OPCW

Scientific Advisory Board

Thirty-Third Session
15 – 18 November 2021

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REPORT OF THE SCIENTIFIC ADVISORY BOARD AT ITS THIRTY-THIRD SESSION

1. AGENDA ITEM ONE – Opening of the session

1.1 The Scientific Advisory Board (SAB) met virtually for its Thirty-Third Session from 15 to 18 November 2021. The session was chaired by Dr Christophe Curty, with Dr Andrea Leisewitz serving as Vice-Chairperson.

1.2 Dr Curty opened the Thirty-Third Session of the SAB by welcoming SAB members, colleagues from the Advisory Board on Education and Outreach (ABEO) and the Technical Secretariat (hereinafter "the Secretariat"), and external speakers and other observers. He thanked the Secretariat for its agility to ensure the needs of the SAB are met for its sessions. He also thanked the interpretation team for their support.

1.3 The Chairperson confirmed that the report of the Thirty-Second Session of the SAB (SAB-32/1, dated 17 June 2021) is available on the website of the Organisation for the Prohibition of Chemical Weapons (OPCW) and thanked everyone for their contributions. The SAB-32 report received positive feedback from the Director-General in his official response (EC-98/DG.21, dated 22 September 2021), where he fully supported the recommendations proposed by the SAB. The Chairperson thanked the Director-General for providing the Board with the necessary resources to continue to advise on the evolving science and technology relevant to the Chemical Weapons Convention (hereinafter "the Convention"). In conclusion, the Chairperson wished everyone an enjoyable meeting with interesting discussions.

Executive summary

1.4 Due to the COVID-19 pandemic, this SAB meeting was conducted in a virtual format with simultaneous interpretation as needed.

1.5 This session was largely dedicated to SAB-related business and work, with time spent on brainstorming ideas for scientific activities that could be held in the OPCW's Centre for Chemistry and Technology (ChemTech Centre), discussing progress made on the Board's Report on Developments in Science and Technology for the Fifth Review Conference,[1] and receiving an update on the SAB's Temporary Working Group (TWG) on the analysis of biotoxins. In addition, the Board heard from several Secretariat staff members on relevant OPCW activities, such as the work of the OPCW Laboratory and the Secretariat's efforts in counter-terrorism. The Board also received technical presentations from two external speakers (Dr Katelyn Mason, who spoke on searching

[1] The Fifth Conference of the States Parties to Review the Operation of the Chemical Weapons Convention.

for biomarkers of chlorine exposure in plants, and Dr Stewart Behie, who provided an overview on the importance of risk assessment and management, especially in the chemical industry) and three SAB members: Dr Daan Noort gave an update on research activities at Defence, Safety and Security at the Netherlands Organisation for Applied Scientific Research (TNO); Dr Robert Mikulak mentioned some of the policy and capacity-building activities to counter the biological threat; and Dr Christophe Curty gave an overview of the Spiez Laboratory in Switzerland. The Board also elected Mr Günter Povoden and Dr Andrea Leisewitz to serve as its next Chairperson and Vice-Chairperson, respectively, starting in 2022.

2. AGENDA ITEM TWO – Adoption of the agenda

The SAB adopted the following agenda for its Thirty-Second Session:[2]

1. Opening of the session
2. Adoption of the agenda
3. *Tour de table*
4. Establishment of a drafting committee
5. Welcome address by H.E. Mr Fernando Arias
6. Updates from the OPCW Technical Secretariat
    (a) Overview of developments at the OPCW since the last session of the Scientific Advisory Board
    (b) Overview of OPCW work in counter-terrorism
    (c) Updates from the OPCW Laboratory
7. Centre for Chemistry and Technology brainstorming session
8. Discovery of chlorine gas exposure biomarkers from vegetation
9. Guidance for effective management of risk associated with highly hazardous chemicals
10. Scientific Advisory Board member presentations
    (a) Chemical and biological defence research at the Netherlands Organisation for Applied Scientific Research
    (b) Recent developments: Strengthening biosecurity
    (c) Nuclear, biological, and chemical protection at Spiez Laboratory

[2] It should be noted that while presentations and agenda items are grouped in this report based on topic matter, they were not always presented sequentially as listed due to scheduling considerations of the presenters and other timing restraints.

11. Updates from the OPCW Advisory Board on Education and Outreach

12. Updates on Scientific Advisory Board-related business

    (a) Fifth Review Conference updates and discussion

    (b) Temporary Working Group on the analysis of biotoxins

    (c) Election of the Scientific Advisory Board Chairperson and Vice-Chairperson

13. Final discussion and comments

14. Adoption of the report

15. Closure of the session

3. AGENDA ITEM THREE – *Tour de table*

The Chairperson invited everyone to briefly introduce themselves, noting that this was the last session scheduled in 2021 and there were some members who would leave the Board at the end of the year.

4. AGENDA ITEM FOUR – Establishment of a drafting committee

The Chairperson called for volunteers who wished to be part of the drafting committee to notify the SAB Chairperson, Vice-Chairperson, or Secretary accordingly.

5. AGENDA ITEM FIVE – Welcome address by H.E. Mr Fernando Arias

5.1 The Director-General of the OPCW Secretariat, H.E. Mr Fernando Arias, welcomed everyone to the Thirty-Third Session of the Board, expressing regret that it could not be conducted in person at the OPCW Headquarters. He noted with appreciation the willingness of SAB members to remain flexible and continue their important deliberations and work in a virtual setting.

5.2 The Director-General reported that the construction of the OPCW's new ChemTech Centre is well under way, and there is every indication that it will be ready to open its doors in early 2023 as planned. The ChemTech Centre will enable the OPCW to conduct research activities to support and strengthen the verification regime, in addition to: providing support for non-routine missions; training and equipping the Secretariat staff for different types of routine and non-routine missions; assisting States Parties through capacity-building activities to fulfil their obligations under the Convention; preventing and responding to chemical weapons use; supporting international cooperation in the peaceful use of chemistry; acting as a knowledge repository for chemical weapons-related expertise; and enhancing the Organisation's capability to lead the network of partner laboratories in research and analysis activities. The expanded space and upgraded facilities and equipment will allow the Secretariat to conduct research, training, and capacity-building activities that were not previously possible.

5.3 The Director-General further noted that a draft decision entitled "Understanding Regarding the Aerosolised Use of Central Nervous System-Acting Chemicals for Law Enforcement Purposes" was adopted at the Ninety-Sixth Session of the Executive Council (hereinafter "the Council") in March 2021 (EC-96/DEC.7, dated 11 March 2021). It will now be considered at the Twenty-Sixth Conference of the States Parties (hereinafter "the Conference"). Noting that the SAB's prior work in this area has been instrumental to the OPCW's understanding and consideration of this issue, the Director-General informed the Board that if the Understanding is adopted, he will be reaching out to the Board yet again, as the SAB's further consideration on this topic is provided for in the text.

