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### REPORT BY THE DIRECTOR-GENERAL

## RESPONSE TO THE REPORT OF THE SCIENTIFIC ADVISORY BOARD ON DEVELOPMENTS IN SCIENCE AND TECHNOLOGY TO THE FIFTH SPECIAL SESSION OF THE CONFERENCE OF THE STATES PARTIES TO REVIEW THE OPERATION OF THE CHEMICAL WEAPONS CONVENTION

### INTRODUCTION

1. Following the practice adopted by the First, Second, Third, and Fourth Review Conferences,<sup>1,2</sup> the Director-General has asked the Scientific Advisory Board (SAB) to prepare a report on developments in science and technology that States Parties to the Chemical Weapons Convention (hereinafter “the Convention”) may wish to take into account in their review of the operation of the Convention, as provided for in paragraph 22 of Article VIII. This has been published as RC-5/DG.1 (dated 22 February 2023) and is now available to States Parties.
2. In its report to the Fifth Review Conference, the SAB has presented its findings by way of an executive summary (paragraphs 8 to 25), a series of recommendations (paragraphs 26 to 70), and an in-depth analysis of developments in science and technology relevant to the Convention in Annex 1. Throughout the detailed analysis, the Director-General notes the SAB has meticulously reviewed and assessed the available information and has drawn particular attention to topic gaps.
3. The Director-General encourages States Parties to familiarise themselves with RC-5/DG.1, which may assist them in their review of the Convention, particularly regarding any policy changes that might be necessary on the basis of scientific and technological changes. This Note provides the Director-General’s own assessment of the Board’s findings and focuses primarily on the content of the executive summary and recommendations and, where needed, draws upon the substantive analysis by the SAB contained in Annex 1 of RC-5/DG.1.
4. The Director-General notes that the SAB serves as a critical source of impartial scientific advice that ultimately assists States Parties in monitoring the key scientific and technological developments relevant to the Convention. The SAB’s advice is instrumental in ensuring that the Technical Secretariat (hereinafter “the Secretariat”)

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<sup>1</sup> RC-1/DG.2, dated 23 April 2003; RC-2/DG.1, dated 28 February 2008 and Corr.1, dated 5 March 2008; RC-3/DG.2, dated 31 January 2013; and RC-4/DG.2, dated 1 June 2018.

<sup>2</sup> Review Conference = Special Session of the Conference of the States Parties to Review the Operation of the Chemical Weapons Convention.



remains fit for purpose and continues to meet the expectations of States Parties. The Director-General acknowledges that the global pandemic has posed many challenges, and as a consequence, the time and opportunities available to the Board to consider developments have been reduced. He commends the Board's unwavering commitment to maintaining momentum and continuing to work collaboratively, productively, and flexibly, despite being unable to meet in person for three years. He appreciates the comprehensive and impactful report the SAB has produced by drawing on the wealth of complementary experience and scientific expertise across a range of disciplines that the SAB members collectively possess.

## **DEVELOPMENTS IN SCIENCE AND TECHNOLOGY RELEVANT TO THE CHEMICAL WEAPONS CONVENTION**

5. The SAB's report to the Fourth Review Conference highlighted the complex, dynamic, and highly transdisciplinary nature of scientific research and development at that time. Scarcely five years later, and in the midst of the Fourth Industrial Revolution, the SAB's latest report attests to a significantly transformed scientific and technological landscape. The fusion of the physical, biological, and digital realms has led to technological advances at an astonishing pace, affecting almost every aspect of life. The Director-General notes that certain "emerging" technologies discussed in SAB reports to previous Review Conferences are now commonplace in industry, having become more affordable and technically accessible over the years. It is clear that these advances—and perhaps most notably those in artificial intelligence, additive manufacturing, and biotechnology—present an ever-changing set of challenges to and opportunities for the implementation of the Convention.
6. Whilst the risk posed by the misuse of developments in science and technology is often the focus of attention, the Director-General notes that the SAB's report highlights the increasing opportunities these same developments may afford to both the Organisation and implementation of the Convention. He assesses that recent developments could have diverse applications, such as in strengthening the verification regime, streamlining or accelerating relevant research activities, increasing personnel and chemical safety, and filling critical knowledge gaps. These developments will not only ensure that the OPCW remains fit for purpose, but could also further enhance its capabilities, enable future challenges to be predicted more readily, and better prepare the Organisation to provide assistance to States Parties.

