ASU COMPLEX ADAPTIVE SYSTEMS
ARIZONA STATE UNIVERSITY

ASSOCIATION OF UNIVERSITY RESEARCH PARKS
Creating Communities of Innovation

Biosecurity:
Enhancing Security in an Increasingly Complex World

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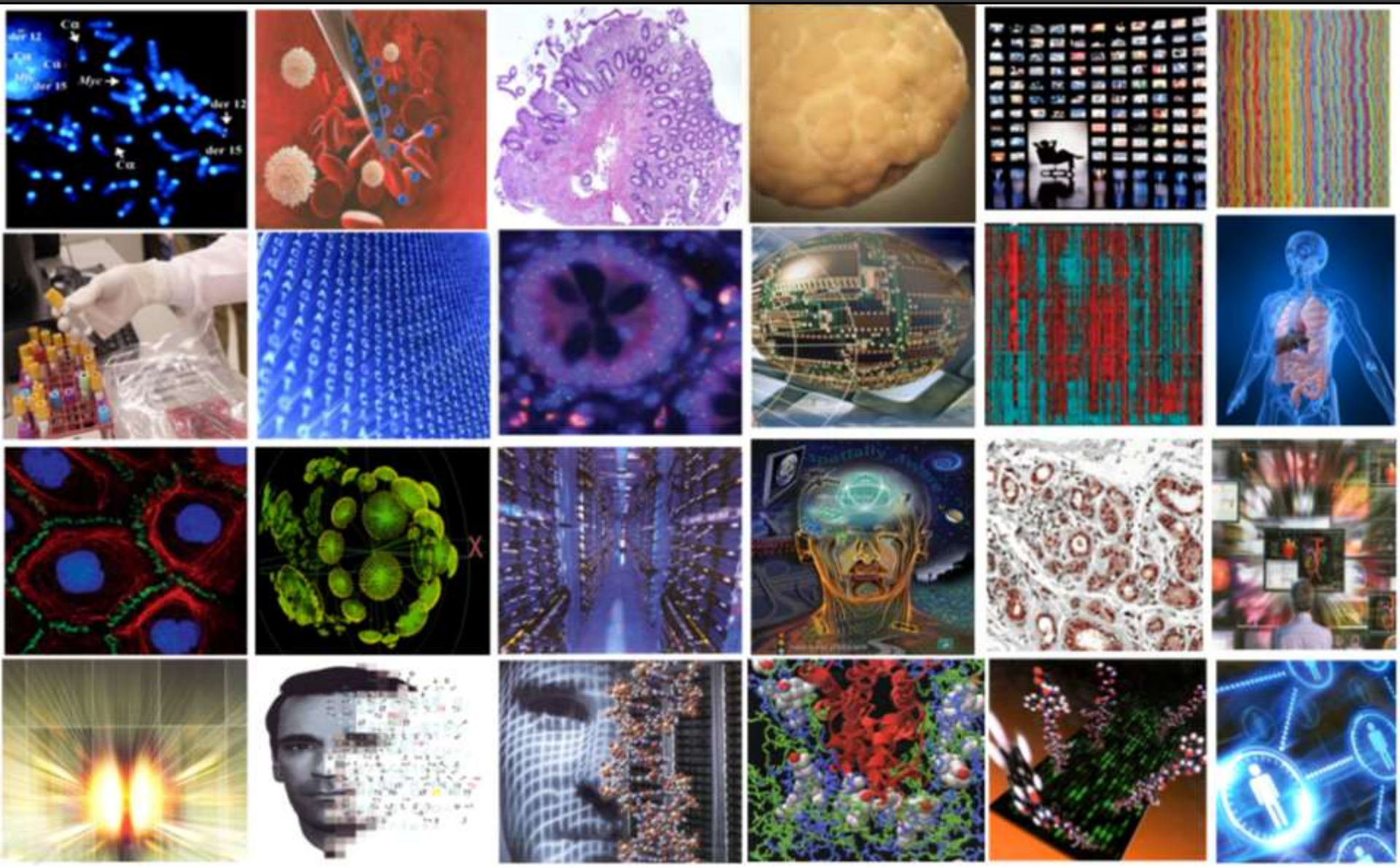
Threat Preparation for the 21st Century:
Association of University Research Parks Annual Meeting

Tempe, Arizona 6 March 2013

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



Seeking Security in an Unsecure World: The Military and National Security Calculus

Expanding Conflict Zones, Political Instabilities and Terrorism

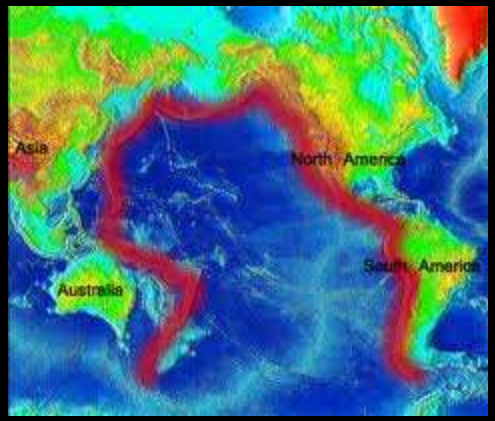
WMD Proliferation

New Power Centers

US Retrenchment: Geopolitical/Fiscal

Seeking Security in an Unsecure World: Economic Risks to Stability and Sustainability

Natural Disasters and Future Increased Risks Due to Climate Change



Environmental Deterioration

Adequacy of Global Food and Water

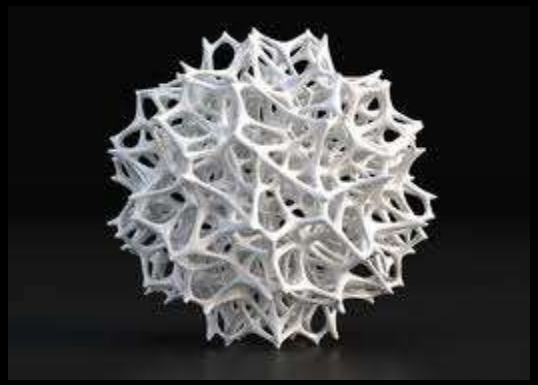
Critical Resources and Non-Renewable Resources

Seeking Security in an Unsecure World: New Technologies and Implications for National Security and Competitiveness

Cyber-Vulnerabilities

Robotic Warriors and Future War

Synthetic Biology



Miniaturization

3D Digital Mfg.

Dual-Use Biology

Biosecurity: Three Inter-related Domains

biodefense

- combating malevolent biological assault from terrorists/nation states
- not just humans as targets (animals, food supply)
- not just bugs (dual-use biology and disruption of key body biological pathways)

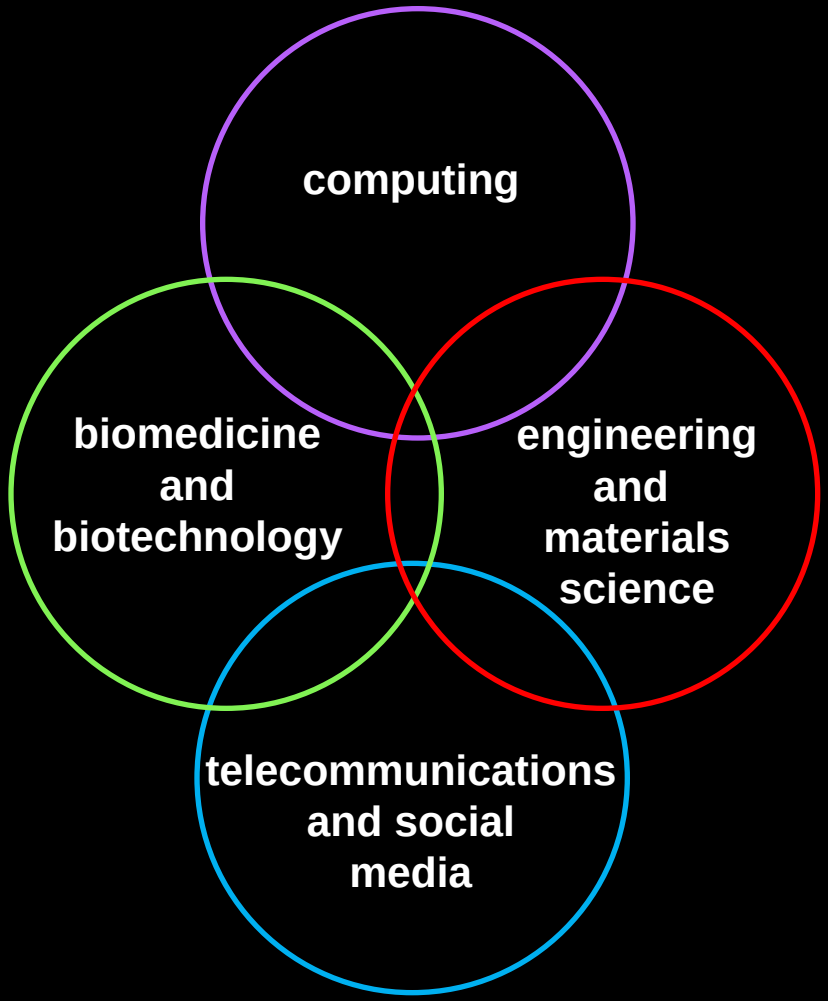
public health

- combating naturally occurring biological threats

dual-use technologies

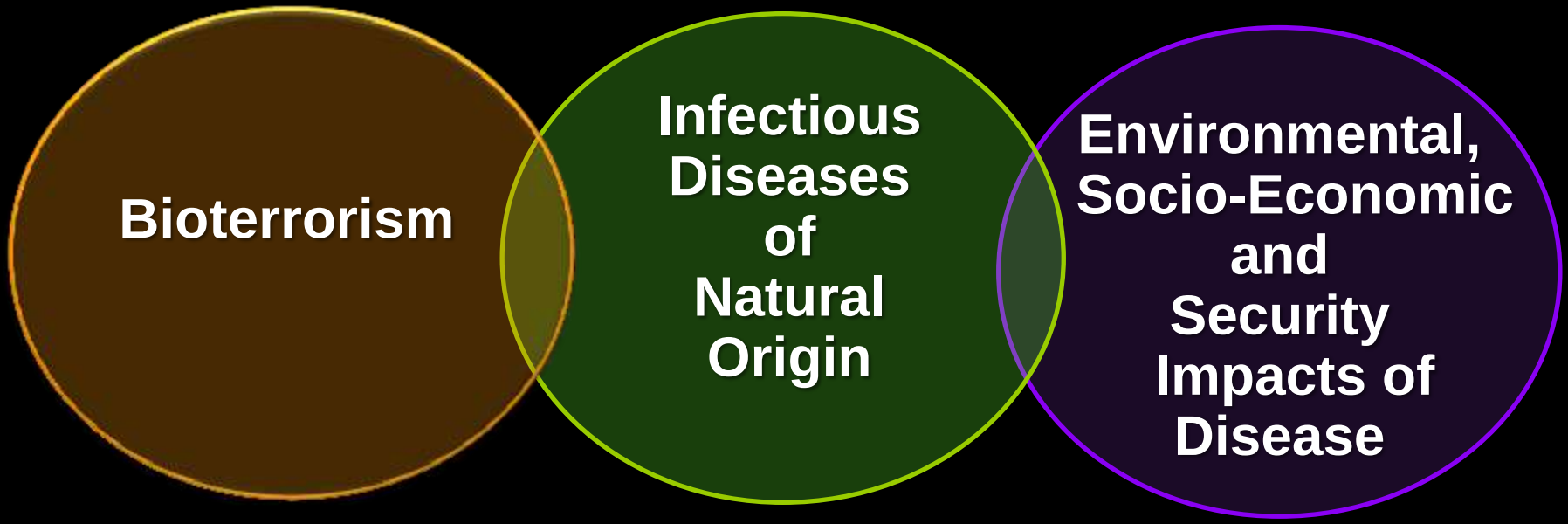
- scientific methods and knowledge which can be used for both beneficent and malevolent purposes

Technology Convergence and the Life Sciences



big data and analytics

Building Resilient and Agile Systems for Biosecurity



Biosecurity

Today

- bioterrorism: low probability, high consequence
- natural infections: high probability, high consequence

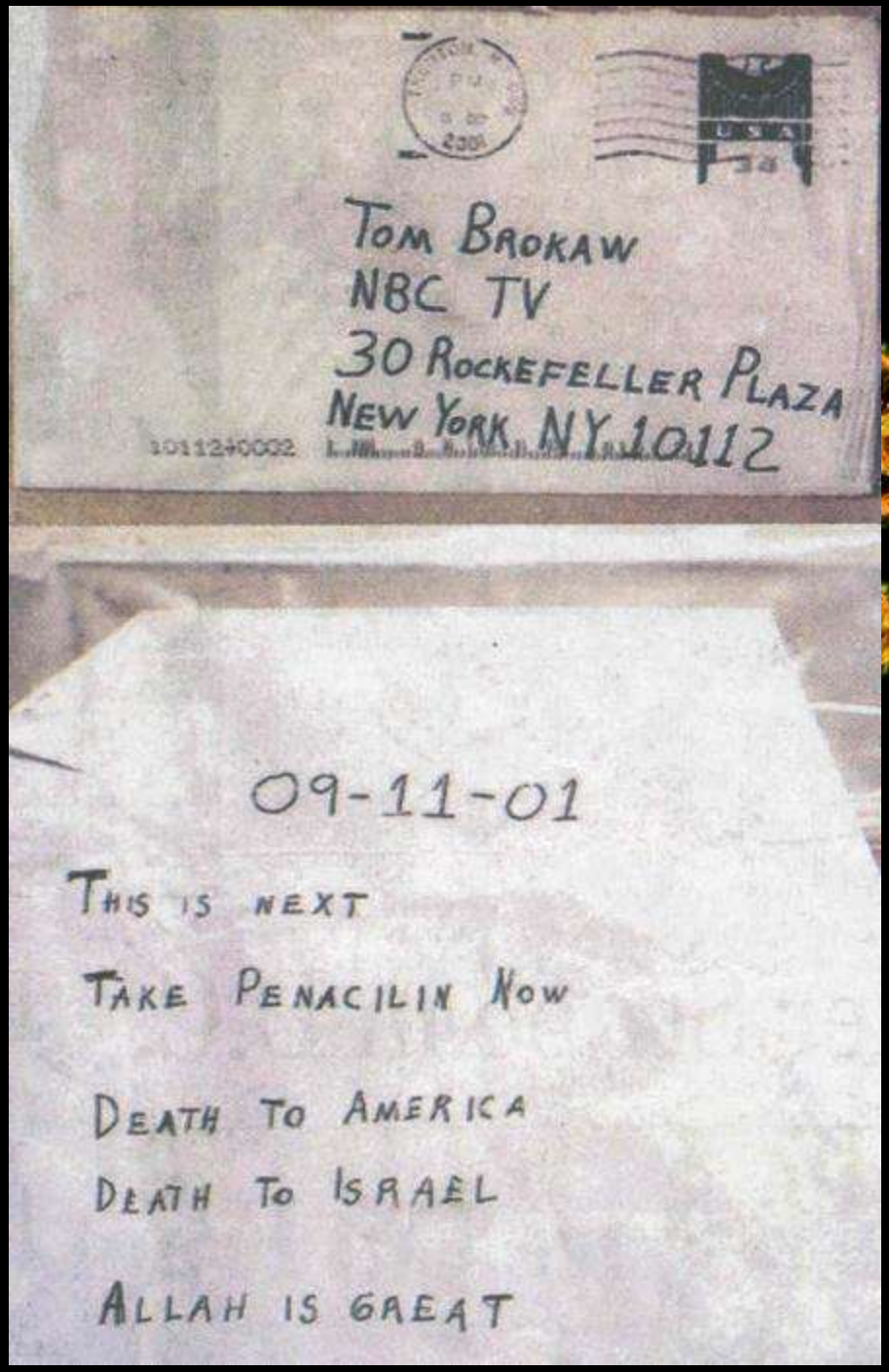
2020 and beyond

- bioterrorism
  - an expanded risk beyond bugs
- outpacing natural infectious diseases
  - old foes, resurgent foes and new EIDs
- synthetic biology
  - the ultimate dual-use technology

