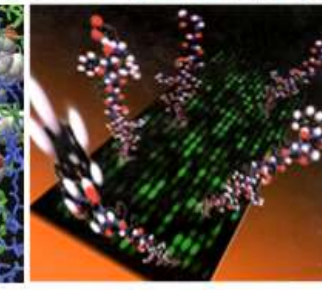
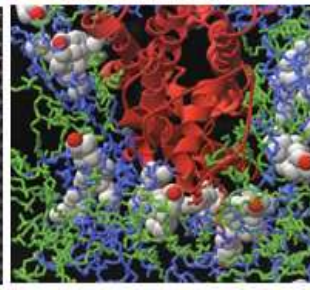
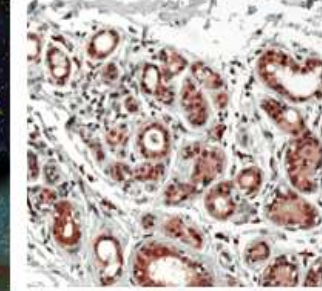
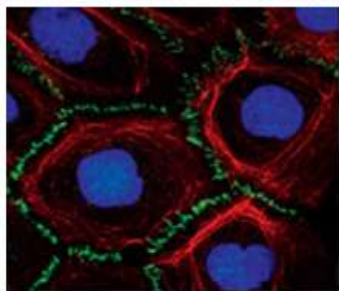
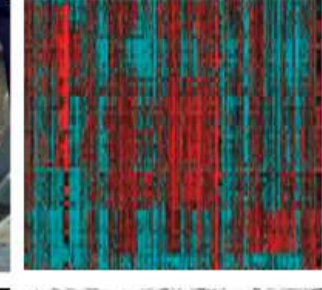
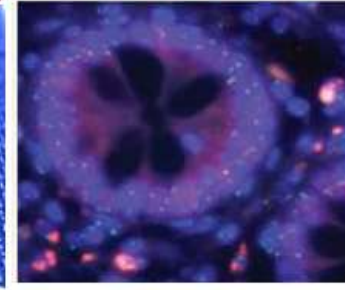
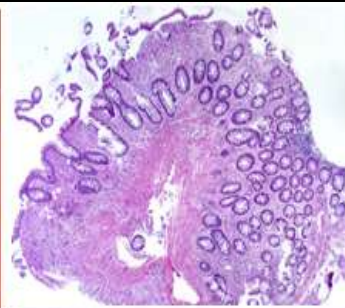
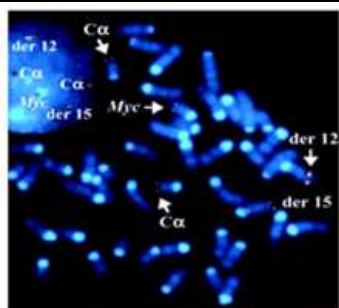


Biosecurity: Enhancing Security in an Increasingly Insecure World

Dr. George Poste
Chief Scientist, Complex Adaptive Systems Initiative
and Del E. Webb Chair in Health Innovation
Arizona State University
george.poste@asu.edu
www.casi.asu.edu

Guest Lecture
Biology and Society Bio 311/HPS 340; Fall 2012
4 October 2012

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



Biosecurity

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

Biosecurity

- **collective term embracing biodefense, public health and dual-use technologies**
- **fundamental component in national security**
- **understanding how changes in biological systems threaten health and societal stability**
 - **directly and indirectly**
 - **infectious disease, food production, climate change**
 - **disruption of transportation and supply chains, economic loss and risk of civil disorder**
- **chronic social and economic instabilities as triggers of political turmoil and military conflict**

Global Health: Understanding the Implications of Major Economic and Environmental Dislocations



Biosecurity

- **identification of the threat spectrum (awareness, intelligence)**
 - static, dynamic, overt or covert
 - natural or anthropogenic
- **adequacy of detection, pre-emption, preparedness, recovery and attribution capabilities (resiliency)**
- **risk assessment and needed level of investment in protection and preparedness (public policy)**
- **who pays for preparedness? (public policy, market dynamics)**
- **who is responsible/accountable for biosecurity? (public policy, organization, politics, media responses)**
- **myriad ethical and legal issues (surveillance, civil liberties, rationing, counter-terrorism targets, publication of dual-use knowledge)**

Understanding Complexity

**A Dangerous Void
in
Seeking Answers to Big Questions
and
Solutions to Global Challenges**

**Preparedness:
Building Resilient Systems
and
The “All Hazards” Challenge**

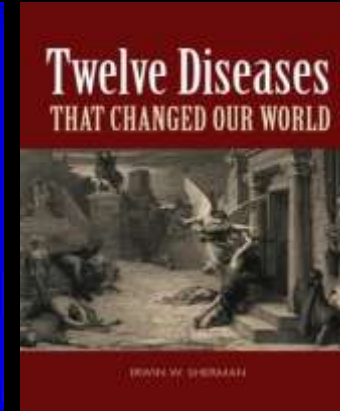
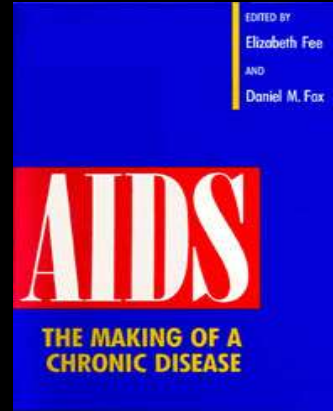
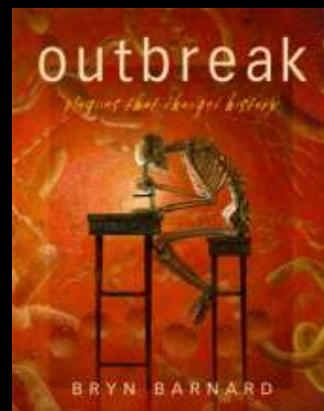
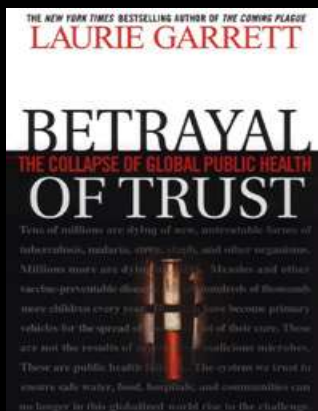
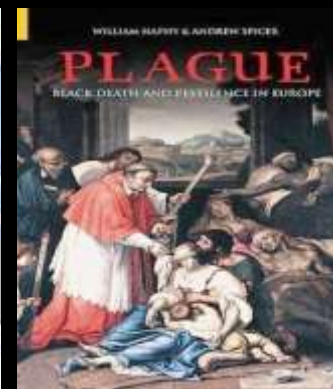
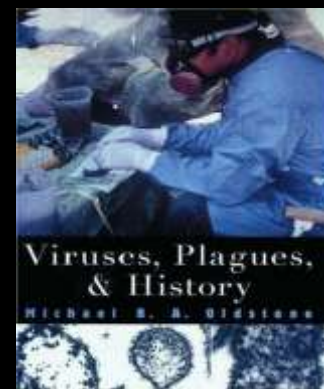
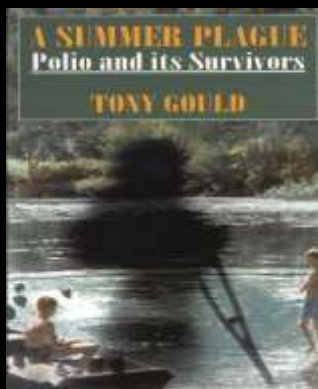
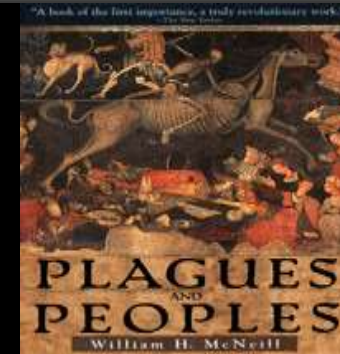
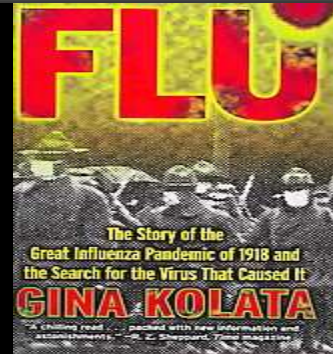
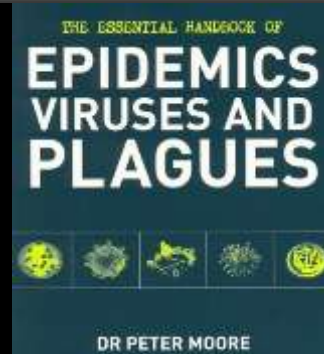
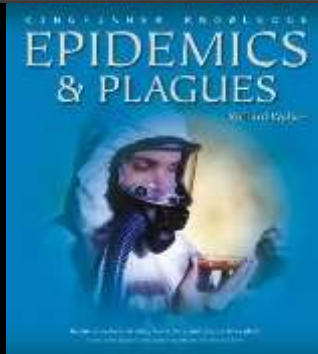
The 'Fog of Disaster': Crisis Standards of Care and Proliferation of Unanticipated Events and Consequences



Infectious Disease: A Powerful Force in Human Evolution

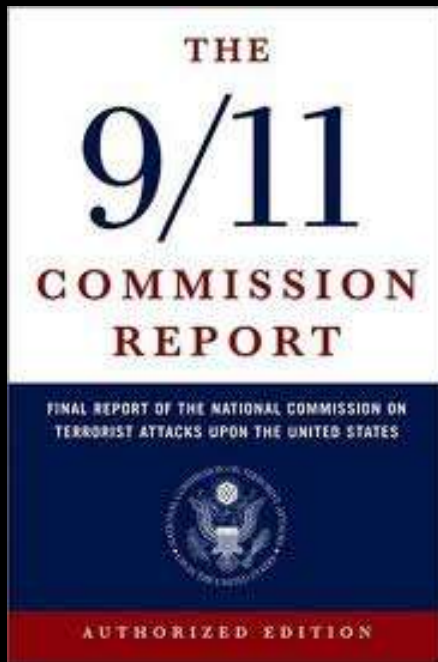


Infectious Disease: A Powerful Force in Human Evolution



Terrorism and The New Calculus of National Security and Foreign Affairs





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

9/11 Commission Report 2004

New Polarities and Asymmetries

- | | | |
|---|---|---|
| ● nation state adversaries | ➡ | ● non-state actors |
| ● geographically constrained adversaries | ➡ | ● new group identities via internet virtualscapes |
| ● dominant concept of national identity | ➡ | ● virtual Jihadist movement/caliphate |
| ● formal, national governing structures for diplomacy | ➡ | ● autonomous cells and global terror networks |
| ● western social democratic ideologies and international legal codes of conduct | ➡ | ● theocratic fundamentalism |
| | | ● 'no limits': 'duty to kill' |

New Polarities and Asymmetries

- massive cost of defense against expanding threat spectrum/sources 
- low cost offensive advantage to adversaries
- increasing fraction of scientific discovery with dual-use potential 
- threat proliferation and diversification
- rapid technology diffusion
- disruptive technologies 
- synthetic biology, cyberspace and outer space as new strategic vectors of radical change
 - industrial competitiveness
 - national security



HOW DO YOU STAY
ONE STEP AHEAD OF



THE NATION'S THREATS
WHEN THEY'RE



ALWAYS MOVING IN
NEW DIRECTIONS?

Building Resilient and Agile Systems for Biosecurity

Bioterrorism

**Infectious
Diseases
of
Natural
Origin**

**Environmental
and
Ecological
Impacts on
Disease
Emergence**



The Evolving Nature of Human Infectious and Parasitic Diseases

1407 species of human pathogens

- 538 bacteria ● 208 viruses ● 317 fungi
- 57 protozoa ● 287 helminths
- 60% are zoonoses
- over 70% zoonoses arise from interactions with wildlife
- Emerging Infectious Diseases (EIDs)
 - 58 in last 25 years
 - viruses significantly over-represented
 - helminths under-represented

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



TOM BROKAW
NBC TV
30 ROCKEFELLER PLAZA
NEW YORK NY 10112

1011240002

09-11-01

THIS IS NEXT

TAKE PENACILIN NOW

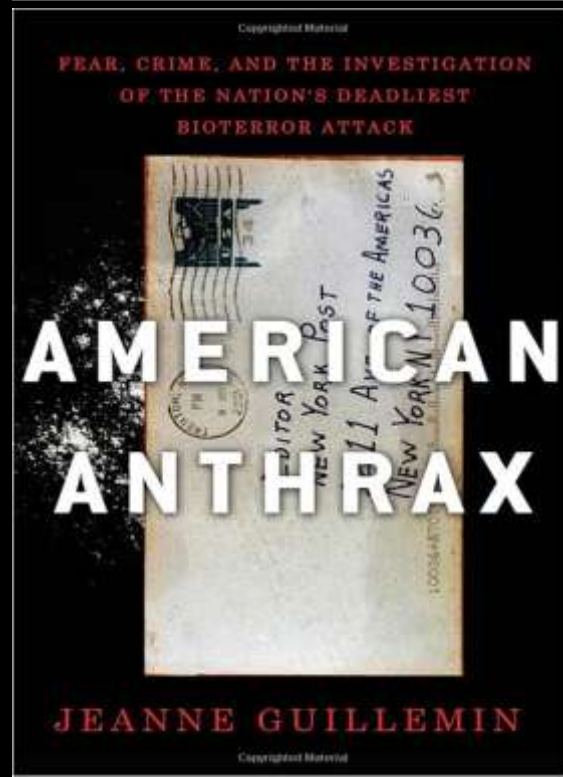
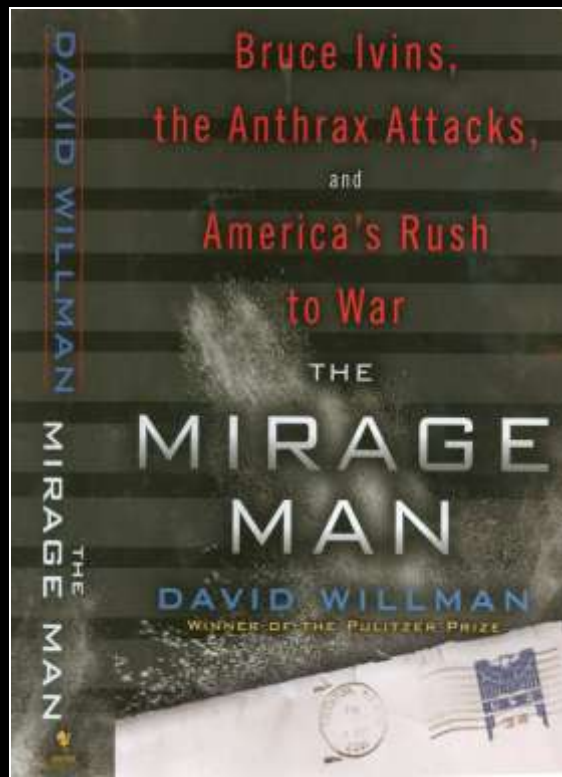
DEATH TO AMERICA

