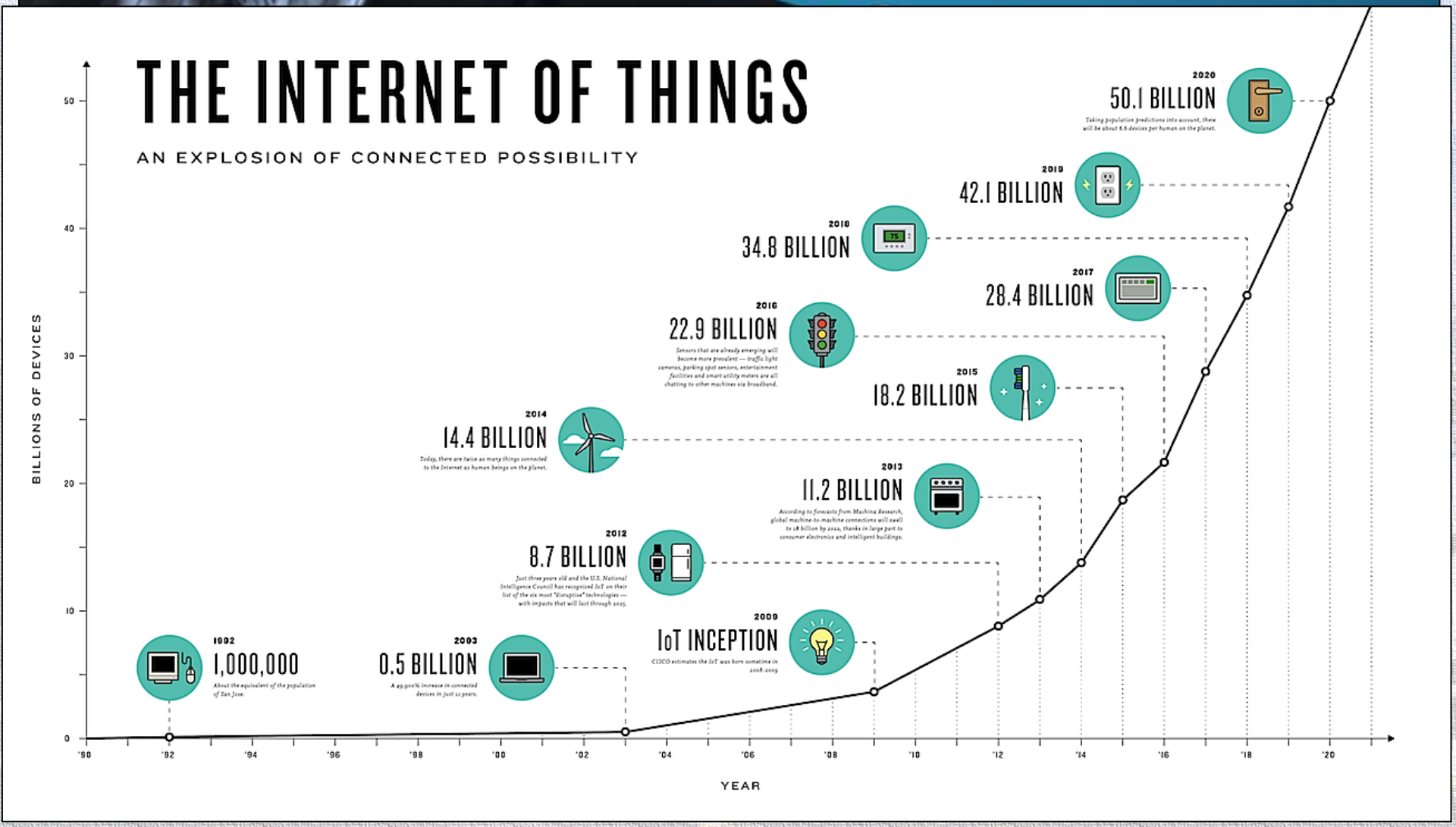
Emerging Technology and the work of the OPCW Scientific Advisory Board