5.4 The Director-General further noted the considerable progress achieved by the TWG on the analysis of biotoxins since its establishment earlier in the year. The Director-General also recognised all the assistance the Board has provided to the Secretariat over the year, including the participation of SAB members in technical review panels for scientific projects, the contribution to OPCW-developed guidelines and handbooks, and the sharing of expertise to numerous international capacity-building and assistance events. The Director-General specifically noted the importance of the Board's Report on Developments in Science and Technology that it will prepare in support of the Fifth Review Conference, and requested the SAB Secretary to prioritise this effort and provide any assistance required to facilitate the SAB's work.

5.5 In conclusion, the Director-General thanked the six members of the Board whose second terms will end at the close of 2021: Professor Zrinka Kovarik, Professor Isel Pascual Alonso, Professor Ponnadurai Ramasami, Ms Farhat Waqar, Dr Christophe Curty, and Dr Robert Mikulak. He expressed his appreciation for their dedication and service over the past six years. He especially thanked Professor Kovarik, who served as Vice-Chairperson of the SAB in 2020, and Dr Curty, who served as Vice-Chairperson of the Board in 2019 and as Chairperson in 2020 and 2021, for their leadership, especially during these challenging times.

6. AGENDA ITEM SIX – Updates from the OPCW Technical Secretariat

6.1 Several Secretariat staff members provided updates on activities of interest to the Board. The SAB Secretary gave the Board an overview of overarching developments at the OPCW that are of relevance to the SAB's work. A representative from the Office of Strategy and Policy provided an overview of some of the counter-terrorism work in which the OPCW is involved. The Board also heard from the Acting Head of the OPCW Laboratory on ongoing activities related to proficiency testing, training, and scientific research.

Subitem 6(a): Overview of developments at the OPCW since the last session of the Scientific Advisory Board

6.2 The SAB Secretary briefed the Board on relevant developments at the OPCW since the Thirty-Second Session of the SAB, including the status of the Plant Biomarkers Challenge, the Twenty-Sixth Session of the Conference, and the expected decision on central nervous system-acting chemicals (CNS-acting chemicals).

6.3 Turning to the Twenty-Sixth Session of the Conference, the SAB Secretary reported that the Conference will be an in-person event with extremely limited participation and interaction. States Parties will be present in person, in addition to some non-governmental organisations and official partners of the OPCW. The SAB Chairperson will provide a written statement to the Conference. EC-96/DEC.7, a Council decision on CNS-acting chemicals, was adopted at the Ninety-Sixth Session of the Council in March 2021 and will be considered at the Twenty-Sixth Session of the Conference. The SAB Secretary provided an overview of what the decision entails, including direction to the Director-General to task the SAB with continuing to review relevant developments in science and technology related to CNS-acting chemicals, and to provide updates to the Conference as appropriate, but at a minimum and as part of its report on developments in science and technology for future Review Conferences. More directions, if any, will be provided after the Twenty-Sixth Session of the Conference.

6.4 In relation to the Plant Biomarker Challenge, which is funded by the European Union, a total of 15 proposals were received by the OPCW (at least one from each of the five regional groups). The technical evaluation team met multiple times and recommended six proposals for funding. Each awardee will receive up to EUR 40,000 to conduct their research over the course of a year. All 15 proposers will be invited to contribute to a review article on the topic at the end of the project. The SAB Secretary provided a brief description of the projects and noted that each of the teams are currently conducting their research.

6.5 The SAB Secretary recalled that six SAB members will tenure out of the SAB at the end of 2021 and, after receiving a number of excellent nominations from States Parties, the Director-General had appointed six candidates to start their first term on the SAB in January 2022. Additionally, he reminded the Board of the election of the SAB Chairperson and Vice-Chairperson, to take place later in the session. He summarised the election process and referred members to a previous email communication that detailed the entire process.

6.6 With regard to the dates of SAB Sessions in 2022, the SAB Secretary noted that the pandemic continues to create uncertainty in allowing the SAB to meet in person, but it is hoped that there will be an opportunity for an in-person meeting sometime in the summer of 2022. Additionally, virtual meetings will be planned for the spring and autumn time periods. There are also several topical workshops that the Board hopes to convene, one in partnership with industry, and another in partnership with the International Union of Pure and Applied Chemistry (IUPAC). He noted the importance of selecting the dates for all these activities to ensure enough time is available for proper planning and execution.

6.7 The SAB Secretary then noted that a journal article entitled "Advice on assistance and protection provided by the Scientific Advisory Board of the Organisation for the Prohibition of Chemical Weapons: Part 3. On medical care and treatment of injuries from sulphur mustard" was recently published in the journal 'Toxicology'.[3] Authors include a number of past (and some current) SAB members. He extended special thanks to Dr Chris Timperley, former SAB Chairperson, and Dr Jonathan Forman, former SAB Secretary, who spearheaded the efforts for this article.

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[3] C. M. Timperley, J. E. Forman, et. Al., Toxicology, 463, 152967 (2021). DOI: 10.1016/j.tox.2021.152967.

Subitem 6(b): Overview of OPCW work in counter-terrorism

6.8 Mr Cormac O'Reilly (Senior Policy Officer, Office of Strategy and Policy, OPCW) provided an update on the work of the Open-Ended Working Group (OEWG) on Terrorism and the latest developments with the OPCW's partnership with other international organisations to ensure effective inter-agency interoperability and coordinated communication in case of chemical and/or biological attacks.

6.9 The OEWG on Terrorism is a working group of States Parties established in 2001, following a decision taken by the Council that recognised that the full and effective implementation of the Convention is itself a contribution to global counter-terrorism efforts (EC-XXVII/DEC.5, dated 7 December 2001). The role of the OEWG on Terrorism has been reiterated in further decisions of the Council, including the decision "Addressing the Threat Posed by the Use of Chemical Weapons by Non-State Actors" (EC-86/DEC.9, dated 13 October 2017). The work of the OEWG on Terrorism is currently focused on the implementation of that decision, and typically meets three times per year ahead of sessions of the Council, to which it reports. This year, the OEWG on Terrorism meetings focused on international cooperation in countering chemical terrorism and capacity-building activities, both associated with strengthening the legislative and regulatory frameworks of Member States, as well as the theme of border safety and security. The working group frequently invites relevant external speakers, often from its collaborating partners (e.g., the International Criminal Police Organization (INTERPOL), the International Chemical Trade Association (ICTA)). The next meeting is scheduled for early March 2022. For 2022, there is interest in continuing to focus on the chemical industry and trade, though a future meeting might also examine the intersection between science and technology and chemical terrorism.

