ELTE ÁJK
ÁLLAM- ÉS JOGTUDOMÁNYI KAR

ELTE LAW WORKING PAPERS
2023/03

Interconnectivity of CBW Regimes in Light of Advances of Science and Technology

Csilla Bertha

DOI: 10.58360/20231201-Bertha

*Csilla Bertha**

DOI: 10.58360/20231201-Bertha

1. Introduction

Scientific and technological development permeates the – peaceful and non-peaceful – uses of chemistry and biology, and, consequently, the Chemical Weapons Convention (the "CWC")[1] and the Biological Weapons Convention (the "BWC")[2] (the CWC and the BWC hereinafter together referred to as the "Conventions"). The Conventions set out the obligations of States Parties in connection with chemical and biological disarmament respectively and promote the use of science for peaceful purposes. This study wishes to assess the potential impacts of scientific and technological development on the international chemical and biological weapons (CBW) regimes that are becoming more and more interconnected, in consideration of the fact that the ever-current state of science and technology is closely interrelated with the scope and implementation of the Conventions.

First, the study explains some recent trends in science and technology, which are relevant for the interpretation of the Conventions. Then, the definitions of chemical and biological weapons are discussed demonstrating that the drafters in fact considered the need for the adaptability of the Conventions *vis-á-vis* future developments in science and technology.

The study also elaborates on institutional issues and on the question of to what extent the institutions established by the CWC, namely the Organisation for the Prohibition of Chemical Weapons (OPCW), the Scientific Advisory Board (SAB) and verification mechanisms, can serve as an example for supporting the BWC regime based on the fact that the core elements of the two Conventions are closely intertwined with the state of science and technology as a consequence of the material scope of the Conventions.

---

* Csilla Bertha PhD Assistant professor, Department of International Law, Faculty of Law, Eötvös University, Budapest. ORCID-number: 0009-0002-4803-1335.

[1] Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on their Destruction. The CWC opened for signature on 13 January 1993 and entered into force on 29 April 1997.

[2] Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction. The BWC opened for signature on 10 April 1972 and entered into force on 26 March 1975.

Science and technology define the capacity of States Parties and the OPCW to respond to a potential CBW attack. Both Conventions prescribe that States Parties shall cooperate in order to enhance peaceful scientific research and provide assistance to each other in case of an attack.[3] It comes naturally that response too requires a chemical or a biological (medicinal) solution, which strongly depends on the material and immaterial resources of States Parties, which drives us back to the state of science and technology.

Finally, the author wishes to mention potential platforms and avenues for cooperation between various stakeholders, emphasizing the importance of education and outreach to initiate and maintain an active dialogue in order to prevent the re-emergence of chemical and biological weapons and to promote the peaceful uses of science.

2. Relevant trends in science and technology

Since the entry into force of the Conventions (1975 and 1997 respectively), life sciences have seen remarkably rapid advances with the prospect of benefitting humankind. Due to the dual-use nature of science and technology, advances might pose unforeseen risks for the object and purpose of the Conventions. However, in order to be able to adequately assess such challenges facing the Conventions, first we have to understand the relevant trends in science and technology. Below, we discuss these trends in light of corresponding literature but without aiming to give an exhaustive list of advances in life sciences.

Globalisation characterises many aspects of the post-Cold War era, including the chemical and biological industry. The globalisation of the industries resulted in thousands of facilities spread all around the world as well as an easier flow of information. Research and development (R&D) increasingly takes place in a new, globalised environment, with the Internet providing a platform for communication and the global distribution of information and knowledge, thereby enabling and encouraging new forms of scientific collaboration, including the emergence of virtual laboratories, shared databases and open-source software.[4] Increasing access and ease of use of communications technologies along with the growing availability of resources to support research, global research capacity expands and diffuses on an international level.[5]

Another notable trend in natural sciences in the 21st century is the prominent convergence of the life sciences. Convergence has been recognised by the OPCW's

[3] CWC, *supra* note 1, Art. X(1); BWC, *supra* note 2, Art. VIII and X

[4] van Ham, Peter; van der Meer, Sico; Ellahi, Malik: Chemical Weapons Challenges Ahead: The Past and Future of the OPCW. With a Case Study on Syria. Clingendael Report, October 2017. https://www.clingendael.org/sites/default/files/2017-10/Clingendael_Report_Chemical_Weapons_Challenges_Ahead_2017.pdf (21.03.2023), p. 20

[5] National Academy of Sciences Report in Brief, Life Sciences and Related Fields: Trends Relevant to the Biological Weapons Convention, 2011. https://nap.nationalacademies.org/resource/13130/Life-Sciences-Related-Fields-Report-Brief-Final.pdf (14.10.2023)

DOI: 10.58360/20231201-Bertha

Scientific Advisory Board and also by a working paper submitted to the Meeting of the States Parties to the BWC, the latter describing convergence as an integrative and collaborative approach in the life sciences, which brings together theoretical concepts, experimental techniques and knowledge of different disciplines at the crossroads of chemistry and biology. The "omics" disciplines are considered as an example of scientific convergence, which are studies of all constituents collectively of a set of data or biomolecules, such as genes (genomics), lipids (lipidomics) or proteins (proteomics).[6]

A logical consequence of the convergence between chemistry and biology on the level of arms control treaties is that it is increasingly becoming the same science base that is underpinning both the CWC and the BWC[7], which requires a clarification of the relationship between the two treaties. Convergence might result in the invention and application of new synthesis routes to existent toxics and the possibility of new, laboratory designed toxics. While usually discussed in the context of the future biotech revolution, as a result of converging sciences, the biotech revolution could also hold implications for the future of chemical weapons. A demonstrative example is the fact that most drugs that will be a result of advanced biotechnology are likely to be chemical agents, and, as such, future chemical weapons will have the potential to profit from the advanced understanding of the biochemical processes in the human body. This could then open the possibility to develop advanced chemical weapons (ACWs). A particular interest of state actors to develop a specific class of ACWs concerns the development of non-lethal (advanced) riot control agents or incapacitants that are not banned under the CWC for law enforcement purposes.[8]