DEATH TO ISRAEL

ALLAH IS GREAT

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





**THE SOVIET
BIOLOGICAL
WEAPONS
PROGRAM**



A HISTORY

MILTON LEITENBERG

RAYMOND A. ZILINSKAS

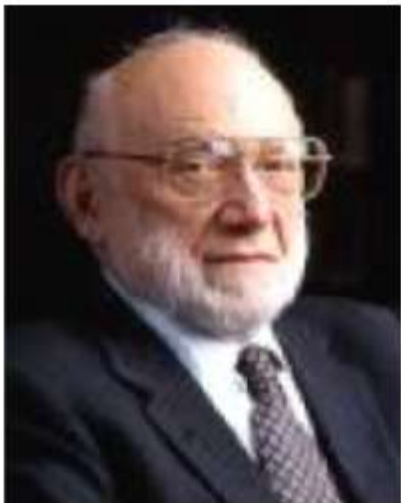
Delusion and Reality



**“It is time to close the book in infectious diseases
and declare the war against pestilence won”**

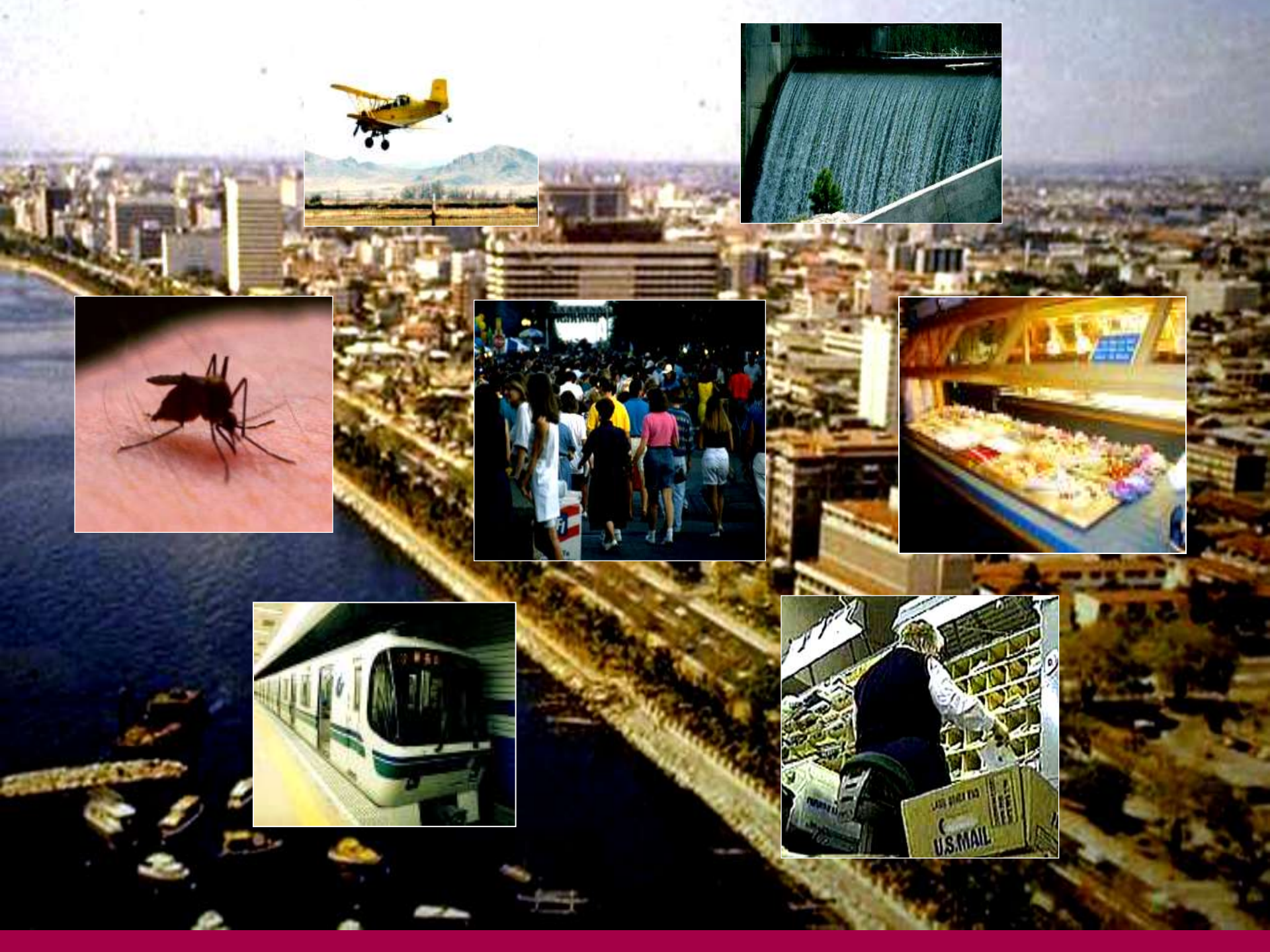
U.S. General William H. Stewart (1966)

Source: <http://www.lhncbc.nlm.nih.gov/apdb/phsHistory/faqs.html>



**“The future of humanity and microbes
will likely evolve as episodes
of our wits versus their genes”**

**Dr. Joshua Lederberg,
Nobel Laureate
Science (2000) 6, 427-30**



Preparedness: Building Resilient Systems



**“It’s no use saying: “We’re doing our best.”
You have got to succeed in doing
what is necessary”**

Sir Winston Churchill



**“Our role is to protect against
the unseen, the unexpected
and the unknown”**

**“It’s not what you don’t know
that can hurt you.
It’s what you can’t find”**

**Donald Rumsfeld
US Secretary of Defense**

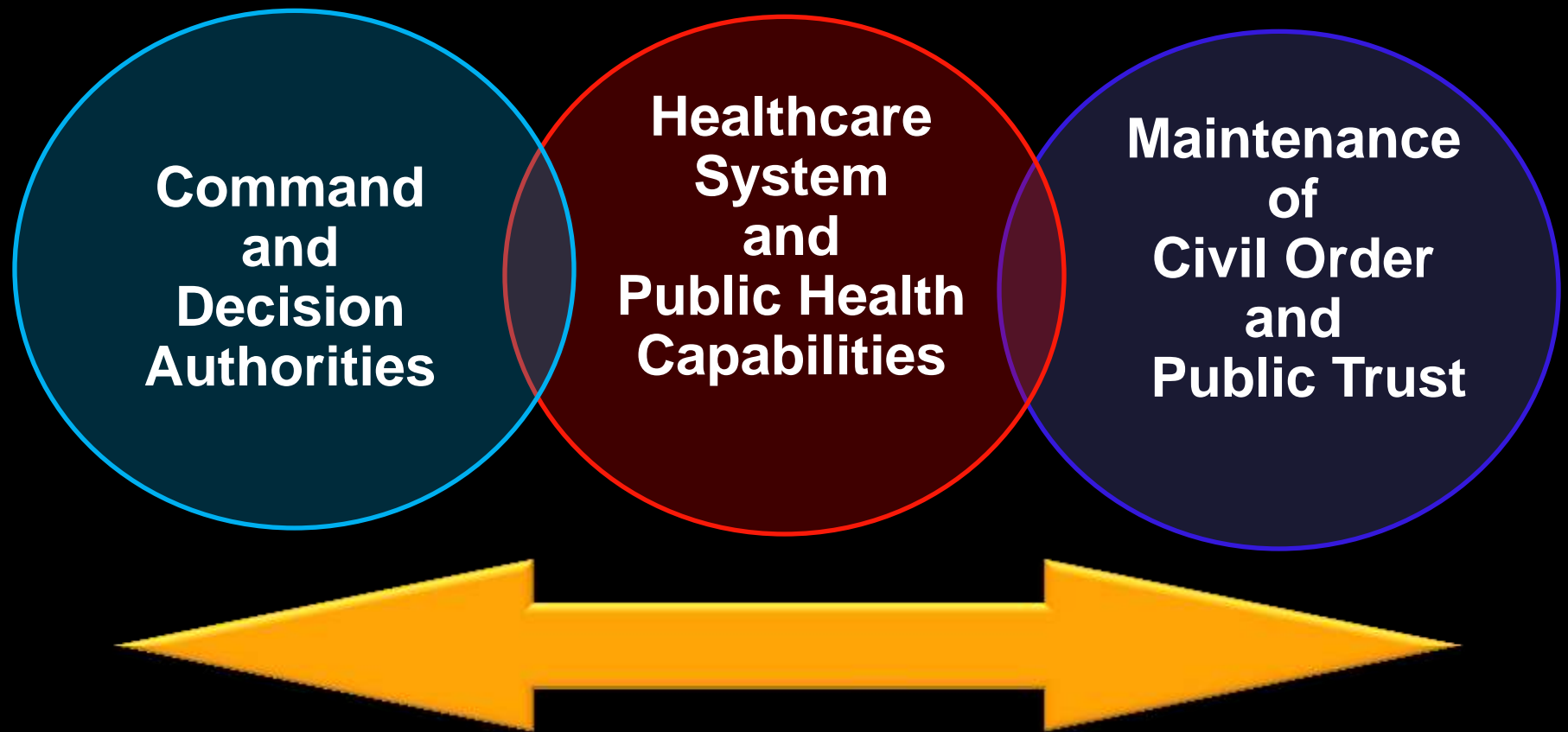
Preparedness: Building Resilient Systems

- is the problem defined?
- are there actions for meaningful intervention?
 - tractable, measurable
- if not, how can these be developed and implemented (resources, infrastructure, logistics cost)?
- what are the principal risks and obstacles to success? (technical, economic, political, social, legal)
- how are these barriers being addressed and, if not, what is needed to reduce/eliminate them? (vulnerability assessment)

Preparedness: Building Resilient Systems

- are the necessary resources available: financial, personnel, skills, infrastructure?
- have all elements been tested under simulated emergency situations?
- are organizational structures and processes sufficiently agile for rapid response?
- are roles, responsibilities and accountabilities defined and understood for every constituency involved?
 - from local to global

The Three Core Components of Bioincident Management

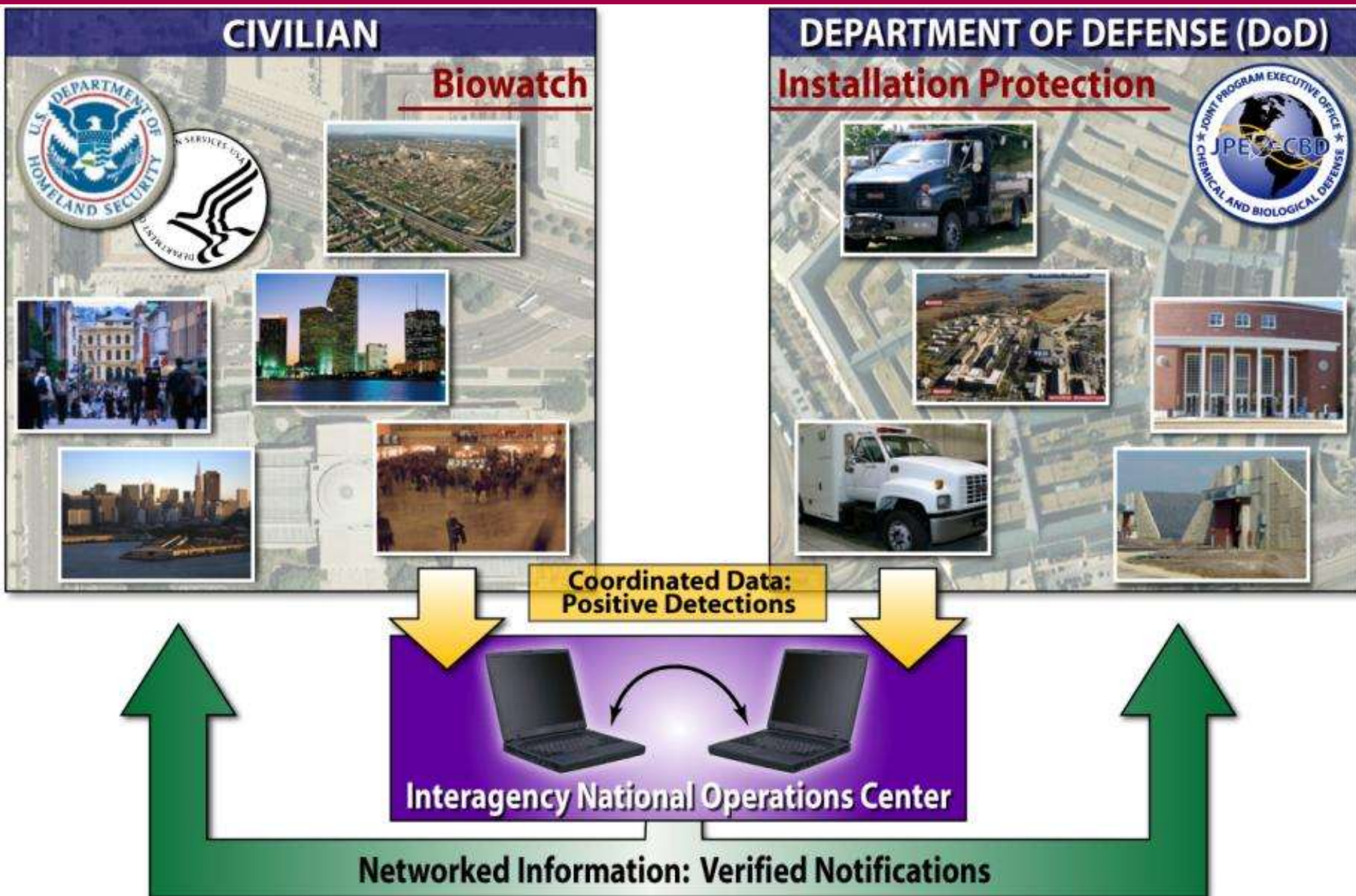


- robust inter-operable communication networks for real-time situational awareness and rapid actions
- managing the media and the 'worried well'
- transparency, credibility and public trust

The Imperative for Integrated CB Defense Capabilities



National Biomonitoring Notification Architecture



Speed Matters!