Preparedness:
Building Resilient Systems and the "All Hazards" Challenge

Northrup Grumman 2011

Immediate Assessment of Damage (Ordinance; Radiation; Chemicals) Versus Unknown Scale of Continued Damage ('Bio')



"I will show you fear in a handful of dust"
T. S. Eliot

COMMISSION ON THE PREVENTION OF WEAPONS OF MASS DESTRUCTION PROLIFERATION AND TERRORISM

Prevention of WMD Proliferation and Terrorism Report Card

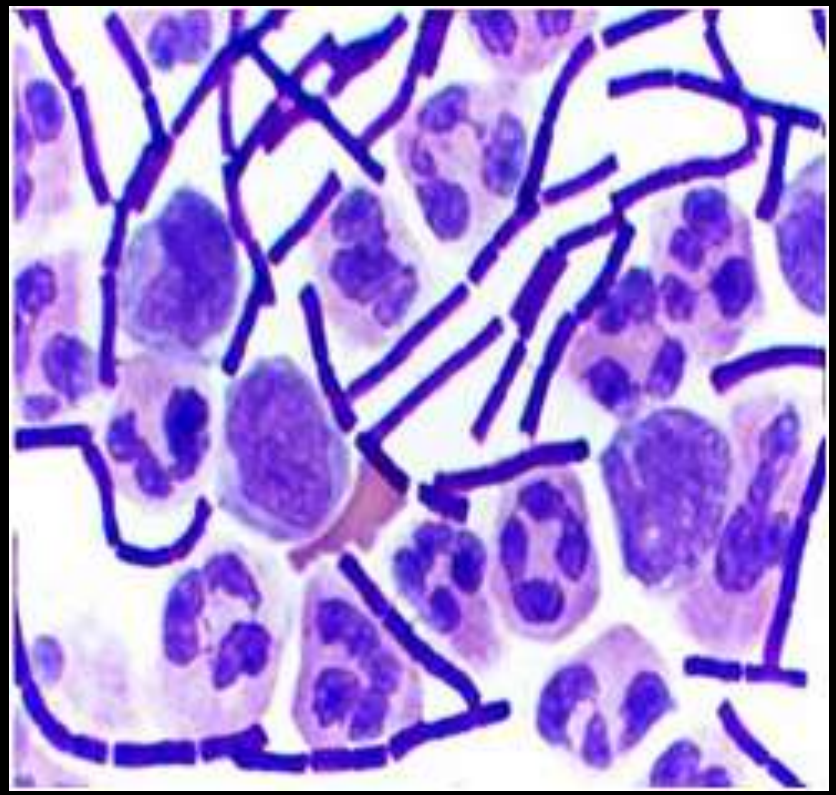
An Assessment of the U.S. Government's Progress in Protecting the United States from Weapons of Mass Destruction Proliferation and Terrorism

January 2010

"Each of the three last Administrations have been slow to recognize and respond to the biothreat"

A $250 Billion ‘Hit’

“Amerithrax 2001”



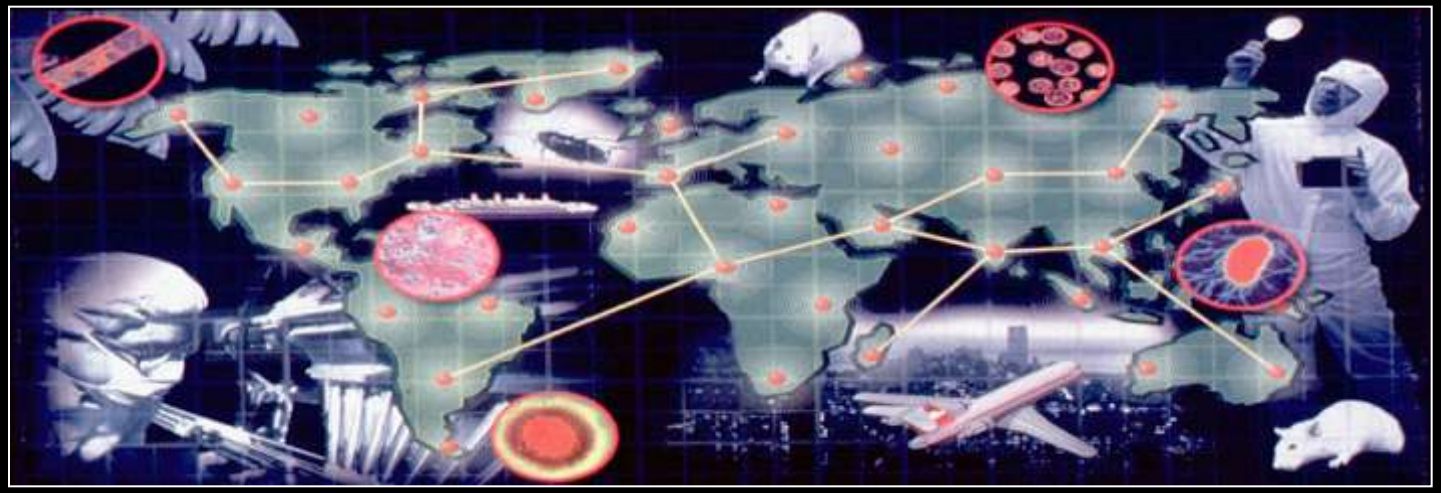
Project Bioshield (July 2004)

Sound-Bite Policies, Big Bucks and No Accountabilities

- Bioshield
- Biowatch
- Medical Counter Measures Initiative
- National Vaccine Plan
- Public Health Emergency Countermeasures
- Creation of BARDA under PAHPA
- Collective Foreign Threat Assessment Restricted Party Screening Authorities

A Shared Global Risk:

The Omnipresent Threat Posed By Microorganisms and Parasites



The Global Public Health Challenge Posed by Rapid Urbanization in Developing Countries

High Disease Transmission

Expanded Eco-niches and Increased Zoonotic EID Risks

Major Deficits in Health Infrastructure

Lack of Safe Water

Toxic Waste

The Ever Shifting Dimension of EIDs

West Nile Virus, New York 2001

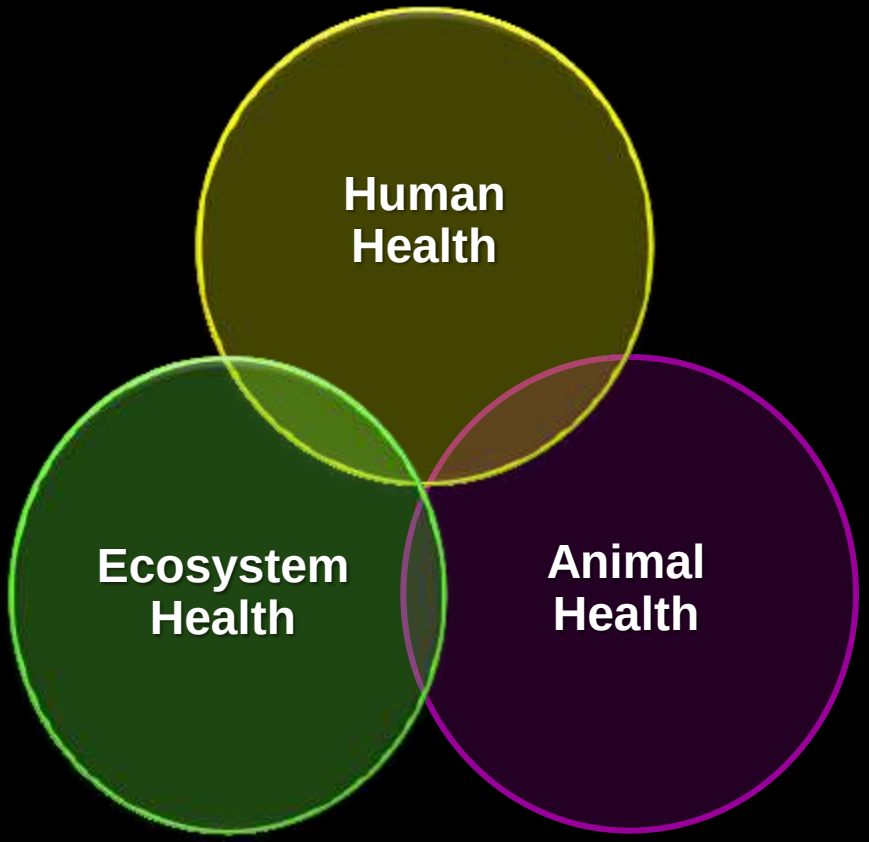
Monkeypox, USA May-June 2003

West Nile Virus, Dallas, TX 2012

African Swine Fever, Russia 2012

The Rationale for Integration of Historically Separate Domains and Responsibilities

"One Health"

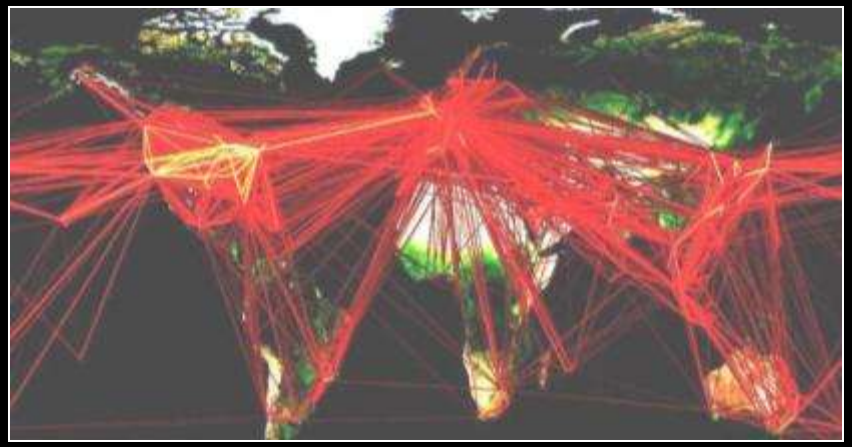


- most effective control route for zoonotic threats to humans is via the relevant animal population(s)
- knowledge of the potential impact(s) of ecosystem perturbations on emergence of novel zoonoses must be accorded high priority
- disparity in animal and human public health capacity undermines global disease control
- food chain safety

Global Transport and Trade: New Interactions of People, Animals and Product Supply Chains

The Super Vector

Billion Cross-Border Travelers



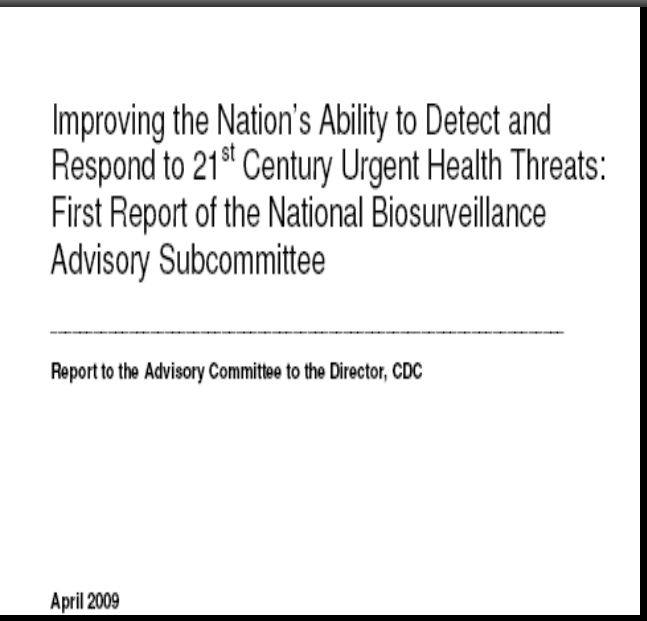
World Container Traffic Doubled Since 1997

Global Food Networks

The Public Health, Economic and Political Challenges of a Major Global Bioincident

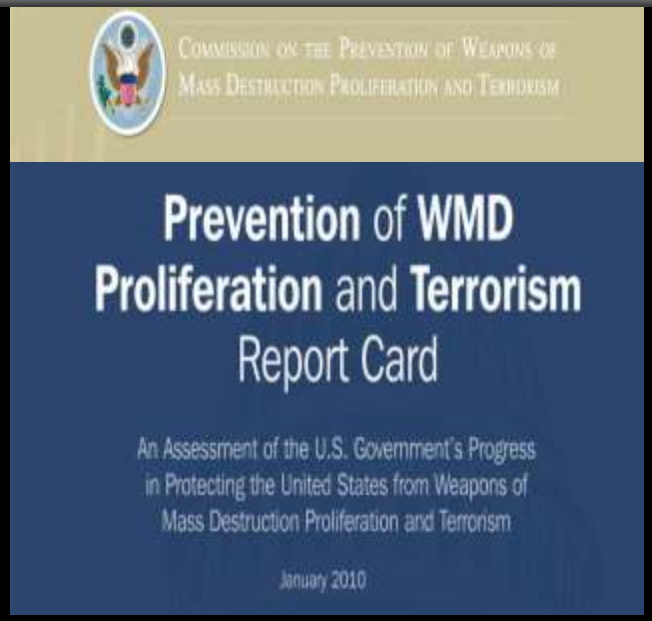
Preparedness for Substantial Societal Dislocations: Systems Versus Silos

