Science for Diplomats

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

26 June 2014

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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

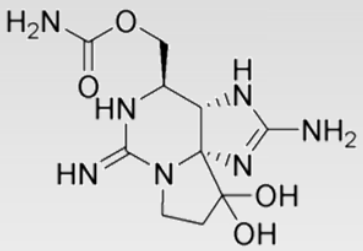
- "**Conviction** that the provisions of the Convention are mutually reinforcing and that the full, effective, and non-discriminatory implementation of all of its provisions, taking into account relevant developments in science, technology and industry, is of critical importance;"

  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;"

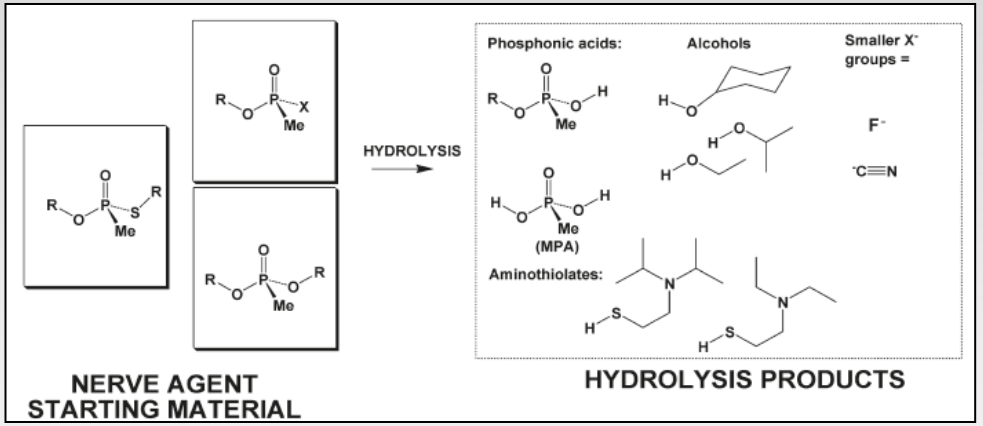
  RC-3/3, paragraph 9.9*

Science and Technology Underpin the CWC



Article II

Article III

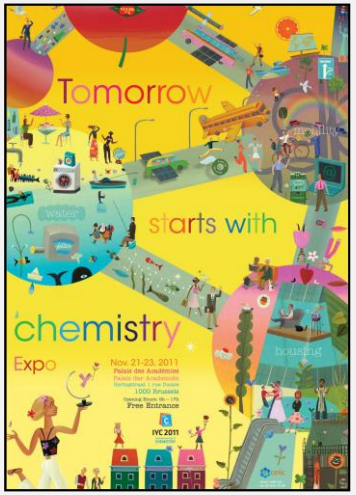


Articles IV and V

Article VI

Article VIII

Articles IX and X



Article XI

Article VII

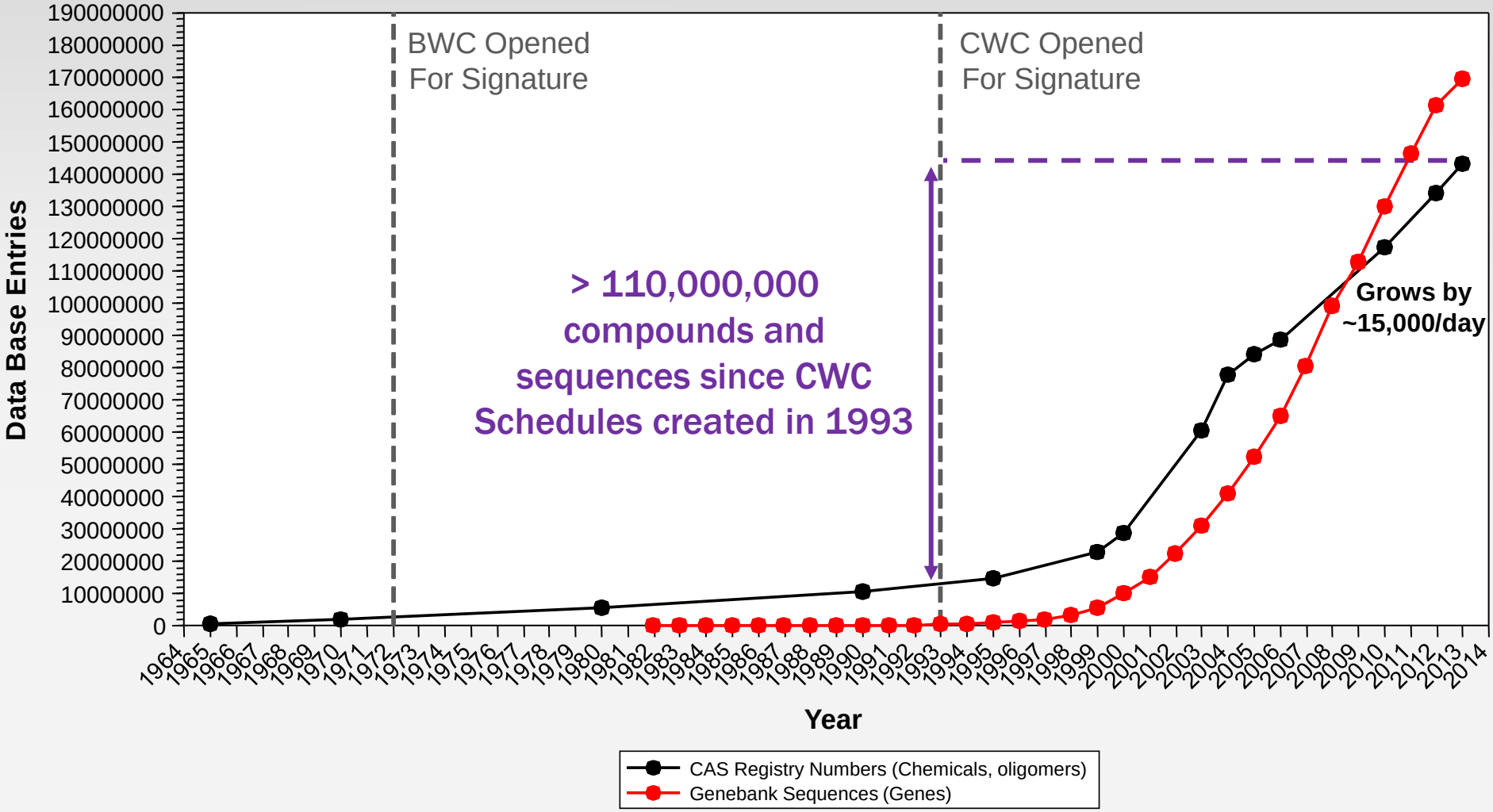
SAB Report of the Developments in S&T to The Third review Conference

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

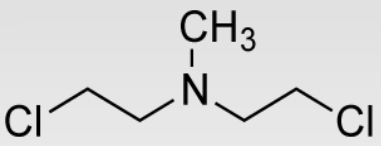
Director General's Recommendations

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

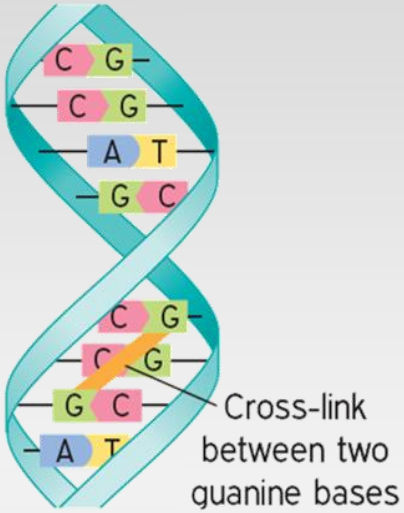
Monitoring Science



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.

