OPCW

Science For Diplomats

at EC-91

Starring the
OPCW Laboratory

Illuminating Chemical Reactivity

Tuesday 9 July 2019
13:30 – 14:45
Ooms Room
(Light lunch available at 13:00)

...an event guaranteed to brighten up your day!

OPCW

Organisation for the Prohibition of Chemical Weapons

Illuminating Chemical Reactivity

an event guaranteed to brighten up your day…

Science for Diplomats at EC-91
The Hague, 9 July 2019

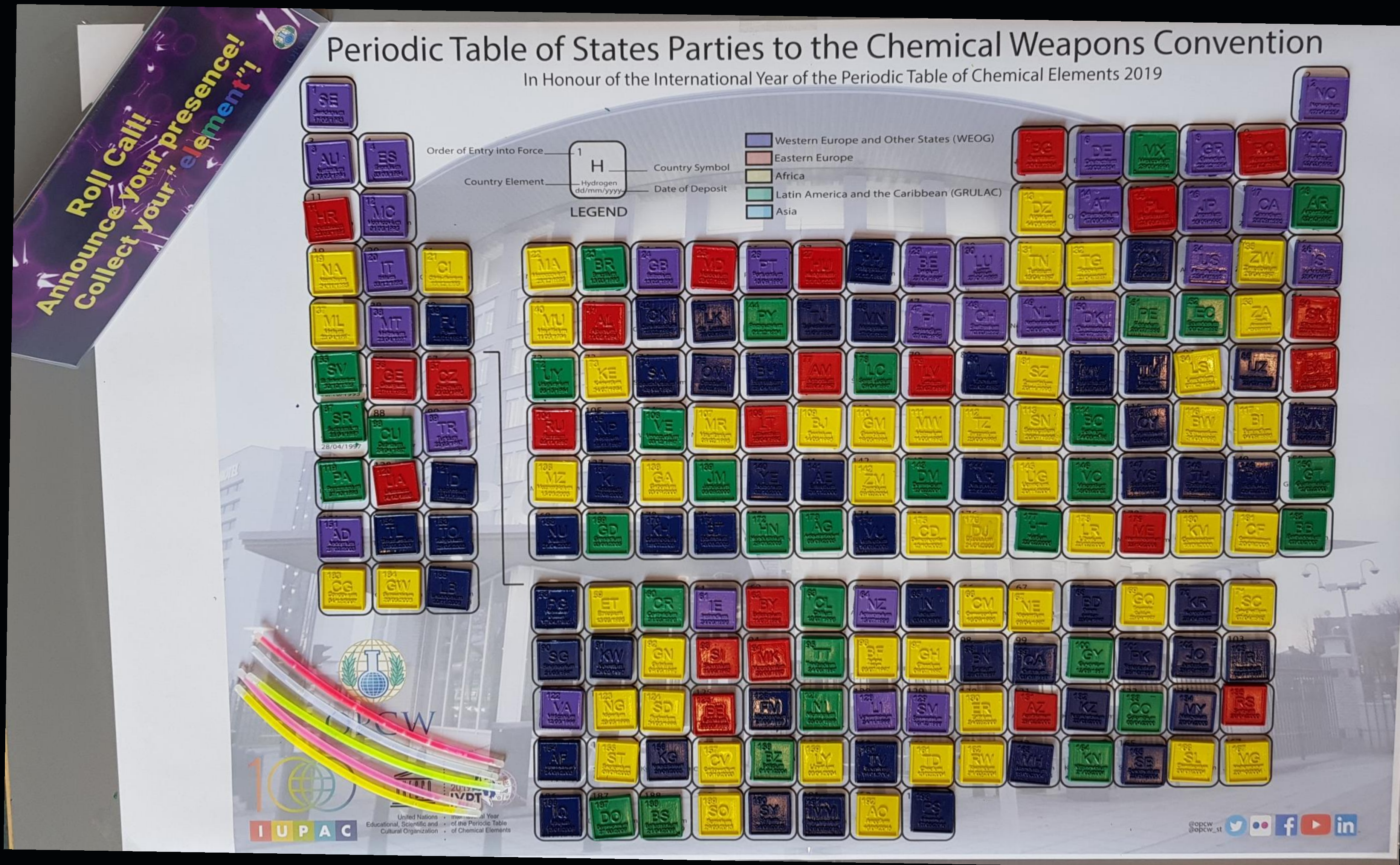
Starring

Dr Marc-Michael Blum, Head OPCW Laboratory

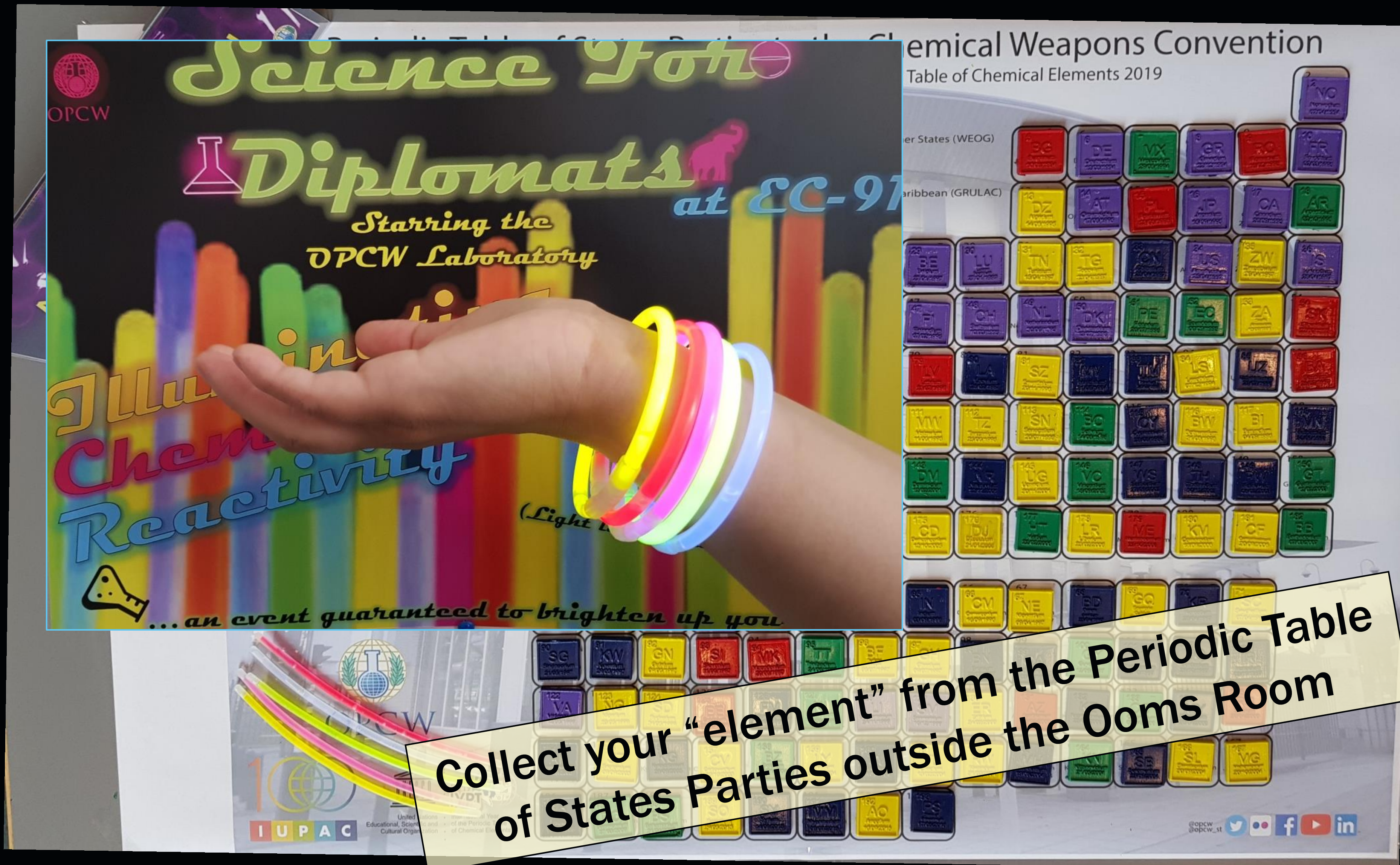
With supporting cast

Mr Cheng Tang (SAB Chair), Mr Lucas Benderitter (OSP), Mr Peter Brud (OSP), Dr Jonathan E. Forman (Science Policy Adviser and SAB Secretary), Ms Giovanna Pontes (OSP), Ms Ayah Wafi (OSP) and special guest Ms Andrea Dymytrova

Let us Know You are Here!

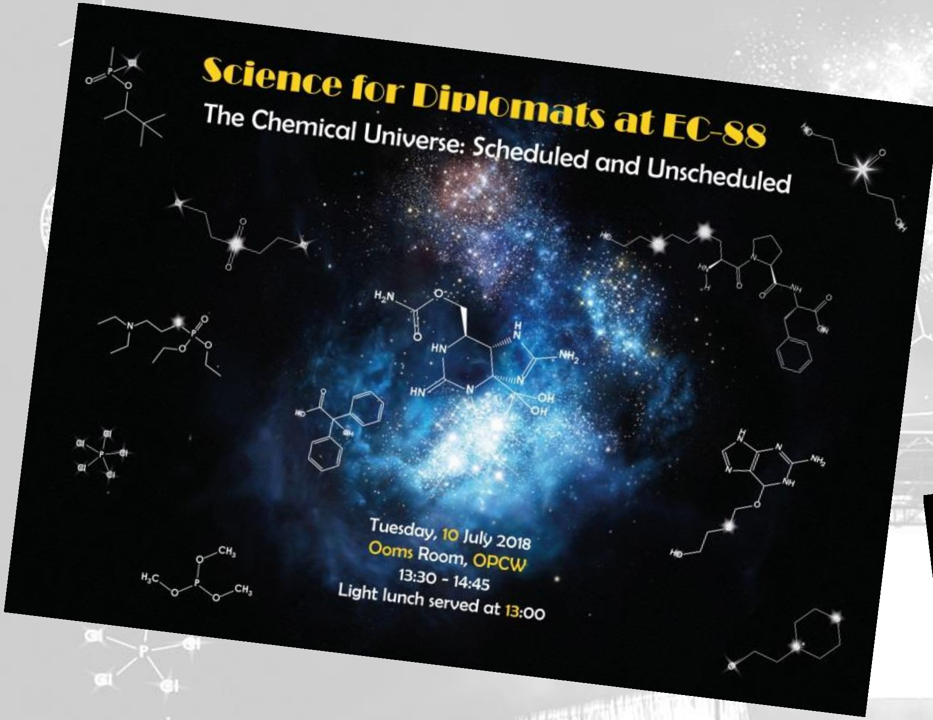


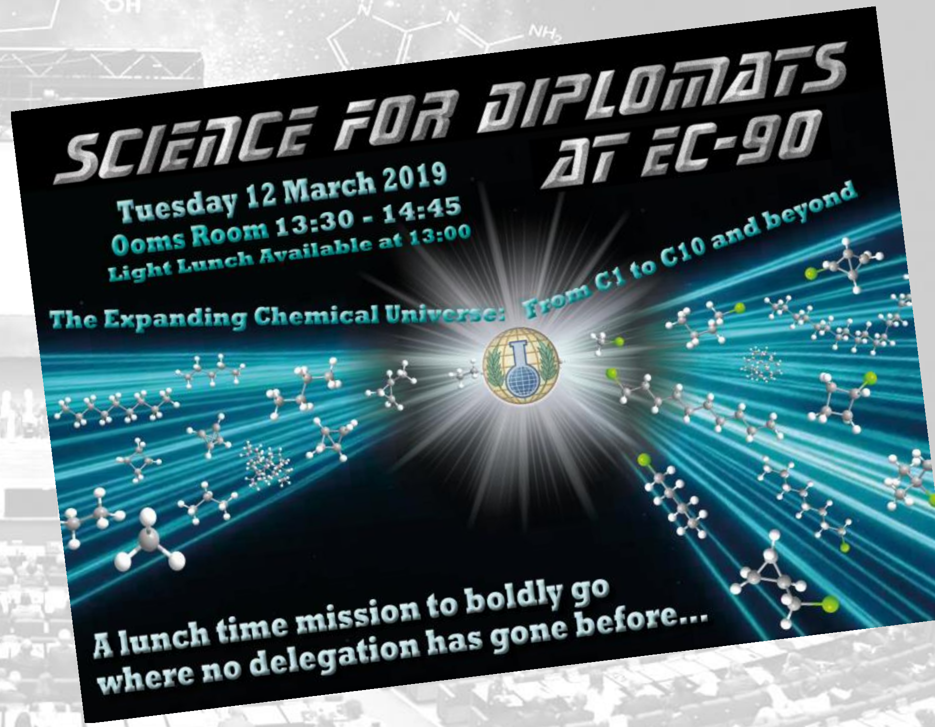
Let us Know You are Here!



Collect your "element" from the Periodic Table of States Parties outside the Ooms Room

Chemistry Lessons





Scheduled Chemicals under the Chemical Weapons Convention (CWC)

Schedule 1

Guidelines for Schedule 1

The following criteria shall be taken into account in considering whether a toxic chemical or precursor should be included in Schedule 1:

(a) It has been developed, produced, stockpiled or used as a chemical weapon as defined in Article II;

(b) It poses otherwise a high risk to the object and purpose of this Convention by virtue of its high potential for use in activities prohibited under this Convention because one or more of the following conditions are met:

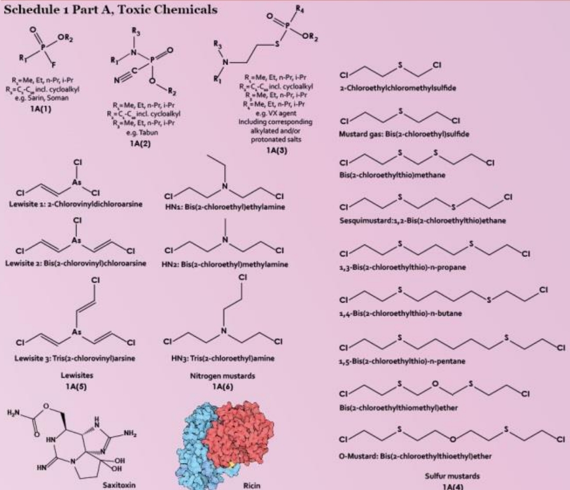
(i) It possesses a chemical structure closely related to that of other toxic chemicals listed in Schedule 1, and has, or can be expected to have, comparableproperties;

(ii) It possesses such lethal or incapacitating toxicity as well as other properties that would enable it to be used as a chemical weapon;

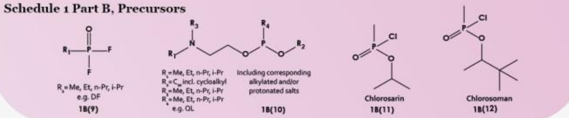
(iii) It may be used as a precursor in the final single technological stage of production of a toxic chemical listed in Schedule 1, regardless of whether this stage takes place in facilities, in munitions or elsewhere;

(c) It has little or no use for purposes not prohibited under this Convention.

Schedule 1 Part A, Toxic Chemicals



Schedule 1 Part B, Precursors



Schedule 2

Guidelines for Schedule 2

The following criteria shall be taken into account in considering whether a toxic chemical not listed in Schedule 1 or a precursor to a Schedule 1 chemical or to a chemical listed in Schedule 2, part A, should be included in Schedule 2:

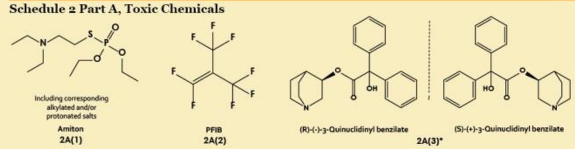
(a) It poses a significant risk to the object and purpose of this Convention because it possesses such lethal or incapacitating toxicity as well as other properties that could enable it to be used as a chemical weapon;

(b) It may be used as a precursor in one of the chemical reactions at the final stage of formation of a chemical listed in Schedule 1 or Schedule 2, part A;

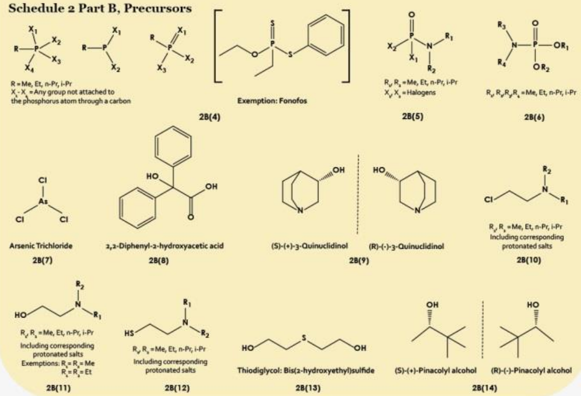
(c) It poses a significant risk to the object and purpose of this Convention by virtue of its importance in the production of a chemical listed in Schedule 1 or Schedule 2, part A;

(d) It is not produced in large commercial quantities for purposes not prohibited under this Convention.

Schedule 2 Part A, Toxic Chemicals



Schedule 2 Part B, Precursors



Schedule 3

Guidelines for Schedule 3

The following criteria shall be taken into account in considering whether a toxic chemical or precursor, not listed in other Schedules, should be included in Schedule 3:

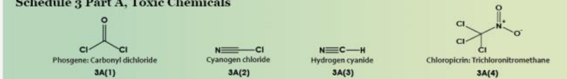
(a) It has been produced, stockpiled or used as a chemical weapon;

(b) It poses otherwise a risk to the object and purpose of this Convention because it possesses such lethal or incapacitating toxicity as well as other properties that might enable it to be used as a chemical weapon;

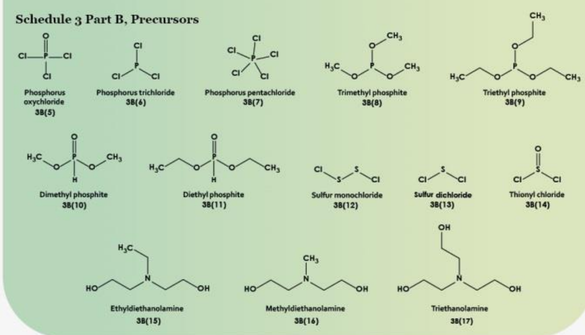
(c) It poses a risk to the object and purpose of this Convention by virtue of its importance in the production of one or more chemicals listed in Schedule 1 or Schedule 2, part B;

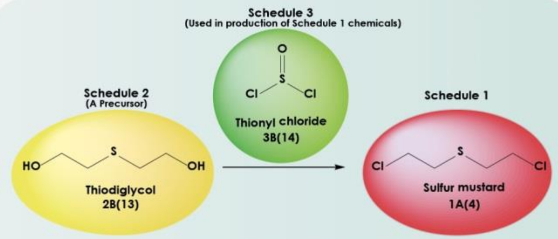
(d) It may be produced in large commercial quantities for purposes not prohibited under this Convention.

Schedule 3 Part A, Toxic Chemicals

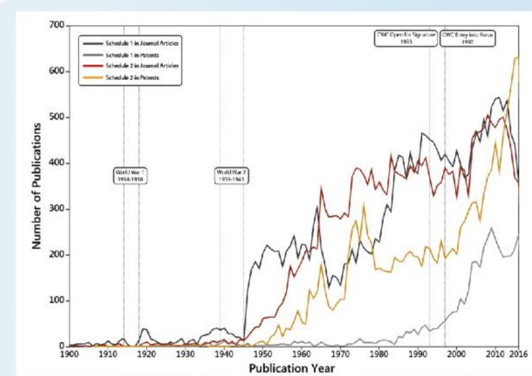


Schedule 3 Part B, Precursors





Relationship between Schedules, illustrated with sulfur mustard.



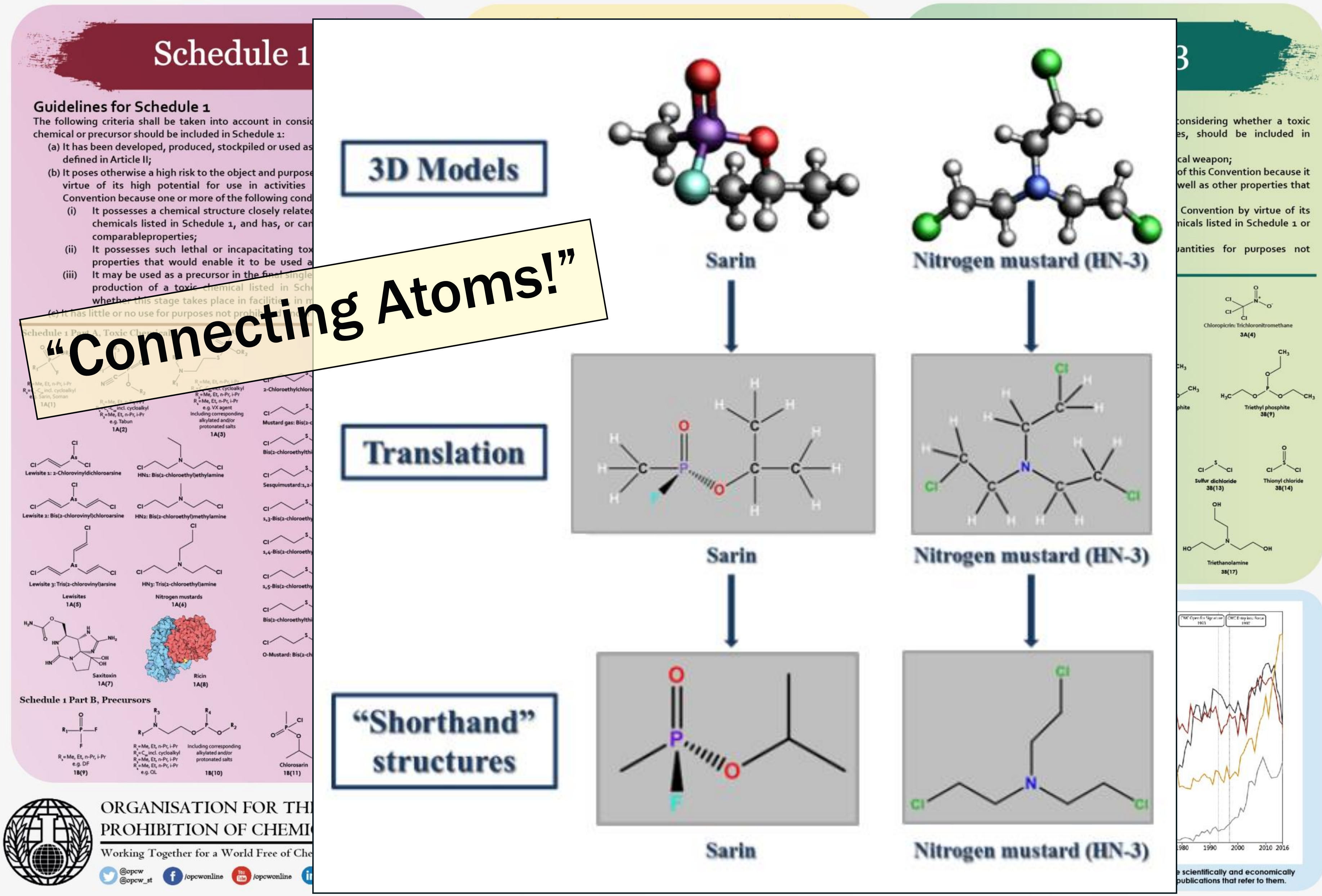
Scheduled chemicals, including those in schedules 1 and 2, can have scientifically and economically important uses. This chart captures the number of yearly scientific publications that refer to them.