## **THE SCIENTIFIC ADVISORY BOARD'S RECOMMENDATIONS TO THE FIFTH REVIEW CONFERENCE**

### **Advice on chemicals (paragraphs 26 to 31 of RC-5/DG.1)**

7. The SAB has highlighted the scant scientific literature, across a number of areas, available on newly scheduled chemicals. The Director-General shares the SAB's view that the paucity of information available on this topic gives rise to significant knowledge gaps, which continue to challenge traditional inspection, enforcement, verification, and capacity-building activities. He therefore urges States Parties to share any information on these chemicals with the Secretariat, and particularly relating to those areas set out by the SAB in its recommendation on this topic. The Director-General reminds States Parties that sharing information is vital for the full and effective implementation of the Convention.

8. Recognising the ever-changing threat landscape and the OPCW's expanding mission needs, the Director-General places great importance on maintaining the Secretariat's capability to identify chemicals, enabling it to perform its verification activities effectively and meet its inspection mandates in full. In light of this, the Director-General encourages States Parties not to limit their information sharing to the newly scheduled chemicals, but to continue to submit information, particularly analytical data, on all chemicals relevant to the Convention. In addition to maintaining the Secretariat's capability, this additional information will support the verification and forensic activities performed by the designated laboratories.
9. In support of maintaining the Secretariat's capability to identify chemicals, the Director-General concurs with the SAB that the OPCW Central Analytical Database (OCAD) and the Validation Group Working Database should be as comprehensive as possible and include information on newly scheduled chemicals, central nervous system-acting chemicals (CNS-acting chemicals), and other relevant chemicals. The Director-General appreciates the work of the Validation Group, which continues to receive and validate data for inclusion in the OCAD.
10. The Director-General recognises the SAB's extensive work and advice in the area of CNS-acting chemicals, and recalls the request to the Board to continue to review relevant scientific and technological developments in this area and provide updates to the Conference of the States Parties as appropriate.<sup>3</sup> In view of the rapidly evolving pharmaceutical and chemical industries, combined with emerging technologies such as artificial intelligence, the Director-General shares the SAB's view that it should remain vigilant for any consequent impact on the topic of CNS-acting chemicals. He considers that an increased understanding of the synthesis, analysis, and safe handling of these chemicals is critical to preventing their emergence as chemical weapons.

**Advice on technology convergence (paragraphs 32 to 37 of RC-5/DG.1)**

11. The Director-General discerns that boundaries between disciplines have blurred, and technology has been used increasingly as a vehicle for innovation. He notes the growing trend for technologies to converge or to be transferred from one sector to another, and for research to be transdisciplinary.
12. The Director-General considers the development and proliferation of artificial intelligence to be particularly striking and acknowledges the significant potential this exciting technology shows. He recognises that leveraging this technology could afford a number of benefits and opportunities across a range of areas related to the Convention. The application of artificial intelligence in diverse experimental processes, as well as in property and hazard prediction, could enable tremendous and accelerated progress in relevant research and could also provide critical data to fill information gaps. Moreover, this emerging technology has the potential to strengthen the verification regime, increase operator safety in conjunction with robotics technologies, and assist in the rapid design and discovery of medical countermeasures for exposure to chemical warfare agents, which is traditionally a time-consuming area of research.

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<sup>3</sup> See C-26/DEC.10, dated 1 December 2021.