Building Resilient Preparedness and Response Capabilities for Biosecurity


Improving the Nation's Ability to Detect and Respond to 21st Century Urgent Health Threats: First Report of the National Biosurveillance Advisory Subcommittee

Report to the Advisory Committee to the Director, CDC

April 2009


Commission on the Prevention of Weapons of Mass Destruction Proliferation and Terrorism

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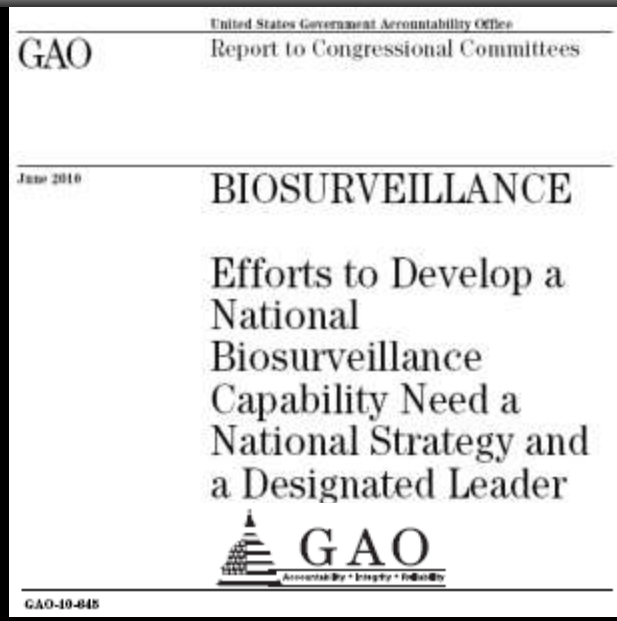

United States Government Accountability Office

GAO

Report to Congressional Committees

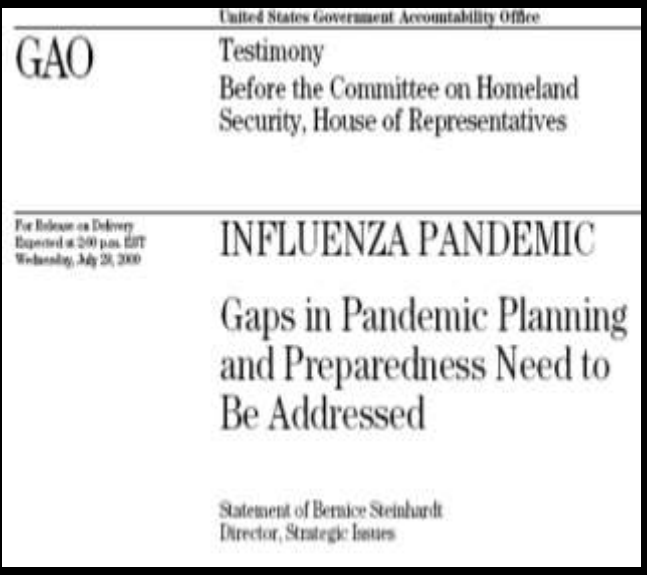
June 2010

BIOSURVEILLANCE

Efforts to Develop a National Biosurveillance Capability Need a National Strategy and a Designated Leader

GAO

GAO-10-625


United States Government Accountability Office

GAO

Testimony

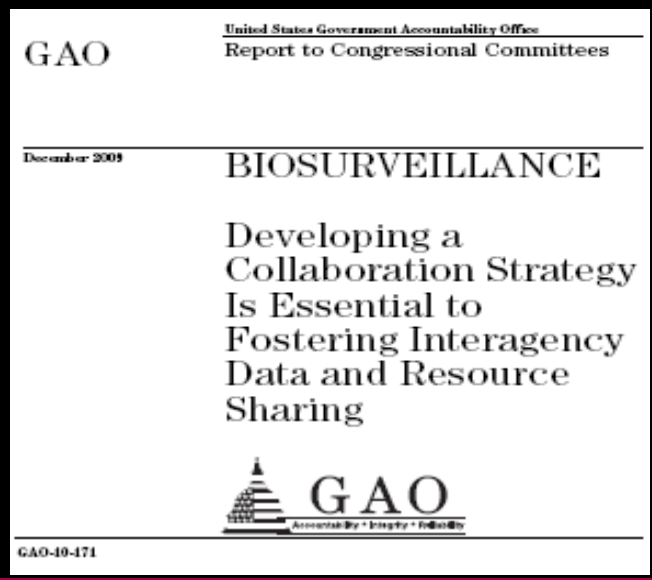
Before the Committee on Homeland Security, House of Representatives

For Release on Delivery
Expected at 2:00 p.m. EDT
Wednesday, July 29, 2009

INFLUENZA PANDEMIC

Gaps in Pandemic Planning and Preparedness Need to Be Addressed

Statement of Bernice Steinhardt
Director, Strategic Issues


GAO

United States Government Accountability Office

Report to Congressional Committees

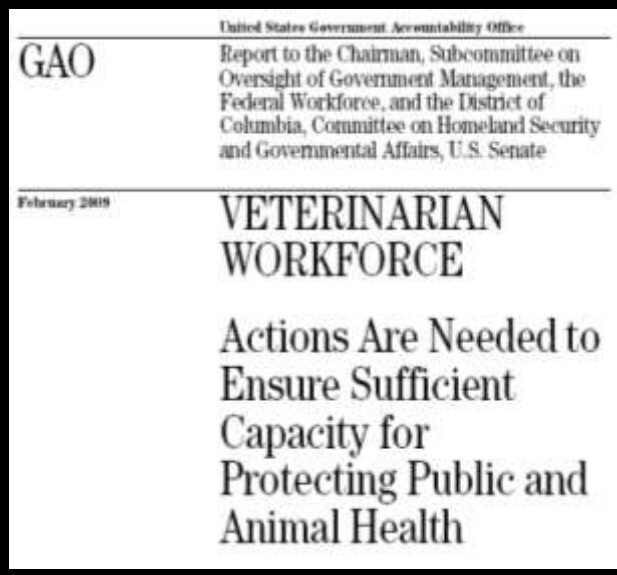
December 2009

BIOSURVEILLANCE

Developing a Collaboration Strategy Is Essential to Fostering Interagency Data and Resource Sharing

GAO

GAO-10-171


United States Government Accountability Office

GAO

Report to the Chairman, Subcommittee on Oversight of Government Management, the Federal Workforce, and the District of Columbia, Committee on Homeland Security and Governmental Affairs, U.S. Senate

February 2009

VETERINARIAN WORKFORCE

Actions Are Needed to Ensure Sufficient Capacity for Protecting Public and Animal Health

Detection of Infectious Disease Threats:

Not A Hazmat or Wide Area Sensor Network Solution

Emergency Rooms and Farms Will be the Front Line

Earlier Diagnosis and Intervention Saves Lives

Improved speed, breadth and accuracy of clinical diagnosis

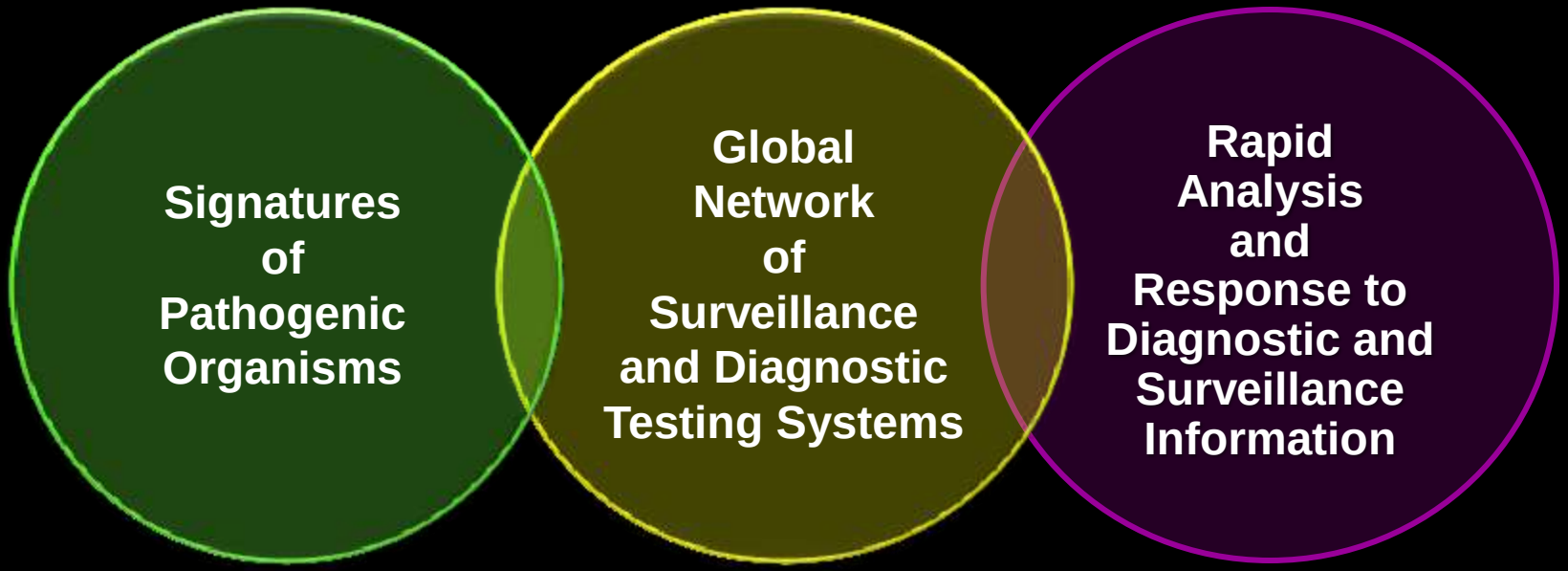
- faster Rx
- accurate Rx
- prophylactic Rx for incident personnel

- robust triage
  - rationing
  - reassurance of "worried well"
  - quarantine decisions

- real time disease surveillance data
- faster ID of incident evolution
- faster incident containment and exposure controls

The Single Most Important Leverage Point For Rapid Mobilization of Resilient Responses to Epi-/Pandemics, Epizootics and WMD Bioterrorism

Surveillance Systems for the Rapid Detection and Control of Infectious and Parasitic Diseases



Profile	Sense	Act
		

Global Disease Surveillance

Eurosurveillance

World Health Organization

CDC
Centers for Disease Control and Prevention

EMERGEncy ID NET

HealthMap
Global Disease Alert Map

IDSA
Infectious Diseases Society of America

Public Health Department's Surveillance

OIE

ProMED-mail

GPHIN
RMISP

biocaster

U.S. Influenza Sentinel Provider Surveillance Network

DoD - GEISWeb
Global Emerging Infections System

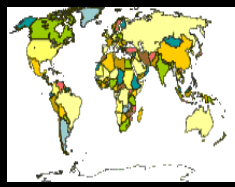
BioPortal

AROC
Argus Research Operations Center

TropNet Europ

GIDEON

Quarantine Activity Reporting System (QARS).



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

google.org

RABNET
Human and Animal Rabies

EUNID
European Network of Infectious Diseases

EMPRES WATCH
emergency prevention systems

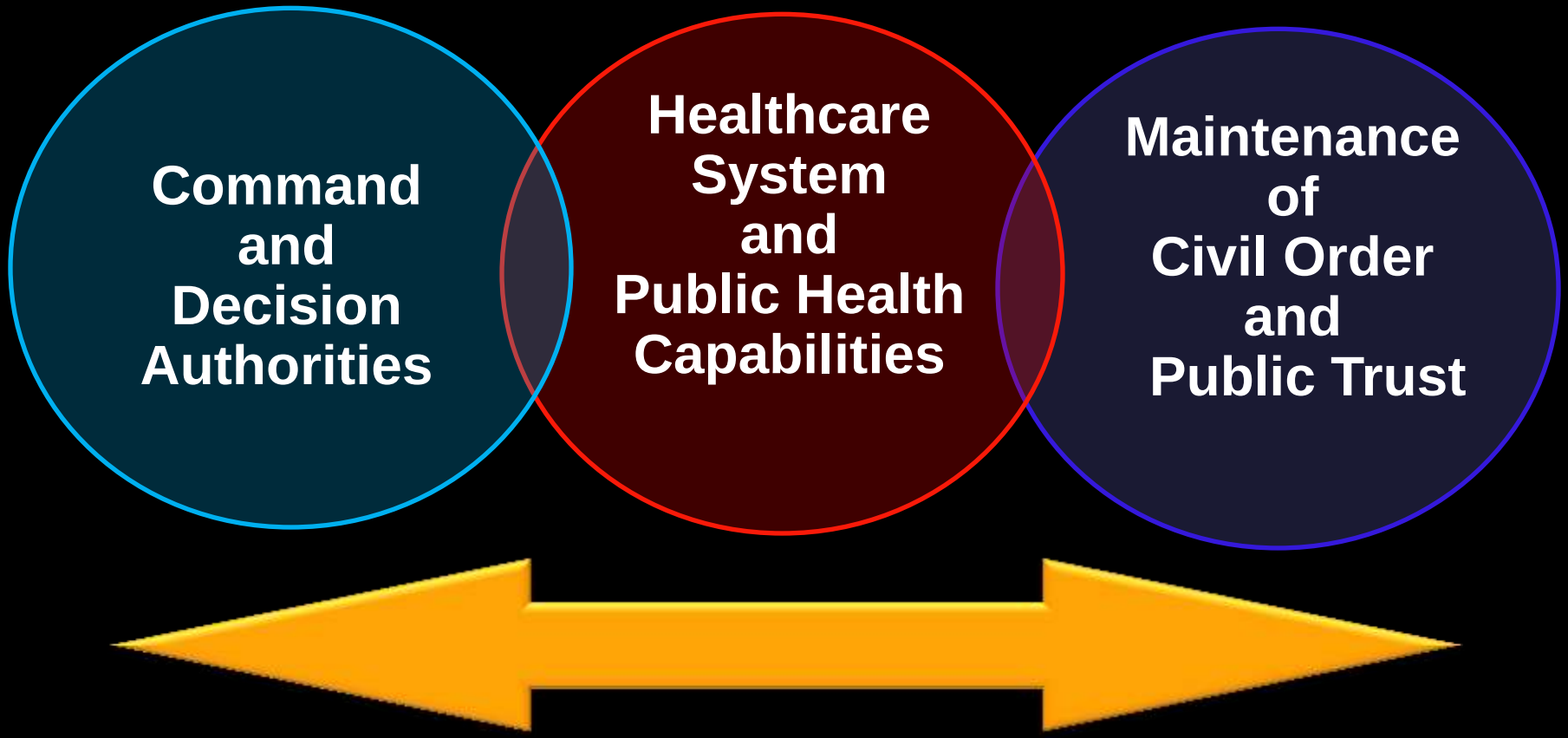
Geodemographic Information Systems (GIS): Real-Time, Front Line, Ground Zero Data from Field Sampling and Sentinels