6.10 Turning to the ongoing inter-agency project, Mr O'Reilly noted that its purpose is to bring together various stakeholders, mostly from the United Nations system, to improve coordination and planning responses to terrorist attacks that may involve chemical or biological weapons. The project is currently in its third phase and is seeking to address 18 key recommendations resulting from the first two phases. Funded by the United Nations Office of Counter-Terrorism, the project is due to run until the end of 2022. Other entities working with the OPCW on this effort include INTERPOL, the Biological Weapons Convention (BWC) Implementation Support Unit, the World Health Organization (WHO), the United Nations Interregional Crime and Justice Research Institute, and the United Nations Office for the Coordination of Humanitarian Affairs.

6.11 Mr O'Reilly was asked whether the OPCW has considered expanding its partnership with the ICTA to work together on additional projects, such as developing videos or programmes on security for small and medium-sized companies. Mr O'Reilly noted that the partnership with the ICTA is indeed growing. At the last meeting of the OEWG on Terrorism, there was a fruitful discussion on strengthening that partnership, and any future joint activities could be considered in that context.

6.12 The SAB Chairperson noted that countering terrorism is a subject that is considered by the SAB in its work, and that it would be interesting to see how collaboration with the SAB on this topic can be continued in the near future, and how the SAB can best support related OPCW activities. He thanked Mr O'Reilly for the presentation and extended an invitation to future SAB meetings to provide relevant updates.

Subitem 6(c): Updates from the OPCW Laboratory

6.13 Dr Timothy Wood, Acting Head of the OPCW Laboratory, noted that the Laboratory's work is central to a variety of OPCW activities related to verification, industry inspections, and non-routine missions (such as the Fact-Finding Mission and the Declaration Assessment Team). The OPCW Laboratory has remained operational throughout the pandemic and executed its core functions, including the Forty-Ninth Environmental Proficiency Test, the Twelfth Convention Chemical Analysis Competency Test, and the Sixth Biomedical Proficiency Test, all of which were concluded successfully; the Fiftieth Environmental Proficiency Test is ongoing, and the OPCW Laboratory is busy with the preparations for the Fifty-First Environmental Proficiency Test and the Seventh Biomedical Proficiency Test. He reminded the Board that there are currently 24 designated laboratories in 21 countries for environmental sample analyses, with Brazil recently joining the list as the first country from the Latin American and Caribbean (GRULAC) region. As for biomedical sample analysis, there are currently 20 designated laboratories in 14 countries. He further reported that the Sixth Toxin Exercise is due to begin at the end of November. The OPCW Laboratory has received positive feedback on the toxin exercises and hopes to have them formalised as a proficiency test in the near future. The OPCW Laboratory continues to issue a yearly update of the OPCW Central Analytical Database (OCAD). This is vital to proficiency test participants as well as those analysing samples for the OPCW. What is noteworthy for the 2021 update is that the tests in 2021 have included a number of compounds that were recently added to the Annex on Chemicals of the Convention (C-24/DEC.4 and C-24/DEC.5, both dated 27 November 2019).

6.14 The Acting Head of the OPCW Laboratory further reported that in the past few years, the Laboratory has been working on developing a Laboratory Information Management System (LIMS). Funded by States Parties, the LIMS is a type of software designed to improve laboratory productivity and efficiency by keeping track of samples, documents, and data associated with samples, experiments, laboratory workflows, and instruments. The Laboratory purchased a commercially available LIMS but has since been busy further customising it to fully meet its own specific requirements and needs. A modern LIMS also allows for more active management of the entire laboratory process, from instruments and samples to people and consumables, and allows for the integration of the Quality Management System to support ISO 17025 compliance.

6.15 Turning to research, the Acting Head of the OPCW Laboratory reported on a recent productive collaboration on chlorine biomarkers with Vrije Universiteit Amsterdam, where they have developed a method for the detection of various chlorinated amino acids in blood. They also have ongoing research on environmental markers associated with exposure to chlorine. The Secretariat also released a Note to States Parties on new saxitoxin detection methods developed at the Laboratory this year (S/1974/2021, dated 21 July 2021).

6.16 He also noted that training, one of the OPCW Laboratory's core activities, has been affected by the COVID-19 pandemic as it relates to hosting external participants for on-site training. However, the Laboratory used this as an opportunity to digitise all its training lectures and successfully hosted three online training courses (with over 30 participants) in 2021.

6.17 The OPCW Laboratory looks forward to conducting and facilitating collaborative research at the new ChemTech Centre. They are grateful for SAB recommendations and advice on scientific activities that the Laboratory might consider conducting there. The Laboratory envisions many exciting opportunities at the ChemTech Centre, including collaborative research between international laboratories, hosting visiting professional and post-doctoral researchers, method development for chemical warfare agents, OCAD enhancement, and much more.

6.18 A robust discussion ensued following a question on the ChemTech Centre's capabilities when it came to different types of incoming samples and the potential for processing them quickly. Dr Wood noted that the OPCW Laboratory can and does receive all types of samples from the field in various shapes and sizes. It is therefore hard to develop any type of automation or high-throughput system given the custom approach needed to prepare samples for further handling and analysis. He indicated that the OPCW Laboratory is looking forward to the enhanced capabilities that the triage room in the ChemTech Centre will afford them in this area. Regarding the types of samples that the OPCW Laboratory handles and analyses, he mentioned that the Laboratory does also deal with biomedical samples, but only in relation to cases of potential exposure to chemical weapons. He reminded the Board that the ChemTech Centre will also have BSL-2[4] compliant laboratories to handle biomedical samples. Also, laboratory sections will be physically separated, based on function, from the other areas of the Laboratory building to minimise the potential for cross-contamination of samples.

6.19 A few questions centred on the analytical instruments at the OPCW Laboratory, in particular on the use of nuclear magnetic resonance (NMR) and stable isotope techniques. Dr Wood indicated that these two techniques are of course useful, especially as part of a suite of orthogonal techniques in the laboratory. The OPCW Laboratory has an NMR instrument that will move to the ChemTech Centre, and it is hoping to find partner laboratories to collaborate on the development of procedures using stable isotope analysis.

7. AGENDA ITEM SEVEN – Centre for Chemistry and Technology brainstorming session

7.1 The SAB Secretary gave a short presentation with an update on the ChemTech Centre project to illustrate its enhancements and upgrades compared to the current OPCW Laboratory and Equipment Store. He recalled that the Director-General is interested in receiving SAB input on potential scientific and research activities at the Centre.

7.2 The SAB Secretary then led the Board through a brainstorming session. Board members provided numerous thoughts and ideas on new scientific activities that might be considered for the ChemTech Centre, as well as considerations on how some of these activities can be done safely and securely. The discussion will continue at the next Session of the Board to consolidate the ideas put forward.

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[4] Biosafety level 2.