ORGANISATION FOR THE PROHIBITION OF CHEMICAL WEAPONS

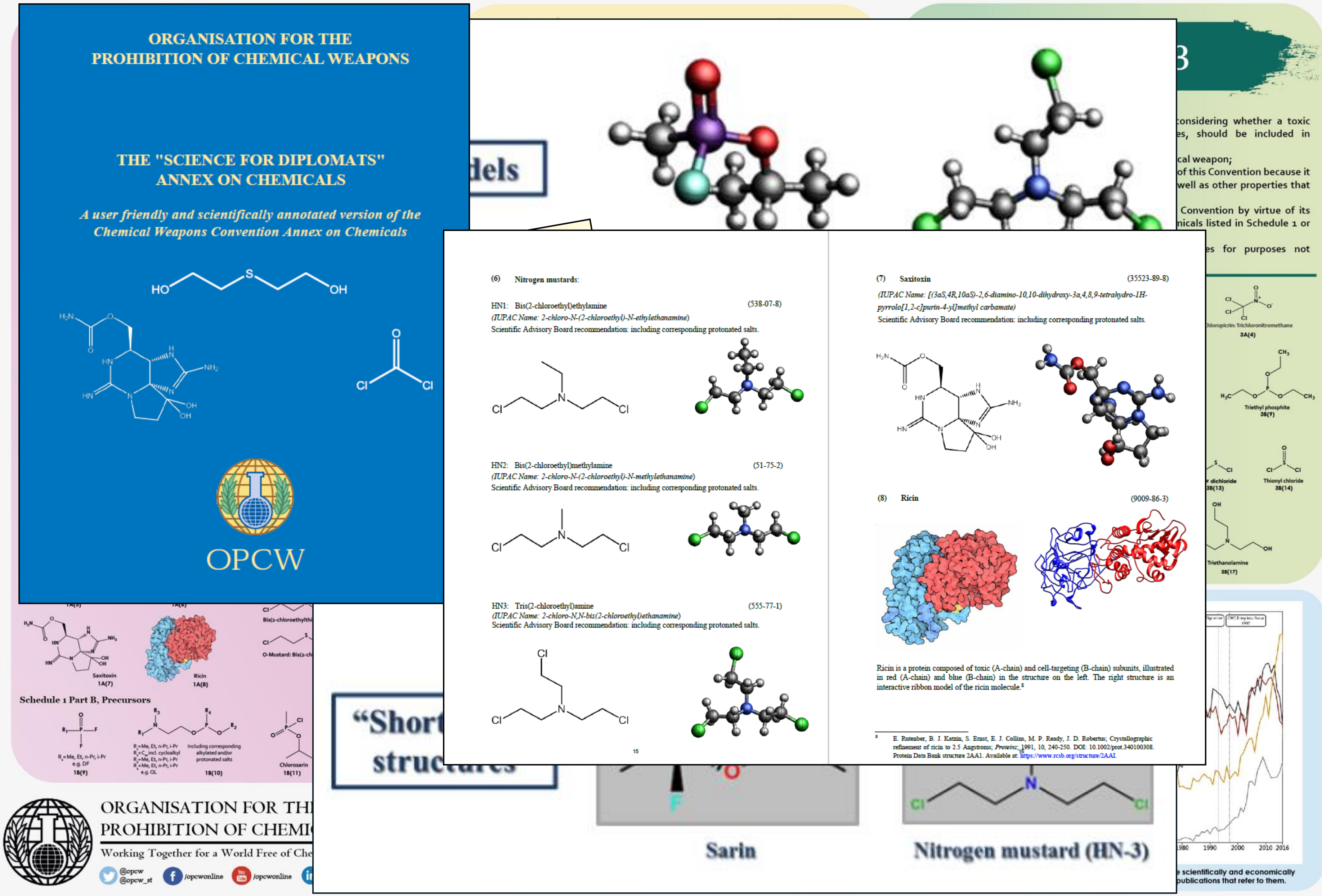
Working Together for a World Free of Chemical Weapons

@opcw @opcw_st /opcwonline /opcwonline /company/opcw /opcw

Scheduled Chemicals under the Chemical Weapons Convention (CWC)



Scheduled Chemicals under the Chemical Weapons Convention (CWC)



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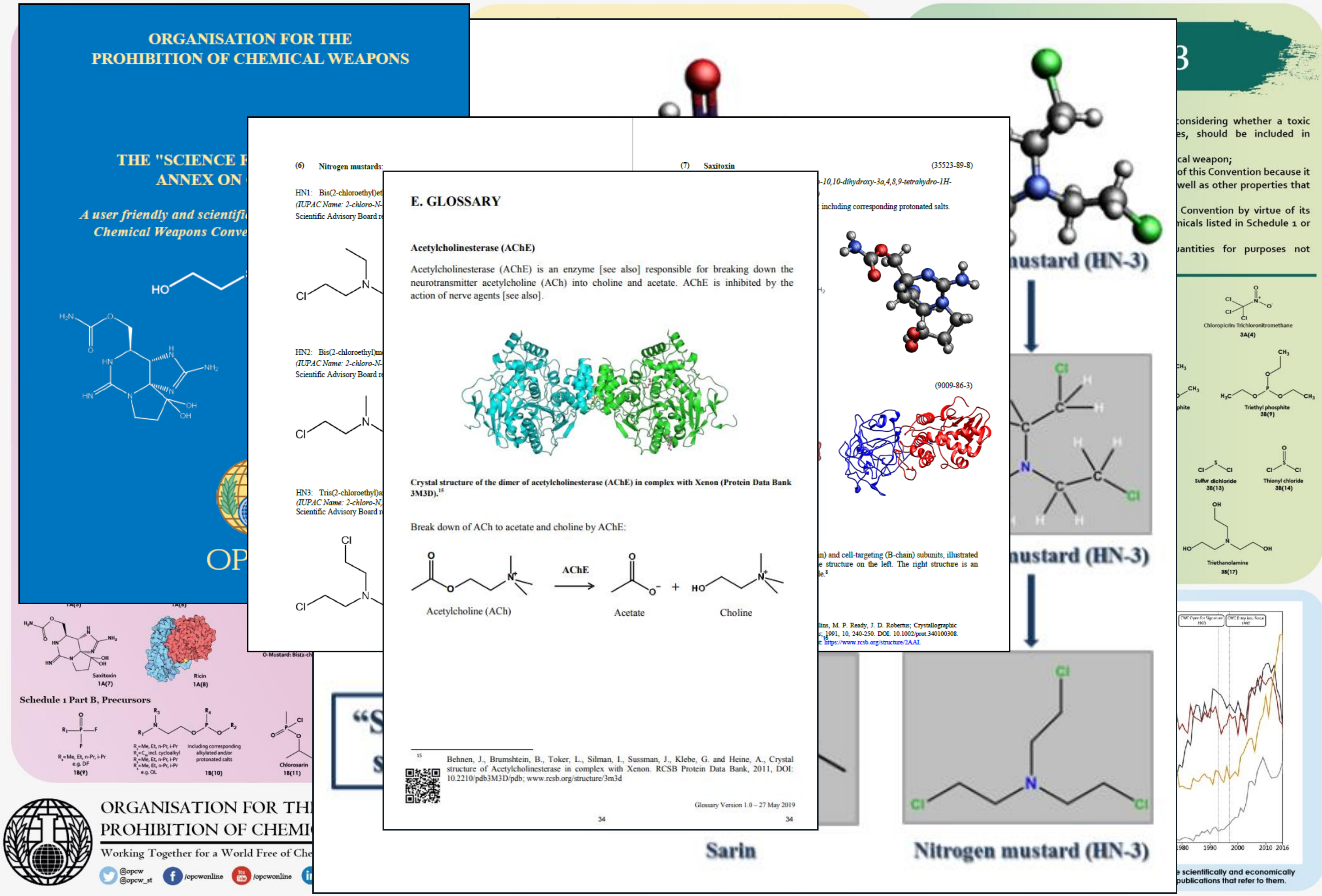
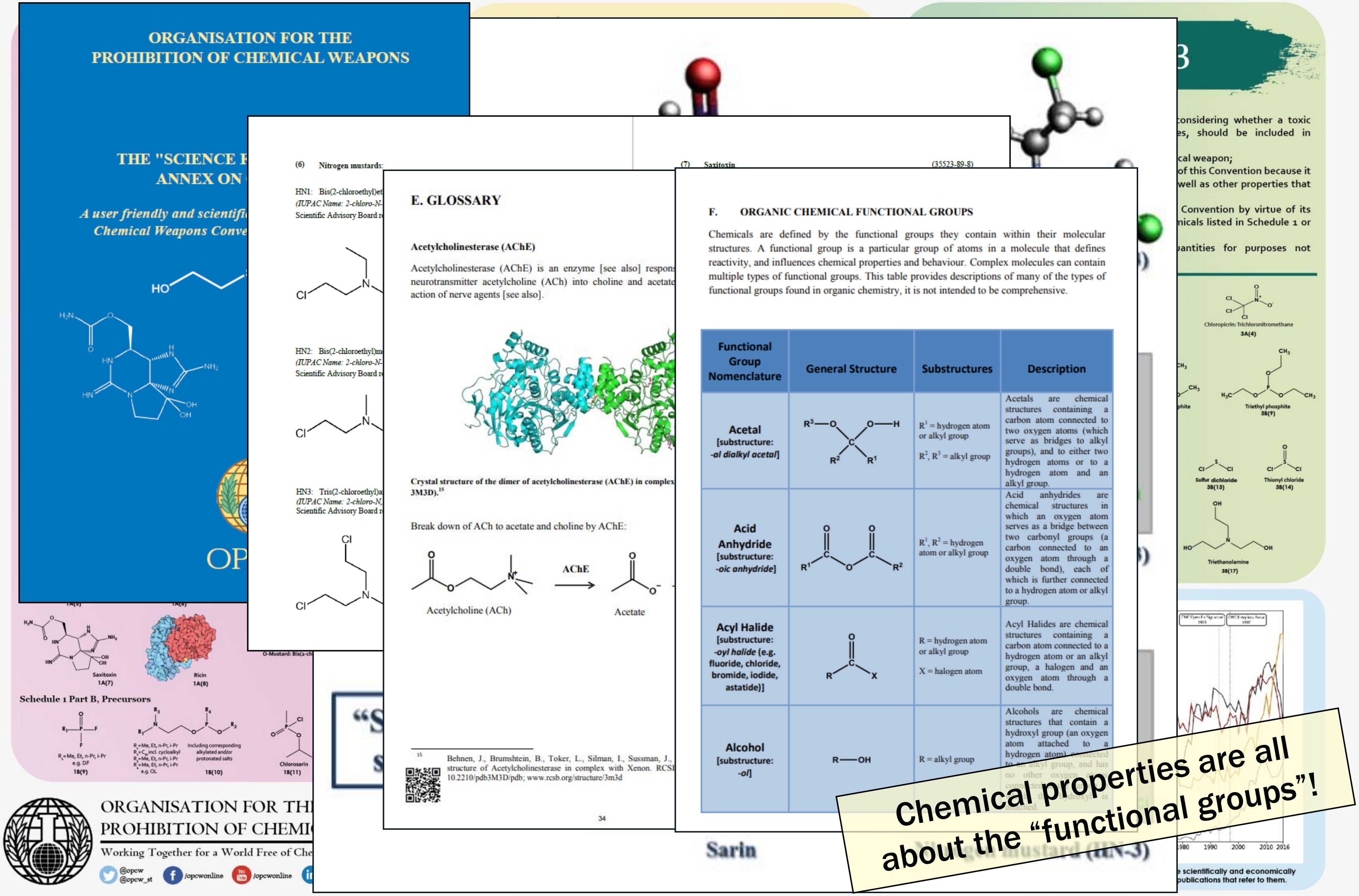


Scheduled Chemicals under the Chemical Weapons Convention (CWC)



Chemical properties are all about the "functional groups"!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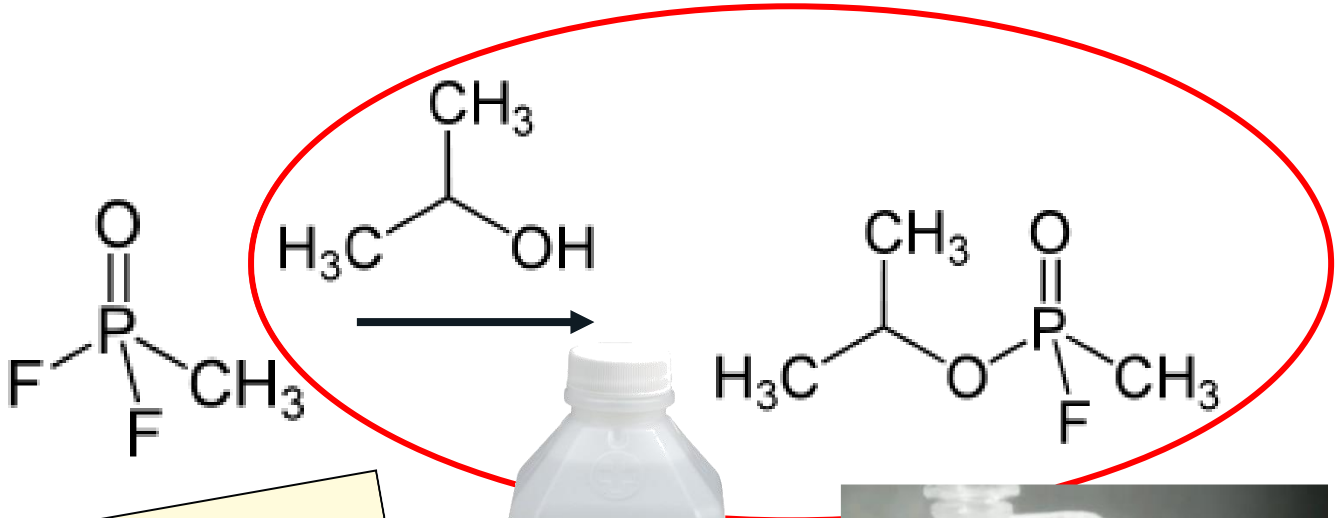
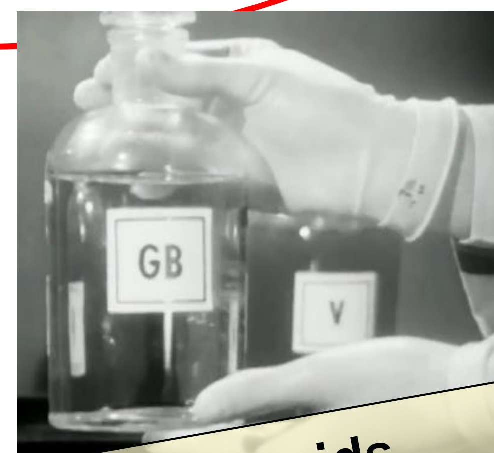
The Elephant in the Room...

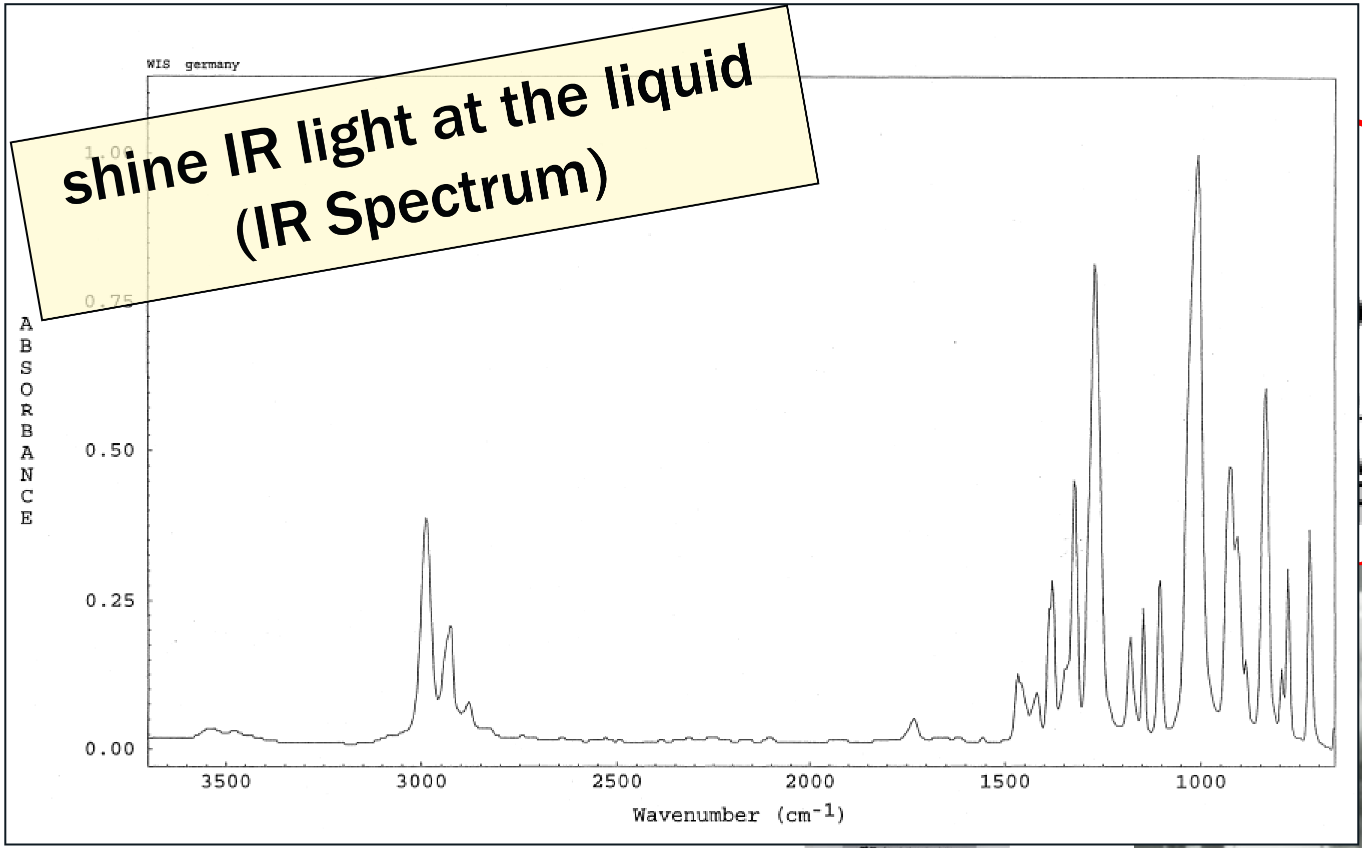


molecules don't actually look like this...

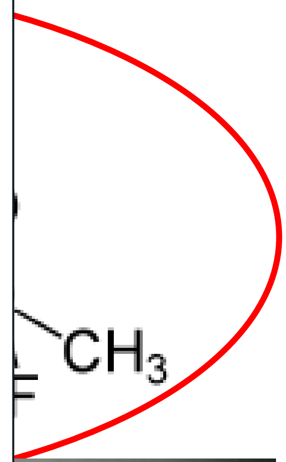


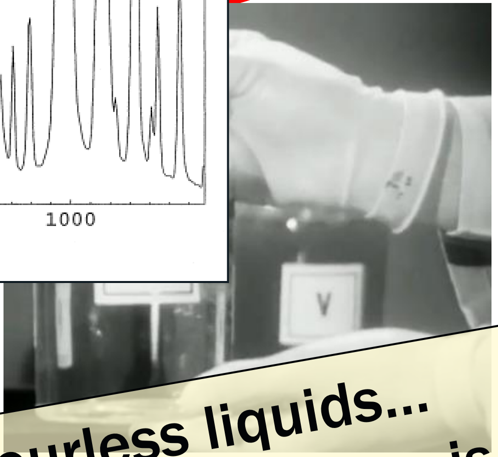
colourless liquids...
How do you know which one is which?

