ASU COMPLEX ADAPTIVE SYSTEMS INITIATIVE
ARIZONA STATE UNIVERSITY

The Impact of the Life Sciences on National Security

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and Del E. Webb Chair in Health Innovation
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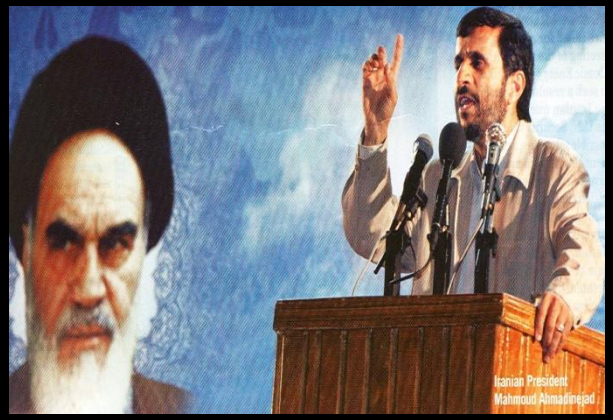
Presentation at: Preserving National Security –
The Growing Role of the Life Sciences
UPMC Center for Biosecurity, Washington, D.C.
3 March 2011

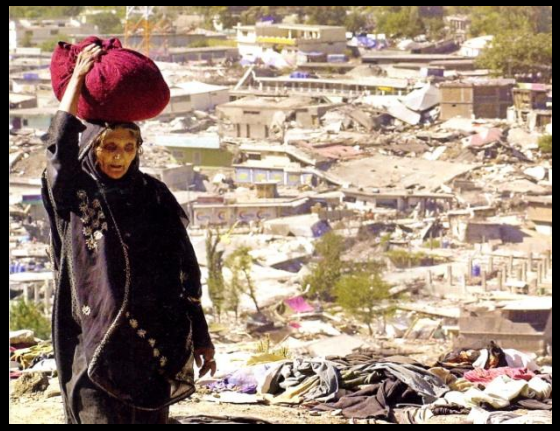
Seeking Security in an Unsecure World

Terrorism

WMD Proliferation



New Power Centers



Natural Disasters

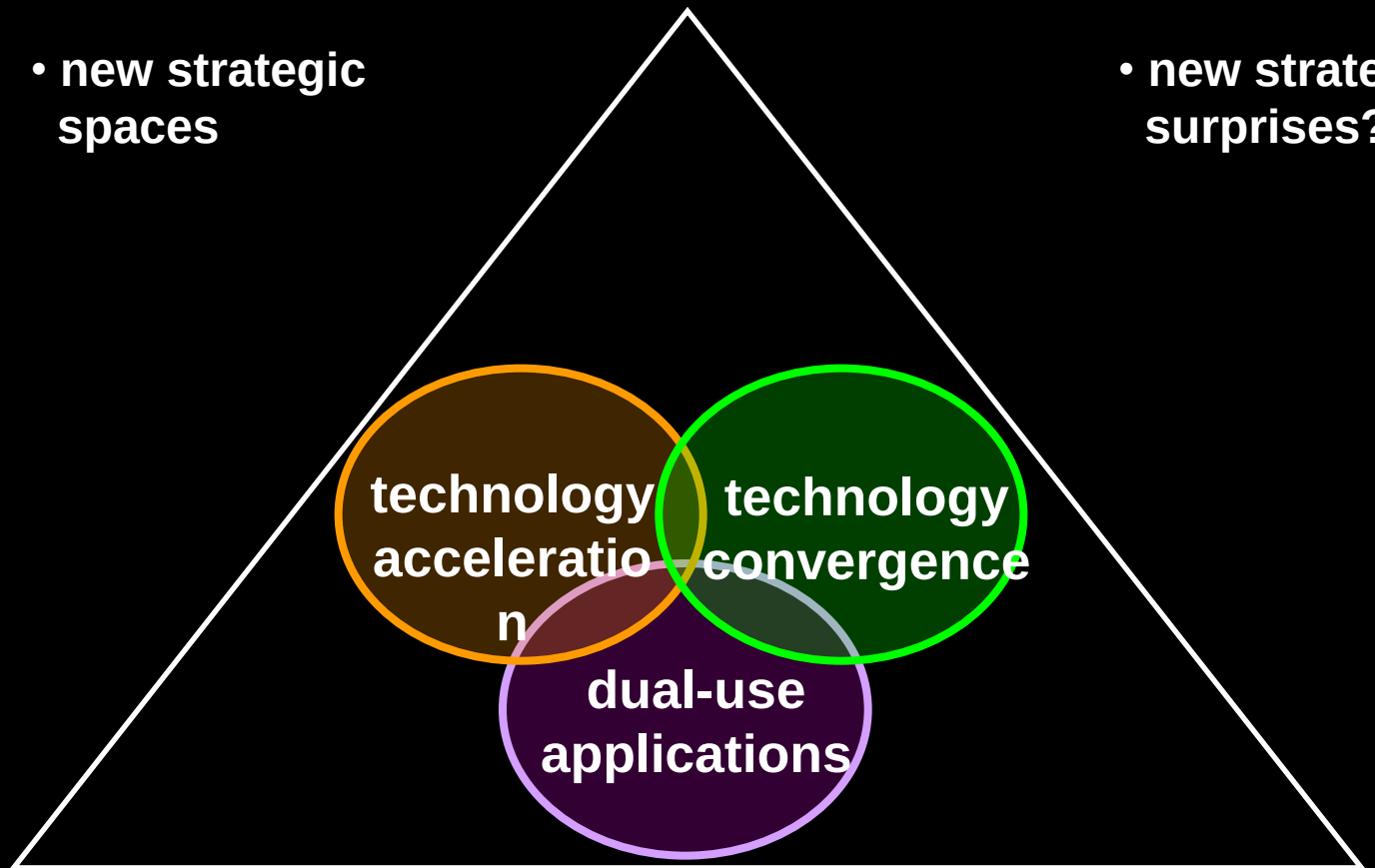
Environmental Deterioration

Critical Resources and Non-Renewables

The Increasingly Complex S&T Landscape

EMERGENCE AND DISCONTINUITIES

- new strategic spaces
- new strategic surprises?



sustaining US competitiveness

rapid diffusion and ubiquity of advanced technologies

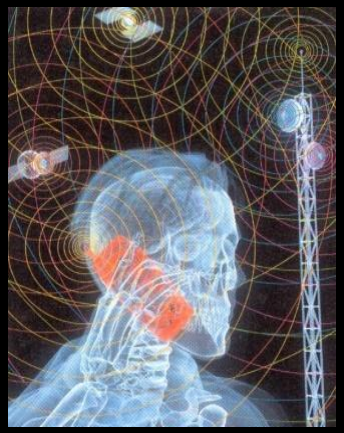
rise of new economic centers

The New Strategic "Spaces" in Military Affairs and National Security Impacted by the Life Sciences

Systems and Synthetic Biology

"Biospace"

Ubiquitous Sensing

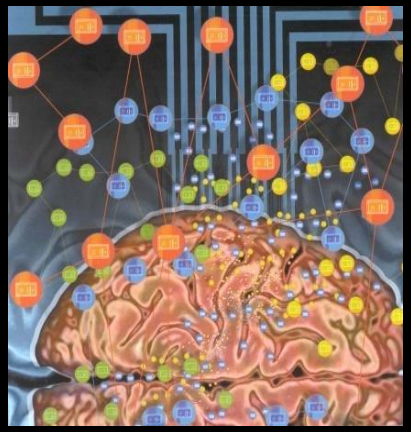


"Connected Space"

Infocosm and Meta-data

" Knowledge Space"

Brain: Machine Interactions



"Smart Space"

Environmental Sustainability

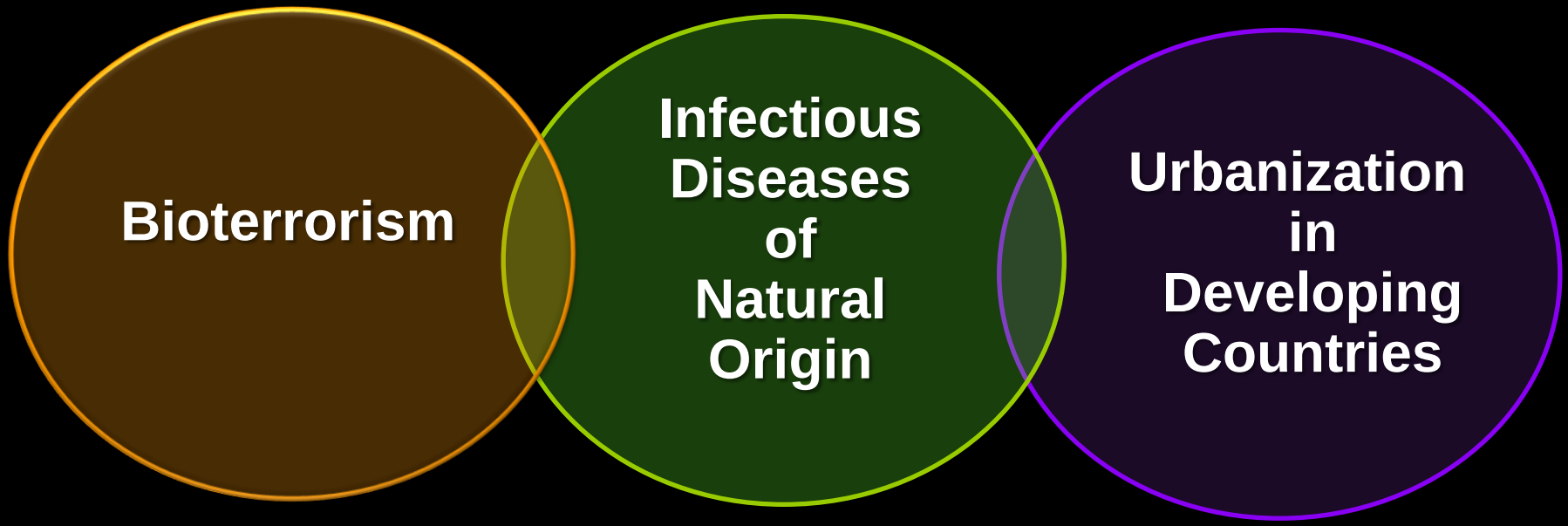
"Shared Space"

Constantly Emerging and Evolving Multi-Dimensional Matrices of Knowledge Ecologies