8. AGENDA ITEM EIGHT – Discovery of chlorine gas exposure biomarkers from vegetation

8.1 Dr Katelyn Mason (Lawrence Livermore National Laboratory (LLNL) Forensic Science Center, United States of America) opened her presentation with a brief introduction to the work of the LLNL Forensic Science Center, a United States national laboratory operating under the auspice of the Department of Energy. LLNL performs cutting-edge research and development, in addition to providing more operational support to many sponsors, including full sample analysis, and engaging in efforts to enable the international community to pursue weapon of mass destruction-related efforts (across chemical, biological, radiological, nuclear, and explosive hazards). LLNL is also an OPCW designated laboratory for both environmental and biomedical samples.

8.2 Dr Mason then turned to the research associated with the title of her talk; how can vegetation be used as a source of biomarkers to confirm the release of chlorine gas in the environment? She noted that usual forensics techniques to confirm the presence of chemical agents in a sample do not work for chlorine gas for several reasons, including its quick dissipation after release, high reactivity, and the large number of naturally occurring chlorinated compounds in the environment. Currently, there are no known biomarkers in the environment specific to chlorine gas exposure. Their approach, therefore, focused on the fact that the chemical reactions that take place following human exposure to chlorine likely also take place in some form in plants exposed to chlorine: specifically, reactions resulting from the dissociation of hypochlorous acid and hydrochloric acid when in contact with water present in vegetative tissues. They wanted to establish if the damage chlorine causes leaves behind a chemical trace in the form of unnatural chlorinated biomarkers that could be used to indicate that chlorine gas had been used or released.

8.3 They utilised a specific species of grass (Aegilops tauschii) and exposed it to different concentrations of chlorine gas. Small molecules, obtained via extraction of the plant material or via enzymatic digestion of their proteins, were identified and compared to reference materials and standards. Comparison with negative controls helped filter candidate biomarkers to those generated only during chlorine exposure. Using this approach, they were able to identify and confirm numerous chlorine-associated biomarkers that were generated from chlorine gas exposure. Dr Mason showed the example of 2,4,6-trichlorophenol and the protein fragments containing either 3-chlorotyrosine or 3,5-dichlorotyrosine, where the concentrations of these biomarkers, not naturally occurring in the plant, correlated directly to the magnitude of chlorine exposure. They were further able to generate some preliminary data showing that 2,4,6-trichlorophenol was detected up to a week after exposure to a low concentration of chlorine gas. Other experiments are focused on identifying additional biomarkers that may be universal across vegetation types.

8.4 In conclusion, the study demonstrated that plant tissue has potential for use to confirm chlorine exposure in the environment. LLNL is already working on the next steps of this research and will expand the number of plant species to test. They hope to establish the potential universality of some of these biomarkers. In future, they also aim to expand their work to search for biomarkers from other toxic industrial chemicals, such as phosgene and ammonia.

8.5 There were a number of questions for Dr Mason. It was asked if LLNL was able to identify and distinguish biomarkers associated with exposure to other chlorinated compounds, such as sodium hypochlorite and calcium hypochlorite. Dr Mason replied that LLNL has not conducted any experimentation exposing leaf material to liquids, only chlorine gas. She noted that they are considering using other chlorinated chemicals, like bleach, in future studies.

8.6 Another question focused on whether follow-up work would allow LLNL to establish limits of detection with confidence intervals. Dr Mason confirmed that they would like to use even more powerful and sensitive analytical techniques and hone in on some targeted methods to determine the limits of detection for these samples, which would also give them more data and statistics to improve confidence in their results.

8.7 The Board then noted that chlorophyl is destroyed when in contact with chlorine and asked Dr Mason if they have searched for degradation compounds of chlorophyl. Dr Mason replied that the research had not included that specifically, but agreed it would be interesting to investigate further. She concluded that there is still much work to be done, but it is exciting work with a lot of potential.

9. AGENDA ITEM NINE – Guidance for effective management of risk associated with highly hazardous chemicals

9.1 Dr Stewart Behie (Mary Kay O'Connor Process Safety Center at Texas A&M University, United States of America) opened his presentation with a brief overview of the nexus between incident investigation and risk assessment, including how his team defines and considers terms like hazard, risk, safety, risk acceptability and risk management. He continued by describing how the risk assessment process plays an important part in ensuring safe operations, combining people and processes to produce safe and successful operations. As incidents continue to happen, there is a need to improve the rigor and effectiveness of the risk assessment process (both for plant operations and chemical storage facilities), embrace the elements of the business case for continued and improved process safety, and improve the working relationship and cooperation with regulators in order to reduce the rate of such incidents. Dr Behie also briefly summarised the different methodologies used for risk assessment (e.g., bow-tie, layers of protection analysis, and the Swiss cheese and spinning disk models).

9.2 Turning to risk management, Dr Behie stressed that it must be an independent, conscious undertaking of an organisation, and that risk assessment must be a critical element at all levels therein. He noted some of the key overarching aspects of risk management.

9.3 He then concluded by outlining some high-level considerations:

(a) Chemical processing and storage facilities pose inherent risks and hazards that need to be effectively controlled through risk assessment and process safety management to prevent recurrence of incidents.

(b) Leadership should focus on risk function and process safety for business continuity.

(c) Regulators can play an important role.

(d) Various tools, such as bow-tie models, can be used effectively.

(e) Digitalised solutions using data analysis through machine learning and artificial intelligence can help assess the health of the protection layers within these facilities.

9.4 The first question asked about which approach to integrating risk management had better success: a top-down or bottom-up approach. Dr Behie replied that it would almost always need to be a combined approach; it is important to start at the top, with senior management needing to reach down into the organisation to instil the right mindset. Likewise, there needs to be an understanding among all staff that safety and security are important and that the appropriate consideration of risk is critical to success. It was noted among the Board that management is pivotal—there has to be commitment from top management on industrial safety indicating that safety comes first and is not something that can be compromised. Second, it was underlined that there needs to be a culture of transparency: incidents should be spoken about openly, ensuring that lessons learned and applied mitigation factors can be shared. All of this lowers the risk involved in industry and increases safety.

9.5 Dr Behie was then asked if multinational companies with branches in many different countries and regions consider risk similarly across all their locations, or apply localised considerations and environments, and whether specific national regulations impact the consideration of risk and what is acceptable. Dr Behie indicated that while specific local conditions must always be considered, the basic underlying principles should remain unchanged.

10. AGENDA ITEM TEN – Scientific Advisory Board member presentations

10.1 Three SAB members, Dr Daan Noort, Dr Robert Mikulak, and Dr Christophe Curty, all gave presentations outlining work that is being carried out at their respective institutions, including research, operational support, and policy development and consideration.

Subitem 10(a): Chemical and biological defence research at the Netherlands Organisation for Applied Scientific Research

10.2 Dr Noort (Defence, Safety and Security, TNO, the Netherlands) provided an overview of the TNO, followed by information on current research within his group, with an emphasis on analysis.