Sensor Networks for Remote Health Status Monitoring: Mobile Phones and Real Time Reporting

- geolocation data (where)
- temporal information (when)
- contextual information (what)
- improved decision support (action)

“For most of us design is invisible until it fails”
Bruce Mau

The Three Core Components of Bioincident Management



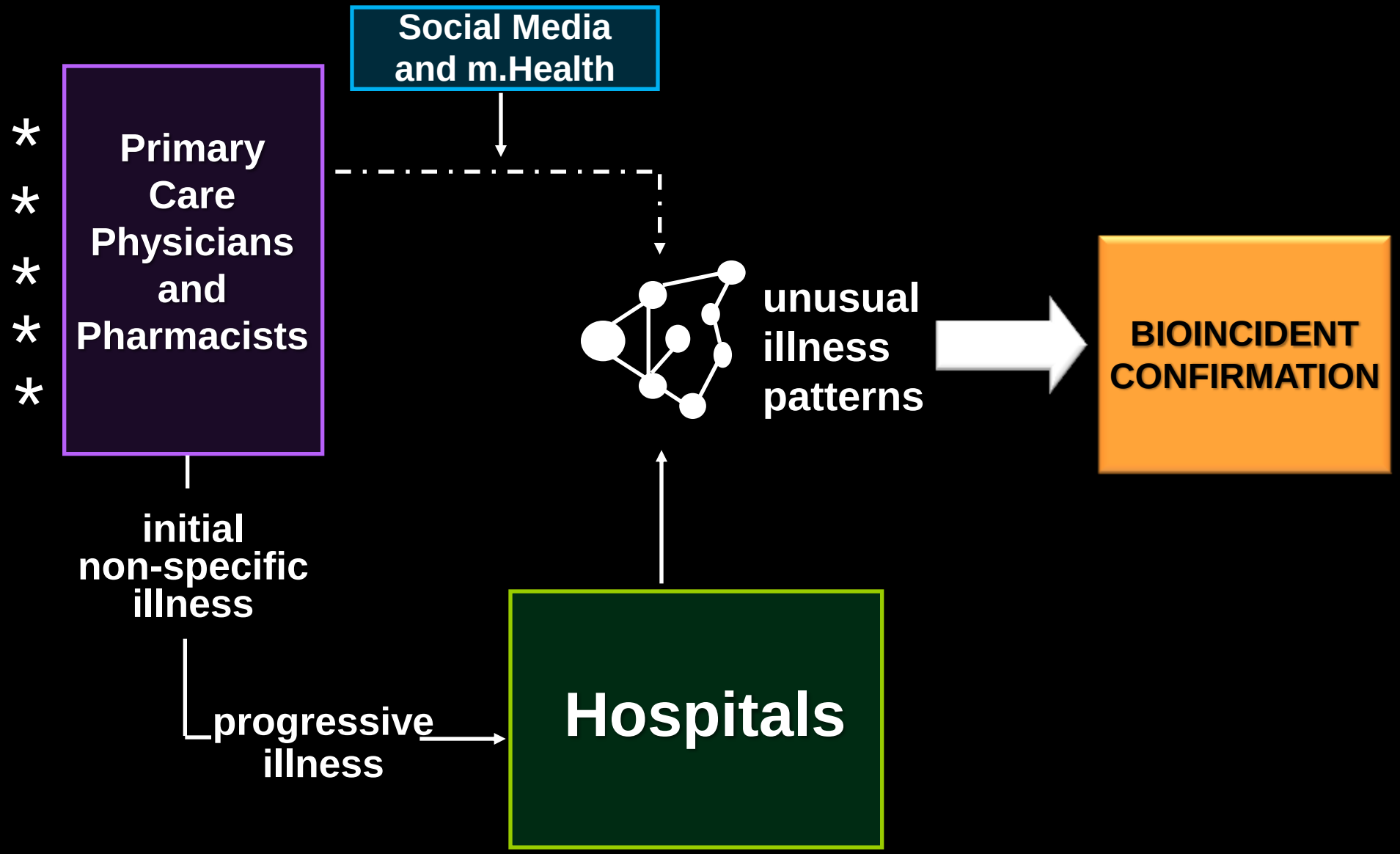
- robust inter-operable communication networks for real-time situational awareness and rapid actions
- managing the media and the ‘worried well’
- transparency, credibility and public trust

Medical Consequence Management of Major Bioincidents

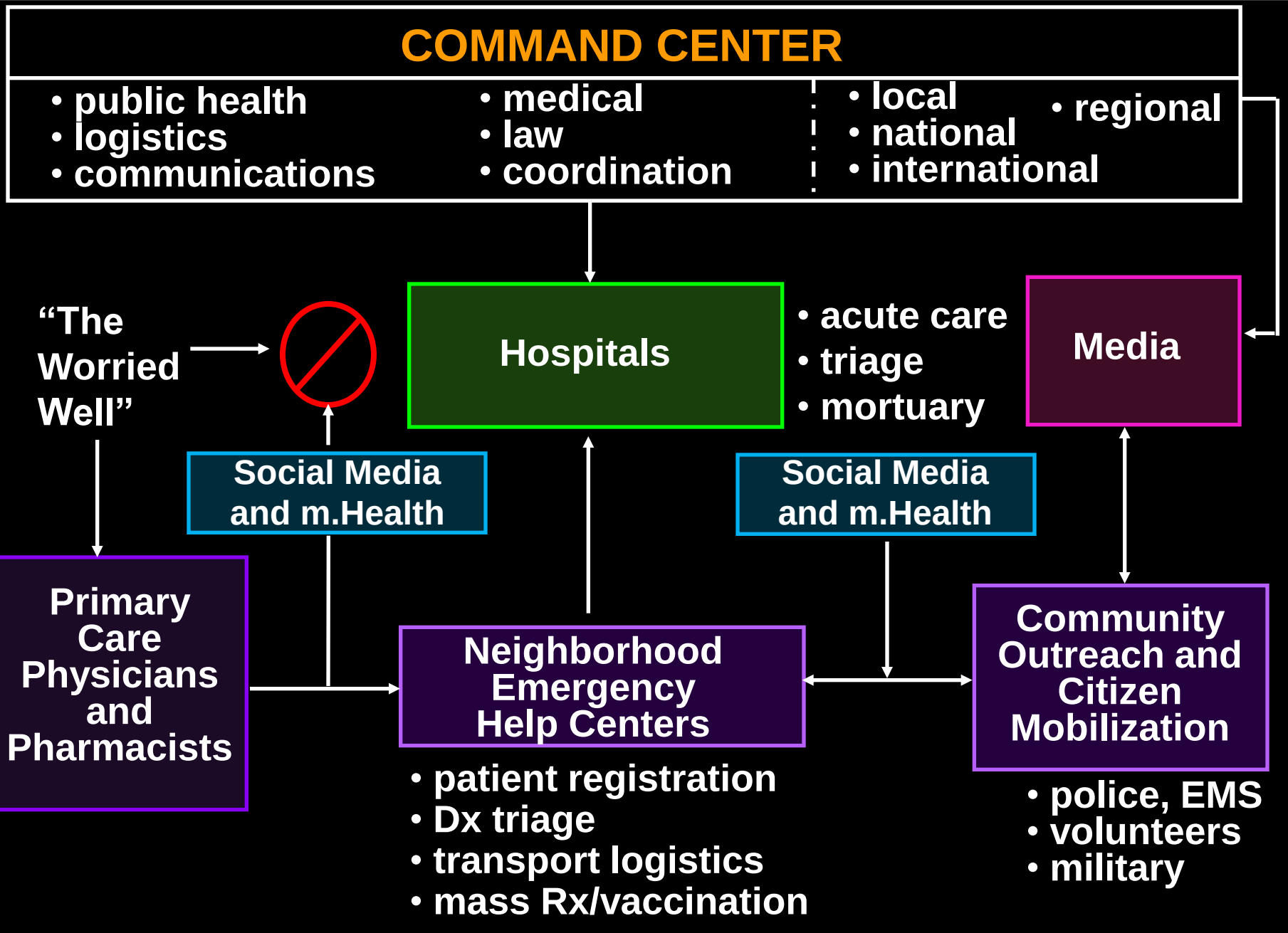
Key Success Factors

- tested disaster management plan
- responder training and education
- command structure
  - demarcated roles, responsibilities, authority
  - robust communication channels
- single source POC for key interfaces
  - ground zero staff (multiple ground zeros in CBW)
  - emergency services and first responders
  - medical/public health
  - politicians and inter-agency coordination
  - conventional media and social media

The Lag Phase in Bioincident Detection

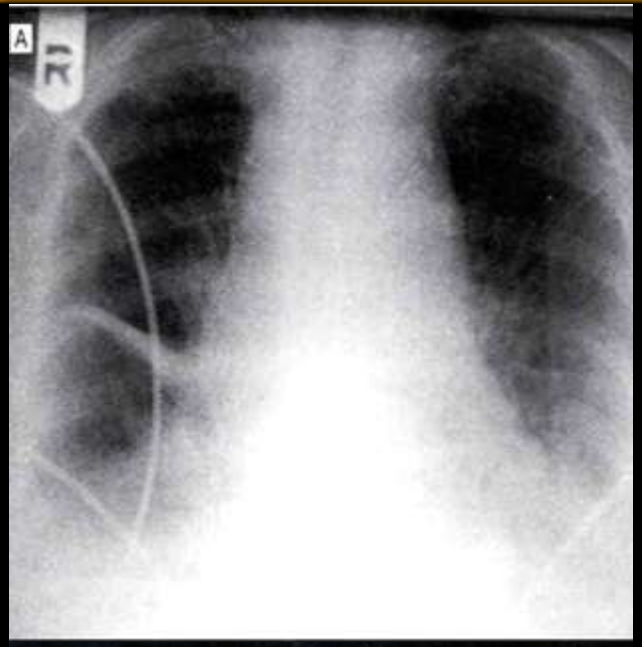


Consequence and Crisis Control in a Bioincident



Education and Training

Diagnostic Accuracy



Infection Control

Availability of Therapy

Overload and Triage

Distribution of Medical Emergency Supplies for a Major Epidemic/Pandemic

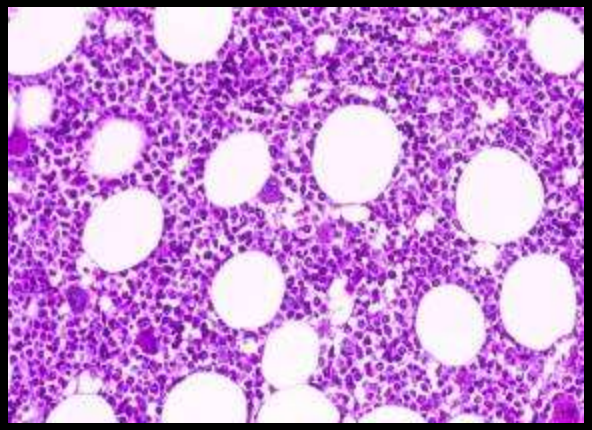
- pre-positioning for known threats: The Strategic National Stockpile
- rapid movement by commercial carriers
- managing political/public/media responses for bioincidents with limited or no Rx/vaccine options

Vulnerability of Global, National and Local Supply Chains in a Major Epidemic/Pandemic

Medicines

- "just-in-time" supply networks
  - major hospitals 2/3 deliveries per day
- out-patient prescription drugs
  - insurance company limits on prescription volume (USA)
- majority of drug intermediates, excipients and final products sourced off-shore
- 95% generic drugs used in US (64% of total Rx) are made off-shore, primarily in PRC and India
- no national stockpile for routine non-BCM prescriptions

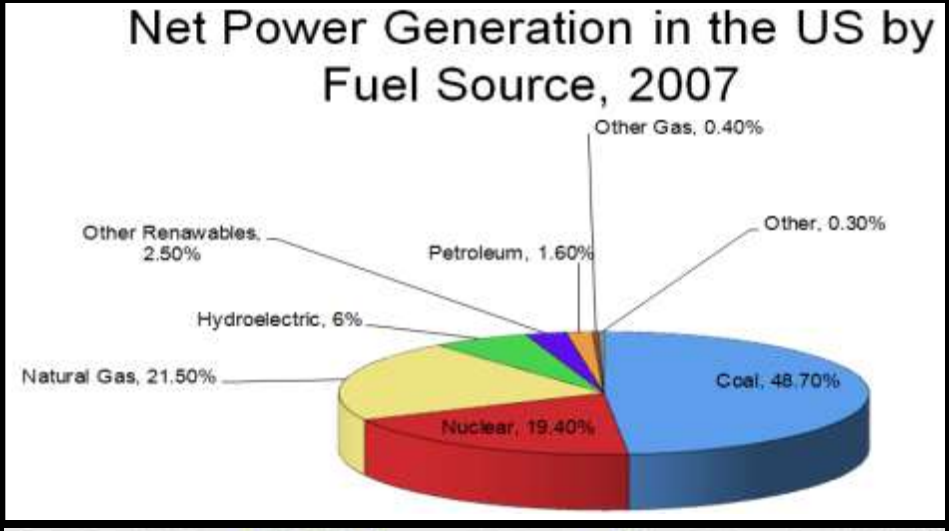
Medical Countermeasures (MCMs) for Special Populations: Emergency Use Authorization

