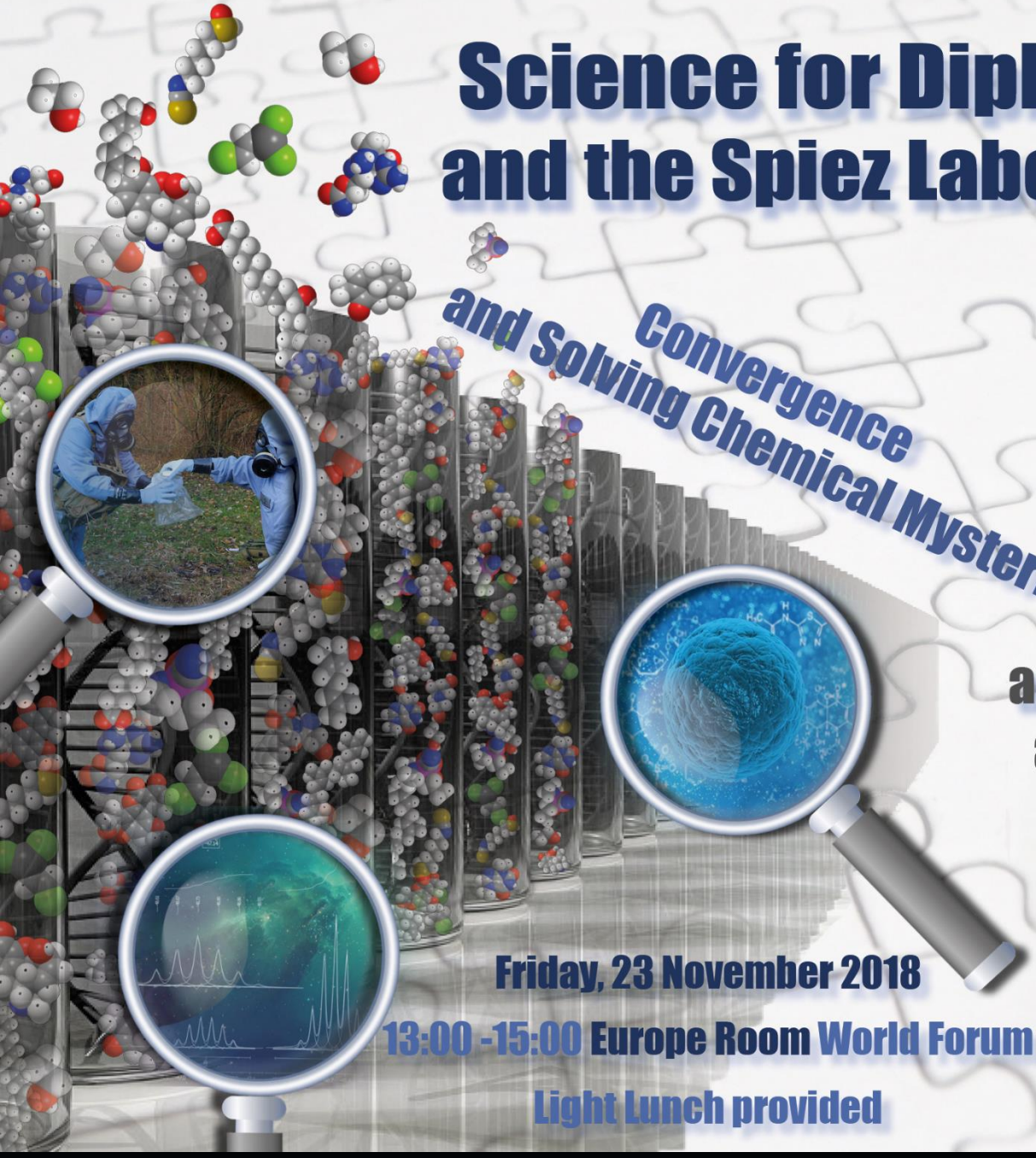
Science for Diplomats at RC-4 and the Spiez Laboratory Present:

Convergence and Solving Chemical Mysteries



a Transdisciplinary Look at Scientific Advances and Problem Solving

Friday, 23 November 2018

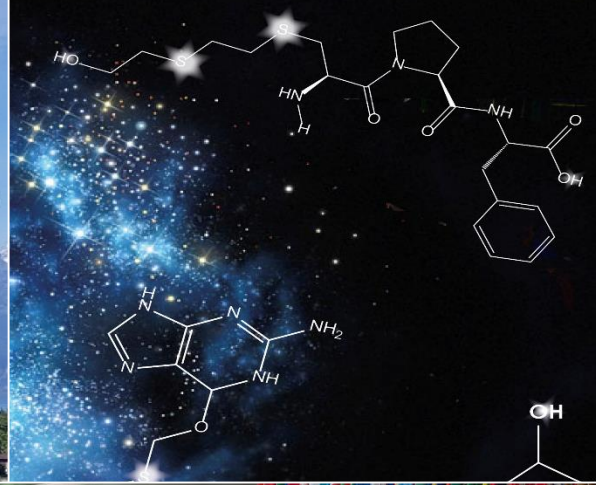
13:00 -15:00 Europe Room World Forum

Light Lunch provided

OPCW

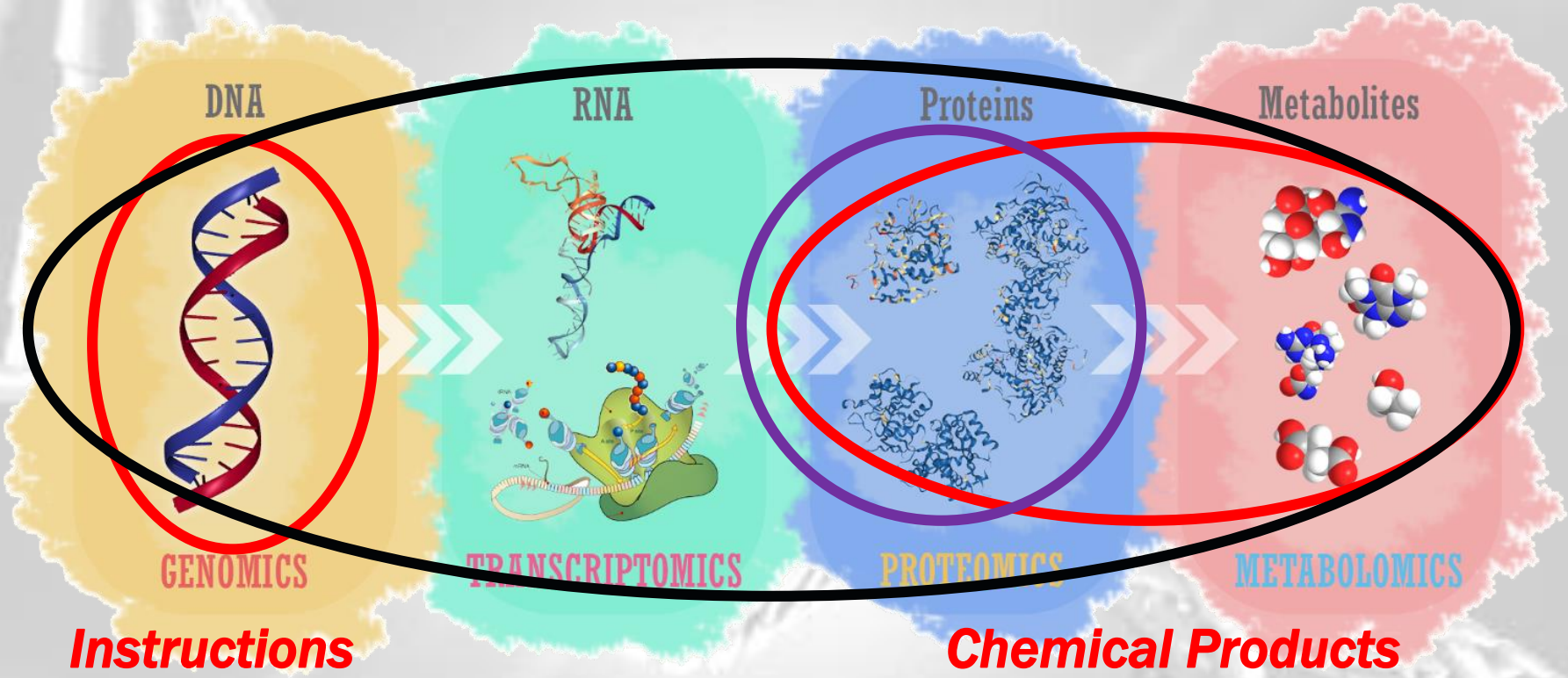
Science for the Fourth Review Conference!

Science for the Fourth Review Conference!



A Convergence of Chemistry and Biology?

"Molecular Devices" (catalysts, decontaminants, materials, toxins…)



Instructions ***Chemical Products***

Biomarkers of exposure

Targets for medical countermeasures

A Convergent Convention?

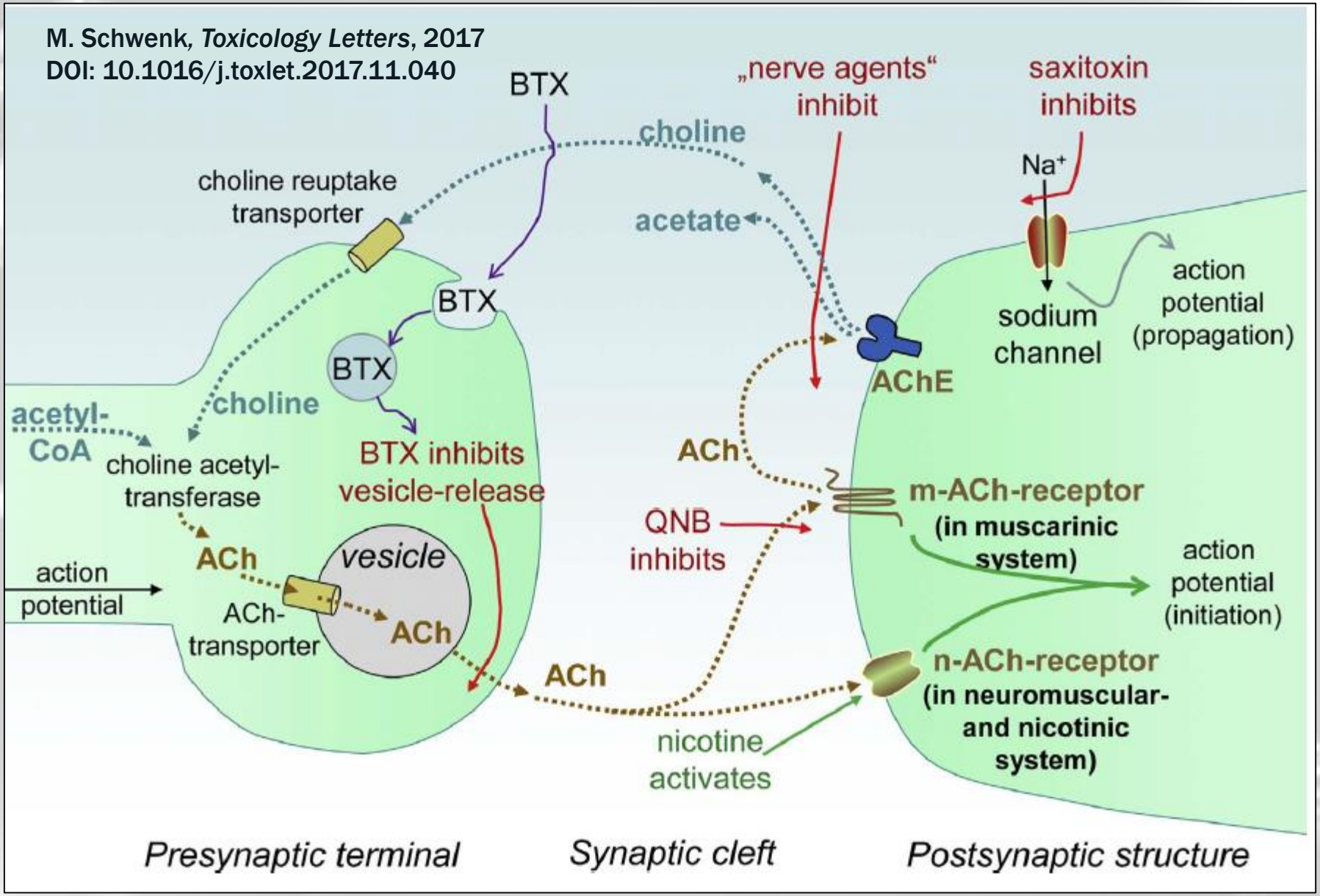
Biology in the Chemical Weapons Convention

The Definition of a Toxic Chemical

Any chemical which through its ***chemical action on life processes*** can cause death, temporary incapacitation or permanent harm to humans or animals. This includes all such chemicals, regardless of their origin or of their method of production, and regardless of whether they are produced in facilities, in munitions or elsewhere

Chemical Weapons Convention Article II, Paragraph 2

M. Schwenk, *Toxicology Letters*, 2017
DOI: 10.1016/j.toxlet.2017.11.040



ORGANISATION FOR THE PROHIBITION OF CHEMICAL WEAPONS

Working Together For a World Free of Chemical Weapons

Temporary Working Group on Investigative Science and Technology

Reporting to the Scientific Advisory Board (SAB), the Temporary Working Group (TWG) will in particular consider the following questions:

Question 1:

Which methods and capabilities used in the forensic sciences could usefully be developed and/or adopted for Chemical Weapons Convention-based investigations?