Delayed Detection Kills Lives

- **global surveillance against infectious disease outbreaks**
 - **E.H. Chen et. al. (2010) PNAS 107, 21701**
- **398 WHO-verified outbreaks 1996-2009**
- **median times**
 - **23 days for event detection**
 - **32 days for public communication**
 - **35 days for official laboratory confirmation**
 - **48 days for inclusion in WHO Disease Outbreak News**

No Ambiguity - No Error: No Problem! The Omnipresent Dilemma of Uncertainty When Political Leaders Want Certainty



“Insufficient data, Captain”



**“Insufficient data is not sufficient,
Mr. Spock.
You’re the Science Officer.
You’re supposed to have sufficient data
all the time”**

**Star Trek
The Immunity Syndrome**

Detection of Infectious Disease Threats:

Not A Hazmat or Wide Area Sensor Network Solution



Emergency Rooms and Farms Will be the Front Line



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

Signatures
of
Pathogenic
Organisms

Global
Network
of
Surveillance
and Diagnostic
Testing Systems

Rapid
Analysis
and
Response to
Diagnostic and
Surveillance
Information

Profile



Sense



Act



The Ever Shifting Dimension of EIDs

West Nile Virus, New York 2001



Monkeypox, USA May-June 2003



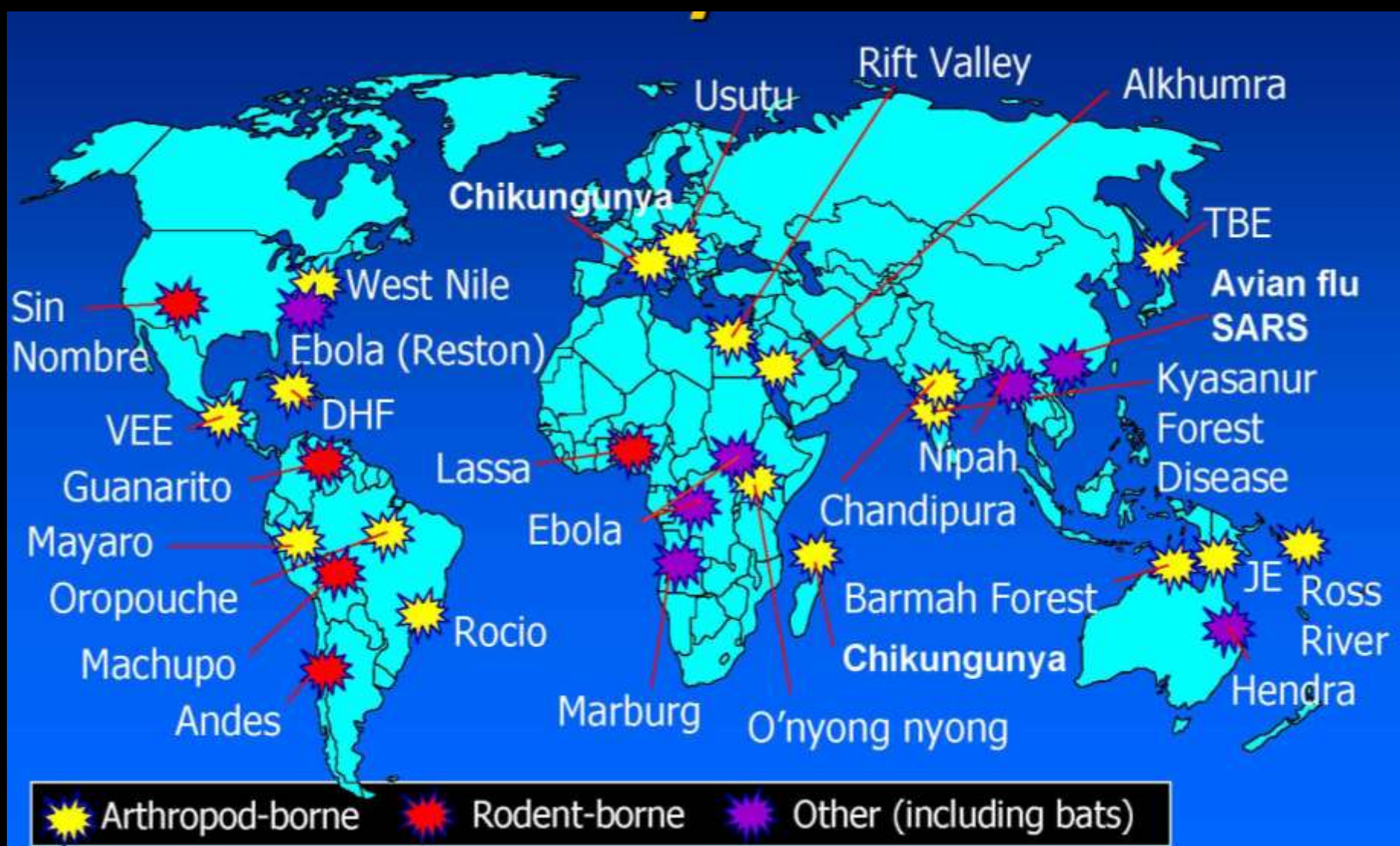
West Nile Virus, Dallas, TX 2012



African Swine Fever, Russia 2012

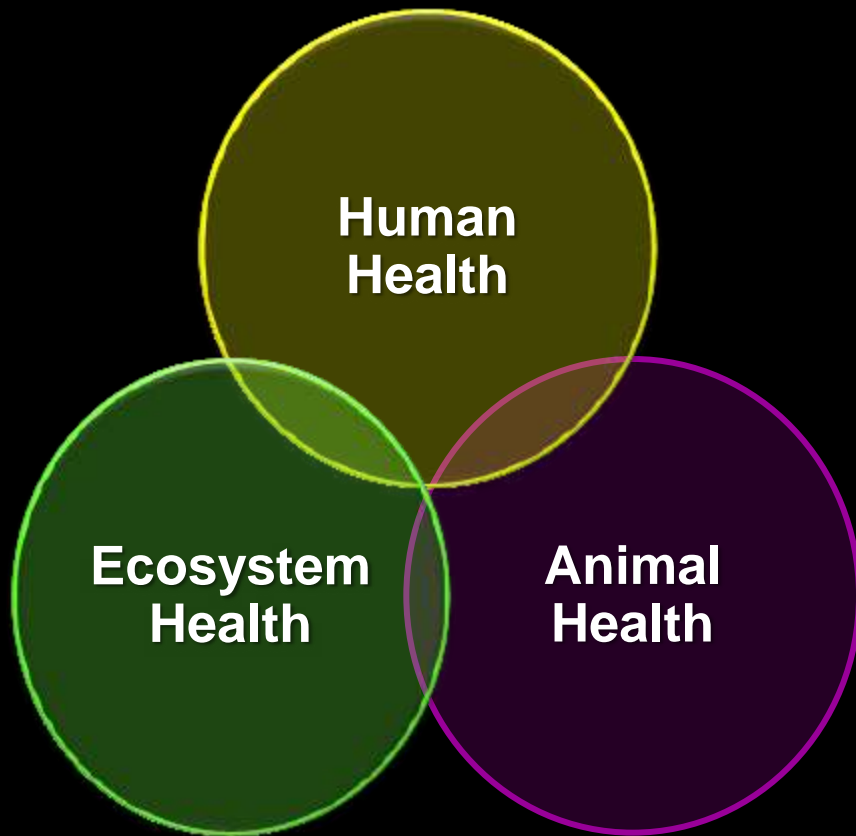


Emerging Infectious Diseases (EIDs)



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 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

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

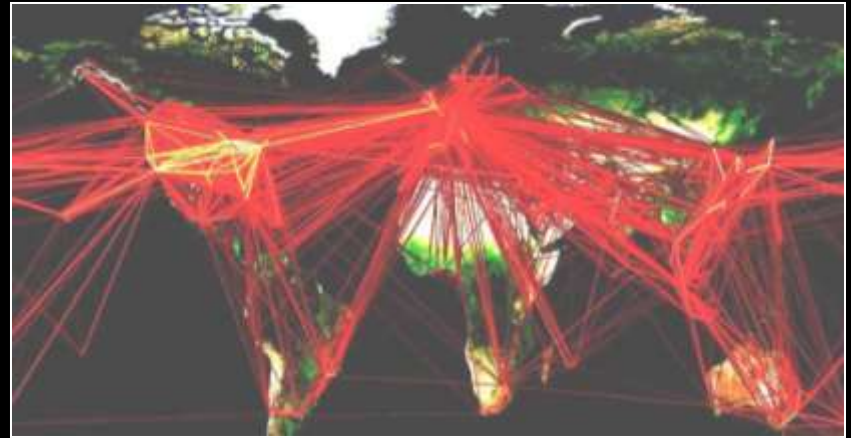
The Super Vector



**World Container
Traffic Doubled
Since 1997**



Billion Cross-Border Travelers



Global Food Networks





Global Disease Surveillance



EMERGENCY ID NET



Public Health Department's Surveillance



U.S. Influenza Sentinel Provider Surveillance Network



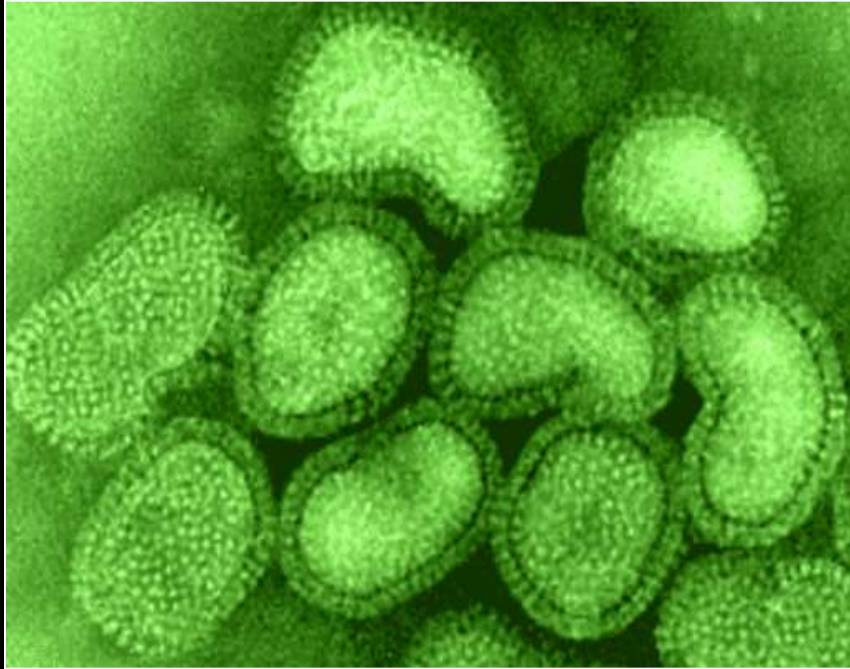
Quarantine Activity Reporting System (QARS).