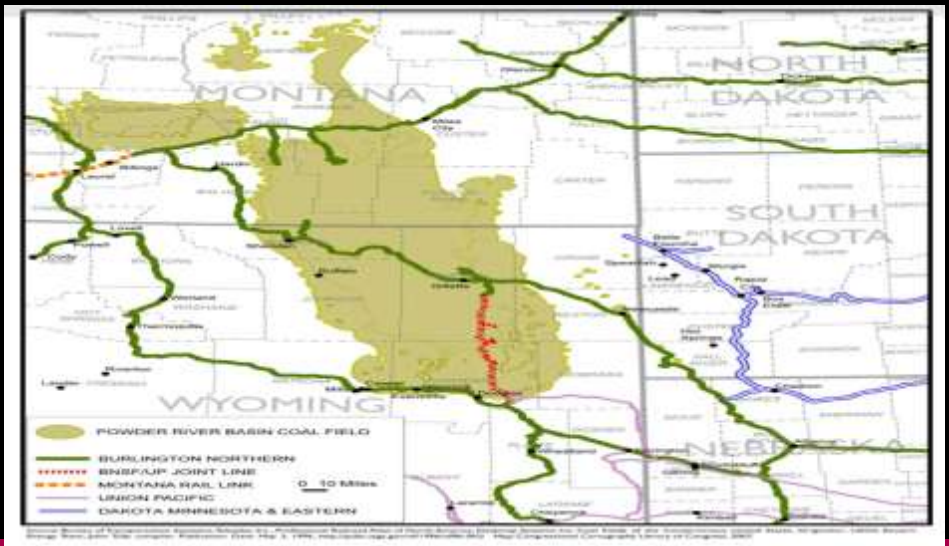
Children	Pregnant	Aged
		
		
Immunosuppressed	Impaired Major Organ Function	ICU-Critical Care

Control of Population Movement and Supply Chain Networks

Vulnerability of Global, National and Local Supply Chains in a Major Epidemic/Pandemic

Energy





The Crucial Role of the Media in Incident Management

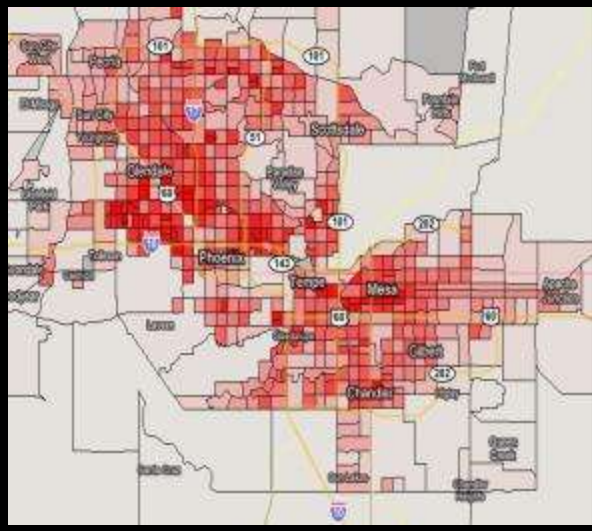
Pre-recorded Modules

Familiar (Trusted?) Face(s)

Credibility and Reality

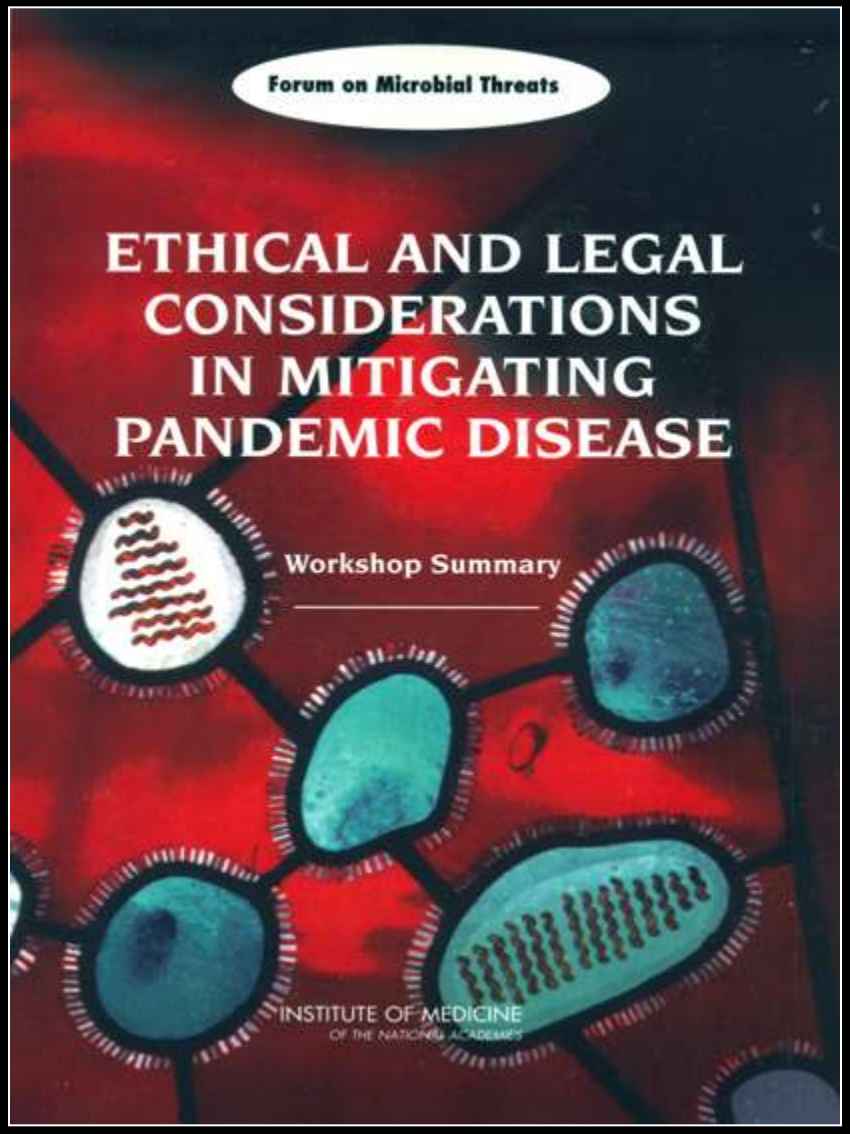
Setting Examples to Limit Civil Disorder

Authoritative Leadership



Community Cooperation

Legal Aspects of Public Health and Counter-Terrorism Actions to Contain Bioincidents



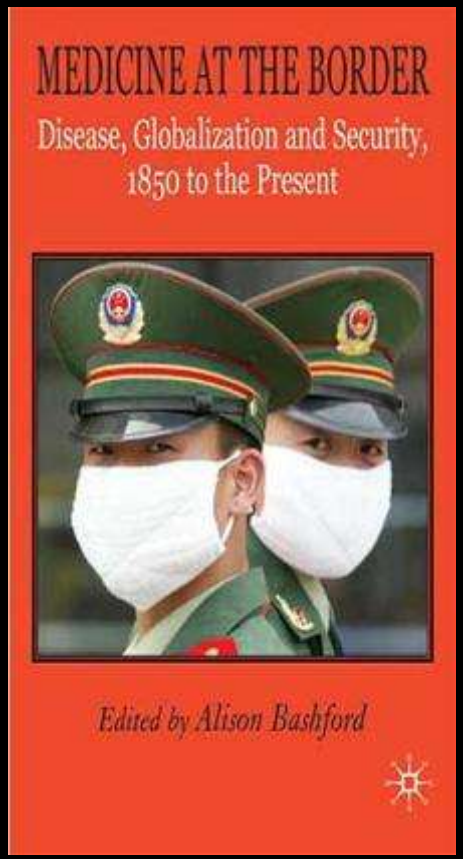
- suspension of civil liberties
- imposition of quarantine
- triage decisions and rationing
- mandatory medical examination and treatment
- mandatory treatment with unapproved drugs and vaccines
  - informed consent
  - indemnification
  - special populations
- DoD and Posse Comitatus

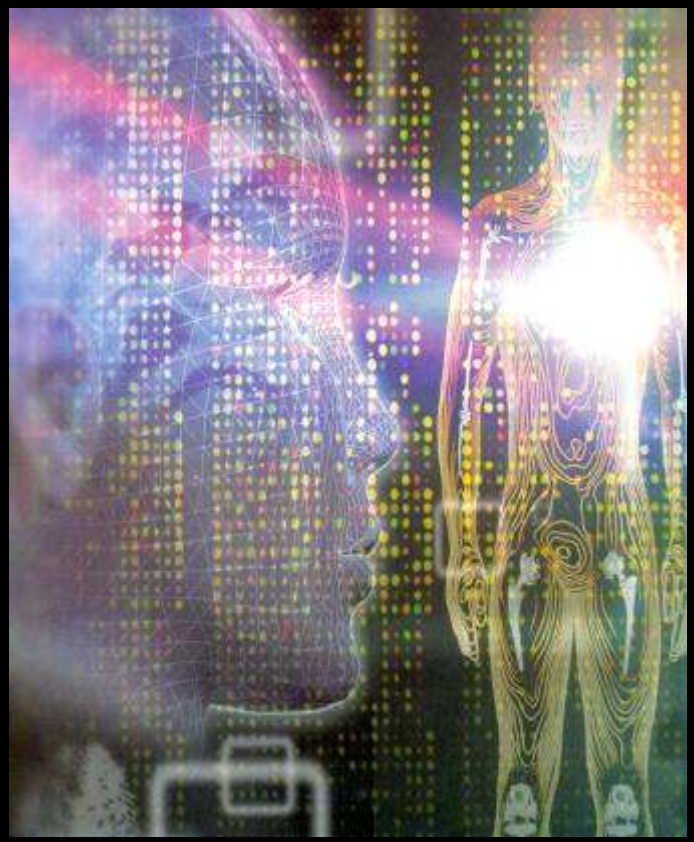
The Mass Casualty Decontamination Challenge and/or Isolation Challenge

How do you go from decontaminating a few ambulatory, protected responders…

…to hundreds or thousands of incapacitated, unprotected civilians?

Biometrics and Infectious Disease Surveillance in a World of Rapid Global Transit



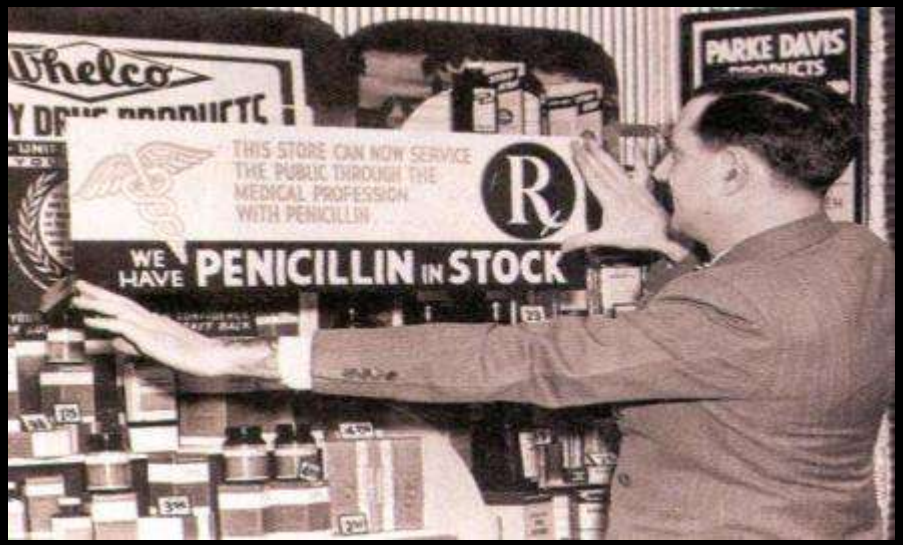


The Growing Threat from Infectious Agents

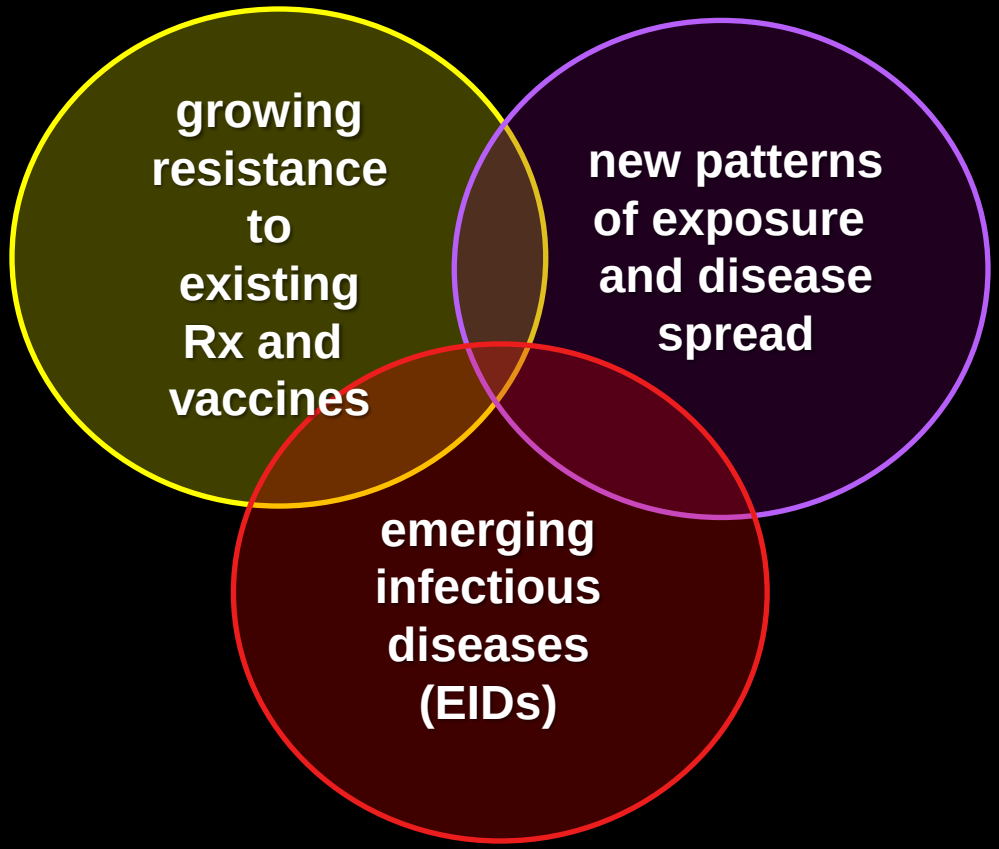
Asleep at the Switch!