Question 2:

What are the best practices and analysis tools used in the forensic sciences for effectively cross-referencing, validating, and linking together information related to investigation sites, materials collected/analysed, and individuals interviewed?

Question 3:

What are the best practices for management of data collected in investigations, including compilation, curation, and analytics?

Question 4:

What are the best practices for the collection, handling, curation and storage, and annotation of evidence?

Question 5:

Which technologies and methodologies (whether established or new) allow point-of-care and non-destructive measurements at an investigation site to help guide evidence collection?

Question 6:

Which technologies and methodologies (whether established or new) can be used in the provenancing of chemical and/or material samples collected in an investigation?

Question 7:

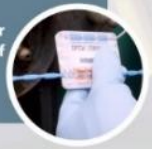
Which methods are available (or are being developed) for the sampling and analysis of environmental and biomedical materials and can be used in the detection of toxic industrial chemicals relevant to the Chemical Weapons Convention?

Question 8:

Which technologies and methodologies (whether established or new) can be used in ensuring chain of custody and verifying authenticity (especially in regard to digital images and video recordings)?

Question 9:

Which technologies and methodologies (whether established or new) can be used to ensure the integrity of an investigation site?



Question 10:

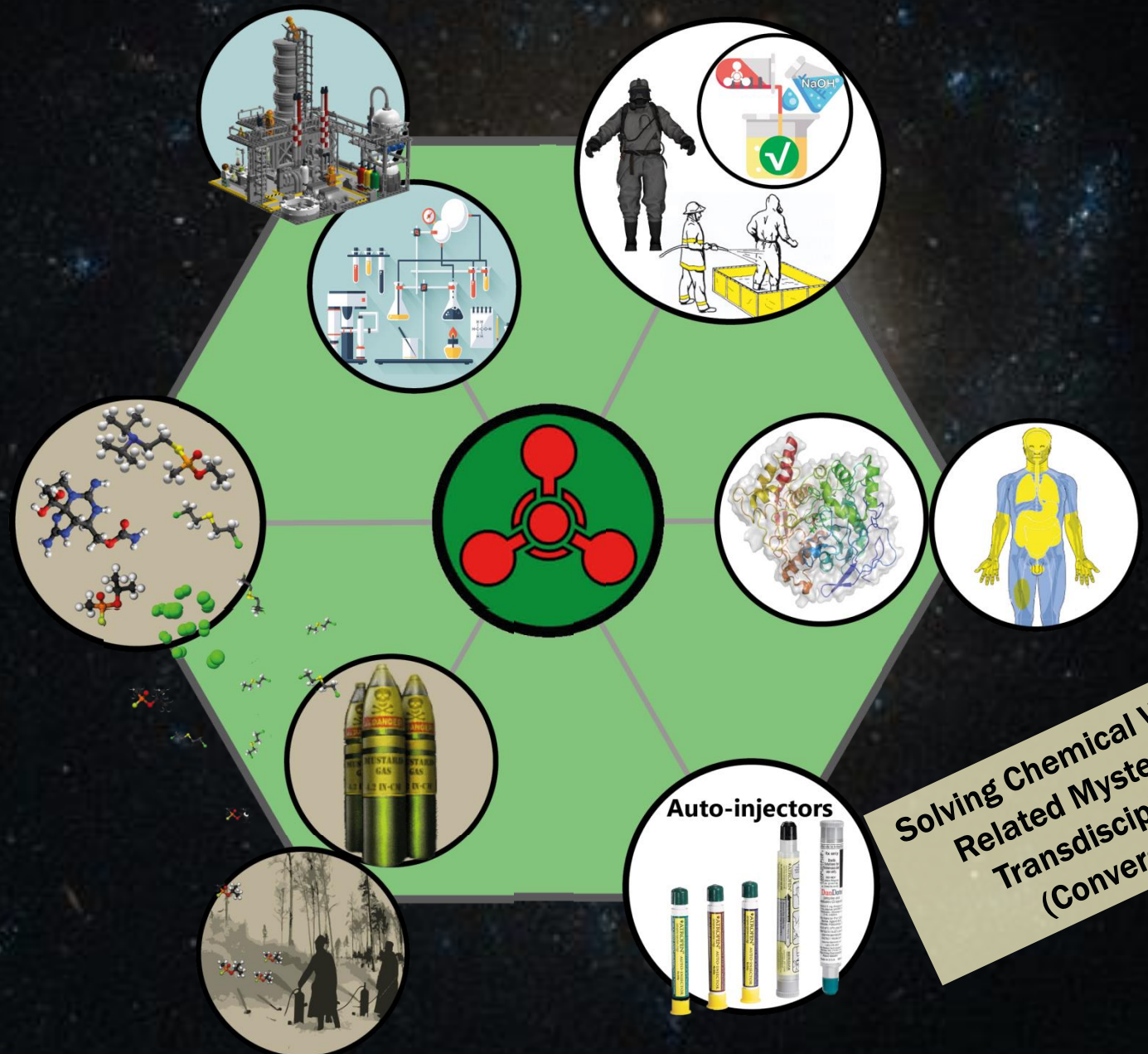
Do collections of physical objects, samples, and other information for chemical weapons-related analysis exist and can they be made available to investigators for retrospective review? How might these collections be used to support investigations?

Question 11:

Are there stakeholders that the Technical Secretariat could usefully engage with to leverage their capabilities on investigative matters?

In addition, the TWG will provide advice on Technical Secretariat proposals for methodologies, procedures, technologies, and equipment for investigative purposes.

Science is vast… What is the Relevant Science of (Bio)Chemical Disarmament and Non-Proliferation?



Science is vast … (Bio)Chemical Disarmament …

Scientific Advisory Board's Recommendations to the Fourth Review Conference of the Chemical Weapons Convention

A quick reference guide to the executive summary recommendations of the OPCW Scientific Advisory Board's report on developments in science and technology to the Fourth Review Conference (RC-4/DG.1, dated 30 April 2018).

Download RC-4/DG.1


sample to
SAMPLE 7.9
The Hague

OPCW

Science for Diplomats

Solving a Chemical Mystery

Your task is to determine the provenance of the "sample" before you. Just follow these instructions!

In front of you sit results from a sample analysis provided by our chemical and biological analysis laboratory, along with a puzzle that indicates where your sample may have been collected.
Your task is as follows: Solve the puzzle (we recommend collaboration) and then consider the chemical analysis.

1. Do the chemical analysis results suggest the presence of a chemical weapon agent? If so, which one?
   - This can be determined by recognizing degradation products and/or data that can be found on the "Degradation and Analysis of Scheduled Chemicals" handout.
   - To assist your interpretation of the data, refer to the back of this card.
   - When you are ready, raise your molecule and one of our capable assistants will check your answer and provide you with additional information.

Agent =

2. In addition to the analytical results, other evidence has been collected that requires consideration and perhaps more puzzle building. Use this additional information to match your sample to the site (A-K) from which it was collected.

3. One last question: is your sample actually from a Chemical Weapon agent?

Yes | No

A, B, C, D, E, F, G, H, I, J, K

Circle the answer

Good Luck!

This exercise has been brought to you by Sofia Sola Sancho, Maria Hemme, Nadine Gürer and Jonathan Forman, as part of Science for Diplomats at RC4 and the Spiez Laboratory Present: Convergence and Solving Chemical Mysteries, a Transdisciplinary Look at Scientific Advances and Problem Solving

Degradation and Analysis of Scheduled Chemicals

OPCW

Science for Diplomats

Analysis of Sarin adducts

Phe–Gly–Glu–Ser–Ala–Gly–Ala–Ala–Ser

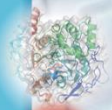
normal peptide "no exposure"

Phe–Gly–Glu–Ser–Ala–Gly–Ala–Ala–Ser

Sarin adduct "exposed"

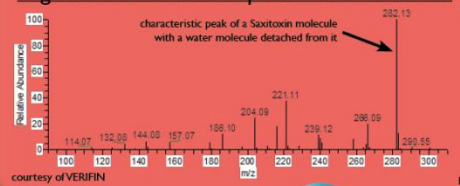
Phe–Gly–Glu–Ser–Ala–Gly–Ala–Ala–Ser

"aged" form of Sarin adduct "exposed"



Saxitoxin

High Resolution Mass Spectrum of Saxitoxin



molecular structure of Saxitoxin

Sulfur mustard

parent molecule

degradation products

BZ

3-Quinuclidinyl benzilate (BZ)

parent molecule

degradation products

Lewisite I

2-Chlorovinyldichloroarsine (Lewisite I)

parent molecule

degradation products

Nitrogen mustard (HN-3)

Tris(2-chloroethyl)amine (HN-3)

parent molecule

degradation products

Sarin

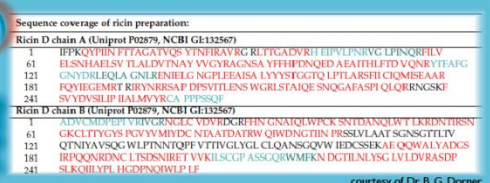
parent molecule

degradation products

HF

Ricin

Peptide Sequencing Analysis of Ricin



courtesy of Dr. B. G. Dorner

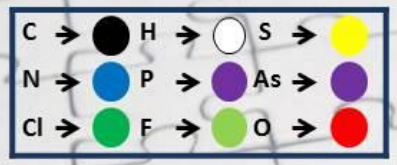
created by Maria Hemme and Jonathan Forman

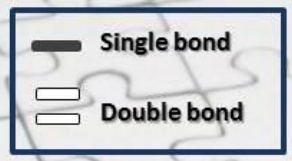
Degradation and Analysis of Scheduled Chemicals