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



Maintaining Global Preparedness for a High Virulence Pandemic



- H1N1: high transmissibility - low virulence/mortality
- H5N1: low transmissibility – high virulence/mortality
- H5N1 x (H1N1) or (X): potential for devastating pandemic

Sensor Networks for Remote Health Status Monitoring: Wireless Integrated Data Systems

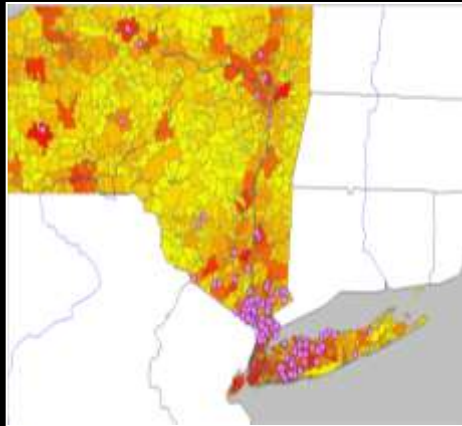


- geolocation data (where)
- temporal information (when)
- contextual information (what)
- improved decision support (action)

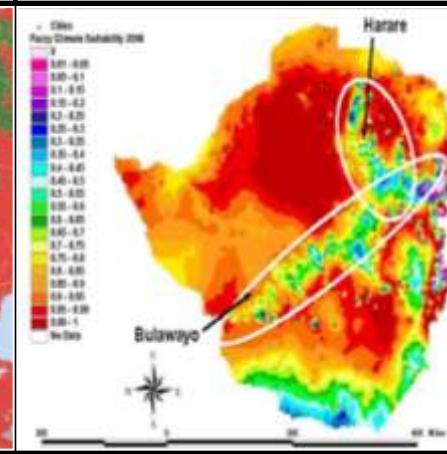
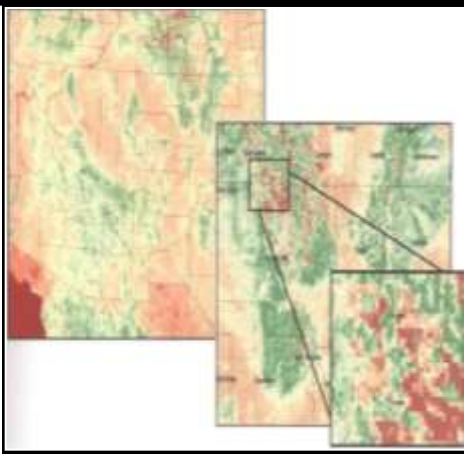
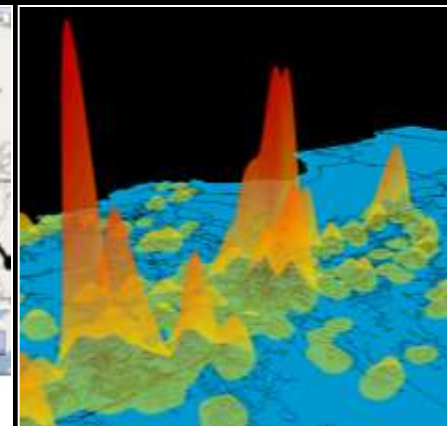
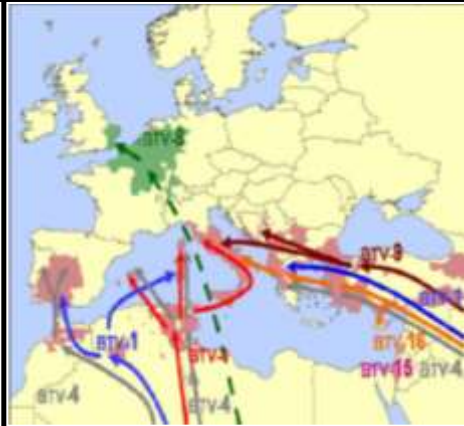


Geodemographic Information Systems: Mapping Disease Patterns and Modeling Trends

Anomaly Detection and Early Alert



Disease Progression

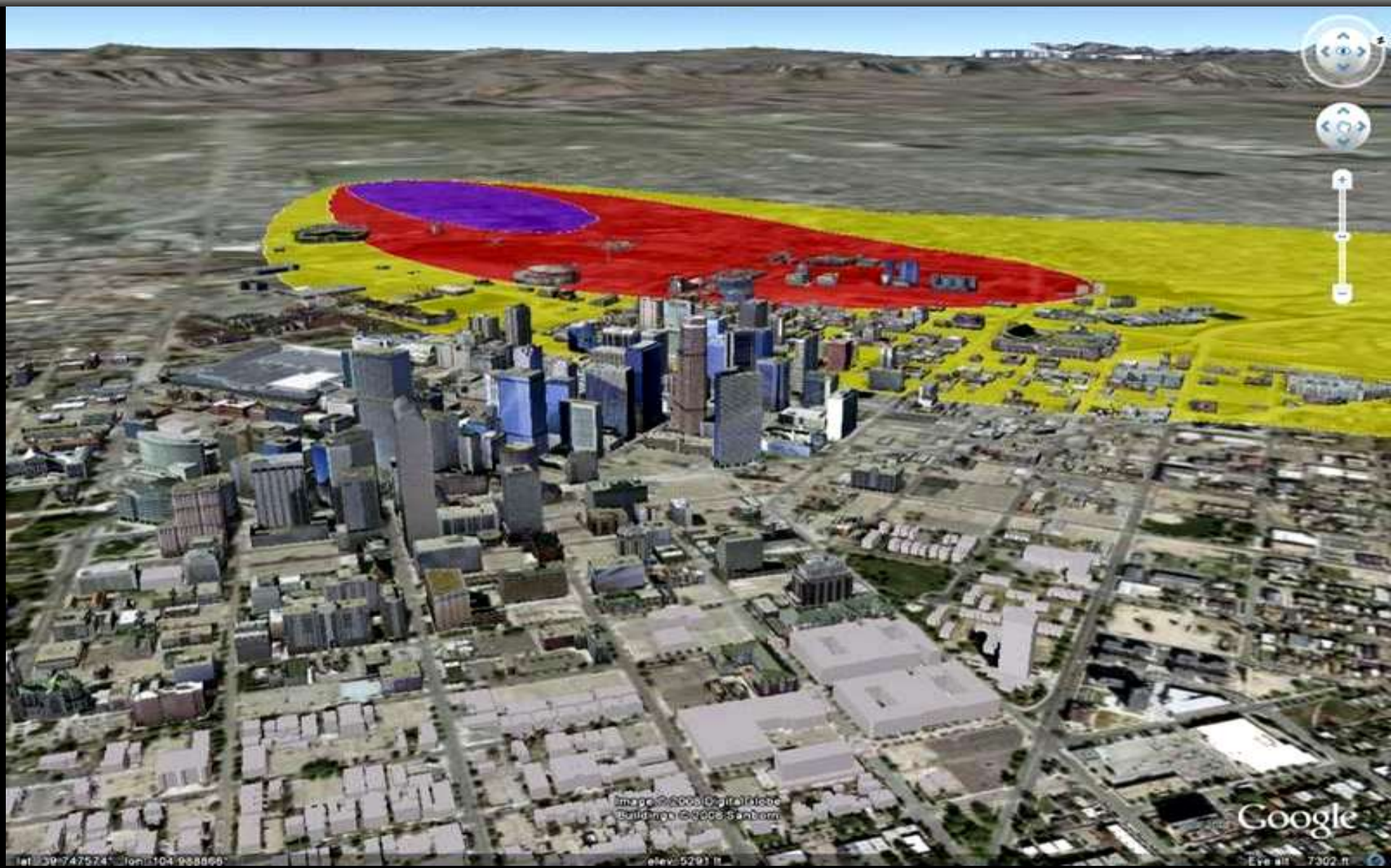


Satellite Surveillance and Predictive Modeling of Disease Trends

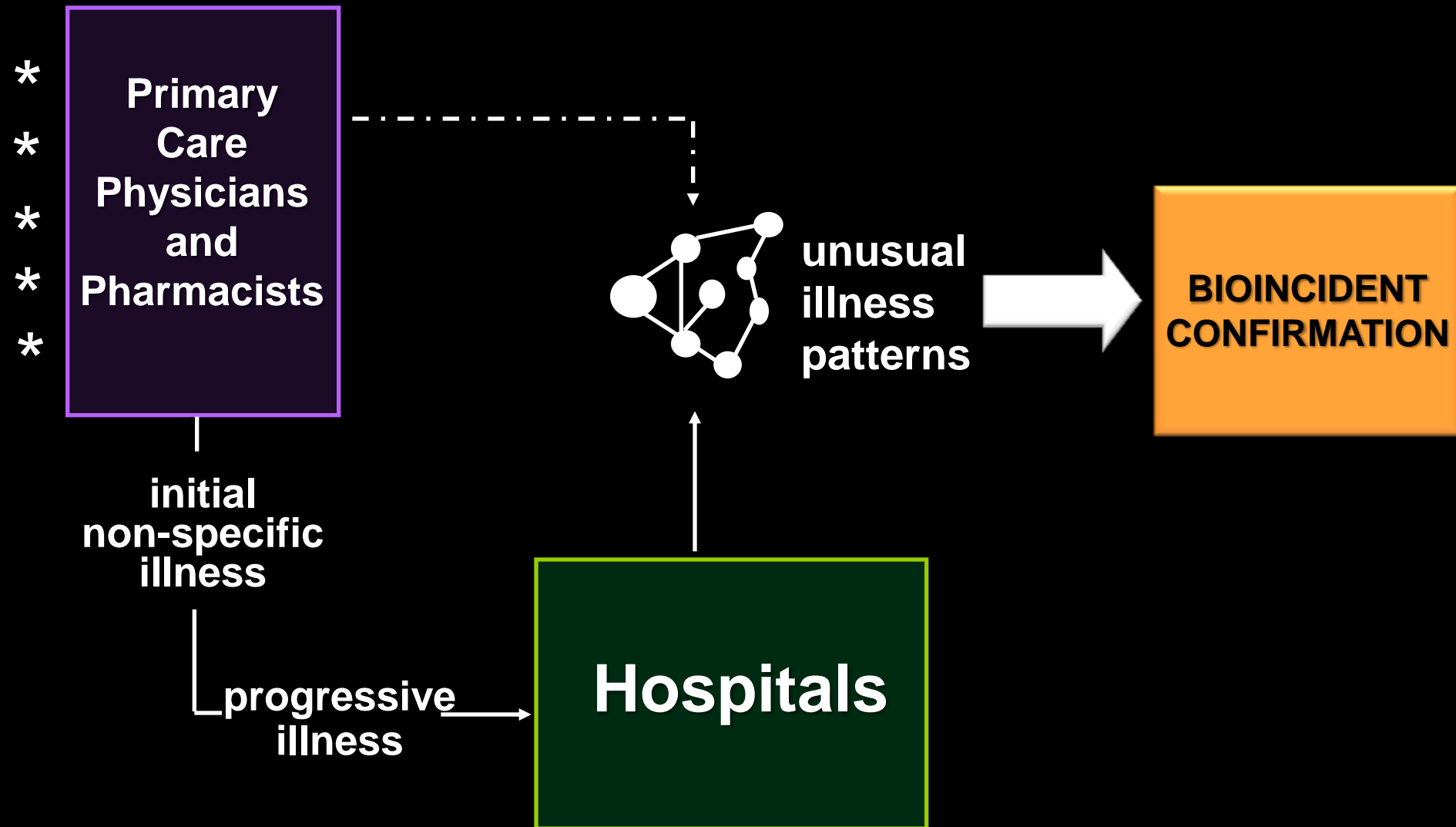
Building Resilience: Complex Systems-Based Integration of Diverse Functions and Organization



Modeling the Exposure Zone Geography (NCB) and Contagion (B)



