The Convergence of Chemistry and the Life Sciences: Some Policy Implications for the Chemical Weapons Convention

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I. Introduction

Analysts, officials and others have periodically emphasized the importance of understanding the implications of the convergence of chemistry and the life sciences so that the 1993 Chemical Weapons Convention's (CWC) prohibition against chemical warfare is maintained and effectively implemented.[1] A gap exists between the scientific literature and research activity versus the legal and policy context of the CWC. This is partly because many of those involved in the implementation of the treaty regime do not have a scientific background. Science and technology (S&T) developments are broad, complex and may appear somewhat diffuse when considered in terms of CWC implementation. In addition, the manner in which S&T issues are dealt with has implications for the cost, scope and level of intrusiveness which the member states deem appropriate for the routine operation of the regime.

Although states agree that the more traditional chemical warfare agents, such as sulphur mustard and VX, are covered by the regime, there is significant uncertainty with regard to the possible development, stockpiling or use of toxic chemicals for purposes whose legality may be unclear or where such activities can be disputed more on the basis of political perceptions and interests. Furthermore, the views of the member states on how to structure the routine verification regime of the convention at the operational level could change if chemicals and biological substances are viewed principally in terms of their effects on cellular systems or at the molecular level, or if S&T developments are viewed in terms of their possible applicability to the design and delivery of non-traditional agents. The evaluation of the capabilities and intentions of non-state actors is another verification challenge that is partly connected to S&T developments.

This policy paper summarizes selected S&T developments and several CWC provisions which may serve as 'intervention points' to take such developments into account. The institutional structures and activity of the Organisation for the Prohibition of Chemical Weapons (OPCW) are considered within the current legal and political context, including perceptions of political acceptability and feasibility. Several measures meant to capture S&T developments based on their assessed risk are indicated with a view to help ensure the future operational relevance (perceived and actual) of the CWC.

[1] E.g. Ed. Ralf Trapp, *Academic Forum, The Hague, 18 & 19 September 2007, Conference Proceedings* (Netherlands Institute for International Relations Clingendael and TNO Netherlands Organisation for Applied Scientific Research: The Hague, 2008).

II. Science and technology developments

Efforts should continue to try to capture the scope and level of detail of S&T developments in a manner that can inform policy.[2] S&T developments may be divided according to chemistry, the life sciences, and engineering and design-related activity. The convergence between chemistry and the life sciences may be characterized as 'biologically mediated processes of chemicals', and 'the chemical synthesis of biological molecules'.[3] Research activity in the life sciences relevant to the consideration of S&T under the CWC include synthetic genomics, systems biology and bioinformatics, brain research and targeted drug delivery.[4]

One can view chemical and/or biological warfare substances as traditional agents developed by prior state military programmes. Alternatively biological and chemical substances can be viewed in terms of their effect at the cellular or molecular level. The latter implies a change in how policy and decision makers in states might determine whether a CWC violation has occurred.

Most of the concern regarding synthetic biology is connected to the creation of genes or whole genomes of existing, extinct or novel pathogens. Synthetic biology is a further advance of genetic engineering. The output can be used as a tool for life sciences applications or as a tool to facilitate deeper understanding of the basic mechanisms of life (e.g. 'the minimum genome'). Synthetic biology also opens cross-disciplinary possibilities—the full scope of which remains uncertain. For example, in the near future one need not necessarily be trained as a microbiologist in order to apply synthetic biology within alternate fields. It also creates the possibility for 'garage science' in the life sciences. This will be a positive development for the life sciences in order to drive innovation. However, it also carries some potential security risks. A somewhat similar scenario was the development and spread of computer programming in society in the 1980s and 1990s. Although individuals may not be able to synthesize a pathogen at home, they may be able to design them using computer software.[5]

The current security concern relates mainly to industry products and associated production capacity which, in turn, can be ordered on the internet. Oversight mechanisms include the development of databases that contain 'red flags' that suggest a suspicious order. Many companies, for example, will not make deliveries to private home addresses. Some DNA sequences are deemed

[2] E.g. 'IUPAC/OPCW International Workshop: Impact of Advances in Science and Technology on the Chemical Weapons Convention'; 22–25 Apr. 2007; Zagreb, Croatia.

[3] Tucker, J. B., 'Convergence of biology and chemistry: an emerging agenda', slide 2. Presentation at OPCW; 22 Mar. 2011; The Hague, Netherlands.

[4] See, for e.g., Labiris, N. R. and Dolovich, M. B., 'Pulmonary drug delivery. Part II: the role of inhalant delivery devices and drug formulations in therapeutic effectiveness of aerosolized medications', *British Journal of Clinical Pharmacology*, no. 56 (28 Mar. 2003), pp. 600–612; and *Brain Waves Module 1: Neuroscience, Society and Policy* (The Royals Society: London, Jan. 2011).

