



## **Science for Diplomats**

# **Scientific discovery, technology development, and the role of the Scientific Advisory Board**

**26 June 2014**

**Jonathan E. Forman  
Science Policy Adviser  
Office of Strategy and Policy  
Organisation for the Prohibition of Chemical Weapons**



## From The Convention

- **The Conference of States Parties Shall:**
  - **“Review scientific and technological developments that could affect the operation of this Convention and, in this context, direct the Director General to establish a Scientific Advisory Board to enable him, in the performance of his functions, to render specialized advice in areas of science and technology relevant to this Convention, to the Conference, the Executive Council or States Parties.”**
  - *CWC Article VIII, Section B, paragraph 21(h)*



## The Third Review Conference

- **“Conviction** that the provisions of the Convention are mutually reinforcing and that the full, effective, and non-discriminatory implementation of all of its provisions, taking into account relevant developments in science, technology and industry, is of critical importance;”

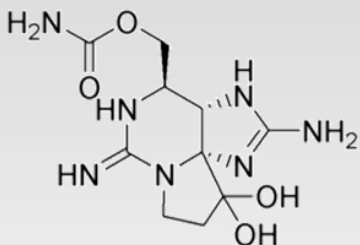
*RC-3/3\* paragraph 9.4*

- **“Recognition** that new challenges related to the Convention continue to arise and that its implementation may need to be improved to continue to achieve the object and purpose of the Convention and to stay abreast of developments in science and technology;”

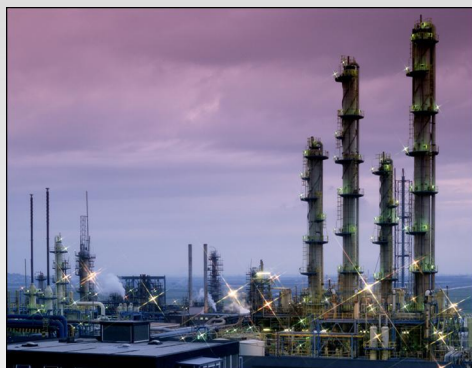
*RC-3/3\*, paragraph 9.9*



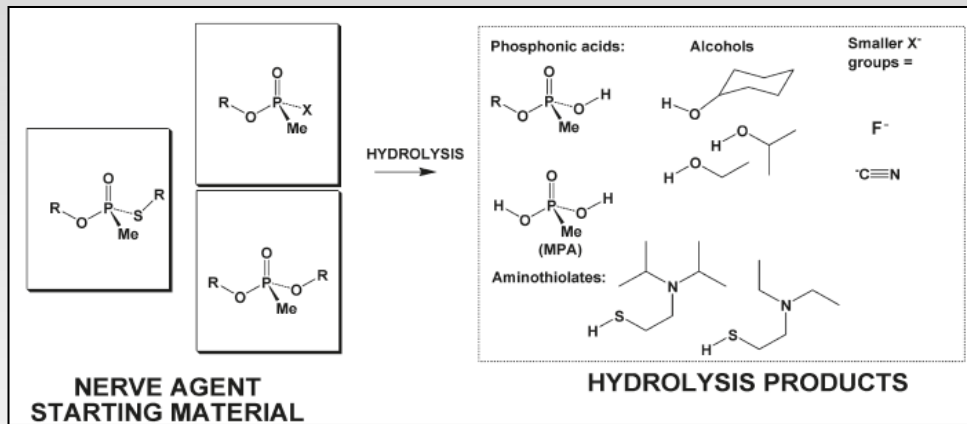
# Science and Technology Underpin the CWC