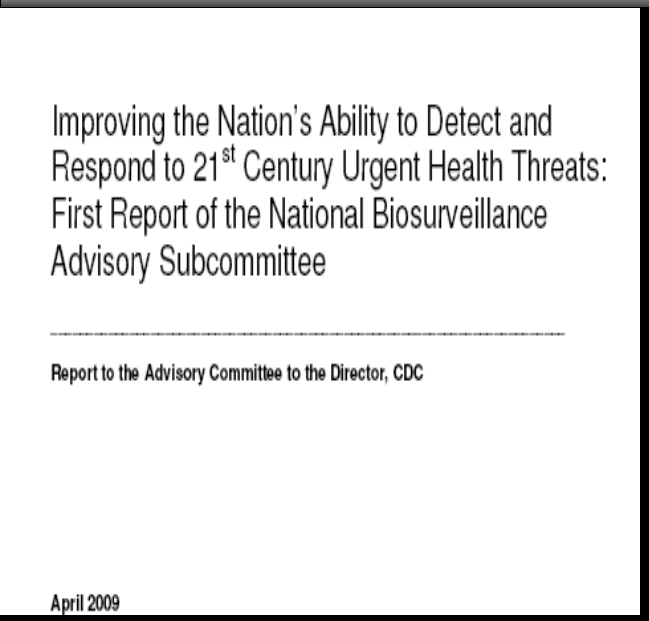
Global Challenges

Systems of Innovation

Biosecurity: Outpacing Infectious Diseases

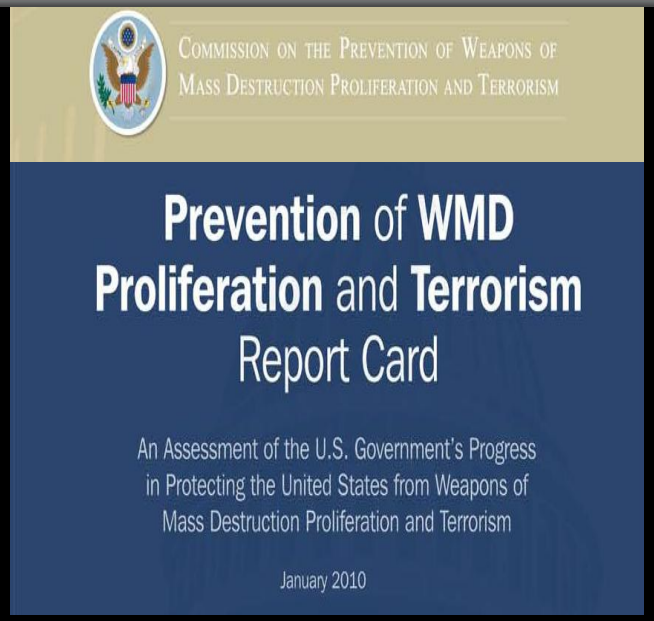


Building Resilient Preparedness and Response Capabilities for Biosecurity: A Less Than Satisfactory Report Card


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

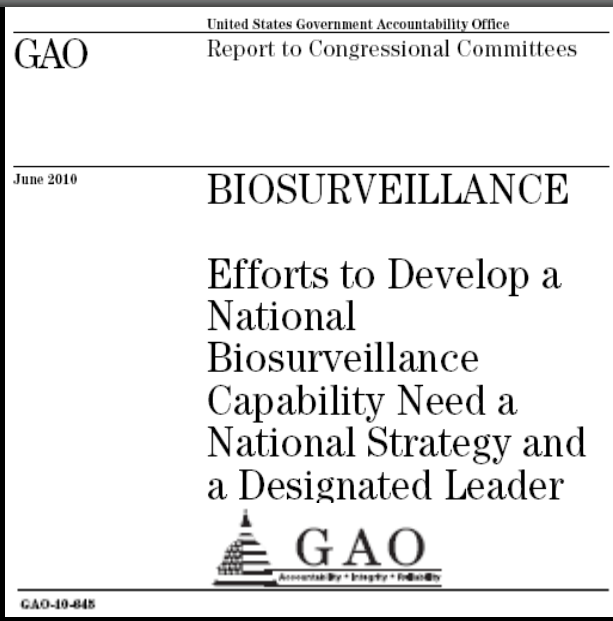
April 2009


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

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


United States Government Accountability Office

GAO

Report to Congressional Committees

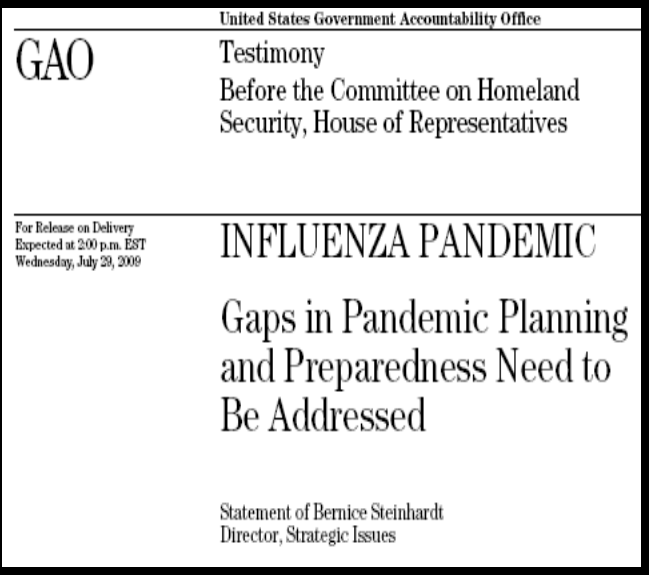
June 2010

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

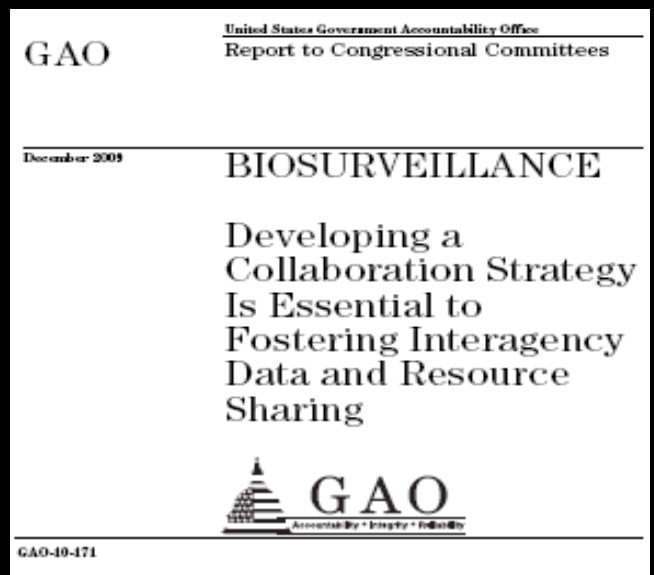
Before the Committee on Homeland Security, House of Representatives

For Release on Delivery
Expected at 2:00 p.m. EST
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

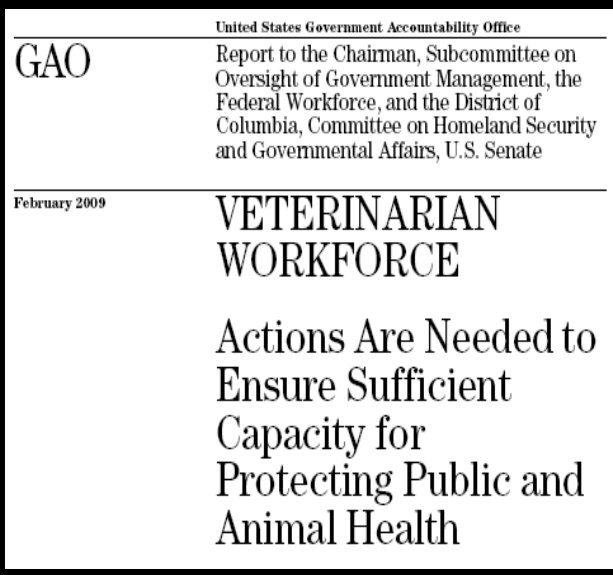
December 2009

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

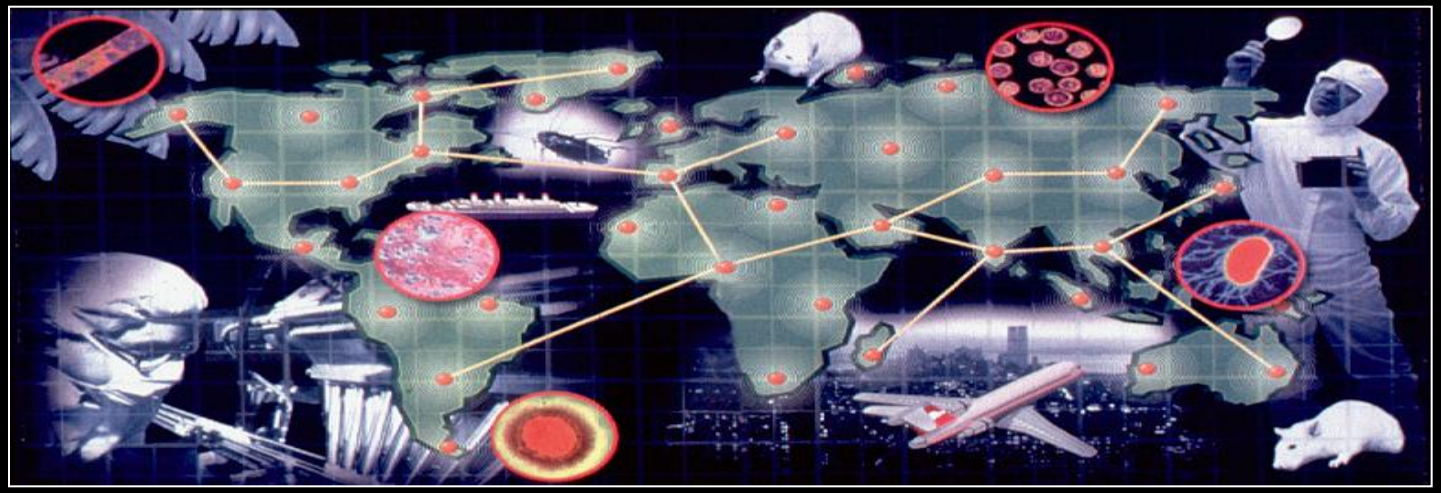
February 2009

VETERINARIAN WORKFORCE

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

A Shared Global Risk:

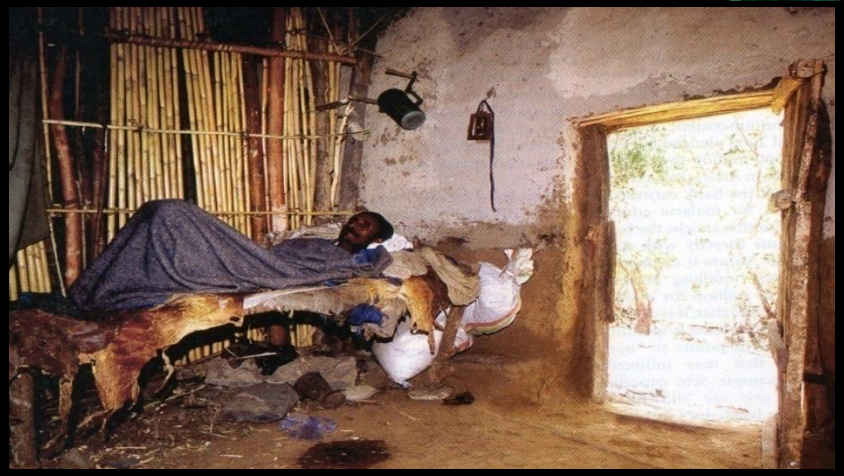
The Omnipresent Threat Posed By Microorganisms and Parasites



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

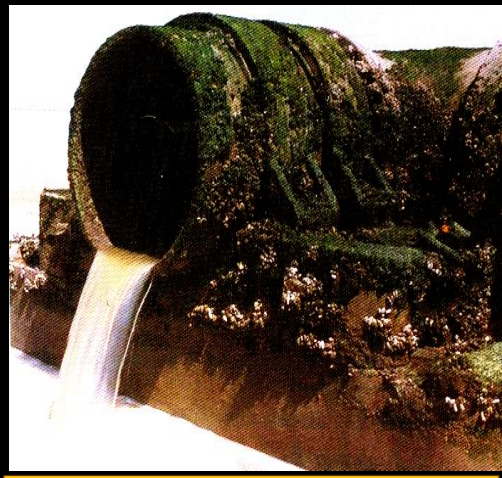
High Disease Transmission

Expanded Eco-niches and Increased Zoonotic EID Risks



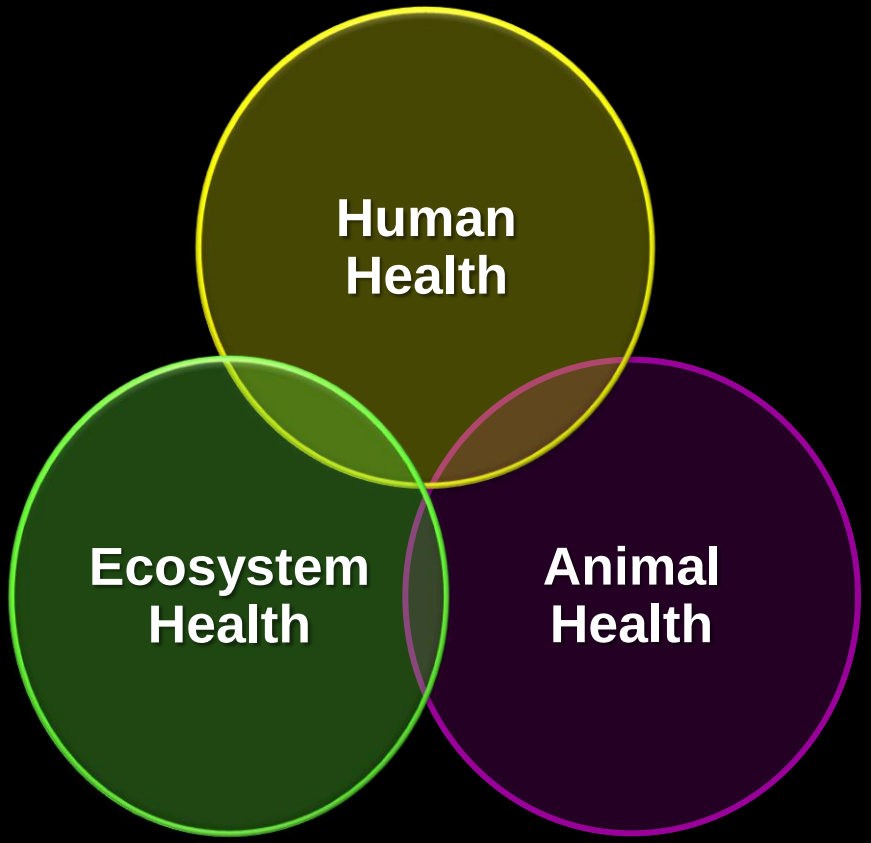
Major Deficits in Health Infrastructure

Lack of Safe Water



Toxic Waste

"One Health": The Rationale for Integration of Historically Separate Domains and Responsibilities



- urbanization of DCs and emergence of new zoonotic EID threats
- food chain as increasing source of disease risks
- enhanced agricultural productivity to support global population growth
- economic impact of agricultural disease on trade, development and resources/production footprints

New Diagnostic Technologies: A Neglected Area of Biodefense and Biosurveillance

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

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

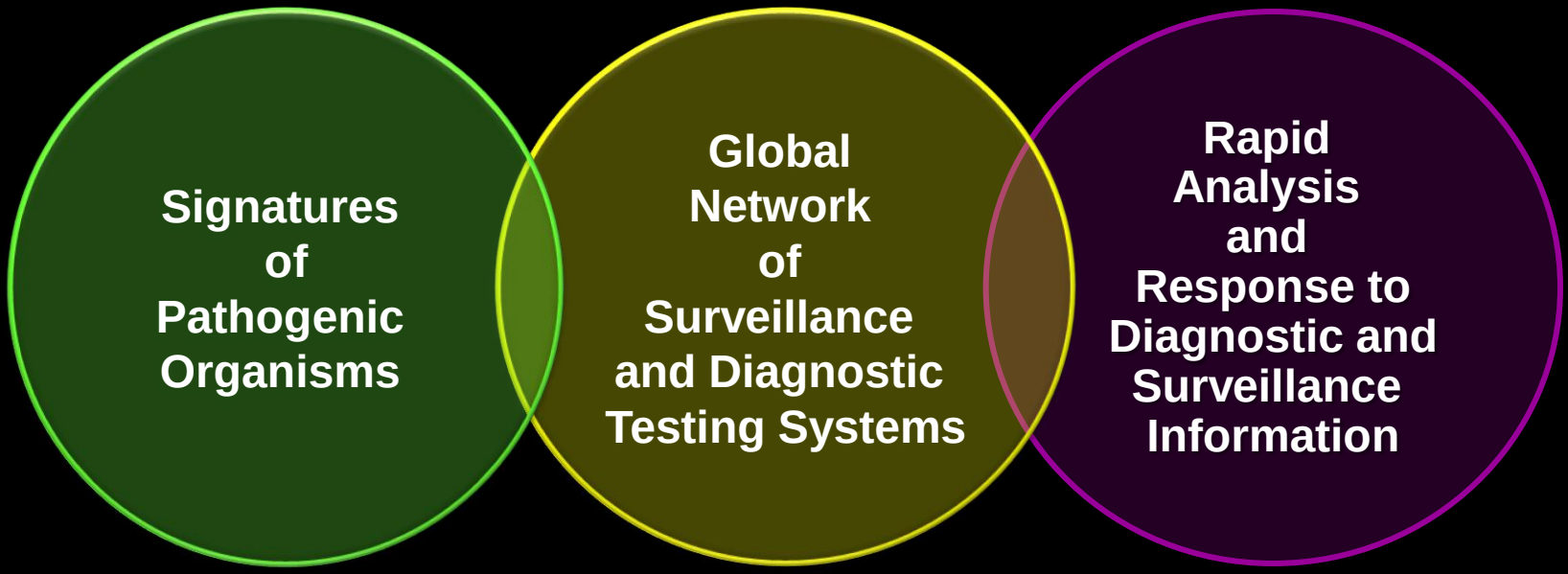
- real time disease surveillance data
- faster ID of incident evolution
- faster incident containment and exposure controls

The Single Most Important Leverage Point For Rapid Mobilization of Resilient Responses to Epi-/Pan-demics and Bioterrorism

Strengthening International Capacity for Surveillance of Infectious and Parasitic Diseases

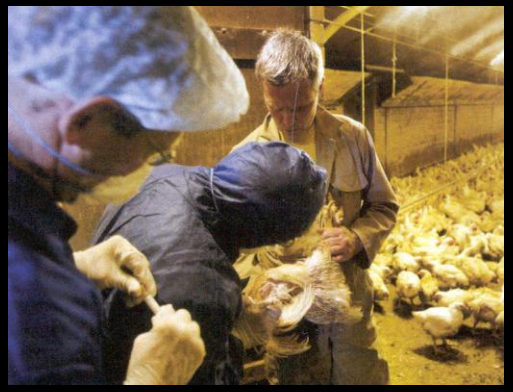
- faster detection and ID of EIDs
- ecoshifts in host spectrum
- vector-borne diseases and emergence of novel vectors
- zoonotic diseases carried by food animals
- sentinel surveillance for food- and water borne diseases
- emergence of Rx resistance
- rapid detection alert for ‘atypical’ events as sentinel of potential bioterrorism
- rich datasets for increasingly robust epidemiological modelling and infection control paradigms

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



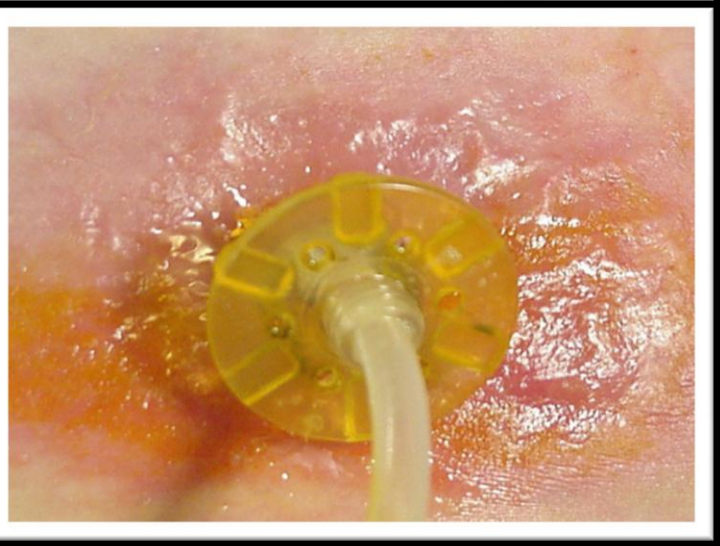
Profile

Sense



Act

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*

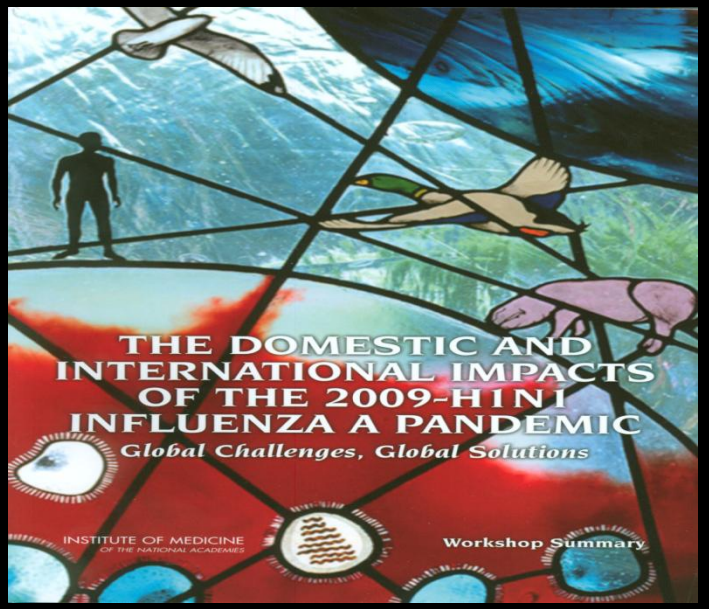
The I0 X ’20 Initiative (20 Nov. 2009)

