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REPORT IN BRIEF

Life Sciences and Related Fields: Trends Relevant to the Biological Weapons Convention

Advances in the life sciences and related fields have the potential to shape the future of the Biological Weapons Convention. For example, are new or novel agents and materials being developed that are not covered by the treaty? Could trends in science and technology affect the implementation of the treaty through national policies and regulatory systems or by increasing the capacity to detect and respond to biological attacks? This report considers three trends that are affecting the scope and operation of the Biological Weapons Convention: (1) the rapid pace of change in the life sciences and related fields; (2) the diffusion of life sciences research capacity both internationally and beyond traditional research institutions; and (3) the increasing extent to which scientific and technical disciplines beyond biology are involved in life sciences research. Although every major article of the Biological Weapons Convention will be affected by developments in science and technology, none of the developments surveyed so far falls outside the scope of the treaty. However, as new developments arise there may be surprise discoveries; hence, continued monitoring of advances in the life sciences and evaluation of their relevance for the Biological Weapons Convention will be important.

Over the past decade, the science community has become increasingly engaged in addressing the fact that continuing advances in the life sciences, while yielding great benefits for health, the economy, and the environment, are also producing knowledge, tools, and techniques with the potential to cause great damage and loss of life. In particular, science organizations have become more involved in considering how to respond to the biosecurity implications of developments in science and technology without unduly hampering continued scientific progress. The upcoming 7th Review Conference of the Biological Weapons Convention (BWC) in December 2011 offers the opportunity for the science community to contribute to the international effort to assess the implications of advances in science and technology for biological weapons nonproliferation and disarmament.

Roderick J. Flower, Professor of Biochemical Pharmacology at Queen Mary University of London, United Kingdom, addresses participants in an international workshop considering scientific and technological developments that may be relevant to the Biological Weapons Convention.
Credit: Chinese Academy of Sciences

As a contribution to these discussions, the National Research Council of the United States National Academy of Sciences convened a committee of international experts to assess the implications of relevant developments in science and technology for the Biological Weapons Convention. The committee organized a workshop in cooperation with IAP—the Global Network of Science Academies[1], the International Union of Biochemistry and Molecular Biology, the International Union of Microbiological Societies, and the Chinese Academy of Sciences to help inform its deliberations.

[1] Formerly the Inter-Academy Panel on International Issues.

Participants at the international workshop discussed key trends in the life sciences and related areas of science and technology that could lead to the production of new or more deadly biological weapons or lower the barriers for bioterrorism, as well as advances in areas like detection methods, diagnostics, and vaccine development that could be used to prevent or respond to biological attacks.

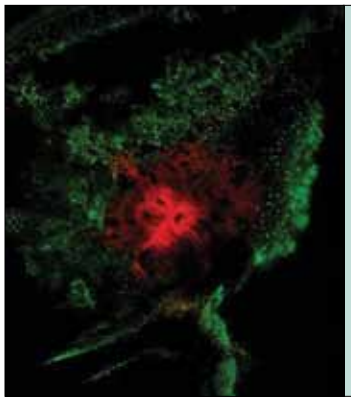
Given the great diversity of current research and development, this report is only able to provide an overview of the areas of science and technology the committee believes are potentially relevant to the future of the Biological Weapons Convention. The report highlights several areas of science and technology that may be ripe for further exploration and analysis. The workshop and the committee's consensus report are intended to be independent contributions from the international science community to the 7th Review Conference.

The Pace of Science and Technology Developments

Advances in science and technology have increased overall understanding and exploration of biological systems—for example, developments in fields such as genomics, the systematic study of genetic information, are helping scientists better understand biological processes and supporting a more complete understanding of humans, animals, plants and microbes. However, the extraordinary complexity of biology remains a significant barrier to the effective understanding and design of biological systems; this complexity is likely to remain a defining feature of the biological sciences for the foreseeable future.

Other fields that have seen notable advances include bioreactor research and the use of transgenic organisms to produce commercially or medically important proteins. Developments have reduced the time needed to produce proteins and have the potential to affect the scale of production facilities required, which has implications for States Parties (countries that have ratified or acceded to the treaty) in implementing the Biological Weapons Convention. Biosensor detector systems have also advanced, although limitations remain in what can be achieved because sensor development must balance factors such as specificity, sensitivity, range of target molecules analyzed, and type of use.

There has been particularly rapid progress in both the availability and power of enabling technologies that underpin life sciences research, including computational resources, communication resources and capacity, and high throughput laboratory technologies. These tools increase the speed with which researchers can conduct studies, as well as the volume of data they can obtain. At the same time, new methods of communication and information sharing enhance scientific collaboration and support research progress.



Brain tissue in a fluorescence microscopy image showing the distribution of two types of nanoparticles. Researchers study nanoparticle properties and distribution to create new treatments.

Source: Dr. Frank Szoka, Jr. and J. A. MacKay, University of California at San Francisco

Diffusion of Research and Capacity

Increasing access and ease of use of communications technologies, combined with growing availability of resources to support research, are helping to foster the expansion of global research capacity, leading to an ever larger number of international collaborations in science and technology. Moreover, the substantial trend over the past decade or more by multinational corporations to diversify their research and development facilities beyond their traditional bases in the West, combined with the growth of significant industries in countries such as India and China, provides another significant driver for the development of life sciences capacity. The rapid diffusion of such capacity may complicate States Parties' abilities to restrict or prevent access to scientific knowledge for purposes other than those permitted by the convention. To try to anticipate any potential negative consequences from increased diffusion of scientific knowledge, a continued emphasis on monitoring and assessing science and technology trends, and on strengthening States Parties' capacity to address concerns, remains important. The increasing scientific capacity also provides the potential for a larger number of States Parties to contribute to the implementation of the Convention, for example by expanding global health and disease surveillance capabilities and collaborations.