**Article II**



**Article III**



**Articles IV and V**



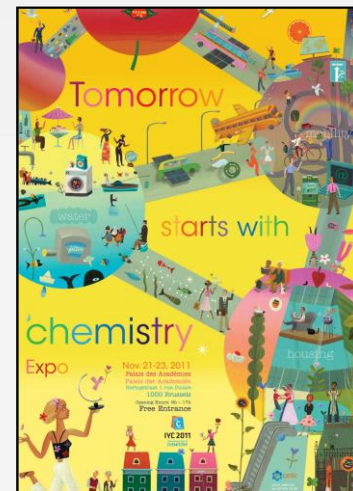
**Article VI**



**Article VIII**



**Articles IX and X**



**Article XI**



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11:44 AM - 11 Oct 2013

1,088 RETWEETS 372 FAVORITES



**Article VII**



# **SAB Report of the Developments in S&T to The Third review Conference**

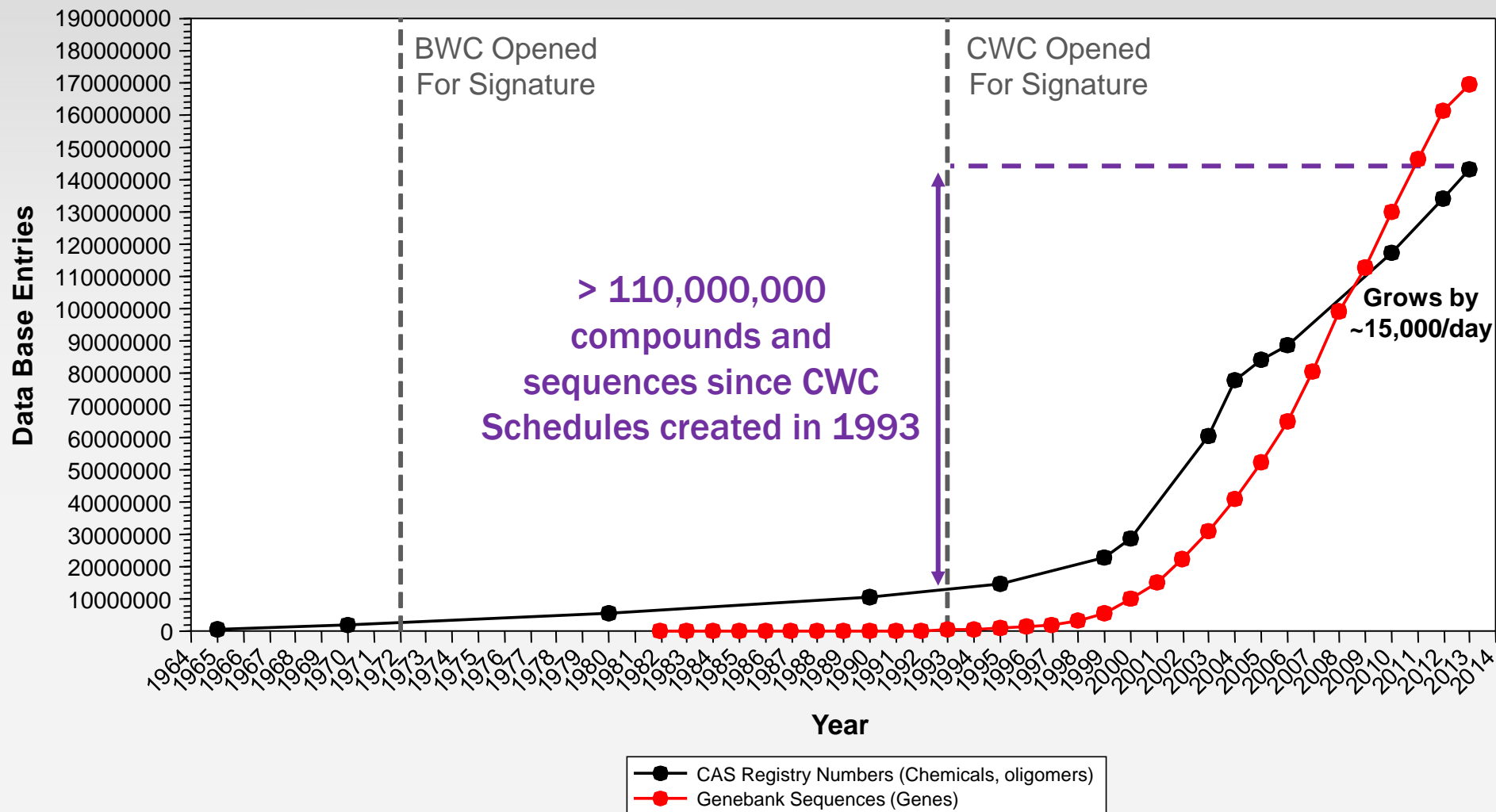
**(RC-3/DG.1, Dated 29 October 2012)**

## **Director General's Recommendations**

**(RC-3/DG.2, Dated 31 January 2013)**

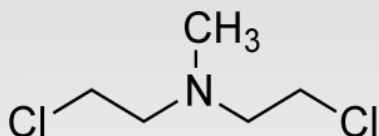


# Monitoring Science

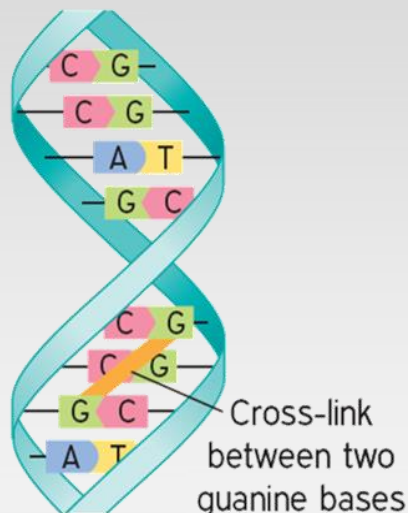




## Chemicals Have Multiple Uses



**Nitrogen Mustard**  
**Schedule 1A**



**and Anti-Cancer Drug**  
**(as a salt)**



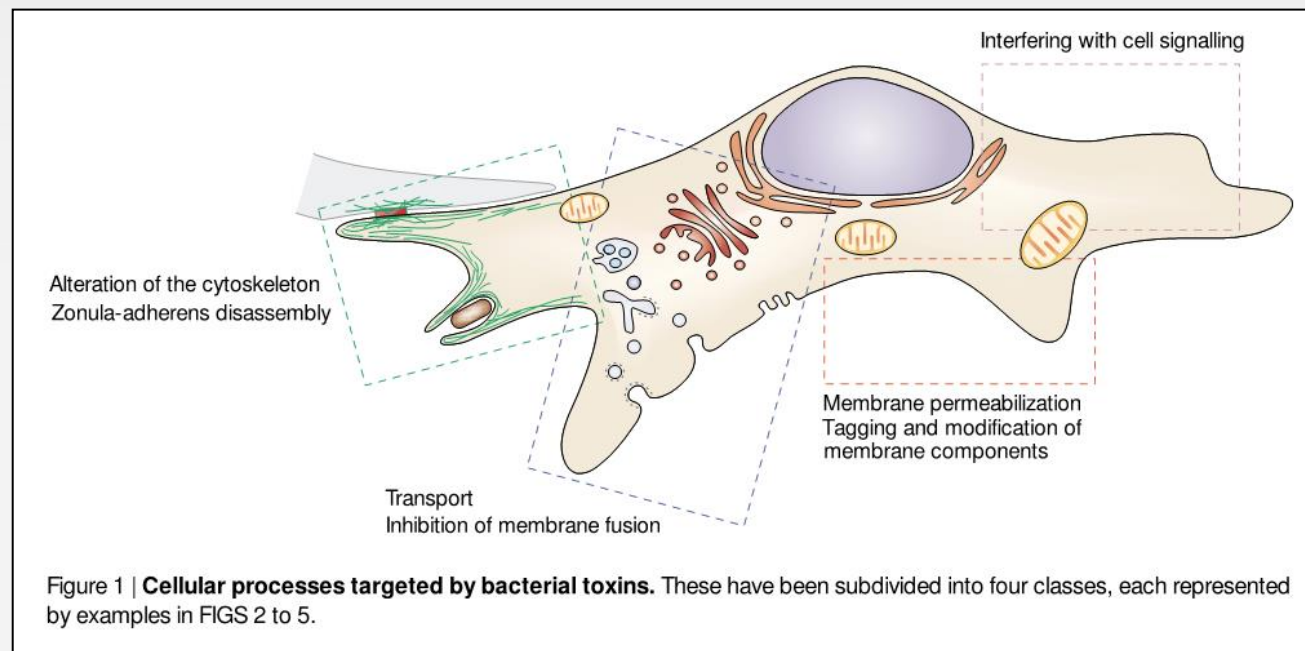


# Research On Toxic Substances

## THE BACTERIAL TOXIN TOOLKIT

*Giampietro Schiavo\* and F. Gisou van der Goot‡*

Pathogenic bacteria and higher eukaryotes have spent a long time together, leading to a precise understanding of one another's way of functioning. Through rapid evolution, bacteria have engineered increasingly sophisticated weapons to hit exactly where it hurts, interfering with fundamental host functions. However, toxins are not only useful to the bacteria — they have also become an essential asset for life scientists, who can now use them as toolkits to explore cellular processes.



*From: Nature Reviews, Molecular cell Biology, 2001, 531-537*





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## Can This Be Easily Discussed?





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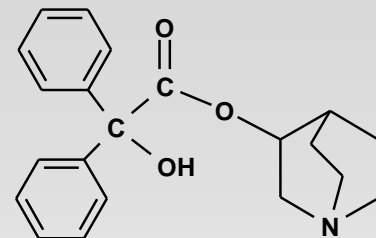