[5] *Symposium on Opportunities and Challenges in the Emerging Field of Synthetic Biology*, Synthesis Report (OECD and the Royal Society: 2010), <http://www.oecd.org/sti/biotechnology>. See also 'European Bioinformatics Institute', <http://www.ebi.ac.uk/Databases/>. This paragraph is partly taken from an interview response by Peter Clevestig and John Hart to a media inquiry in April 2011.

'sensitive' under some guidelines being developed by the United States and others.

In November 2009 five gene-synthesis companies established together an International Gene Synthesis Consortium (IGSC) and a 'harmonized screening protocol for gene sequence & customer screening to promote biosecurity'.[6] The agreement covers five core components: (*a*) complete DNA sequence screening of every synthetic gene order against a pathogen database, developed by the consortium, also including screening of amino acid translated sequences (screening against US select agent lists will be included for all US domestic orders); (*b*) screening of customers for establishing identity and clearance in accordance with national guidelines; (*c*) record keeping of all orders and customers for up to 8 years; (*d*) order refusal at the liberty of the companies and reporting to authorities of problematic orders; and (*e*) regulatory compliance with all applicable laws and regulations governing the synthesis, possession, transport, export and import of synthesized genes and other related products.[7] The same month the US Department of Health and Human Services (DHHS) issued for public comment a draft voluntary screening framework guidance for commercial providers of synthetic double-stranded DNA 200 base pairs or more.[8] The framework entails confirming the identity of customers, being aware of 'red flags' (e.g. unusual method of payment or shipping or labeling requests), and screening key nucleic acid segments based on select agents and toxins on the US Export Administration Regulation's (EAR) Commerce Control List (CCL).[9]

'Sequences of concern' are largely based on Australia Group lists and focus on sub-sequences that are associated with pathogenicity or that encode listed toxins. The screening lists are thus target-based, rather than agent-driven. There are currently approximately 2000 requests for sequences per year for the IGSC. The typical screening length is 200 base pairs (bp). From an industry perspective there are a number of uncertainties and concerns, including whether a 'sequence of concern' can be meaningfully defined and flagged as part of mail order screening.[10]

[6] Anonymous, 'Gene-synthesis firms set up biosecurity protocol', *Genetic Engineering & Biotechnology News*, 18 Nov. 2009, <http://www.genengnews.com/news/bnitem_print.aspx?name=68850005>.

[7] International Gene Synthesis Consortium (IGSC), Harmonized Screening Protocol, undated, <www.genesynthesisconsortium.org/.../IGSC%20Harmonized%20Screening%20Protocol.pdf>.

[8] Double-stranded DNA sequences are of greater concern than single-stranded ones.

[9] Department of Health and Human Services, Office of the Secretary, 'Screening framework guidance for synthetic double-stranded DNA providers', *Federal Register*, vol. 74, no. 227 (27 Nov. 2009), pp. 62319–27.

[10] Notka, F., 'The relevance and potential applicability of screening framework guidance for commercial providers of synthetic double-stranded DNA: current software screening and review mechanisms'. Presented at *Addressing Future Challenges to the Biological and Toxin Weapons Convention in Connection with Scientific and Technological Developments*; SIPRI; 5–6 Mar. 2011; Stockholm.

III. Assessment and related activity

The member states should consider further what constitutes fundamental non-compliance with the CWC in terms of S&T. This entails both maintaining and strengthening an awareness of general S&T developments and maintaining awareness of activity that might give rise to a specific compliance concern. It would be useful to further consider the mandate and operation of the constituent bodies of the OPCW, including the Scientific Advisory Board (SAB), in relation to the link between S&T and the CWC's verification regime. There are at least two underlying views to how such activity should be carried out. One includes a desire to continue the routine verification regime with few or no fundamental changes. This entails a desire to limit the cost, scope and level of intrusiveness of the regime according to established implementation practice. A second view is more amenable to the possible desirability of modifying the cost, scope or level of intrusiveness of the regime in light of an increased emphasis on non-traditional threat scenarios, including those based on S&T developments.

Defence establishments are continuing to explore and assess potential agents for protective purposes in permitted types and quantities, including with respect to non-traditional threat scenarios. Large scale state CW programmes were easier to assess as 'offensive', especially if the stockpiling and integration of the weapons into military doctrine had occurred. Today the intentions of evaluation programmes and the possible existence of breakout capacities are more difficult to determine. Many (perhaps most) activity can be described by states as defensive and therefore permitted. Ultimately the member states must periodically consider such issues both in the general terms and in terms of specific activities of other member states and non-state actors.

IV. Options

Possible intervention points should be further considered to meet S&T-related concerns. Most (if not all) of such points have been proposed in some form over the years.

The OPCW continues to consider the how the verification regime for so-called Other Chemical Production Facilities (OCPFs) should be structured. These are defined as plant sites that produce by synthesis certain discrete organic chemicals that may contain the elements phosphorus, sulphur or fluorine (DOC/PSF) (excluding explosives and hydrocarbons).[11] Such plants are usually multi-purpose and able to produce a wide range of fine chemicals. OCPF inspections are more focused on the facility capability as compared to other types of chemical industry inspection.