- grand challenge to develop 10 new antibiotics by 2020

New US-EU Task Force (2 Nov. 2009)

- encourage R&D on new antimicrobial drugs
- yet to be defined strategy/funding

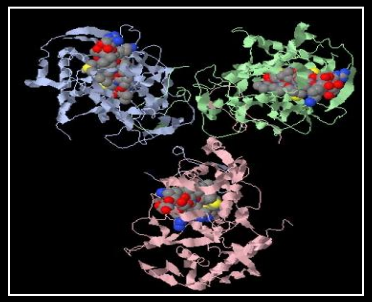
The Imperative for Innovation in Vaccine Production Technologies



"If this virus (H1N1) 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
USA Today 8 Oct. 2009

Combating ‘Agent-X’
The Imperative for Innovation in Vaccine Production Technologies

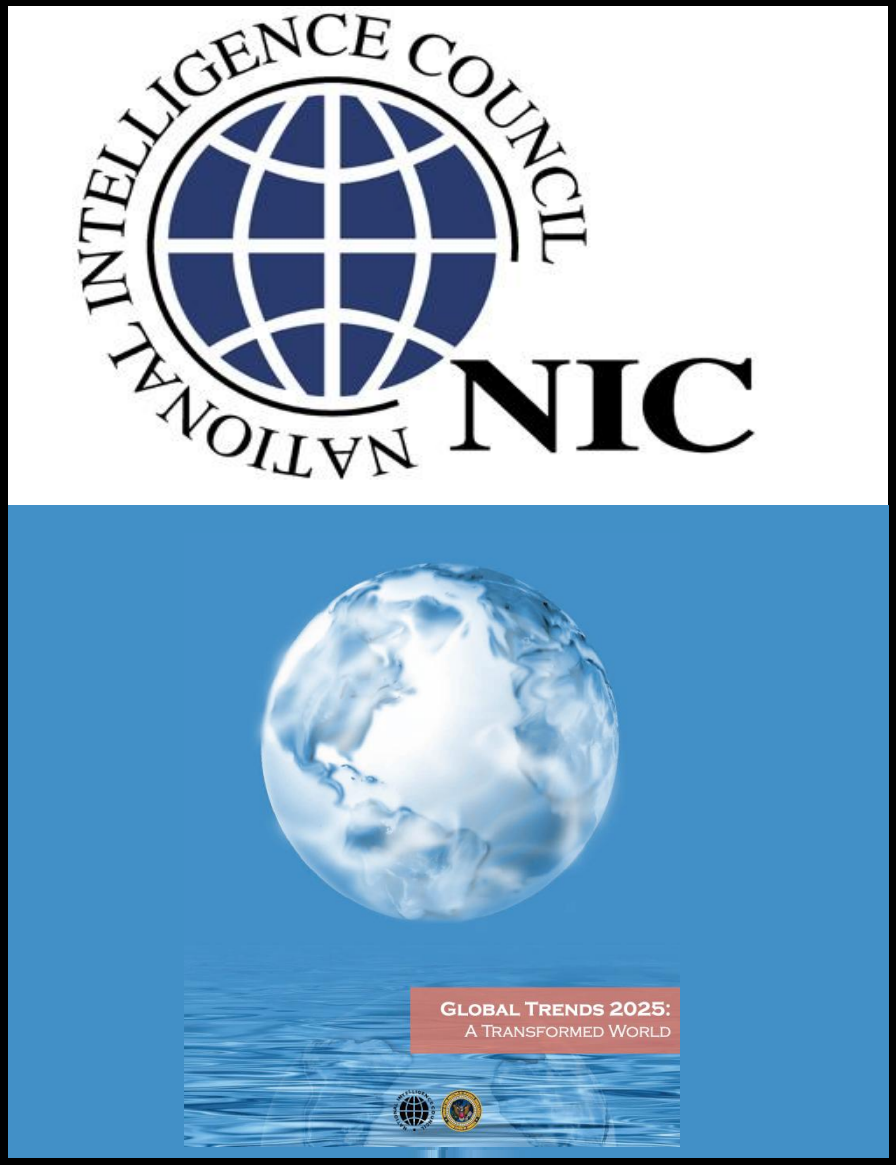


- production of the relevant epitopes by chemical synthesis versus traditional ‘biological’ production methods
- dramatic reduction in vaccine production time
- rapid scaleability and production plant flexibility versus ‘biological’ methods
- compositional uniformity of chemically synthesized antigens eliminates need for regulatory approval of individual lots (unlike biological products)

FDA

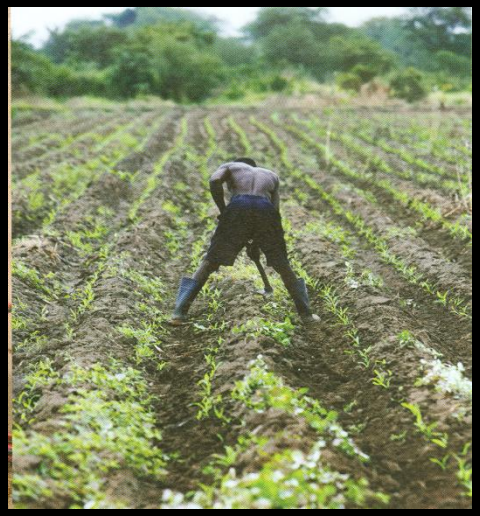
EUROPEAN MEDICINES AGENCY
SCIENCE MEDICINES HEALTH

Framing Future Security Issues
Demands a Broadened Conceptualization of National Security



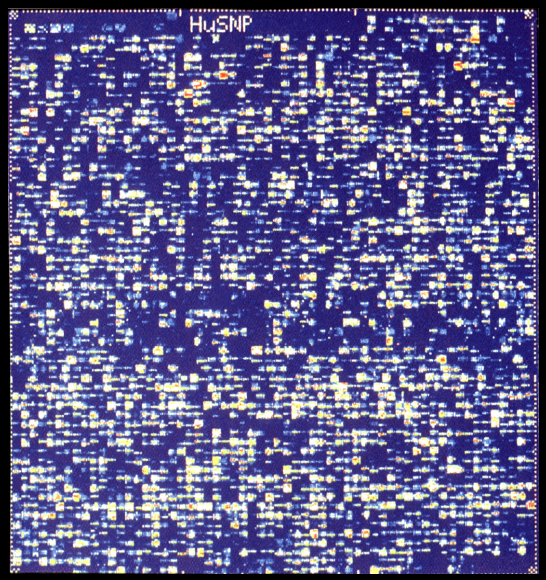
- population, food and water
- infectious/parasitic diseases
- urbanization and resources footprint
- energy
- climate and environmental sustainability
- depletion of non-renewable resources
- global trade and finance
- military and security implications of economic and social instabilities

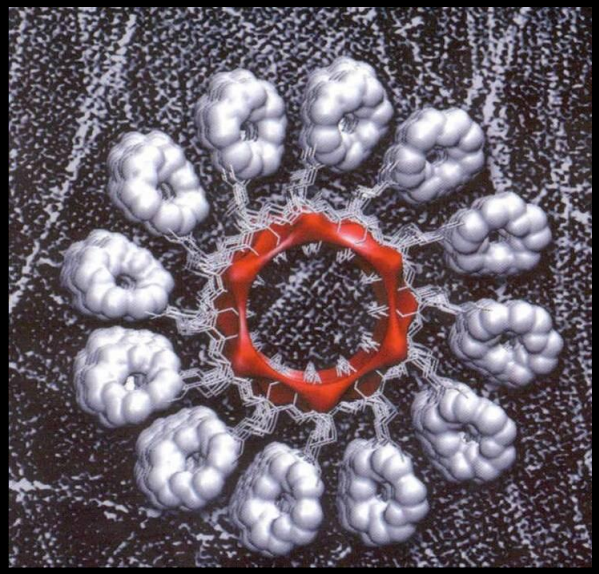
Feeding The Future

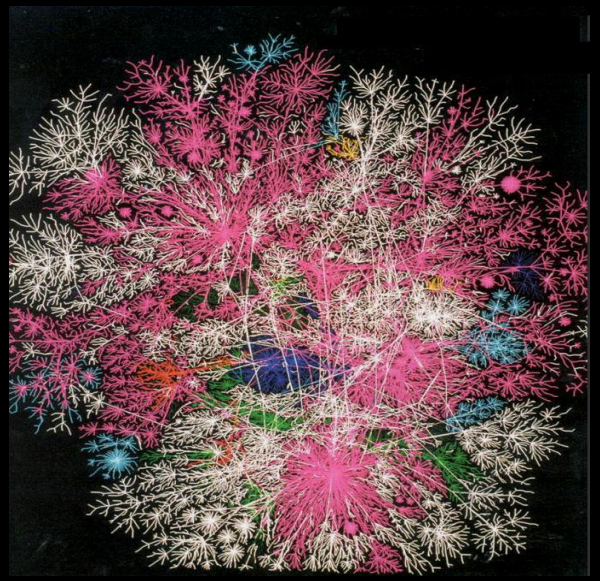


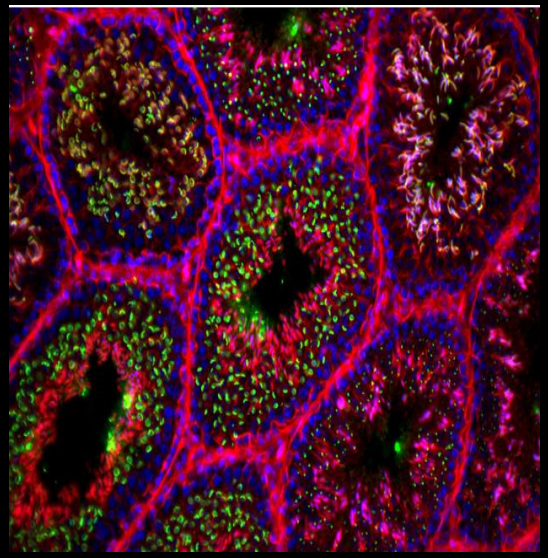
- food chain increasingly complex, international and inter-dependent
- food production over next 25 years Ξ total for 10,000 years
- expanding middle class (1-2 billion) in NICs and some DCs and increased demand for grain and meat projected to increase by 160% by 2020
- famines, shortages and food riots in DCs
- impact of climate change on agricultural productivity