Another concern closely related to the convergence of chemistry and biology is the advances of nanotechnology. Nanotechnology and nanoscience are terms that refer to the investigation and use of entities (particles) at the nanoscale, where at least one of the dimensions is somewhere between 1 and 100 nm.[9] Nanotechnology and nanoscience also encompass a range of techniques rather than a single discipline and stretch across the whole spectrum of science, touching medicine, physics, engineering and chemistry[10], which may have potential military applications. Three aspects of chemical and biological arms control can be identified where the advances of nanotechnology could have an impact. These fields are the development of novel agents, the use of nanotechnology as

[6] Trapp, Ralf: Convergence of Chemistry and Biology and Nanotechnology. In: Preventing Chemical Weapons: Arms Control and Disarmament as the Sciences Converge. Eds.: Crowley, Michael; Dando, Malcolm; Shang, Lijun, 2018, 193-227, p. 194 -195. DOI: https://doi.org/10.1039/9781788010092-00191
[7] Mathews, Robert, J.: Chemical and Biological Weapons (October 26, 2015). Forthcoming in R. Liivoja & T. McCormack (eds): Routledge Handbook of the Law of Armed Conflict, Routledge, University of Melbourne Legal Studies Research Paper No. 723, Available at https://ssrn.com/abstract=2679720 (23.03.2023), p. 22
[8] Sweijs, Tim; Kooroshy, Jaakko: The Future of CBRN. The Hague Centre for Strategic Studies, 2010, Available at https://hcss.nl/report/the-future-of-cbrn/ (23.03.2023), p. 14-15
[9] Trapp, *supra* note 6, p. 206
[10] Whitman, Jim: The Arms Control Challenges of Nanotechnology, In *Contemporary Security Policy,* 32:1, 2011, 99-115, p. 101. DOI: https://doi.org/10.1080/13523260.2011.556848

DOI: 10.58360/20231201-Bertha

delivery systems and applications in the protection against CBW. As nanotechnology advances, it is likely to be possible to design materials that act like chemical agents but may be out of the scope of either the CWC or the BWC.[11]

Structural and technological trends in the chemical and biological industries (manufacturing) should also be examined to better understand the operation of the Conventions. The structural changes in industry emerge from globalisation – as discussed above –, resulting in new production locations, changes in trade patterns and market conditions, which cause a shift from industry's product-driven approach to a solution-oriented one. New production locations are being established in developing countries, where national implementation of the Conventions is less advanced.[12]

On the technological side, the developments in flow reactors, especially the use of microreactors, need to be monitored as a prominent factor altering chemical industrial practice. The major advantages of microreactors include the safe production of hazardous, corrosive chemicals and certain classes of biologically active chemicals, which are not or hardly possible under batch conditions. In addition, it became easier to perform highly energetic reactions, work with unstable intermediates, employ reactive agents and use catalysts more effectively in microreactors, which could potentially result in novel production processes.[13] A further advantage is that microreactors can be operated in parallel in order to afford an increased throughput. This way, despite their small size, microreactors could produce tons of materials per year if operated in parallel.[14]

In the biotech industry, the space and resources necessary for the production of biologics has decreased and more compact equipment can be used in smaller, lower-cost facilities. The increased use of biosynthesis and bio-based production, scaffolds and "biopharming" accelerates the speed and yield of producing biological agents. In addition, there is an increase in the use of disposable or single-use equipment, which offers possibilities for

[11] Wallach, Evan J.: A Tiny Problem with Huge Implications – Nanotech Agents as Enablers or Substitutes for Banned Chemical Weapons: Is a New Treaty Needed? In: *Fordham International Law Journal,* Vol. 33, 3, 2009, 858-956, p. 859

[12] Trapp, Ralf: Research, development and production: impact and challenges for future verification under the CWC. In: The future of the CWC in the post-destruction phase. (Ed.: Zanders, Jean Pascal), Report no. 15, European Union Institute for Security Studies, 2013, 15-27, p. 18-19. DOI: 10.2815/32605

[13] Smallwood, Katie; Trapp, Ralf; Mathews, Robert; Schmidt, Beat; Sydnes, Leiv K.: Impact of scientific developments on the Chemical Weapons Convention (IUPAC Technical Report). In: *Pure and Applied Chemistry,* Vol. 85., No. 4, 2013, 851-881, p. 856. DOI: https://doi.org/10.1351/PAC-REP-12-11-18

[14] Parshall, George W.: Scientific and Technological Developments and the CWC. In: The Chemical Weapons Convention. Implementation Challenges and Solutions (Ed.: Tucker, Jonathan B.), April 2001, Monterey Institute of International Studies, 53-58, p. 54

DOI: 10.58360/20231201-Bertha

faster technological breakout enabling switching from permitted to prohibited technologies.[15]

The use of computers and automation in manufacturing processes have become more widespread. These methods can facilitate production under the most efficient reaction conditions and enhance the safety of plant operators, which advantages could also be applied in the context of production of CBW by minimising operator exposure and limiting the release of toxic vapours into the atmosphere that might be detected by sensitive monitoring equipment.