13. Despite these considerable and promising prospects, the Director-General also notes with concern the potential risks that artificial intelligence-assisted chemistry may pose to the Convention and the work of the OPCW. Of particular concern are the ease and speed with which new toxic chemicals may be discovered, as well as the ease and speed with which novel routes to existing toxic compounds can be identified. The Director-General calls upon the SAB to monitor relevant developments in artificial intelligence with renewed interest, to explore capabilities, and to identify specific opportunities for the Secretariat.
14. Similarly to the recent boom observed in artificial intelligence, the SAB's report visibly demonstrates that additive manufacturing technology has progressed significantly, with a corresponding widening of its application. Advances in areas such as laser power and materials have made it possible to 3D print objects of almost any shape, and ranging in size from a third of the width of a human hair to an entire building. The Director-General recognises this technology is a powerful tool in industry and may have potential applications in work conducted by the Secretariat.
15. The dual-use nature of additive manufacturing means that it may also be used to produce weapons of mass destruction-related equipment and components in unconventional ways. The Director-General notes that engagement with experts from multilateral export control regimes may provide further insight and understanding on this topic.
16. The SAB's report describes how developments in areas of biotechnology, such as synthetic biology and metabolic engineering, are enabling cells to be transformed into "biofactories" for the production of chemicals. This presents considerable benefits in terms of low-cost, sustainable, and environmentally friendly chemical production, but equally raises concerns regarding its potential to be used to produce toxic chemicals or their precursors.
17. The Director-General observes that the technical barriers for the artificial design and chemical synthesis of dangerous bacteria or a viral genome, toxin, or bioregulator chemical, are falling quickly due to advances in synthetic biology technologies that have reduced the cost and increased accessibility. The convergence of biotechnology with other fields, including artificial intelligence and nanotechnology, has led to further breakthroughs. The Director-General shares the SAB's view that this field should continue to be monitored closely, with particular attention paid to the effects it may have on the future of verification.
18. The SAB's report impresses upon the Director-General the extent to which technologies have advanced over the past five years. Developments in science and technology are revolutionising production processes, as well as transforming ways of communicating and collaborating, and he recognises that industrial chemical production has evolved dramatically since the negotiation of the Convention. Not only has chemical production evolved, but global trends in production have also changed, and these have been accompanied by an increased industry size and a marked geographical shift in production locations. The Director-General considers reviewing and monitoring the changing landscape of chemical production technologies as one of the key priority areas for the Secretariat; in his view, this topic merits in-depth examination, with special emphasis on its potential impact on the verification regime.