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# What Defines a Chemical?



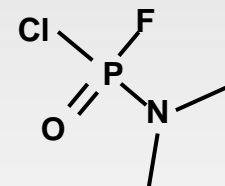
# Understanding Chemicals

- **> 140 Million CAS Numbers!**



- **How Many Possible Scheduled Chemicals?**

*Infinite number of possibilities!*  
*(generic structures in Schedule 1 and Schedule 2)*

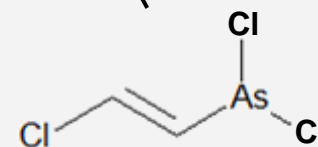
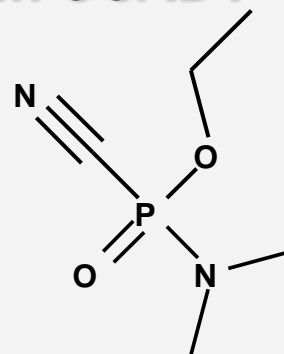
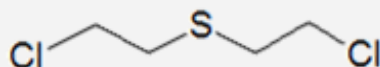
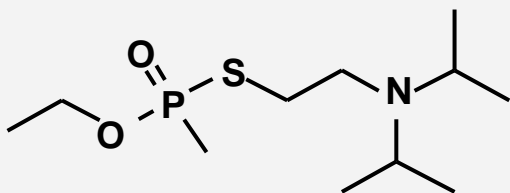
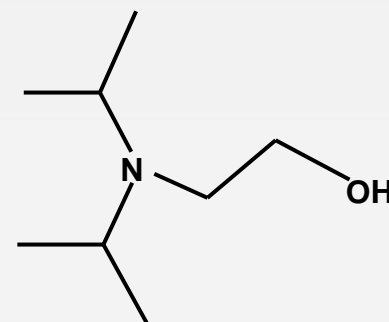
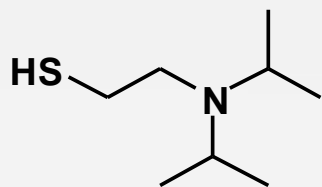


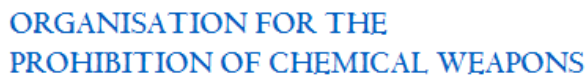
- **How Many Actual Scheduled Chemicals**

*~35,000 CAS Numbers Reported*

- **How Many Mass Spectra in OCAD?**

*~5,000*





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# Organic chemicals: A broad class of substances containing carbon

**PSF = Phosphorus, Sulfur, Fluorine**

# The Elements

# The Elements

PSF = Phosphorus, Sulfur, Fluorine

Photographs show samples of the pure or nearly pure element, as far as possible, under standard conditions. The elements are arranged in order of increasing atomic number. The elements are color-coded: Carbon (C) is green, Nitrogen (N) is blue, Oxygen (O) is light blue, Fluorine (F) is red, Phosphorus (P) is pink, Sulfur (S) is yellow, and Chlorine (Cl) is green.

Periodic table of elements showing atomic numbers, symbols, and names. The elements are arranged in rows and columns, with atomic numbers and symbols. The title 'The Elements' is at the top, and 'PSF = Phosphorus, Sulfur, Fluorine' is written in red above the table.