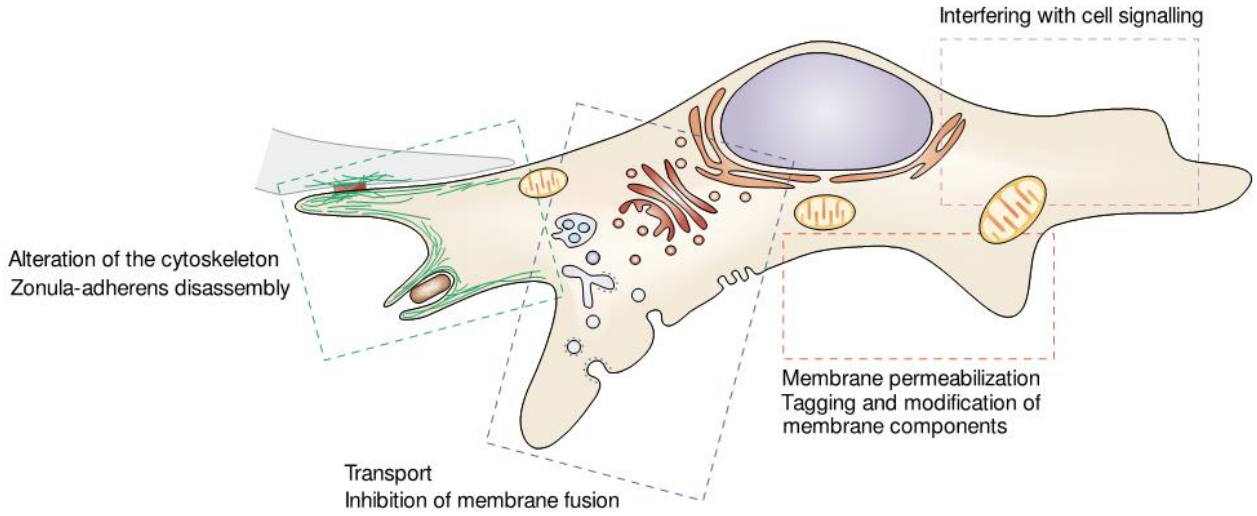


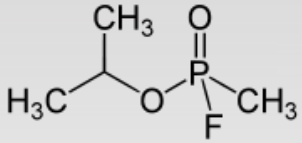
Figure 1 | **Cellular processes targeted by bacterial toxins.** These have been subdivided into four classes, each represented by examples in FIGS 2 to 5.

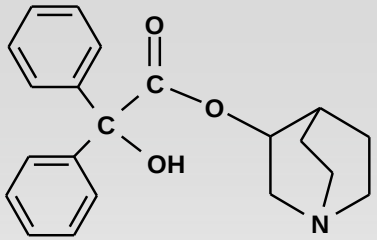
From: Nature Reviews, Molecular cell Biology, 2001, 531-537

Can This Be Easily Discussed?

What Defines a Chemical?

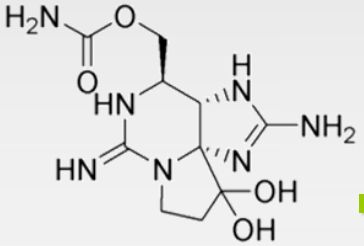
Understanding Chemicals



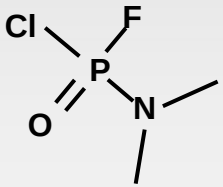


- **> 140 Million CAS Numbers!**

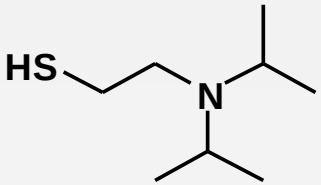
- **How Many Possible Scheduled Chemicals?**



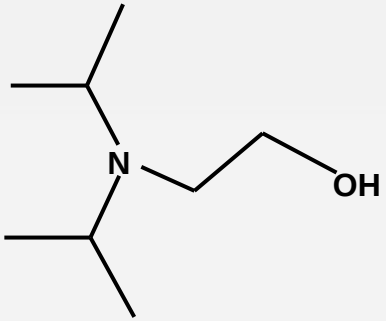
Infinite number of possibilities!
(generic structures in Schedule 1 and Schedule 2)



