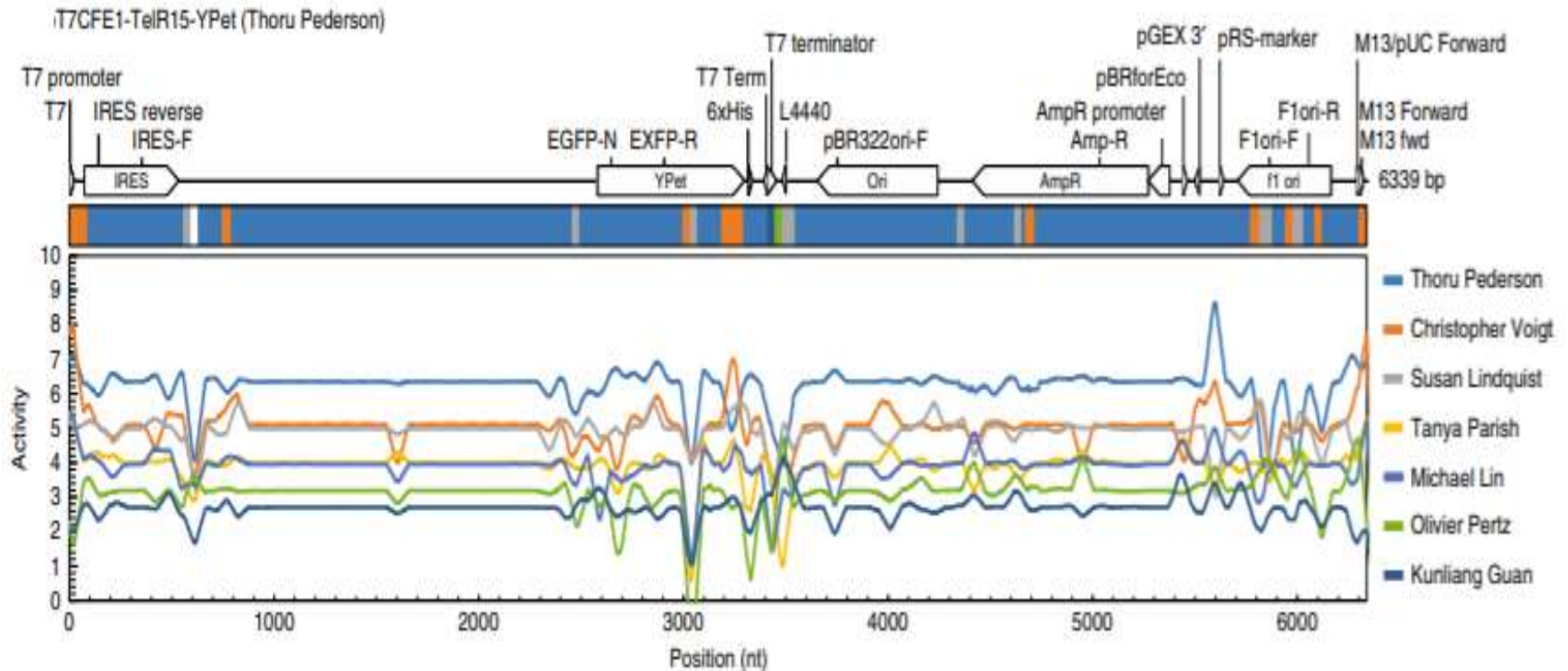
Submission by the Export Council of Australia

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

Deep Learning Convolutional Neural Networks Profiling of Plasmids and 'Lab-Specific Drift' Patterns