In connection with the spread of new computer-based techniques in the chemical industry, a new method known as combinatorial chemistry also developed. Combinatorial chemistry provides the possibility to synthesize large libraries of chemical compounds that can then be evaluated for useful properties. Generally speaking, the procedure involves mixing reactive chemicals in multiple combinations to generate hundreds or thousands of compounds. In correspondence with the high productivity enabled by computerisation/automation and combinatorial chemistry, an equally effective method for screening large numbers of compounds became necessary. From a non-proliferation perspective, the risks posed by combinatorial chemistry as a new development method are its potential abuse to develop new lethal or toxic chemical weapons for military or terrorist purposes.[16]

Computation, the interplay of biotechnologies with artificial intelligence, machine learning and a high degree of automation are accelerating the development of biomedical products, too. Synthetic biology, the scientific disciple encompassing all aspects of the engineering of biosystems, is rapidly developing and tools that lower the education, training, cost, time and equipment threshold required to modify and employ pathogenic organisms as biological weapons.[17] A particularly powerful development in biotechnology has been the creation and subsequent widespreading of genome editing methods, notably the CRISPR/Cas9, which allows the selective cutting and modification of DNA sequences.[18]

[15] The InterAcademy Partnership Conference Report. The Biological and Toxin Weapons Convention. Implications of advances in science and technology, June 2016, pp. 12 and 16. https://www.interacademies.org/publication/biological-and-toxin-weapons-convention-implications-advances-science-and-technology (14.10.2023)
[16] Parshall, *supra* note 14, p. 54-55
[17] Wickiser, J. Kenneth; O'Donovan, Kevin J.; Washington, Michael; Hummel, Stephen; Burpo, F. John: Engineered Pathogens and Unnatural Biological Weapons: The Future Threat of Synthetic Biology. In: CTC Sentinel, August 2020, Vol. 13, Issue 8, p. 2. https://ctc.westpoint.edu/engineered-pathogens-and-unnatural-biological-weapons-the-future-threat-of-synthetic-biology/ (14.10.2023)
[18] Reiners, Sophie; Thränert, Oliver: The Biological Weapons Ban and Scientific Progress. CSS Analyses in Security Policy No. 321, April 2023, p. 3. https://css.ethz.ch/en/center/CSS-news/2023/04/the-biological-weapons-ban-and-scientific-progress.html (14.10.2023)

DOI: 10.58360/20231201-Bertha

3. The definition of chemical and biological weapons

3.1. The General Purpose Criterion

The central concepts of the CWC and the BWC are the definition of chemical weapons[19] and biological weapons[20] respectively. The CWC further clarifies the definition of chemical weapons by providing a definition of toxic chemicals[21] as well as the term "purposes not prohibited under this Convention".

The clause, "purposes not prohibited under this Convention" constitute the General Purpose Criterion ("GPC"), which makes the definition of chemical weapons and the CWC itself future proof. According to the definition set forth in Article II(9)

> *"Purposes not Prohibited Under this Convention" means: (a) Industrial, agricultural, research, medical, pharmaceutical or other peaceful purposes; (b) Protective purposes, namely those purposes directly related to protection against toxic chemicals and to protection against chemical weapons; (c) Military purposes not connected with the use of chemical weapons and not dependent on the use of the toxic properties of chemicals as a method of warfare; (d) Law enforcement including domestic riot control purposes.*

The CWC thus makes it clear that toxic chemicals, their precursors and the delivery equipment and devices designed for their employment are by definition chemical weapons, except when intended for peaceful purposes (purposes not prohibited under the CWC), provided that the types and quantities are consistent with such purposes. In particular, the CWC contains three Schedules containing lists of chemicals and precursors which provide a framework for verification activities depending on the toxicity and

---

[19] CWC, *supra* note 1, Art. II(1) *"Chemical Weapons" means the following, together or separately: (a) Toxic chemicals and their precursors, except where intended for purposes not prohibited under this Convention, as long as the types and quantities are consistent with such purposes; (b) Munitions and devices, specifically designed to cause death or other harm through the toxic properties of those toxic chemicals specified in subparagraph (a), which would be released as a result of the employment of such munitions and devices; (c) Any equipment specifically designed for use directly in connection with the employment of munitions and devices specified in subparagraph (b).*

[20] BWC, *supra* note 2, Art. I *[...](i) microbial or other biological agents, or toxins whatever their origin or method of production, of types and quantities that have no justification for prophylactic, protective or other peaceful purposes; (2) weapons, equipment or means of delivery designed to use such agents or toxins for hostile purposes or in armed conflict.*

[21] CWC, *supra* note 1, Art. II(2) *Any chemical which through its chemical action on life processes can cause death, temporary incapacitation or permanent harm to humans or animals. This includes all such chemicals, regardless of their origin or of their method of production, and regardless of whether they are produced in facilities, in munitions or elsewhere.*

DOI: 10.58360/20231201-Bertha

industrial application of the listed chemicals.[22] The CWC makes it clear that the Schedules shall not be understood as a definition or an exhaustive list of chemical weapons,[23] taking into consideration that the advances of science and technology might extend or alter the category of chemical weapons. The Schedules were drafted based on conceptions of utility dating from the Cold War period, which means that the lists of chemicals were prepared based on types of agents that fitted old war requirements. Basically, this meant focusing on toxic chemicals with intensely aggressive features, however, a limited number of such toxic chemicals exist,[24] which also has implications for industry verification.

The definition of biological weapons set forth by the BWC also operates with a General Purpose Criterion to avoid that the BWC could be considered outdated by future scientific developments, although the term is not explained further in the text of the BWC. In the BWC, the General Purpose Criterion is manifested in the requirement that States Parties may never produce biological agents or toxins of types and quantities that are not justified for prophylactic, protective or other peaceful purposes. Similarly to the CWC, it is in fact the vagueness of the General Purpose Criterion that ensures that the BWC is future proof.[25] The BWC, however, differs from the CWC in a sense that no schedules or lists have been agreed by the States Parties on the types and quantities of agents and toxins, which are the most likely to be used as biological weapons, providing less demarcation as to the borders of prohibited and legitimate activities. More importantly, the BWC does not establish a verification system as the CWC does, which is considered one of the major areas where the BWC need to be improved. The possibility of introducing a verification system to the BWC regime as well as implications of its absence are discussed under chapter 4.2.

