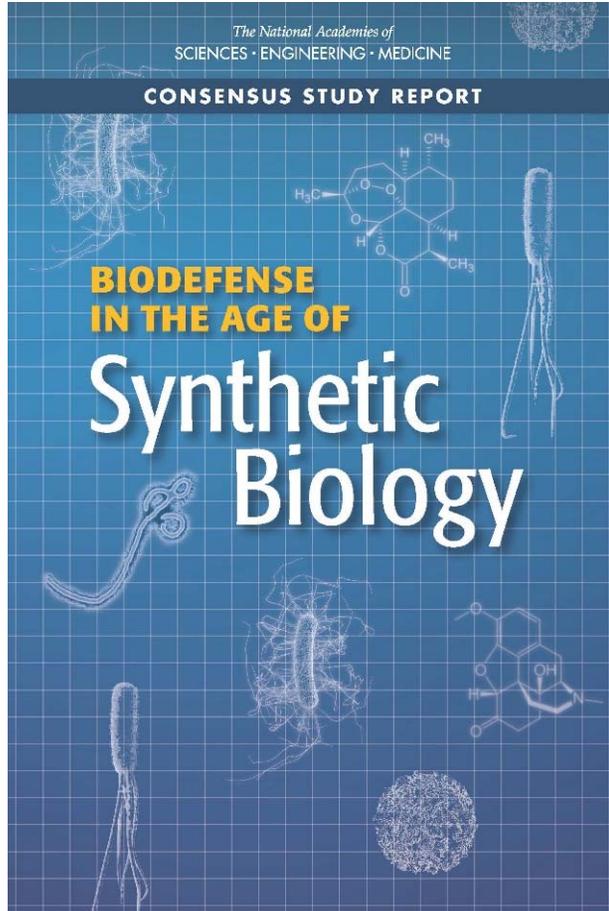


Biodefense in the Age of Synthetic Biology



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(Committee Chair)

Biological Weapons Convention
Meeting of Experts
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Report's Task

- 1. Develop a strategic framework to guide assessment of security vulnerabilities** associated with advances in biotechnology, with emphasis on synthetic biology:
 - What are security concerns on the horizon?
 - What are time frames of development of these concerns?
 - What are potential options for mitigating these concerns?
- 2. Use the framework to assess a set of synthetic biology-enabled capabilities**

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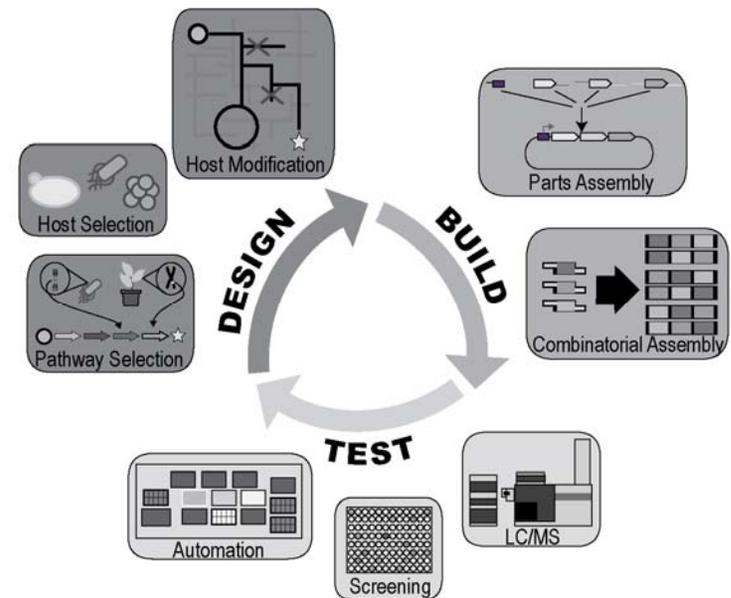
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Biotechnology in the Age of Synthetic Biology - What Do We Mean?