The Elephant in the Room...



shine IR light at the liquid
(IR Spectrum)





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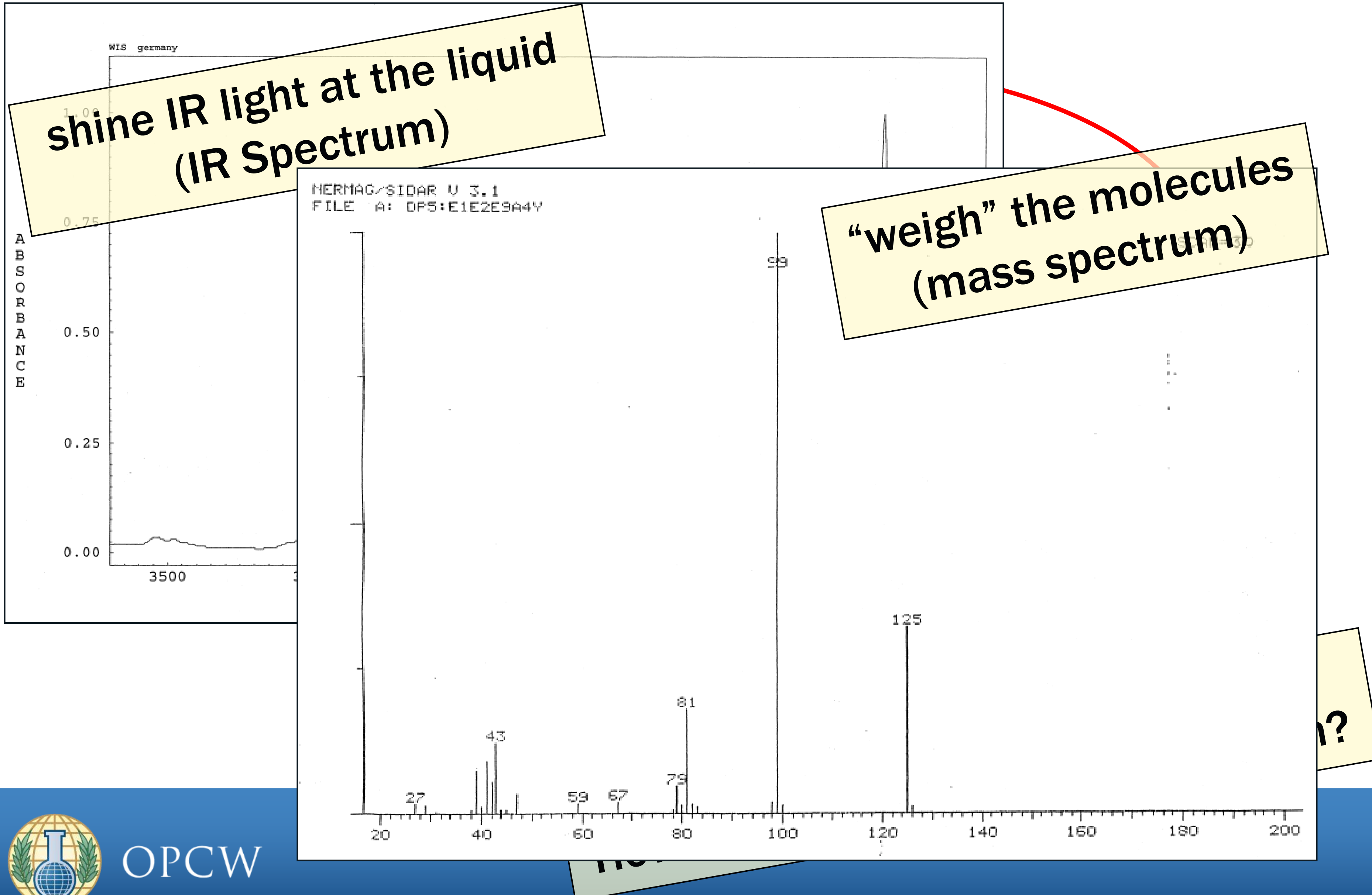

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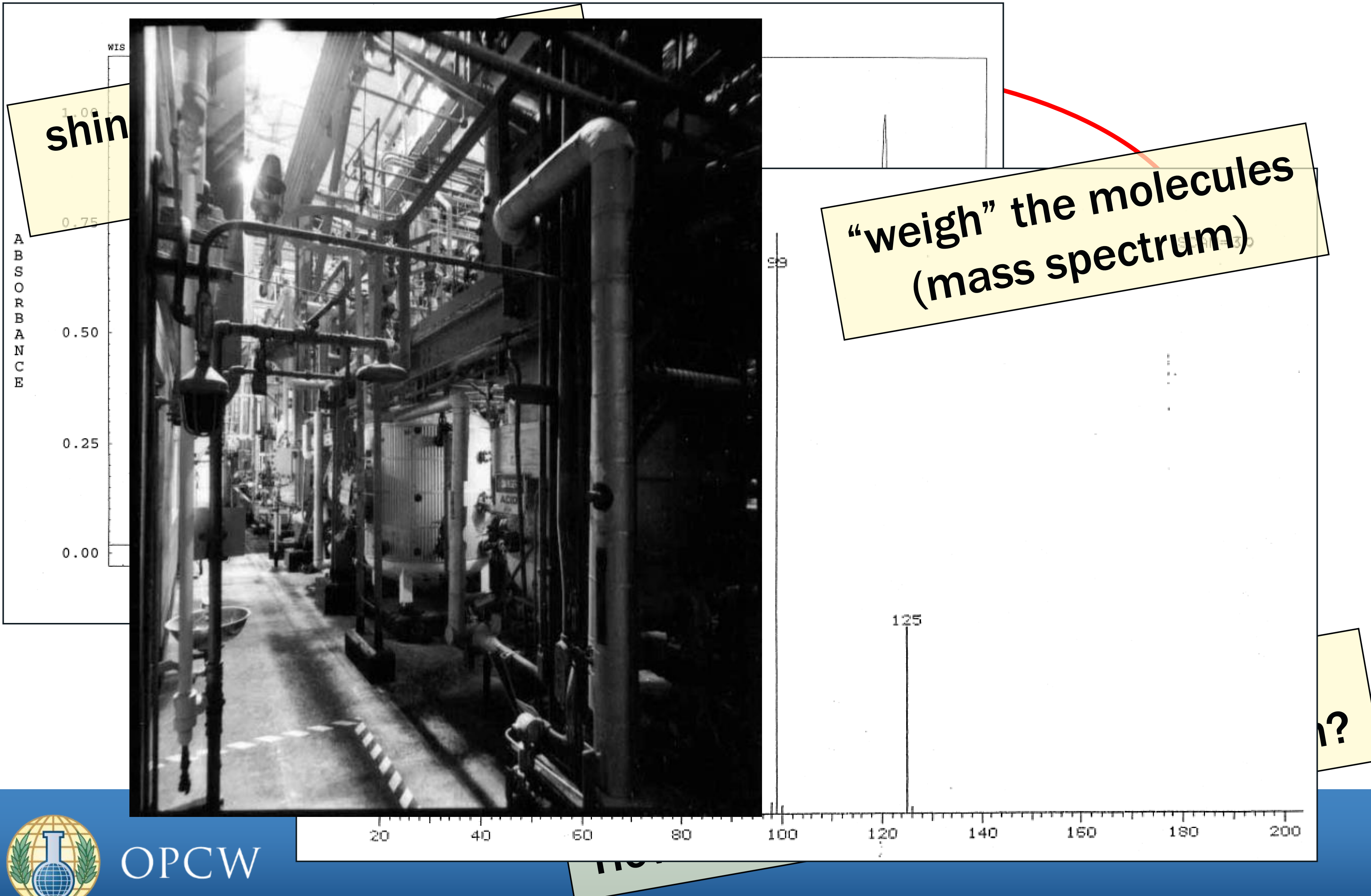
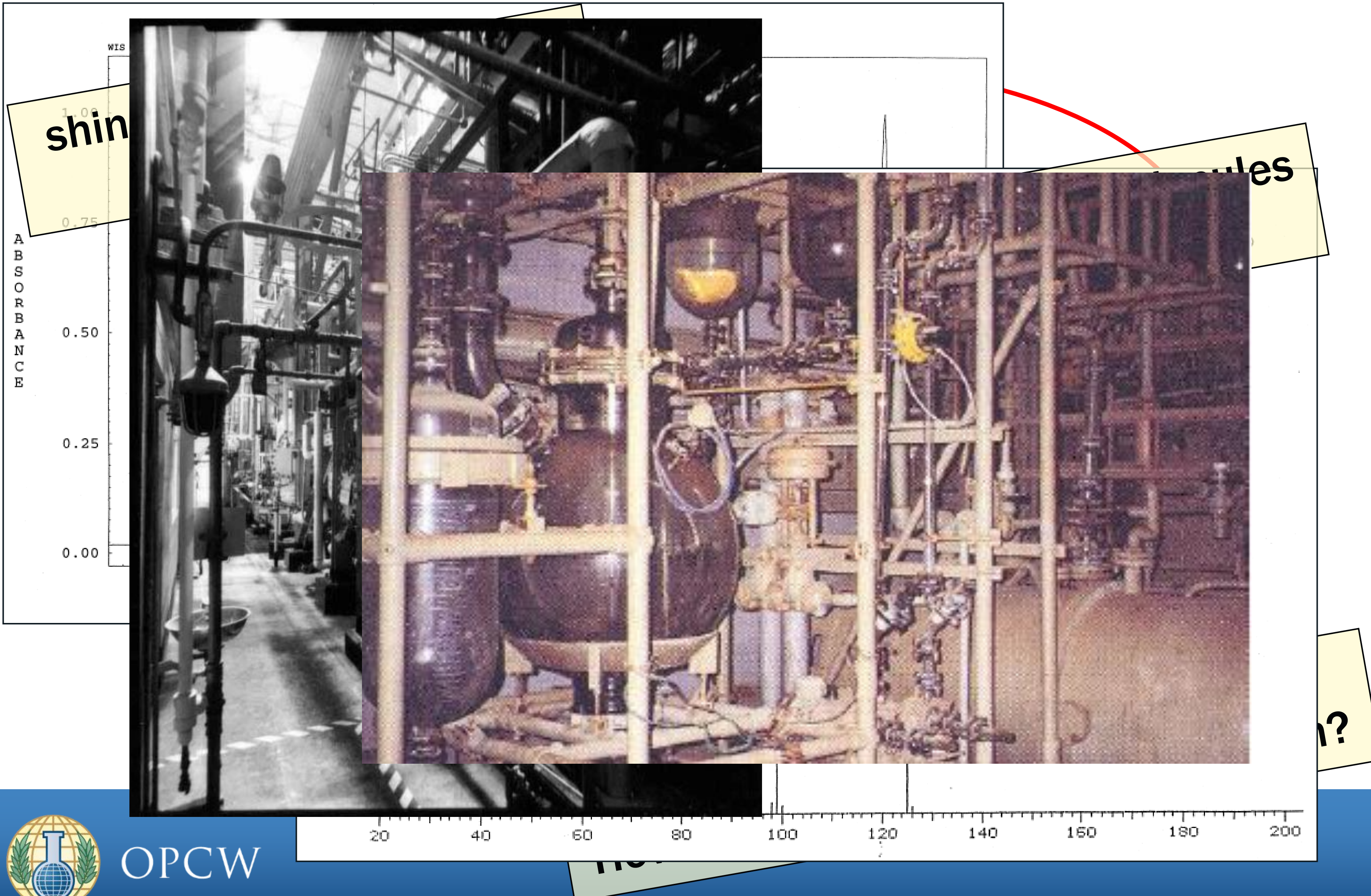
The Elephant in the Room…



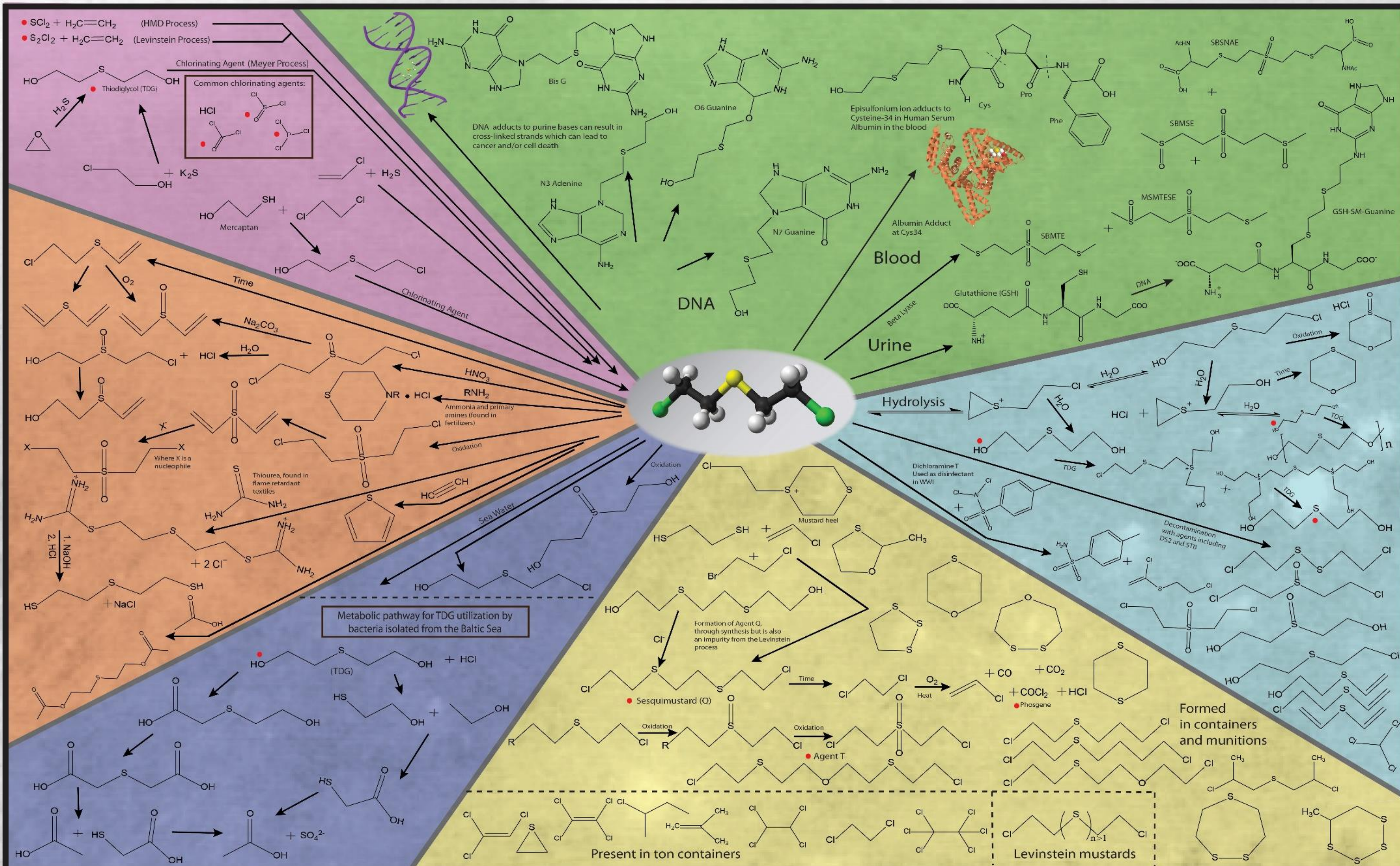
The Elephant in the Room...



Degradation and Environmental Fate of Sulfur Mustard

Darcy van Eerten

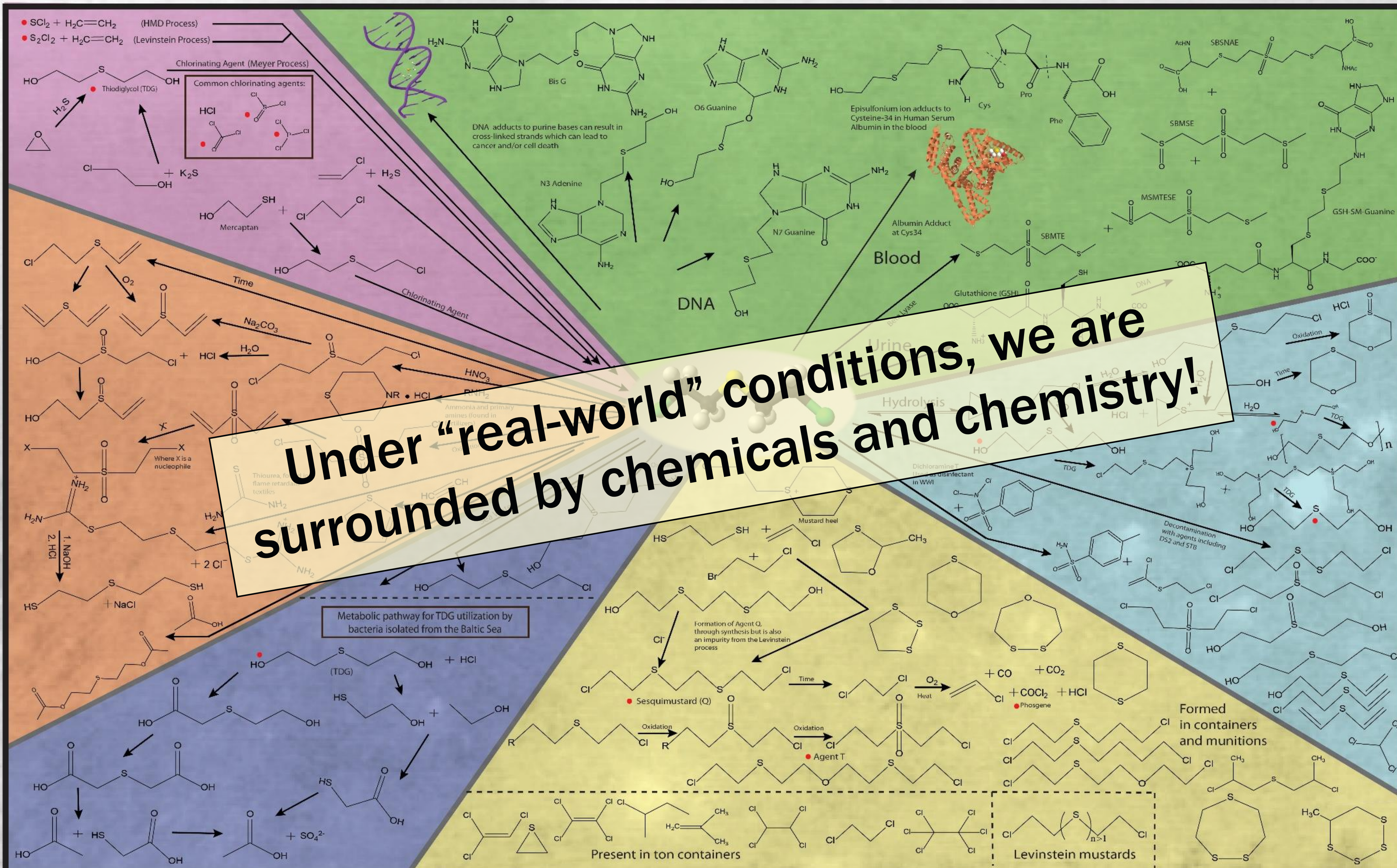
@opcw @opcw_st /opcwonline /opcwonline /company/opcw /opcw



Environmental fate in: Cement & Soil | Sea Water | Synthesis Routes | Toxicology | Reported Impurities | Decontamination • Scheduled Chemical

Degradation and Environmental Fate of Sulfur Mustard

Darcy van Eerten



Under "real-world" conditions, we are surrounded by chemicals and chemistry!

Environmental fate in: Cement & Soil | Sea Water | Synthesis Routes | Toxicology | Reported Impurities | Decontamination | •Scheduled Chemical

Degradation and Environmental Fate of Sulfur Mustard

Darcy van Eerten

@opcw @opcw_st /opcwonline /opcwonline /company/opcw /opcw

Environmental fate in: Cement & Soil | Sea Water | Synthesis Routes | Toxicology | Reported Impurities | Decontamination | •Scheduled Chemical

What you see may not look exactly like the chemists Explanation!

("language" describes things, but objects do not always look like words!)

Today's Briefing:

What does chemistry really look like?

(and how does it actually relate to the world you see and feel?)

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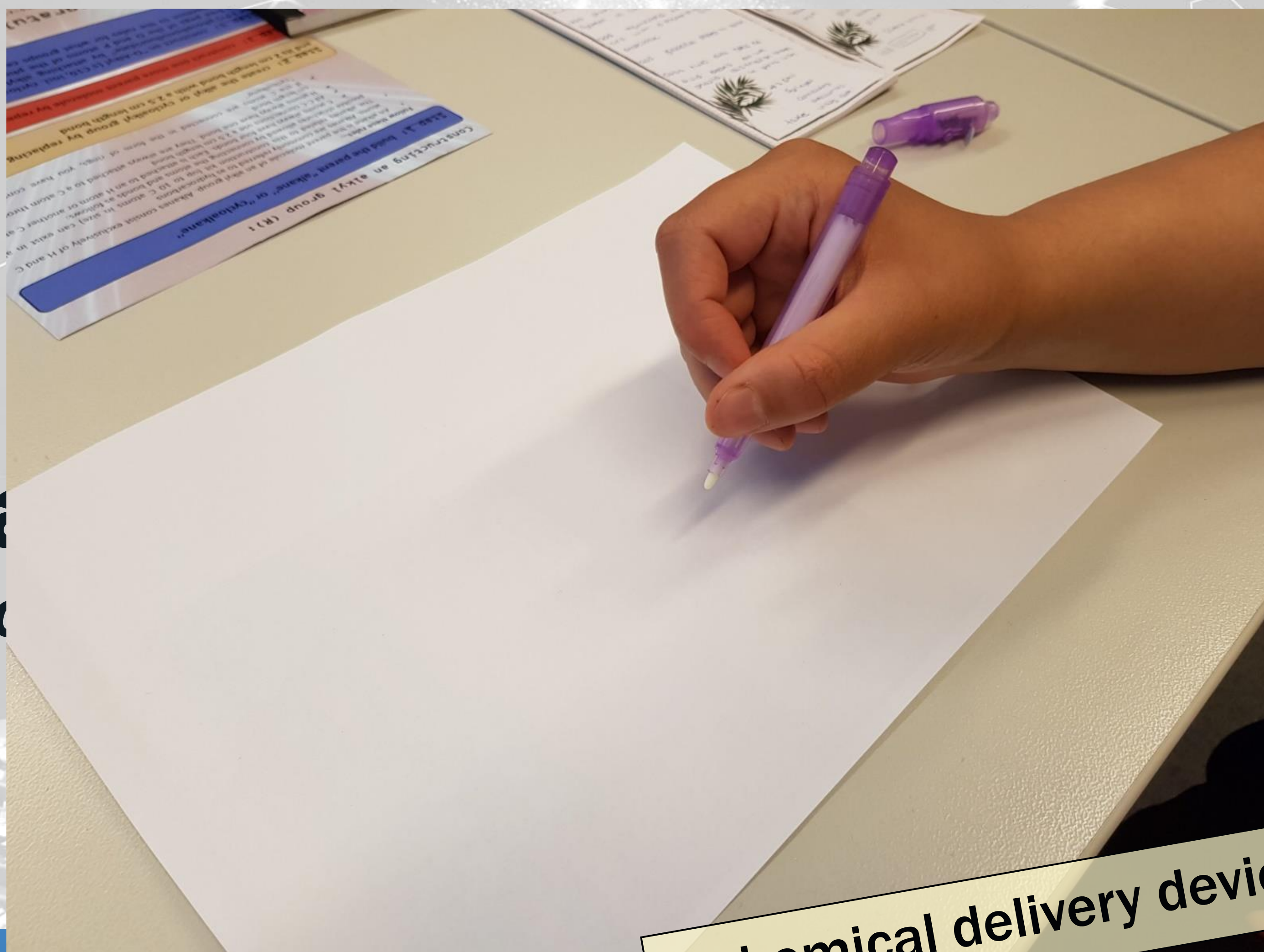
What you see may not look exactly like the chemists Explanation!