**Advice on science and technology relevant to verification (paragraphs 38 to 54 of RC-5/DG.1)**

19. The Convention's robust verification regime is the gold standard among multilateral disarmament agreements. The Director-General is mindful that whilst this regime is a tried and tested tool, the current science and technology landscape bears little resemblance to that at the time of the entry into force of the Convention. The Director-General supports the evolution and adaptation of verification capabilities in line with both advances in science and technology and the OPCW's expanding mission needs. This will ensure that the verification regime remains fit for purpose, fully effective, and best prepared in the face of future challenges. The Director-General welcomes the SAB's in-depth review of recent developments on this topic.
20. The Director-General concurs with the SAB's view that the applicability of next-generation analytical techniques, technologies, and equipment to the mission of the OPCW should continue to be evaluated in order to maintain this gold standard for years to come. Furthermore, he notes that this should not only include equipment to enhance both on- and off-site capabilities, but should also consider remote-sensing techniques. The latter has the potential to optimise verification and monitoring activities, while simultaneously increasing the safety and security of Secretariat personnel, one of the Director-General's highest priorities.
21. The Director-General notes the potential of the emerging field of plant biomarkers and recognises the wide abundance and geographic distribution of plants make them particularly useful sentinels of chemical exposure. The results generated by the Plant Biomarker Challenge are bolstering research on this topic, and the Director-General encourages follow-up work and discussions to continue in order to increase understanding of this relatively underexplored area. The ability to identify toxic chemicals and their breakdown and reaction products with the highest level of confidence is central to the effectiveness of the designated laboratories. Furthermore, expanding the toolbox of methods and techniques available to both the Secretariat and the designated laboratories is vital for the unambiguous identification of chemicals in investigations of alleged use.
22. The SAB's report draws attention to the outstanding questions relating to the use of chlorine and the unresolved challenges concerning the unambiguous confirmation of its use. In light of the recent proven cases of chlorine used as a chemical weapon, the Director-General encourages work to continue on this important topic, and notes that considering novel methods may yield critical results.
23. Exchanging information and working collaboratively provide significant value and mutual benefits, and are paramount for building, maintaining, and enhancing the capabilities of both the Secretariat and its designated laboratories. The Director-General recognises that there are numerous opportunities for engagement within the context of verification activities. Notably, for the analysis of non-scheduled toxic chemicals such as CNS-acting chemicals, toxic industrial chemicals, and biotoxins, sources of expertise exist beyond the designated laboratory network and should be leveraged. The Director-General believes that the OPCW's Centre for Chemistry and Technology (ChemTech Centre) will significantly augment the Secretariat's capabilities to engage with a broad range of partners and stakeholders, and recognises that this flagship facility will play a pivotal role in supporting verification activities.

24. It is evident that the key findings of the Temporary Working Group (TWG) on the Analysis of Biotoxins have been taken into account in the SAB's review of biotoxins. The Director-General considers these findings to be particularly insightful and draws attention to the investigative challenges posed by biotoxins, in part due to their great diversity. The Director-General looks forward to reviewing the TWG's end-of-mandate report and considering the recommendations with a view to implementing them where possible.
25. As a consequence of the differing methods required for the analysis of low molecular weight biotoxins and high molecular weight biotoxins, few laboratories are skilled in both types of analysis. The Director-General notes the importance of identifying capacities to analyse a broader range of biotoxins. He recognises that engagement with the UNSGM<sup>4</sup> laboratory network could be particularly fruitful, and that its expertise may be further leveraged to harmonise analytical techniques and reporting criteria in relation to biotoxins.
26. The Director-General supports further work in the field of biotoxins and encourages the continuation of the biotoxin confidence-building exercises, with an eventual transition to a series of biotoxin proficiency tests. Furthermore, the Director-General notes the SAB's advice that performance and reporting criteria should be reviewed and revised to ensure they remain both up to date and relevant.
27. In order to further enhance the Secretariat's capability to identify chemicals, the Director-General notes the SAB's proposal to broaden the scope of optional biomedical sample confidence-building exercises to include analogues of sulfur mustard, nitrogen mustards, different organophosphate chemicals, and newly scheduled chemicals.
28. The Director-General appreciates the in-depth analysis conducted by the TWG on Investigative Science and Technology. This Group considered the experiences of current and former members of the Secretariat, the non-routine investigative experiences of other organisations, and the wide range of existing tools and transdisciplinary approaches that can be applied to the reconstruction of past events and to determine the provenance of chemicals. In light of the OPCW's increasing involvement in non-routine missions reflecting the evolving threat landscape, the Director-General recognises the growing call for the Organisation to strengthen its chemical forensics capabilities, and chemical profiling in particular.
29. The Director-General notes with interest the many benefits that dried blood spot sampling may afford, especially as the biomarker concentration remains unchanged for a longer period than for liquid blood samples. He concurs that this promising new technique merits further attention.
30. The destruction of declared stockpiles is on track for completion in 2023 and will mark a significant milestone in the OPCW's mission. In this regard, the Director-General is cognisant of the need to capture and preserve the knowledge, skills, and expertise accumulated through past and ongoing operations and missions. He recognises that this tremendous achievement should not lead to complacency; the risk of the use of chemical weapons remains real. Chemical weapons—namely old, abandoned, and

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<sup>4</sup> The United Nations Secretary-General's Mechanism for Investigation of Alleged Use of Chemical and Biological Weapons.

sea-dumped chemical weapons—will exist outside of declared stockpiles beyond 2023. The Director-General notes the significant challenges associated with this latter category of chemical weapons, and the increased spotlight on them as economic and environmental interests gain momentum.