The member states might further consider the relevance of the term 'hierarchy of risk', in parallel to achieving a more broadly shared

[11] CWC, Verification Annex, Part IX.

understanding on the geographic distribution of the various proposed site selection methodologies.

The OPCW might consider further a site nomination mechanism by states parties for non-challenge inspections for OCPFs.[12] The regional groups could collectively nominate one site for such inspection on a trial basis. It is also possible to develop a site nomination methodology that would provide for a single nomination from one regional grouping in any given year and where the right of nomination rotates. This could form one element of informing consultations on the geographic distribution of OCPF inspections.

The OPCW might consider making public some further information on chemical industry site selection methodologies and frequency of inspection algorithms. Some outside analyses could serve as useful points for comparison with those carried out by the member states and the Secretariat, particularly if they were linked to chemical industry developments, and base research in chemistry and the life sciences.

The member states might consider it useful to develop or further consider generic 'target models' for CWC non-compliance scenarios that link the principal S&T developments to non-state actor threats or to standby capabilities. Models developed for assessing traditional state programmes include: (*a*) chemical weapon systems models, (*b*) chemical weapon system test models and (*c*) chemical weapon development organisation models.[13] In 1993 the US Congress' Office of Technology Assessment (OTA) published a model depicting chemical weapon acquisition pathways.[14] Another methodology for assessing possible offensive chemical weapon-related activity is to categorize information according to 'defensive' and 'offensive' indicators, as has been done by Milton Leitenberg in the biological field.[15] Such models act as organizing principles with which to analyse information, including for case studies. Due regard to the principles of equal rights and obligations of member states inherent in any multilateral arms control and disarmament regime could be maintained partly by considering such models in terms of the verification principles and methods elaborated by the United Nations as part of the periodic exercise 'Verification in all its aspects, including the role of the United Nations in the field of verification'.

The OPCW member states could consider adopting annexes to the CWC. They could include one to allow for the declaration of less-than-lethal agents for counter-terrorism and peacekeeping purposes, and one for the declaration

[12] CWC, Verification Annex, Part IX, para. 11(c). See also Krutzsch, W. and Trapp, R., *A Commentary on the Chemical Weapons Convention* (Martinus Nijhoff Publishers: Dordrecht, Netherlands, 1994), pp. 460–61.

[13] Based on Clark, R. M. *Intelligence Analysis: a Target-Centric Approach* (CQ Press: Washington, DC, 2010), pp. 44–45.

[14] US Congress, Office of Technology Assessment, *Technologies Underlying Weapons of Mass Destruction*, OTA-BP-ISC-115 (US Government Printing Office: Washington, DC, Dec. 1993), p. 20.

[15] E.g. Leitenberg, M., 'Biological weapons arms control', *Contemporary Security Policy*, vol. 17, no. 1 (Apr. 1996), pp. 57–58.

of dual-purpose equipment and technology. A third proposal is to add a peptide bioregulator as a place holder to one of the Schedules.[16]

The OPCW should further consider the implications for CWC verification of the DNA segment screening guidelines, including within the context of its work with customs and licensing officials.

Eventually, the consultation and clarification provisions of the Biological and Toxin Weapons Convention (BTWC) and CWC should be considered in terms of progressive synergies. From the CWC framework, this could be conceptualized from the standpoint of presenting a review of biocatalysis processes[17] and its possible relevance to the routine declaration and verification system. This week the Preparatory Committee to the BTWC is being held. There currently appears to be greater general support for agreeing measures to assess S&T developments.[18] Various formal and informal liaison or consultation mechanisms between the two regimes, including in the area of S&T, continue to be raised. Perhaps the Seventh Review Conference could be used as an opportunity to further define or formalize such a mechanism as part of an inter-sessional process between the 7th and 8th BTWC Review Conferences.

V. Conclusions

The member states should further consider what, if any activity, related to S&T developments they believe to be a fundamental violation to the CWC. In parallel, they should take all necessary steps to ensure that they understand the principal threats associated with S&T developments to the object and purpose of the convention. Finally, they could develop options to deal with representative theoretical S&T-related compliance scenarios. These options would then be available should specific developments occur that cause the member states to modify the manner in which the verification regime should function.

[16] Jonathan Tucker has suggested substance P or oxytocin be added to Schedule 2A. Tucker, J. B., 'Convergence of biology and chemistry: an emerging agenda', slide 24. Presentation at OPCW; 22 Mar. 2011; The Hague, Netherlands.

[17] For a general review, see Davis, G. G., and Boyer, V., 'Biocatalysis and enzymes in organic synthesis', *Natural Product Reports*, vol. 18 (2001), pp. 618–40.

[18] This could be achieved through a more regular review of such developments between the Seventh and Eighth Review Conferences.