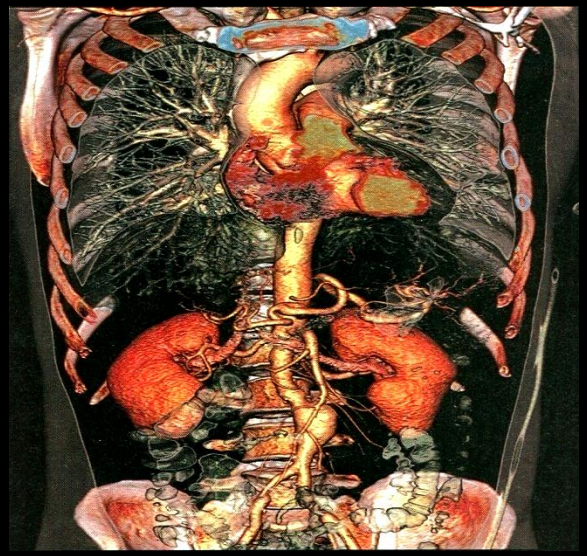
Systems Biology:
Comprehending the Design Principles of Complex, Adaptive Networks of Increasingly Higher Structural Order

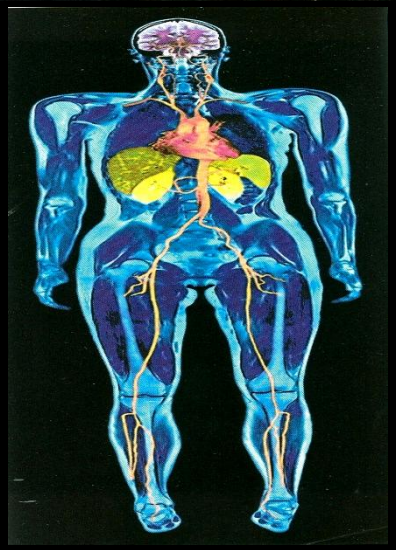




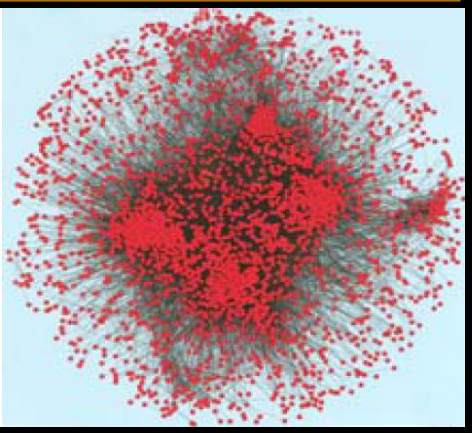
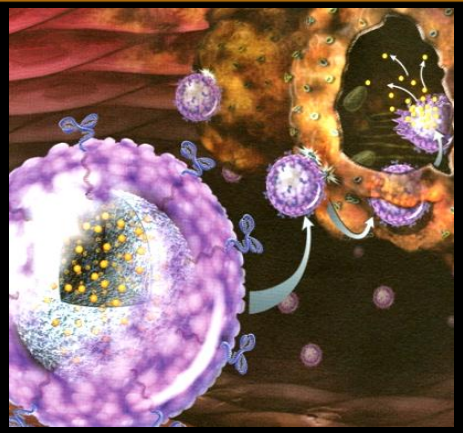
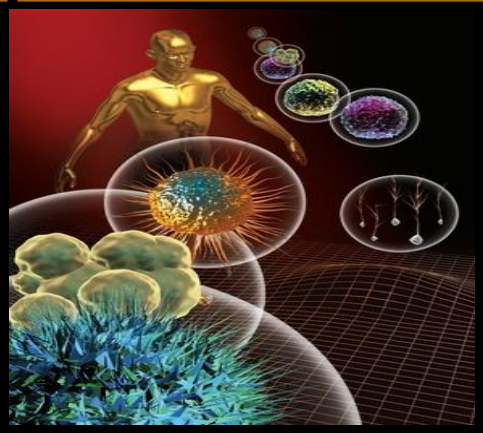
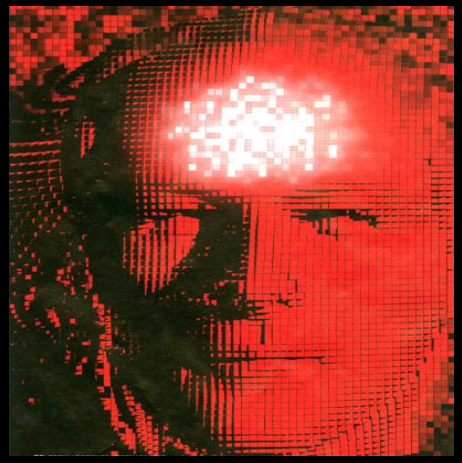




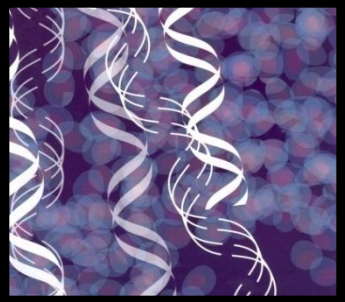




Transcending Boundaries: Emergent Domains Arising from Technology Convergence In the Life Sciences

Systems Biology and Synthetic Biology	Reprogramming Cell Differentiation	Regenerative Medicine	HPO
			
Bio-Enhancement	**Bionic-Enhancement**	**Cognitive Enhancement**	**Genetic Enhancement**
			

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: engineered organisms with novel virulence features
  - designer organisms to attack materials/infrastructure

INSTITUTE OF MEDICINE AND NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

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
web royalsociety.org/policy