10.3 He began by describing a bit of the history and current operational status of the TNO. He then delved into the CBRN protection group, where Dr Noort works. He noted that the TNO is an OPCW designated laboratory for both environmental and biomedical samples. The research areas covered by the CBRN protection group include threat analysis, situational awareness, and countermeasures, with work also in enabling technologies and related enabling facilities.

10.4 Moving to biomedical sample analysis, Dr Noort gave a brief overview of his involvement with the OPCW in this area and how the space has evolved. Typically, metabolites will be excreted in urine (usually within days), whereas adducts from some Schedule 1 nerve agents in plasma may be persistent for up to 90 days. Dr Noort gave an overview of a recent publication from his research group dealing with newly added

Schedule 1 chemicals. In it, it is shown that a nonapeptide approach that is often used to assess nerve agent exposure can in fact be applied to nerve agents in the so-called 'novichok' group of agents.[5] The research team then went further and evaluated the possibility of identifying unknown exposures by applying precursor ion scanning in combination with high resolution mass spectrometry. They found that they could elucidate the structure of particular nerve agents from their corresponding adducts—an important capability in the event that no reference materials are available in a situation of the alleged use of a nerve agent. He then provided some other examples of being able to use metabolites from exposure to both chemical weapon agents and opiates (fentanyl) to provide information related to their synthesis.[6]

10.5 Dr Noort then turned to the TNO's work on the identification of pathogenic bacteria. He went through some of the TNO's work related to the identification of bacteria and viruses using laboratory-based techniques, then described some work on the development of more portable biosensors for the detection of pathogens, based on CRISPR Cas-12a.[7] They developed a colorimetric DNA detection assay utilising copper nanoparticles, whereby a positive identification can be made with the naked eye from the fluorescent signal upon ultraviolet excitation. He indicated that this platform can be used for many other pathogen DNA and could be potentially used to detect biotoxins.

10.6 He then pivoted to some of the TNO's work on using artificial intelligence and machine-learning techniques to autonomously evaluate multiple continuously measured physiological signals to detect exposure to different chemical agents.[8] These kinds of detection and identification methods could be used to alert individuals to take prompt appropriate medical countermeasures. Initial results indicated that a trained model could detect intoxication with an opioid or nerve agent before actual signs were visible to the naked eye. Importantly, the model could distinguish between the two classes of chemicals, even though they often show similar symptoms of exposure. He noted that most research into medical countermeasures for nerve agent intoxication is focused on military scenarios; however, in a civilian setting, first treatment is delayed until first responders arrive at the scene.

10.7 Finally, Dr Noort provided examples of their research in the field of protection. One of the topics the TNO is currently working on includes using metal-organic frameworks (MOFs). Because of their high surface area, such molecules have great capacity for absorption of small molecules (e.g., toxic chemicals such as Schedule 1 chemicals). There is great interest in using MOFs as an alternative to active charcoal as an absorption material in respiratory protection, decontamination, and protective clothing. Dr Noort also noted some of the TNO's recent work in using custom-synthesised MOFs integrated into fibres to rapidly neutralise both Gram-negative and Gram-positive bacteria, as well as to rapidly degrade sulphur mustard and some of its analogues.[9] This

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5 D. Noort, A. Fidder, et al. Chem Res Toxicol. 34, 8, 1926-1932 (2021). DOI: 10.1021/acs.chemrestox.1c00198.

6 M. de Bruin-Hoegée, D. Kleiweg, et al. Forensic Chemistry, 24, 100330 (2021). DOI: 10.1016/j.forc.2021.100330.

7 J. F. M. Bogers, N. F. Berghuis, et al. Biology Methods and Protocols, 6, 1 (2021). DOI: 10.1093/biomethods/bpaa020.

8 J. U. van Baardewijk, S. Agarwal, et al. Sensors. 21, 11, 3616 (2021). DOI: 10.3390/s21113616.

9 Y. H. Cheung, K. Ma, et al. J. Am. Chem. Soc. 143, 40, 16777-16785 (2021). DOI: 10.1021/jacs.1c08576.

new material has the potential to serve as protective cloth against both biological and chemical threats. He finished by describing how the TNO is also using MOFs not only to detect V-series nerve agents but, also to degrade them at the same time.[10] The applicability of this material was illustrated by a proof-of-concept detection kit for VX-contaminated surfaces, as exemplified with VX-contaminated metal panels coated with military paint. This procedure requires minimal training, and VX contamination down to a level of about 1–2 μg/cm^2 could be reliably visually established.

10.8 Dr Noort was first asked about the time limits for detecting protein adducts of sulphur mustard. He explained that the proteins that the TNO has been focusing on (blood proteins) have a relatively short life span, but that there are proteins in the body with much longer life spans; however, these are located in organs that are difficult or painful to collect samples from (e.g., eyes, bones). They have considered these possibilities, but have yet to identify a protein that is both easy to sample and has a very long life span. He indicated this is a good topic for continued discussion within the SAB, as it is clearly a field that should be explored more in the field of biomedical sample analysis. The Board concurred, noting that while there have been decades of research in this area, there are still many questions left unanswered.

10.9 A discussion then ensued on Dr Noort's work with MOFs. It was first asked if he could indeed recommend using MOFs for personal protective equipment for medical personnel or other first responders. Dr Noort replied that initial results indicate that incorporating MOFs into PPE could be beneficial, as they can be functionalised to meet specific needs. However, he notes that their cost is still quite high, though this could be justifiable in the right scenarios. It is still a very new area of science, even if the initial research is exciting.

10.10 Considering the newly scheduled chemicals added to Schedule 1 in the Annex on Chemicals to the Convention, a question was asked whether Dr Noort thinks a method or approach to detecting exposure to carbamates may be possible. He replied that he would certainly expect carbamates to form adducts in the body like other nerve agents, but that at least for the few carbamates that he has examined closely, the most informative part of the molecule is lost via a leaving group when it forms an adduct, making the resulting adduct less unique and unambiguous determination of exposure more challenging.

Subitem 10(b): Recent developments: Strengthening biosecurity

10.11 Dr Mikulak (United States Department of State) gave an overview of some current work he has been involved in, including more effective implementation of the BWC, improved ability to investigate disease outbreaks of uncertain origin, and prevention of accidental or deliberate release of dangerous pathogens.

10.12 The BWC is a global ban on biological and toxin weapons, that came into force in 1975 and has 183 Member States.[11] Unlike the Convention, it contains no declaration obligation, no verification provisions, and no inspections. As such, it does not have a

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10 M. C. de Koning, G. W. Peterson, et al. Chem. Mater. 31, 18, 7417-7424 (2019). DOI: 10.1021/acs.chemmater.9b02073.