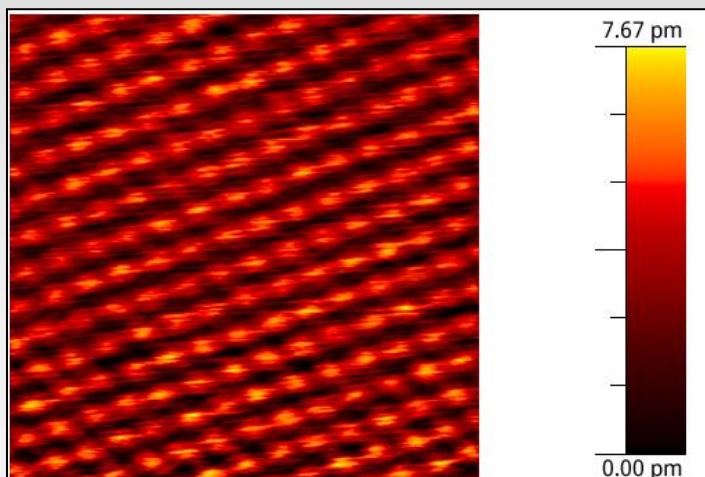




## From Atoms to Compounds

### ■ Atoms are the building blocks

**Silver (Ag)  
atoms in a  
crystal**



$$1 \text{ pm} = \frac{1 \text{ meter}}{1,000,000,000,000}$$

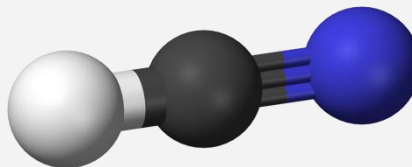
### ■ Atoms combine to form molecules

**HCN**

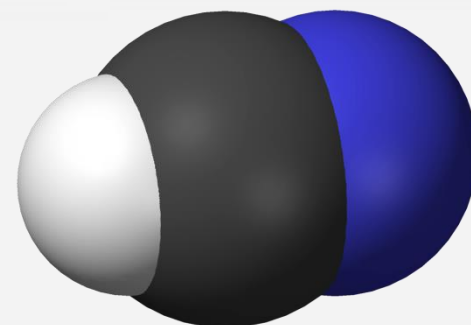
Hydrogen (H)

Carbon (C)

Nitrogen (N)



Depiction of how atoms are bonded to one another



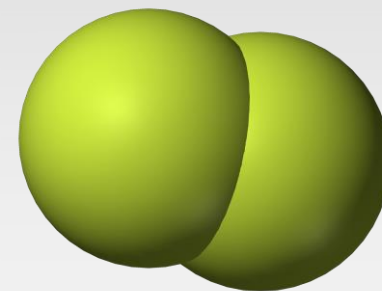
3D Representation showing  
relative sizes of atoms



## Some Definitions

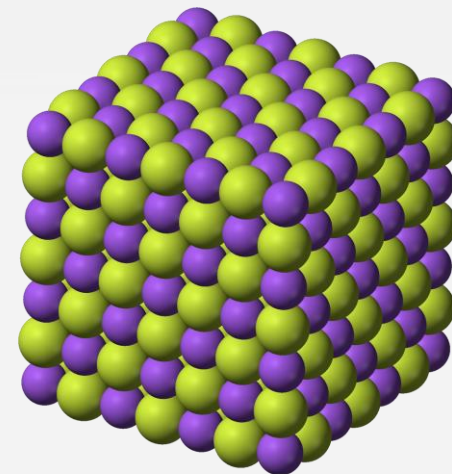
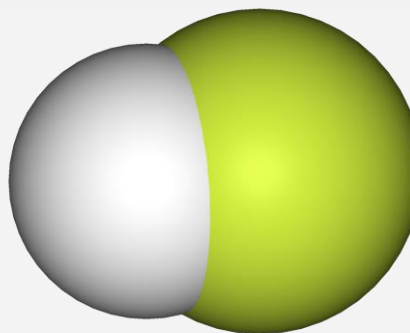
### ■ Elements can be described as atoms or molecules

- Fluorine atom (F)
- Fluorine molecule ( $F_2$ )



### ■ Compounds are composed of multiple elements

- Hydrogen fluoride (HF)
- Sodium fluoride (NaF)







# Scheduled Chemicals Span a Broad Range of Properties

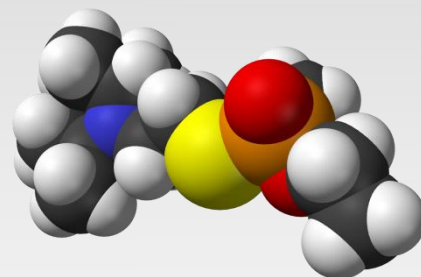
## O-ethyl-S-[2(diisopropylamino)ethyl] methylphosphonothiolate (VX)

43 atoms ( $C_{11}H_{26}NO_2PS$ )

Schedule 1

liquid

Molecular mass = 267



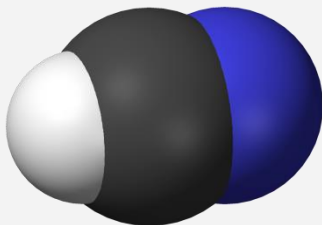
## Hydrogen Cyanide (HCN)

3 atoms

Schedule 3

Gas

Molecular mass = 27



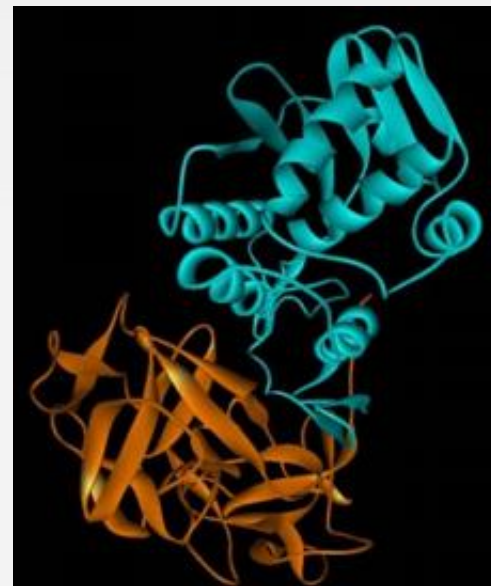
## Ricin

A sequence of  
> 520 amino acids

Schedule 1

Solid

Molecular mass ~62,000  
(~260X larger than VX)