3.2. The impacts of scientific and technological advances on the definition of CBW

Recent trends in science and technology – discussed above in chapter 2 – pose new challenges for the interpretation and application of the definition of CBW, and, more closely, the General Purpose Criterion. Although it is theoretically clear that the GPC provides protection against yet unknown chemical and biological weapons that could be invented as a result of new technologies and the application of advanced biological and chemical processes, the ultimate success of the GPC in practice lies on its implementation. The Conventions set out obligations for their respective States Parties, however, national

[22] Sossai, Mirko: Drugs as Weapons: Disarmament Treaties Facing the Advances in Biochemistry and Non-Lethal Weapons Technology. In: *Journal of Conflict & Security Law,* Vol. 15, No. 1, 2010, 5-24, p. 11-12. DOI: https://doi.org/10.1093/jcsl/krq004
[23] CWC, *supra* note 1, Annex on Chemicals, Part B, paragraph 1
[24] Robinson, J. P. Perry: Difficulties Facing the Chemical Weapons Convention. In: *International Affairs (Royal Institute of International Affairs 1944-)*, Mar. 2008, Vol. 84, No. 2, 223-239, DOI: https://doi.org/10.1111/j.1468-2346.2008.00701.x, p. 226
[25] Reiners; Thränert, *supra* note 18, p. 2

implementation of the General Purpose Criterion of the CWC and the BWC alike need to be improved.[26] There could be multiple reasons behind the inaccurate and incomplete implementation of the GPC, which are, *inter alia,* the difficulty of executing effective policies as a matter of practical administration on the basis of a flexible definition[27], or the fact that States Parties could also profit from the scientific advances to develop agents for purposes prohibited by the Conventions, while still respecting their obligations[28]. Apart from ensuring that States Parties comply with their obligations, they must also implement national legislation to ensure that private actors do not abuse chemical and biological agents on their territory, under their jurisdiction or control.[29][30] An important challenge for both regimes arises from the fact that scientific and technological advances provide easier access to materials, equipment, scientific knowledge and technical know-how, and that the convergence of sciences and sectors enable private companies or even individuals to be in a position to produce and/or use CBW.[31]

Advances in nanotechnology also need to be highlighted in connection with the definition of chemical and biological weapons. As discussed above, the two Conventions ban any existing and future chemical and biological weapons, which include nano-sized particles used as weapons, unless they fall into any of the exceptions set forth by the Conventions. This is underlined by the definitions of the CWC and the BWC, which render the regimes applicable to toxic chemical and biological agents and toxins regardless of their origin or of their method of production. The same absolute ban should also be applied *mutatis mutandis* to nano delivery systems.[32]

The applicability of the CWC, the BWC and the Geneva Protocol[33] to nano-sized mechanical systems (mimics) or nanomimics is a more difficult question. The notion of nanomimics might seem futuristic or could even be considered as something created in

[26] E.g. Pearson, Graham S.: Implementation of the General Purpose Criterion of the Chemical Weapons Convention. Bradford, Bradford Disarmament Research Centre, Department of Peace Studies, University of Bradford, 2003. CWC Review Conference Papers: First Review Conference, No. 3. Available at https://bradscholars.brad.ac.uk/handle/10454/876 (30.03.2023)
[27] Robinson, *supra* note 24, p. 238
[28] Sossai, *supra* note 22, p. 12-13
[29] BWC, *supra* note 2, Art. IV
[30] CWC, *supra* note 1, Art. VII, points 1-3
[31] Lentzos, Filippa: How to protect the world from ultra-targeted biological weapons. In: The Bulletin of Atomic Scientists, December 7, 2020 DOI: https://doi.org/10.1080/00963402.2020.1846412
[32] Wallach, *supra* note 11, p. 942-943
[33] Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare (the Geneva Protocol) drawn up and signed at the conference which was held in Geneva under the auspices of the League of Nations from 4 May to 17 June 1925, and it entered into force on 8 February 1928. The provisions of the Geneva Protocol are explicitly recognized by the CWC and the BWC.

DOI: 10.58360/20231201-Bertha

science fiction but their application to become reality is advancing.[34] Nanomimics are robots on the nanoscale, which could possibly enter the human body, penetrate cells, and cause them to act in a programmed fashion, and the risk exists that they could also be used for hostile purposes. Accordingly, any attempt to avoid their coverage under the CWC, the BWC and the Geneva Protocol might result in ambiguities and unwanted consequences. In fact, there are strong arguments for their coverage, such as the intents of the drafters of the aforementioned Conventions, their wordings, the fact that all of these weapons cause a chemical and/or biological reaction and the general principle of good faith under international law.[35] On the basis of these arguments, there is no real need to amend either the CWC or the BWC, since the presented arguments overwhelmingly support the interpretation that nanomimics could be covered under the current wording of the CWC and/or the BWC if used for hostile purposes. However, once the threats posed by nanomimics and other nanobots become closer to reality, it would be sensible to consider the addition of a clarificatory wording to the definitions of chemical weapons and biological weapons (e.g. to include the term 'equivalents' and/or 'analogous devices' of toxic chemicals in the definition of chemical weapons in the CWC and do the same with the definition of biological and toxin weapons in the BWC).[36]

4. The adaptability of the Conventions on an institutional level

The BWC came into force during the Cold War period and CWC was drafted and adopted at the end of the Cold War era, which means that the drafters of both Conventions were in a position to consider the experiences of the Cold War. Accordingly, the primary focus of the Conventions was demilitarisation through the destruction of CBW stockpiles and the tools envisaged by the drafters were drawn on the basis of the experiences of the Cold War era.