11 For more information see: https://www.un.org/disarmament/biological-weapons/.

large implementation body akin to the OPCW, but rather a small three-member Implementation Support Unit. There have been efforts to strengthen the implementation and organisational structure of the BWC, but progress has slowed over the last two decades. However, there is a realisation that in the current environment of rapid advances in science and technology, this stalemate needs to be broken.

10.13 One important new development is the work on a code of conduct for biological scientists, similar to The Hague Ethical Guidelines for the Convention. Recently, the Tianjin Biosecurity Guidelines for Codes of Conduct for Scientists were endorsed by the umbrella body for national academies of sciences—the InterAcademy Partnership — based on an earlier proposal by China and Pakistan.[12] Strong support for the Guidelines from the technical community is key to their ultimate acceptance and impact.

10.14 Another ongoing effort is on the establishment of a systematic science advisory mechanism for the BWC, akin to the SAB for the OPCW. There have been numerous proposals over the years, but no agreement on a common approach. To negotiate the outstanding issues, discussion is currently focused on incorporating elements from several approaches, hopefully resulting in an agreed approach before the BWC Review Conference, which is scheduled for August 2022.

10.15 Turning to the area of disease outbreak investigations, Dr Mikulak recalled the United Nations Secretary-General's Mechanism (UNSGM) for investigating alleged chemical or biological weapons attacks.[13] Unlike for chemical weapons, an investigation has never been conducted on an alleged use of a biological weapon. There are also some important differences between investigations of the two weapon types, including the potential requirement to sample, transport, and analyse an extremely dangerous biological material, and the role that intellectual property considerations of new and emerging biological developments might play. Dr Mikulak has been involved with trying to develop greater laboratory capability to support UNSGM investigations. They are developing a table-top exercise with participation of experts from all relevant areas (the United Nations, WHO, countries that might contribute samples, etc.) with a focus on difficulties that may occur when transferring highly pathogenic biological samples through multiple countries and across international borders, as well as ways to mitigate those potential problems.

10.16 Turning to the prevention of the release of dangerous pathogens, Dr Mikulak noted that the COVID-19 pandemic has highlighted the importance of safe and secure handling of dangerous pathogens. Countries are increasingly interested in approaches that help raise the global standard for the safety and security of biological laboratories that work with dangerous pathogens. This involves building political commitments at a very high level, strengthening laboratory measures and procedures, practical assistance programmes for laboratories, and strengthening guidelines and standards for handling pathogenic materials, among other factors.

10.17 A question was asked regarding how international bodies are incorporated into emergency response and management, particularly in the areas of biological and/or chemical incidents or disasters. Dr Mikulak explained that when it comes to disaster

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12 See: https://www.interacademies.org/news/iap-endorses-tianjin-biosecurity-guidelines.

13 See: https://www.un.org/disarmament/wmd/secretary-general-mechanism/.

response (e.g., disease outbreak), much of the assistance will come from public health channels (e.g., through WHO or bilateral and regional response) which are well developed in terms of infrastructure and procedures, among others, and are being further strengthened as a result of the pandemic. The BWC itself has a provision for States to provide assistance through its Implementation Support Unit, but this has its limitations. He noted that in recent years, there has been more discussion and interest in having a structured way in which Member States can request assistance, even if it is not clear if there has been a deliberate attack or a natural outbreak.

10.18 Another question addressed the willingness of countries to assist others financially in terms of resources and training to raise standards and global capabilities. Dr Mikulak confirmed that the willingness is absolutely there, noting the active efforts to strengthen laboratory infrastructure and capacities (e.g., improving safety and procedures), and setting up training laboratories to handle dangerous pathogens for public health reasons. There is a lot of work under way, particularly in Africa, where there is also strong local and regional interest in developing, for instance, capacities, sharing resources, experiences, and developing their own laboratories. The resources required are enormous, but the trend is towards greater assistance.

10.19 Finally, discussions touched on the topic of synthetic biology and the rapid developments in the field. Dr Mikulak remarked that synthetic biology covers an enormous range of practical activities and intellectual investigation, and that it is a classic dual-use problem that is familiar both in chemistry and biology. These new technologies can greatly benefit mankind, but they can also be misused. There are serious risks that need to be identified and considered, but it is a matter of balance. He concluded that the real challenge is to enact safeguards, but in a way that it does not hamper the enormous benefits that synthetic biology can provide.

Subitem 10(c): Nuclear, biological, and chemical protection at Spiez Laboratory

10.20 Dr Curty (Spiez Laboratory, Switzerland) started by providing an overview of Spiez Laboratory, a Swiss Government laboratory, noting that Spiez Laboratory is an OPCW designated laboratory for environmental samples. It also contains a Schedule 1 facility with a wide range of synthesis capability and a BSL-4 laboratory. Spiez Laboratory consists of several divisions, and provides services relating to arms control, protection measures, and health and incident management for international organisations, federal authorities, and the general population, among others. Operationally, they are requested to deal with unknown samples from the field; they have a separate building (the Sample Reception Unit) from the main laboratory to prevent contamination of the main investigation systems. They can thus appropriately triage incoming samples with various analysis techniques. They also train Swiss defence forces in their repetition courses on nuclear, biological, and chemical threats.

10.21 Spiez Laboratory collaborates with many international organisations, both for sample analyses (e.g., assisting with the analysis of samples from the 2020 Beirut, Lebanon, explosion) and by providing training (e.g., training for the International Committee of the Red Cross staff in the field of protection, field detection, and sample packing). They also ran seven OPCW mock inspections between 2007 and 2011 in their Schedule 1 facility, helping to train 68 inspectors. They plan to resume this activity in 2022.

10.22 Dr Curty noted that Spiez Laboratory is strongly involved in arms control efforts. They provide technical advice to Swiss delegations and federal authorities, and support discussions on all the regulations in Switzerland relevant to chemical warfare agents. The laboratory is part of the Swiss National Authority; they are a collecting point for all declarations for the Convention, take part in every inspection, and organise topical workshops. Dr Curty then reflected on the Spiez Convergence, a biennial platform where participants can share and discuss the latest advances associated with the convergence of chemistry and biology.[14] The last workshop was held from 13 to 15 September 2021 and featured topics such as organic chemistry as a tool in diagnostics, biocatalysis in chemical production, genome engineering, and DNA synthesis, to name a few. In addition, a UNSGM workshop was held in Spiez from 16 to 17 September 2021 on the analysis of biological agents.[15]

10.23 Dr Curty was asked whether the potential for the Spiez Laboratory's triage facility to receive samples of non-volatile nerve agents, known or unknown, would require changes to their screening operations. He replied that while these types of agents would be somewhat new, they already utilise swipe sampling to detect the presence of non-volatile compounds, so their operational procedures should not need much modification.