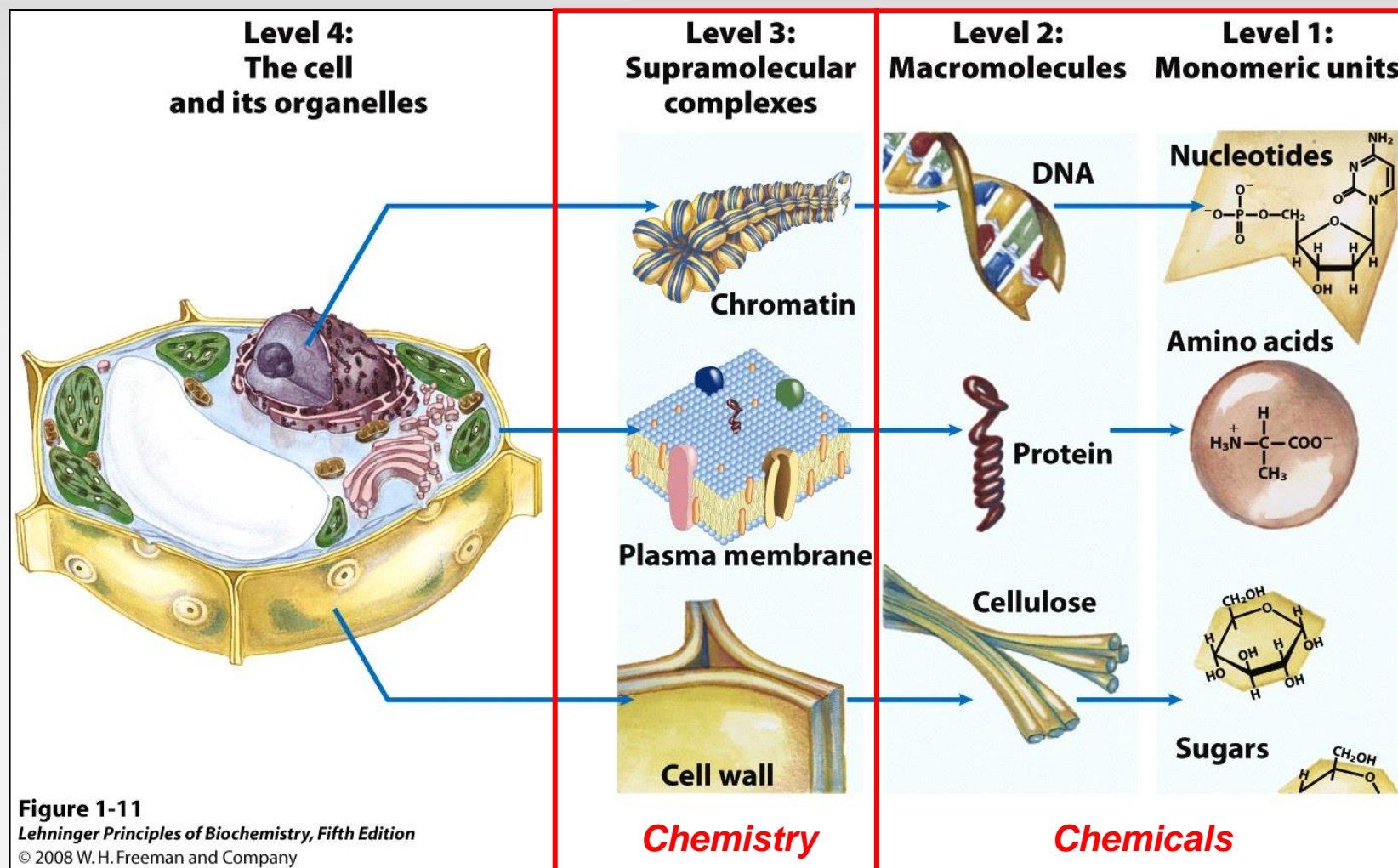
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# The Convergence of Chemistry and Biology