- Synthetic biology refers to a set of concepts, approaches, and tools within biotechnology that enable modification or creation of biological organisms
- Hallmark: adoption of approaches common to other engineering disciplines
 - standardization of components
 - use of software and computational modeling for designing biological systems
 - iterative Design-Build-Test (DBT) cycles for continuous improvement



Benefits: Important But Outside Task

- Synthetic biology contributes to societal goals for health and the environment, and adds to the economy.

Examples include:

- Pharmaceuticals
 - Organs for transplant
 - Fuel production
- However, report focus is on a framework for assessing potential concerns
 - Report does not attempt to compare size or nature of benefits with risks; nor is there intent to curtail legitimate synthetic biology research

A Conceptual Framework is a Valuable Tool for Assessing Risk and Contributes to Planning

How a Framework is Useful

- Aids in parsing the changing biotechnology landscape
- Helps structure discussions in systematic way
- Helps clarify assumptions, open questions, and areas of agreement or disagreement
- Provides mechanism to incorporate technical experts in the assessment
 - e.g., synthetic biology and biotechnology; public health; intelligence
- Facilitates identification of bottlenecks and barriers & supports efforts to monitor advances that change what is possible

Framework

Usability of the Technology

- Ease of use
- Rate of development
- Barriers to use
- Synergy with other technologies

Usability as a Weapon

- Production and delivery
- Scope of casualty
- Predictability of results

Requirements of Actors

- Access to expertise
- Access to resources
- Organizational footprint requirements

Potential for Mitigation

- Deterrence and prevention capabilities
- Capability to recognize an attack
- Attribution capabilities
- Consequence management capabilities

**Level of Concern
about the Capability**

Using the Framework

Provides a basis for assessing potential concerns associated with synthetic biology and biotechnology

Can apply it to:

- Analyze specific applications of synthetic biology
- Identify current areas of concern
- Identify future potential areas of concern created by new advances

Applying the Framework to Assess a Set of Capabilities: Results, Conclusions and Recommendations

Analysis of Potential Capabilities

Assessed 12 capabilities related to:

- Synthesis and modification of pathogens
- Production of chemicals, biochemicals and toxins
- Modulation of human physiology

Committee's Approach

- Organized information about each capability being assessed in terms of the 4 framework factors and elements under each factor
- Compared information about a given capability to information about the other capabilities to determine relative level of concern
- Went through analysis factor by factor (e.g., assessed all capabilities relative to each other on “Usability of the Technology,” then on “Usability as a Weapon” etc.)
- Integrated this information into a holistic assessment of relative levels of concern across the full landscape of factors and capabilities

Overarching Recommendation

Biotechnology in the age of synthetic biology expands the landscape of potential defense concerns

Ongoing strategies for chemical and biological defense remain relevant in the age of synthetic biology

Also need approaches to account for the broader capabilities enabled by synthetic biology, now and into the future

Highest Concern

Re-creating known pathogenic viruses

Making biochemicals via in situ synthesis

Making existing bacteria more dangerous

Making existing viruses more dangerous

Manufacturing chemicals or biochemicals by exploiting natural metabolic pathways

Manufacturing chemicals or biochemicals by creating novel metabolic pathways

Modifying the human microbiome

Modifying the human immune system

Modifying the human genome

Re-creating known pathogenic bacteria

Creating new pathogens

Modifying the human genome using human gene drives

Lowest Concern

Relative Concern of Capabilities Assessed

Pathogens

Synthetic biology is expected to:

- **expand the range of what could be produced**
- **decrease the amount of time required**
- **expand the range of actors**

Creation and manipulation of pathogens is facilitated by increasingly accessible technologies and starting materials, including DNA sequences in public databases. A wide range of pathogen characteristics could be explored as part of such efforts.

Chemicals, Biochemicals, and Toxins

Synthetic biology:

- **blurs the line between chemical and biological weapons**

High potency molecules that can be produced through simple genetic pathways are of greatest concern, as they could conceivably be developed with modest resources and organizational footprint.