twenty ten and beyond | 350 years of excellence in science

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

NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

THE ROYAL SOCIETY
CELEBRATING 350 YEARS

Synthetic biology

2 and 3 June 2008

scientific
DISCUSSION MEETING
SUMMARY

web royalsociety.org

twenty ten and beyond | 350 years of excellence in science

EUROPEAN COMMISSION
Community research

SYNTHETIC BIOLOGY

A NEST PATHFINDER INITIATIVE

Parliamentary Office of Science and Technology

postnote

July 2009 Number 340

THE DUAL-USE DILEMMA

Department of Health and Human Services

SCREENING FRAMEWORK GUIDANCE FOR PROVIDERS OF SYNTHETIC DOUBLE-STRANDED DNA

Synthetic Biology

- emerging technology with myriad applications across diverse industrial sectors

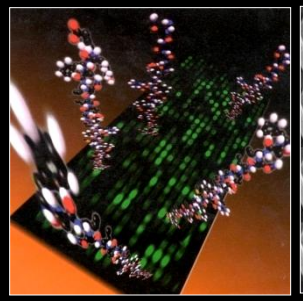
Healthcare

Public Health

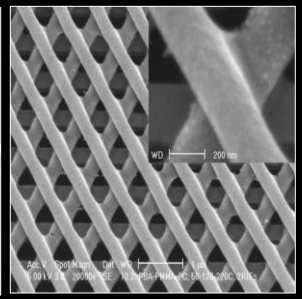
Agriculture

Functional Foods

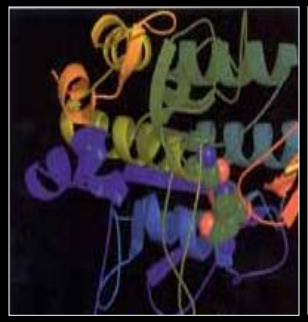
Novel Materials



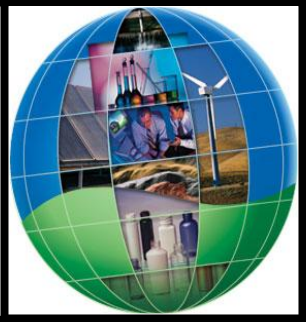
Textiles



Bioenergy and Biofuels



Industrial Enzymes



'Green' Mfg

Bio-remediation

Clean Water

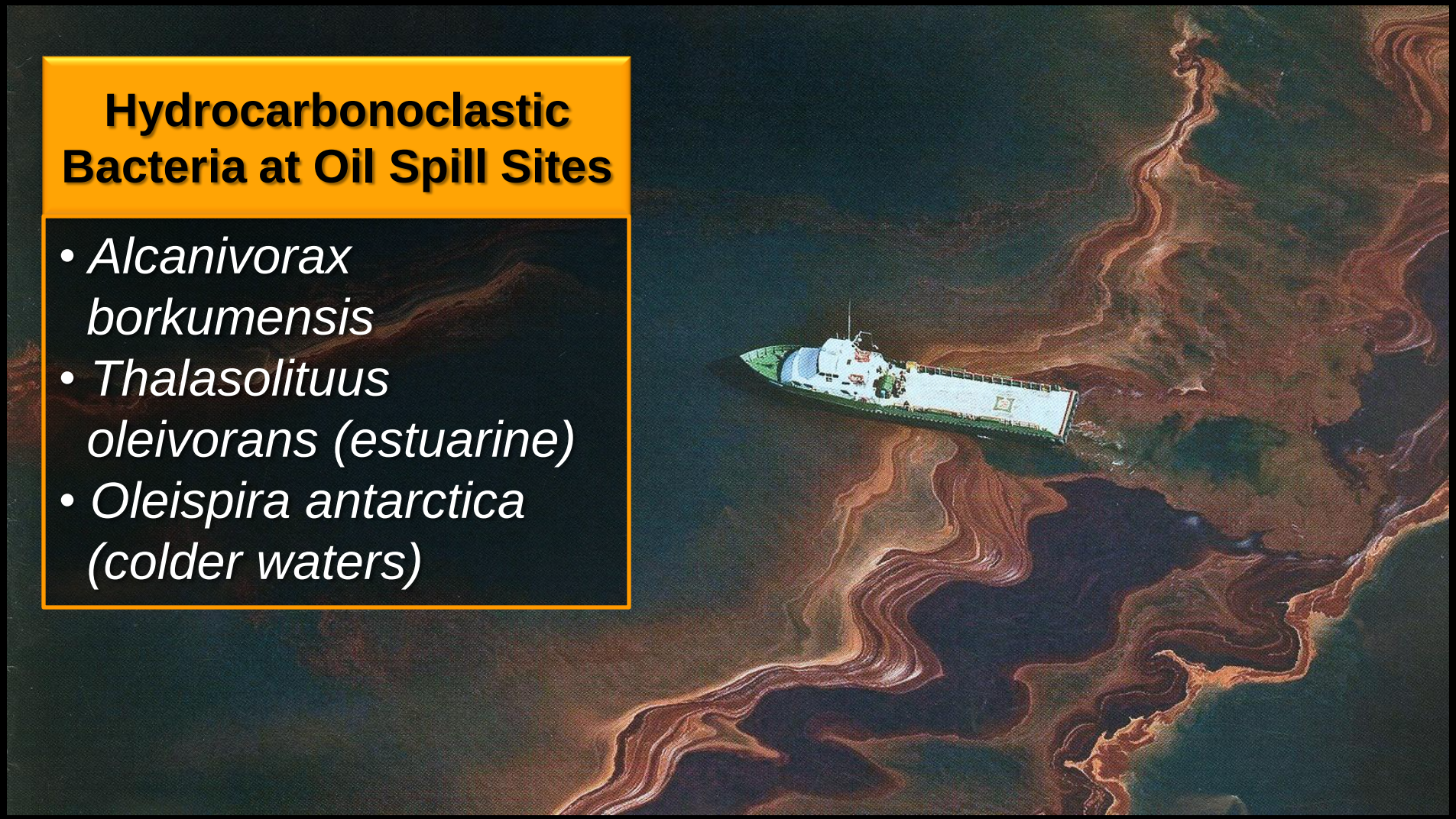
Ubiquitous Sensors

Synthetic Biology and Bio-inspired Systems Engineering

- use of microorganisms as bio-factories
- high performance materials made in completely different ways
- mimic resource efficiency of natural ecosystems
  - self-sustaining renewal resources
  - limit/eliminate waste stream
- manufacturing at room temperature in water versus high temperatures and toxic solvents
- highly distributed manufacturing units
- decoupling design and manufacture

Synthetic Biology:
Genetic Modification of Living Cells to Produce Biofuels And Other Complex or Scarce Materials

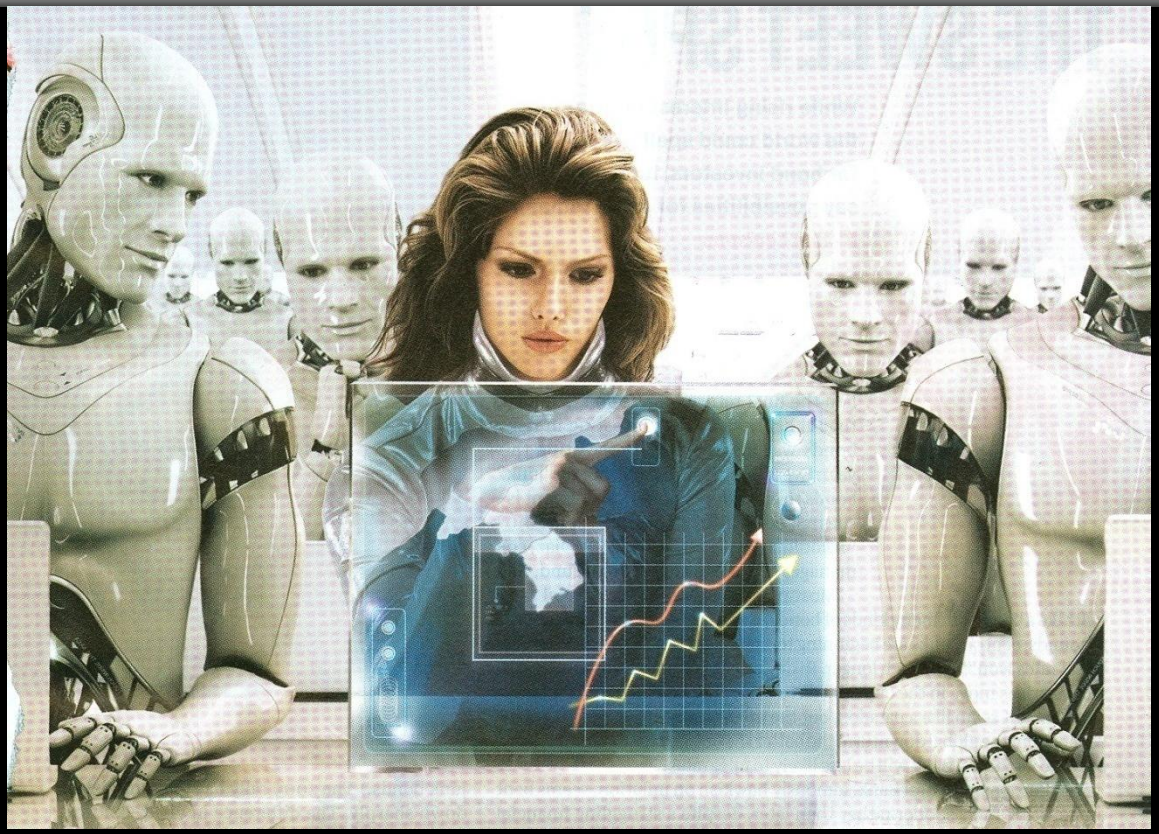
Designer Organisms and Environmental Bioremediation



Hydrocarbonoclastic Bacteria at Oil Spill Sites

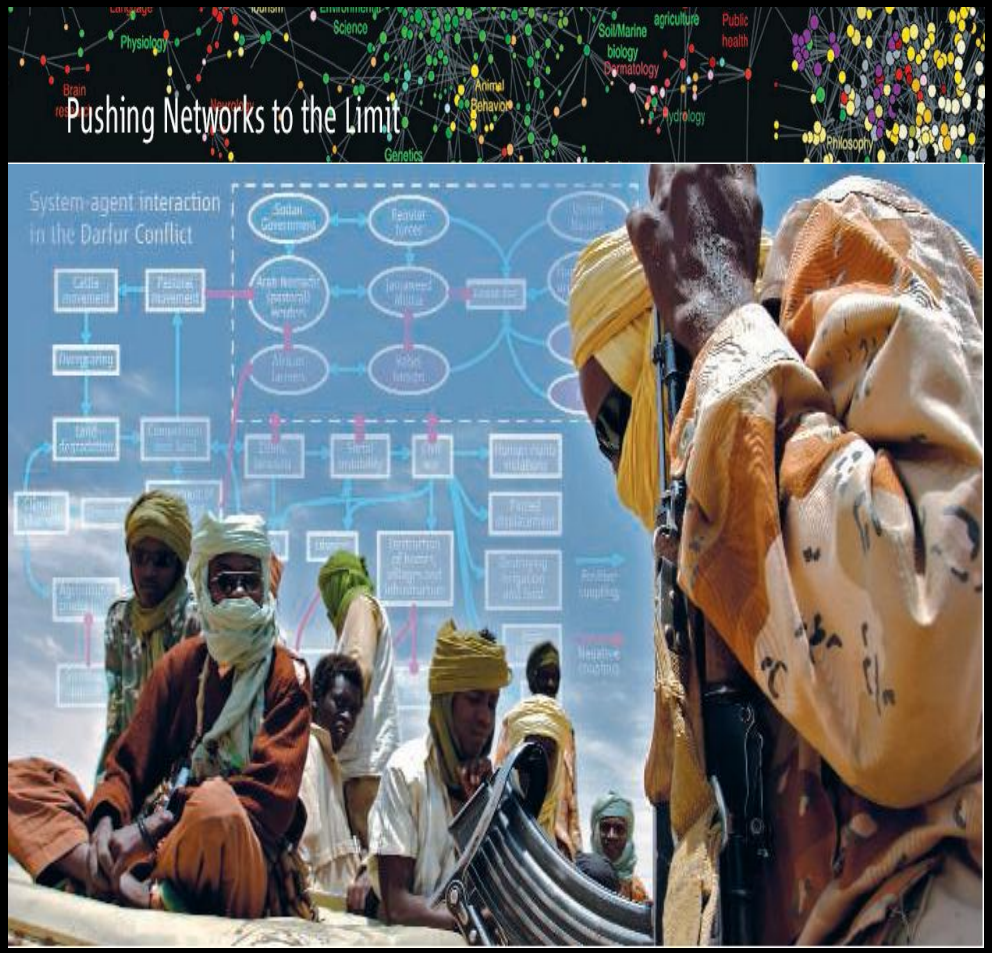
- *Alcanivorax borkumensis*
- *Thalassolituus oleivorans (estuarine)*
- *Oleispira antarctica (colder waters)*

Touch the Future:
Computing Platforms as Socio-Biological Systems



- modification of social patterns
- modification of cognitive structures
- memes as selection agents
- “the brain(s) in the cloud”

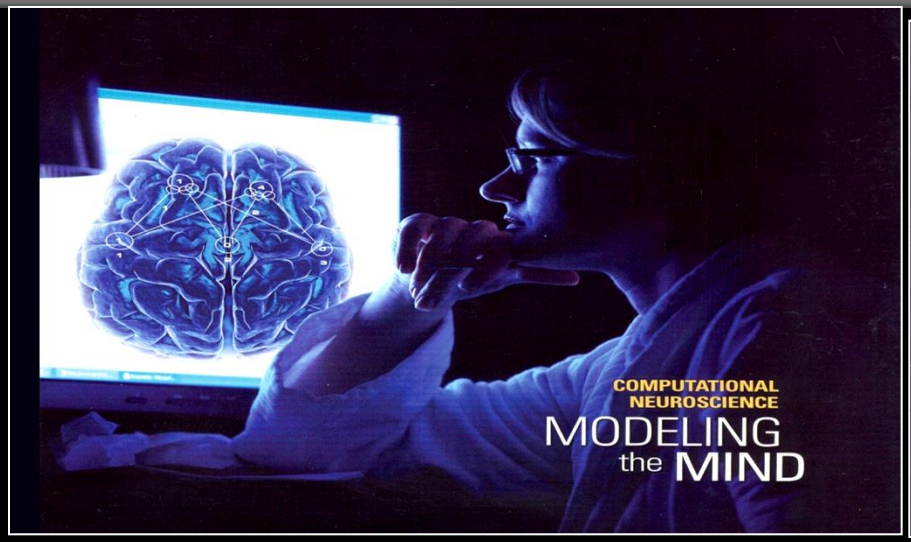
Ourselves and Our Interactions: The Ultimate Mathematical and Physics Problem?