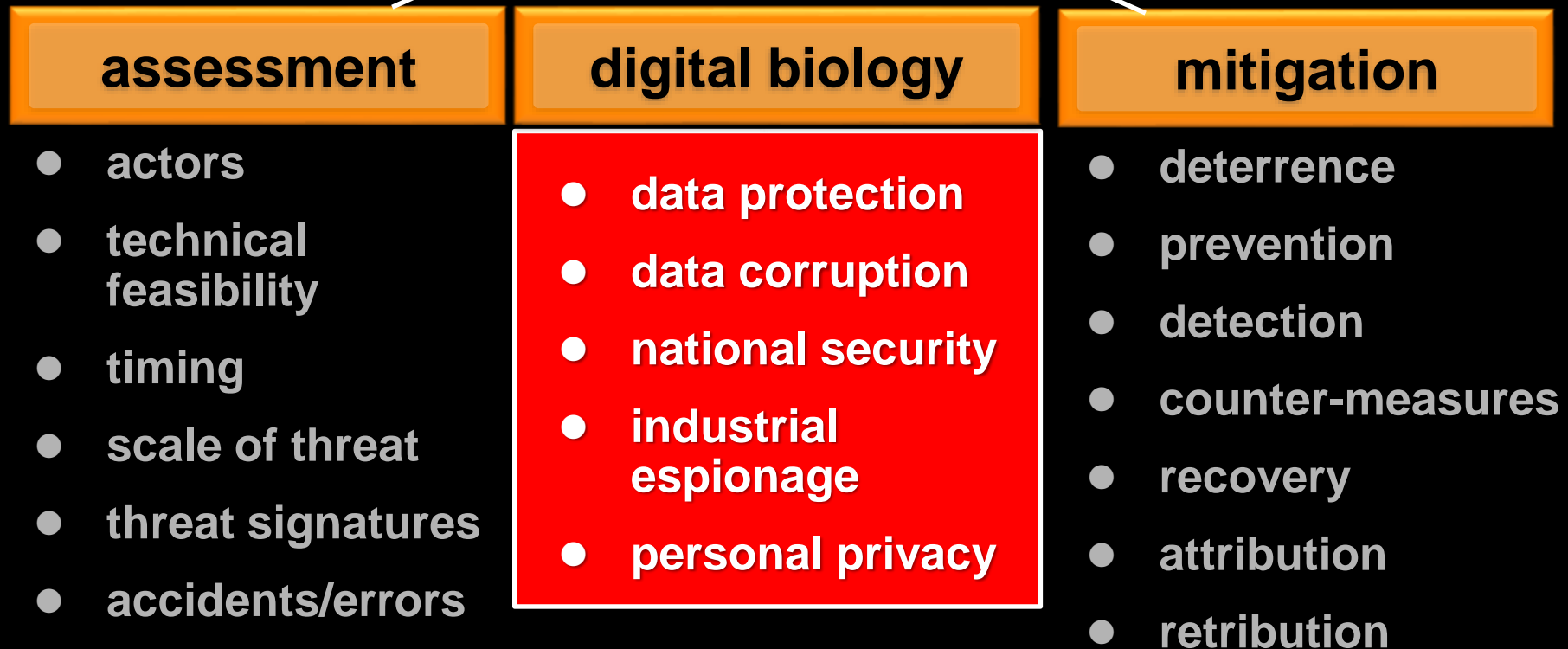
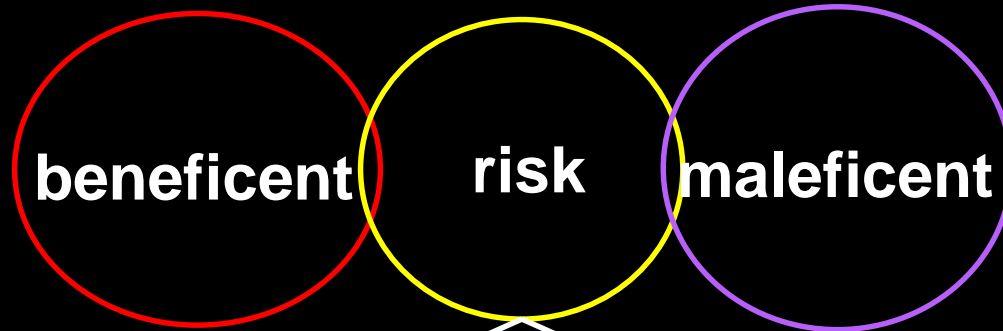


new class of potential signatures to predict
lab-of-origin in engineered DNA sequences