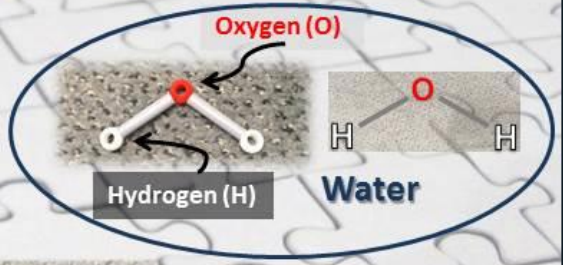
OPCW

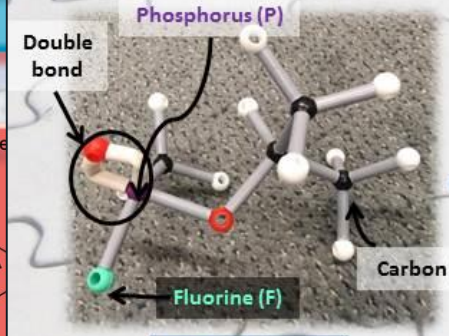
Science for Diplomats

Visualising and Reading Molecules

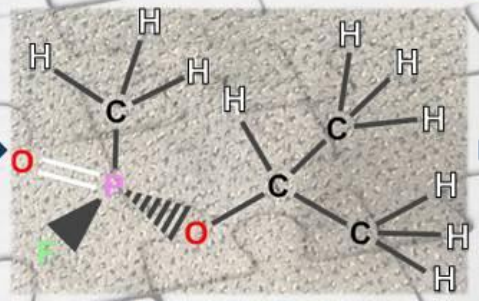




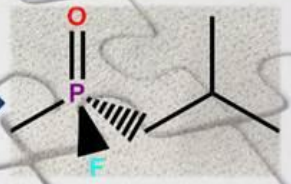




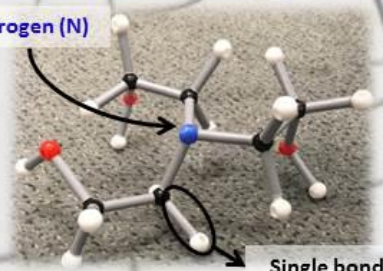
Models

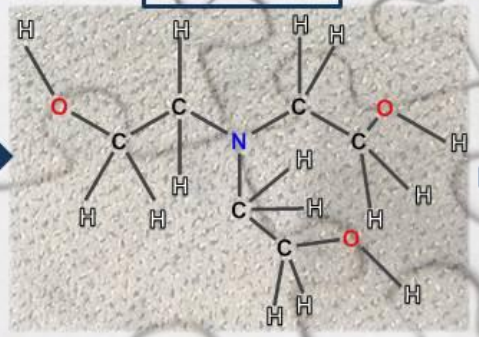


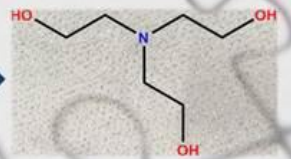
Translation



"Short hand" used in "Degradation and Analysis of Schedule Chemicals" handout





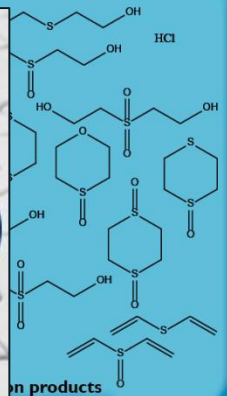


High Resolution Mass Spectrum of Saxitoxin

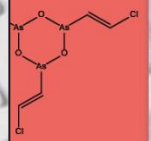
parent molecule

degradation products

Sulfur mustard



products



products

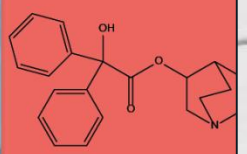
Phe–Gly–Glu–Ser–Ala–Gly–Ala–

normal peptide

Sarin adduc

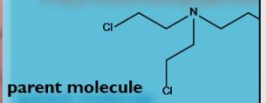
"aged" form of Sarin

3-Quinuclidinyl benzilate

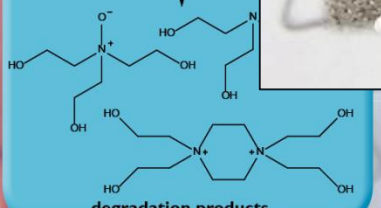


parent molecule

Tris(2-chloroethyl)amine (

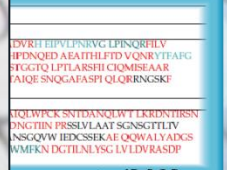


parent molecule



degradation products

of Ricin



courtesy of Dr. B. G. Dorner

created by Maria Hemme and Jonathan Forman

The Rules

- **Follow the instructions!**
- **Identify chemicals! Build the map!**
- **Convergence of chemistry, biology, cartography, puzzle making and finding matching pictures**
- **Once you are ready for the next clue – Raise your sample number or a "molecule"**
- ***Promote Science Diplomacy – work together!***


Let’s Begin!

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Federal Office for Civil Protection FOCP
SPIEZ LABORATORY

Spiez CONVERGENCE 2018

S&T @ crossroad of chemistry and biology

RC-4, Science for Diplomats, 23 Nov. 2018

Stefan Mogl, Beat Schmidt Spiez Laboratory

Spiez CONVERGENCE workshop series 2014 / 2016 / 2018

- Explore S&T challenges to CWC and BWC
- 3rd Review of S&T at intersection of biology and chemistry
- Participants from academia, industry, arms control

https://www.labor-spiez.ch/pdf/de/rue/Spiez_Convergence_2014_web.pdf
https://www.labor-spiez.ch/pdf/en/Report_on_the_second_workshop-5-9_September_2016.pdf

Subjects Reviewed 2018

- CRISPR Genome editing
- Synthetic Biology
- Synthetic and Analytical Chemistry
- Material Sciences including Nanotechnology
- Additive Manufacturing
- Bioinformatics, Omics, and Big Data
- Policy discussion

Revisiting subjects:

- Deeper understanding of maturity
- Shows speed of progress
- Relevance
- Allows better predictions

CRISPR Genome editing:
Trends and industrial applications

- Makes genome editing:
  - Easier
  - Faster
  - More accessible
- Target any gene
- With biocatalysts cause variety of desired modifications
- Practical applications:
  - Reversal of antibiotic resistance in bacteria
  - Development of diagnostic techniques

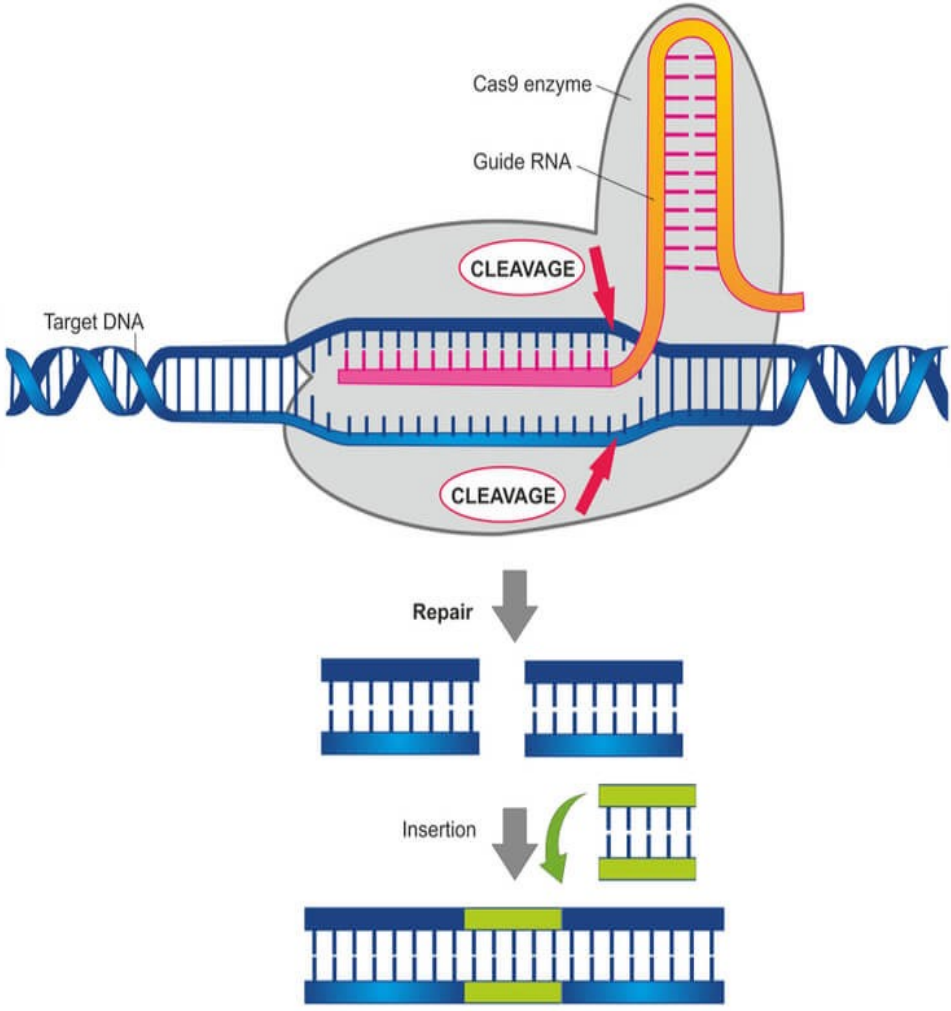


Image: https://labiotech.eu

CRISPR Genome editing:
Trends and industrial applications

- Many applications still at proof-of-concept stage
- Practical challenges before clinical application of CRISPR based therapeutics:
  - Delivery and off-target effects
  - Ethical issues regarding gene editing in the germ line

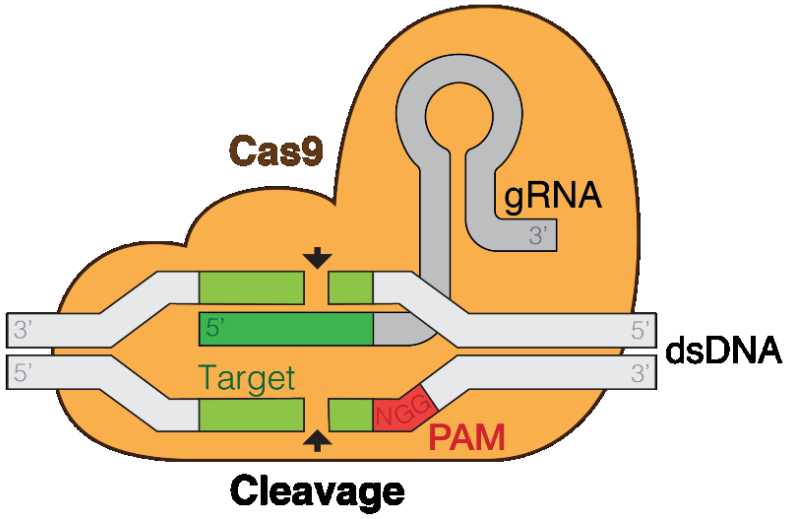
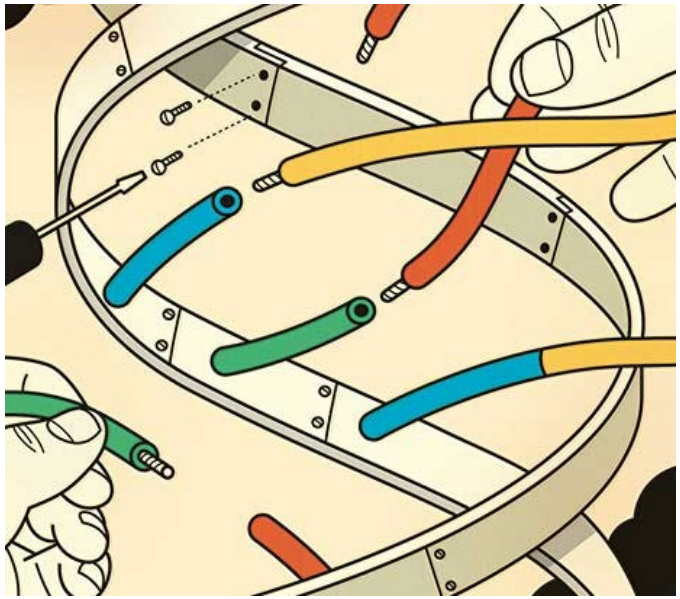


Image: http://thepigeonpress.org/

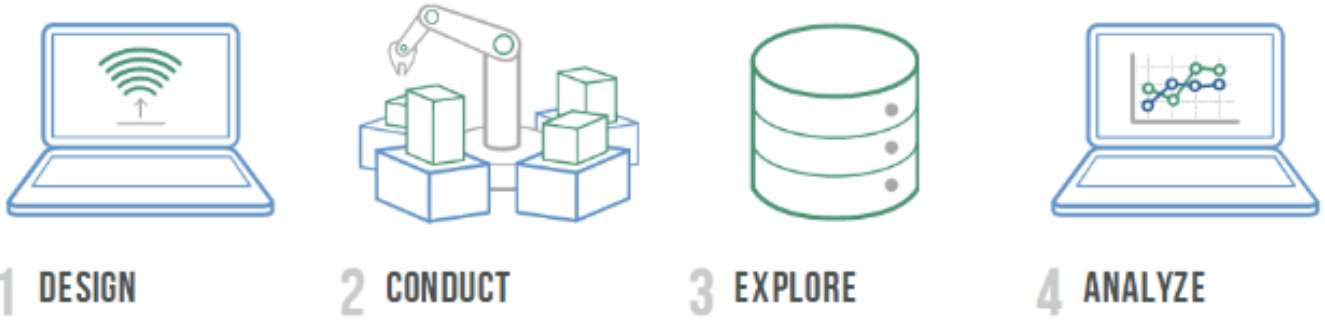
Synthetic Biology:
Trends and industrial applications

- Industry manufactures complex biomolecules using synthetic biology
- *In vitro* designs provide access to oligosaccharides, proteins, assays
- Moving to *in vivo* systems requires change from engineering design to evolution



Synthetic Biology:
Trends and industrial applications

- Analysis of pathogen specific resistance processes by targeted mutagenesis
- Practical application: diagnostic tests for antibiotic resistance in bacteria
- Limitations remain to engineer biological system
- Tacit knowledge still important



Source: www.emeraldcloudlab.com

Synthetic Biology:
Trends and industrial applications

- Cloud laboratories increase speed of synthesis
- Provide reproducible environment, standardised protocols
- Security:
  - Utilisation for malevolent purposes ?
  - Target for remote attacks ?