- **How Many Actual Scheduled Chemicals**

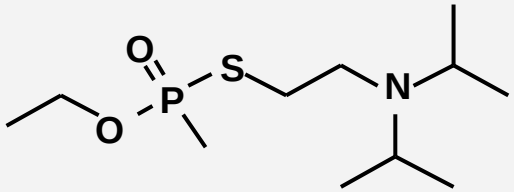


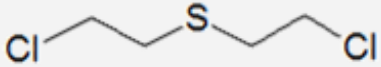
~35,000 CAS Numbers Reported

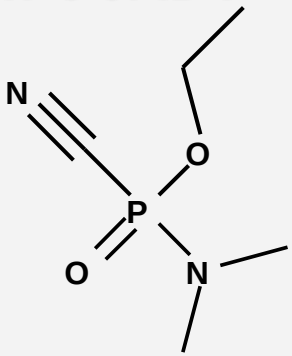


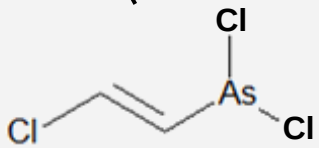
- **How Many Mass Spectra in OCAD?**

~5,000



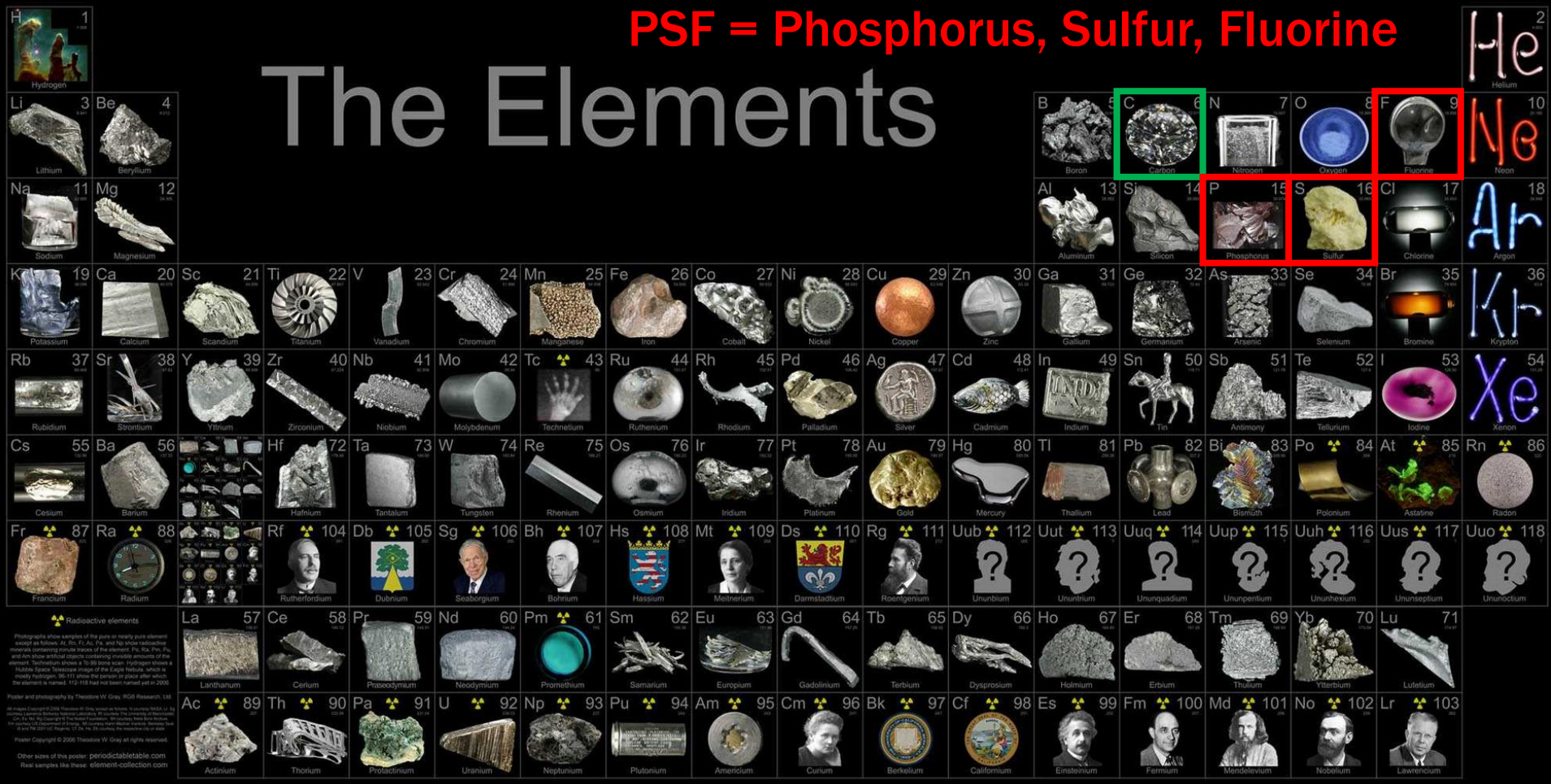






Organic chemicals: A broad class of substances containing carbon

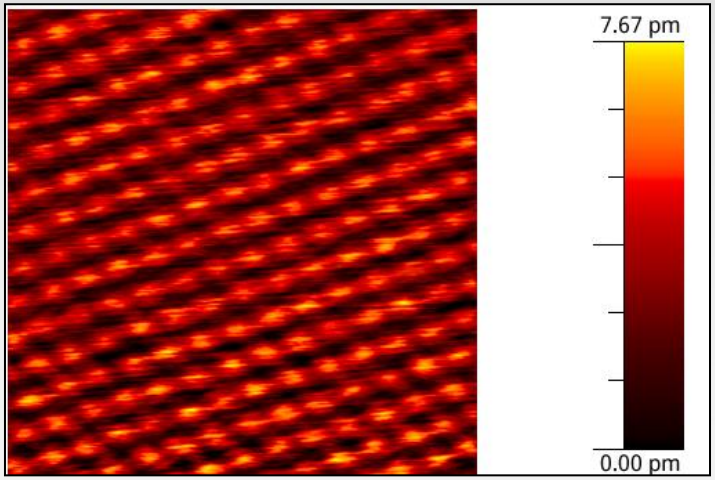
PSF = Phosphorus, Sulfur, Fluorine



From Atoms to Compounds

- **Atoms are the building blocks**

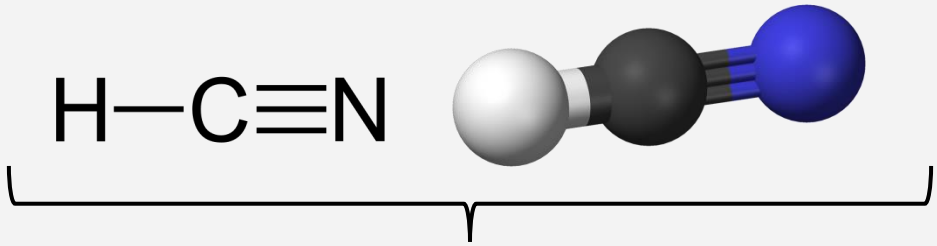
Silver (Ag) atoms in a crystal



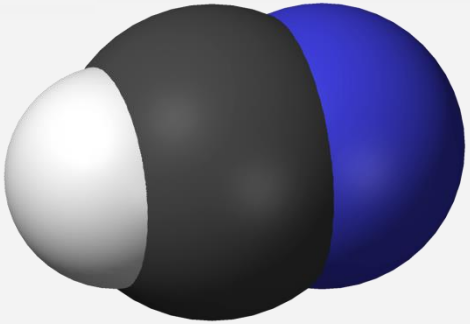
$$1\ \text{pm} = \frac{1\ \text{meter}}{1{,}000{,}000{,}000{,}000}$$

- **Atoms combine to form molecules**

HCN
Hydrogen (H)
Carbon (C)