The drafters of both the CWC and BWC were conscious of the potential impact scientific and technological development could have on the implementation of the Convention, which is reflected in the Conventions as an obligation of States Parties to review the operation of the Conventions to assess whether their provisions are adequately implemented and to consider any new scientific and technological developments relevant to the Conventions.[37][38] Such reviews are organised in the form of Review Conferences.

4.1. The role of the OPCW and the SAB

[34] Cf. e.g. Aggarwal, Muskan; Kumar, Sunil: The Use of Nanorobotics in the Treatment Therapy of Cancer and Its Future Aspects: A Review. Monitoring editor: Muacevic, Alexander and Adler, John R., 2022, Available at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9584632/ (23.03.2023). DOI: https://doi.org/10.7759/cureus.29366
[35] For more details, see Wallach, *supra* note 11, p. 945-952
[36] Wallach, *supra* note 11, p. 954-955
[37] BWC, *supra* note 2, Art. XII
[38] CWC, *supra* note 1, Art. VIII(22)

On the institutional side, the CWC establishes the Organisation for the Prohibition of Chemical Weapons (OPCW) as the international organisation to achieve the object and purpose of the CWC, to ensure the implementation of the CWC, including international verification, and to provide a forum for consultation and cooperation among States Parties.[39] This means that the CWC has a designated international organisation to monitor the compliance of States Parties and to provide a platform for international consultations. On the other hand, the BWC does not establish an international organisation with a similar function as the OPCW, resulting that it is only the Meeting of States Parties and the Meeting of Experts, which were both established by the decision of the Fifth Review Conference in 2002 with the aim of facilitating more regular meetings to discuss the actions that States Parties wish to take in connection with ever-current issues relating to the BWC.[40]

Now with the Cold War over, and globalisation becoming a norm with its own consequences, the need to update the BWC to par with the CWC is increasing.[41] Although the OPCW itself has its own challenges arising from, *inter alia*, scientific and technological development, funding issues or the lack of consensus between its States Parties, it would be a welcome development to establish an international organisation to monitor compliance with the BWC and provide a more sophisticated platform for cooperation between States Parties. The establishment of an international organisation could also support exchanging experience and could open up opportunities to conduct joint technical reviews between the two regimes, which were identified by the OPCW advisory panel as important steps to be taken to tackle the issues arising from the interconnectivity of the Conventions. Many of the national delegates and technical experts sitting at CWC and BWC meetings are already the same,[42] which could also support the potential establishment of an international organisation to monitor compliance with the BWC similar to the OPCW.

The Scientific Advisory Board (SAB) is an advisory body of the OPCW, which enables the channelling of scientific and technological expertise into the decision-making processes of the OPCW. Pursuant to the CWC, the SAB is a subsidiary body to provide specialised advice to the OPCW Director-General and the OPCW policy-making organs, as well as

---

[39] CWC, *supra* note 1, Art. VIII(1)

[40] Huigang, Liang; Menghui, Li; Xiaoli, Zhu; Cui, Huang; Zhiming, Yuan: Development of and Prospects for the Bioloigcal Weapons Convention. In: Journal of Biosafety and Biosecurity 4 (2022) 50-53, p. 51. DOI: https://doi.org/10.1016/j.jobb.2021.11.003

[41] Guillemin, Jeanne: Scientists and the History of Biological Weapons. EMBO reports Vol. 7, special issue, 2006, p. 48-49. DOI: https://doi.org/10.1038/sj.embor.7400689

[42] Hart John; Trapp, Ralf: Science, Technology and the Biological Weapons Convention. Arms Control Association ,June 2, 2022. https://www.armscontrol.org/act/2012-10/science-technology-biological-weapons-convention (14.10.2023)

DOI: 10.58360/20231201-Bertha

States Parties about areas of science and technology relevant to the Convention.[43] The SAB is composed of twenty-five independent experts serving in their individual capacity for up to two consecutive three-year terms. The members of the SAB are chosen based on their professional experience in scientific fields that are relevant to the implementation of the CWC. In the early years of the OPCW, the SAB was working on specific issues the Director-General and the Conference of the States Parties provided it with in order to ensure the SAB's independence and objectivity from political influence. The Director-General also established temporary working groups comprising of scientific experts to involve specialised scientific expertise in the SAB's and the OPCW's work.[44][45] By way of an example, the Temporary Working Group on Convergence established in 2011 was tasked with the assessment of the impact the convergence of sciences has on the implementation of the Convention.[46]

The BWC however, has not established a scientific advisory body as the CWC does. Based on recent literature and research, BWC States Parties indicated support for a mechanism to systematically review science and technology relevant to the BWC.[47] In fact, a recent T20 Policy Brief explicitly proposes the institutionalisation of an independent scientific expert group within the ambit of the BWC – similar to the OPCW SAB –, which could provide scientific and technical advice to address the shortcomings of the BWC in light of scientific and technological developments.[48] It is, however, not so evident that a potential future scientific advisory mechanism of the BWC should be exactly like the OPCW SAB. While there seems to be a support for the establishment of a systematic scientific and technical advisory mechanism, BWC States Parties will need to agree on its objectives and operation, further, the method of using the outputs of scientific reviews need to be clarified. The UNIDIR study prepared with the participation of 42 respondents provide a comprehensive review of the benefits and challenges of proposed models for establishing a science and technology mechanism under the BWC, encompassing a limited participation model (such as the OPCW SAB), an open-ended participation model and a hybrid model. The study highlights specific issues which should be considered before establishment of a scientific and technology mechanism. These questions relate to

