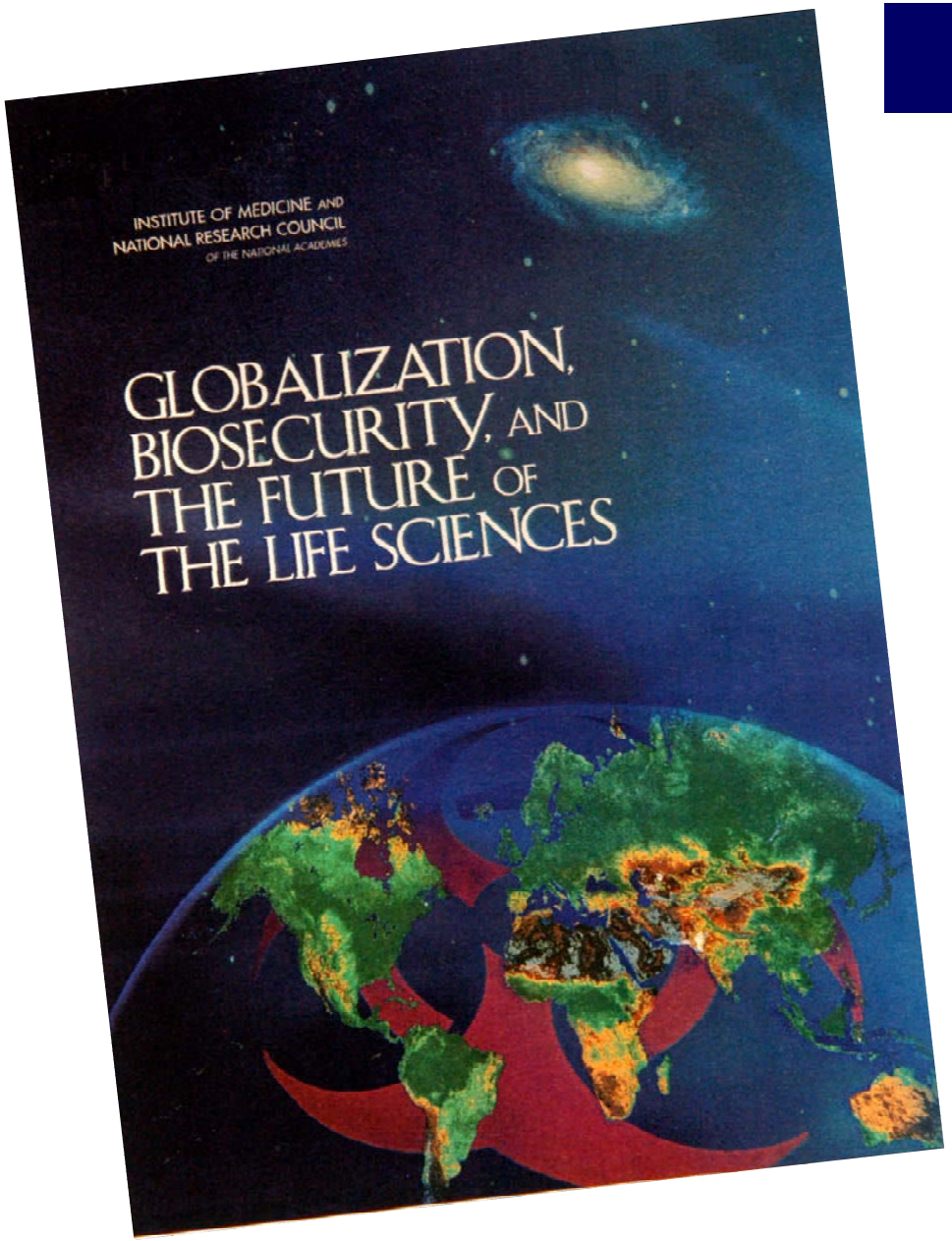

THE NATIONAL ACADEMIES
Advisers to the Nation on Science, Engineering, and Medicine

Committee on Advances in Technology and the Prevention of their Application to Next Generation Bioterrorism and Biological Warfare Threats