Nitrogen (N)



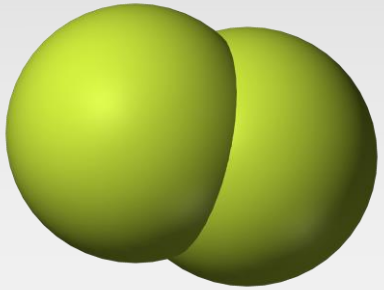
Depiction of how atoms are bonded to one another



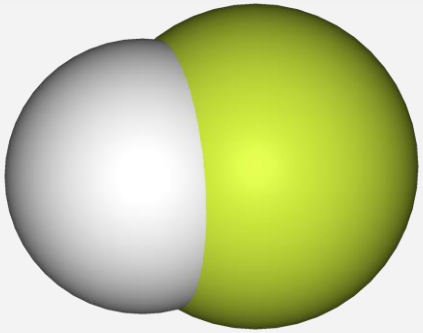
3D Representation showing relative sizes of atoms

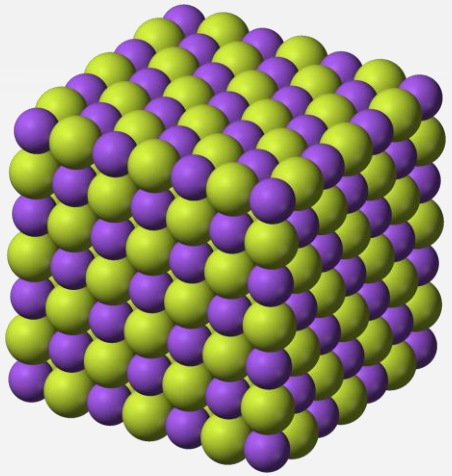
Some Definitions

- **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)

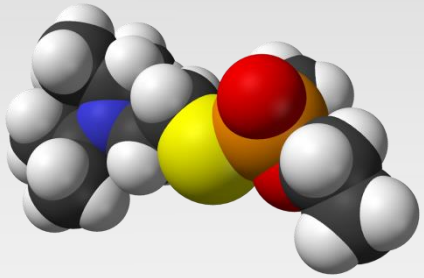




Scheduled Chemicals Span a Broad Range of Properties

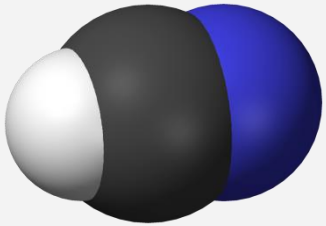
<u>*O*-ethyl-*S*-[2(diisopropylamino)ethyl] methylphosphonothiolate (VX)</u>

43 atoms ($C_{11}H_{26}NO_2PS$)
Schedule 1
liquid
Molecular mass = 267



<u>Hydrogen Cyanide (HCN)</u>

3 atoms
Schedule 3
Gas
Molecular mass = 27



<u>Ricin</u>

A sequence of
> 520 amino acids
Schedule 1
Solid
Molecular mass ~62,000
(~260X larger than VX)