Bag Bugs and Few New Drugs

Comfort and Complacency: The Enemies of Vigilance and Preparedness



Outpacing Infectious Diseases



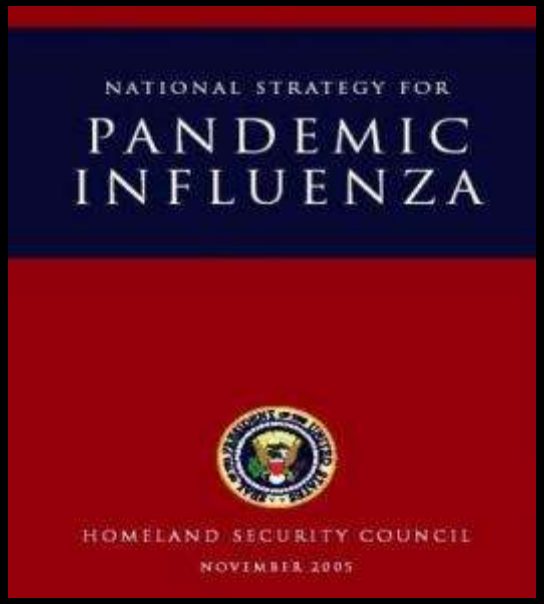
NO ESKAPE!: Resistant Bugs and Few New Drugs

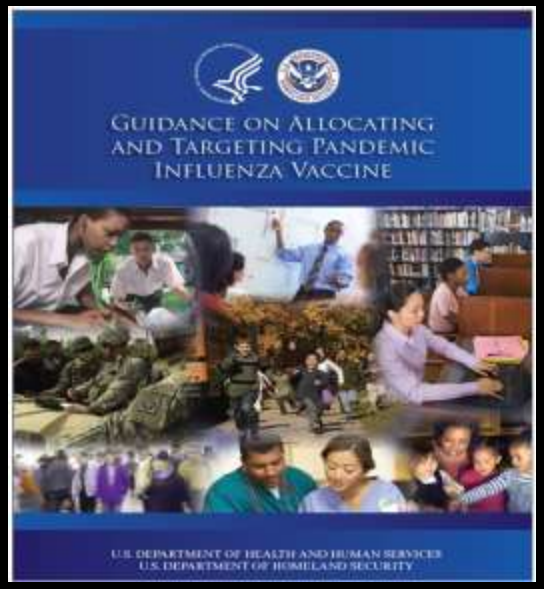
- increasing resistance in G^+ and G^- pathogens in hospital and community settings
- the **ESKAPE** pathogens
  - ***E**nterococcus faecium*
  - ***S**taphylococcus aureus*
  - ***K**lebsiella pneumoniae*
  - ***A**cinetobacter baumanii*
  - ***P**seudomonas aeruginosa*
  - ***E**nterobacter species*

The Valley of Dearth:
The Consequence of Declining R&D Investment in Antibiotic Discovery*

- 75% decrease in antibacterials approved from 1983 to 2013
- only 16 agents currently in Phase II / III clinical trials (versus total 1218; 820 for cancer)
  - only 3 as new ‘classes’ with novel mechanisms of action
  - absence of agents for therapy of resistance in G^-bacilli and MDR-TB
  - lack of systemic agents in advanced development for organisms resistant to all current antibacterials

The Imperative for Innovation in Vaccine Production Technologies

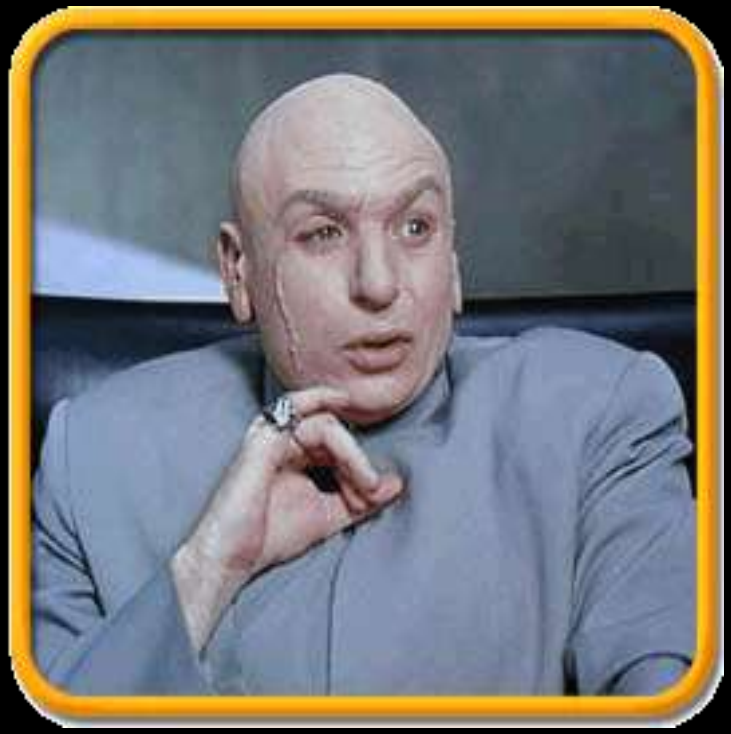




"If this virus was killing more of its victims, there'd be lots of questions about whether this vaccine was produced soon enough"

Dr. Michael Osterholm
Director, CIDRAP, Univ. Minnesota

Future Trajectory Trends and Threat Expansion



New ‘Dual-Use’ Technologies

Dual-Use Technologies

Expanding the Biothreat Spectrum

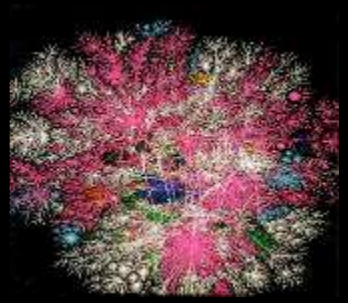
Synthetic Biology: A Powerful Dual-Use Technology

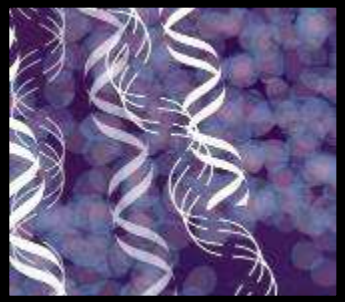
Synthetic Biology

“Creating artificial life with DNA synthesis.
That’s sort of the equivalent
of machine-language programming.
If you want to change the world in some big way,
use biological molecules.”

Bill Gates
Wired 2010

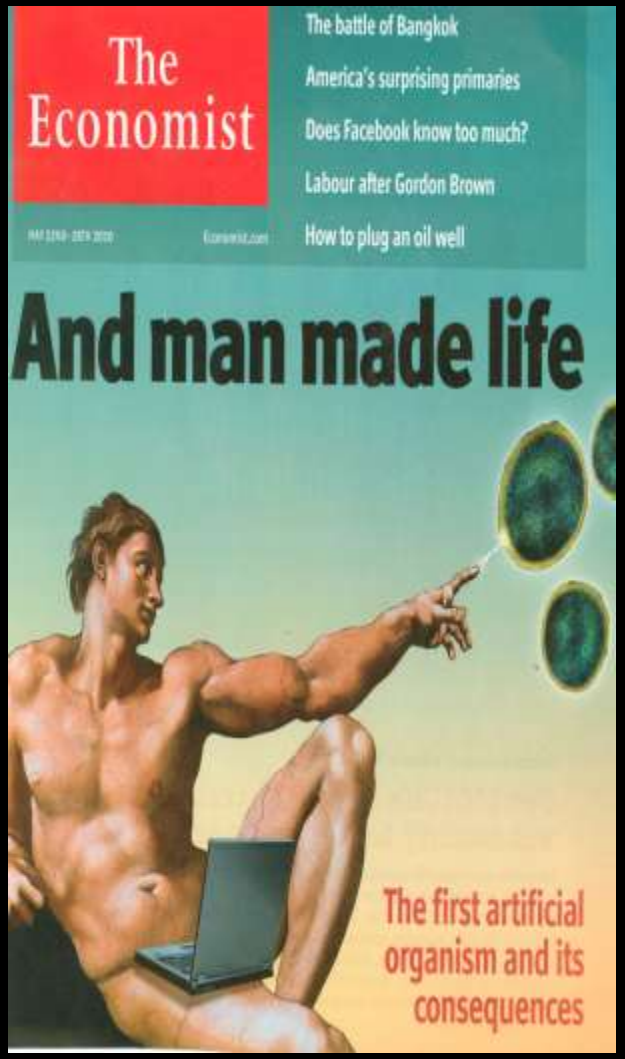
The Expanded Dimension of the ‘Bio’ Challenge

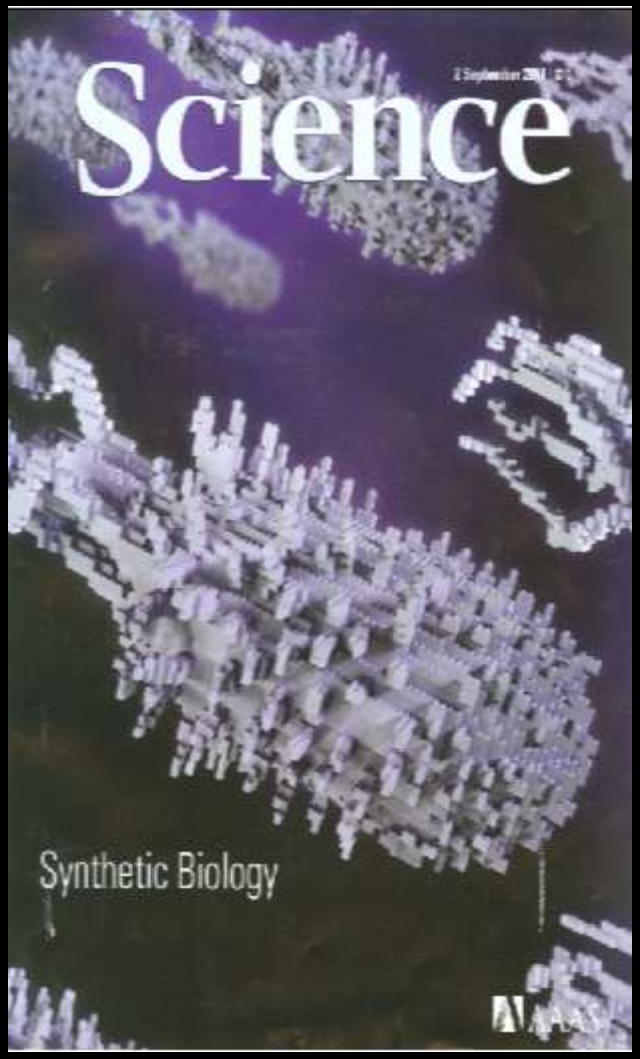




- thinking beyond ‘bio’ as just infectious agents (bugs)
- systems biology
  - targeted disruption of ANY body function
  - novel C and B threats
- synthetic biology
  - exploring biospace: designing new life forms
  - designer organisms to attack materials/infrastructure