Stanley M. Lemon, co-chair, University of Texas Medical Branch
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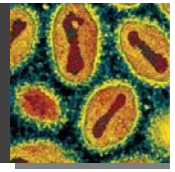
Globalization, Biosecurity and the Future of the Life Sciences

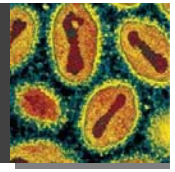


Charge to the Committee

- **Examine current scientific trends and the likely trajectory of future research activities in public health, life sciences, biomedical and materials science that contain applications relevant to development of "next generation" agents of biological origin 5 to 10 years into the future.**
- **Evaluate the potential for hostile uses of research advances in genetic engineering and biotechnology that will make biological agents more potent or damaging. Included in this evaluation will be the degree to which the integration of multiple advancing technologies over the next 5 to 10 years could result in a synergistic effect.**

Charge to the Committee (continued)

- **Identify the current and potential future capabilities that could enable the ability of individuals, organizations, or countries to identify, acquire, master, and independently advance these technologies for both beneficial and hostile purposes.**
- **Identify and recommend the knowledge and tools that will be needed by the national security, biomedical science, and public health communities to anticipate, prevent, recognize, mitigate, and respond to the destructive potential associated with advancing technologies.**

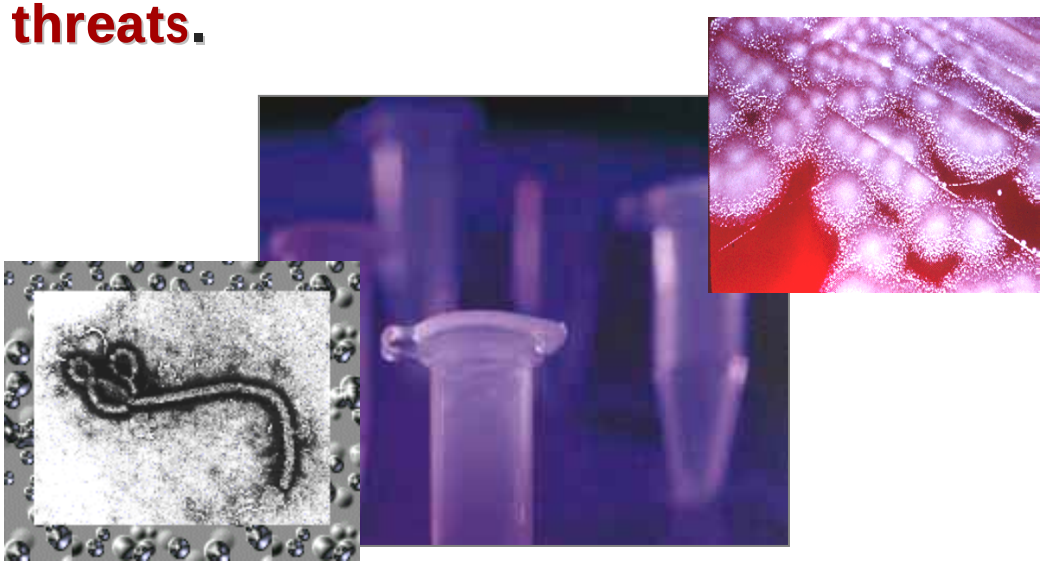


Differences between NRC/IOM Study and that of the "Fink Committee"

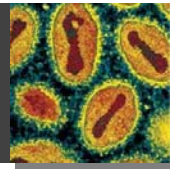
- Modest difference in time perspective: NRC/IOM Study looked further into future
- Greater emphasis on global agenda (NRC/IOM Study)
- Much greater emphasis on impact of advancing technologies (NRC/IOM Study)

Globalization, Biosecurity and the Future of the Life Sciences

- Biotechnology is **powerful**, relatively **inexpensive**, and does not require special infrastructure.
- Biotechnology is based on **publically available** knowledge. It is **accessible** and does not require rare materials.
- Biotechnology is increasingly **global** in its distribution, and can contribute to **both beneficial and malevolent purposes**.
- Rapid advances in molecular biology, driven by basic and applied medical research, make it necessary to **contemplate novel man-made biological threats**.