**Advice on technologies for the delivery and dissemination of toxic chemicals and drugs (paragraphs 55 to 56 of RC-5/DG.1)**

31. The SAB's report highlights that the trend towards technology convergence has also infiltrated the field of drug delivery, enabling advances in drug product design. In turn, this has provided a foundation for targeted and tailored treatments, so-called "personalised medicine". The Director-General notes that the rapid advances in this area may facilitate the development of effective delivery methods for medical countermeasures to treat chemical weapons exposure. Alternatively, they may also facilitate the nefarious delivery of toxic chemicals.
32. The use of unmanned aerial vehicles, or drones, in agriculture has continued to rise. More recently, drones have also been used to disinfect surfaces contaminated with COVID-19. As crop sprayers, their capabilities have been influenced by technological developments: they can now fly further, carry a greater payload, and may even incorporate artificial intelligence technology for crop mapping and monitoring. The Director-General shares the view of the SAB that the misuse of drones remains an area of concern and requires further monitoring.

**Advice on assistance and protection (paragraphs 57 to 61 of RC-5/DG.1)**

33. Capacity-building and assistance activities are essential elements of supporting the prevention of the re-emergence of chemical weapons and strengthening the OPCW's ability to fulfil its mission. The Director-General recognises the value gained through engagement or partnership with relevant organisations and agencies to increase chemical weapons awareness in States Parties, and specifically to strengthen the capabilities of first responders.
34. The Director-General notes the importance of risk-based operational decision making in providing informed advice on assistance and protection, and enabling the OPCW to fulfil its mission objectives. He recognises the recurrent issue whereby the scarcity of information available on the newly scheduled chemicals is creating critical information gaps—this time in the areas of hazard management and medical countermeasures. He reiterates his call to States Parties to share any relevant data available on this topic.
35. The Director-General shares the SAB's view that in investigations into the use of a chemical weapon, or in ensuring the absence of a toxic chemical following a clean-up operation, a statistical approach that leads to high confidence in the results is important.
36. In order to carry out missions fully, effectively, and safely, consideration must be given to whether current approved equipment affords adequate protection to Secretariat personnel against CNS-acting chemicals and newly scheduled chemicals. The Director-General supports evaluating current equipment, seeking additional equipment, and developing capabilities as necessary to allow operations to continue in environments where these chemicals may be present.