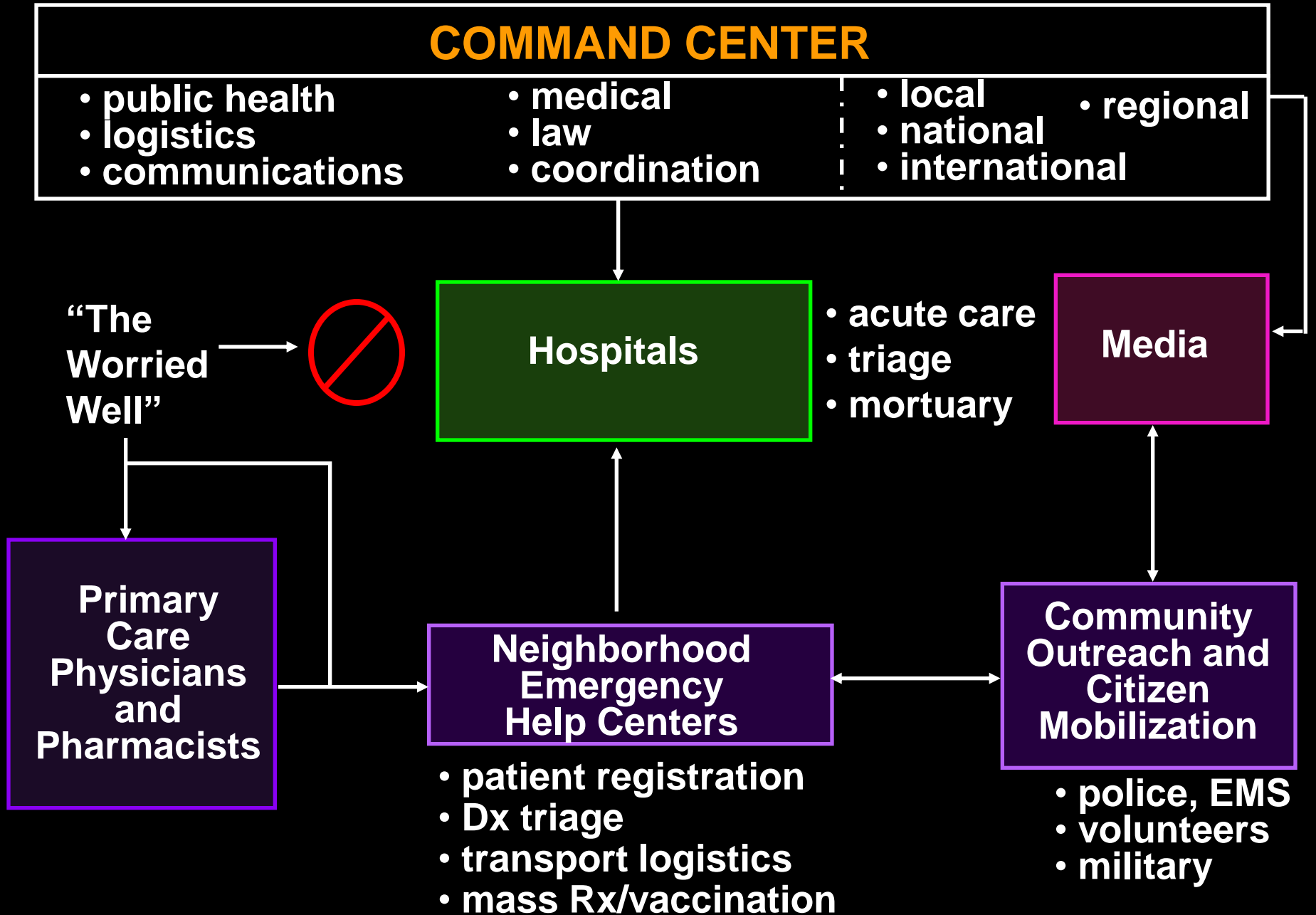
The Lag Phase in Bioincident Detection



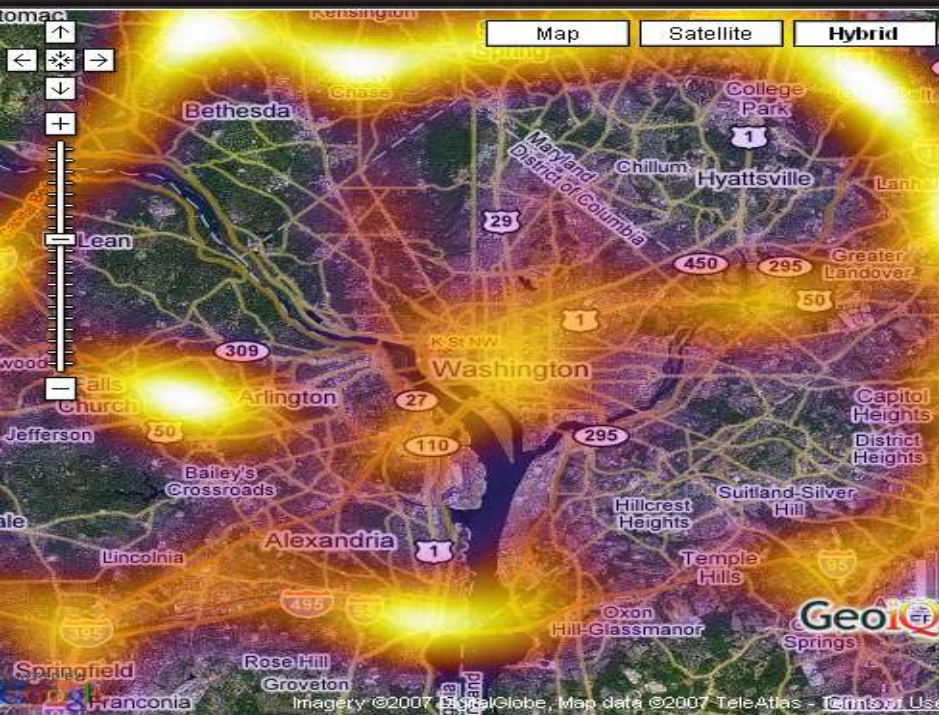
Location, Location, Location



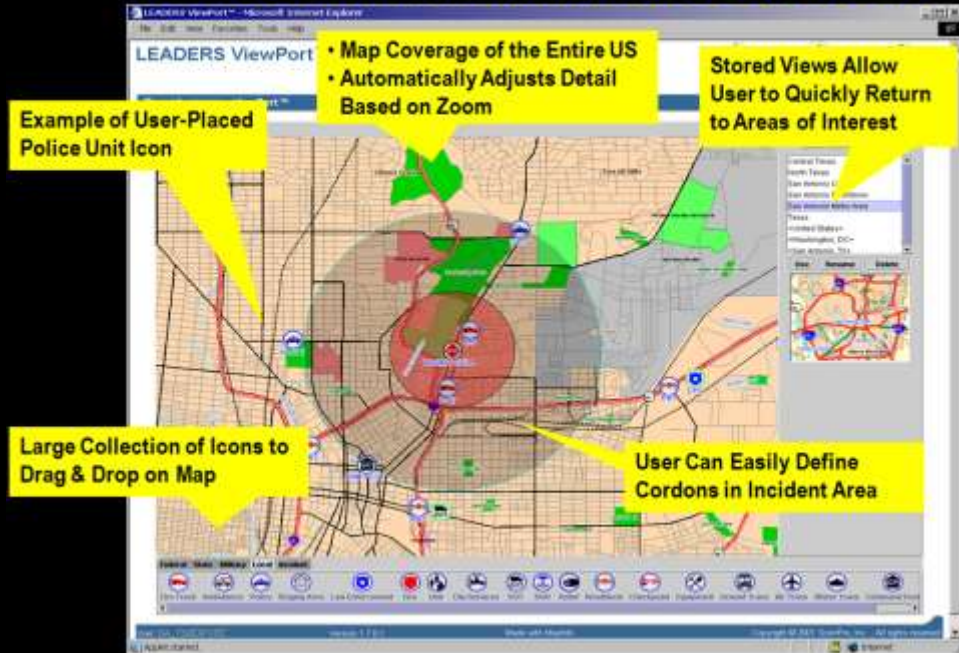
Consequence and Crisis Control in a Bioincident



Use of GIS for Management of Population Movement, Healthcare Facilities and Supply Chains for Optimum Bioincident Control



Resource/Situation Awareness - ViewPort™



- **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 prescriptions**

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

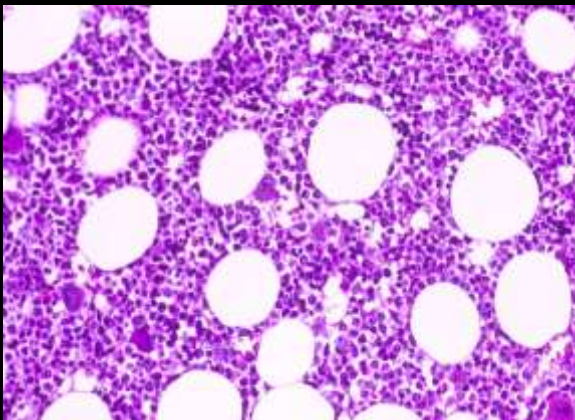
Children



Pregnant



Aged?



Immunosuppressed



**Impaired Major
Organ Function**



ICU-Critical Care

Control of Population Movement and Supply Chain Networks

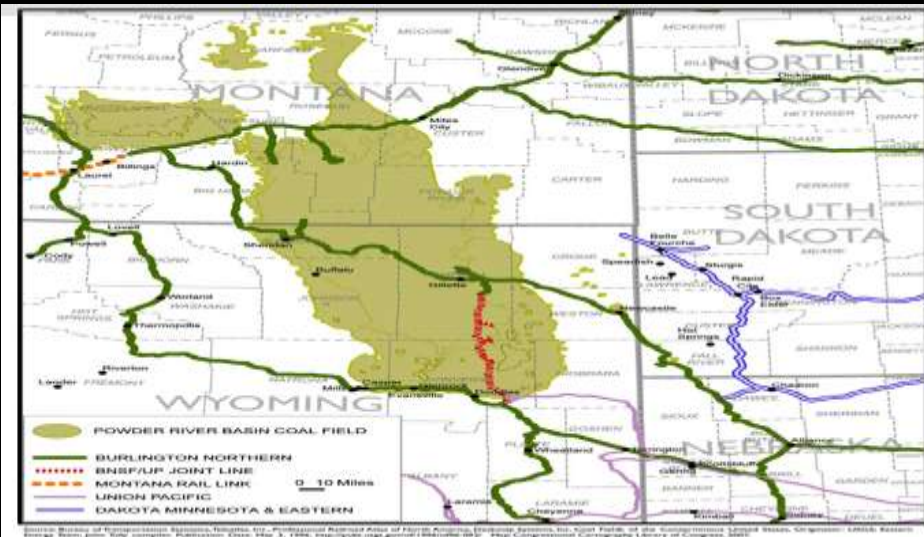
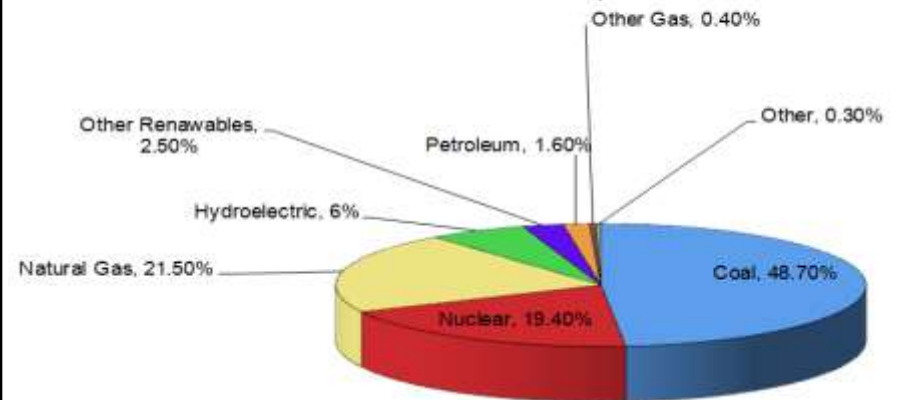


Vulnerability of Global, National and Local Supply Chains in a Major Epidemic/Pandemic

Energy



Net Power Generation in the US by Fuel Source, 2007



SO-H1N1 (2009)

**The first question President Obama received during his press conference on April 29, 2009 was:
“Why aren’t you closing the Mexico-US border to prevent the entry of swine flu?”**



Informing the Public: A Critical and Unenviable Challenge

- **media sensationalism and public panic**
- **pressure on governments to make illogical but politically expedient decisions**
- **in a severe outbreak the shock factor from level of fatalities will be unprecedented in modern peace times with unpredictable consequences**
- **unpredictable unilateral decisions by other governments, restricting trade, travel and shipment of goods**
- **extended supply chains might break down completely**

The Crucial Role of the Media in Incident Management



Pre-recorded Modules



Familiar (Trusted?) Face(s)



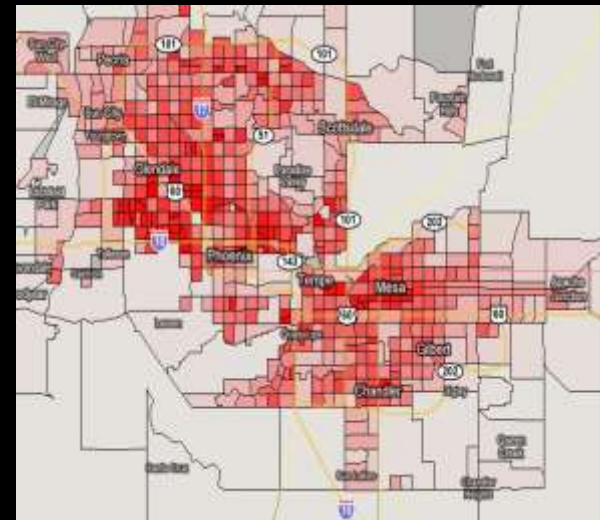
Credibility and Reality



Setting Examples to Limit Civil Disorder



Authoritative Leadership



Community Cooperation

International Response, Coordination and Containment of Global Incidents

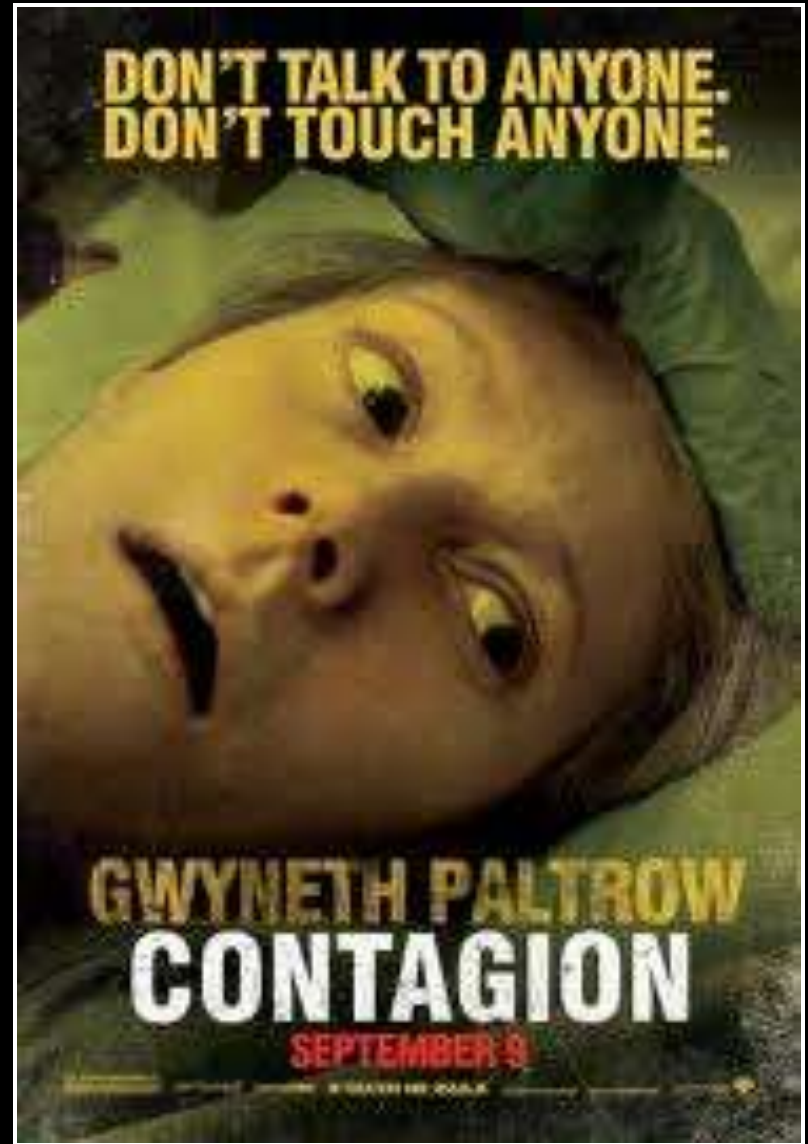
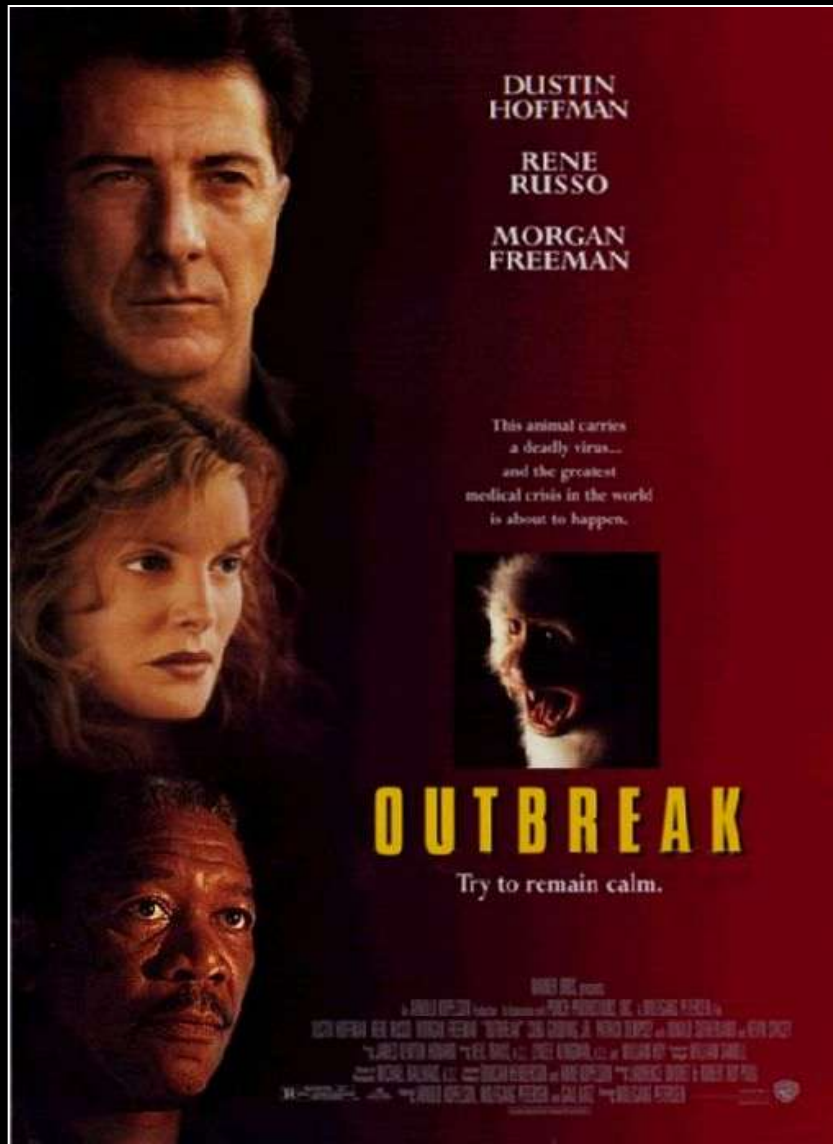
- **international Health Regulations and timely alerting**
 - **incentives not penalties**
- **epicenter “cordon sanitaire” and quarantine**
 - **prudent resource deployment**
- **national sovereignty**
 - **decisions**
 - **samples**
 - **treatment**
- **priorities for rationed distribution of treatments**
 - **producer nations vs. epicenter vs. DCs**
- **lack of harmonized international response policies**