[43] CWC, *supra* note 1, Art. VIII(21)(h)
[44] CWC, *supra* note 1, Art. VIII(45)
[45] Trapp, Ralf: The Chemical Weapons Convention – Past Success, Current Challenges. In: Preventing Chemical Weapons: Arms Control and Disarmament as the Sciences Converge. Eds.: Crowley, Michael; Dando, Malcolm; Shang, Lijun, 2018, 27-68, p. 35-36, 54. DOI: https://doi.org/10.1039/9781788010092-00025
[46] Trapp, *supra* note 45, p. 36
[47] Revill, James; Anand, Alisha; Persi Paoli, Giacomo: Exploring Science and Technology Review Mechanisms Under the Biological Weapons Convention, Geneva, Switzerland: UNIDIR, 2020, https://doi.org/10.37559/SECTEC/2021/SandTreviews/01
[48] Todi, Saurabh; Naik, Shambhavi: BWC Scientific Experts Group to Combat Biological Threats, T20 Policy Briefs, June 2023, pp. 3, 7, 13-14. https://www.orfonline.org/research/bwc-scientific-experts-group-to-combat-biological-threats/ (15.10.2023)

DOI: 10.58360/20231201-Bertha

objectives, participation methods, leadership, way of working, institutional support, outputs and funding.[49]

4.2. The importance of verification

The verification system established by the CWC is considered as a crucial element for compliance management in connection with the international chemical weapons ban. The main tool of verification is the conduct of on-site inspections performed by the inspectors working for the OPCW Technical Secretariat. The Verification Annex of the CWC provides the detailed rules on verification procedures, with special emphasis put on on-site inspections, which are complemented by the provisions of bilateral facility agreements entered into between the OPCW and States Parties for each State Party respectively.[50]

The verification mechanisms established by the CWC can be categorised as (i) routine inspections and (ii) non-routine inspections (i.e. challenge inspections and investigations of alleged use). Pursuant to the CWC, the purpose of routine inspections is twofold: on the one hand, routine inspections aim to verify the declarations on the destruction of chemical weapons, storage facilities and chemical weapons production facilities performed by possessor States Parties; and on the other hand, inspections are targeted at verifying that the industrial activities of States Parties primarily those relating to Scheduled chemicals, are conducted for peaceful purposes.[51] Challenge inspections and investigations of alleged use are irregular verification measures, which are intended to detect and clarify States Parties' alleged non-compliance with the provisions of the CWC.

With the chemical weapons destruction phase nearing its end, routine verification measures performed by the OPCW tend to focus more on ensuring that no chemical weapons are being produced. From the perspective of scientific and technological development, routine industry inspections pose greater challenge to the effectiveness of the CWC's routine verification system than monitoring the destruction of chemical weapons. This is due to the fact that the scientific background necessary to review the destruction of chemical weapon stockpiles was clear and available to the OPCW, whereas the scientific and technological competences required for successful industry verification (e.g., the selection criteria applied to decide which sites should be inspected and with what frequency, the maintaining institutional knowledge within the OPCW Technical Secretariat, etc.) strongly depend on the OPCW's ability of understanding and applying the advances of science and technology.

[49] Revill *et al, supra* note 47
[50] E.g. Trapp, Ralf: Compliance Management under the Chemical Weapons Convention. *UNIDIR WMD Compliance & Enforcement Series,* Paper Three, 2019. DOI: https://doi.org/10.37559/WMD/19/WMDCE3
[51] See CWC, *supra* note 1, Verification Annex for more details

DOI: 10.58360/20231201-Bertha

As demonstrated above through the example of the CWC, verification is key to the effective implementation of WMD-treaties. Apart from Confidence Building Measures introduced by the Second Review Conference that encourage States Parties to publish information about biodefense developments, the BWC does not provide a verification mechanism, which is often considered one of the main shortcomings of the treaty. During the first decade of the BWC being in force, there were States Parties (especially the former Soviet Union) that failed to comply with the BWC and other States Parties did not pay sufficient attention to the lack of verification measures in the BWC. With the rapid development of biotechnology, right after the end of the Cold War, an *ad hoc* group of experts, VEREX was established at the Third Review Conference of the BWC in 1991 to scientifically and technologically examine and determine possible verification measures. Later, a proposal was put forward on to establish an international organisation such as the OPCW and apply a similar verification mechanism as the CWC does. [52] The idea was to adopt a legally binding Additional Protocol to the BWC. However, the proposal was rejected by the US at the 2001 Review Conference because of political and practical reasons, with Russia's and China's tacit approval. Since then, there has been no substantial progress in the questions of verification for about 20 years, until the Ninth Review Conference held in 2022. During the Conference, States Parties agreed to (i) extend the mandate of the Implementation Support Unit by adding a fourth person; (ii) establish a new working group that is open to all States Parties to prepare a report to be adopted by consensus by the end of 2025 on, international cooperation for peaceful purposes, scientific and technological developments relevant to the BWC, confidence-building measures and transparency, compliance and verification, national implementation of the BWC, assistance in preparing for biological attacks, and, organisational, institutional and financials questions. Although there is still a wide divergence of views on how to strengthen the BWC, the renewed effort of States Parties to address more intensively the issue of verification of the BWC is a welcome development.[53]

5. Response capacities

The Conventions recognise the importance of assistance and protection against CBW in and encourage States Parties to cooperate in order to reach the highest protection against CBW.[54][55] As mentioned above, the Ninth Review Conference of the BWC underlined the importance of assistance in preparing for biological attacks by entrusting a working group to assess, among others, this question. The OPCW itself, too, has already recognised its role on multiple occasions to contribute to assisting States Parties to strengthen their response capacities by facilitating the exchange of information between States Parties