**Advice on science and technology of relevance to chemical safety and security (paragraphs 62 to 65 of RC-5/DG.1)**

37. Today, chemicals are ubiquitous and play a key role in virtually every sector of the economy. With this in mind, the Director-General attaches great importance to promoting a culture of chemical safety and security to help prevent the re-emergence of chemical weapons and contributing to the peaceful and safe use of toxic chemicals. He encourages the Secretariat to continue to champion the complementary areas of chemical safety and security, and he supports maintaining engagement with technical experts in the chemical industry and at international organisations in order to strengthen the assistance it provides to States Parties in this area. The Director-General recognises that sharing information, policies, and best practices with chemistry practitioners, policymakers, National Authorities, and chemical industry associations is essential to enhance capabilities and improve cooperation, and may be of particular benefit to States Parties with developing and transitional economies.
38. Regarding chemical safety, the Director-General concurs with the SAB that regulations have become more stringent over the last few years, triggering the development of a strong safety culture with rigorous safety protocols in many chemical companies. Furthermore, the growing emphasis on more sustainable and environmentally friendly chemical production is driving a shift towards alternative processes and materials in the chemical industry. The Director-General recognises that substituting hazardous chemicals with less harmful ones is an important step in this endeavour, and notes that it will additionally reduce hazardous chemical inventories available for potential misuse.
39. The trend of transferring technologies between sectors is not confined to the traditional chemical research and development and manufacturing sectors, but extends across industry and academia. The Director-General believes that this increasing emphasis on chemical safety, bolstered by the application of technologies such as artificial intelligence and virtual reality, is leading to strengthened chemical safety on a global scale.
40. Chemical security is also undergoing a transformation with the use of technologies such as blockchain infrastructure, and the application of enhanced material controls and cybersecurity. The Director-General notes the prevalence of cybercrime and the risk it poses to the chemical industry.
41. The Director-General recalls that the use of chemicals as weapons is not limited to scheduled chemicals, but could apply to any hazardous chemical, including toxic industrial chemicals. Indeed, there have been confirmed instances of the use of chlorine, a toxic industrial chemical, as a weapon. In light of this, the Director-General recognises that additional information on toxic industrial chemicals, such as property and hazard data, will provide an enhanced understanding of the risks posed by their potential misuse.

**Advice on scientific literacy and scientific advice (paragraphs 66 to 70 of RC-5/DG.1)**

42. The issues and crises of the past few years, such as climate change, security threats, and especially the COVID-19 pandemic, have put scientific advice firmly in the spotlight. Scientific advice is interdisciplinary in approach, impartial, and free from political, cultural, economic, ethnic, or religious interests and has been invaluable in the formulation of public policies. The Director-General recognises and appreciates the unbiased, factual advice that the SAB continues to provide.



43. Scientific literacy is paramount when it comes to the application of scientific advice, and the Director-General credits the work of the Advisory Board on Education and Outreach (ABEO) in this regard. He supports closer collaboration between the SAB and the ABEO to enhance the synergy between scientific advice and literacy relevant to the effective implementation of the Convention.
44. The Director-General recognises that social media may be viewed as a double-edged sword within the context of scientific literacy and scientific advice. On one hand, it is a powerful tool that can be leveraged to engage a wide audience effectively and equitably, and to make science more accessible. On the other hand, it provides an avenue for the rapid and indiscriminate dissemination of misinformation or disinformation. The Director-General underscores the importance of fact-based, robust, and objective scientific information to build trust and credibility.
45. The COVID-19 pandemic has permanently altered the ways in which we work and communicate, and has generated creative and innovative solutions to enhance remote working and learning experiences. The newfound focus on virtual learning modes has led to the development of e-learning systems and the incorporation of gamification tools to simulate some practical scenarios. The Director-General recognises the shift towards virtual learning and believes that some of the tools and approaches now in use could benefit the Organisation.

#### **Other issues**

46. A fundamental theme throughout the SAB's report and recommendations is the importance of collaborating with others, building synergies, and leveraging complementary expertise, with a collective objective of enabling the OPCW to deliver on its mission. The Director-General is confident that the ChemTech Centre will be instrumental in supporting some of these collaborative efforts and enabling key stakeholders to get involved in developments in science and technology. Moreover, the Director-General shares the SAB's view that the ChemTech Centre will be an important nucleus for facilitating activities related to research, analysis, training, the exchange of information, and capacity building.
47. The Director-General supports the SAB's recommendations and encourages States Parties to review Annex 1 of RC-5/DG.1, which provides further context on the topics discussed herein. He looks forward to constructive and fruitful discussions of the SAB's findings among States Parties in the lead-up to, and during, the Fifth Review Conference.
48. Lastly, the Director-General thanks the States Parties and organisations that have supported the work of the SAB. Recently, this includes a contribution to the SAB Trust Fund from the Russian Federation, and ongoing support from the European Union, via Council decision 2019/538, dated 1 April 2019, which provided funding for both the Plant Biomarker Challenge and the recent work of the TWGs.