Comfort, Complacency and Commitment

**“But I must go and meet the danger there,
or it will seek me in another place,
and find me worse provided.”**

- William Shakespeare, Henry IV

..... and then a technical miracle cure occurs with dramatic rapidity
..... and always created by an individual scientific genius



**Bad Bugs
and
Few New Drugs**

OUTBREAK: Deadliest Pandemics in History

OUTBREAK

Deadliest Pandemics in History

Because a virus doesn't care about state lines or national borders, it can wipe out millions and span multiple continents rapidly. Here is a look at the infectious diseases the world has battled throughout history.

What is a Pandemic?

Derived from the Greek word *pandemos* meaning "pertaining to all people," a pandemic is a widespread disease that affects humans over a wide geographic area.

Key:

PANDEMIC YEAR DEATH TOLL



A bubo is an abnormal swelling of the lymph nodes.



Honorable Mentions

Although the following viruses do not have a figure for total amount of lives claimed, they continue to terrorize various areas around the world.

MALARIA 1600 - Today

Common Symptoms

Chills, Headache, Fever, Jaundice, Muscle Pain, Nausea, Vomiting, Seizures

Death Toll

According to the World Health Organization's 2010 "World Malaria Report," an estimated 781,000 people are killed by the virus every year.

TUBERCULOSIS 700 BC - Today

Common Symptoms

Chest Pain, Cough, Fever, Chills, Fatigue

Death Toll

There are almost 2 million tuberculosis-related deaths worldwide every year.

YELLOW FEVER 16th Century - Today

Common Symptoms

Bleeding, Fever, Nausea, Vomiting, Delirium, Seizures, Jaundice

Death Toll

Worldwide, 30,000 deaths are caused by the infection every year.

MEASLES

7th Century BC - 1963

200 million

HIV / AIDS
1981 - TODAY

25+ million

PLAGUE of JUSTINIAN
541 - 750

25 million

SMALLPOX

10,000 BC - 1979

300+ million

Bigpox?

In terms of an estimated death toll, smallpox is the deadliest pandemic in history. The highly contagious, non-infectious infection has killed more than 300 million people. Some believe that 30 percent of the native population of the New World was wiped out by the disease.

SPANISH FLU

1918 - 1919

50-100 million

BLACK DEATH

1340 - 1771

75 million

Ring Around the Rosie, a Pocket Full of Plague

Legend says the Black Death plague inspired the children's rhyme "Ring Around the Rosie," which alluded to the rash-like rings and ashes of the deceased victims.

TYPHUS
430 BC - TODAY

4 million

CHOLERA
1817 - TODAY

3 million

THIRD PANDEMIC
1855

12 million

HONG KONG FLU
1968 - 1969

1 million

Comfort and Complacency: The Enemies of Vigilance and Preparedness





Copyright of Sidney Harris 2003, <http://www.ScienceCartoonsPlus.com>

“WOULD YOU LIKE THAT TO BE A STEAK WITH A BROAD-SPECTRUM ANTIBIOTIC, OR ONE WITH A VARIETY OF THERAPEUTIC PROTEINS?”

NO ESKAPE!: Resistant Bugs and Few New Drugs



- increasing resistance in G⁺ and G⁻ pathogens in hospital and community settings

- the **ESKAPE** pathogens

Enterococcus faecium

Staphylococcus aureus

Klebsiella pneumoniae

Acinetobacter baumannii

Pseudomonas aeruginosa

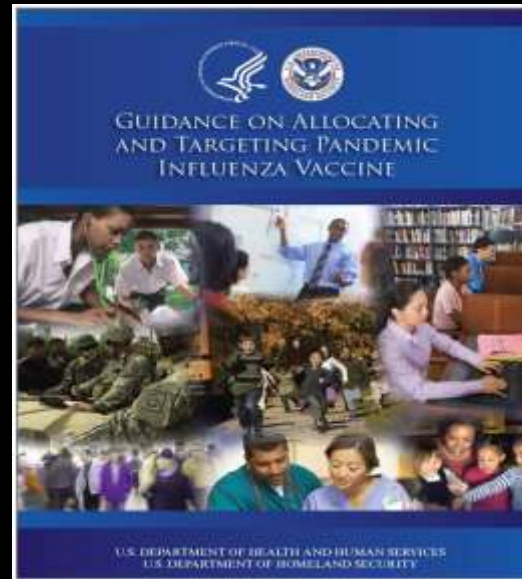
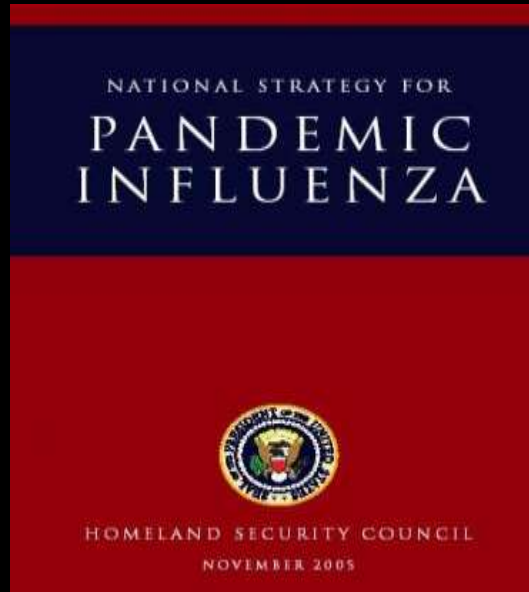
Enterobacter species



SOI H1N1 Influenza (“Hamageddon?”)



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
USA Today 8 Oct. 2009**

Challenges in Development and Production of Prepandemic Influenza Vaccine

- ultimate causative agent is not known
- timing cannot be predicted
- 13 billion doses required
- harmonized global policies
 - production
 - priorities for use
 - rapid regulatory approval

Public Response to H1N1 Vaccine for Pandemic Protection



**“Millions demand it,
millions refuse it,
and millions don’t know what to think”**

**John Carroll
Editor, FierceBiotech (23 Oct. 2009)**

Vaccine Safety: Media Sensationalism and Celebrity Quackery



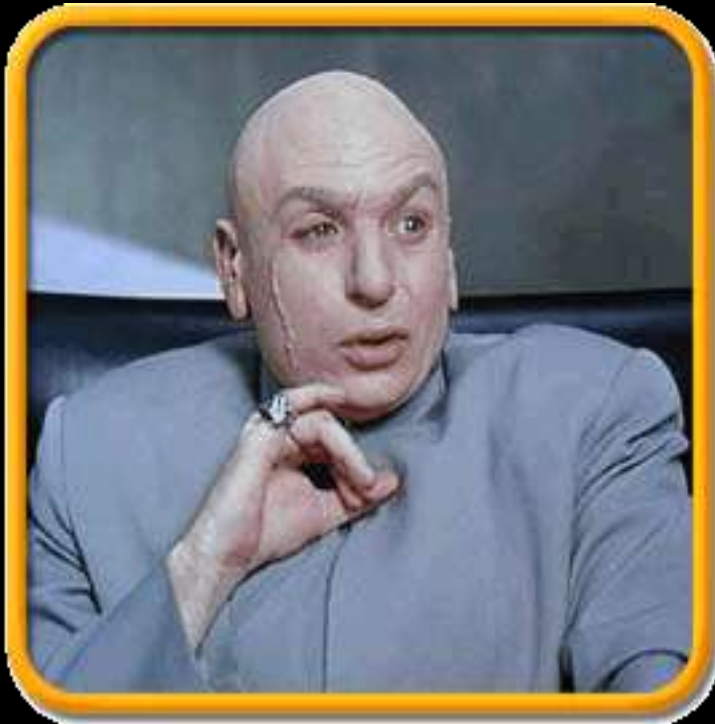
Mass Casualty Decontamination Challenge

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



...to hundreds of incapacitated, unprotected civilians?

Future Trajectory Trends and Threat Expansion

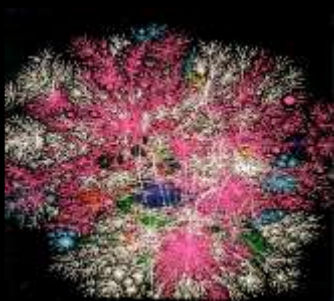


New 'Dual-Use' Technologies

The Expanded Dimension of the 'Bio' Challenge



- **thinking beyond 'bio' as just infectious agents (bugs)**



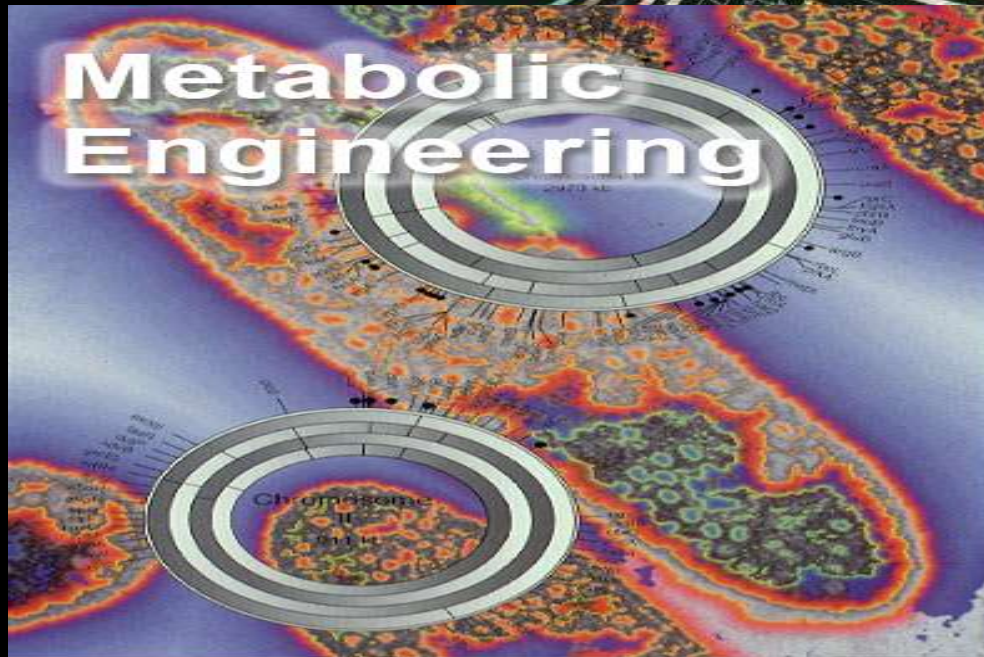
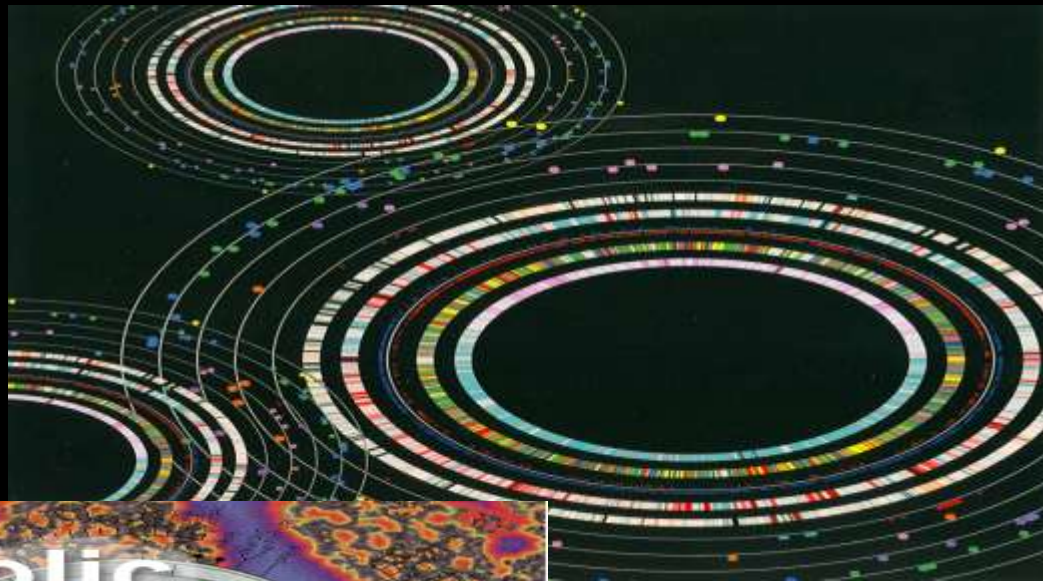
- **systems biology**
 - **targeted disruption of ANY body function**
 - **novel C and B threats**