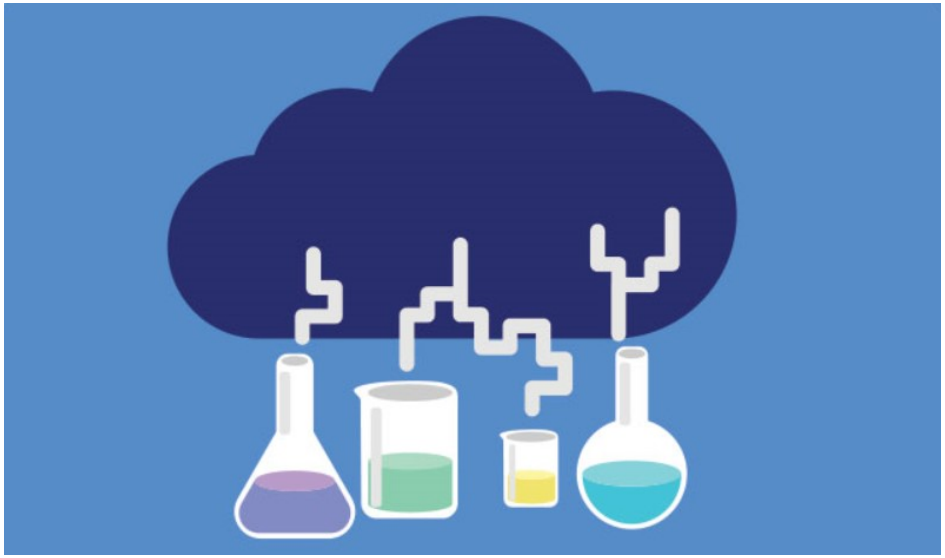


Image: https://www.the-scientist.com/bio-business/bringing-the-internet-of-things-into-the-lab

Synthetic and Analytical Chemistry: *Integrated continuous processing*

- Distinct advantages over batch production in chemical manufacturing
- Widely applied but not for production of pharmaceuticals
- Many advantages for pharmaceutical manufacturing
- For bio-processes, working with living organisms poses challenges

image: https://www.ypsofacto.com/

Synthetic and Analytical Chemistry: *Integrated continuous processing*

- Supervisory Control And Data Acquisition (SCADA) systems need adaptation for bio-process monitoring and control
- Process optimization is specific for a particular production process
  - Each target molecule requires a dedicated process
- Development of continuous bio-manufacturing processes for a range of pharmaceutical products
  - Target specificity is serious obstacle

Synthetic and Analytical Chemistry: *Integrated continuous processing*

- Radial synthesizer as solution:
  - Automated, remotely controlled, modular assembly system
  - Manufactures several small molecules
  - Using same hardware
  - Suitable for multistep syntheses
- Centralisation of chemical synthesis:
  - Operated anywhere
  - Shift in the way chemistry is performed
  - Experiments outsourced to remote automated systems

Material Sciences: *Nanotechnology*

- DNA Origami:
  - Experiments with DNA objects as cancer therapeutics
  - Form rigid DNA structures
  - For targeted drug delivery
- Stability *in vivo* remains problematic
- Practical applications need manufacturing costs to be reduced

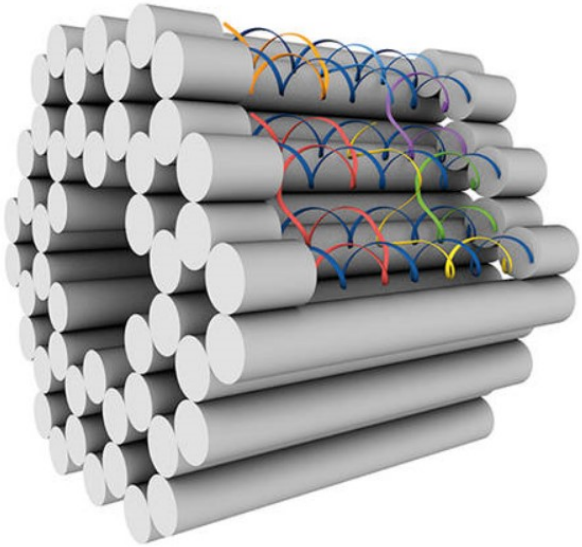


Image: https://www.tum.de/die-tum/aktuelles/pressemitteilungen/detail/article/34360/

Material Sciences:
Nanotechnology for drug delivery

- "Functional Food":
  - Nanostructure formation by self-organization through biological systems in the body
  - Food inspired nanostructures as carrier for drugs
- Nanocarriers:
  - To improve the efficacy of drugs
  - Design stimuli responsive delivery systems

Source image: https://www.asianscientist.com/

Material Sciences:
Nanotechnology for drug delivery

- A wide range of treatments use graphene oxides (GO)
- Two-dimensional nano-scale carbon structures
- Easy to functionalise as drug loading structure
- CBW context:
  - Nanoparticles used as aerosols and inhaled
  - Uptake through Blood Brain Barrier
  - Suitable for targeted delivery of toxins

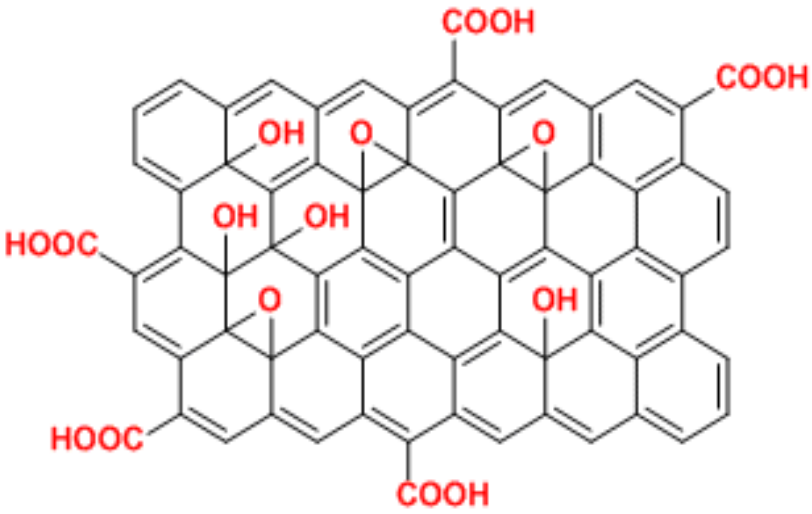


Image: https://www.tcichemicals.com/

Additive Manufacturing (AM)

- AM industry grows rapidly
  - End user controls product design
- Different processes with range of materials available
- Faster manufacturing but cannot compete with sheet metal fabrication
- Complex parts to high performance standards remains a challenge

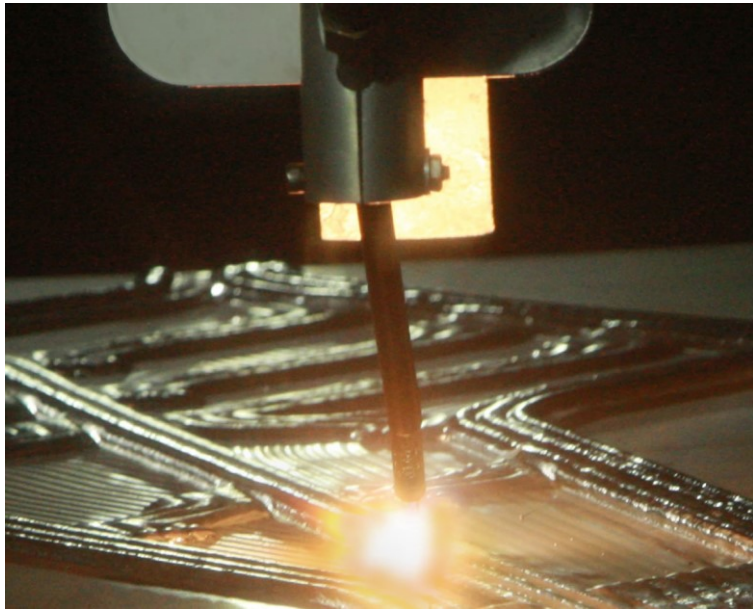


Image: www.additivemanufacturing.com

Additive Manufacturing (AM)

- Of interest for CBW arms control are 3D objects that withstand:
  - High temperature
  - Pressure steam sterilization
  - Highly corrosive chemicals
- Today: only industrial AM systems able to produce such high-quality parts

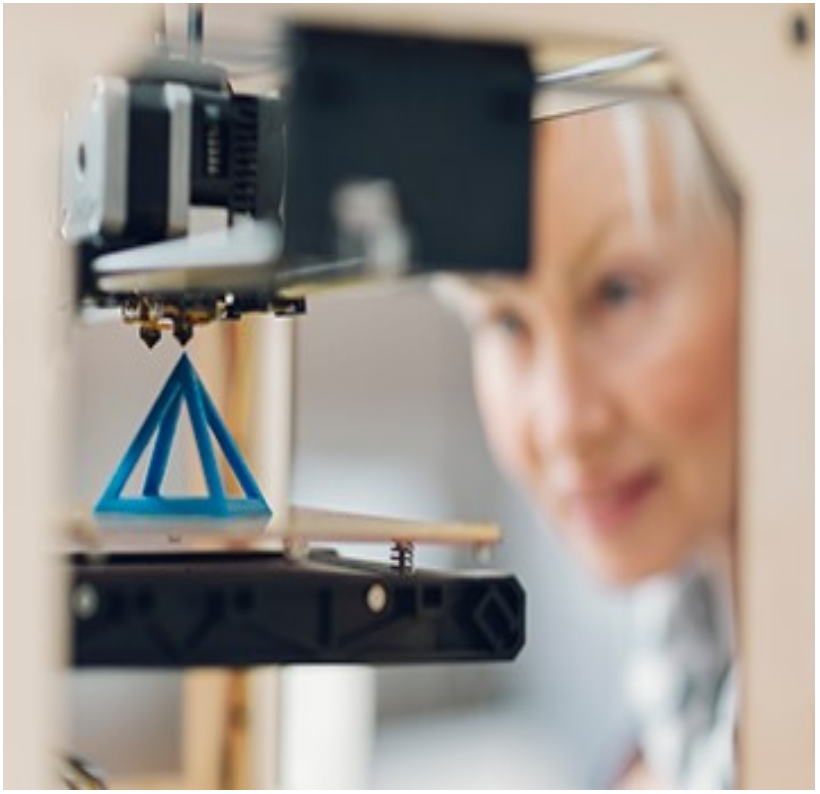


Image: https://www.dsm.com

Additive Manufacturing (AM)

- Industrial AM systems require:
  - Professional know-how
  - Technical competence
- Unlikely, 3D printers capable of manufacturing corrosion resistant parts would be available to individuals or consumers soon
- Next 5 years:
  - List of printable materials will grow
  - AM adopted across multiple industries
  - Regulatory standards will have to be developed

Bioinformatics, 'Omics', Big Data: *Next Generation Sequencing*

- Advances driven by next-generation sequencing (NGS) techniques
  - NGS relies on DNA and RNA as information carriers
  - DNA and RNA can easily be written and read
- Performance today:
  - Parallel read operations of 10 billion molecules in single experiment
  - Precision increased to single molecule manipulations

Image: https://www.illumina.com

Bioinformatics, ‘Omics’, Big Data: *Data Protection*

- Genomes carry information about individual:
  - Data could be used to link individual to genetic characteristics
  - Compromise privacy rights
  - Multiomics projects challenge the protection of patient-specific data
- For Data Mining: Privacy-preserving technologies need improvement

Image: https://www.forbes.com//

Bio informatics, Omics and Big Data
Artificial Intelligence (AI)

- AI offers way to make sense of vast amounts of data:
  - Machine Learning (ML) progressed to improve predictions with neural network architectures
  - Requires access to Big Data and high computational power
- Expl. of predictive power:
  - Reaction performances for organic syntheses
  - Builds models from simple representations of chemical and biological entities
  - Suggest structures with improved properties
  - Expands number of synthesizable materials
- Reliable safeguards need to be found and implemented

Policy discussion
Impact of S&T Advances on Treaties

- Since 2014 focus of discussions shifted:
  - From materials and equipment
  - To information, automation and remote manufacturing
- New opportunities for oversight compliance monitoring and verification

Image: http://rogerpielkejr.blogspot.com

Policy discussion
Impact of S&T Advances on Treaties

- Additive manufacturing:
  - Production is moving closer to the point of use
- Bio-manufacturing of pharmaceuticals:
  - Radial synthesisers centralise chemical synthesis
- Synthetic Biology:
  - Cloud laboratories centralise lab work, separate scientist from lab experiment

- Consequences:
  - Role of end-users or actors in process is changing
  - Access to data and intangibles transfers become more relevant (regulation, control)

Policy discussion:
How would changes affect potential CBW programmes ?

- Novel CBW production facilities compared to past state programs:
  - Smaller footprint
  - Different technological features
- Non-state actors:
  - Attempts to remain opportunistic
  - Constraints: materials, equipment, agent dissemination, costs
  - Tacit knowledge
- State actor:
  - How to fit new materials and methods into contemporary CBW programme ?
  - CBW as WMD vs. sabotage, assassinations
- Are Implementation systems still effective in this changing environment ?