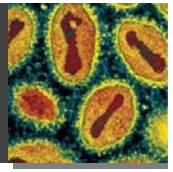
Globalization, Biosecurity and the Future of the Life Sciences



New advances in the life sciences and related technologies are being generated domestically and globally

- **The tools and technologies being employed in the life sciences enterprise are globally dispersed**
- **This global dispersion is being driven by a multitude of economic, social and political forces**
- **The pace of scientific discovery abroad is increasing**
- **The US may no longer hold a monopoly on these leading technologies**

Biotechnology is a Global Enterprise



China

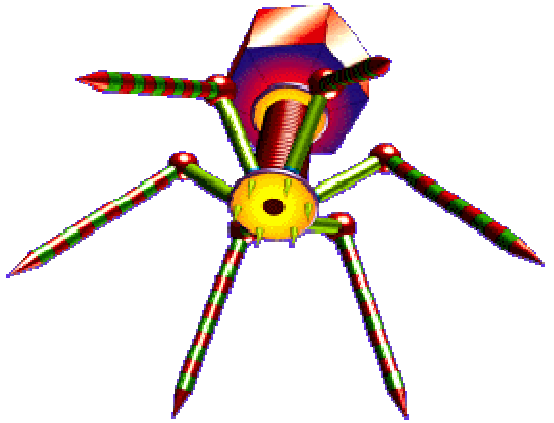
>500 biotech companies employing >50,000 persons; between 1996-2000, approved field trials of >250 genetically modified (GM) plants, animals, and recombinant microorganisms.

India
Brazil
Singapore
Indonesia...

"In 2004, China graduated over 600,000 engineers, India 350,000 and America about 70,000."
--Geoffrey Colvin, "America isn't ready." Fortune Magazine, July 25, 2005.

Is mother nature the worst of all possible terrorists?

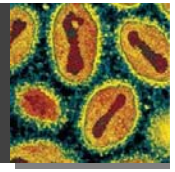
Genetically-engineered pathogens can be qualitatively different from conventional BW agents. Effectiveness in short term may not require successful competition in natural world.



Dangerous attributes may include:

- **Novel disease phenotype, targets**
- **Altered tropism**
- **Greater transmissibility**
- **Stealth**
- **Greater subtlety in pathogenic effects**