- **synthetic biology**
 - **exploring biospace: designing new life forms**
 - **designer organisms to attack materials/infrastructure**

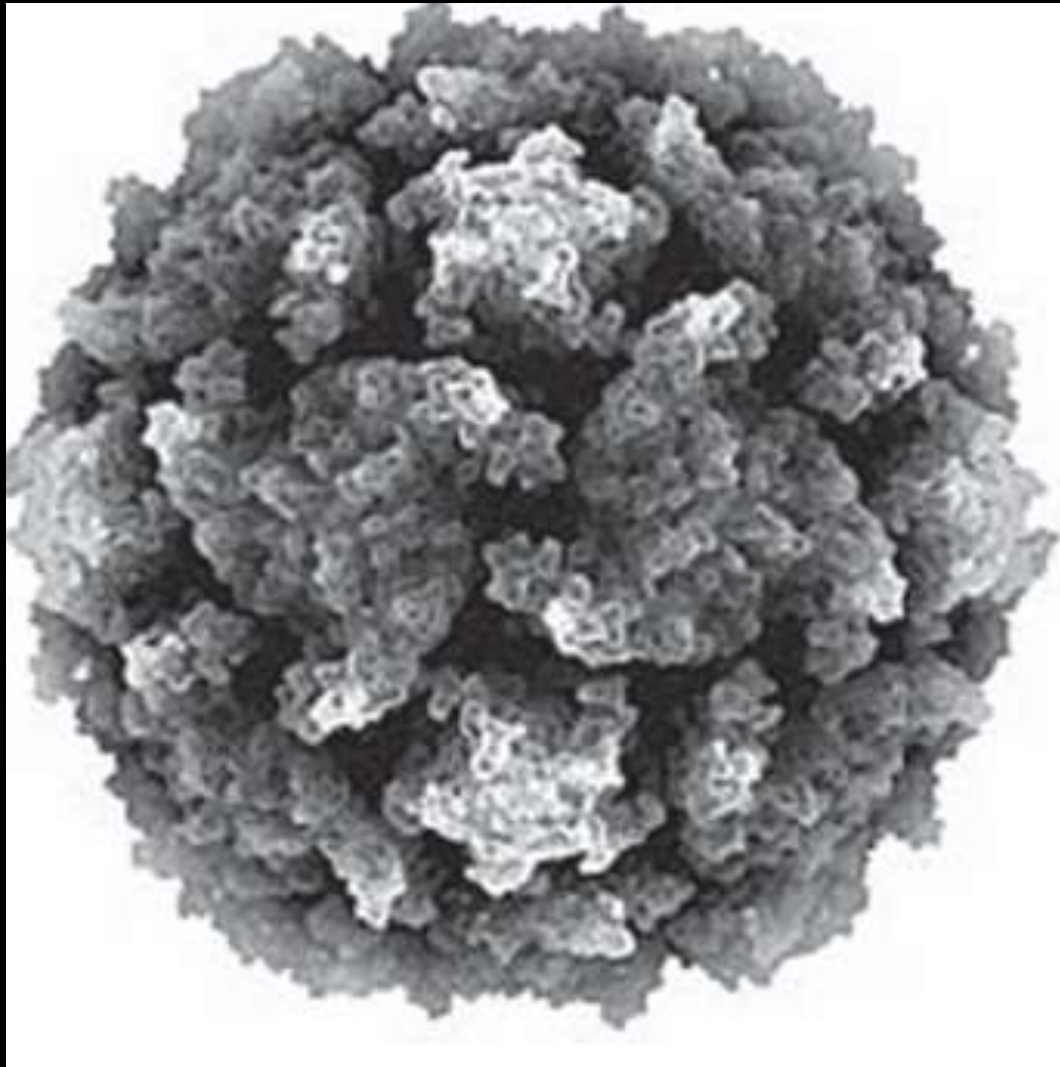
Synthetic Biology: Engineering Novel Organisms with Novel Functions

**Programmable
Genomes**



**A New Industrial
Ecology and Novel
Biosynthesis**

**C332,652; H492, 388; N98, 245; O131, 196 P7, 501; S2,340
(a.k.a. poliovirus)**



ATTGACTGCAA(design specifications)

Pandemic Avian Influenza as a Natural and/or Engineered Pathogen



From: F. Guterl. Scientific American June 2012

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**

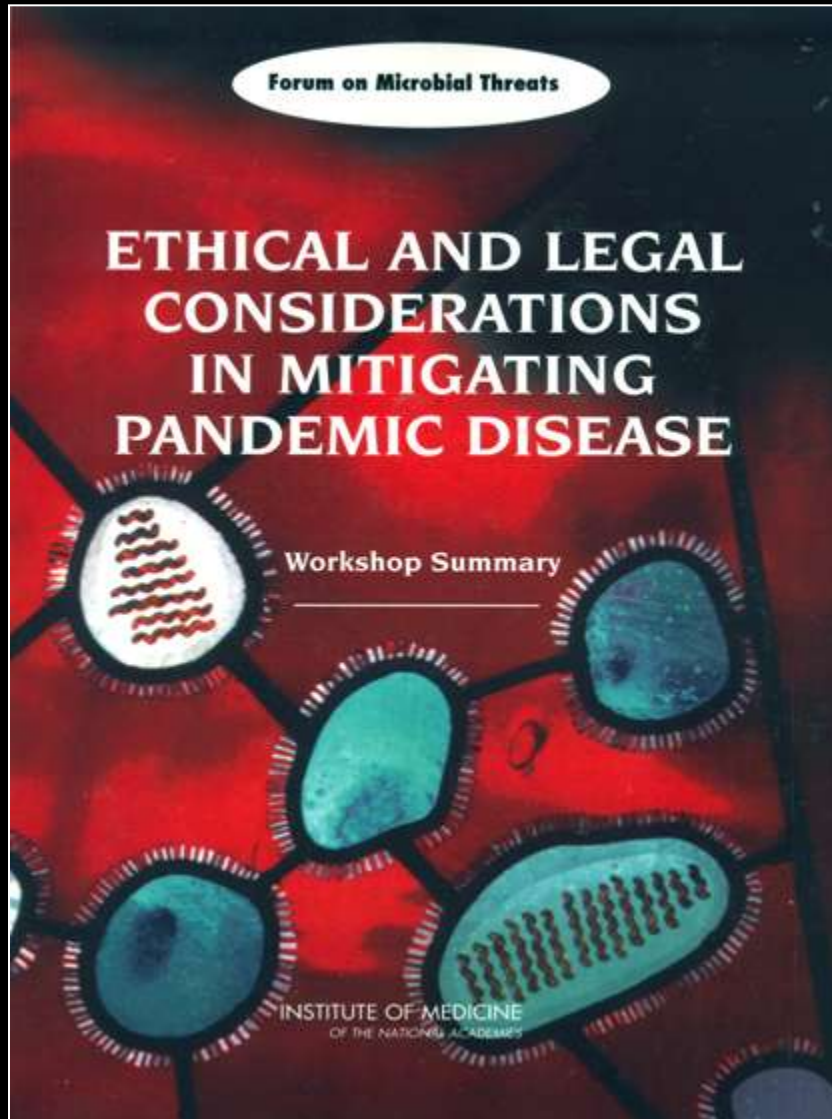


**Screening of Purchases/
Supply Transactions**

**Regulation, Legislation
and
Codes of Conduct**

**International
Harmonization**

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

Quarantine



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



MEDICINE AT THE BORDER

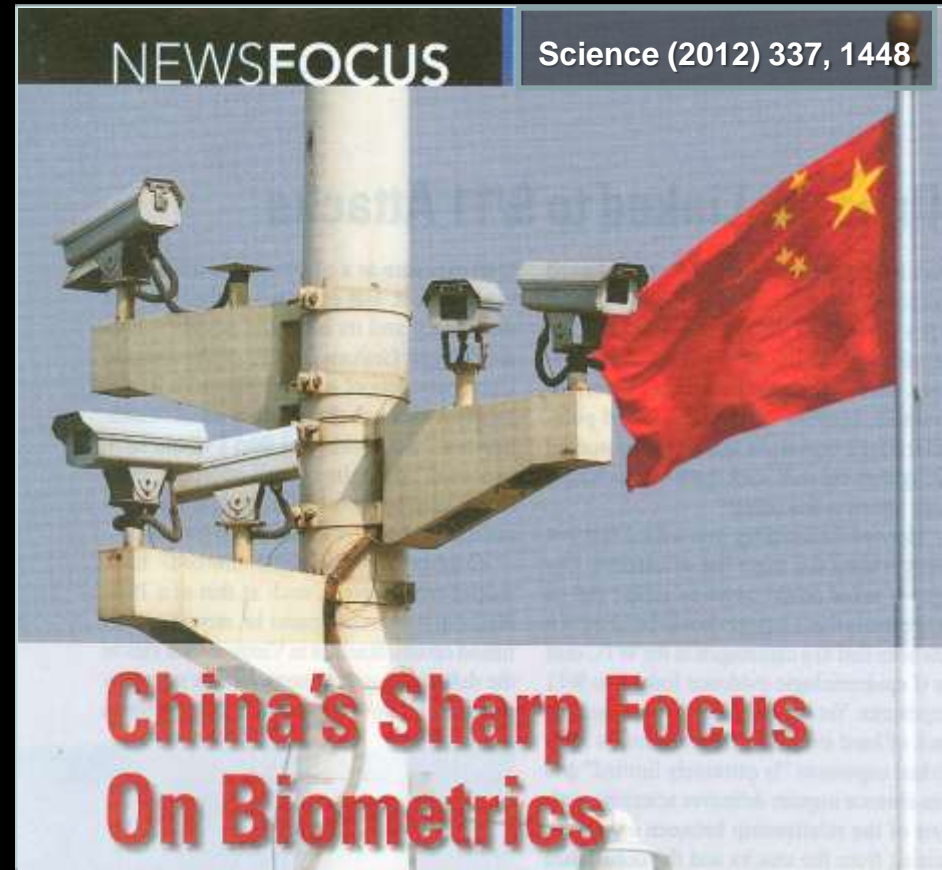
Disease, Globalization and Security,
1850 to the Present



Edited by Alison Bashford

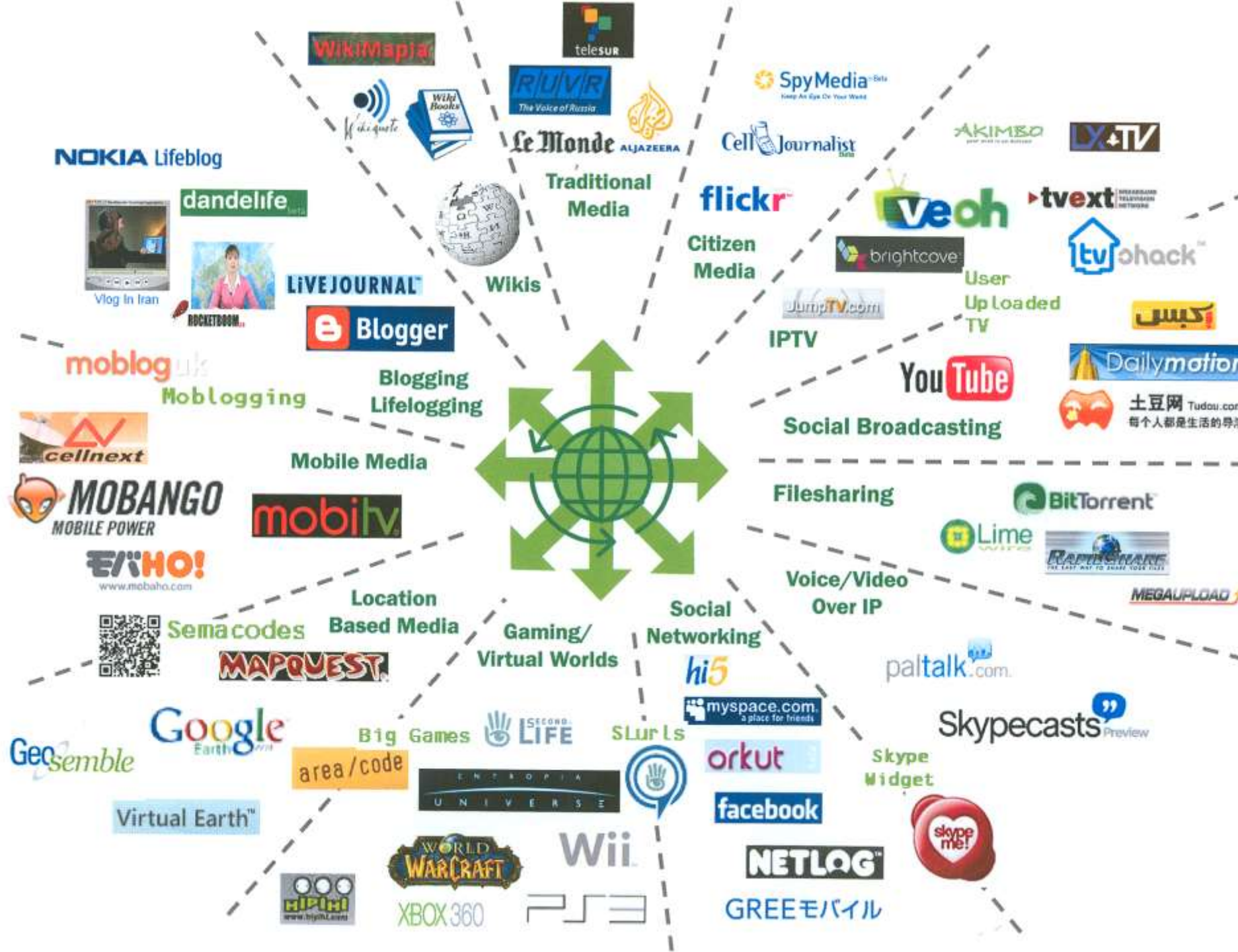


- **National Security Presidential Directive - NSPD-59/
Homeland Security Presidential Directive - HSPD-24**
- **“Biometrics for Identification and Screening to Enhance National Security (5 June 2008)**