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



Dual Use Technologies



**Complex, Multi-dimensional Problems Cannot be Solved
by Uni-dimensional Approaches**

Reactive, Incident Driven, Episodic Investments

Versus

**Proactive Sustained Systems-Based Investment to
Develop Resilient Systems and Agile Response Capabilities**

**Massive Gaps in Preparedness for Large Scale Bioincident(s)
(Natural or Nefarious)**

Massive Gaps in Bioincident Preparedness



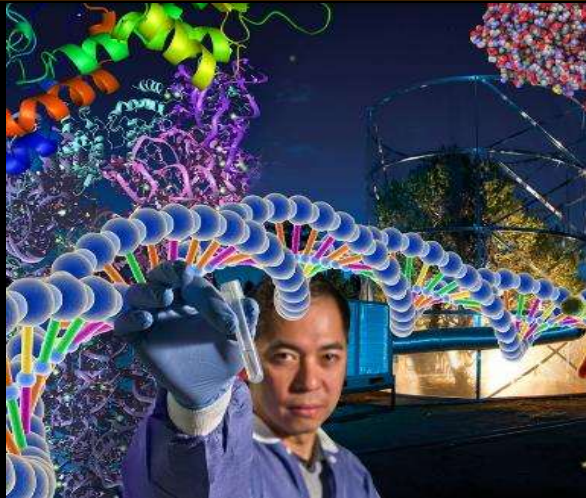
UNSW
SYDNEY



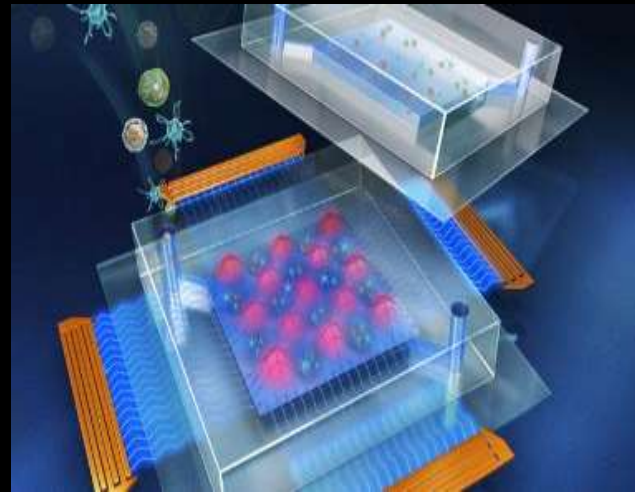
Kirby Institute

Faster Diagnosis Saves Lives: The Primacy of Diagnostics in Biosurveillance and Preparedness Mobilization

Profile:
signatures of infectious agents



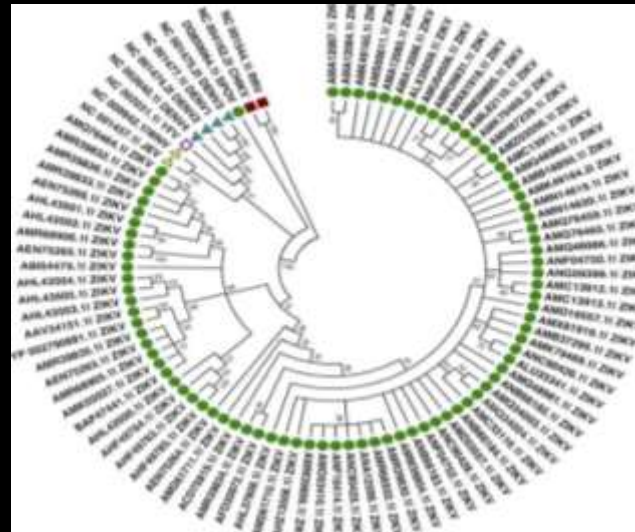
Detect:
rapid automated PON/POC diagnostics