[52] Huigang *et al*, *supra* note 40, p. 52
[53] Reiners; Thränert, *supra* note 18, pp. 3-4
[54] CWC, *supra* note 1, Art. X
[55] BWC, *supra* note 2, Art. VII and X

DOI: 10.58360/20231201-Bertha

and by increasing transparency. Certain related tasks of the OPCW are defined by the Convention, which are primarily implemented by the Technical Secretariat. Accordingly, the Technical Secretariat maintains a data bank, which contains freely available information on various means of protection against chemical weapons, in addition, the Technical Secretariat needs to be able to provide expert advice and assistance for a requesting State Party with identifying how its programmes for the development and improvement of a protective capacity against chemical weapons could be implemented.[56] The ability of States Parties as well as the OPCW to remain competent to adequately address a potential CBW attack correlates with their ability to remain up-to-date with the new developments in science and technology.

From the scientific and technological trends identified in chapter 2, the convergence of chemistry and biology and the applications of nanotechnology are expected to strengthen the response capacities of States Parties and the OPCW. The convergence of chemistry and biology could enhance the potential to respond to a CBW attack by more effective diagnosis and treatments. Convergence is also expected to increase the pace of drug discovery and to introduce new delivery methods which could neutralise the effect of certain toxins (such as ricin or botulinum toxin) or lead to a long-term protection against them. For example, the SAB's Temporary Working Group on Convergence directed attention to the emergence of protein and antibody-based drugs as effective medical countermeasures against chemical warfare agents.[57]

[The potential applications of nanotechnology in the areas of protection against CBW and decontamination are recognised as important developments interrelated with the convergence of sciences. The development of nanofibers for protective clothing is a tangible example of the practical application of nanotechnology for protection against chemical weapons exposure.[58] As for medical countermeasures, the (future) results of research on nano-based drug delivery mechanisms (such as nanopolymers) could have useful applications for the targeted delivery of antidotes.[59][60]]

6. Education and outreach

Education, outreach and international cooperation play an important role in preventing the re-emergence of CBW. A message that emerges from the interaction between the advances of science and technology and the implementation of the Conventions is that it is a difficult challenge for the CBW regimes to keep in track with scientific and

[56] CWC, *supra* note 1, Art. X(4)-(5)
[57] Trapp, *supra* note 6, p. 205
[58] Smallwood *et al*, *supra* note 13, p. 859
[59] It is important to note that the scientific advances concerning delivery mechanisms described in this section may also be relevant for the assessment of the risk of delivering CBW, if such advances are used for hostile purposes.
[60] Trapp, *supra* note 6, p. 208-209

DOI: 10.58360/20231201-Bertha

technological developments to address the potential threats facing the object and purpose of the Conventions. To surmount this challenge, States Parties – in the OPCW or through other venues – should actively engage and cooperate with stakeholders in academia and industry, which has already been recognised by the OPCW on multiple occasions.

6.1. Institutional background in the CWC

The Third Review Conference of the CWC formally recognised the importance of education and outreach in the implementation of the CWC. Based on the recognition of the Third Review Conference, the Executive Council established the Advisory Board on Education and Outreach (ABEO) in 2015 to support the continuous and sustainable implementation of the CWC, bearing in mind the importance of education and engagement with a range of audiences, such as scientists, industry, students, educators, civil society and policymakers.[61]

The ABEO is a subsidiary advisory body of the OPCW, which provides specialised advice in areas of education and outreach relevant to the OPCW's mandate in consideration of the latest advances in these fields. The ABEO may provide advice to the Director-General, the OPCW's policy-making organs and, upon their request, States Parties. The members of the ABEO are in a position similar to the members of the SAB. Accordingly, the ABEO is a group of fifteen independent experts in subjects including education in science, technology, engineering, mathematics and other relevant disciplines or science communication. The members of the ABEO serve in a personal capacity and not as representatives of their respective governments and their tenure is limited to two three-year terms.[62]

As part of the OPCW's and States Parties' cooperative investment in science and technology, the construction of the Centre for Chemistry and Technology or the ChemTech Centre within the OPCW began in 2017 to upgrade the capabilities of the Laboratory and Equipment Store. Initially, the work of the Laboratory and Equipment Store focused primarily on supporting the demilitarisation activities and missions as well as the routine inspections of industrial facilities performed by the OPCW. With the advances of science and technology, the work of the Laboratory and Equipment Store has changed and grown to reflect new requirements, including responding to the emergence of new chemical weapons threats with new and improved verification tools and expanding the capabilities to conduct non-routine missions, and also providing greater support for international cooperation and assistance activities.[63]

---

[61] Report on the Role of Education and Outreach in Preventing the Re-emergence of Chemical Weapons. ABEO-5/1, 2018, Available at https://www.opcw.org/fileadmin/OPCW/EC/83/en/ec83s01_c21s01_e_.pdf (26.03.2023)
[62] See https://www.opcw.org/about/subsidiary-bodies/advisory-board-education-and-outreach (26.03.2023)
[63] See https://www.opcw.org/media-centre/featured-topics/chemtech-centre (28.03.2023)

DOI: 10.58360/20231201-Bertha

6.2. Cooperation with the science community and industry

Achieving an effective CBW security policy requires the active engagement of many stakeholders, including the science community, non-governmental organisations with related agendas and the actors in chemical and biological industry.