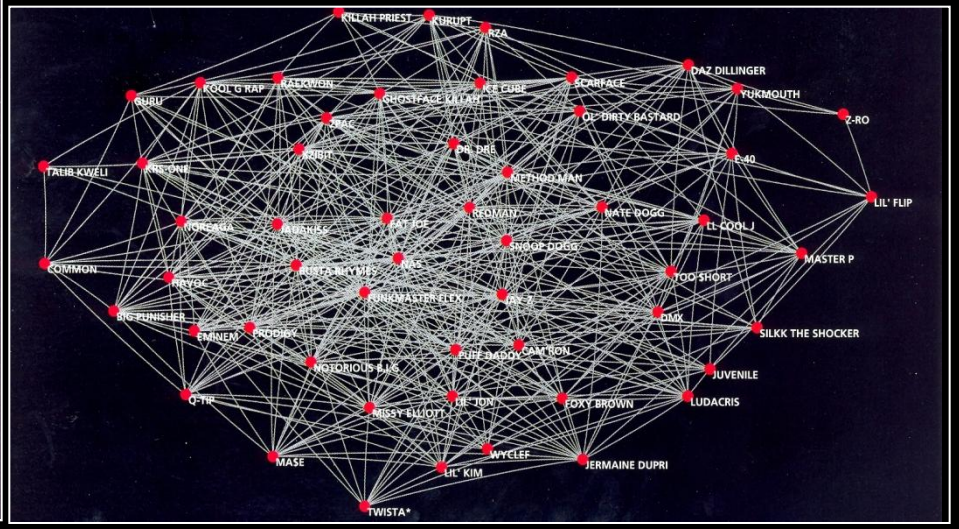


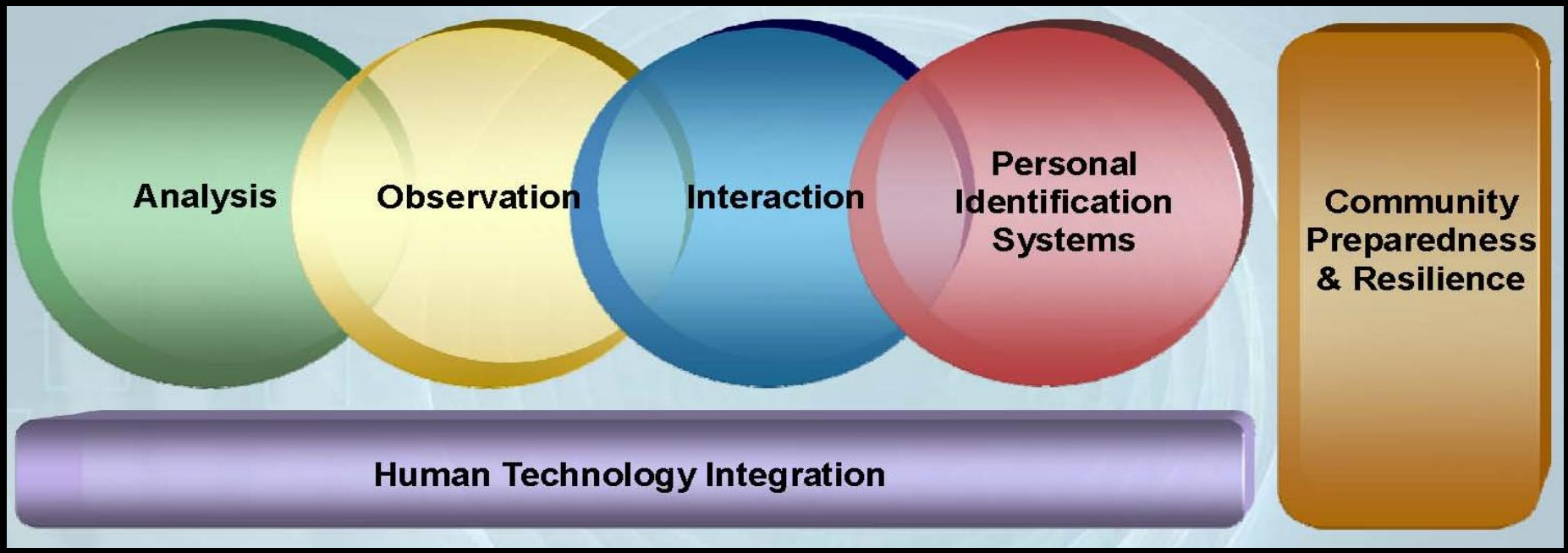
"Thanks to the proliferation of the many electronic devices
that we use on a daily basis,
from cell phones to GPS and the internet,
that capture everything from our communications
to our whereabouts,
the complex system that we are most likely to tackle first in a truly quantitative fashion
may not be the cell or the internet
but rather society itself"

A.L. Barabasi
Science (2009) 325, 413

Social Network Analysis and Predictive Behavioral Modeling

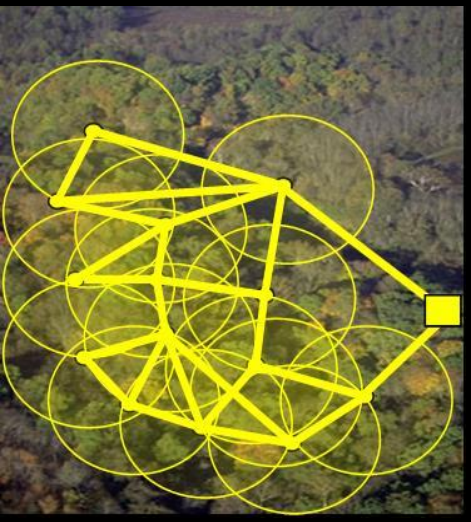


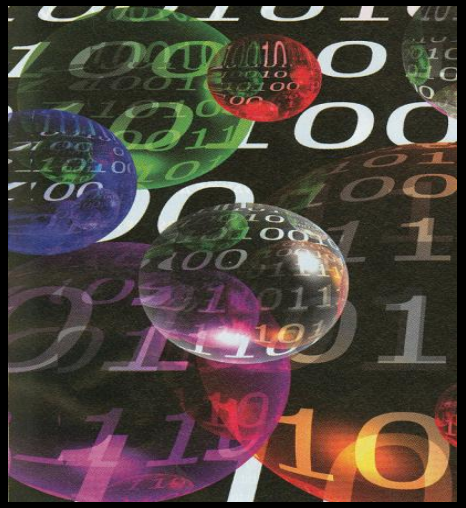


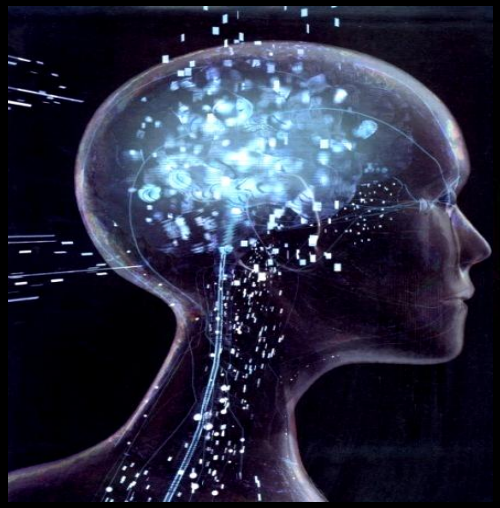


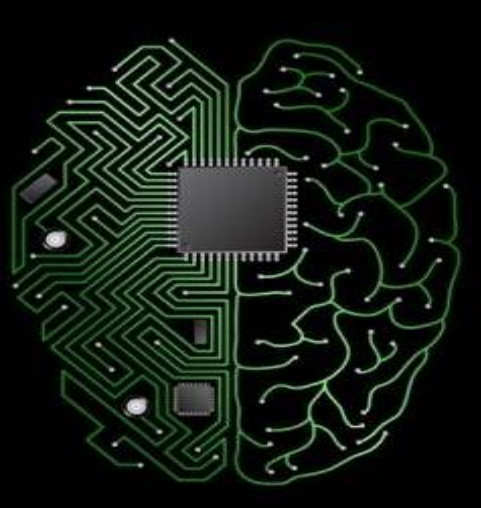
The Expanding Infocosm:
Massive Scale, Pervasive Surveillance and New Vistas in Cognition

Sensor Networks and Ambient Intelligence	Digital Anthropology: Surveillance and Privacy	Neurobiology and Decision Systems	Intelligent Machines