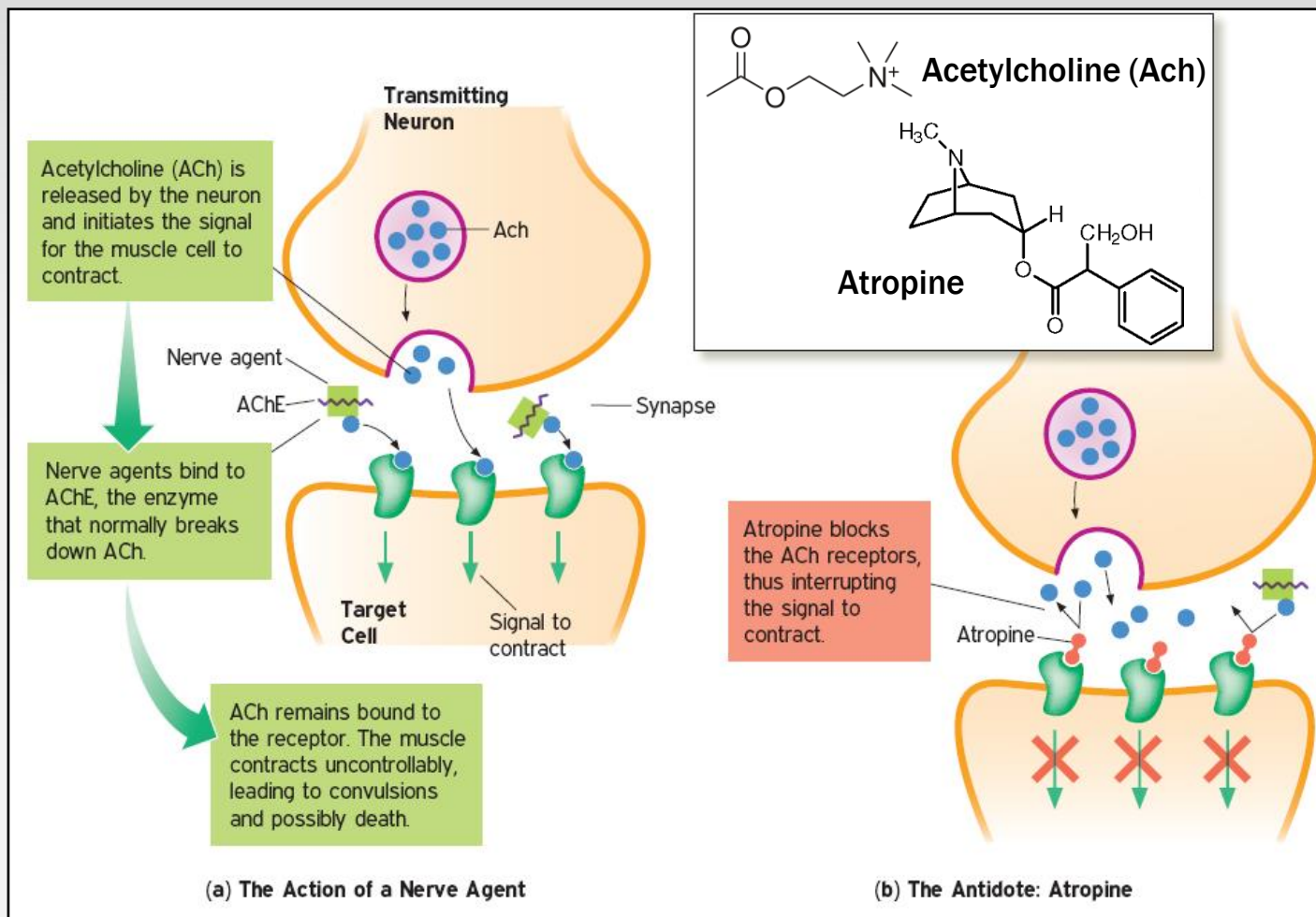


# Chemistry Underpins Biology





## Chemicals Influence Biology





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# Chemical Production





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# Chemistry is a Science of Change







## Technology is the Integration of functional components into Multifunctional Tools





# Production Technology: Production by Synthesis?

## Separation

From Petroleum



Distillation



Reactor



Raw  
Material  
(*Bulk  
Chemical*)



Pre-  
Process



Chemical Formation  
(Synthesis?)



Separate  
(Purify)



Product  
(*Bulk  
Chemical*)



From Biomass



Milling  
Mashing  
Digestion



and/or Fermentor



DOC



## Continuous Flow Technologies



**Microreactor**

**1 metric tonne ~700,000 days**



**Larger “Microreactor”**

**1 metric tonne ~1,070 days  
“number up” to increase throughput**







## Production Scale Continuous Flow System





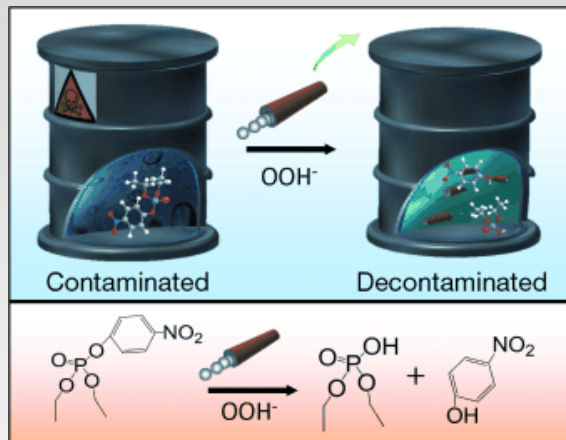
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# Scientific and Technological Development



## Basic Research vs. Fieldable Applications



***Clever ideas – but are they practical and effective?***

***~150,000/ml ~ 200 rpm mechanical stirring in 15 ml volume  
using  $\text{H}_2\text{O}_2$  as both fuel for stirrers and neutralization agent***

***Angewandte Chemie International Edition, 2013, 50, p13276***

**Portable systems adopted for use in 2013**







# How Do Ideas and Research Results Become Realities?





# Converging Science is the Norm, Not the Exception!



**Chemistry – Biology – Physics – Engineering – Informatics and More...**

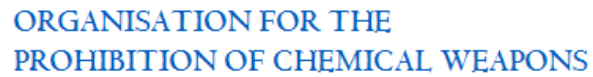


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# Deciphering Technical Reports





## What Does It Mean and How Applicable Is it?





## Scrutinising Technical Reports

- Differences and chance cause variation
- No measurement is exact
- Bias is rife
- Bigger is usually better for sample size
- Correlation does not imply causation
- Regression to the mean can mislead
- Extrapolating beyond the data is risky
- Beware the base-rate fallacy
- Controls are important
- Randomization avoids bias
- Seek replication, not pseudoreplication
- Scientists are human
- Significance is significant
- Separate no effect from non-significance
- Effect size matters
- Study relevance limits generalizations
- Feelings influence risk perception
- Dependencies change the risks
- Data can be dredged or cherry picked
- Extreme measurements may mislead