(“language” describes things, but objects do not always look like words!)



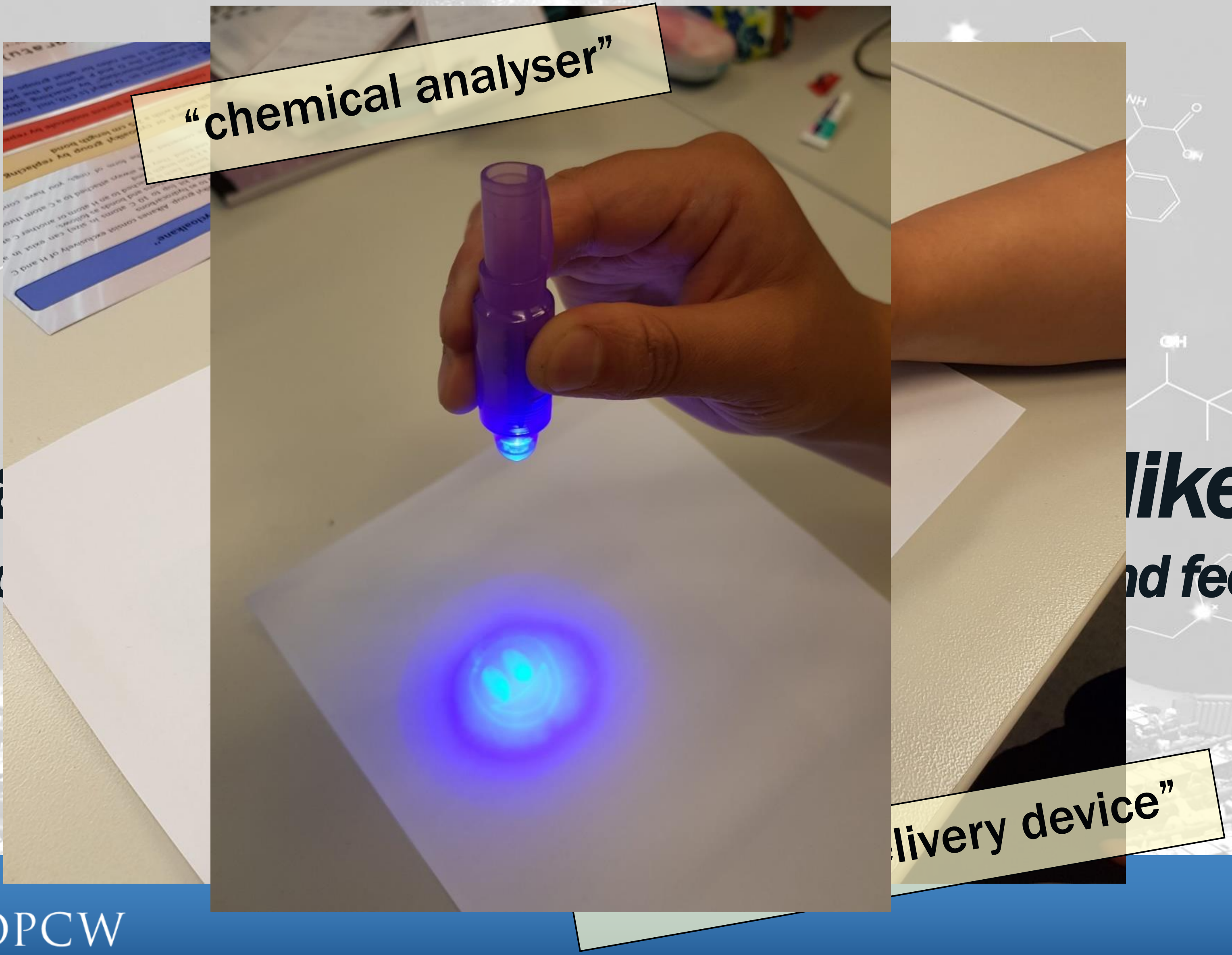
Wha… like?

(and h… nd feel?)

“chemical delivery device”

What you see may not look exactly like the chemists Explanation!

(“language” describes things, but objects do not always look like words!)



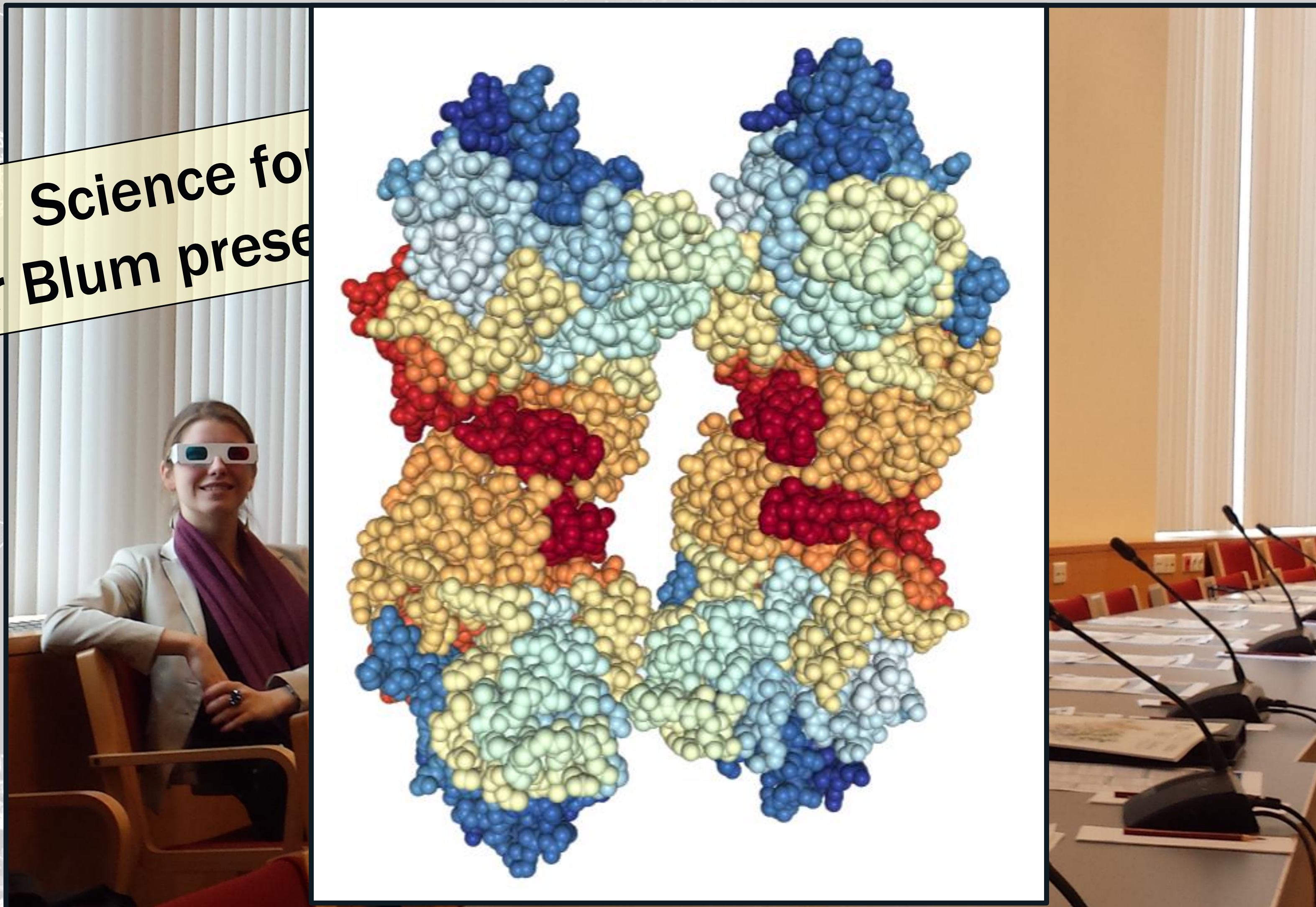
Wha ... like?

(and h ... nd feel?)

Before we Begin…

Science for Diplomats 2014
Dr Blum presented to 5 delegations

Before we Begin…



Before we Begin…

Scie

Dr Blum

Science for Diplomats 2017

Standing room only!

Before we Begin…

Scie
Dr Blum

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Presentation by Dr Blum

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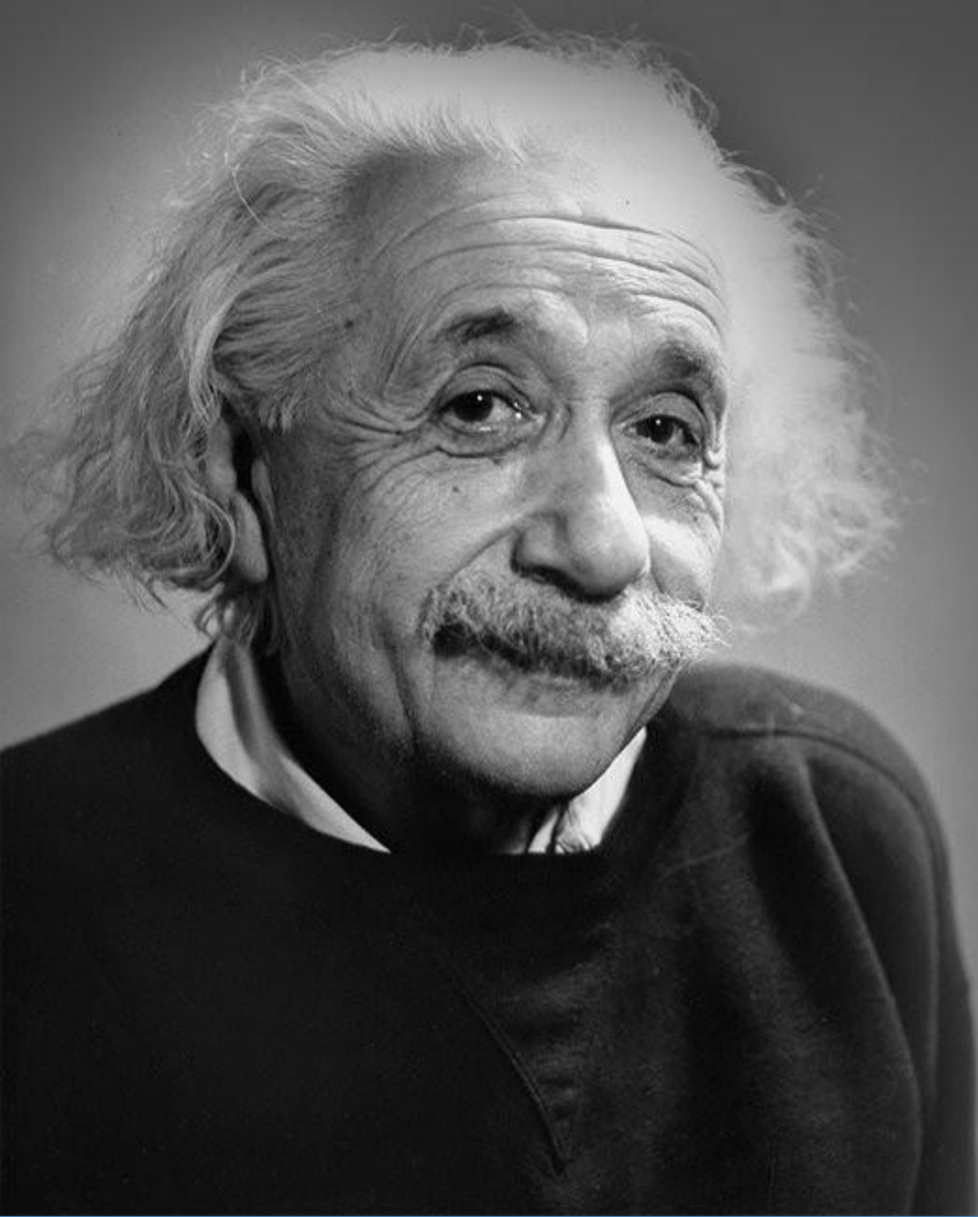
Organisation for the Prohibition of Chemical Weapons

Chemical reactivity

or why
Chemistry is basically the same as Politics

Marc-Michael Blum, Ph.D.
Head, OPCW Laboratory



Politics is more difficult than physics

Albert Einstein

Chemistry is basically the same as politics

Marc-Michael Blum
Head, OPCW Laboratory

(somehow implying that Chemistry is more difficult than Physics)

Chemistry:

Chemistry is the study of matter, its properties, ***how and why substances combine or separate to form other substances***, and how substances interact with energy.

The Chemical Weapons Convention is quite focused on chemicals themselves:

- Declarations based on production, consumption and/or transfers of chemicals
- Annex on Chemicals of the CWC listing those chemicals for which special verification measures are in place
- Sampling & Analysis is conducted to confirm the presence or absence of a CWC relevant chemical
- …

But we also deal with REACTIONS of chemicals:

- We discuss the meaning of “production by synthesis”
- We discuss the the productions of DOCs via biomediated processes
- Sampling & Analysis is looking for precursors and degradation products of chemical agents in IAUs
- Reaction products of agents with biomolecules (“adducts”) are valuable biomarkers and important in biomedical verification
- …

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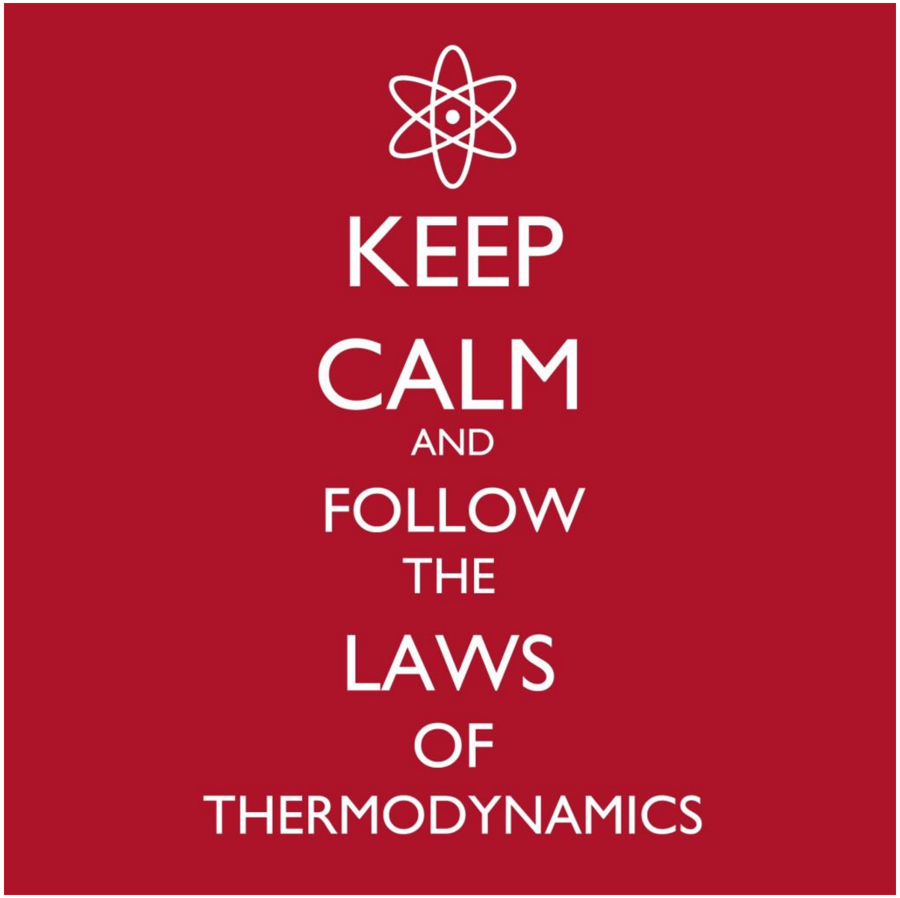
So why do chemicals react with each other?

What are the laws that determine in what direction a chemical reaction is proceeding?



The first law of thermodynamics is a version of the law of conservation of energy, adapted for thermodynamic systems. The law of conservation of energy states that the total energy of an isolated system is constant; energy can be transformed from one form to another, but can be neither created nor destroyed.

The second law of thermodynamics states that the total entropy of an isolated system can never decrease over time. The total entropy of a system and its surroundings can remain constant in ideal cases where the system is in thermodynamic equilibrium. In all processes that occur, including spontaneous processes, the total entropy of the system and its surroundings increases and the process is irreversible in the thermodynamic sense. The increase in entropy accounts for the irreversibility of natural processes, and the asymmetry between future and past.

Chemical equilibrium

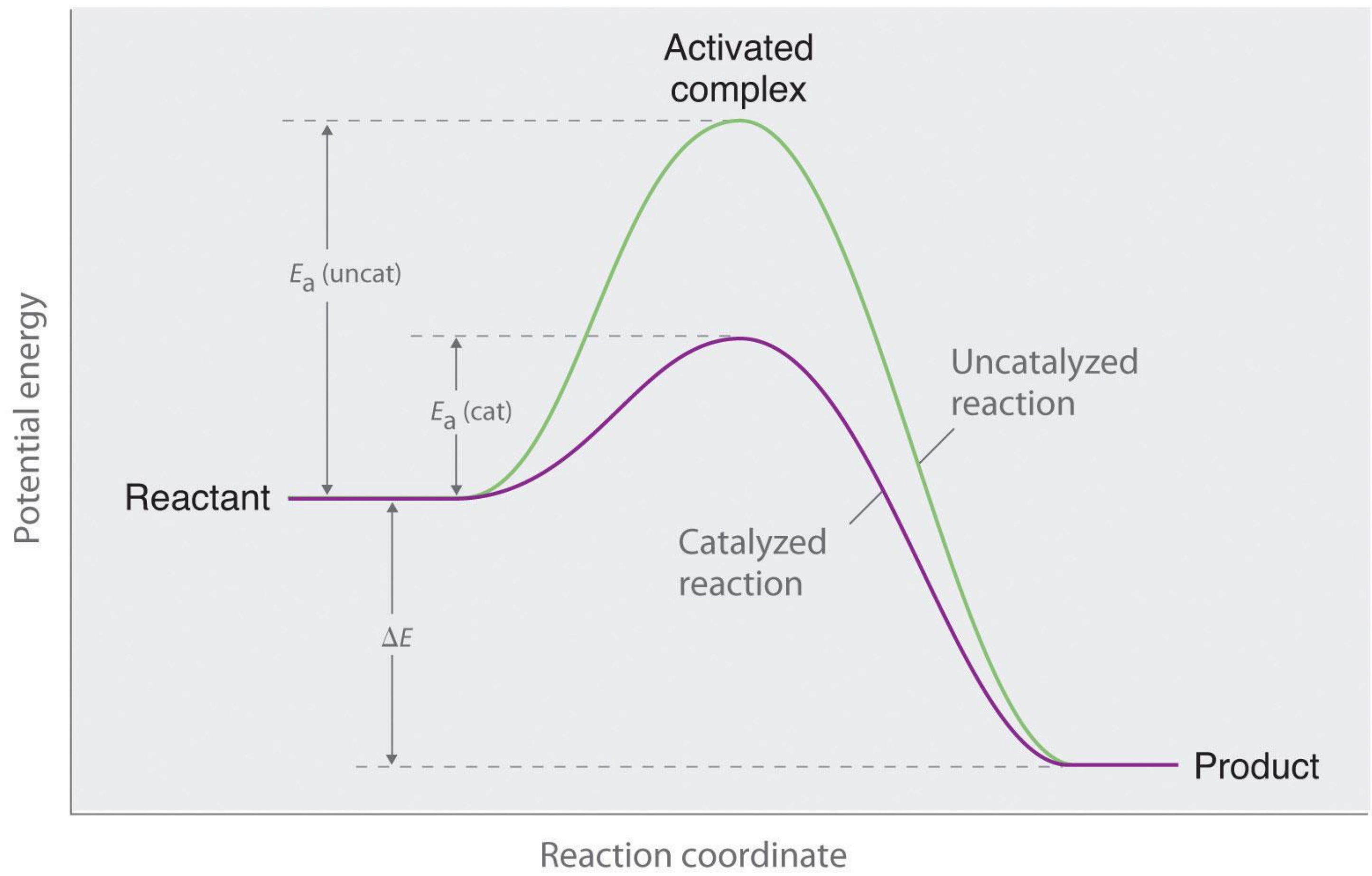
$$A+B \rightleftharpoons C+D$$

Thermodynamics determine if A and B or C and D are the favoured products and where the equilibrium is located. It does NOT determine reaction rates.