The Infocosm: Emerging Networks of Global Connectivity



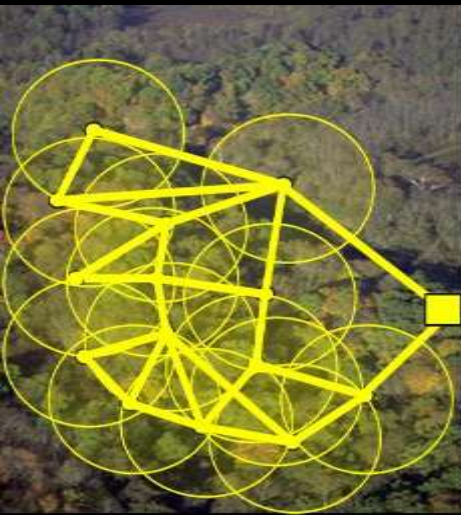


The Future Environment for Intelligence: A Burgeoning Infocosm and An Expanding Metaverse

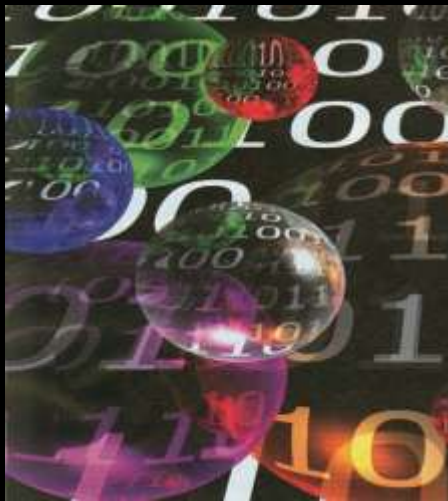
- **everything is a reporter**
 - **everything goes everywhere**
 - **everybody sees everything**
 - **everything moves fast**
-
- **two thirds of new products now come with electronic tracking component**
 - **maintaining more than one viable identity in the infocosm will be virtually impossible**
 - **being off-grid will be suspicious**

Shepherding the 'FLOCK': Fast Local Clustering of Critical Knowledge

**Senior Networks
and Ambient
Intelligence**



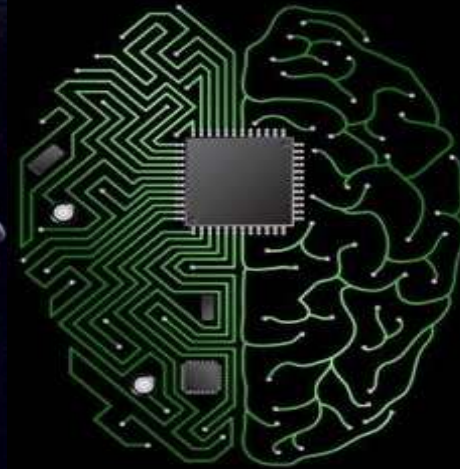
**Digital
Anthropology**



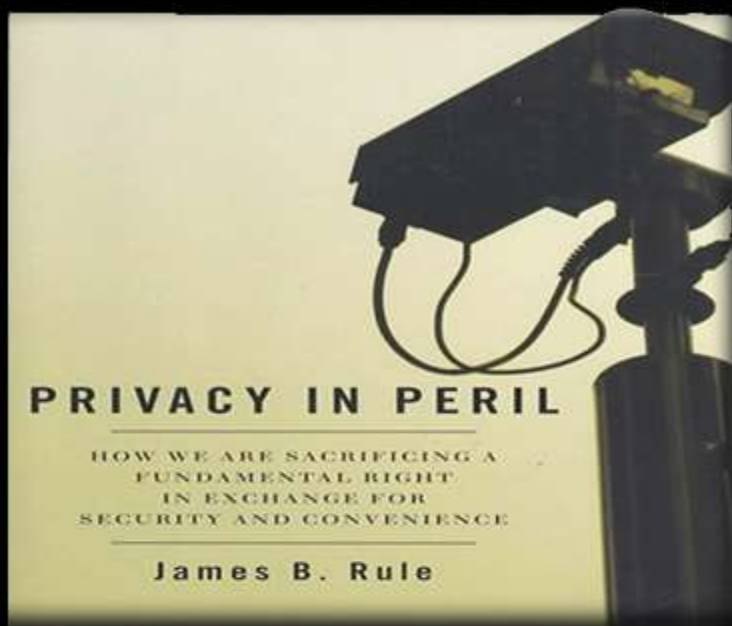
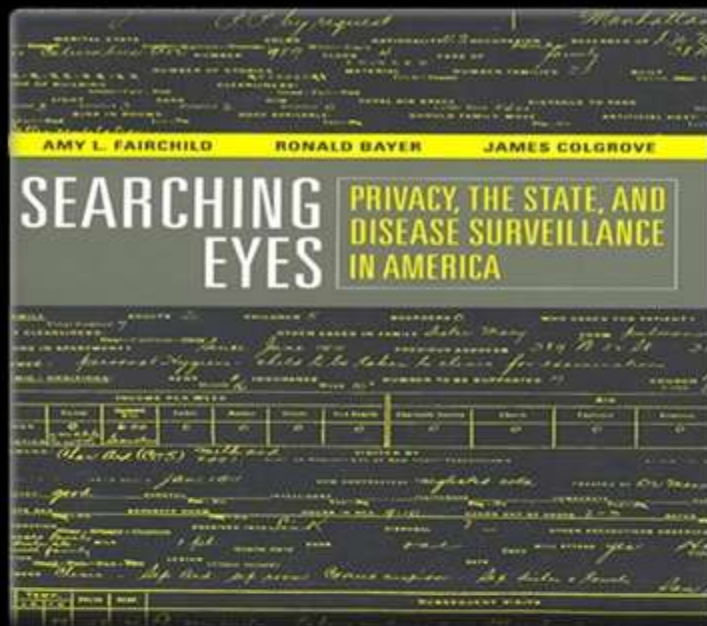
Cogint



**Intelligent
Machines**



Massive Computing Power and Analytical Parsing



**“Security is always excessive
.....until it’s not enough”**

The Delusional Value of Quick-Fixes: The Curse of Contemporary Governance



**“Of course, every complex problem
has an instant solution;
and it’s always wrong!”**

H.L. Mencken (1935)

Protecting US Infrastructure

- 87,000 communities
- 1800 federal reservoirs
- 80,000 dams
- 2800 power plants (104 nuclear)
- 5000 airports
- 120,000 miles of roads
- 590,000 bridges
- 2 million miles of pipeline
- 85% of infrastructure is privately held

Infrastructure Vulnerabilities



- 22 Kt
- 1×10^{14} Joules



- 20 million pounds HE
- 2.7×10^7 acre feet stored water
- 8.6×10^{15} Joules



- 3×10^7 acre feet stored water
- 1.2×10^{16} Joules

- destruction of Hoover by destruction of Glen Canyon
 - deprive 22 million people of water
 - eliminate 50% electrical power in California
 - destroy irrigation of 1.5 million acres US farmland

Cyber-Attacks and Vulnerable Infrastructure: Compromising Critical Systems



From Silos to Systems



The Fragmented Silos of USG: A Dangerous Vulnerability





Who Pays for Preparedness?



The Obligate Role of Private-Public Partnerships in Biosecurity Policy



Who Pays for Shared Global Risks from Infectious and Parasitic Diseases?

“Fewer countries have discovered, developed and registered drugs to an international standard, than have developed atomic bombs”



Chris Hentshel

Medicines for Malaria Venture

Lancet (2004) 363, 2198



**“Only industry can give us a clear answer to these questions (on Bioshield)
This would require a process of government listening and industry speaking.”**

**Sen. J. Lieberman (I-CT)
2006**

Biosecurity

environmental
sustainability
and
non-
renewable
resources

global
public
health

political
instability
and
escalating
conflict

terrorism
and
international
security

**International Engagement,
Commitment and Political Resolve**



Biosecurity: A Daunting Complex Systems Challenge

- **multi-dimensional, multi-disciplinary challenge**
- **complexity increased by disparate socio-economic, and technological capabilities in different geographies**



The Obligate Need for a Systems Approach

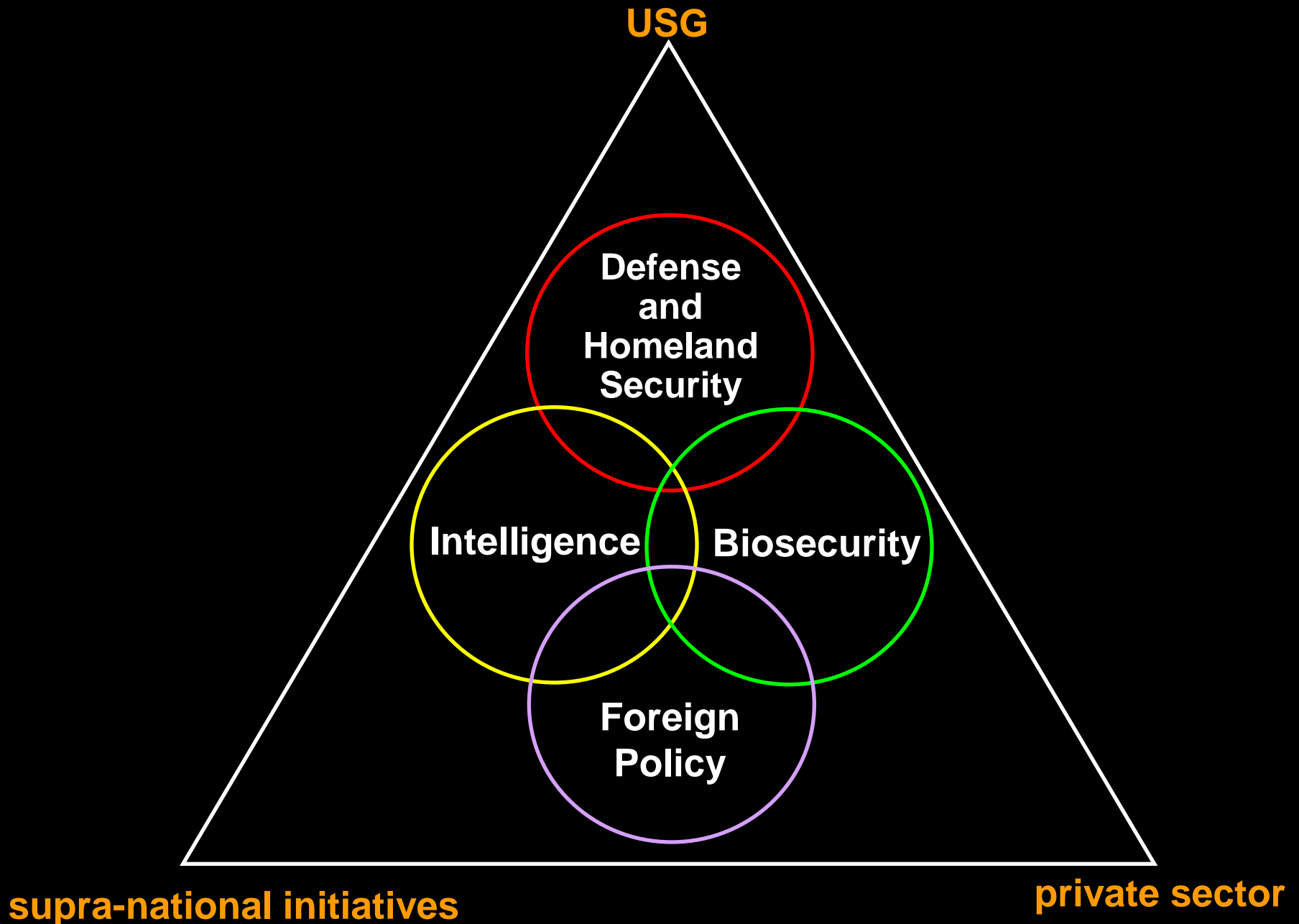


**Political Will and Commitments for
Infrastructure, Training, Research and Service**



One World: One Health: One Objective

Biosecurity: A Complex System



Building Robust Defenses for Biosecurity

- **naturally occurring infectious diseases pose an equal, if not greater, threat to society as bioterrorism**
- **governments must accord higher priority to 'biosecurity' as a integral component of national security and foreign policy**
- **(re)building a national and international infrastructure for the surveillance, diagnosis and containment of infectious diseases is fundamental to future protection against major instabilities triggered by infectious agents, whether of natural or malevolent origins**

Addressing Global Challenges in Biosecurity

- mobilize new expertise 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 collaboration networks whose composition will change constantly with new threats and new technologies
- financial incentives for industry for biodefense products with no civilian markets
- timely and accurate communication to the public and maintaining public support and cooperation



**“History is the sum total
of the things that could have been avoided.”**

Chancellor Konrad Adenauer

**“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/>