Emerging Technologies and the CWC:
Mobile Data Collection, Big Data and Artificial Intelligence
21st Conference of the States Parties of the Chemical Weapons Convention
28 November 2016

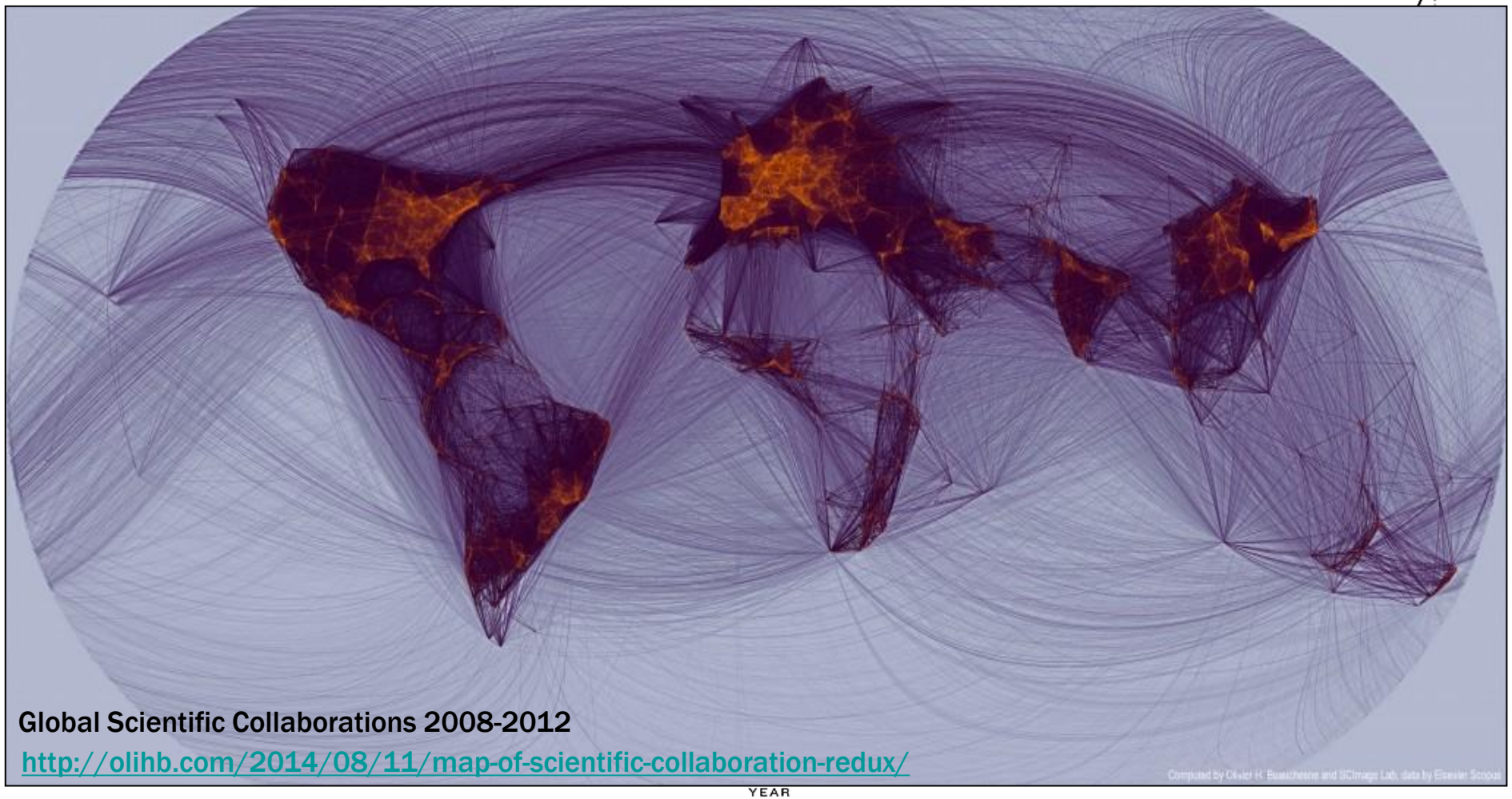
Jonathan E. Forman, Ph.D.
Science Policy Adviser and Secretary to the Scientific Advisory Board