Policy discussion
Impact of S&T Advances on Treaties

- Multi-stakeholder approaches
  - Academia, Industry, National Authority
  - Develop Partnership and Gov. Systems
- Evaluations may have a short and longer-term perspective:
  - 3D printers could require swift response to manage risks
  - Cloud services in chemical and biological manufacturing may affect implementation over time
- Spiez CONVERGENCE wants to support assessment of S&T advances by stakeholder communities of CWC and BWC

TEMPORARY WORKING GROUP (TWG) ON INVESTIGATIVE SCIENCE AND TECHNOLOGY

Dr Veronica Borrett. Member, SAB
Chair, TWG on Investigative Science and Technology

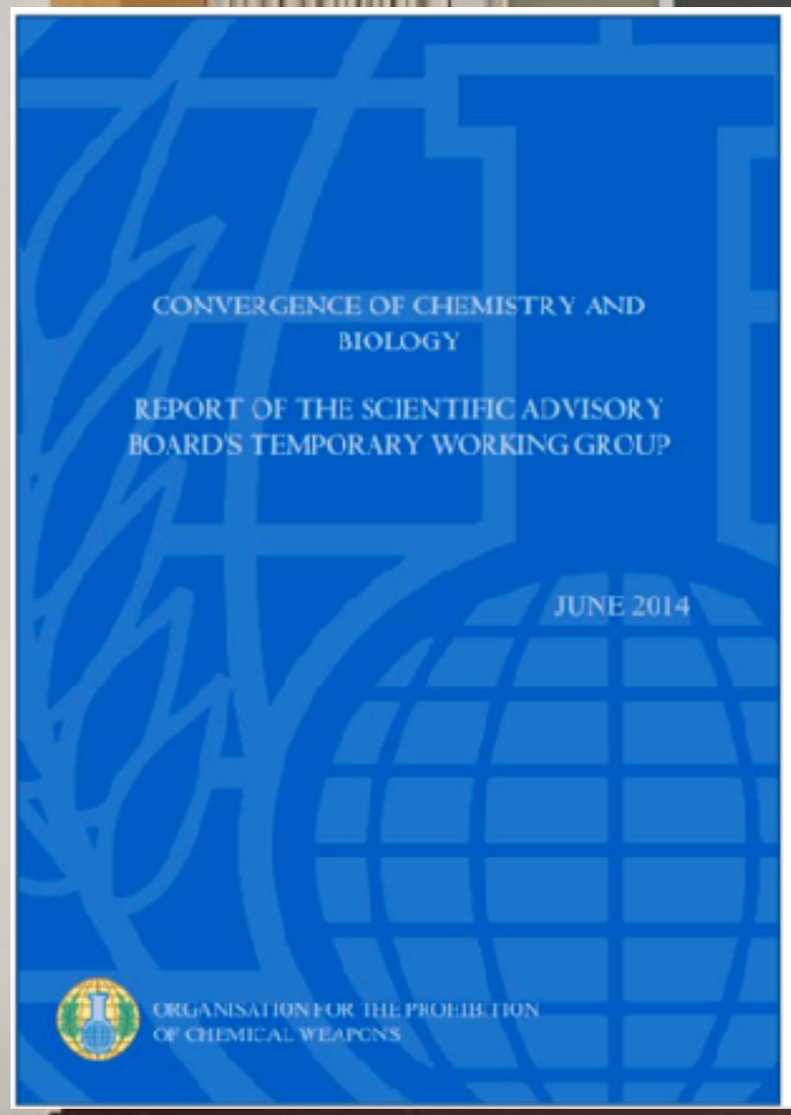
OPCW TWG on Investigative Science and Technology Second Meeting
14 to 16 November 2018

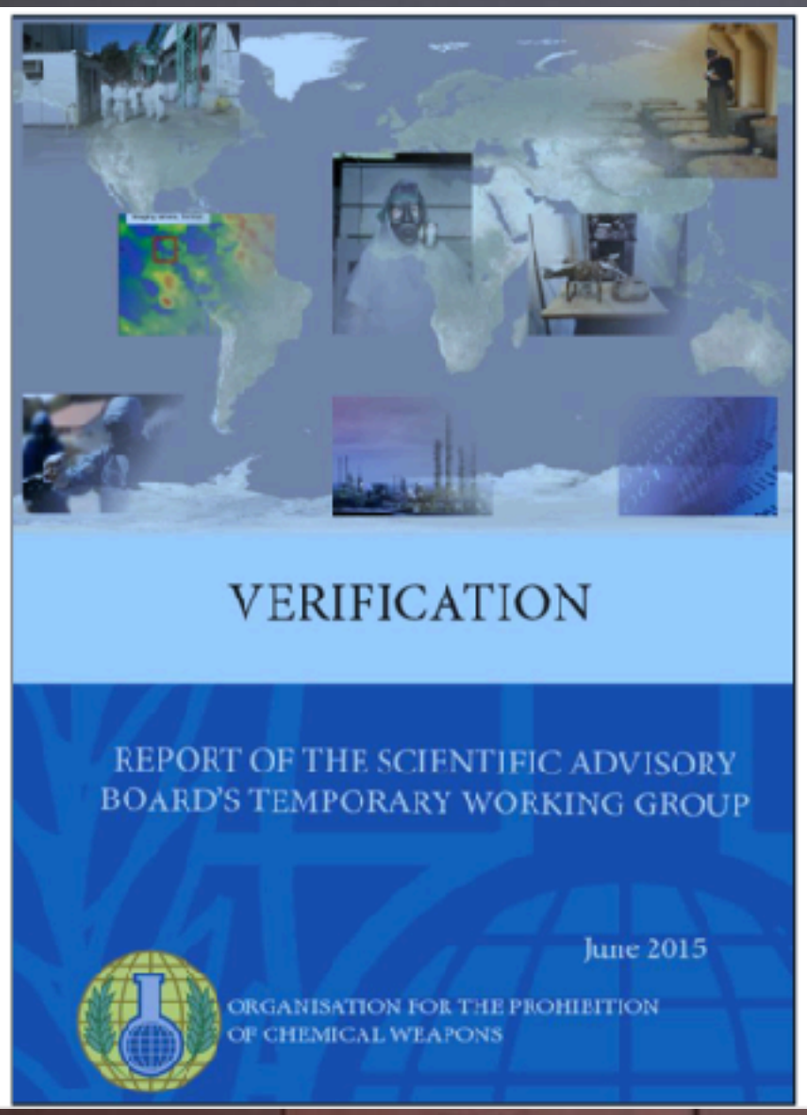
REPORTING

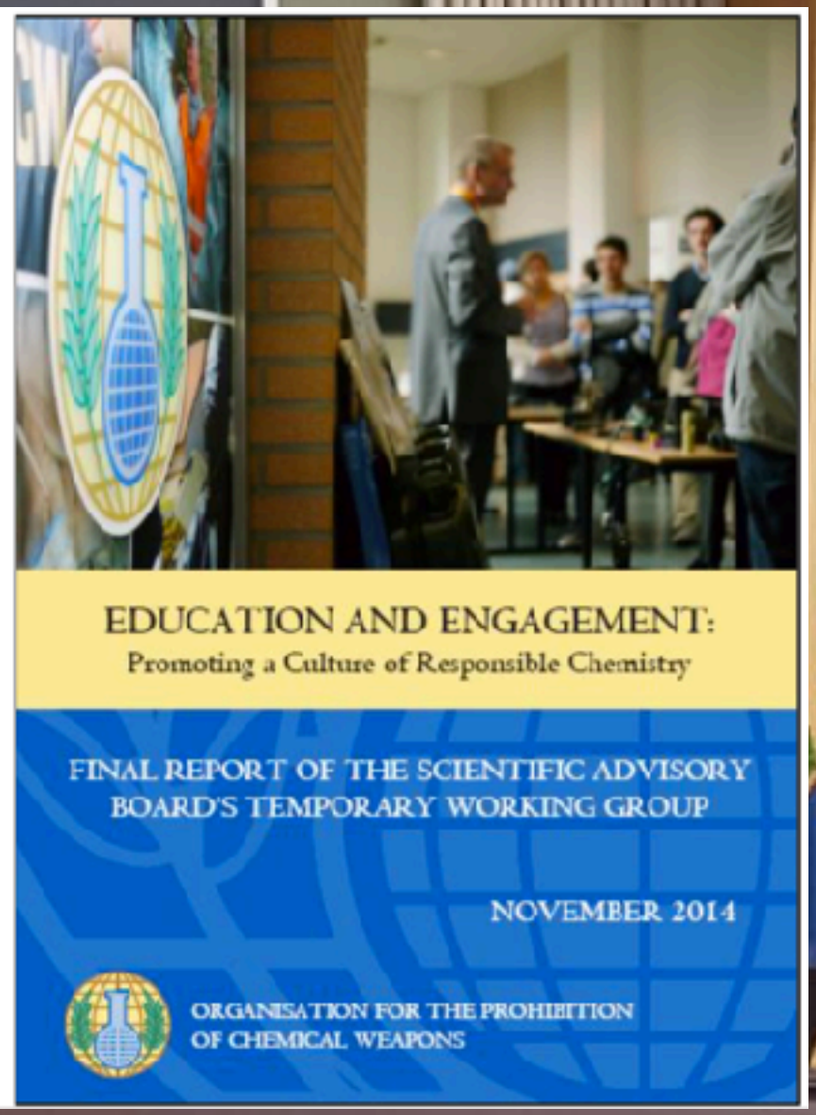

TWG established by the OPCW Director General
TWG report and recommendations reviewed and approved by SAB (Scientific Advisory Board)
SAB provides TWG report to the Director General for consideration

TWG ON INVESTIGATIVE SCIENCE AND TECHNOLOGY

REPORTING







SAB provides TWG report to the Director General for consideration

TWG ON INVESTIGATIVE SCIENCE AND TECHNOLOGY

BACKGROUND

- The lessons learned from contingency operations, such as the OPCW Fact-Finding Mission in the Syrian Arab Republic, have highlighted the need for continued broad engagement and evaluation of technologies and methods (both current and emerging) relevant to the verification regime.
- In response, the OPCW/VERIFIN convened a Workshop on "Chemical Forensics: Capabilities across the Field and the Potential Applications in CWC Implementation" in Helsinki 2016.
- In its report from the workshop, the SAB recommended (SAB-24/WP.1) that additional workshops or a temporary working group (TWG) could be considered to strengthen the understanding of technologies, procedures and capabilities that forensics can bring to investigations.
- The SAB also highlighted the importance of engagement with forensic experts, forensic practitioners and OPCW inspectors and laboratories, to explore methods and capabilities relevant to the verification of the Chemical Weapons Convention.

TWG ON INVESTIGATIVE SCIENCE AND TECHNOLOGY

BACKGROUND

EC-84/DG.9 Response to the Report of the Twenty-Fourth Session of the Scientific Advisory Board (Recommendations to the Director-General (paragraph 1.2 of SAB-24/1))

- 8. The Director-General thanks the SAB for its recommendations from the 2016 workshop on chemical forensics endorsed by the Board at its Twenty-Fourth Session (paragraphs 8.12 to 8.17 of SAB-24/1, and paragraph 18 below). He notes the relevance of this advice to the verification regime, especially for sampling and analysis, and collection and validation of information in support of contingency operations such as deployments of the OPCW Fact-Finding Mission in Syria. The recommendations supporting adoption of fit-for purpose tools and methods would also be relevant to initiatives such as the Rapid Response and Assistance Mission.
- 9. In accordance with paragraph 9 of the SAB's terms of reference (C-II/DEC.10/Rev.1, dated 2 December 2004), the Director-General requests that the SAB establish a new temporary working group (TWG) and appoint a Chairperson for it. **This TWG will address questions relating to science and technology relevant in investigative work, and will undertake further consideration of topics described in paragraph 8 above, other recommendations from the chemical forensics workshop, and in particular questions falling under subparagraphs 2(e) and (g) of the SAB's terms of reference relevant to investigative methods in contingency operations.** The Director-General will in the near future prepare a mandate for theTWG, which should hold its first meeting before the end of the first quarter of 2018.

TWG on Investigative Science and Technology

Terms Of Reference for the TWG

1. The ongoing contingency operations of the Technical Secretariat have increasingly involved investigations, analysis, and fact-finding, with collection and evaluation of oral, material, and digital evidence of the use of chemical agents. Such activities are not part of routine inspection and verification activities under the Chemical Weapons Convention. **The Director-General has decided that it would be useful to have an in-depth review of the methods and technologies used in investigative work, and that these would be relevant to and augment the capacity of the Technical Secretariat.** Further to his response to the report of the Twenty-Fourth Session of the SAB (SAB-24/1, dated 28 October 2016) and in accordance with paragraph 9 of the terms of reference of the SAB (Annex to C-II/DEC.10/Rev.1, dated 2 December 2004), the Director-General has therefore established a Temporary Working Group (TWG) on Investigative Science and Technology and has appointed Dr Veronica Borrett as the Chairperson of the Group.