The Convergence of Chemistry and Biology

Chemistry Underpins Biology

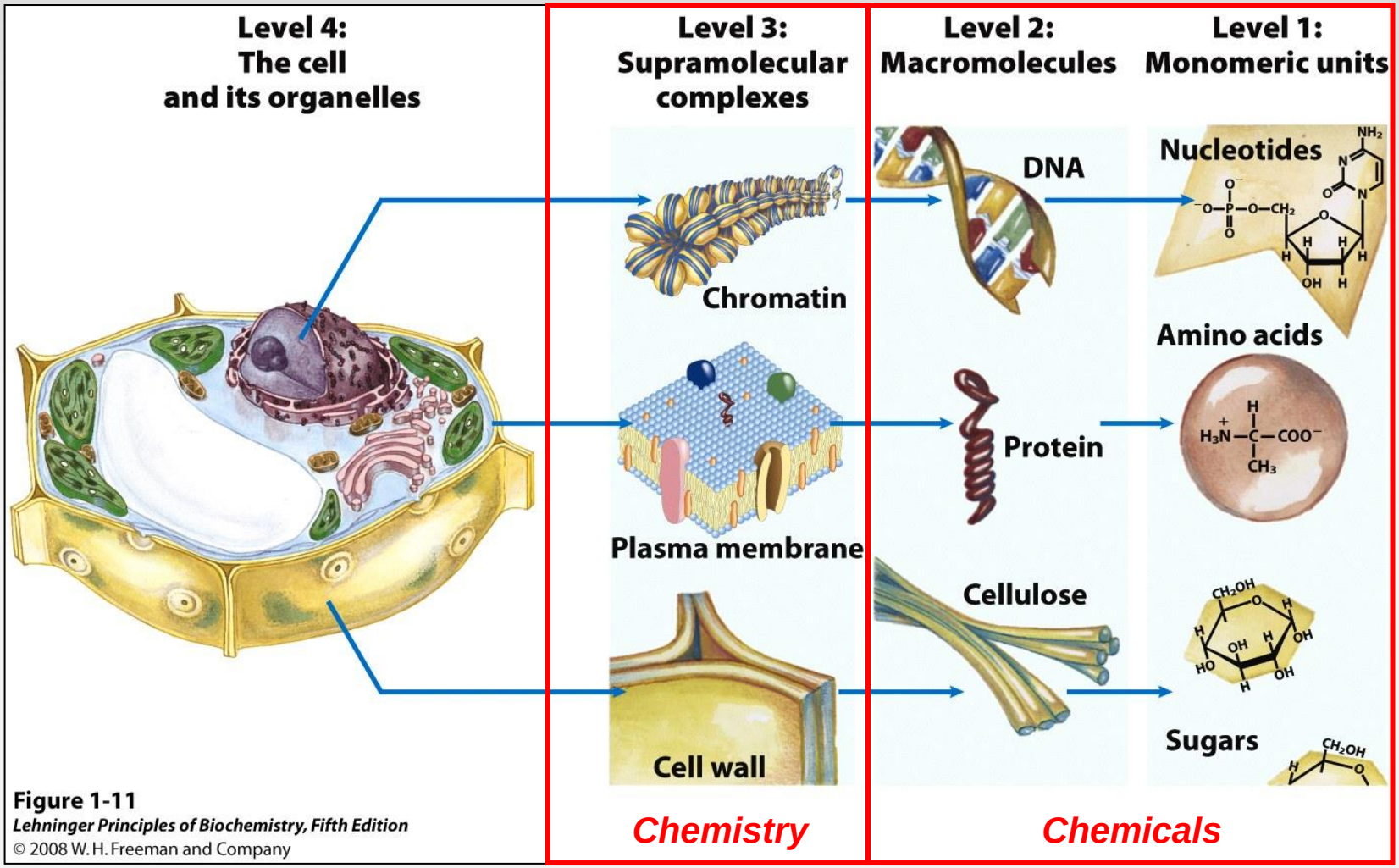
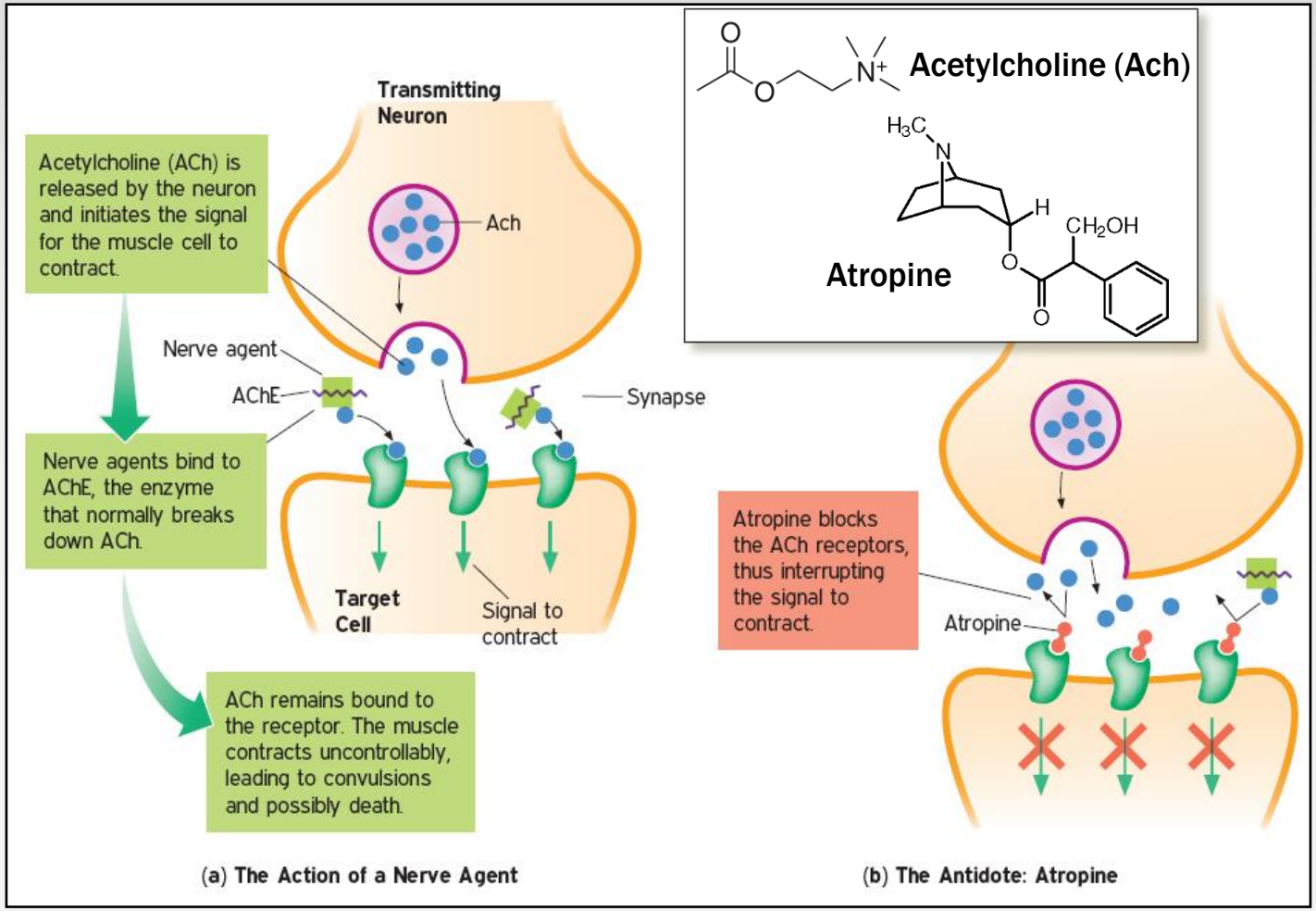