From: “Twenty tips for interpreting scientific claims”, *Nature*, 2013, 503,p337





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# The Scientific Advisory Board



■ 25 Members, nominated by States Parties and appointed by the DG



## SAB Terms of Reference

- **Independent Experts**
- **Assess developments** in science and technology
  - Emerging technologies
  - Methodologies for verification
- **Provide advice** on proposed changes to the Annex on **Chemicals**
- **Provide scientific and technological advice** relevant to the Convention, including in relation to co-operation and assistance



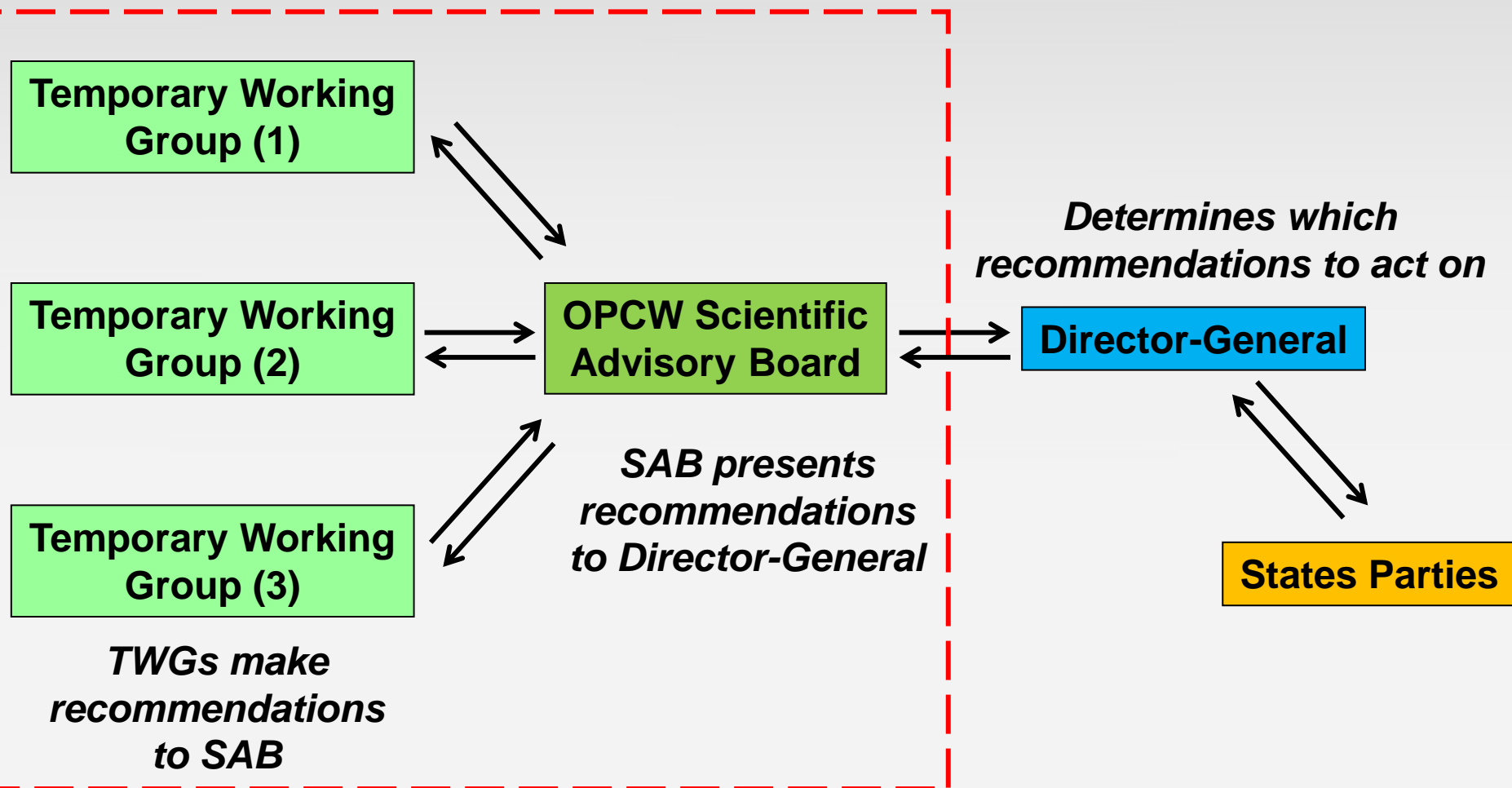
## SAB Temporary Working Groups (TWGs)

- Main work of the SAB is conducted by its working groups
- Chaired by a member of the SAB; additional experts appointed by the Director-General
- TWG recommendations considered by SAB and submitted to the Director-General
- Current TWGs:
  - **Verification**
  - **Education and outreach** – TOR ends in 2014
  - **Convergence** of chemistry and biology – TOR ended in 2013



# Mechanism for Bringing SAB Recommendations Forward

***Recommendations are made independent of  
the OPCW Technical Secretariat***





## **SAB Recommendations**

- **SAB Report on Developments in S&T to The Third review Conference**

RC-3/DG.1, Dated 29 October 2012

[www.opcw.org/index.php?eID=dam\\_frontend\\_push&docID=15865](http://www.opcw.org/index.php?eID=dam_frontend_push&docID=15865)