Enabling Technologies

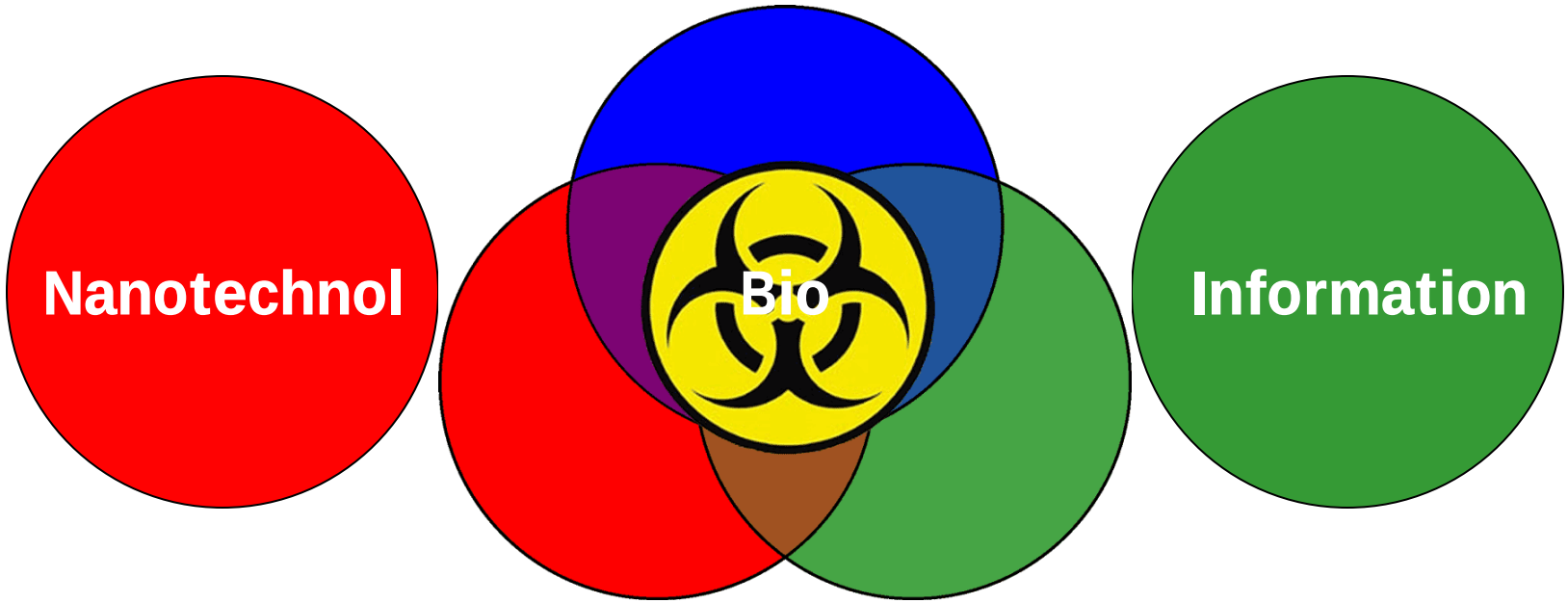


Process-based classification of life sciences technologies

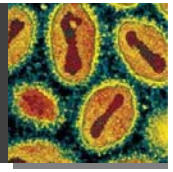
- Acquisition of novel biological or molecular diversity (e.g., DNA synthesis, DNA shuffling, combinatorial chemistry)
- Directed design (e.g., synthetic biology, reverse genetic engineering)
- Understanding and manipulating biological systems (e.g., “systems biology”, RNAi, modulators of homeostatic systems)
- Production, packaging, delivery (e.g., microfluidics/microfabrication, nanotechnology, microencapsulation, gene therapy/targeting)

Convergent Technologies

Advances in biotechnology pose significant risks for the future, but its convergence with other technologies (*e.g.*, nanotechnology, chemistry, materials science) poses special risks that are difficult to anticipate.



General Conclusions



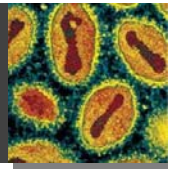
- The life sciences will **inevitably** create new opportunities for bioterrorism. These sciences and technologies are widely **dispersed**, easily **accessible**, and **increasingly global**.
- We can anticipate some developments, but not others. There will be a need for **frequent re-assessment of the threat spectrum**.
- Attention should not be constrained by any list. Non-pathogens can be readily **engineered** in the future to be **pathogens**. The **threat horizon** is extremely broad and **rapidly changing**.
- The problem is **global**; so too must be any solution.
- The best defense will be to **maintain a scientific edge** over potential adversaries, and to promote a **global** culture of awareness and responsibility among life scientists.

Study Recommendations

- **The Committee endorses and affirms policies and practices that, to the maximum extent possible, promote the free and open exchange of information in the life sciences.**

….*science depends on it, and science is our best defense against malevolent uses of life sciences and associated technologies***.**

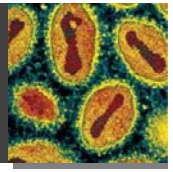
Study Recommendations



- **The Committee recommends adopting a broader perspective on the "threat spectrum"**

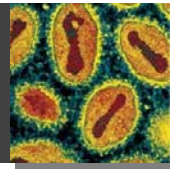
> *….we must get beyond lists and consider novel applications of converging technologies.*

Study Recommendations



- **The Committee recommends strengthening and enhancing the scientific and technical expertise within and across the intelligence and national security communities.**
  - **The Committee recommends the creation of an independent science and technology advisory group for the intelligence community.**

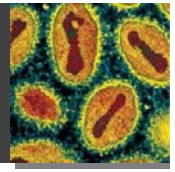
Study Recommendations



- **The Committee recommends the adoption and promotion of a common culture of awareness and a shared sense of responsibility within the global community of life scientists.**

...such a global culture will provide a greater likelihood of preventing or recognizing mis-applications of the life sciences, but it will require an international effort, and a much greater awareness of the threat than exists now among the world's scientists.

Study Recommendations



- **The Committee recommends strengthening the public health infrastructure and existing response and recovery capabilities.**

...the misuse of the life sciences is virtually inevitable; no common culture of awareness or "web" of regulatory rules or oversight can provide absolute protection. Strong public health infrastructure remains the best means of mitigating the consequences of such an event.