2. **The objective of the TWG is to review the science and technology relevant to investigations such as those mandated under Articles IX and X of the Chemical Weapons Convention. This would include science and technology for the validation and provenancing (i.e. determining the chronology of ownership, custody and/or location) of evidence, and the integration of multiple and diverse inputs to reconstruct a past event,** as well as further considerations of topics in the recommendations from the SAB's 2016 chemical forensics workshop (SAB-24/WP.1, dated 14 July 2016), and topics falling under subparagraphs 2(e)108 and 2(g)109 of the SAB's terms of reference. **The work of this TWG is intended to identify capabilities, skill sets, and equipment that would augment and strengthen the Technical Secretariat's capabilities.** The findings will be considered by the SAB and recommendations will be provided to the Director-General.

3. The TWG will consist of individuals who collectively have **expertise in the theory and practice of investigative work, including but not limited to investigational chemical analysis, evidence collection, forensic sciences, informatics, crime scene reconstruction, toxicology, inspection, or experience of implementation of the Chemical Weapons Convention.** Qualified members of the SAB may join the TWG. Members of relevant scientific and international organisations may also be invited to join the TWG. Guest speakers may be invited from time to time. The TWG may also, when necessary, draw upon the expertise of the Technical Secretariat, in particular the OPCW Laboratory, Inspectorate, and the Assistance and Protection Branch.

108 "... assess the scientific and technological merit of a present, or proposed, methodology for use by the Technical Secretariat in verification under the Convention".
109 "assess and report on emerging technologies and new equipment which could be used on verification activities".

TWG ON INVESTIGATIVE SCIENCE AND TECHNOLOGY

MEMBERS

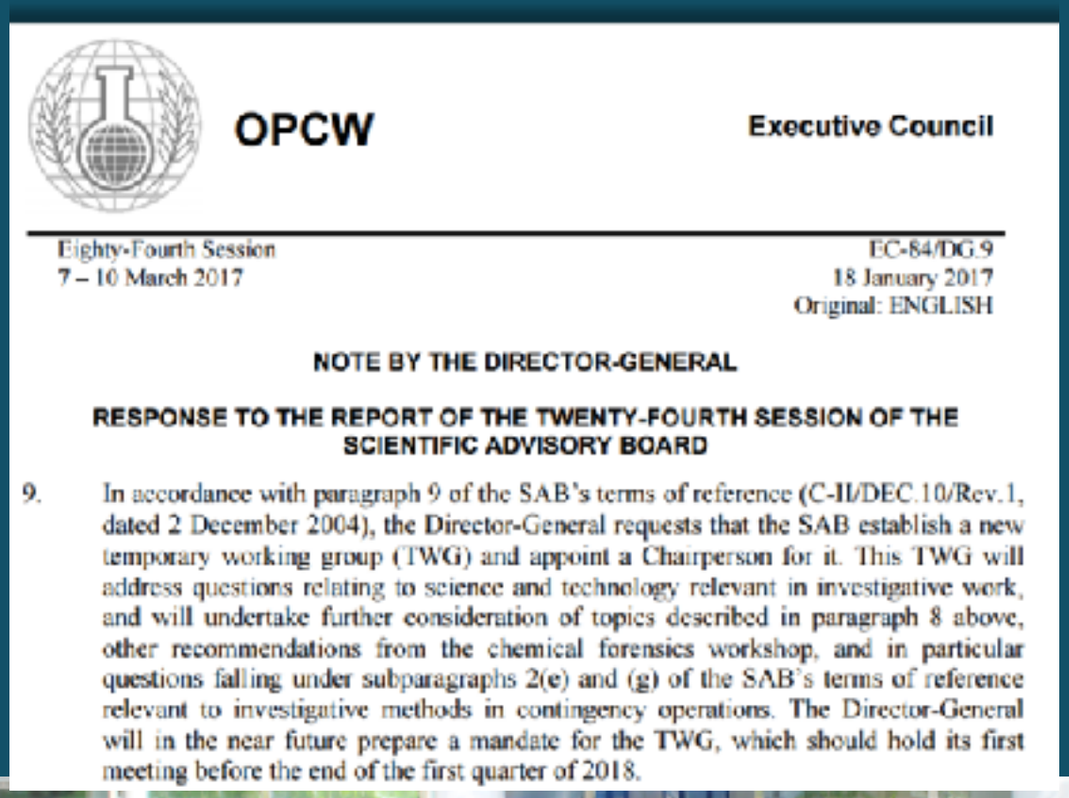
- Veronica Borrett (Australia); TWG Chair *
- Augustin Baulig (France) *
- Christophe Curty (Switzerland) *
- David Gonzalez (Uruguay) *
- Robert Mikulak (USA) *
- Syed Raza (India) *
- Valentin Rubaylo (Russian Federation) *
- Cheng Tang (China); SAB Vice-chair *
- Christopher Timperley (United Kingdom); SAB-Chair *
- Francois van Straten (South Africa) *
- Farhat Waqar (Pakistan) *
- Daan Noort (TNO, The Netherlands)*

- Ed van Zalen (Netherlands Forensic Institute (NFI); TWG Vice Chair
- Crister Åstot (FOI, Sweden)
- Brigette Dorner (RKI, Germany)
- Carlos Fraga (Pacific Northwest National Laboratory, USA)
- Paula Vanninen (VERIFN, Finland)

*** SAB Members**

TWG ON INVESTIGATIVE SCIENCE AND TECHNOLOGY

SAB REPORTS REVIEWED PRIOR TO FIRST TWG MEETING INCLUDE:



OPCW

Executive Council

Eighty-Fourth Session
7 – 10 March 2017

EC-84/DG.9
18 January 2017
Original: ENGLISH

NOTE BY THE DIRECTOR-GENERAL

RESPONSE TO THE REPORT OF THE TWENTY-FOURTH SESSION OF THE SCIENTIFIC ADVISORY BOARD

9. In accordance with paragraph 9 of the SAB's terms of reference (C-II/DEC.10/Rev.1, dated 2 December 2004), the Director-General requests that the SAB establish a new temporary working group (TWG) and appoint a Chairperson for it. This TWG will address questions relating to science and technology relevant in investigative work, and will undertake further consideration of topics described in paragraph 8 above, other recommendations from the chemical forensics workshop, and in particular questions falling under subparagraphs 2(e) and (g) of the SAB's terms of reference relevant to investigative methods in contingency operations. The Director-General will in the near future prepare a mandate for the TWG, which should hold its first meeting before the end of the first quarter of 2018.

OPCW/VERIFIN Workshop "Chemical Forensics: Capabilities across the Field and the Potential Applications in CWC Implementation" Helsinki 2016

SAB Session Reports, SAB-22

TWG on Verification Final Report

OPCW/IUPAC/ABC/AAS "International Workshop on Innovative Technologies for Chemical Security" Brazil 2017

TWG ON INVESTIGATIVE SCIENCE AND TECHNOLOGY

SAB REPORTS REVIEWED PRIOR TO FIRST TWG MEETING INCLUDE:

Forensics:
Potential
' Helsinki 2016

Workshop on
al Security" Brazil

OPCW

Eighty-Fourth Session
7 – 10 March 2017

NOTE BY THE DIRE

RESPONSE TO THE REPORT OF THE
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OPCW

Review Conference

Fourth Session
21 – 30 November 2018

RC-4/DG.1
30 April 2018
Original: ENGLISH

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

Introduction

1. The Scientific Advisory Board (SAB) was established by the Director-General in accordance with subparagraph 21(h) and paragraph 45 of Article VIII of the Chemical Weapons Convention (hereinafter "the Convention"), so that he could render to the Conference of the States Parties (hereinafter "the Conference") and the Executive Council (hereinafter "the Council") specialised advice in areas of science and technology relevant to the Convention. In keeping with this mandate, and as its contribution to the Fourth Special Session of the Conference of the States Parties to Review the Operation of the Chemical Weapons Convention (hereinafter "the Fourth Review Conference"), to be held from 21 to 30 November 2018, the SAB has prepared this report, which analyses relevant developments in science and technology over the past five years and presents recommendations and observations that the SAB considers to be important for the review of the operation of the Convention and its future implementation.

2. This report contains an executive summary and recommendations addressing issues that may impact the implementation of the Convention and the work of the Technical Secretariat (hereinafter "the Secretariat"). The analysis of developments in science and technology that informed the recommendations, as well as additional, more detailed recommendations, are provided in Annex 1.

3. This is the fourth report for a Review Conference by the SAB on developments in science and technology relevant to the Convention. The three earlier reports were presented to the First Special Session of the Conference of the States Parties to Review the Operation of the Chemical Weapons Convention[1] (hereinafter "the First Review Conference"), the Second Special Session of the Conference of the States Parties to Review the Operation of the Chemical Weapons Convention[2] (hereinafter "the Second Review Conference"), and the Third Special Session of the Conference

ORGANISATION FOR THE PROHIBITION OF CHEMICAL WEAPONS

Working Together For a World Free of Chemical Weapons

Temporary Working Group on Investigative Science and Technology

Reporting to the Scientific Advisory Board (SAB), the Temporary Working Group (TWG) will in particular consider the following questions:

Question 1:

Which methods and capabilities used in the forensic sciences could usefully be developed and/or adopted for Chemical Weapons Convention-based investigations?

Question 2:

What are the best practices and analysis tools used in the forensic sciences for effectively cross-referencing, validating, and linking together information related to investigation sites, materials collected/analysed, and individuals interviewed?

Question 3:

What are the best practices for management of data collected in investigations, including compilation, curation, and analytics?

Question 4:

What are the best practices for the collection, handling, curation and storage, and annotation of evidence?

Question 5:

Which technologies and methodologies (whether established or new) allow point-of-care and non-destructive measurements at an investigation site to help guide evidence collection?

Question 6:

Which technologies and methodologies (whether established or new) can be used in the provenancing of chemical and/or material samples collected in an investigation?

Question 7:

Which methods are available (or are being developed) for the sampling and analysis of environmental and biomedical materials and can be used in the detection of toxic industrial chemicals relevant to the Chemical Weapons Convention?

Question 8:

Which technologies and methodologies (whether established or new) can be used in ensuring chain of custody and verifying authenticity (especially in regard to digital images and video recordings)?

Question 9:

Which technologies and methodologies (whether established or new) can be used to ensure the integrity of an investigation site?

Question 10:

Do collections of physical objects, samples, and other information for chemical weapons-related analysis exist and can they be made available to investigators for retrospective review? How might these collections be used to support investigations?

Question 11:

Are there stakeholders that the Technical Secretariat could usefully engage with to leverage their capabilities on investigative matters?

In addition, the TWG will provide advice on Technical Secretariat proposals for methodologies, procedures, technologies, and equipment for investigative purposes.

ORGANISATION FOR THE PROHIBITION OF CHEMICAL WEAPONS

Working Together For a World Free of Chemical Weapons

Forensic Methods and Capabilities

Subgroup A

Question 1:

Which methods and capabilities used in the forensic sciences could usefully be developed and/or adopted for Chemical Weapons Convention-based investigations?

Question 11:

Are there stakeholders that the Technical Secretariat could usefully engage with to leverage their capabilities on investigative matters?

ORGANISATION FOR THE PROHIBITION OF CHEMICAL WEAPONS

Working Together For a World Free of Chemical Weapons

Data Collection and Management

Subgroup B

Question 2:

What are the best practices and analysis tools used in the forensic sciences for effectively cross-referencing, validating, and linking together information related to investigation sites, materials collected/analysed, and individuals interviewed?

Question 3:

What are the best practices for management of data collected in investigations, including compilation, curation, and analytics?

ORGANISATION FOR THE PROHIBITION OF CHEMICAL WEAPONS

Working Together For a World Free of Chemical Weapons

Sampling, Detection and Analysis

Subgroup C

Question 5:

Which technologies and methodologies (whether established or new) allow point-of-care and non-destructive measurements at an investigation site to help guide evidence collection?

Question 7:

Which methods are available (or are being developed) for the sampling and analysis of environmental and biomedical materials and can be used in the detection of toxic industrial chemicals relevant to the Chemical Weapons Convention?

ORGANISATION FOR THE PROHIBITION OF CHEMICAL WEAPONS

Working Together For a World Free of Chemical Weapons

Temporary Working Group on Investigative Science and Technology

Integrity of Scene and Evidence Collection

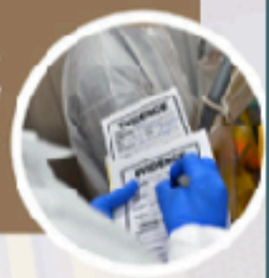
Subgroup D

Question 4:

What are the best practices for the collection, handling, curation and storage, and annotation of evidence?