10.24 The Board then inquired as to what sequence of sampling and analysis they follow when faced with an unknown sample. Dr Curty replied that it depends on available information on any given unknown sample. The sequence he shared in his presentation is a good approach, but biological samples always present a challenge due to the hazards associated with them.

11. AGENDA ITEM ELEVEN – Updates from the OPCW Advisory Board on Education and Outreach

11.1 Dr Alastair Hay opened his presentation with an overview of the establishment of the ABEO's TWG on e-learning following the ABEO's recommendation from its session on February 2019 (EC-98/DG.17 C-26/DG.13, dated 16 September 2021). The TWG, comprised of six ABEO members and four external contributors, had three objectives: look at best practices in e-learning and inform the OPCW of these; review, with the OPCW, the OPCW's current e-learning tools; and advise the OPCW on different learning management systems and platforms to consider when expanding or enhancing its e-learning offerings. It provided a list of recommendations to the OPCW. [16]

11.2 One of the first recommendations was that the OPCW should make sure that all its e-learning tools and materials were co-located. It should use a platform that permits greater usage and access by more people at any given time. Another recommendation was for the OPCW to have a standing e-learning working group to review content and help to systematise the way in which the e-learning modules are put together. There is a need for the OPCW to reach a very wide audience, and another recommendation was that the OPCW consider content for various audiences with the goal of providing attractive material with plenty of opportunities for engagement and participation. The ABEO indicated that it would assist the OPCW in this respect.

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14 More information on Spiez Convergence can be found at: https://www.spiezlab.admin.ch/de/home/meta/convergence.html.

15 More information on the UNSGM Workshop can be found at: https://www.spiezlab.admin.ch/en/kontrolle/unsgm.html.

16 See the final report of the ABEO's TWG on e-learning as an annex in the referenced document.

11.3 Turning to the ABEO's other current work, Dr Hay noted the ongoing conversation with National Authorities and identifying opportunities to engage them and assist them in acquiring e-learning materials on various topics. He also mentioned that the ABEO is looking to support the Secretariat's contribution to the United Nations Secretary-General's Report on Disarmament Education, as needed. He further mentioned the ABEO's ongoing work to develop course content packs for use by universities.

11.4 In conclusion, Dr Hay noted that National Authorities want more information on health and safety in the chemical industry. It is unclear exactly how detailed that material should be. Online content does exist, but it is sometimes of poor quality, as this topic is often neglected in universities and could be made to be more interactive. This is something that National Authorities could have access to and use as a way of communicating with academia. The ABEO is at the early stage of discussion on how this may be done.

11.5 The Board commented that course content needs to be audience specific and appreciated the challenges in determining how best to meet the needs of various types of audiences, each with different backgrounds and different content needs. Dr Hay concurred, reminding the Board that the OPCW has done a lot of good work to date, and has a lot of usable, appropriate content. There now just needs to be more focus on packaging that content appropriately for certain audiences and regions. He indicated that further interaction and collaboration with the chemical industry, such as the International Council of Chemical Associations and the ICTA, would be welcome.

11.6 Lastly, it was mentioned by both Dr Hay and Dr Cormick that since the start of the pandemic, educators have learned an enormous amount about how people learn online. Developing and offering engaging materials that promote active participation ultimately leads to a better e-learning product. Now with the conclusion of the TWG on e-learning, the ABEO remains ready to assist the OPCW in developing excellent materials for use in its e-learning offerings.

12. AGENDA ITEM TWELVE – Updates on Scientific Advisory Board-related business

12.1 During the session, the Board had some specific areas of SAB-related business to discuss. Several hours were spent on the path forward on its scientific report to support the Fifth Review Conference. In addition, the Board received a detailed update on the work of the TWG on the analysis of biotoxins by Dr Suzy Kalb, Vice-Chairperson of the TWG. In addition, as this session was the last scheduled session for the year, the Board also elected its Chairperson and Vice-Chairperson for the next year.

Subitem 12(a): Fifth Review Conference updates and discussion

12.2 The SAB Secretary provided a brief overview of preparations for the Board's scientific report for the Fifth Review Conference, and reminded the Board of the subgroups and their topical areas of focus. He also noted that with six SAB members leaving and six new members joining, there may be some shuffling of the subgroup compositions to ensure people are able to contribute effectively based on their expertise.

12.3 As for the timeline, the Fifth Review Conference is expected to take place in the April – May timeframe of 2023, meaning that the accompanying scientific report needs to be finalised in October. As such, the SAB Chairperson and Secretary are looking for subgroups to provide their initial input to the report by February 2022. This will allow for feedback to be given before the planned Thirty-Fourth Session of the SAB and will allow for another chance for discussion among the Board. The SAB Secretary and SAB Chairperson will start reaching out to each of the group leads to get a status report and understand where they need additional assistance.

12.4 It was recognised that unlike in the preparation for the scientific report for the Fourth Review Conference, there has been a paucity of conferences and workshops over the past two years due to the pandemic. The SAB Chairperson agreed and suggested that the Board will need to rely on open-source literature and SAB expertise. The roadmap was agreed upon by everyone.

Subitem 12(b): Temporary Working Group on the analysis of biotoxins

12.5 Dr Kalb recalled that the TWG on the analysis of biotoxins was formed earlier in the year, with a two-year mandate, and with the purpose of reviewing the science and technology relevant to the analysis of biotoxins that need to be considered in investigations of their alleged use. TWG members are experts in the theory and practice of biotoxin analysis (low and high molecular weight biotoxins, evidence collection, forensic sciences, toxicology, and implementation of the Convention). The TWG is chaired by Dr Daan Noort, with Dr Suzy Kalb as Vice-Chairperson. The TWG has had three meetings to date which took place in May, June, and November (all virtually).

12.6 The TWG was given terms of reference, which note that the use of all biological toxins as weapons is prohibited under both the Convention and the BWC. Saxitoxin and ricin are included in Schedule 1 of the Annex on Chemicals of the Convention. The work of the TWG is intended to identify capabilities, skill sets, and equipment to augment and strengthen the Secretariat's capabilities. The findings will be considered by the SAB and recommendations will be provided to the Director-General.

12.7 The first TWG meeting held in May 2021 focused on introductions, the formation of five subgroups (based on questions from the terms of reference), overview of all subgroups, a general discussion on biotoxin presentation, lists of biotoxins, and OPCW needs (SAB-32/WP.1, dated 6 May 2021). The second meeting took place in June 2011 and was dedicated to a discussion on potential external speakers and featured subgroup breakout sessions, updates by subgroup leads, and a presentation on a clinical approach to biotoxins and dual use (SAB-33/WP.1, dated 15 October 2021). At the third meeting in November 2021, subgroups gave updates and held subgroup breakout sessions, and external speakers presented on a variety of topics, including analytical methods for toxin detection, combining affinity-based and mass spectrometry methods, quality assurance for the detection of high molecular weight toxins in foods, toxin analysis in realistic matrices, current and recent biotoxin exercises, and the laboratory setup at the UNSGM (SAB-33/WP.2, dated 14 February 2022). The general discussion was devoted to topics like databases, the availability of reference standards, proving alleged use in natural backgrounds, the importance of complementary methods, consideration of new toxins, reporting format, and interaction between the UNSGM and the OPCW.