Modulation of Human Physiology

Through synthetic biology:

- **may be possible to modulate human physiology in novel ways**

These include physiological changes that differ from the typical effects of known pathogens and chemical agents. Synthetic biology expands the landscape by potentially allowing the delivery of biochemicals by a biological agent, and by potentially allowing the engineering of the microbiome or immune system. While unlikely today, these types of manipulations may become more feasible as knowledge of complex systems grows.

Bottlenecks and Barriers

Some malicious applications may not seem plausible now, but could become achievable if certain barriers are overcome.

It is important to continue to monitor advances in biotechnology that may lower these barriers.

Barriers include:

- Knowledge barriers, as is the case for building a novel pathogen
- Technological barriers, as in engineering complex biosynthetic pathways into bacteria or re-creating known bacterial pathogens

Related Developments May Impact Ability to Use Synthetic Biology-Enabled Weapon

Convergent technologies from outside of synthetic biology may assist in overcoming some of the barriers in areas such as production, fidelity and testing, delivery, targeting

- Gene therapy
- Nanotechnology
- Automation
- Additive manufacturing
- Health informatics

Synthetic Biology Poses Mitigation Challenges

Many traditional approaches to biological and chemical defense preparedness will be relevant to synthetic biology. But synthetic biology also presents new challenges

- The potential unpredictability related to how a synthetic biology-enabled weapon could manifest creates an added challenge to monitoring and detection
- Range of strategies needed to prepare and respond
 - Continue exploring strategies that are applicable to a wide range of chemical and biodefense threats
 - Evaluate the infrastructure that informs population-based surveillance, identification, and notification of both natural and purposeful health threats
 - Consider strategies that manage emerging risk better than current agent-based lists and access control approaches

Exploration Areas: Potential Opportunities to Advance Mitigation Capabilities

- Developing capabilities to detect unusual ways in which a synthetic biology-enabled weapon may manifest
- Harnessing computational approaches for mitigation
- Leveraging synthetic biology to advance detection, therapeutics, vaccines, and other medical countermeasures

More Information

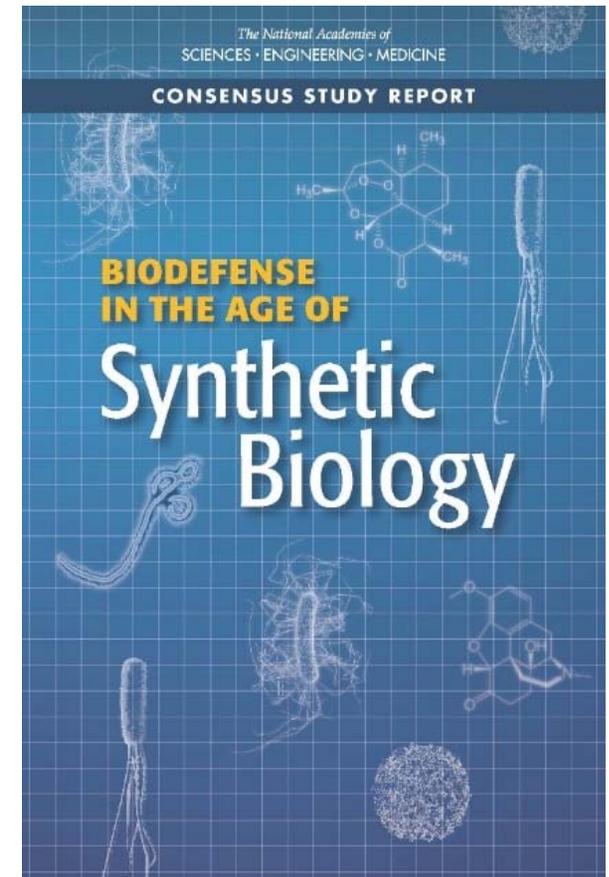


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Download report and 4-page brief:

<http://nas-sites.org/dels/studies/strategies-for-identifying-and-addressing-vulnerabilities-posed-by-synthetic-biology/>



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