Relevance of NRC/IOM Study to the work of the NSABB

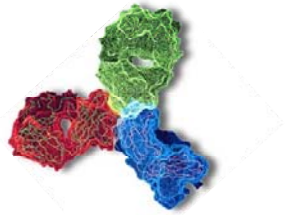
- Importance of open exchange of scientific information
- Definition of dual use and breadth of threat spectrum
- International dimensions of the issues
- Global scientific community must assume responsibility

Enabling Technologies

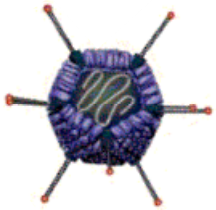
DNA synthesis, DNA shuffling

RNAi – Selective inhibition of gene expression

Genetic manipulation of fungi, bacteria and viruses; reverse genetics

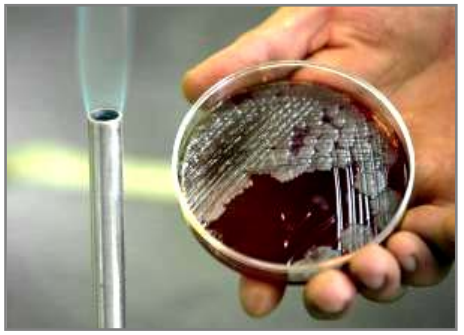


“Systems biology”, identification of critical nodes in homeostatic systems

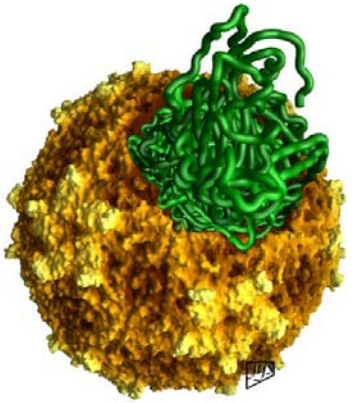


Advances in gene delivery

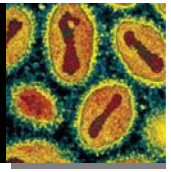
Near-term Biological Threats



- **Microbes engineered to:**
  - Evade antibiotics (multidrug resistance)
  - Evade vaccines (altered surface antigens)
  - Evade sensors, diagnostics (altered sequence/epitopes)
  - Express potent toxins (regulators)
  - Produce novel disease (turn off essential host genes)
  - Infect new hosts, tissues (altered tropism)
  - Disrupt host defenses (innate or adaptive immunity)



DHHS and USDA Select Agent List



Where we are in 2006

~40 microorganisms + 12 toxin types; >60 microorganisms in combined HHS/USDA/APHIS list

VIRUSES (14)	**BACTERIA** (12)	**FUNGI** (2)	**TOXINS** (12)
Crimean-Congo hemorrhagic fever	*Rickettsia prowazekii*	*Coccidioides posadasii*	Abrin
Ebola	*Rickettsia rickettsii*	*Coccidioides immitis*	Conotoxins
Herpes B (Cercopithecine herpes I)	*Yersinia pestis*		Diacetoxyscirpenol
Lassa fever	*Bacillus anthracis*		Ricin
Marburg	*Brucella abortis*		Saxitoxin
Monkeypox	*Brucella melitensis*		Tetrodotoxin
S.A. hemorrhagic fevers (Junin, Machupo, Flexal, Sabia, etc.)	*Brucella suis*		Shiga-like ribosome inhibitors
Tick-borne flavivirus encephalitis (Central European, Russian Sum/Spr, Omsk, Kyasanur forest , etc.)	*Burkholderia mallei*		Botulinum toxin
Variola major and Variola minor	*Burkholderia pseudomallei*		*C. perfringens* epsilon toxin
Eastern equine encephalitis	Botulinum toxin-producing strains of *Clostridium*		Shigatoxin
Nipah and Hendra virus	*Coxiella burnetii*		*Staphylococcus* enterotoxins
Rift Valley fever	*Francisella tularensis*		T-2 toxin
Venezuelan equine encephalitis			
Highly pathogenic influenza viruses			