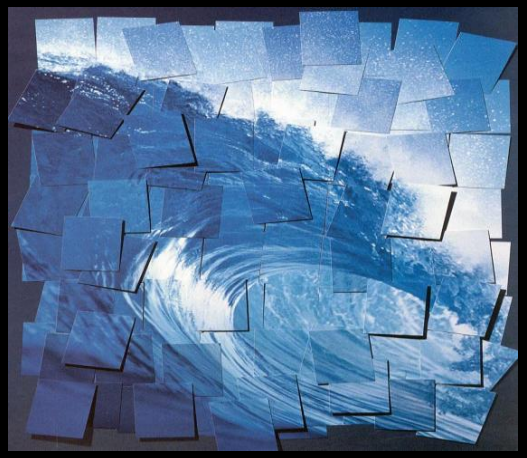


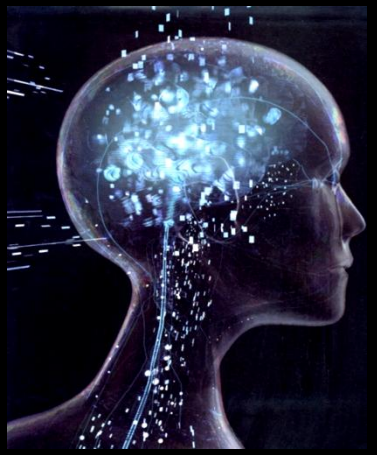




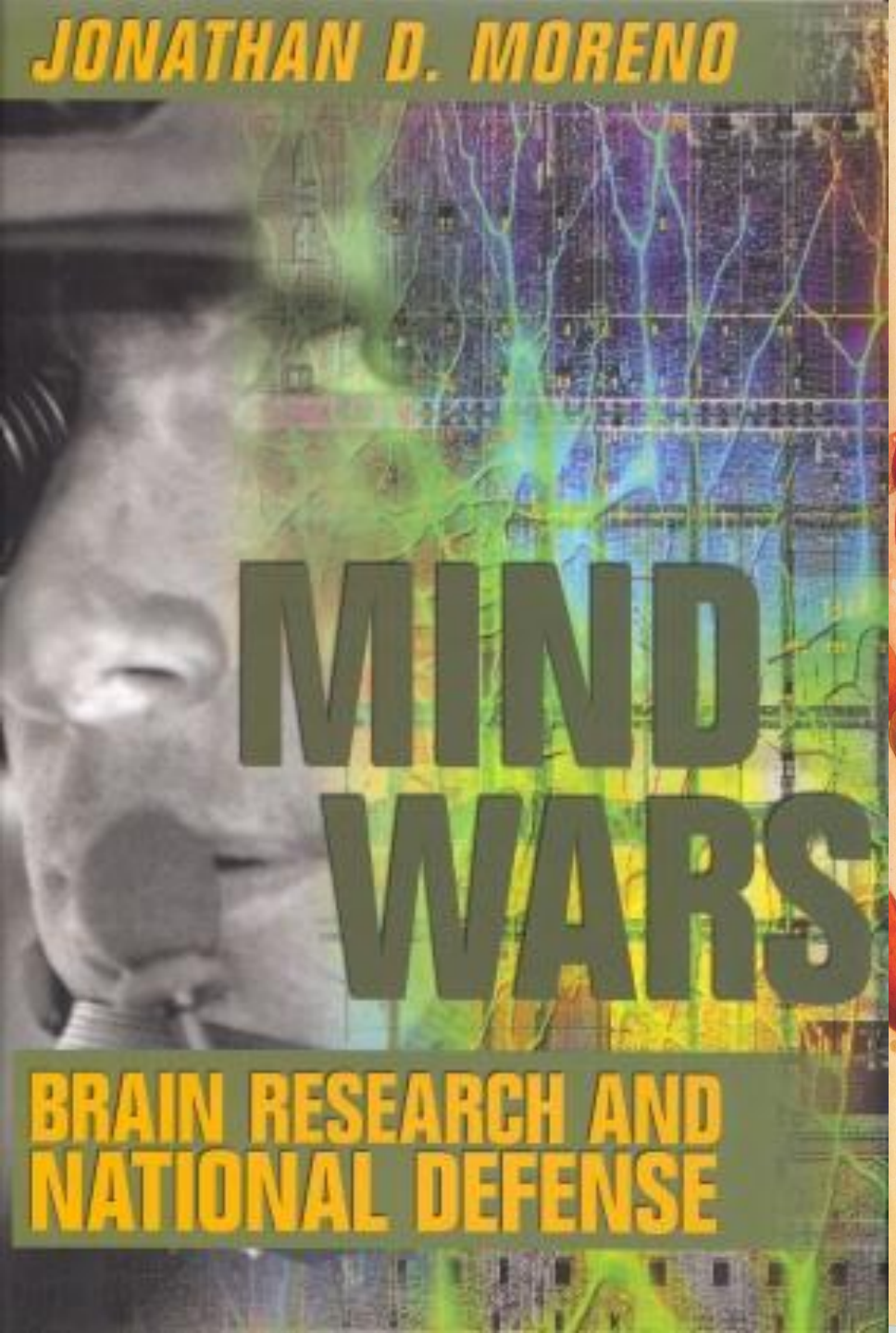
Massive Computing Power and Analytical Parsing

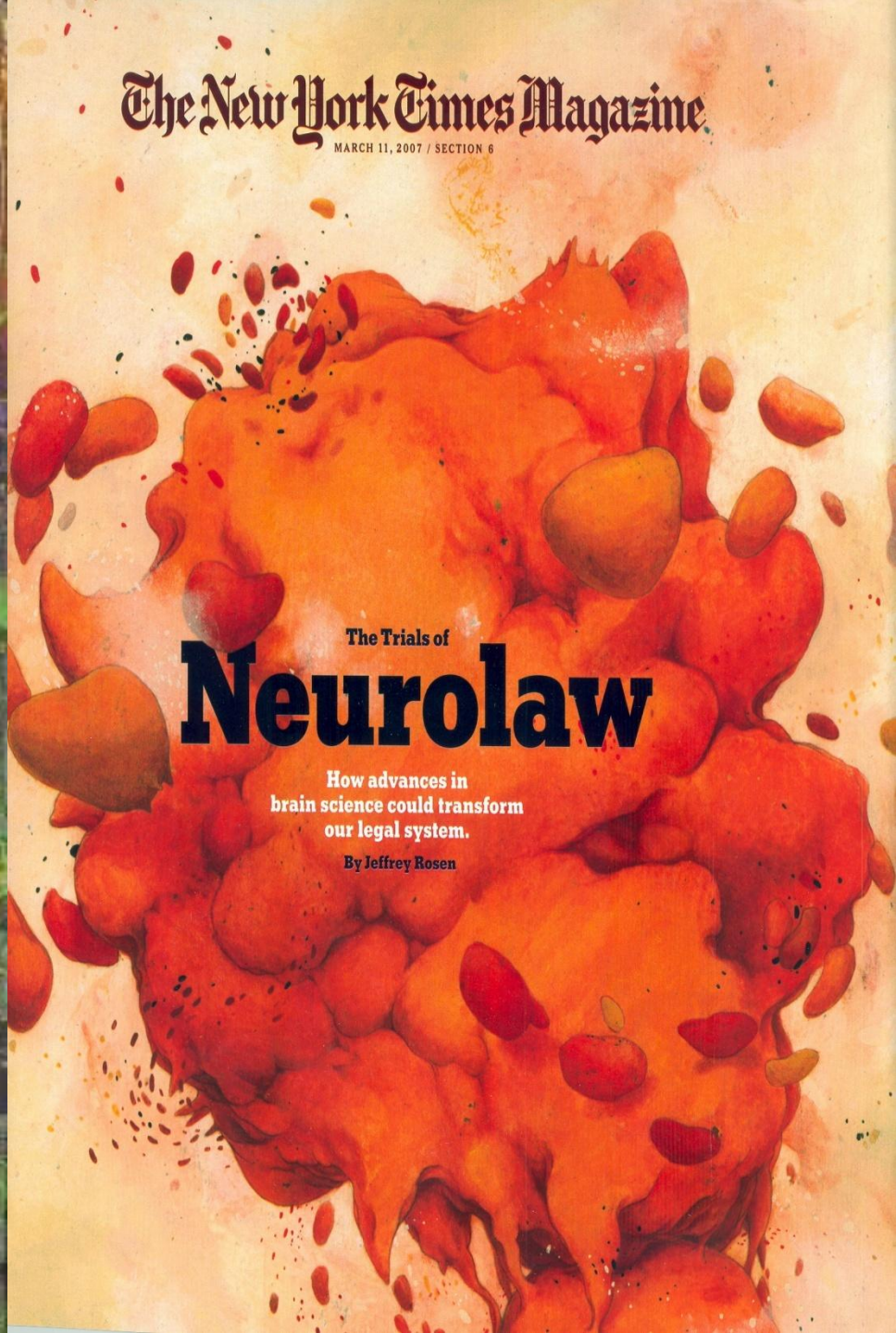
"Brains-on-Target": Interactive Immersive Visualization of Complex Datasets for Optimum Decisions





- large scale computer simulations of complex phenomena
- integration of high volume datasets
  - high resolution imaging and sensor streams
- VR and AR environments
- systemic application of advances in cognitive neurobiology
- scenario modeling and gaming for systems performance assessment and public policy

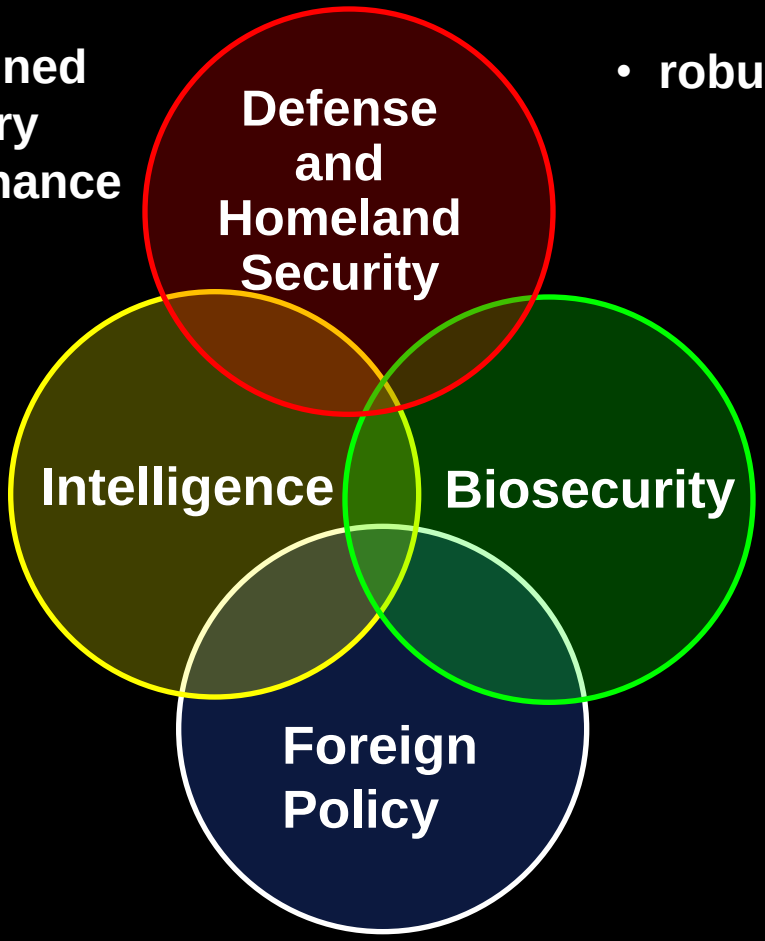

JONATHAN D. MORENO
MIND WARS
BRAIN RESEARCH AND NATIONAL DEFENSE


The New York Times Magazine
MARCH 11, 2007 / SECTION 6
The Trials of
Neurolaw
How advances in brain science could transform our legal system.
By Jeffrey Rosen

The Multidimensional Roles of Science and Technology in National Security

- sustained military dominance

- robust homeland defense



- new capabilities for threat ID and pre-emption

- managing 'the global commons'

- science and technology as key (but neglected) elements of foreign policy

The Fragmented Silos of USG: A Dangerous Vulnerability

Ignoring Systems Complexity: A Dangerous Void in Military Affairs and National Security

- increasing evidence of dysfunctional USG analysis and decision-making frameworks
  - dual-use technologies, healthcare, energy, environment, education
- growing expertise gap in USG agencies
  - threat diversification, new technologies
  - open-source analysis
- under-leveraged engagement with private sector
  - novel technology trajectories
  - broadening international scope
  - access to expertise pool
- anachronistic legal and regulatory frameworks for global challenges

The Retreat from Complexity: The Insularity and Risk-Aversion of USG Analytical and Decision Frameworks

- CB threat viewed by too many as a ‘too hard’ problem
- denial, avoidance, paralysis
- sustained focus/funding on ‘the familiar’ and engagement of ‘usual suspects’
- false assurances from flawed, “quick-fix” initiatives
- lack of coherent integrated strategy

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 tangible results
- extravagant resources are/will be wasted until a forceful integrated, cross-agency, cross-sector, ‘systems’ approach is adopted
- the engagement of corporate and international agencies is a critical success factor in addressing global biosecurity challenges