Act:
real-time situation awareness, decisions



**surveillance
sans frontières**

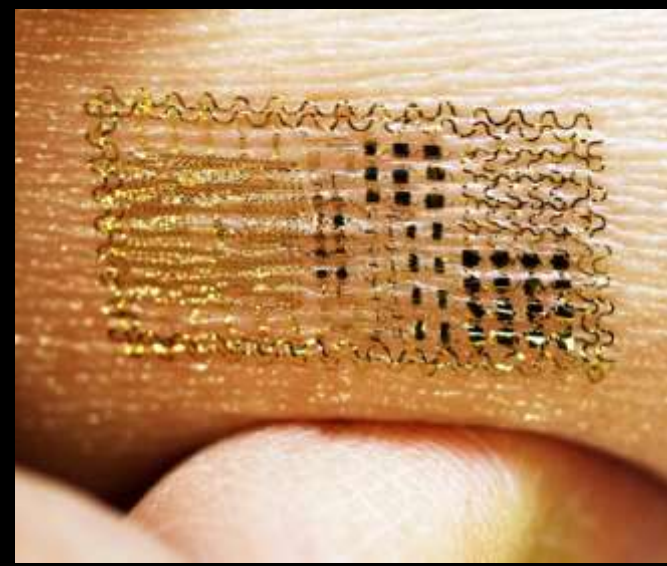


pathogen evolution



**dual-use research and
engineered biothreats**

Remote Monitoring Technologies: Faster Detection of Emergent Infections



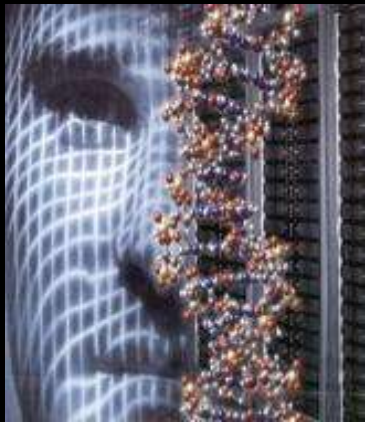
PReemptive Expression of Protective Alleles and Response Elements (PREPARE)



- proposals to reversibly “tune” innate body defenses against biological, chemical and radioactive threats
 - influenza
 - opioid overdose
 - organophosphate poisoning
 - gamma radiation

Technology Acceleration and Convergence: Escalating Complexities in Biosecurity

**First Generation
Biotechnology**



“Bio-Space”

**Synthetic Biology
and Digital
Biology**



**“Design
Space”**

**Ubiquitous
Sensing/
Devices**



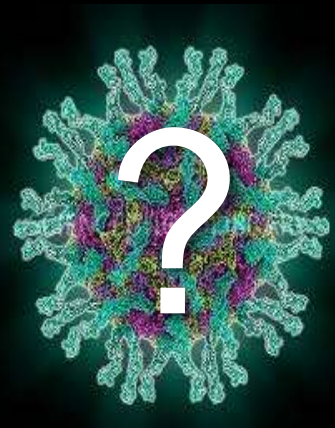
**“Detection
Space”**

**Mega-Data,
Advanced
Computing and
AI**



**“Analysis
Space”**

**Proliferation
of Dual-Use
Risks**



**“Preparedness
Space”**

Technology Acceleration and the Changing Biosecurity Landscape

- **convergence** (technology)
- **context** (dual-use and intent)
- **capabilities** (risk assessment)
- **computing** (digital biology, threat expansion, data security)
- **consequences** (preparedness and incident management)
- **compliance** (oversight, regulations, laws, codes of conduct)
- **controls** (export, publications)