$$A+B \rightleftharpoons C+D$$

$$A+B \rightleftharpoons C+D$$

Activation Energy and reaction rates



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A practical example

Fritz Haber (1868-1934)

"Father" of chemical warfare in World War I

But also Nobel Laureate in Chemistry 1918

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Carl Bosch (1874-1940)

Chemist and Industrialist

Nobel Laureate in Chemistry 1931

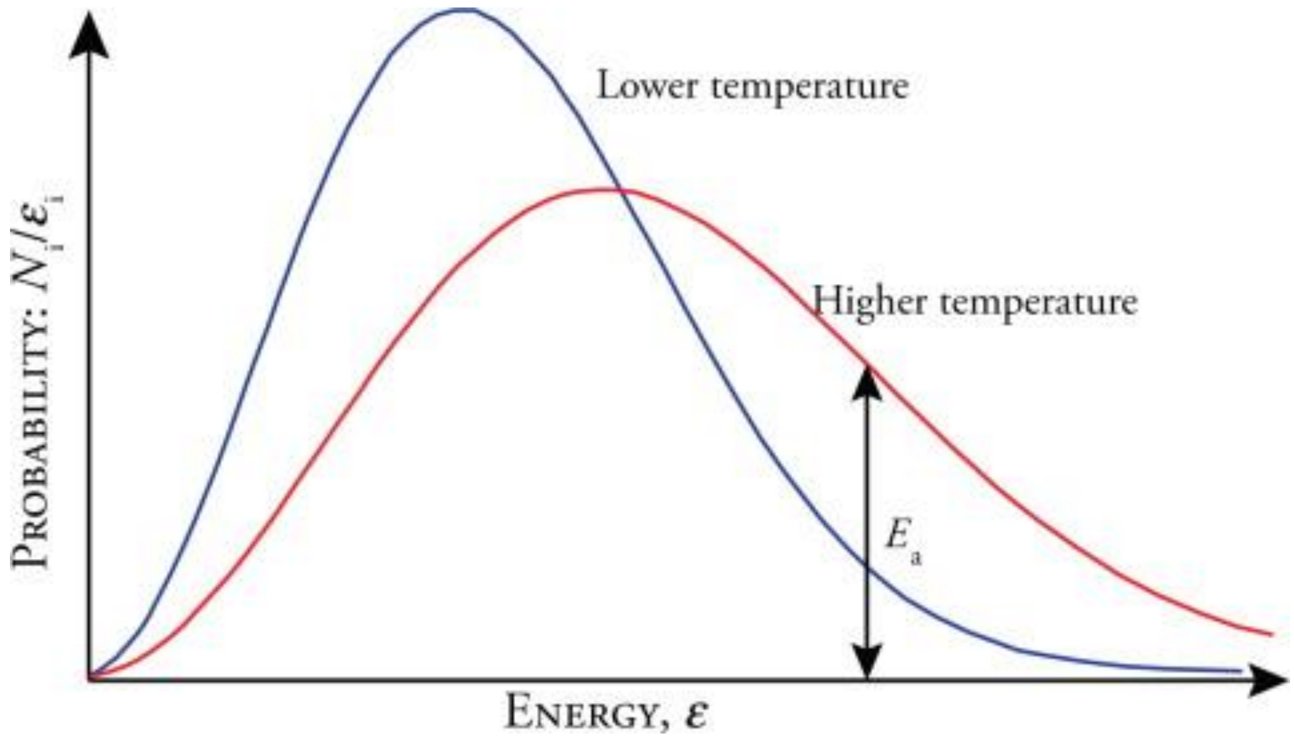
The Haber-Bosch process

Making ammonia with nitrogen from the air

$$N_2 + 3\,H_2 \rightleftharpoons 2\,NH_3$$

- Nitrogen is a very stable and unreactive molecule.
- Process has high activation barrier.
- Raising the temperature makes reaction faster but shifts equilibrium from ammonia towards starting products

Reaction rate and temperature



The Haber-Bosch process

The solution:

- Lowering activation energy a using metal catalyst
- Temperature for reasonable reaction rates now lower but still favouring the starting products
- Shifting the equilibrium towards ammonia by applying high pressure.

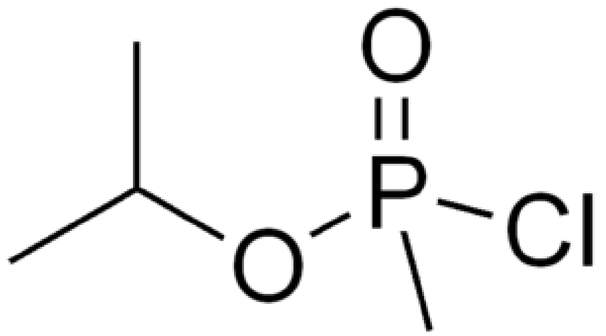
The Haber-Bosch process

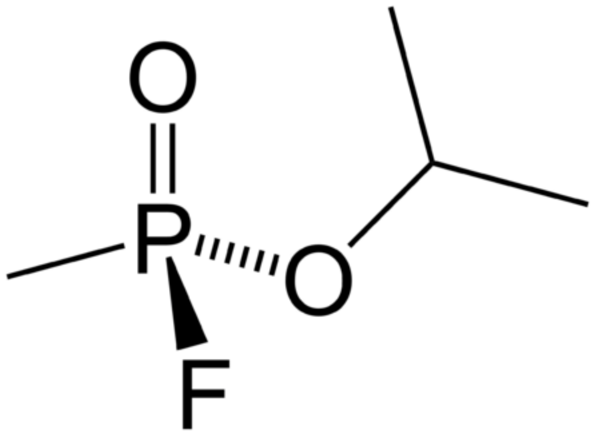
Major technological breakthrough (high pressure reactions in industry). Uses about 1-2% of world energy consumption.

- Enabled Imperial Germany to continue to fight World War I despite being blocked from accessing natural nitrate deposits Enabled the mass production of nitrogen fertilizers
- Enabling massive growth of agricultural production
- Without the Haber process the current world population would not be possible
- About half of all nitrogen atoms in the human body are derived from air nitrogen via the Haber process.

Chemical warfare and reactivity

- Nerve agents should have high reactivity with the biological target (Acetylcholinesterase) but low reactivity towards water (hydrolytic stability). Fluoridates better than chloridates.





But back to Chemistry and Politics....

$$A+B \rightleftharpoons C+D$$

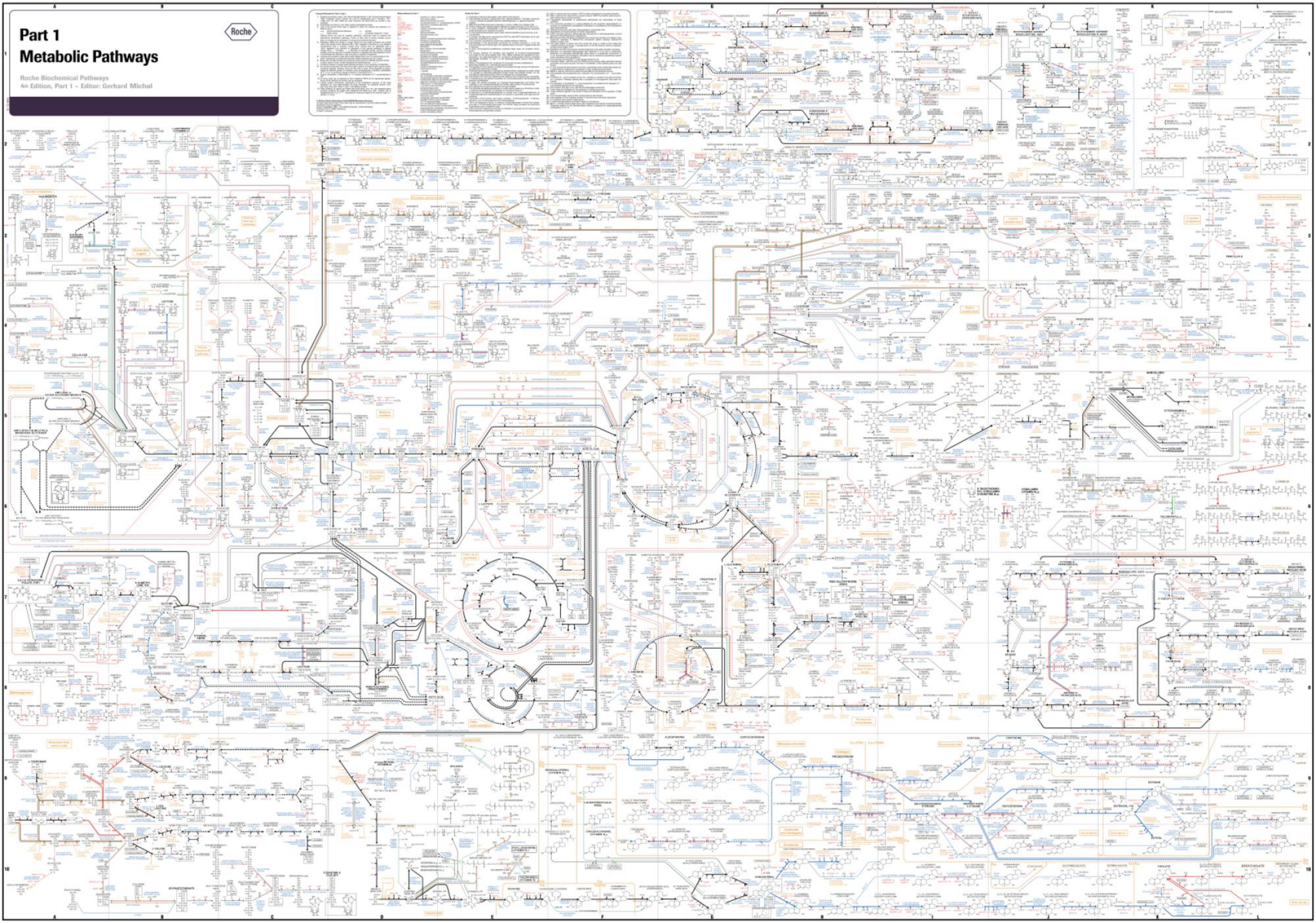
How can this be similar to politics? Clearly defined start and end states? Predictable reaction rates and equilibrium? No room for negotiations?

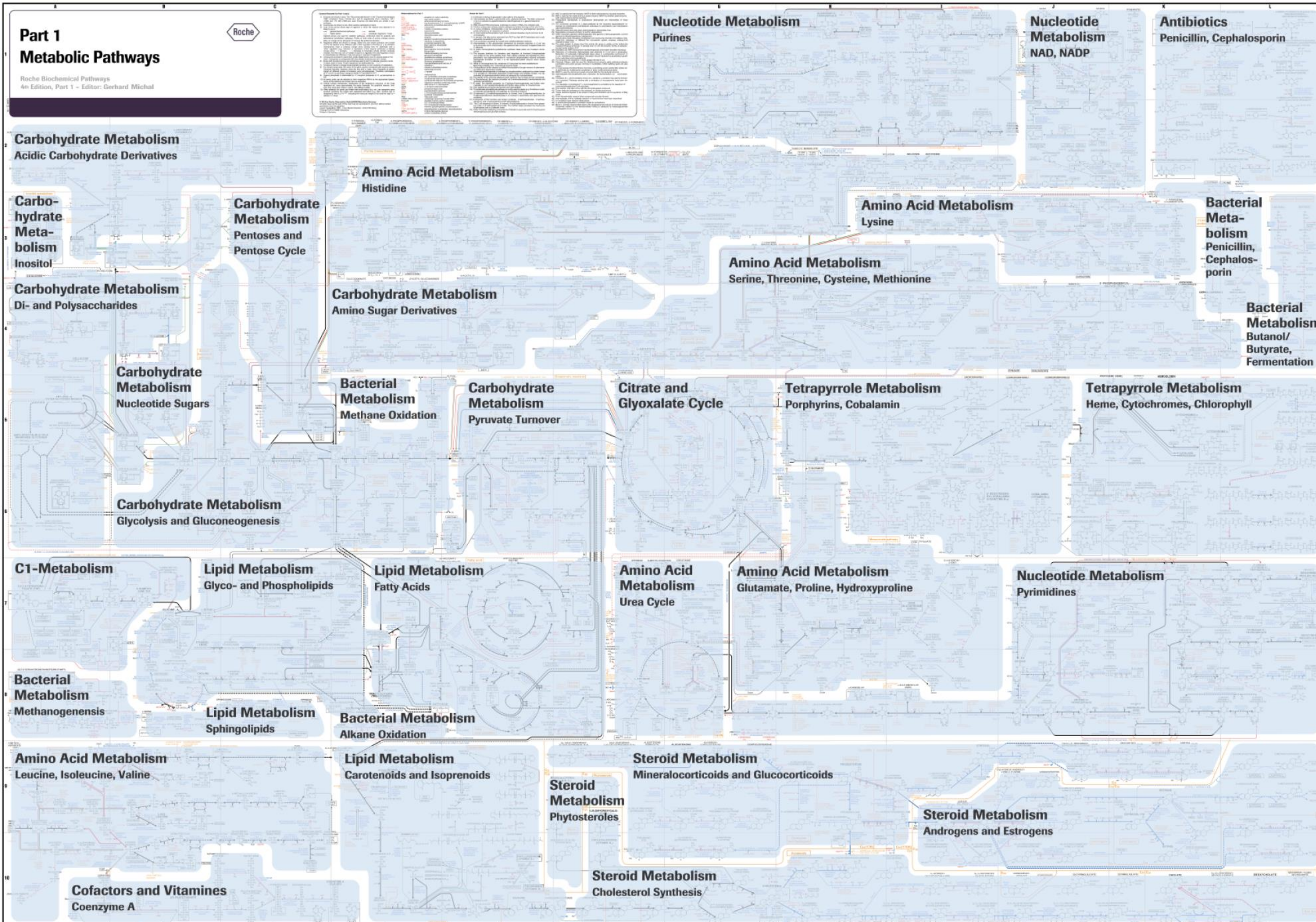
Chemistry can be a little bit more complicated.....

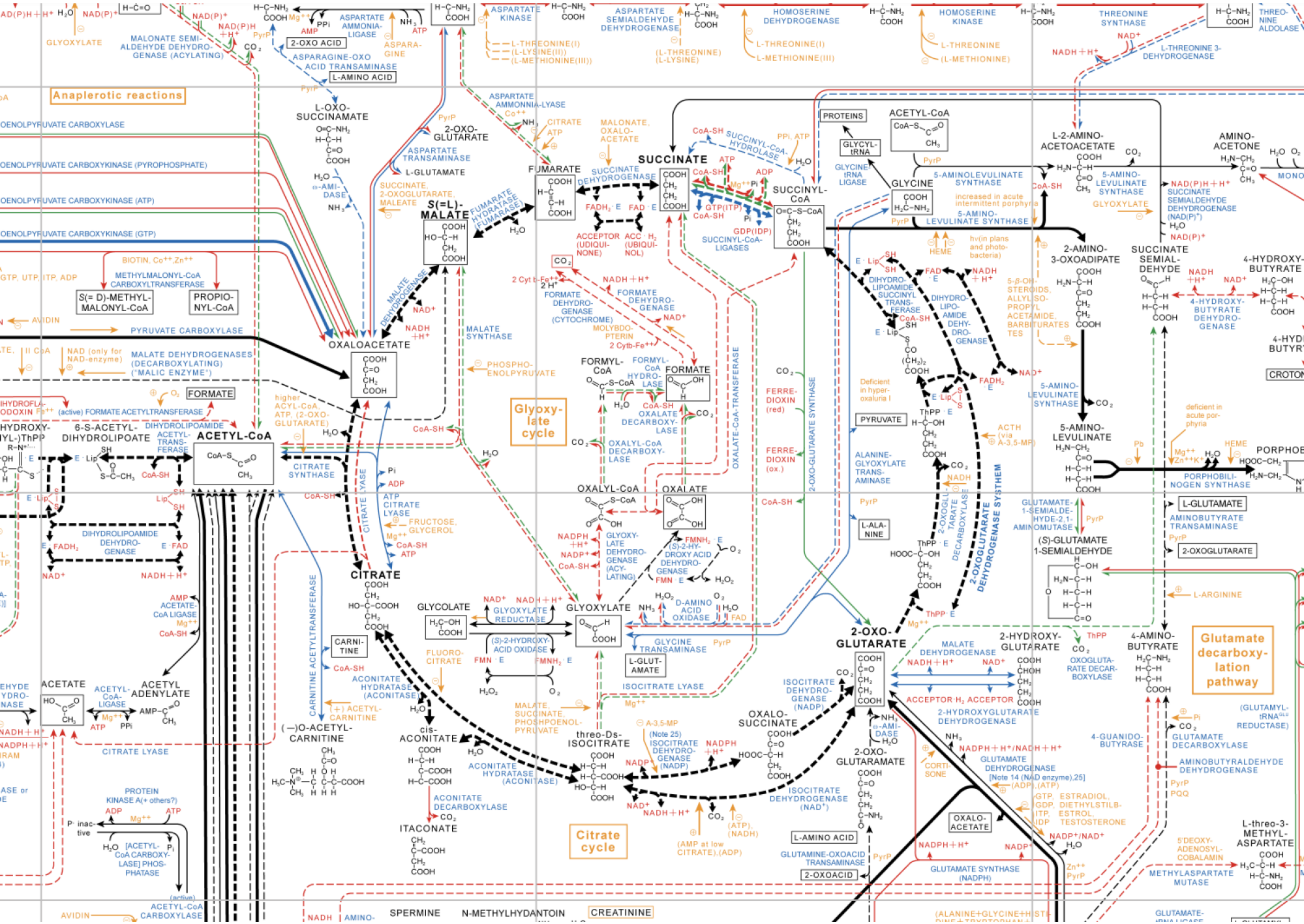
Part 1
Metabolic Pathways

Roche

Roche Biochemical Pathways
4th Edition, Part 1 – Editor: Gerhard Michal

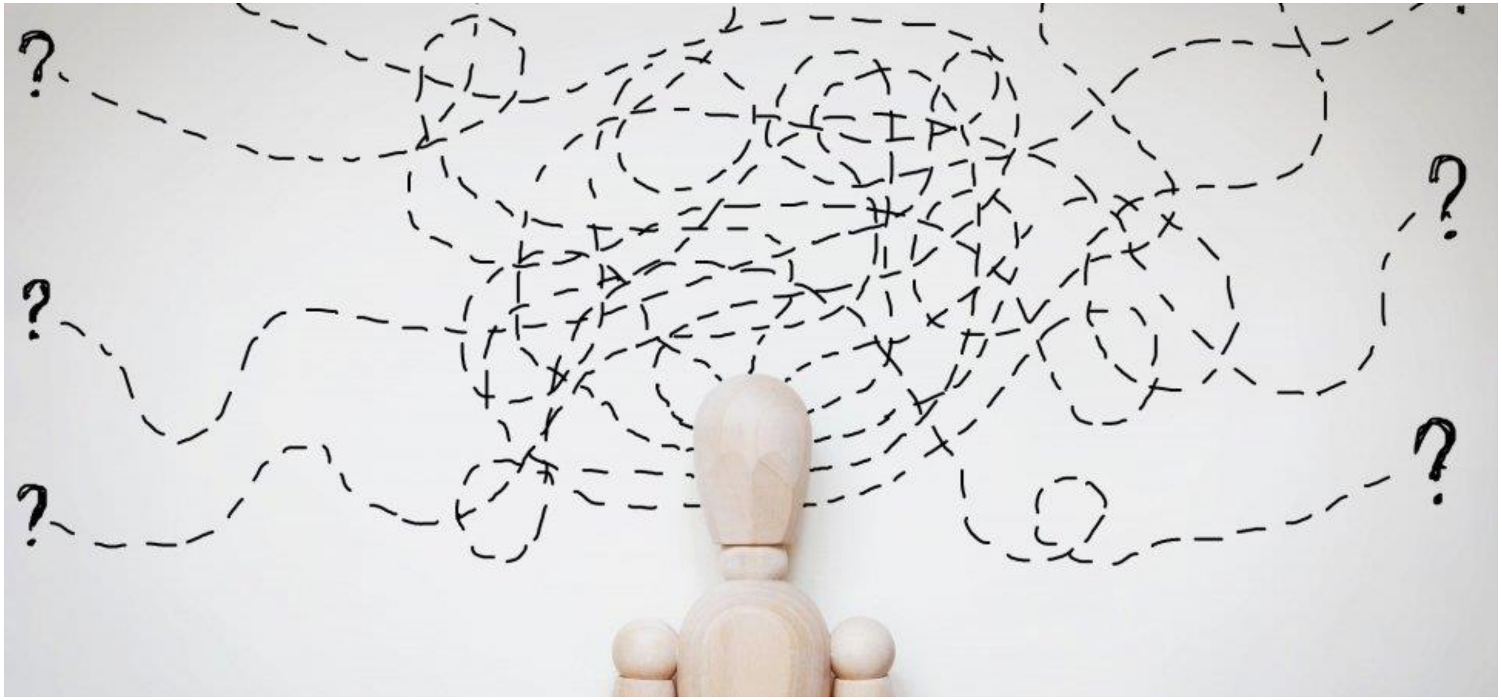



Part 1
Metabolic Pathways
Roche
Roche Biochemical Pathways
4th Edition, Part 1 – Editor: Gerhard Michal
Nucleotide Metabolism
Purines
Nucleotide Metabolism
NAD, NADP
Antibiotics
Penicillin, Cephalosporin
Carbohydrate Metabolism
Acidic Carbohydrate Derivatives
Amino Acid Metabolism
Histidine
Carbohydrate Metabolism
Inositol
Carbohydrate Metabolism
Pentoses and Pentose Cycle
Amino Acid Metabolism
Lysine
Bacterial Metabolism
Penicillin, Cephalosporin
Amino Acid Metabolism
Serine, Threonine, Cysteine, Methionine
Carbohydrate Metabolism
Di- and Polysaccharides
Carbohydrate Metabolism
Amino Sugar Derivatives
Bacterial Metabolism
Butanol/ Butyrate, Fermentation
Carbohydrate Metabolism
Nucleotide Sugars
Bacterial Metabolism
Methane Oxidation
Carbohydrate Metabolism
Pyruvate Turnover
Citrate and Glyoxalate Cycle
Tetrapyrrole Metabolism
Porphyrins, Cobalamin
Tetrapyrrole Metabolism
Heme, Cytochromes, Chlorophyll
Carbohydrate Metabolism
Glycolysis and Gluconeogenesis
C1-Metabolism
Lipid Metabolism
Glyco- and Phospholipids
Lipid Metabolism
Fatty Acids
Amino Acid Metabolism
Urea Cycle
Amino Acid Metabolism
Glutamate, Proline, Hydroxyproline
Nucleotide Metabolism
Pyrimidines
Bacterial Metabolism
Methanogenesis
Lipid Metabolism
Sphingolipids
Bacterial Metabolism
Alkane Oxidation
Amino Acid Metabolism
Leucine, Isoleucine, Valine
Lipid Metabolism
Carotenoids and Isoprenoids
Steroid Metabolism
Mineralocorticoids and Glucocorticoids
Steroid Metabolism
Phytosteroles
Steroid Metabolism
Androgens and Estrogens
Steroid Metabolism
Cholesterol Synthesis
Cofactors and Vitamines
Coenzyme A