The diffusion of knowledge is also making it easier to conduct life science research outside of

traditional research institutions. There are now commercial kits and services available for some laboratory techniques, and secondhand laboratory equipment can be used to construct private laboratories. As well as making research more convenient for trained scientists, this also allows amateur practitioners lacking extensive biological training to perform certain experiments. This underscores the need to understand how training and know-how are propagated and cultures of safely developed in such non-institutional environments.

Integration of the Life Sciences with Other Disciplines

Life sciences research draws on the expertise not only of biologists, but also of scientists from engineering, physics, mathematics, and many other disciplines. The convergence of disciplines, particularly between biology and chemistry, may pose challenges to the operation of regimes like the Biological Weapons Convention and the Chemical Weapons Convention. New scientific developments might alter or expand the types of agents that could be of concern as certain molecules fall under the purview of both treaties. As science continues to advance, the convergence of multiple disciplines will continue. The science community could play a role in developing better technical understanding of converging science and technology areas to help inform future policy discussions.

Drivers and Roadblocks

Engaging a range of expertise within the science community—from academia, industry, and government—can contribute to efforts to both monitor the state of science and technology and to assess the implications of developments for the scope and operations of the Biological Weapons Convention. In addition to tracking advances across diverse fields, the science community can contribute to a better appreciation of the drivers and roadblocks that broadly affect how science and technology actually develops. Examples include the current challenge of developing mathematical models to capture the complexity of biological systems.

Ways in Which Life Sciences Research Can Help Support the Biological Weapons Convention

There are a variety of ways in which life sciences research from around the world can help support the goals embodied in the Biological Weapons Convention. There is already substantial effort under way to create a combination of approaches including forensics, improved biosensors, epidemiological monitoring, vaccine research, and other laboratory investigations that can contribute broadly to effective disease detection, investigation, and response systems worldwide, with applications to health as well as to security. One important area for the future is the development of international capacity in microbial forensics and the creation of better tools to investigate and discriminate between natural and deliberate disease outbreaks.

Looking Ahead: Future Approaches to Monitoring Science and Technology Trends for the Biological Weapons Convention

Preparations for the 7th Review Conference have highlighted the potential for adoption of a more systematic process to monitor and assess developments in science and technology. International scientific organizations are one potential resource for gaining access to a wide range of expertise to assist in understanding the state of the science in assessing its implications.

Conclusions

The committee's analysis led to four major conclusions:

- None of the trends surveyed for this report currently falls outside the scope of the Biological Weapons Convention. The language of the treaty, as reinforced by the common understandings reached in prior review conferences, provides a degree of flexibility that has so far allowed it to adapt to progress in the life sciences and related scientific fields. The committee recognizes, however, that as new developments arise, including in

Research on vaccines that could protect against viruses with potential use as biological weapons.
Credit: James Gathany, Centers for Disease Control and Prevention

fields of research that this report did not assess in depth, there may be surprise discoveries; hence, continued monitoring of advances in the life sciences and evaluation of their relevance for the Biological Weapons Convention will be important.

- Beyond the question of whether these trends pose fundamental challenges to the scope of the treaty, every major article of the treaty will be affected by the developments surveyed. The trends may pose challenges to the implementation of some aspects, but they also offer important opportunities to support the operation of the convention.
- The three broad trends that provided the organization of the report—the increasing pace, diffusion, and convergence of science and technology—will continue for the foreseeable future. The diversity of the fields potentially relevant to the Biological Weapons Convention and the potential for surprise discoveries make efforts to predict developments problematic. Within these trends, however, particular fields will be affected in important ways by factors such as commercial interests that drive developments at different rates, as well as roadblocks that impede progress. Gaining a deeper understanding of the drivers and roadblocks would provide a more meaningful picture of how and when continuing science and technology developments are likely to affect the convention.
- There are potential roles for the scientific community in helping to monitor trends in science and technology and to assess their implications for the Biological Weapons Convention and there are a number of mechanisms by which input and advice could be provided. The most effective starting point for the Seventh Review Conference, therefore, would be to address the functions that such advice and analysis will serve for the future operation of the convention, including increasing the capacity of States Parties to participate fully in its implementation.

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The National Academies appointed the above committee of experts to address the specific task requested by the Alfred P. Sloan Foundation, Chinese Academy of Sciences, IAP—The Global Network of Science Academies, U.K. Global Partnership Programme, U.S. Defense Threat Reduction Agency, U.S. Department of State, U.S. National Institutes of Health, and U.S. National Academies The members volunteered their time for this activity; their report is peer-reviewed and the final product signed off by both the committee members and the National Academies. This report brief was prepared by the National Research Council based on the committee's report.

For more information, contact the Board on Life Sciences at (202) 334-2638 or visit http://dels.nas.edu/bls. Copies of *Life Sciences and Related Fields: Trends Relevant to the Biological Weapons Convention* are available from the National Academies Press, 500 Fifth Street, NW, Washington, D.C. 20001; (800) 624-6242; www.nap.edu.