PROCRASTINATE
NOW
AND
PANIC
LATER



Choices

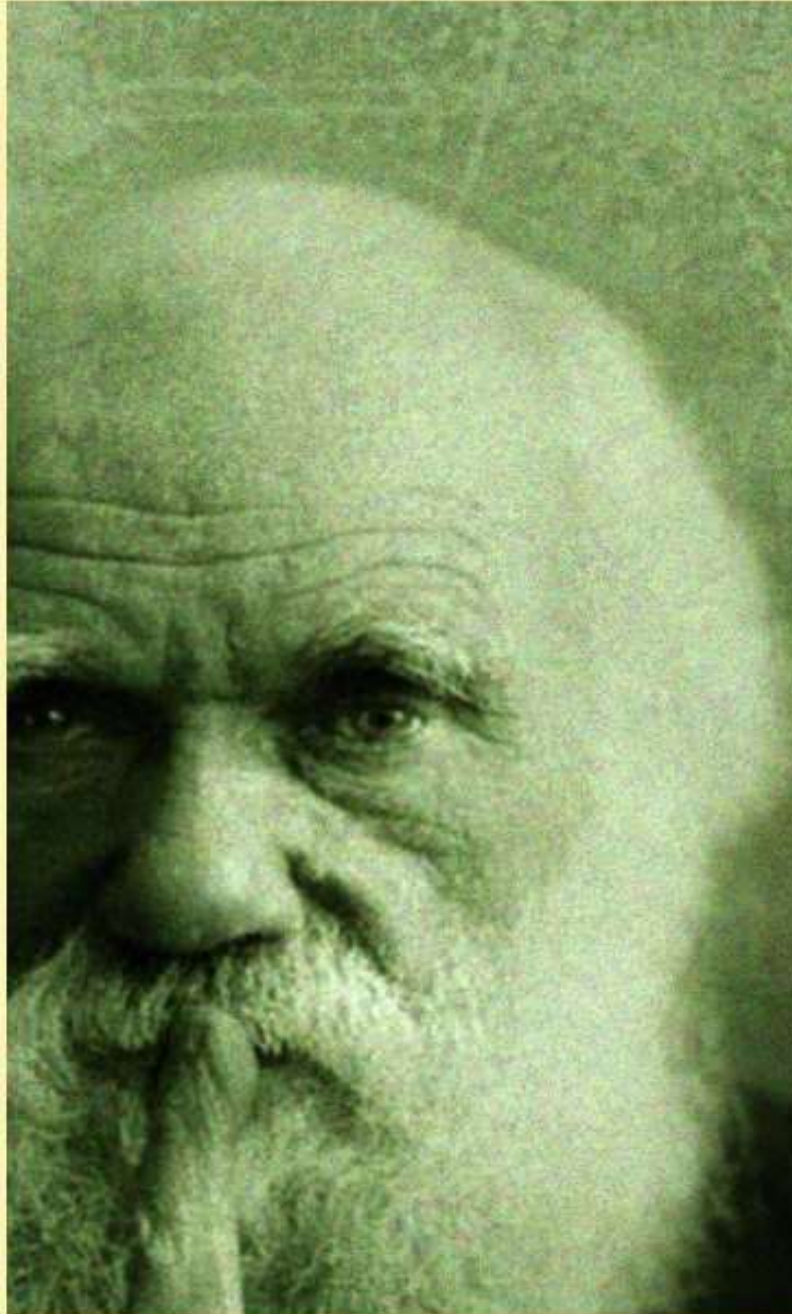


KEEP
CALM
AND
EDIT ON

The Changing Biosecurity Landscape

COMPLACENCY!!

- **need for higher priority of biosecurity in national security strategy and international engagement**
- **development of more sophisticated threat assessment capabilities**
- **strengthen surveillance, analysis and 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**



“It is not the
strongest of the
species that
survives, nor the
most intelligent,
but the one most
responsive to
change.”

~Charles Darwin, 1809

Slides available @ <http://casi.asu.edu/>