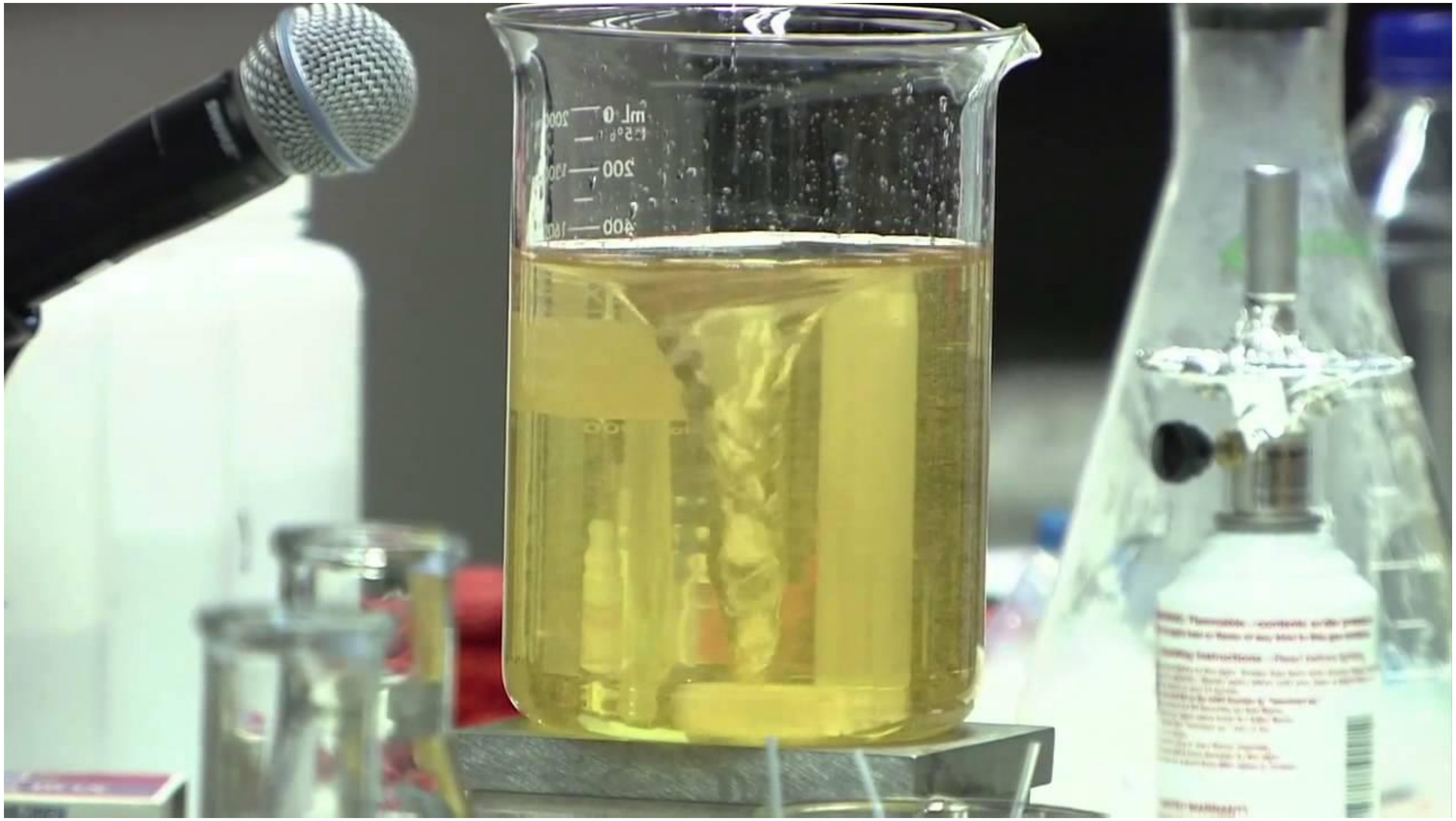


GLYOXYLATE
MALONATE SEMI-ALDEHYDE DEHYDRO-GENASE (ACYLATING)
2-OXO ACID
ASPARTATE AMMONIA-LIGASE
ASPARA-GINE
ASPARAGINE-OXO ACID TRANSAMINASE
L-AMINO ACID
ASPARTATE KINASE
ASPARTATE SEMIALDEHYDE DEHYDROGENASE
L-THREONINE(I)
(L-LYSINE(III))
(L-METHIONINE(III))
(L-THREONINE)
(L-LYSINE)
HOMOSERINE DEHYDROGENASE
L-THREONINE(I)
L-METHIONINE(III)
HOMOSERINE KINASE
L-THREONINE
(L-METHIONINE)
THREONINE SYNTHASE
THREO-NINE ALDOLASE
L-THREONINE 3-DEHYDROGENASE
Anaplerotic reactions
PHOSPHOENOLPYRUVATE CARBOXYLASE
PHOSPHOENOLPYRUVATE CARBOXYKINASE (PYROPHOSPHATE)
PHOSPHOENOLPYRUVATE CARBOXYKINASE (ATP)
PHOSPHOENOLPYRUVATE CARBOXYKINASE (GTP)
BIOTIN, Co++,Zn++
METHYLMALONYL-CoA CARBOXYLTRANSFERASE
S(= D)-METHYL-MALONYL-CoA
PROPIO-NYL-CoA
GTP, UTP, ITP, ADP
AVIDIN
PYRUVATE CARBOXYLASE
NAD (only for NAD-enzyme)
MALATE DEHYDROGENASES (DECARBOXYLATING) ("MALIC ENZYME")
FORMATE
(active) FORMATE ACETYLTRANSFERASE
DIHYDROLIPOAMIDE ACETYL-TRANSFERASE
6-S-ACETYL-DIHYDROLIPOATE
ACETYL-CoA
DIHYDROLIPOAMIDE DEHYDRO-GENASE
L-OXO-SUCCINAMATE
ω-AMI-DASE
2-OXO-GLUTARATE
ASPARTATE TRANSAMINASE
L-GLUTAMATE
SUCCINATE, 2-OXOGLUTARATE, MALEATE
S(=L)-MALATE
FUMARATE HYDRATASE (FUMARASE)
MALATE DEHYDROGENASE
OXALOACETATE
higher ACYL-CoA, ATP, (2-OXO-GLUTARATE)
CITRATE SYNTHASE
ATP CITRATE LYASE
FRUCTOSE, GLYCEROL
CITRATE
CARNITINE ACETYLTRANSFERASE
CARNI-TINE
ACONITATE HYDRATASE (ACONITASE)
(+) ACETYL-CARNITINE
(−)-O-ACETYL-CARNITINE
cis-ACONITATE
ACONITATE DECARBOXYLASE
ITACONATE
ACETATE
ACETYL-CoA LIGASE
ACETYL ADENYLATE
AMP ACETATE-CoA LIGASE
CITRATE LYASE
PROTEIN KINASE A(+ others?)
[ACETYL-CoA CARBOXYLASE] PHOS-PHATASE
ACETYL-CoA CARBOXYLASE
ASPARTATE AMMONIA-LYASE
CITRATE
MALONATE, OXALO-ACETATE
FUMARATE
SUCCINATE DEHYDROGENASE
ACCEPTOR (UDIQUI-NONE)
ACC·H₂ (UBIQUI-NOL)
SUCCINATE
SUCCINYL-CoA HYDROLASE
SUCCINYL-CoA
SUCCINYL-CoA LIGASES
FORMATE DEHYDRO-GENASE (CYTOCHROME)
FORMATE DEHYDRO-GENASE
MOLYBDO-PTERIN
MALATE SYNTHASE
PHOSPHO-ENOLPYRUVATE
Glyoxy-late cycle
FORMYL-CoA
FORMYL-CoA HYDRO-LASE
FORMATE
OXALATE DECARBOXY-LASE
OXALYL-CoA DECARBOXY-LASE
OXALATE-CoA-TRANSFERASE
OXALYL-CoA
OXALATE
GLYOXY-LATE DEHYDRO-GENASE (ACY-LATING)
(S)-2-HY-DROXY ACID DEHYDRO-GENASE
GLYCOLATE
GLYOXYLATE REDUCTASE
GLYOXYLATE
(S)-2-HYDROXY-ACID OXIDASE
D-AMINO ACID OXIDASE
GLYCINE TRANSAMINASE
L-GLUT-AMATE
ISOCITRATE LYASE
FLUORO-CITRATE
MALATE, SUCCINATE, PHOSPHOENOL-PYRUVATE
threo-Ds-ISOCITRATE
ISOCITRATE DEHYDRO-GENASE (NADP)
Citrate cycle
(AMP at low CITRATE),(ADP)
FERRE-DIOXIN (red)
FERRE-DIOXIN (ox.)
2-OXO-GLUTARATE SYNTHASE
PROTEINS
GLYCYL-tRNA
GLYCINE-tRNA LIGASE
GLYCINE
ACETYL-CoA
5-AMINOLEVULINATE SYNTHASE
increased in acute intermittent porphyria
5-AMINO-LEVULINATE SYNTHASE
HEME
hv(in plants and photo-bacteria)
DIHYDRO-LIPOAMIDE SUCCINYL-TRANS-FERASE
DIHYDRO-LIPO-AMIDE DEHY-DRO-GENASE
5-β-OH-STEROIDS, ALLYLISO-PROPYL ACETAMIDE, BARBITURATES
PYRUVATE
Deficient in hyper-oxaluria I
ALANINE-GLYOXYLATE TRANS-AMINASE
L-ALA-NINE
ACTH (via A-3,5-MP)
2-OXOGLU-TARATE DECARBOXYLASE
2-OXOGLUTARATE DEHYDROGENASE SYSTEM
2-OXO-GLUTARATE
OXALO-SUCCINATE
ISOCITRATE DEHYDRO-GENASE (NADP)
ISOCITRATE DEHYDROGENASE (NAD⁺)
ω-AMI-DASE
2-OXO-GLUTARAMATE
L-AMINO ACID
GLUTAMINE-OXOACID TRANSAMINASE
2-OXOACID
MALATE DEHYDROGENASE
2-HYDROXY-GLUTARATE
ACCEPTOR·H₂ ACCEPTOR
2-HYDROXYGLUTARATE DEHYDROGENASE
CORTI-SONE
GLUTAMATE DEHYDROGENASE [Note 14 (NAD enzyme),25]
GTP, GDP, ITP, IDP
ESTRADIOL, DIETHYLSTILB-ESTROL, TESTOSTERONE
OXALO-ACETATE
GLUTAMATE SYNTHASE (NADPH)
L-2-AMINO-ACETOACETATE
AMINO-ACETONE
5-AMINO-LEVULINATE SYNTHASE
SUCCINATE SEMIALDEHYDE DEHYDROGENASE (NAD(P)⁺)
GLYOXYLATE
2-AMINO-3-OXOADIPATE
SUCCINATE SEMIAL-DEHYDE
4-HYDROXY-BUTYRATE
4-HYDROXY-BUTYRATE DEHYDRO-GENASE
CROTON
deficient in acute por-phyria
5-AMINO-LEVULINATE SYNTHASE
5-AMINO-LEVULINATE
PORPHOBILI-NOGEN SYNTHASE
PORPHOBILINOGEN
L-GLUTAMATE
AMINOBUTYRATE TRANSAMINASE
2-OXOGLUTARATE
GLUTAMATE-1-SEMIALDE-HYDE-2,1-AMINOMUTASE
(S)-GLUTAMATE 1-SEMIALDEHYDE
L-ARGININE
OXOGLUTA-RATE DECAR-BOXYLASE
4-AMINO-BUTYRATE
Glutamate decarboxy-lation pathway
4-GUANIDO-BUTYRASE
GLUTAMATE DECARBOXYLASE
(GLUTAMYL-tRNA REDUCTASE)
AMINOBUTYRALDEHYDE DEHYDROGENASE
5'DEOXY-ADENOSYL-COBALAMIN
METHYLASPARTATE MUTASE
L-threo-3-METHYL-ASPARTATE
AVIDIN
SPERMINE
N-METHYLHYDANTOIN
CREATININE
(ALANINE+GLYCINE+HISTI-

Looks like the org chart of the UN? Reminds you of political decision making?



Sometimes even a chemical reaction does not know in what direction it wants to run…



Sometimes even a chemical reaction does not know in what direction it wants to run…

$\rightleftarrows$

Ok you say. Colour changes are nice but I need a green light from capital. How can chemistry help me with that?

Ok you say. Colour changes are nice but I need a green light from capital. How can chemistry help me with that?

Captured on Video!

https://www.youtube.com/watch?v=shZtgWBWFAA&feature=youtu.be

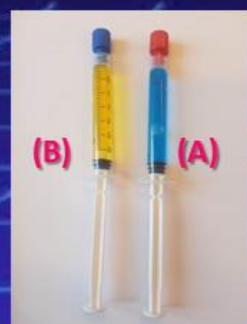
The Science For Diplomats Flow Chemistry System

You are in possession of a DIY flow chemistry kit!

Your kit contains:

- 1 Lego laboratory bench
- 1 flow chemistry assembly (consisting of three fluidic blocks with 5 connecters, tubing and a stopcock)
- 2 syringe to tubing connectors
- 1 syringe (3 ml) containing precursor A (blue)
- 1 syringe (3 ml) containing precursor B (yellow)
- 1 product collection container

Syringes containing precursors



Product collection container

Syringe to tubing connectors

Flow chemistry assembly

Lego laboratory bench

Your kit includes all the parts you will need to safely mix component chemicals (precursors) together to produce and collect a new chemical product.

The Science For Diplomats Flow Chemistry System

OPCW

You are in possession of a DIY flow chemistry kit!

Your kit contains:

- 1 Lego laboratory bench
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- 2 syringe to tubing con
- 1 syringe (3 ml) contai
- 1 syringe (3 ml) contai
- 1 product collection co

Syringes containing precursors

roduct collection container

Syringe to tubing connectors

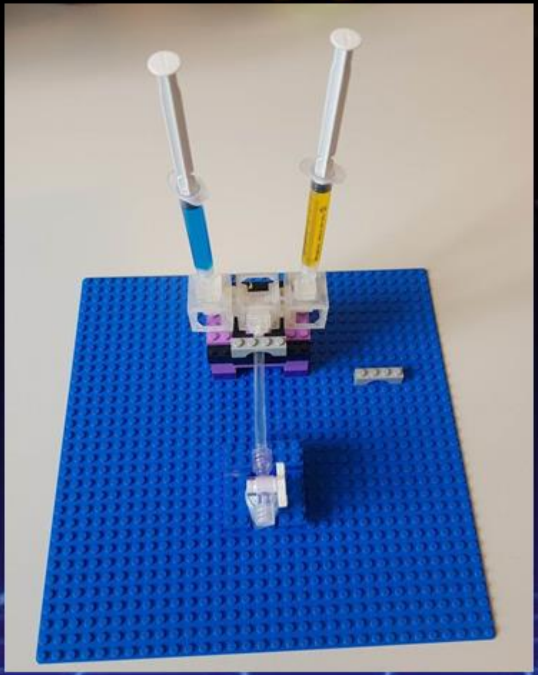
Flow chemistry assembly

Lego laboratory bench

Your kit includes all the parts you will need to safely mix component chemicals (precursors) together to produce and collect a new chemical product.

A fully assembled flow chemistry system should look like this:

OPCW



Your task:

1. Figure out how to assemble the system
2. Mix precursors A and B
3. Collect the product (without spilling, leaking or otherwise contaminating your work space!)

Prizes will awarded for the perfect combination of system assembly, chemical containment, product purity and product yield. Good luck diplochemists!

Assembly instructions?

We keep hearing how easy it is to produce chemicals using DIY approaches, now you can show us how!

... in case you really want instructions... just ask! A cheat sheet is available upon request.

A fully assembled flow chemistry system should look like this:

Your task

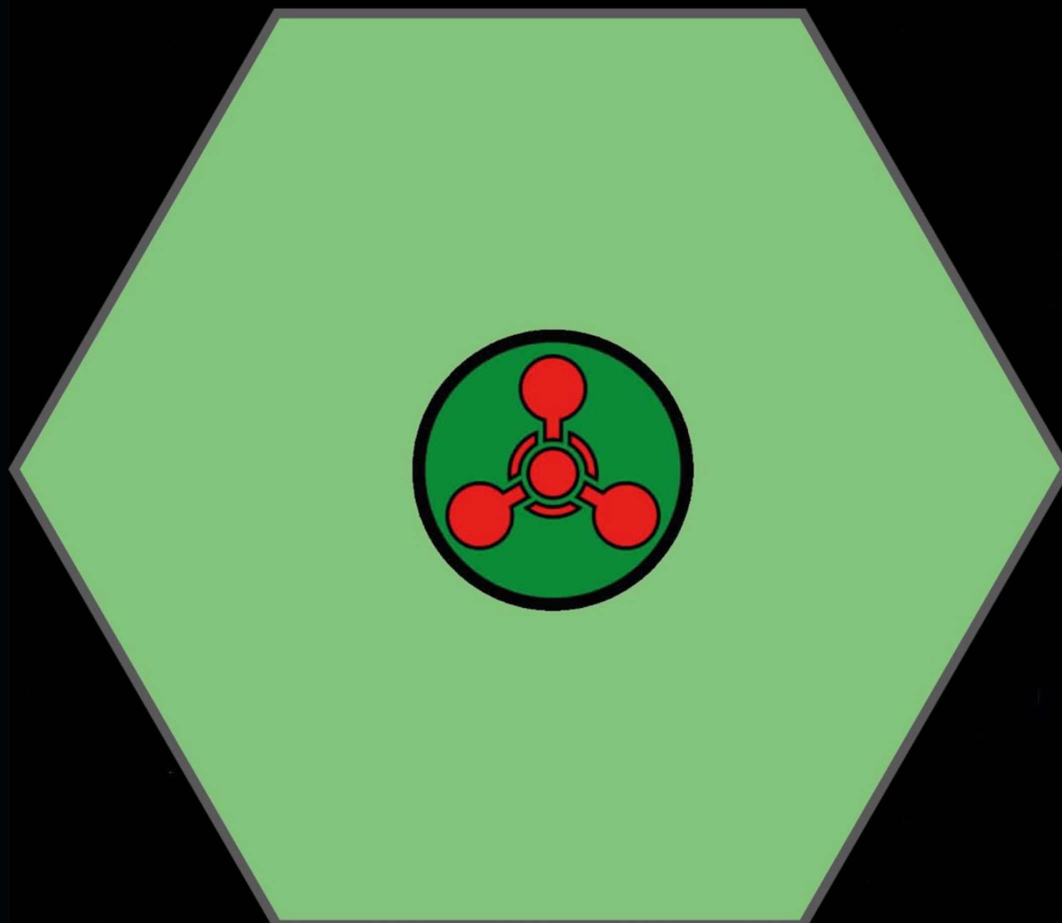
1. Figure ou
2. Mix pre
3. Collect th

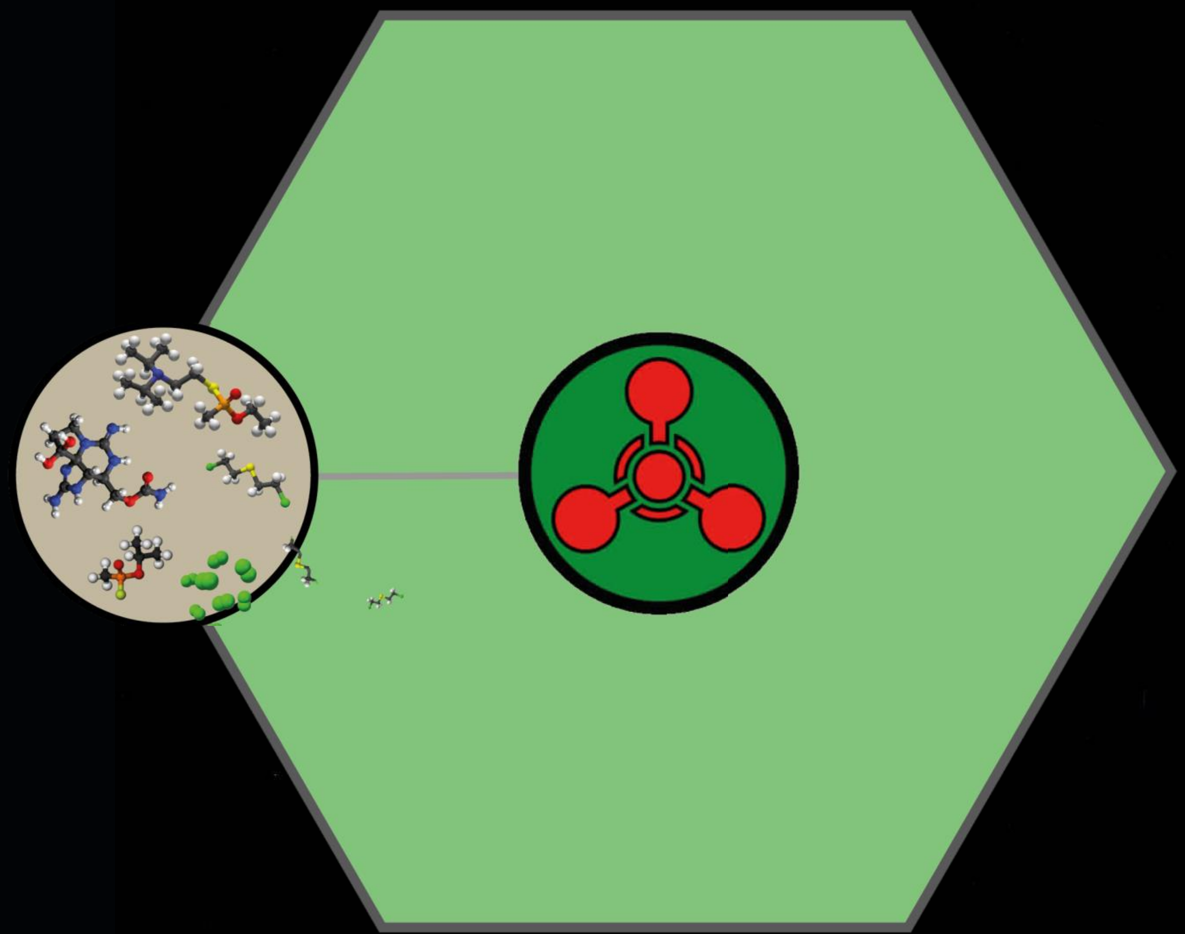
Prizes will a … rity and
product yiel

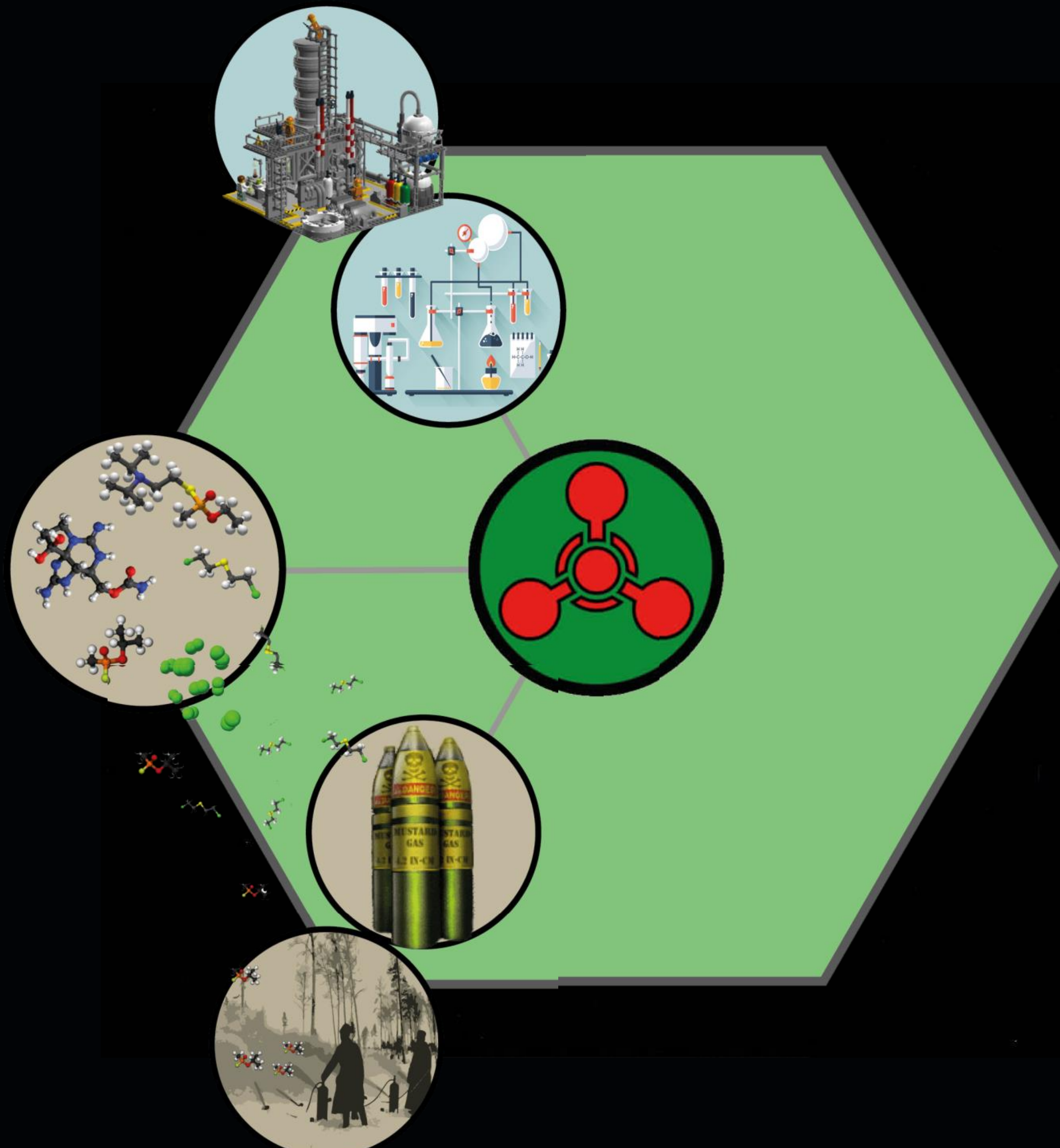
Assembly

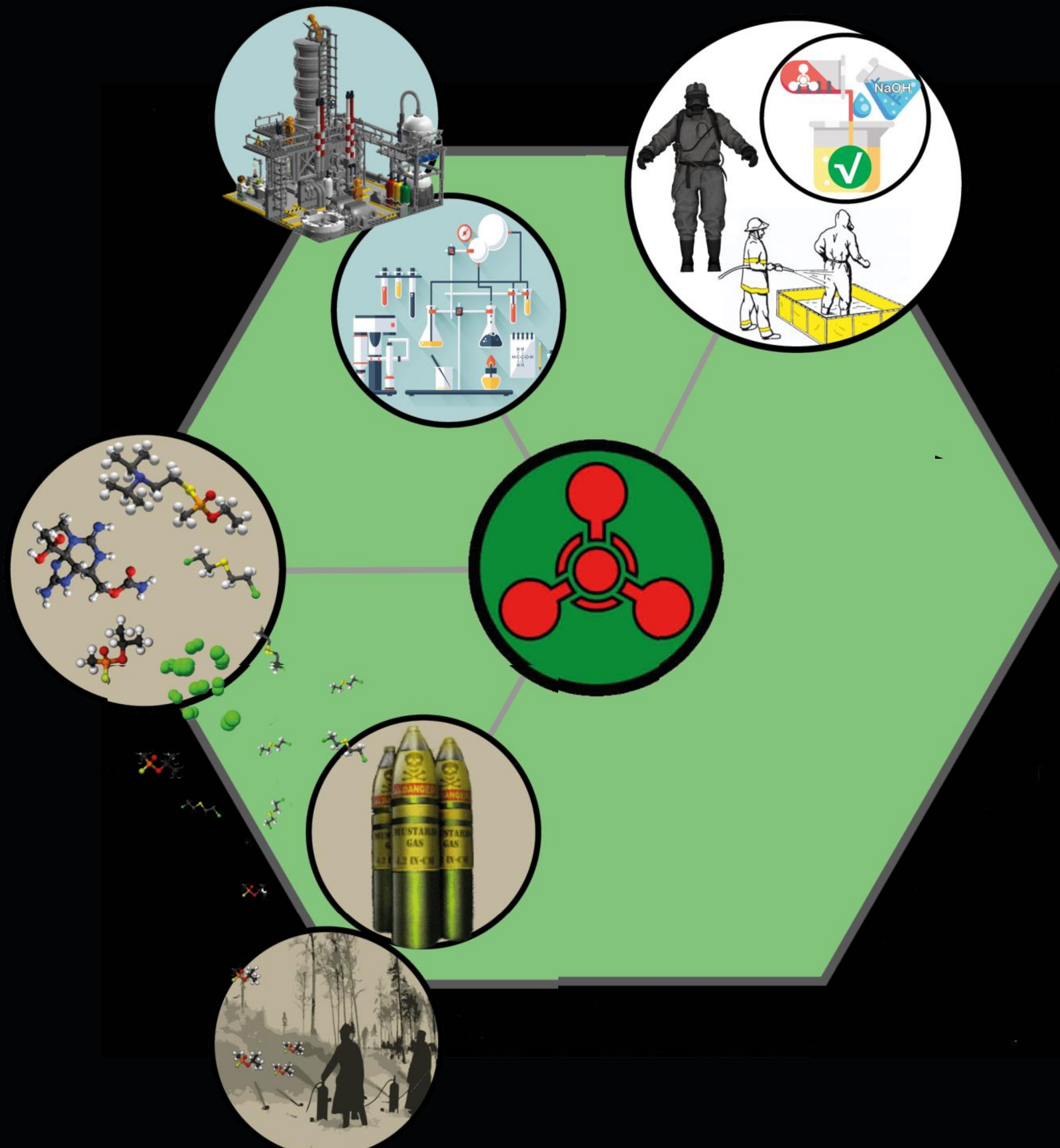
We keep he … w!

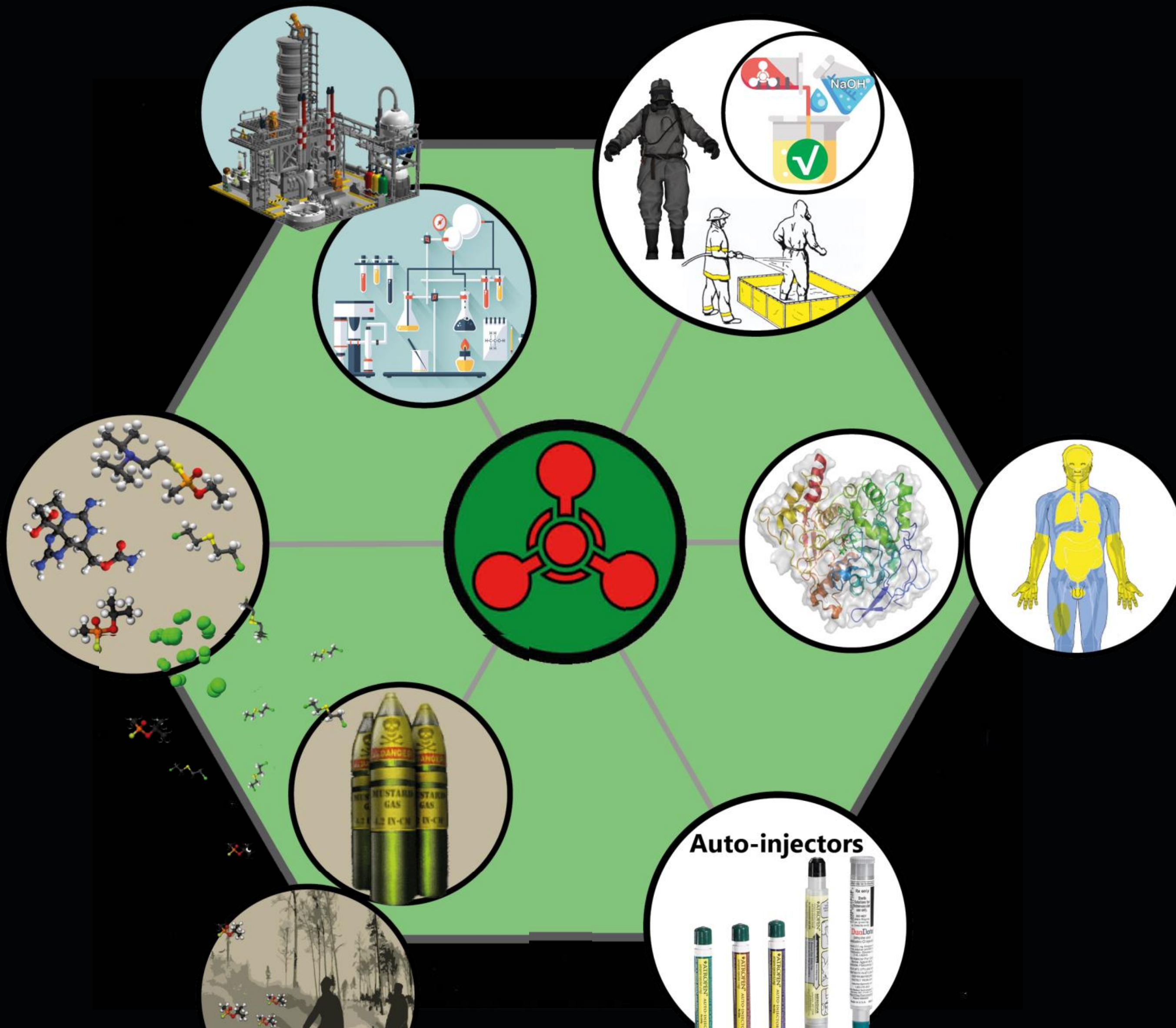
... in case you really want instructions... just ask! A cheat sheet is available upon request.

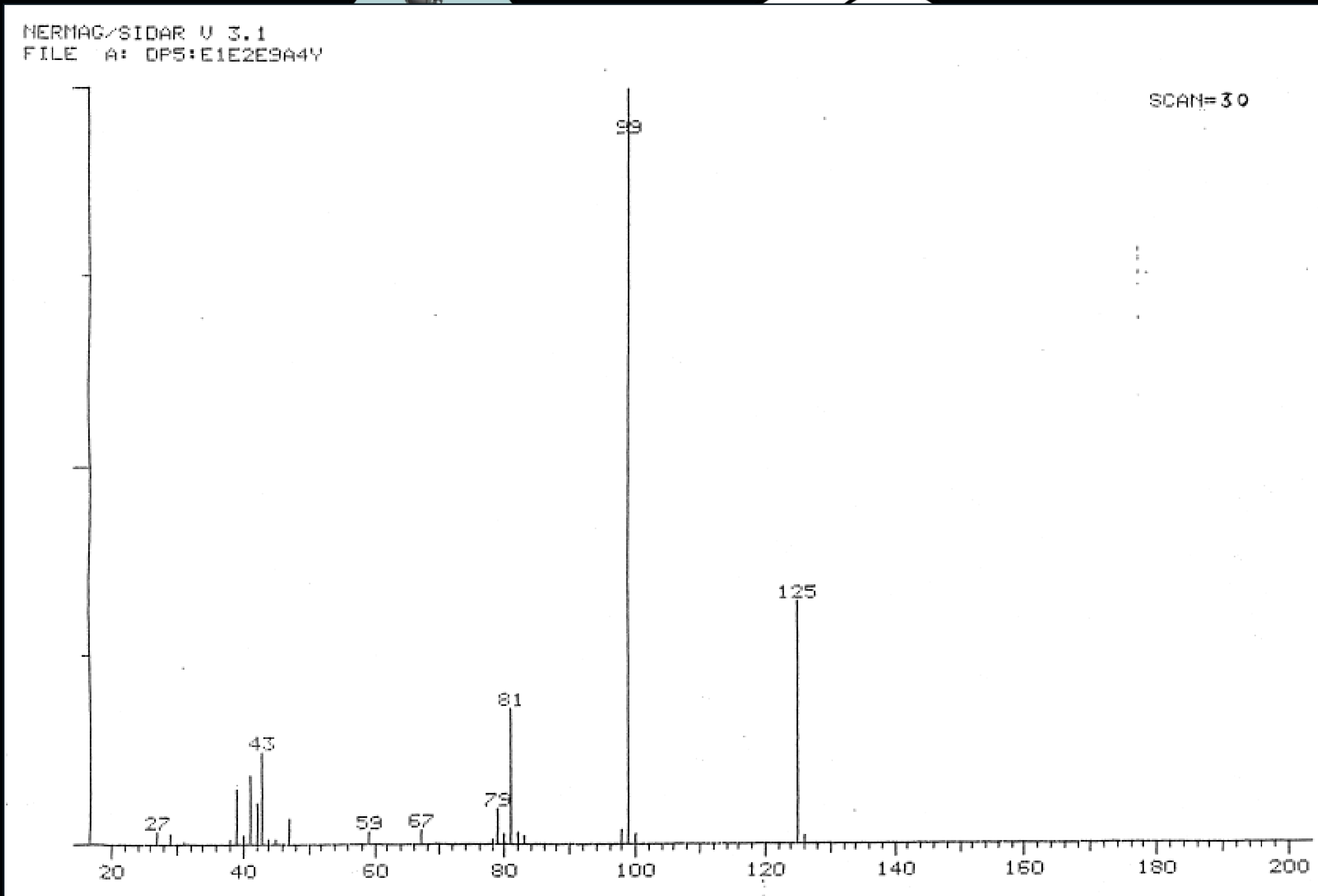


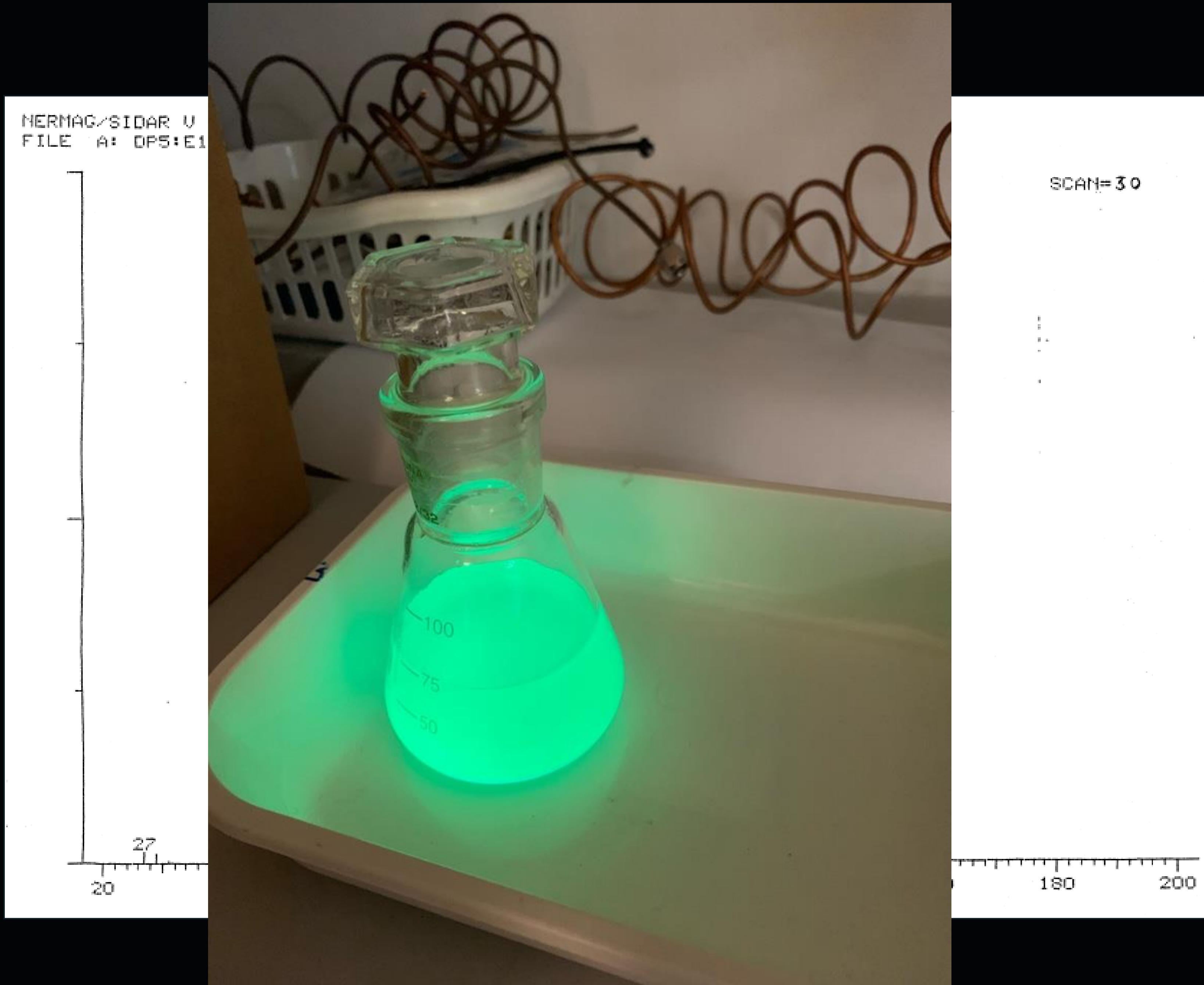



MUSTARD GAS

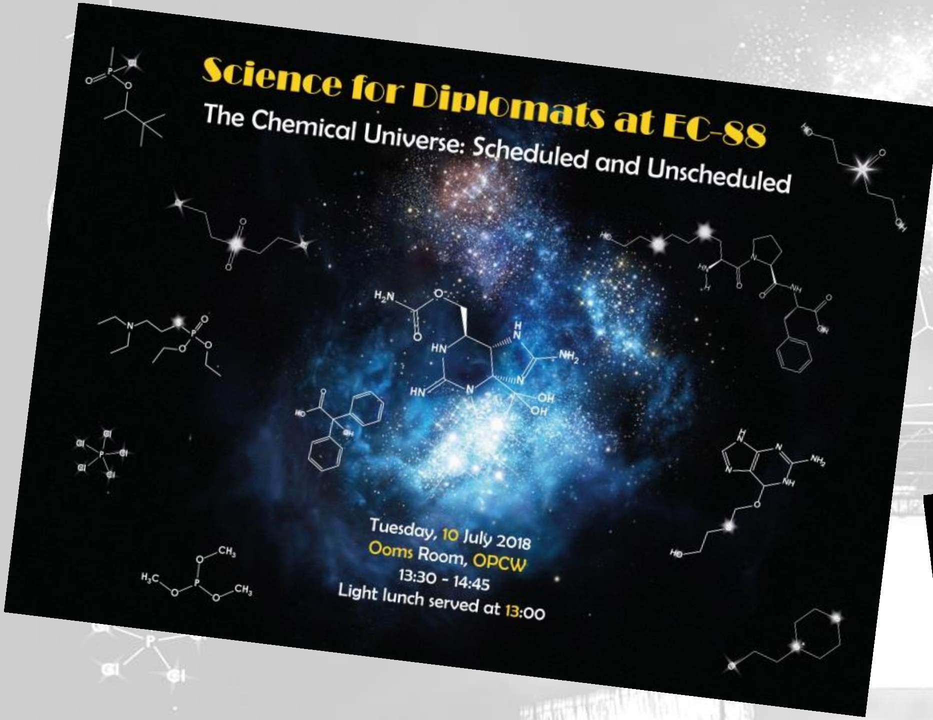

NaOH
DANGER
MUSTARD GAS
4.2 IN-CM


NaOH
Auto-injectors


NERMAG/SIDAR V 3.1
FILE A: DPS:E1E2E9A4Y
SCAN=30
99
125
81
43
79
27
59
67
20
40
60
80
100
120
140
160
180
200


NERMAG/SIDAR V
FILE A: DP5:E1
SCAN=30
27
20
180
200
100
75
50

Chemistry Lessons



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Chemistry Lessons

What is missing?