- **Director General's Recommendations**

RC-3/DG.2, Dated 31 January 2013

[www.opcw.org/index.php?eID=dam\\_frontend\\_push&docID=16090](http://www.opcw.org/index.php?eID=dam_frontend_push&docID=16090)

EC=77/DG.11, Dated 5 September 2014

[www.opcw.org/index.php?eID=dam\\_frontend\\_push&docID=16090](http://www.opcw.org/index.php?eID=dam_frontend_push&docID=16090)

- **Report of the TWG on the Convergence of Chemistry and Biology**

SAB/REP/1/14, Dated 26 June 2014

[www.opcw.org/index.php?eID=dam\\_frontend\\_push&docID=17438](http://www.opcw.org/index.php?eID=dam_frontend_push&docID=17438)

- **Director General's Response to Report of SAB-21**

Includes recommendations from Convergence report

EC-77/DG.10, Dated 5 September 2014

[www.opcw.org/index.php?eID=dam\\_frontend\\_push&docID=17603](http://www.opcw.org/index.php?eID=dam_frontend_push&docID=17603)





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# Keeping Abreast of S&T Developments

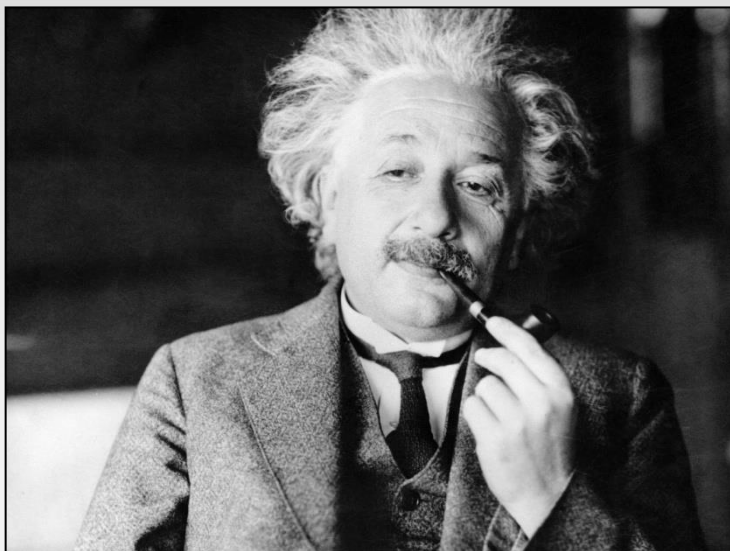


## On Going Activities

- **Follow-up activities to SAB Recommendations**
- **The Secretariat and the SAB continue to augment the capacity to monitor relevant developments in S&T**
  - Reviewing scientific literature
  - Engaging with national and international scientific societies and relevant international organisations
  - Developments in S&T Report for RC-4



## The Nuances of Science Advice for Policy



### Scientists

Ask Questions

Analyze Data

Uncertainty

Create Solutions



### Policy Makers

Seek Answers

Present Conclusions

Certainty

Find Solutions



## **Science advice is most effective when...**

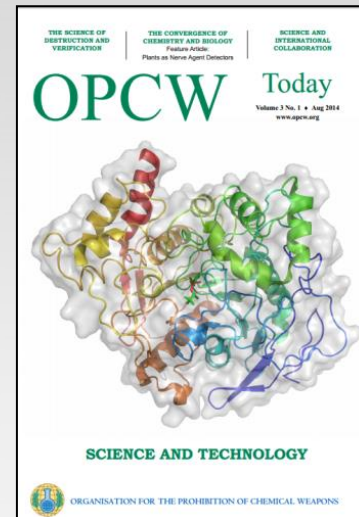
- Questions are clearly phrased and strictly related to S&T
- Technical considerations and are not politicized
- All relevant information (from all sources) is considered
- Sufficient funding is available
  - General Budget
  - Voluntary contributions (Trust Fund)
  - EU Joint Action/Council Decision



# Stimulating Greater Engagement with States Parties

## ■ August Issue of *OPCW Today*

- Special issue on S&T



## ■ “Science and Technology for Diplomats”

- Next discussion 10 October 2014, 13:30 in the Ooms Room
  - Biomedical sample analysis
  - Previous topics: introduction and chemical analysis
- On-going series of events on relevant S&T topics
  - Videos of presentations forthcoming
  - December event at CSP-19, convergence themed





## Links to SAB Reports and S&T Relevant Information

- Report of the SAB and TWGs

[www.opcw.org/about-opcw/subsidiary-bodies/scientific-advisory-board/documents/reports/](http://www.opcw.org/about-opcw/subsidiary-bodies/scientific-advisory-board/documents/reports/)

- SAB Related Documents

[www.opcw.org/about-opcw/subsidiary-bodies/scientific-advisory-board/documents/related-documents/](http://www.opcw.org/about-opcw/subsidiary-bodies/scientific-advisory-board/documents/related-documents/)

- OPCW Reading Section – often features S&T related content

[www.opcw.org/our-work/readings/](http://www.opcw.org/our-work/readings/)



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# Summary and Future Discussion



## **From The Director General's Recommendations to RC-3** **(RC-3/DG.2, Dated 31 January 2013)**

- **Monitoring S&T Developments (paras 7, 8, 29, 37)**
- **Verification (paras 12, 13, 14, 17, 18, 20, 21, 22)**
  - Includes recommendations on Transfer Notifications (para 11) and
  - Incapacitating Agents (paras 15, 16)
- **Laboratory Capabilities and Analysis (paras 24, 25, 26, 30, 32)**
- **Expertise, Training and Knowledge (paras 34, 36, 37)**
- **Assistance and Protection (para 35)**
- **Education and Outreach (para 28)**