Data Collection and Sharing has Never Been Easier

Data Collection and Sharing has Never Been Easier



Data Collection and Sharing has Never Been Easier



Global Scientific Collaborations 2008-2012

http://olihb.com/2014/08/11/map-of-scientific-collaboration-redux/

All of this Advanced Science and Technology with Misuse Potential and…

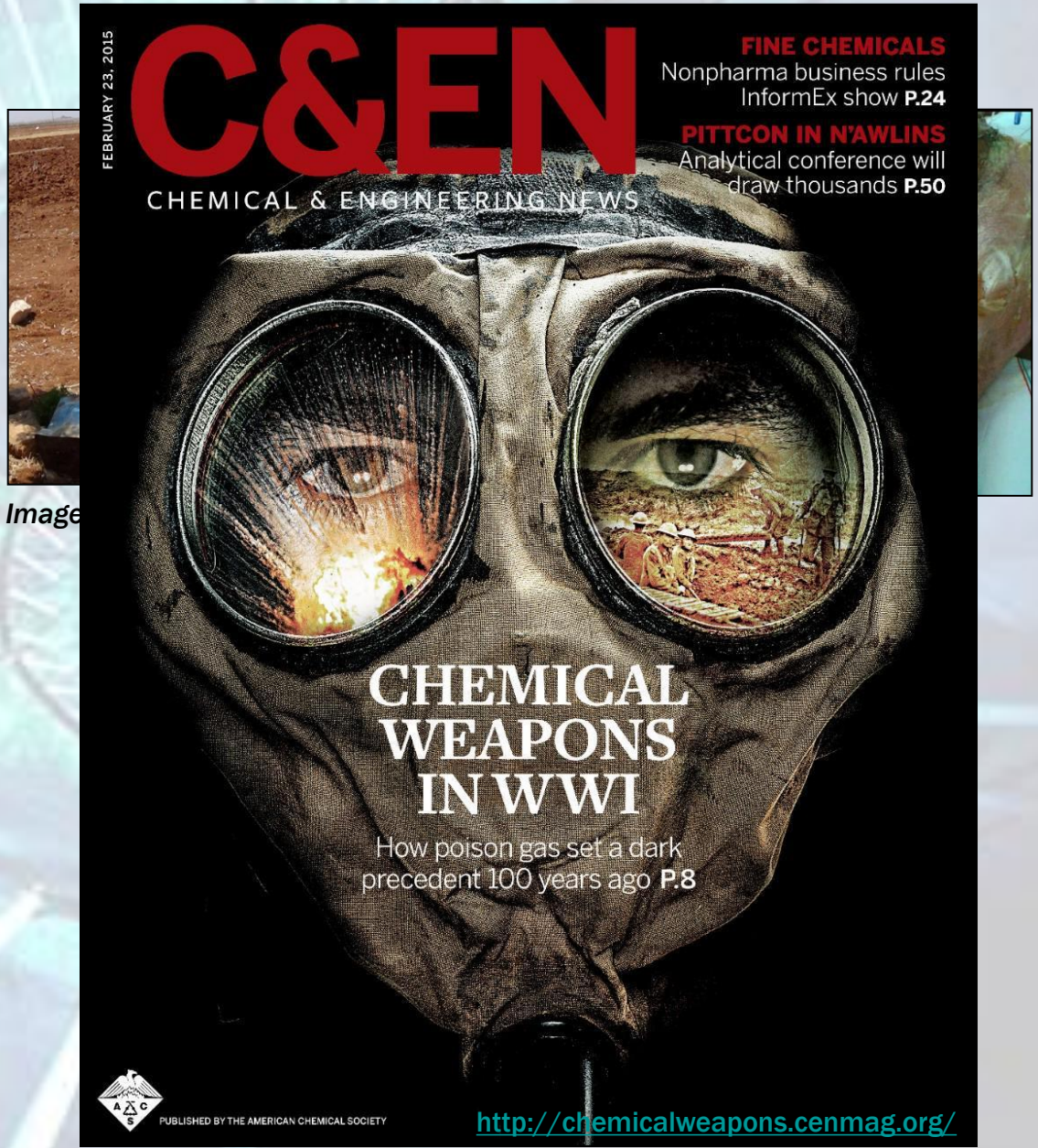
- **Allegations of use of Chlorine Gas and Sulphur Mustard**