Figure 1-11
Lehninger Principles of Biochemistry, Fifth Edition

Chemicals Influence Biology



Chemical Production

Chemistry is a Science of Change

Technology is the Integration of functional components into Multifunctional Tools

Production Technology: Production by Synthesis?

From Petroleum

Distillation

Reactor

Separation

Raw Material *(Bulk Chemical)*

Pre-Process

Chemical Formation (Synthesis?)

Separate (Purify)

Product *(Bulk Chemical)*

From Biomass

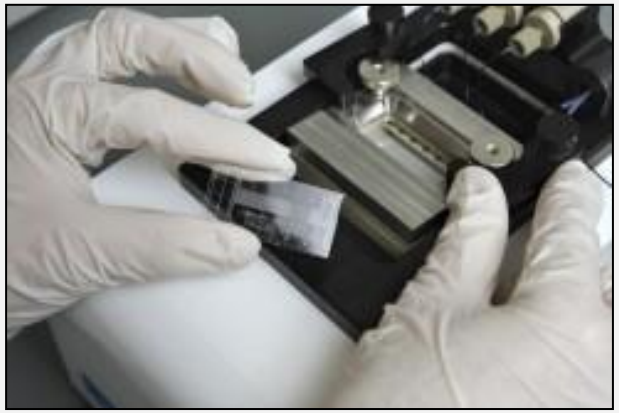
Milling Mashing Digestion

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

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 H_2O_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…