Question 8:

Which technologies and methodologies (whether established or new) can be used in ensuring chain of custody and verifying authenticity (especially in regard to digital images and video recordings)?



Question 9:

Which technologies and methodologies (whether established or new) can be used to ensure the integrity of an investigation site?

retrospective review? How might these collections be used to support investigations?

on investigative matters?

purposes.

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ORGANISATION FOR THE PROHIBITION OF CHEMICAL WEAPONS

Working Together For a World Free of Chemical Weapons

Temporary Working Group on Investigative Science and Technology

Provenance

Subgroup E

Question 6:

Which technologies and methodologies (whether established or new) can be used in the provenancing of chemical and/or material samples collected in an investigation?

Question 10:

Do collections of physical objects, samples, and other information for chemical weapons-related analysis exist and can they be made available to investigators for retrospective review? How might these collections be used to support investigations?

ORGANISATION FOR THE PROHIBITION OF CHEMICAL WEAPONS

Working Together For a World Free of Chemical Weapons

Temporary Working Group on Investigative Science and Technology

Subgroup F - Other Considerations

Reporting to the Scientific Advisory Board, consider the following questions:

Question 1:

Which methods and capabilities used in the forensic sciences could usefully be developed and/or adopted for Chemical Weapons Convention-based investigations?

Question 2:

What are the best practices and analysis tools used in the forensic sciences for effectively cross-referencing, validating, and linking together information related to investigation sites, materials collected/analysed, and individuals interviewed?

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What are the best practices for management of data collected in investigations, including compilation, curation, and analytics?

Question 4:

What are the best practices for the collection, handling, curation and storage, and annotation of evidence?

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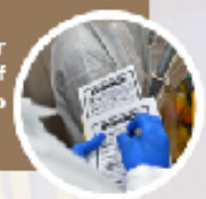

Question 9:

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Question 11:

Are there stakeholders that the Technical Secretariat could usefully engage with to leverage their capabilities on investigative matters?

In addition, the TWG will provide advice on Technical Secretariat proposals for methodologies, procedures, technologies, and equipment for investigative purposes.

CONSIDERATIONS

- Operational context - challenges and requirements
- Laboratory capabilities
- Sample collection, dangerous goods shipment, analysis
- Chain of Custody
- Current best-practice and SOPs
- What new capabilities and connections are required?
- Connections with forensic community
- Forward thinking and emerging technologies from broader scientific community
- Approaches to combine multiple information streams

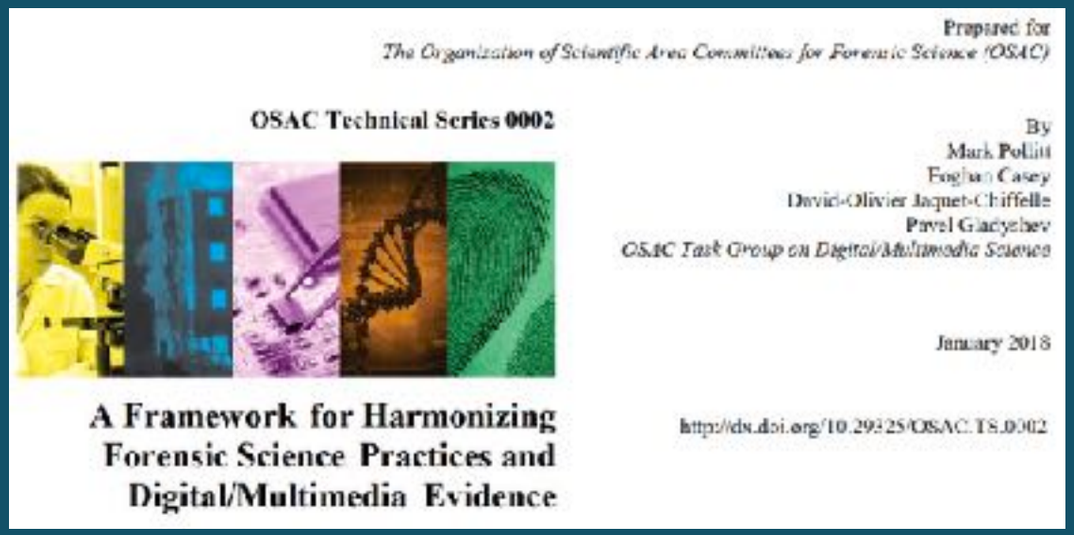
TECHNOLOGY SOLUTIONS

- The ability to access and apply new technology solutions for evaluating and documenting a scene or equipment, and detection and sampling.
  - help highlight sampling hotspots (the best place to take a sample)
    - can reduce the number of samples and increase their utility, reduce logistic burden and workload for OPCW lab and DL
    - increase effectiveness of time spent at the scene
  - support risk assessment for inspectors
  - support planning to reduce the time required at a scene - e.g. to reduce hazards that may be associated with working in personal protective equipment
- Robust forensic methods to ensure the integrity of information and sampled materials
  - Best practice for chain of custody, scene documentation, detection and analysis

- Site assessment, documentation, sampling and analysis, and Chain of Custody may benefit from the application of technology solutions, such as:
  - UGV/UAVs,
  - imaging (particularly satellite imaging),
  - 3D and 2D scanning, and
  - inclusion of RFIDs (i.e. electronic tags) for monitoring, tracking and Chain of Custody.

TWG ON INVESTIGATIVE SCIENCE AND TECHNOLOGY

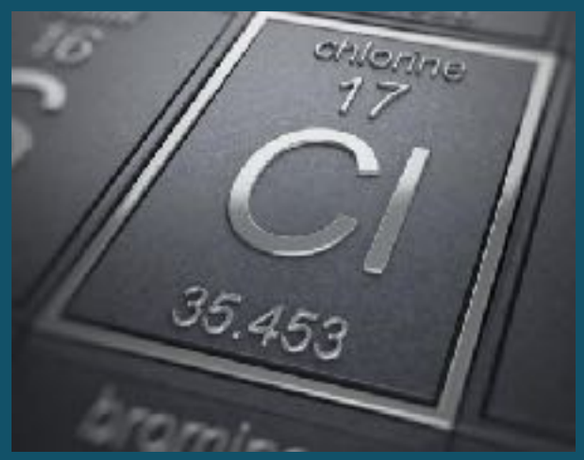
TECHNOLOGY



Authentication and validation of data

UAV/UGV and robotics for sampling

Chlorine markers and biomarkers



Profiling of CW to determine provenance

Imagery: Value and need for expert interpretation

UNOSAT

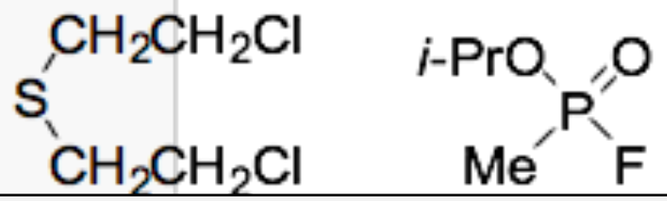
unitar
United Nations Institute for Training and Research

Builds on SAB work

Advice on chemical weapons sample stability and storage provided by the Scientific Advisory Board of the Organisation for the Prohibition of Chemical Weapons to increase investigative capabilities worldwide

Christopher M. Timperley,[1a*] Jonathan E. Forman,[§*] Mohammad Abdollahi,[2] Abdullah Saeed Al-Amri,[3] Isel Pascual Alonso,[4] Augustin Baulig,[5] Veronica Borrett,[6] Florida A. Cariño,[7] Christophe Curty,[8] David González Bermúdez,[9] Zrinka Kovarik,[10] Roberto Martínez-Álvarez,[11] Robert Mikulak,[12] Nicia Maria Fusaro Mourão,[13] Ramasami Ponnadurai,[14] Slawomir Neffe,[15] Syed K. Raza,[16] Valentin Rubaylo,[17] Koji Takeuchi,[18] Cheng Tang,[19b] Ferruccio Trifirò,[20] Francois Mauritz van Straten,[21] Paula S. Vanninen,[22] Volodymyr Zaitsev,[23] Farhat Waqar,[24] Mongia Saïd Zina,[25] Marc-Michael Blum,[26c] Hugh Gregg[26d], Elena Fischer,[27e] Siqing Sun,[27e] Pei Yang[27e]

Review of, and advice given on, chemical weapons sample storage and stability, to assist chemical weapons-related forensic studies worldwide



Builds on SAB work

OPCW Scientific Advisory Board

Twenty-Eighth Session — SAB-28/WP.

3 – 7 June 2019 — 19 November 2018

ENGLISH only

SUMMARY OF THE SECOND MEETING OF THE SCIENTIFIC ADVISORY BOARD'S TEMPORARY WORKING GROUP ON INVESTIGATIVE SCIENCE AND TECHNOLOGY

1. AGENDA ITEM ONE – Opening of the meeting

1.1. The Scientific Advisory Board's (SAB) Temporary Working Group (TWG) on Investigative Science and Technology held its Second Meeting from 14 to 16 November 2018 at OPCW Headquarters in The Hague. The meeting was chaired by Dr Veronica Borrett on behalf of the SAB, with support from Vice-Chairperson Dr Ed van Zalen.

1.2. Dr Borrett opened the meeting by reiterating the TWGs objectives.[1] She thanked the TWG members for their intersessional work, as well as the invited speakers, who have kindly given their time to support the meeting. Dr Borrett outlined the process for reviewing progress on the questions summarised in the TWGs terms of reference (TOR)[1] and also the efforts to explore new and emerging technologies or approaches relevant to investigations mandated under Articles IX and X of the Chemical Weapons Convention (hereinafter, "the Convention"). In addition to engagement with forensic experts on best practices for investigation, she highlighted the importance of engagement with experts from the Technical Secretariat (hereinafter, "the Secretariat") and the Designated Laboratories (DLs), to ensure that TWG advice is guided by the needs and experience of those carrying out the investigative work. Dr

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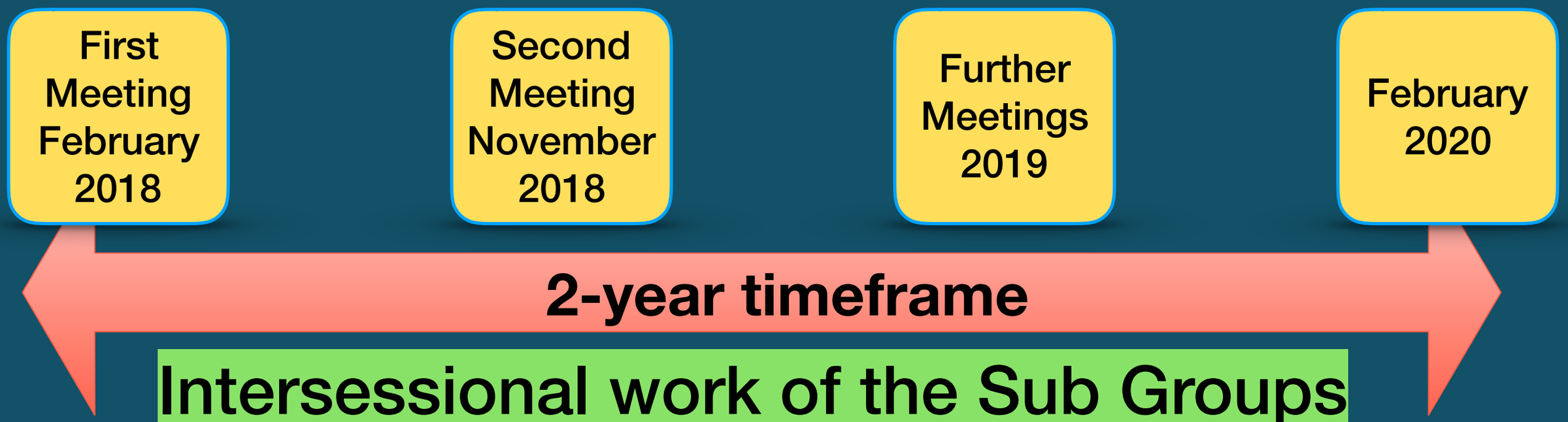
Abdullah Saeed
rida A. Cariño,[7]
rtínez-Álvarez,[11]
lawomir Neffe,[15]
ruccio Trifirò,[20]
Farhat Waqar,[24]
[27e] Siqing Sun,[27e]

TIMELINE

- First meeting was held 12 to 14 February 2018
- Second meeting was held 14 to 16 November 2018
- Third meeting proposed for April 2019

REPORTING

- Report to the SAB
- Potential for Interim Report
- Potential for DG request to SAB for Advice



For 2019?