How can we make the "Unnofficial" Annex on Chemicals more informative?

From the audience:

rule

ses explanations of cemic

more real chemical exerci

hal compositions

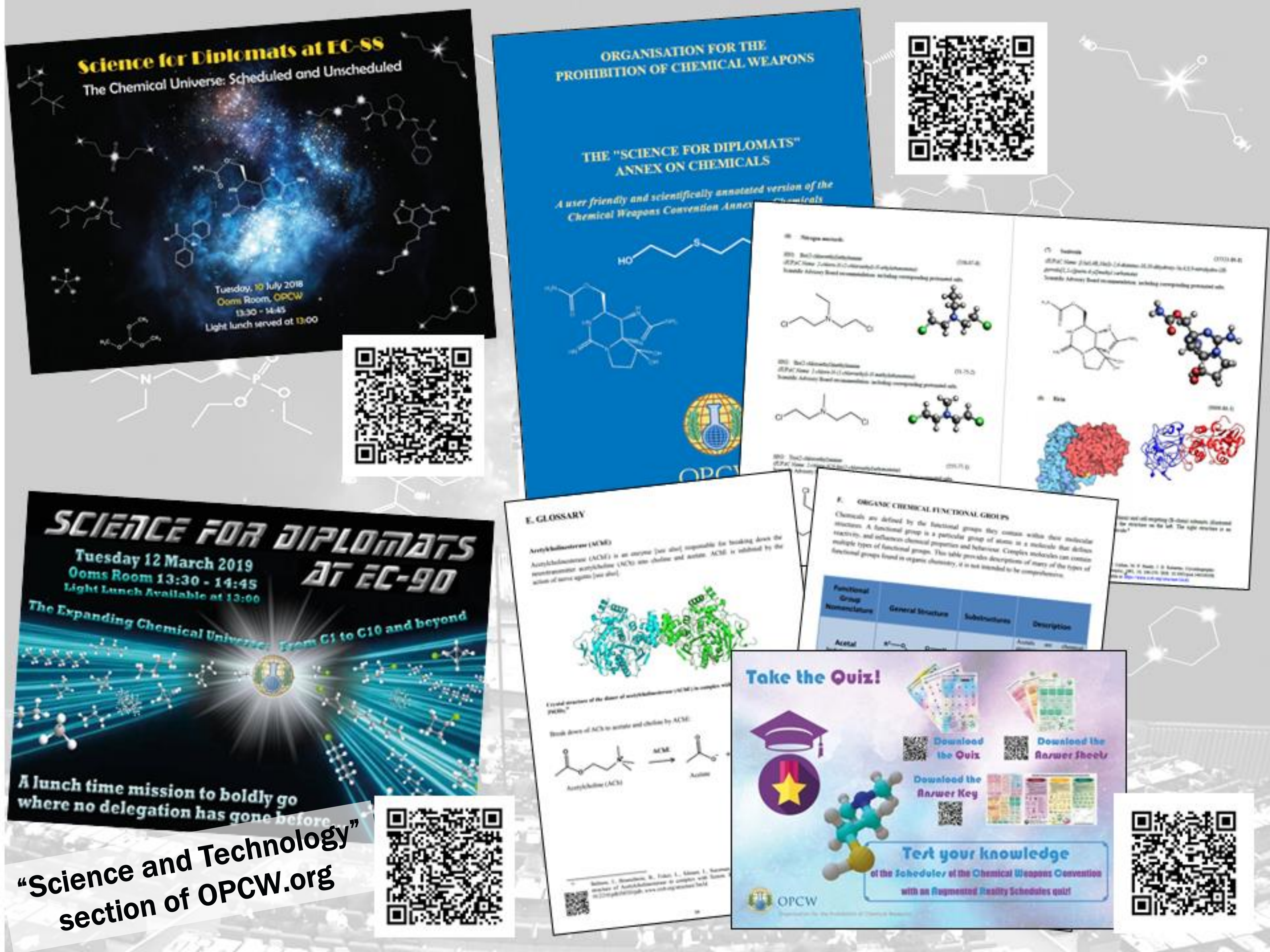
links

guys

you

3

What is missing



Science for Diplomats at EC-88
The Chemical Universe: Scheduled and Unscheduled
Tuesday, 10 July 2018
Ooms Room, OPCW
13:30 - 14:45
Light lunch served at 13:00
ORGANISATION FOR THE PROHIBITION OF CHEMICAL WEAPONS
THE "SCIENCE FOR DIPLOMATS" ANNEX ON CHEMICALS
A user friendly and scientifically annotated version of the Chemical Weapons Convention Annex on Chemicals
HO
S
OPCW
E. GLOSSARY
Acetylcholinesterase (AChE)
Acetylcholine (ACh)
Acetate
F. ORGANIC CHEMICAL FUNCTIONAL GROUPS
Functional Group Nomenclature
General Structure
Substructures
Description
Acetal
SCIENCE FOR DIPLOMATS AT EC-90
Tuesday 12 March 2019
Ooms Room 13:30 - 14:45
Light Lunch Available at 13:00
The Expanding Chemical Universe: From C1 to C10 and beyond
A lunch time mission to boldly go where no delegation has gone before
"Science and Technology" section of OPCW.org
Take the Quiz!
Download the Quiz
Download the Answer Sheets
Download the Answer Key
Test your knowledge
of the Schedules of the Chemical Weapons Convention
with an Augmented Reality Schedules quiz!
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Scientific Advisory Board Update

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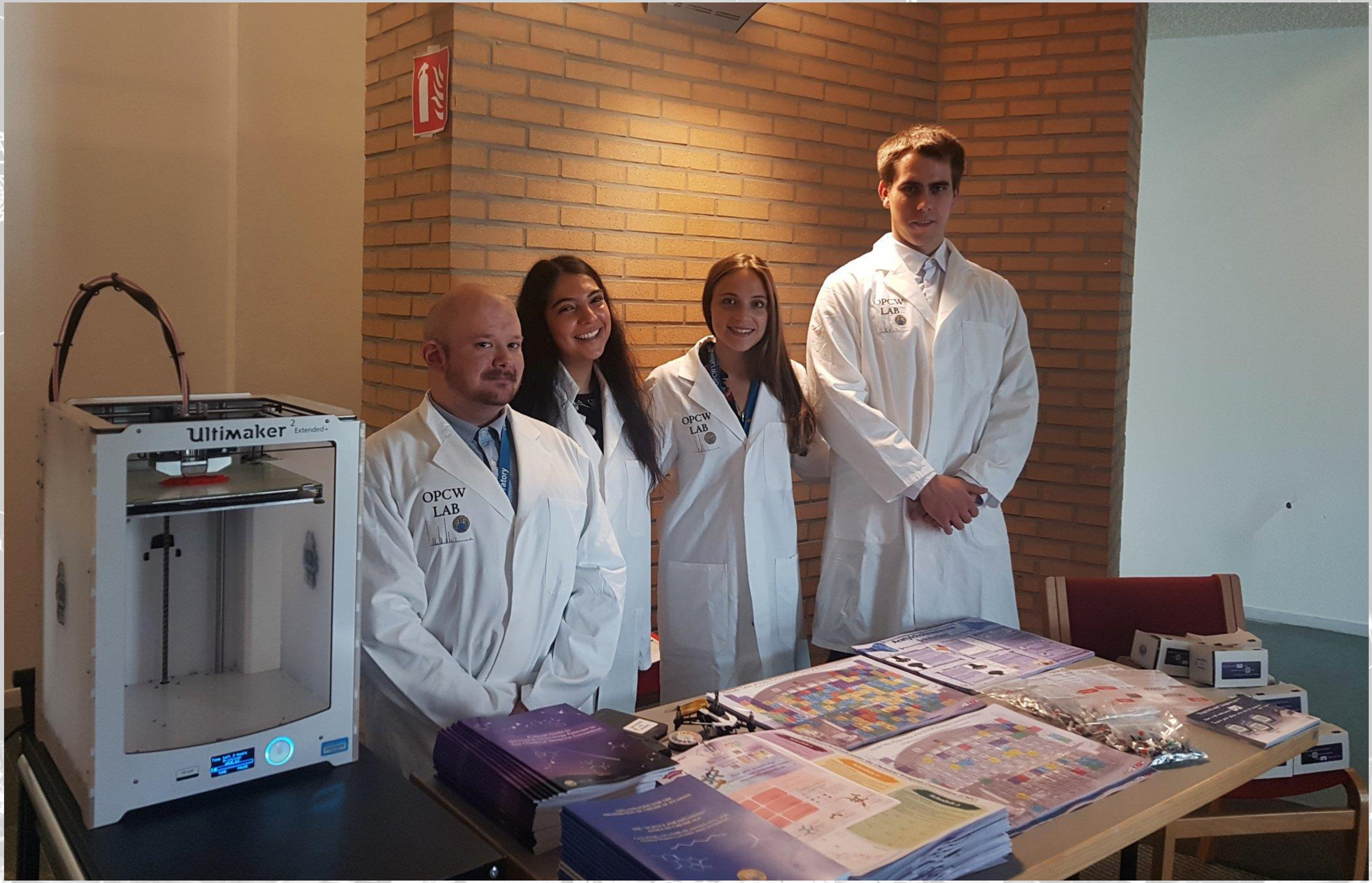
Scientific Advisory Board Update

Third report now available.
TWG will meet twice more, then produce a final report.

OPCW

Some Acknowledgements: Interns!



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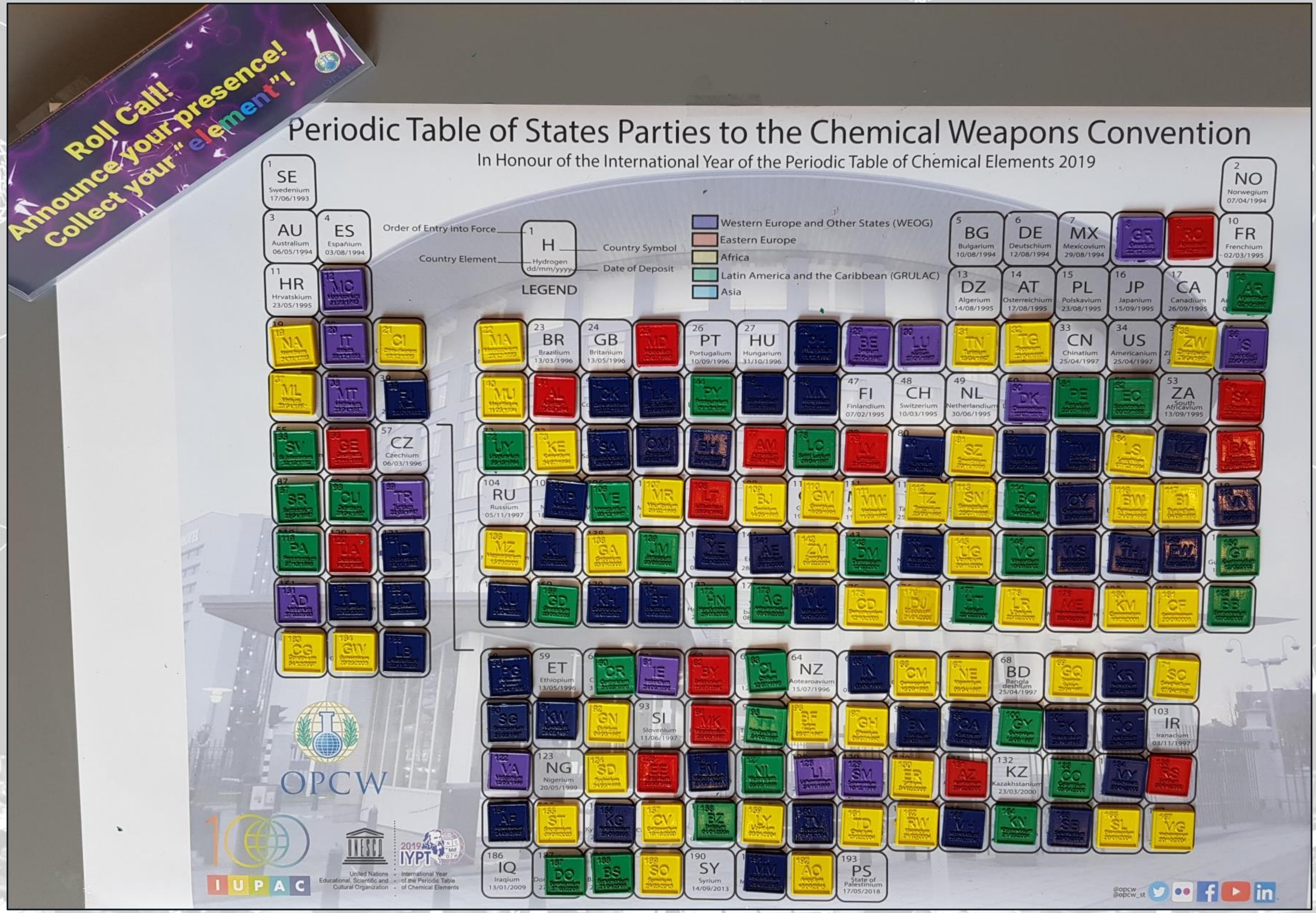
Thank you for Joining Us!



Periodic Table of States Parties to the Chemical Weapons Convention
In Honour of the International Year of the Periodic Table of Chemical Elements 2019
Order of Entry into Force
Country Element
1 H Hydrogen dd/mm/yyyy
Country Symbol
Date of Deposit
LEGEND
Western Europe and
Eastern Europe
Africa
Latin America and th
Asia
6 DE Deutschium 12/08/1994
Thank you for lunch!
1 SE Swedenium 17/06/1993
2 NO Norwegium 07/04/1994
3 AU Australium 06/05/1994
4 ES Españium 03/08/1994
8 GR Greecium 22/12/1994
9 RO Romanium 15/02/1995
10 FR Frenchium 02/03/1995
11 HR Hrvatskium 23/05/1995
12 MC Monacovium 01/06/1995
16 JP Japanium 15/09/1995
17 CA Canadium 26/09/1995
18 AR Argentinium 02/10/1995
19 NA Namibium 24/11/1995
20 IT Italium 08/12/1995
21 CI Côte dIvorium 18/12/1995
22 MA Moroccovium 28/12/1995
23 BR Brazilium 13/03/1996
24 GB Britanium 13/05/1996
25 MD Moldovium 08/07/1996
26 PT Portugalium 10/09/1996
27 HU Hungarium 31/10/1996
28 PH Philippin
34 US Americanium 25/04/1997
35 ZW Zimbabwium 25/04/1997
36 IS Icelandium 28/04/1997
37 ML Malium 28/04/1997
38 MT Maltavium 28/04/1997
39 FJ Fijium 20/01/1993
40 MU Mauritisium 09/02/1993
41 AL Albanium 11/05/1994
42 CK Cook Islandium 15/02/1994
43 LK Sri Lankium 19/08/1994
44 PY Paraguayium 01/12/1994
45 TJ Tajikistanium 11/01/1995
46 MN Mongoli
52 EC Ecuadorium 06/09/1995
53 ZA South Africavium 13/09/1995
54 SK Slovakium
55 SV El Salvadorium 30/10/1995
56 GE Georgium 27/11/1995
57 CZ Czechium 06/03/1996
72 UY Uruguayium 06/10/1994
73 KE Kenyatium 24/07/1994
74 SA Saudia Arabium 09/08/1996
75 OM Omanium 08/02/1995
76 BH Bahrainium 28/04/1997
77 AM Armenium 27/01/1997
78 LC Saint Lucium 09/04/1997
Latvium 23/07/1996
Laovium
Eswatinium 20/11/1996
Maldivium 31/05/1994
84 LS
85
86 BA Bosnium
87 SR Surinamium 28/04/1997
88 CU Cubatium 29/04/1997
89 TR Turkium 22/05/1997
104 RU Russium 05/11/1997
105 NP Nepalium 18/11/1997
106 VE Venezuelium 03/12/1997
107 MR Mauritanium 09/02/1998
108 LT
109 BJ Beninium
110 GM Gambium
111 MW
112
113
115 CY Cyprussium
116 BW 31/08/1998
117 BI Burundium 04/09/1998
118 VN Vietnamium 30/09/1998
119 PA Panamanium 07/10/1998
120 UA Ukrainium 14/10/1998
121 ID Indonesiuum 12/11/1998
136 MZ Mozambiqium 15/08/2000
137 KI Kiribatium 07/09/2000
138 GA Gabonium 08/09/2000
139 JM Jamaicium 08/09/2000
140 YE
AE Emiratium
ZM Zambium 09/02/2001
DM Dominicium 12/02/2001
NR Nauruvium 12/11/2001
145 UG Ugandium 30/11/2001
146 VC Vincentium 18/09/2002
147 WS Samoatium 27/09/2002
148 TH Thailandium 10/12/2002
149 PW Palauvium 05/02/2003
150 GT Guatemalium 12/02/2003
151 AD Andorrium 27/02/2003
152 TL Timor Lestium 07/05/2003
153 TO Tongovium 29/05/2003
168 NU Niuium 21/04/2005
169 GD Grenadium 03/06/2005
170 KH Cambodium 19/07/2005
171 BT Bhutanium 18/08/2005
172 HN Hondurasium 29/08/2005
173 AG Antigua barbudium 08/09/2000
174 VU Vanuatium 16/09/2005
175 CD Demcon gonium 09/02/2001
176 DJ Djiboutium 21/01/2006
177 HT Haitium 22/02/2006
178 LR Liberium 23/02/2006
179 ME Montenegrium 15/04/1998
180 KM Comorosium 18/08/2006
181 CF Centrafri cainium 21/01/2006
182 BB Barbadosium 07/03/2007
183 CG Congovium 04/12/2007
184 GW Guineabisium 20/05/2008
185 LB Lebanonium 20/11/2008
58 PG Papua New Guinium 17/04/1996
59 ET Ethiopium 13/05/1996
60 CR Costaricium 31/05/1996
61 IE Irelandium 24/06/1996
62 BY Belarusium 11/07/1996
63 CL Chilium 12/07/1996
64 NZ Aotearoavium 15/07/1996
65 IN Indium 03/09/1996
66 CM Cameroonium 16/09/1996
67 NE Nigeratium 09/04/1997
68 BD Bangla deshium 25/04/1997
69 GQ Equatorial Guinium 25/04/1997
70 KR Koreatium 28/04/1997
71 SC Seychellium 07/04/1993
90 SG Singaporium 21/05/1997
91 KW Kuwaitium 29/05/1997
92 GN Guinium 09/06/1997
93 SI Slovenium 11/06/1997
94 MK Macedonium 20/06/1997
95 TT Trinibagium 24/06/1997
96 BF Brukina Fasium 08/07/1997
97 GH Ghanium 09/07/1997
98 BN Brunium 28/07/1997
99 QA Qatarium 03/09/1997
100 GY Guyanium 12/09/1997
101 PK Pakistanium 28/10/1997
102 JO Jordanium 29/10/1997
103 IR Iranacium 03/11/1997
122 VA Vaticanium 12/05/1999
123 NG Nigerium 20/05/1999
124 SD Sudanium 24/05/1999
125 EE Estonium 26/05/1999
126 FM Micronesium 21/06/1999
127 NI Nicaragium 05/11/1999
128 LI Lichten steinium 24/11/1999
129 SM Sanmarinium 10/12/1999
130 ER Eritrium 24/02/2000
131 AZ Azerbijanium 29/02/2000
132 KZ Kazakhstanium 23/03/2000
133 CO Colombium 05/04/2000
134 MY Malaysium 20/04/2000
135 RS Serbium 20/04/2000
154 AF Afghani stanium 24/09/2003
155 ST Saotomium 09/09/2003
156 KG Kyrgyzstanium 29/09/2003
157 CV Carboverdium 10/10/2003
158 BZ Belizium 01/12/2003
159 LY Libyatium 06/01/2004
160 TV Tuvalium 19/01/2004
161 TD Chadium 13/02/2004
162 RW Rwandium 31/03/2004
163 MH Marshallium 19/05/2004
164 KN Kittsnevisium 21/05/2004
165 SB Solomonium 23/09/2004
166 SL Sierraleonium 30/09/2004
167 MG Madagas carium 20/10/2004
186 IQ Iraqium 13/01/2009
187 DO Dominicanium 27/03/2009
188 BS Bahamasium 21/04/2009
189 SO Somalium 29/05/2013
190 SY Syrium 14/09/2013
191 MM Myanmarium 06/07/2015
192 AO Angolium 16/09/2015
193 PS State of Palestinium 17/05/2018
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IUPAC
United Nations Educational, Scientific and Cultural Organization
International Year of the Periodic Table of Chemical Elements
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Good Luck Dr Blum, we will miss you!

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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