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

The Scientific Advisory Board

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

SAB Terms of Reference

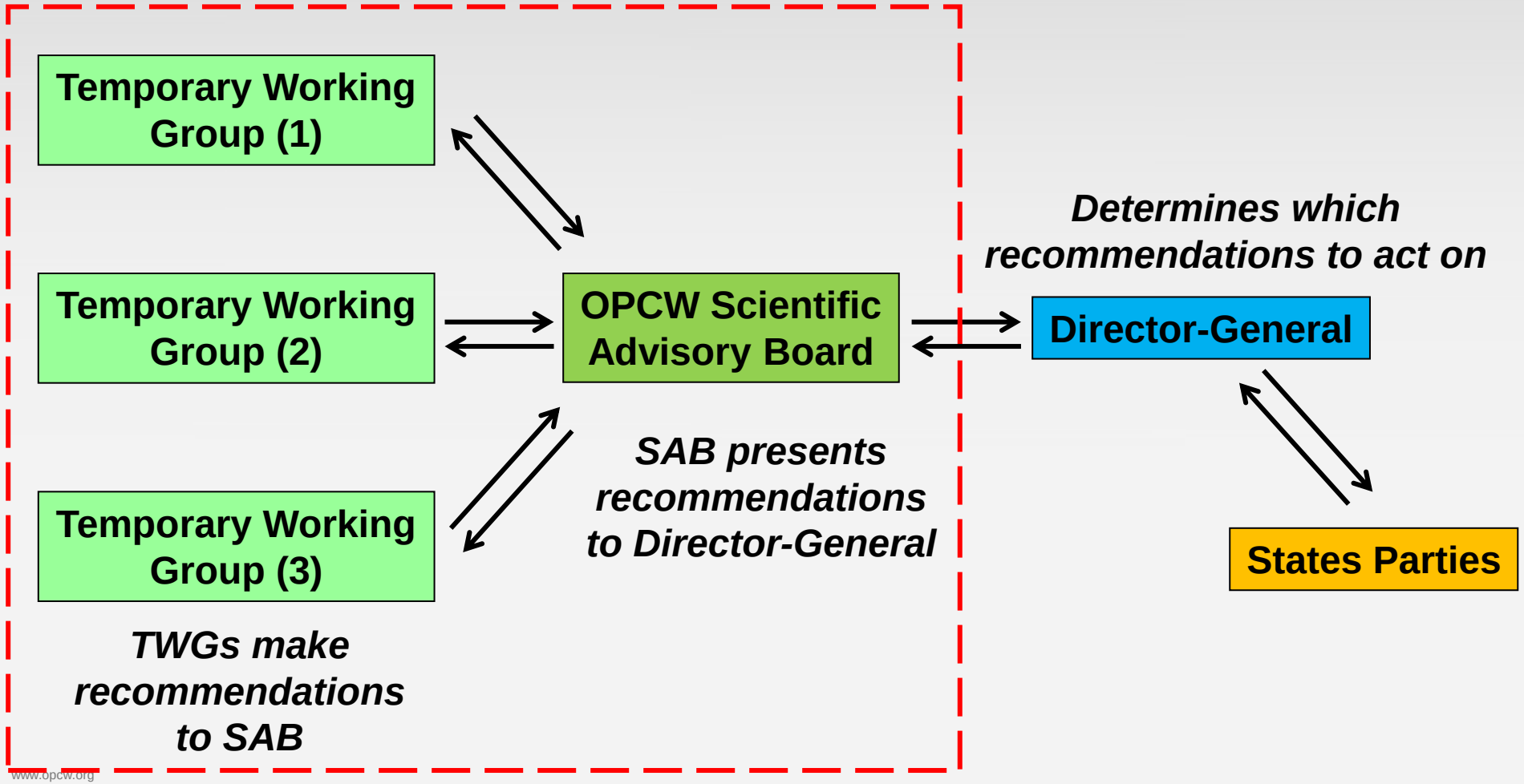
- **Independent Experts**
- **Assess developments** in science and technology
  - Emerging technologies
  - Methodologies for verification
- **Provide advice** on proposed changes to the Annex on **Chemicals**
- **Provide scientific and technological advice** relevant to the Convention, including in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

- **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

- **Director General's Recommendations**

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

- **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

- **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

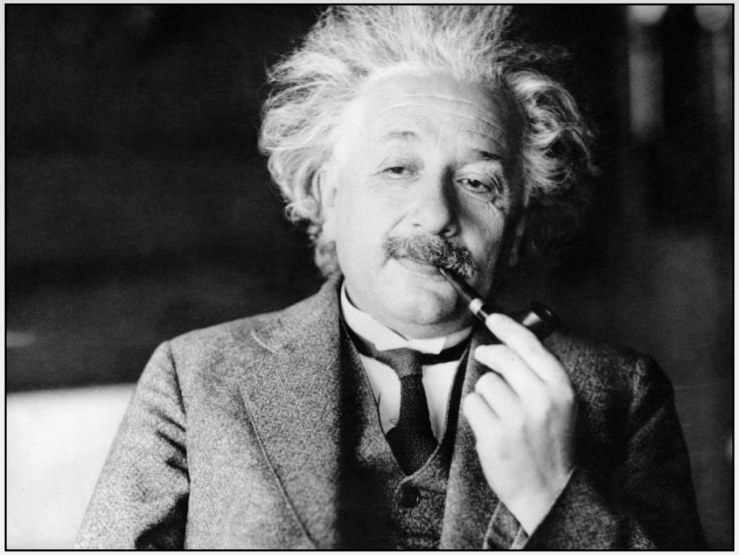
Keeping Abreast of S&T Developments

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	**Policy Makers**
Ask Questions	Seek Answers
Analyze Data	Present Conclusions
Uncertainty	Certainty
Create Solutions	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/

- SAB Related Documents

  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/

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)