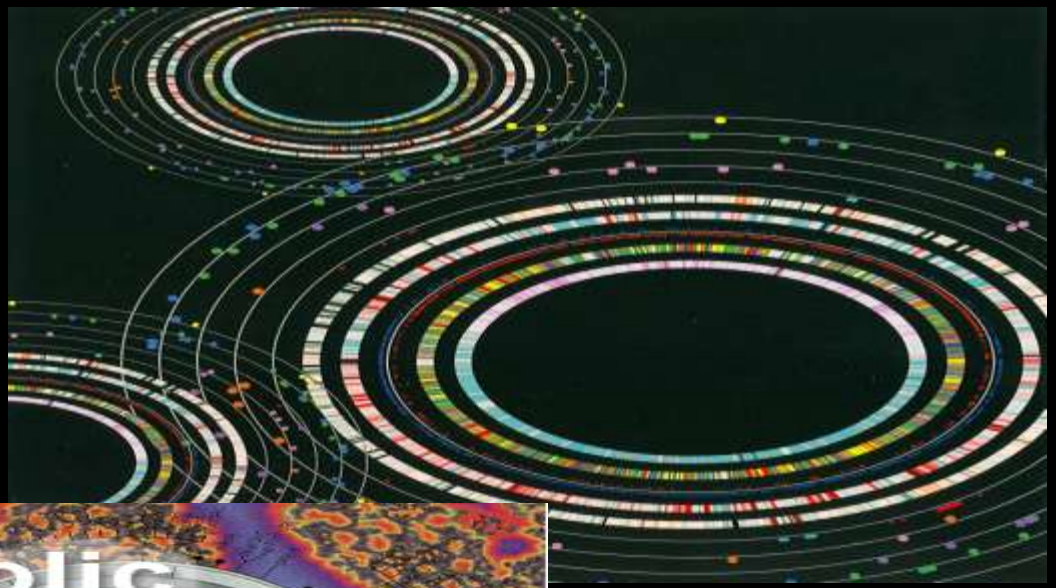
Synthetic Biology

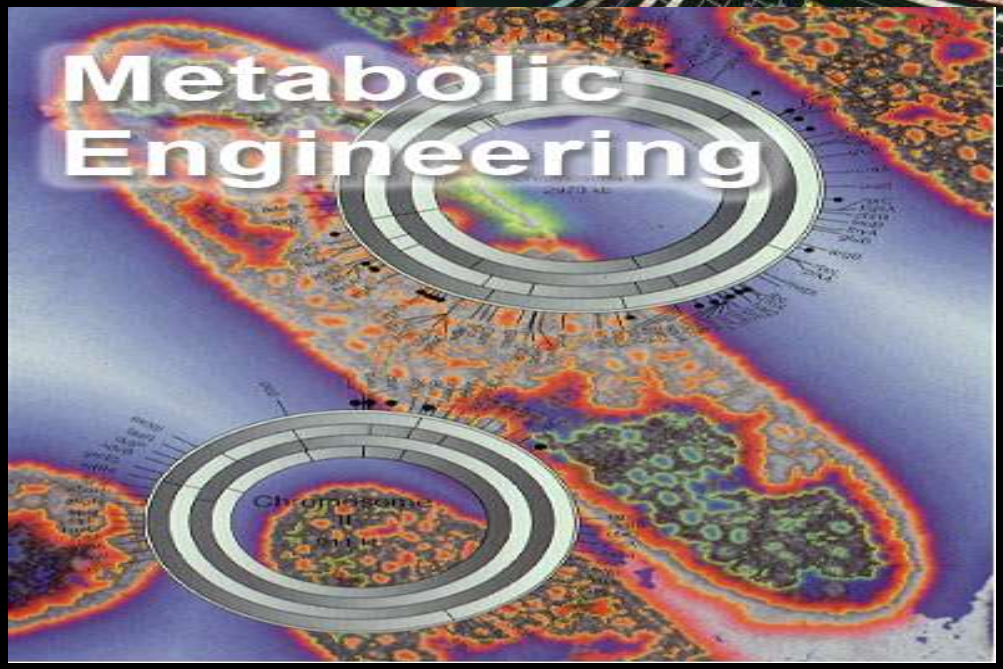




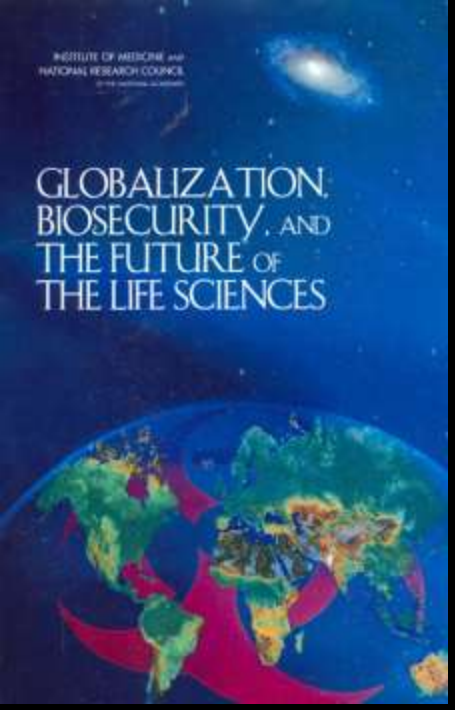
Synthetic Biology:
Engineering Novel Organisms with Novel Functions

Programmable Genomes

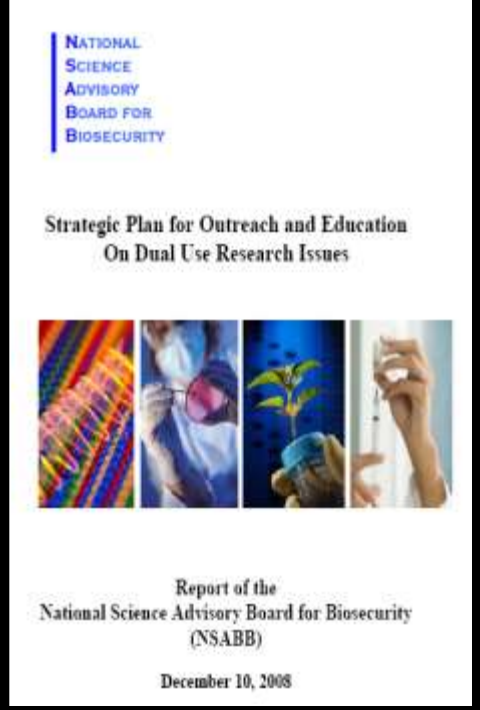


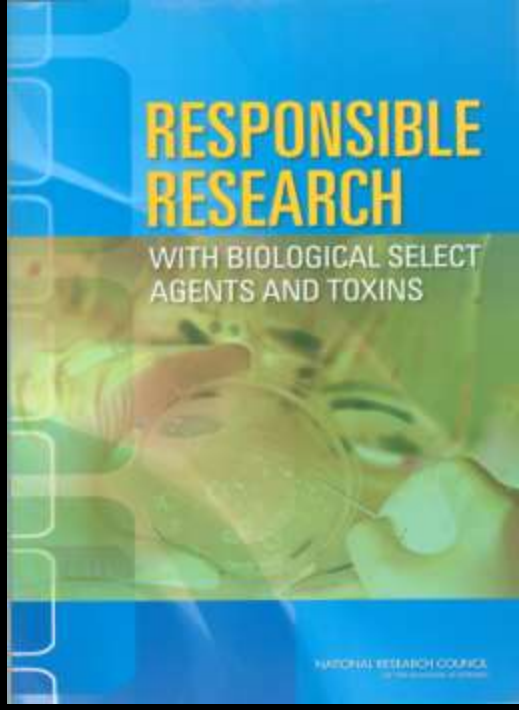


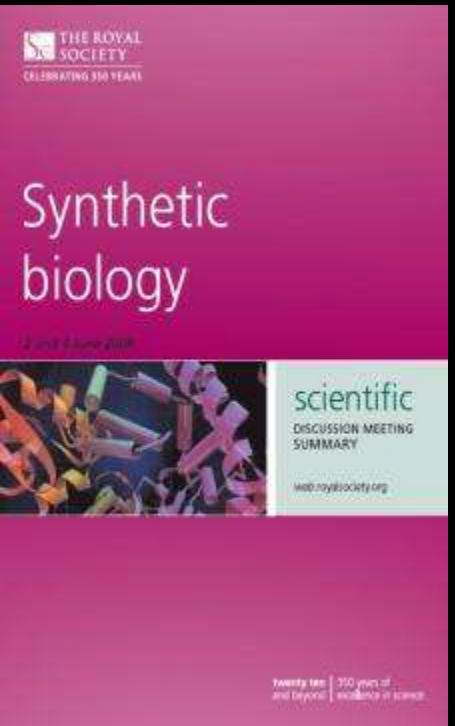
A New Industrial Ecology and Novel Biosynthesis

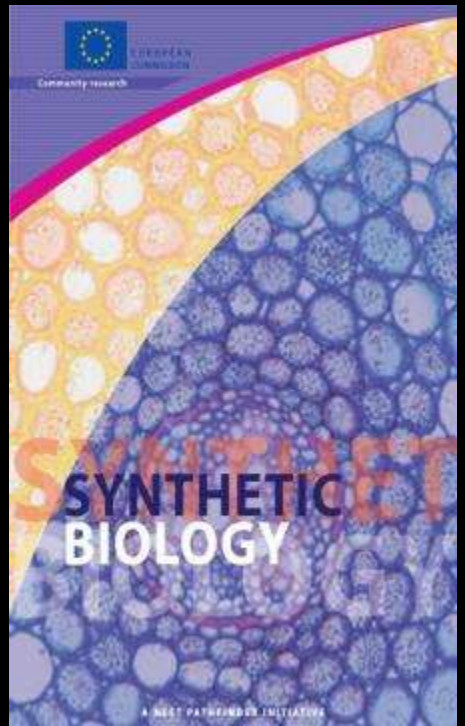

GLOBALIZATION, BIOSECURITY, AND THE FUTURE OF THE LIFE SCIENCES

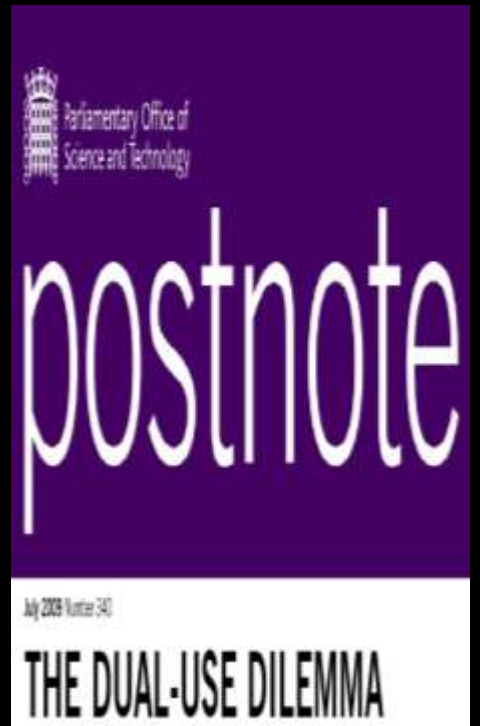

THE ROYAL SOCIETY
CELEBRATING 350 YEARS
New approaches to biological risk assessment
Science Policy Centre
INTERNATIONAL WORKSHOP

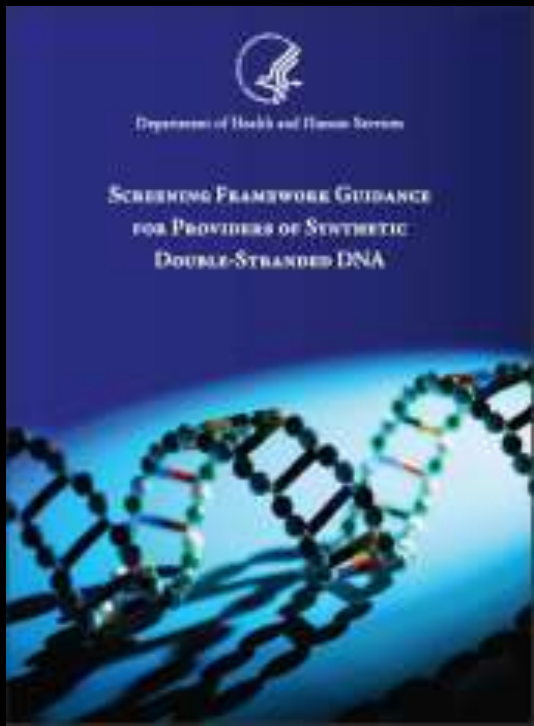

NATIONAL SCIENCE ADVISORY BOARD FOR BIOSECURITY
Strategic Plan for Outreach and Education On Dual Use Research Issues
Report of the National Science Advisory Board for Biosecurity (NSABB)
December 10, 2008


RESPONSIBLE RESEARCH
WITH BIOLOGICAL SELECT AGENTS AND TOXINS


THE ROYAL SOCIETY
CELEBRATING 350 YEARS
Synthetic biology
scientific
DISCUSSION MEETING SUMMARY


SYNTHETIC BIOLOGY


Parliamentary Office of Science and Technology
postnote
THE DUAL-USE DILEMMA


SCREENING FRAMEWORK GUIDANCE FOR PROVIDERS OF SYNTHETIC DOUBLE-STRANDED DNA

Oversight of Synthetic Biology: Risk, Regulation and Responsibility

Biosafety: Risk from Legitimate R&D/Industrialization	Biosecurity: Deliberate Use to Cause Harm	Biohackers and Democratization of New Technology
		
		
Screening of Purchases/ Supply Transactions	**Regulation, Legislation and Codes of Conduct**	**International Harmonization**

Dual-Use Research of Concern (DURC)

Nature (2012) 482, 153

COMMENT

INFLUENZA Further explanation of the NSABB recommendations p.159

PRIMATES Imitation and social learning in apes p.159

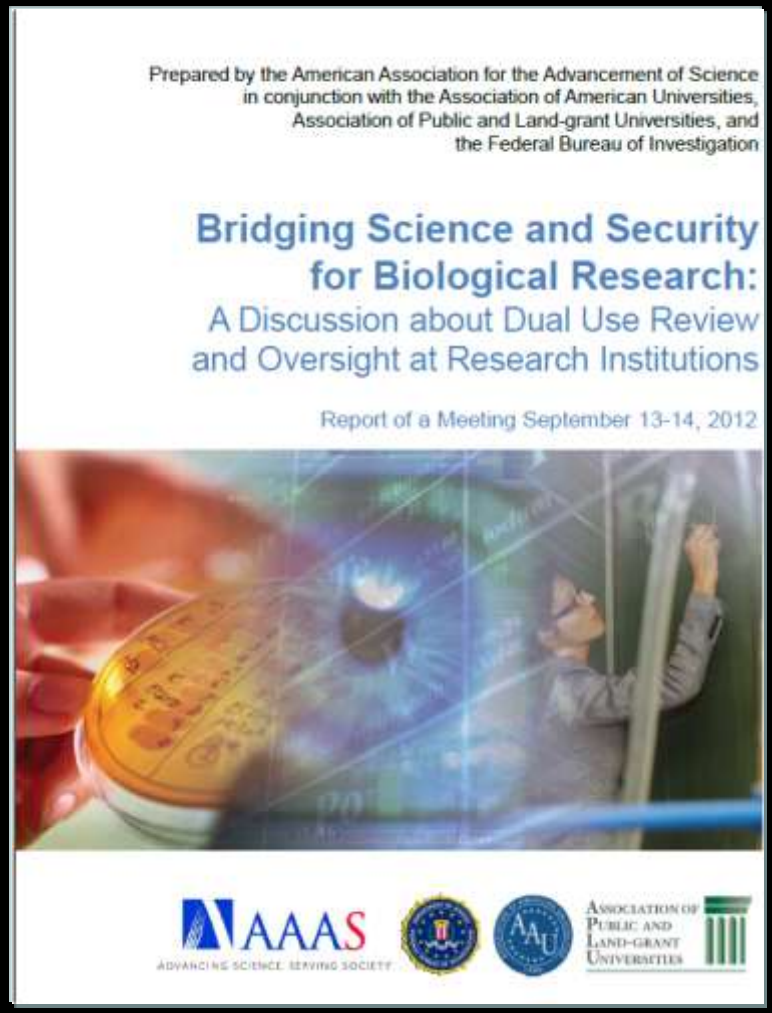
HISTORY John Dee's sweaving of scientific magic in the Elizabethan court p.160

CONSERVATION Trade in whale 'quotas' may be insufficient protection p.162

Pathogenic H5N1 avian influenza has led to the culling of hundreds of millions of birds. A human-transmissible form could have much worse consequences.

Adaptations of avian flu virus are a cause for concern

Members of the US National Science Advisory Board for Biosecurity explain its recommendations on the communication of experimental work on H5N1 influenza.