Scientific organisations could provide opportunities for scientists to contribute as scientific experts to the effective implementation of the Conventions and other disarmament and non-proliferation efforts. A remarkable example of the OPCW's cooperation with academia is its close relationship with the International Union of Pure and Applied Chemistry (IUPAC). IUPAC is a particularly strong partner for the OPCW as the only independent, non-governmental, international organisation devoted to chemistry and the chemical sciences and their application in research, industry and society. IUPAC first engaged with the OPCW through an independent project on examining options for the destruction of chemical weapons stockpiles, which was the first major challenge of the CWC. Even though the OPCW already had the SAB to advise on scientific issues, it was the SAB itself that recognised the benefits of engaging a wider array of expertise to provide scientific inputs for the work of the SAB and the OPCW. This was the first time when an international disarmament treaty organisation requested independent advice from an international scientific organisation, which could serve as a good example to follow by other disarmament treaty mechanisms, such as the BWC. Since then, the IUPAC held workshops with the participation of researchers from academia, industry, the OPCW and also government technical experts and policy experts with scientific backgrounds to discuss scientific and technological developments and their implications for the CWC. These workshops could also serve as a model for the active involvement of scientists in the implementation of international disarmament treaties, providing a platform for the analysis of scientific trends over time. In fact, the success of the IUPAC workshops inspired a similar effort for the BWC, namely, the Biosecurity Working Group of the InterAcademy Partnership (IAP) in cooperation with international scientific partners has organised assessment of scientific and technological trends for the BWC Review Conferences. However, the difficulty of involving all relevant actors of biology and biosecurity lies in the diversity and fragmentation of the field, which is manifested in the fact that there are around a dozen of international unions whose activities are relevant for the operation of the BWC, whereas the IUPAC is clearly the only dominant international union in the chemical field. On the positive side, the Biosecurity Working Group of the IAP has become an informal science advisory system, aiming at filling the gap that no such mechanism is established by the BWC itself.[64]

[64] Bowman, K.W., Hay, A.W.M. and Husbands, J.L.: Role of the Non-governmental Chemical Science Community in Combatting the Development, Proliferation, and Use of Chemical Weapons. In: Preventing Chemical Weapons: Arms Control and Disarmament as the Sciences Converge. Eds.: Crowley, Michael; Dando, Malcolm; Shang, Lijun, 2018, 517-535, p. 518-523. DOI: https://doi.org/10.1039/9781788010092-00515

DOI: 10.58360/20231201-Bertha

In consideration of new scientific and technological developments, the involvement of industry through conferences and other platforms for exchanging of information and experience is equally important but might as well occur in a more formal manner through public-private partnerships. A viable option for industry's contribution to the object and purpose of the Conventions is the promotion of responsible science through self-regulation by the application of codes of conduct. Codes of conduct are self-governance mechanisms that establish a set of common principles, which professional communities agree to abide by. A breach of such professional code that amount to a serious deviation of professional practice could possibly incur severe criticism and may even result in exclusion from the "guild". Hence, codes of conduct have a twofold purpose: they allow professionals a considerable space for self-regulation and self-discipline, while at the same time they protect the integrity of the profession by discouraging professional misconduct.[65][66] As regards CBRN security, a list of duties has been suggested to be included in codes of conduct for researchers to address the risk of possible hostile misuse of their results, including the duty to prevent (CBRN) terrorism, to engage in response activities, to consider negative implications of research, to keep sensitive information confidential and to oversee and limit access to dangerous materials.[67]

A good example is the Hague Ethical Guidelines (the "Guidelines"), which is a code of conduct developed by a group of chemical practitioners around the world that was adopted in 2015 by the Conference of the States Parties based on the understanding that achievements in the field of chemistry should be used to benefit humankind and the environment. The document is considered an important step to advance the understanding among chemistry practitioners of the importance of nurturing responsible and ethical norms for scientific research and development. The Guidelines have also been widely disseminated to professional societies and industry organisations and has received a recognition of a global code of ethics for chemists.[68]

7. Conclusion

The ever current state of science and technology underpin the implementation of the CBW regimes as their subject matters are based on scientific grounds. Hence, it is argued that the unprecedented development of science and technology witnessed during the last

---

[65] C.f. King, Andrew A.; Lenox., Michael J.: Industry Self-Regulation withot Sanctions: The Chemical Industry's Responsible Care Program. In: *The Academy of Management Journal*, Vol. 43, No. 4 (Aug., 2000), p. 698-716. DOI: https://doi.org/10.2307/1556362

[66] Kwik Grönvall, Gig: A New Role for Scientists in the Biological Weapons Convention. In: Nature Biotechnology, Vol 23, No. 10, October 2005, p. 1215. DOI: https://doi.org/10.1038/nbt1005-1213

[67] Novossiolova, Tatyana; Martellini, Maurizio: Promoting responsible science and CBRN security through codes of conduct and education. In: *Biosafety and Health,* 1, 2019, 59-64. DOI: https://doi.org/10.1016/j.bsheal.2019.08.001

[68] Bowman *et al, supra* note 64, p. 531

couple of decades needs to be assessed in the context of CBW disarmament and non-proliferation.

Most importantly, the convergence of life sciences and industrial and technological trends, such as computation, automation, easier access to scientific knowledge and equipment, point at the same direction for the chemical and biological weapons regimes, resulting that the CWC and the BWC are facing similar challenges. Consequently, the interconnectivity of CBW norms grows as the subject matters of the two regimes become more and more intertwined.

The author proposes to strengthen the cooperation between the two regimes on multiple levels and for the two regimes to learn from each other by considering the application of good practices established by one of them, but not by copy-pasting the institutions of one regime by the other (with a more likely scenario that the institutions of the CWC serve as an example to the BWC). At the same time, it is equally important to constantly monitor scientific and technological developments with the involvement of various stakeholders from academia and industry to surmount the challenges posed by the advances of sciences and technology.

DOI: 10.58360/20231201-Bertha