- 28th Session, June 2019
- Final TWG Meeting: Late 2019/Early 2020
- Launching the Science Review for RC-5

OPCW Scientific Advisory Board

Briefing to States Parties

Thursday 22 March 2018

Ieper Room | 13:30-15:00

Light lunch served at 13:00

visory Board

es Parties

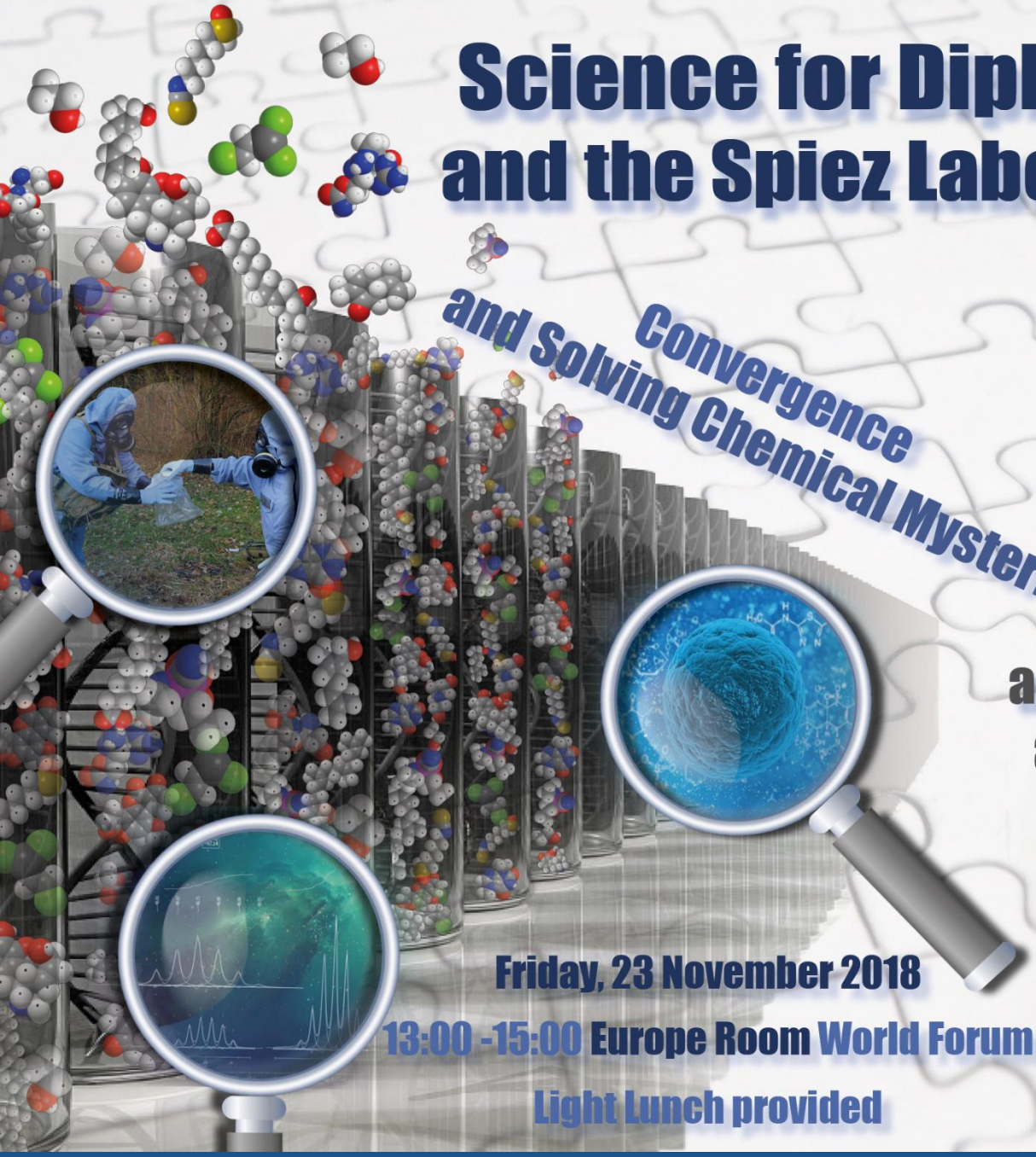
Thursday

Ieper Roor

Light lunch

Science for Diplomats at RC-4 and the Spiez Laboratory Present:

Convergence and Solving Chemical Mysteries



a Transdisciplinary Look at Scientific Advances and Problem Solving

Friday, 23 November 2018

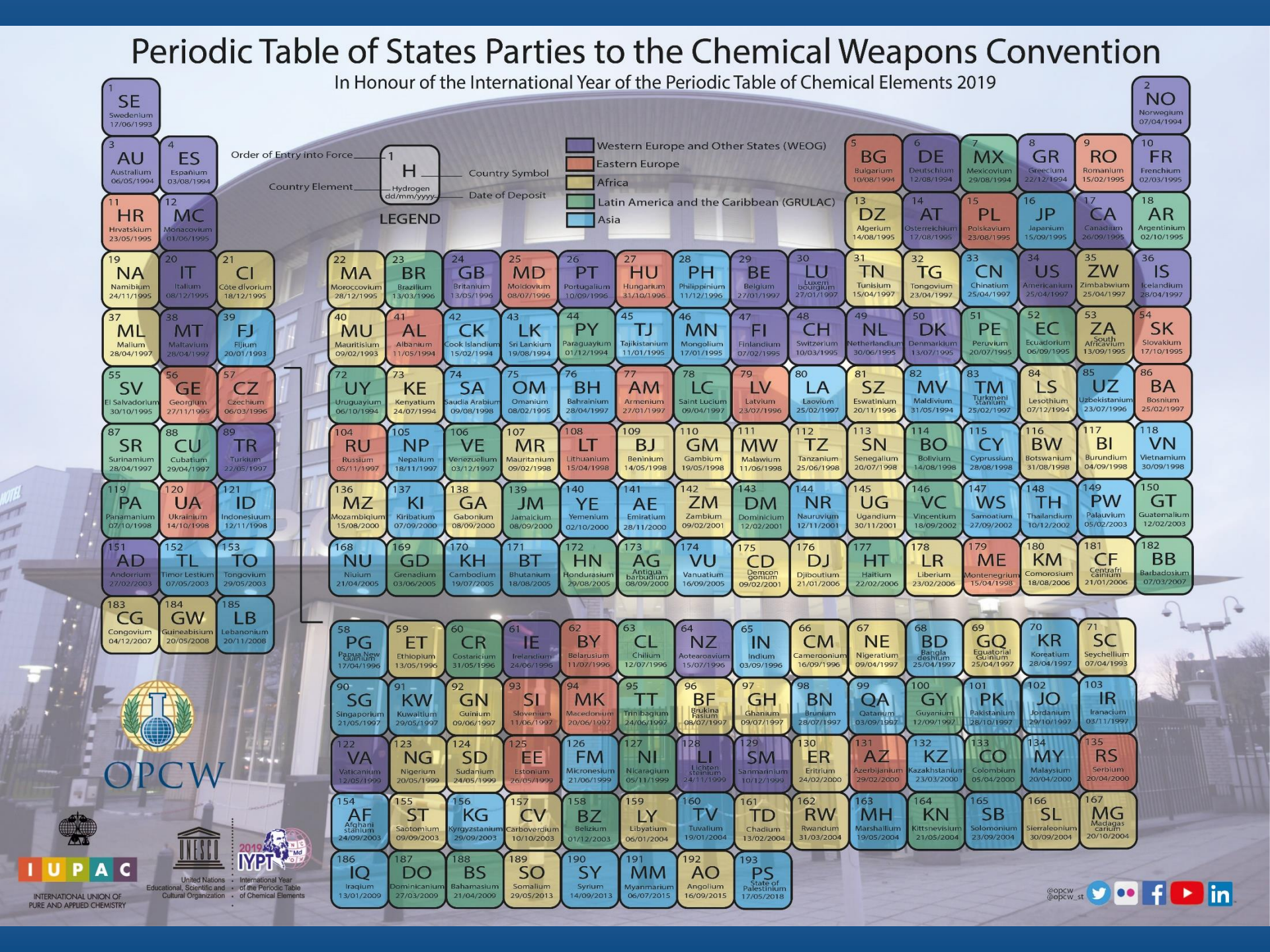
13:00 -15:00 Europe Room World Forum

Light Lunch provided

OPCW

Periodic Table of States Parties to the Chemical Weapons Convention

In Honour of the International Year of the Periodic Table of Chemical Elements 2019

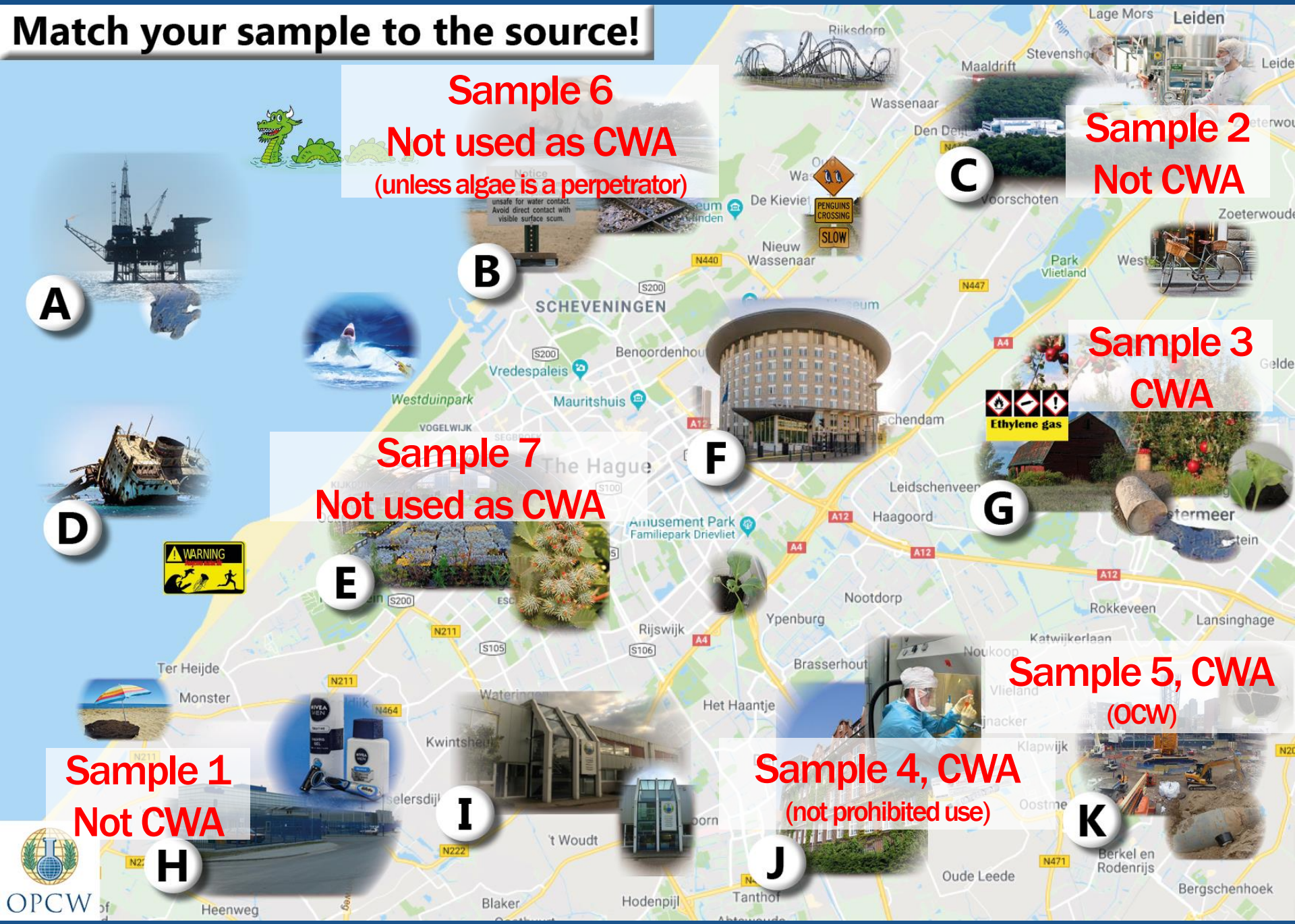


Match your sample to the source!

Did you match your sample to the source?

OPCW

Match your sample to the source!



One Last Thing…

Dr Christopher Timperley
SAB Chairperson
2015 – 2018

6 Sessions of the SAB
4 TWG Meetings
4 International SAB Workshops

Led on 3 intersessional reports

10 Papers published/accepted for publication in scientific literature with SAB

#IamaScienceDiplomat

OPCW

منظمة حظر الأسلحة الكيميائية

禁止化学武器组织

Organisation for the Prohibition of Chemical Weapons

Organisation pour l’Interdiction des Armes Chimiques

Организация по запрещению химического оружия

Organización para la Prohibición de las Armas Químicas