Prepared by the American Association for the Advancement of Science in conjunction with the Association of American Universities, Association of Public and Land-grant Universities, and the Federal Bureau of Investigation

Bridging Science and Security for Biological Research:

A Discussion about Dual Use Review and Oversight at Research Institutions

Report of a Meeting September 13-14, 2012

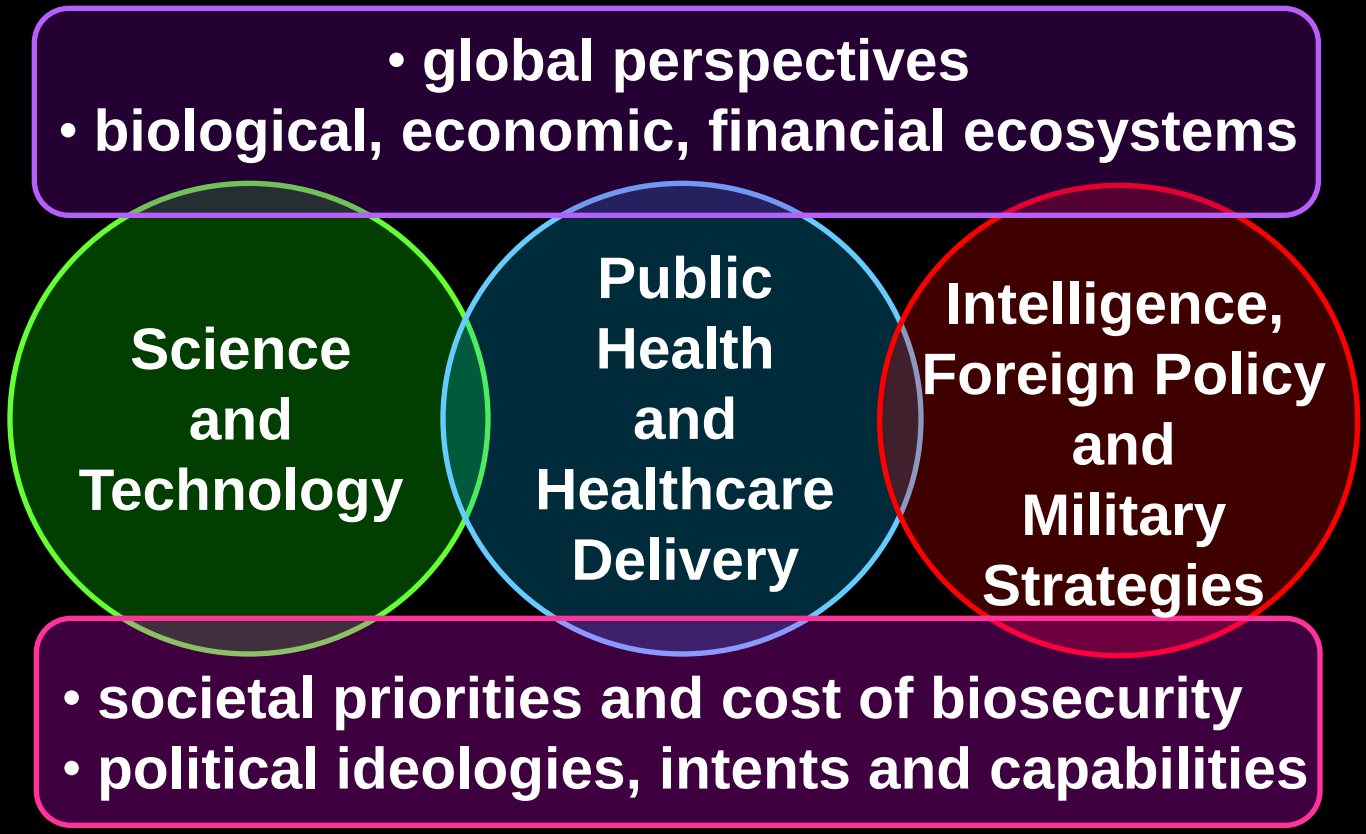
AAAS

ADVANCING SCIENCE, SERVING SOCIETY

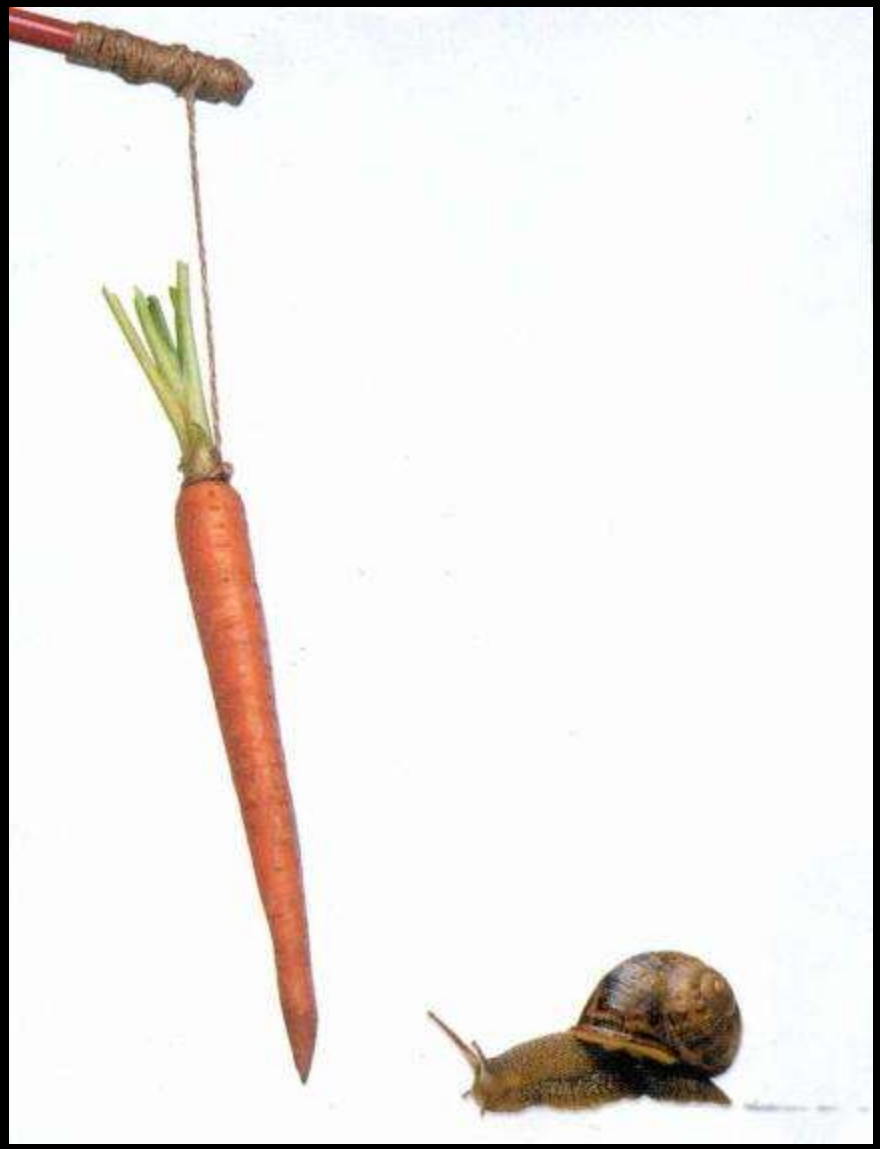
Association of Public and Land-grant Universities

Dual-Use Research of Concern (DURC)

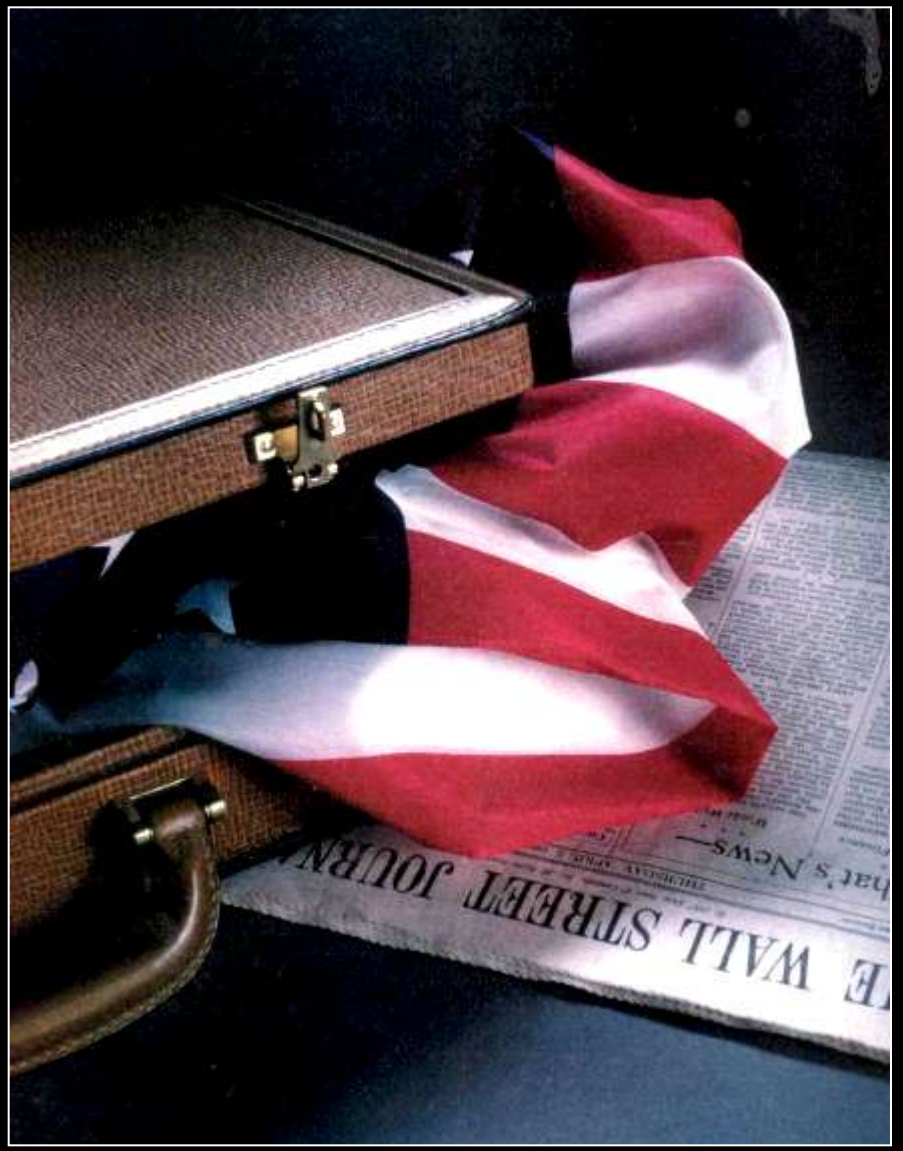
Biosecurity:
A Classic Complex Systems Challenge

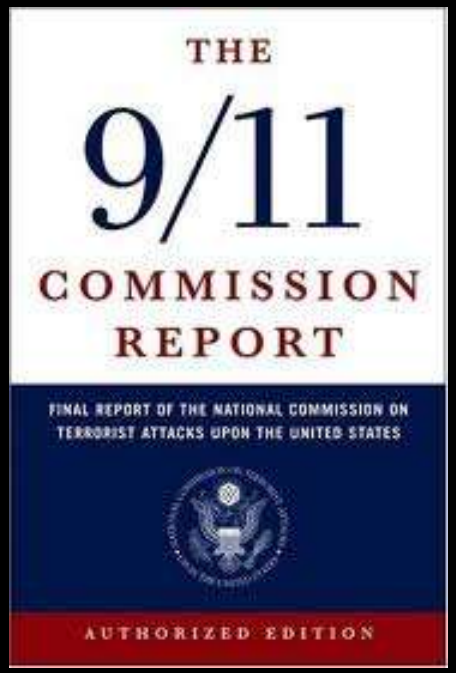


Who Pays for Preparedness?



The Obligate Role of Private-Public Partnerships in Biosecurity Policy





"We believe the 9/11 attacks
revealed four kinds of failures;
in imagination,
policy,
capabilities
and management."

9/11 Commission Report 2004

Biosecurity:
A Growing Void in USG Policy, Planning and Preparedness

multi-dimensional challenges demand cogent, holistic solutions

current US capabilities are dangerously fragmented and under-resourced

we are not alone: governmental neglect of biosecurity is an omnipresent and growing global vulnerability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UNITED STATES OF AMERICA


National Security Council


U.S. DEPARTMENT OF HOMELAND SECURITY


DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA


DEPARTMENT OF JUSTICE
FEDERAL BUREAU OF INVESTIGATION


DEPARTMENT OF HEALTH & HUMAN SERVICES
USA


Central Intelligence Agency
Top
Secret


NO
ENTRY
RAW
FE
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SIS

The retreat from complexity: timidity trumps boldness

Is US boldness in driving advanced technologies at risk?

The Curse of Contemporary Governance: 'Quick Fixes' and the Retreat from Complexity

- public complacency and political populism as major policy barriers
- unidimensional, short term policies to address multidimensional complexity with long term consequences
- public policy defined increasingly by length of legislative terms
- did not meet the street's expectations: the tyranny of quarterly earnings on industry boldness to invest in long-term R&D
- influence of media in shaping public policy and operational constraints
- the retreat from complexity

The Retreat from Complexity

BIG IDEAS
GO
UNEXPLORED
AND
UNFUNDED

TIMIDITY AND PRESERVATION OF STATUS QUO TRUMP BOLDNESS AND DISRUPTIVE INNOVATION

The Need for Greater Urgency and Adoption of Systems-Based Approaches to Biosecurity

- current USG institutions and R&D vehicles are ill-suited to address current and projected challenges
- ‘rapid’ and ‘translation’ are countercultural to much of the academic and USG communities
- the cosmetic salve of seeming to ‘do something’ is meaningless absent of results
- extravagant resources are/will be wasted until a forceful integrated, cross-agency ‘systemic’ approach is adopted
- the engagement of corporate and international agencies is a critical success factor in addressing global biosecurity challenges

Building Robust CB Defenses

- major vulnerabilities exist across the full spectrum of biodefense
  - pre-emptive detection and interdiction
  - early warning detection of biothreat agent release
  - rapid diagnosis
  - healthcare resources for mass casualty management
  - drug and vaccine coverage (quantitative and qualitative)
  - large scale decontamination
  - outdated public health laws
  - emergency control of media/commerce

Addressing Global Challenges in Biosecurity

- mobilize new expertize networks to achieve end-to-end solutions
- funding and assembly of requisite expertise
  - cross-disciplinary, cross-sector
  - obligate role of industrial partners
- sophisticated management of complex network whose composition will change constantly with new threats and new technologies
- financial incentives for industry for investment of market failure
  - antimicrobials and vaccines (public health, DDW)
  - biodefense medical countermeasures with no civilian markets

“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)

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