12.8 Dr Kalb then gave an update on each of the five subgroups, noting the progress they have made in considering each of the questions from the terms of reference that they were assigned.

12.9 One question focused on whether the TWG has looked into the use of saliva as a medium for biotoxin analysis in light of the inapplicability of urine for some biotoxins. Dr Kalb confirmed that saliva had come up in discussion as a possible matrix for biotoxins. She shared her own experience in working with botulinum neurotoxin (a very high molecular weight biotoxin), noting that the most effective matrix in that case was stool (faeces), where it is often found in orders of magnitude-higher concentrations than in serum. Saliva is something that can be considered for some other toxins.

Subitem 12(c): Election of the Scientific Advisory Board Chairperson and Vice-Chairperson

12.10 The Board reconvened after the break on the third day of the session in a private virtual meeting in order to elect its next Chairperson and Vice-Chairperson, who would start in 2022. The SAB elected, by consensus, Mr Günter Povoden as the next Chairperson, and Dr Andrea Leisewitz to continue in her role as Vice-Chairperson. The Board thanked Dr Christophe Curty, who is leaving the SAB at the end of the year, for his two-year term as Chairperson of the Board, following his Vice-Chairmanship for one year before that.

13. AGENDA ITEM THIRTEEN – Final comments and discussion

13.1 The SAB Chairperson expressed his congratulations to Mr Günter Povoden and Dr Andrea Leisewitz on their election as the SAB Chairperson and Vice-Chairperson, respectively, for 2022, noting that with their expertise, the Board is in great hands. He wished them and the entire Board a lot of success in the future. He also took the opportunity to express his appreciation for the outgoing members of the SAB and thanked them for their commitment and hard work in the previous six years. Upon the invitation from the Chairperson, each of the departing SAB members took the floor to say farewell.

13.2 In conclusion, the SAB Chairperson thanked the Secretariat staff for their flexibility, dedication, and support. He recounted the interesting presentations and information shared over the course of the four-day meeting, as well as the updates on the work of the TWG on the analysis of biotoxins and on the preparations for the report on developments in science and technology for the Fifth Review Conference. He encouraged the members of the SAB to continue to provide suggestions on potential external speakers. The SAB Chairperson expressed his appreciation to the Director-General of the OPCW Secretariat for his full confidence and support. Finally, he thanked all the SAB members, past and present, for their enthusiasm and efforts to support the activities of the SAB.

13.3 The SAB is grateful for the voluntary contributions made to support its work, as well as the European Union for its April 2019 Council decision, which provides funding for TWGs.

14. AGENDA ITEM FOURTEEN – Adoption of the report

The SAB agreed to adopt the report for its Thirty-Third Session via correspondence after the session.

15. AGENDA ITEM FIFTEEN – Closure of the session

The Chairperson closed the session at 15:38 CET on 18 November 2021.

Annex: List of Participants in the Thirty-Third Session of the Scientific Advisory Board

Annex

LIST OF PARTICIPANTS IN THE THIRTY-THIRD SESSION OF THE SCIENTIFIC ADVISORY BOARD

	Participant	Institution
Members of the Scientific Advisory Board		
1.	Dr Khaldoun Bachari	Algerian Public Scientific and Technical Research Centre in the Physico-Chemical-CRAPC, Algeria
2.	Dr Renate Becker-Arnold	BASF, Germany
3.	Dr Elma Biscotti	Scientific and Technical Research Institute for Defense, Argentina
4.	Dr Anne Bossée	DGA CBRN Défense, France
5.	Dr Christophe Curty (Chairperson)	Spiez Laboratory, Switzerland
6.	Prof Vladimir Dimitrov	Institute of Organic Chemistry with Centre of Phytochemistry, Bulgarian Academy of Sciences, Bulgaria
7.	Dr Mostafa Ghanei, MD	Baqiyatallah University of Medical Sciences, Islamic Republic of Iran
8.	Dr Norman Govan	Defence Science and Technology Laboratory, United Kingdom of Great Britain and Northern Ireland
9.	Mr Wilford Zungkat Jwalshik	Institute of Chartered Chemists of Nigeria, Nigeria
10.	Prof Victor Kholstov	Ministry of Industry and Trade, "GosNIIOKhT", Russian Federation
11.	Dr Zrinka Kovarik	Institute for Medical Research and Occupational Health, Croatia
12.	Dr Andrea Leisewitz (Vice-Chairperson)	Universidad San Sebastián, Chile
13.	Prof Imee Su Martinez	University of the Philippines-Diliman, Philippines
14.	Dr Robert Mikulak	United States Department of State, United States of America
15.	Dr Daan Noort	TNO, Rijswijk, Netherlands
16.	Prof Ponnadurai Ramasami	University of Mauritius, Mauritius
17.	Mr Günter Povoden	EU CBRN Centres of Excellence Initiative, Ministry of Defence, Austria
18.	Dr Syeda Sultana Razia	Bangladesh University of Engineering and Technology (BUET), Dhaka, Bangladesh
19.	Prof Ahmed E. M. Saeed	Sudan University of Science and Technology, Sudan
20.	Dr Yasuo Seto	RIKEN SPring-8 Center, Japan
21.	Dr Maciej Sliwakowski	Lukasiewicz Research Network – Institute of Industrial Organic Chemistry, Poland
22.	Prof Fengxia Sun	Hebei University of Science and Technology, China
23.	Dr Nomandla Magnificent Vela	Protechnik Laboratories, South Africa
24.	Ms Farhat Waqar	Pakistan Atomic Energy Commission, Islamabad, Pakistan

Invited Participants		
25.	Dr Stewart Behie	Mary Kay O'Connor Process Safety Center, Texas A&M University, United States of America
26.	Dr Craig Cormick (Member of the ABEO)	Independent Consultant, Australia
27.	Dr Alastair Hay (Member of the ABEO)	University of Leeds, United Kingdom of Great Britain and Northern Ireland
28.	Dr Katelyn Mason	Lawrence Livermore National Laboratory, United States of America
29.	Mr Cormac O'Reilly	Organisation for the Prohibition of Chemical Weapons, Netherlands
30.	Dr Timothy Wood	Organisation for the Prohibition of Chemical Weapons, Netherlands
Secretary to the Scientific Advisory Board		
31.	Dr Peter Hotchkiss	Organisation for the Prohibition of Chemical Weapons, Netherlands

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