Image from bellingcat

Image circulating on social media, August 2015

All of this Advanced Science and Technology with Misuse Potential and…

- **Allegations of use of Chlorine Gas and Sulphur Mustard**



Image

All of this Advanced Science and Technology with Misuse Potential and…

- **Allegations of use of Chlorine Gas and Sulphur Mustard**
- **Diseases found in nature**
  - Nature does not sign or honour treaties!

Disarmament Cannot Afford to be Scientifically or Technologically Illiterate

- **Maintain Critical Knowledge**
  - Analytical capabilities
  - Protection and treatment
  - Agents
  - Production methods
  - Delivery methods
- **Science and Technology**
  - *Recognize opportunities*
  - *Understand concerns*
  - *Evolve with technology*

Opportunities Abound for Chemistry

GC/MS

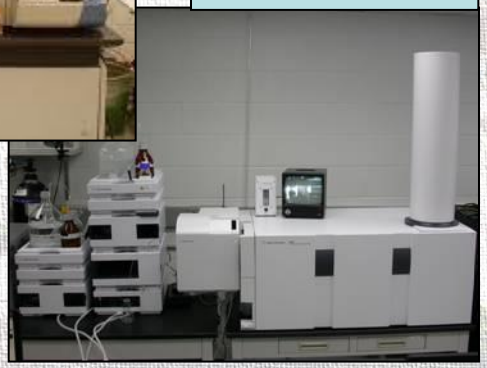
GC/FTIR

GC/FPD

GC/AED

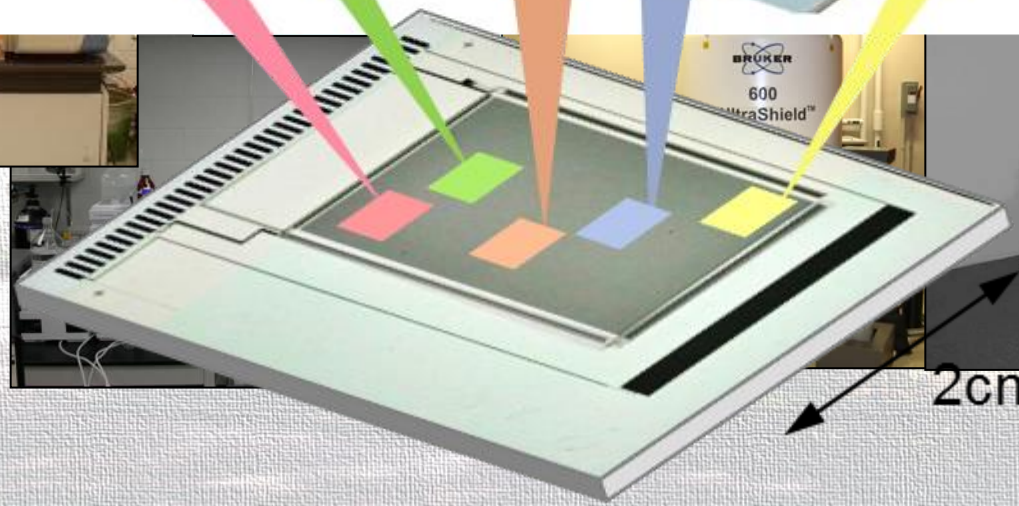
LC/MS

LC/HRMS



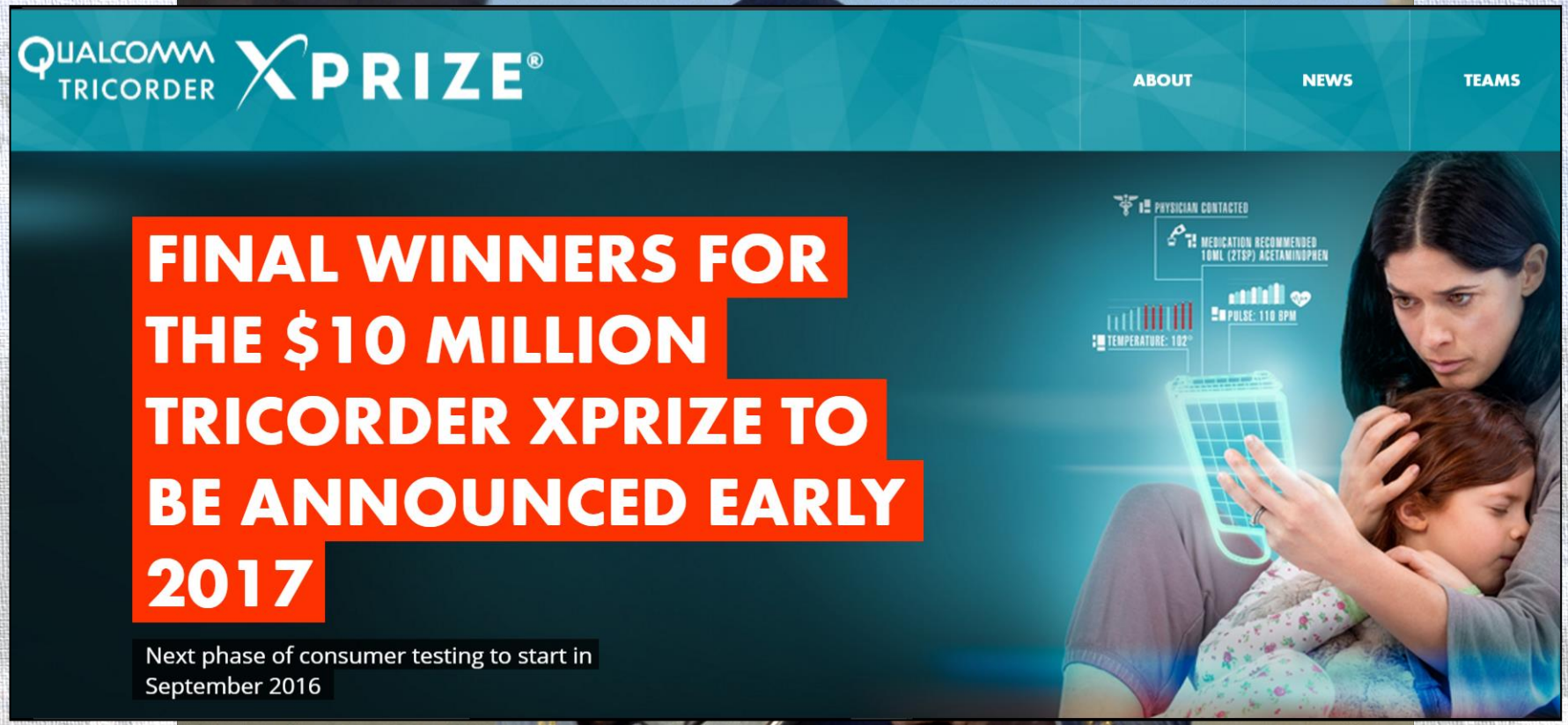
NMR

Opportunities Abound for Chemistry

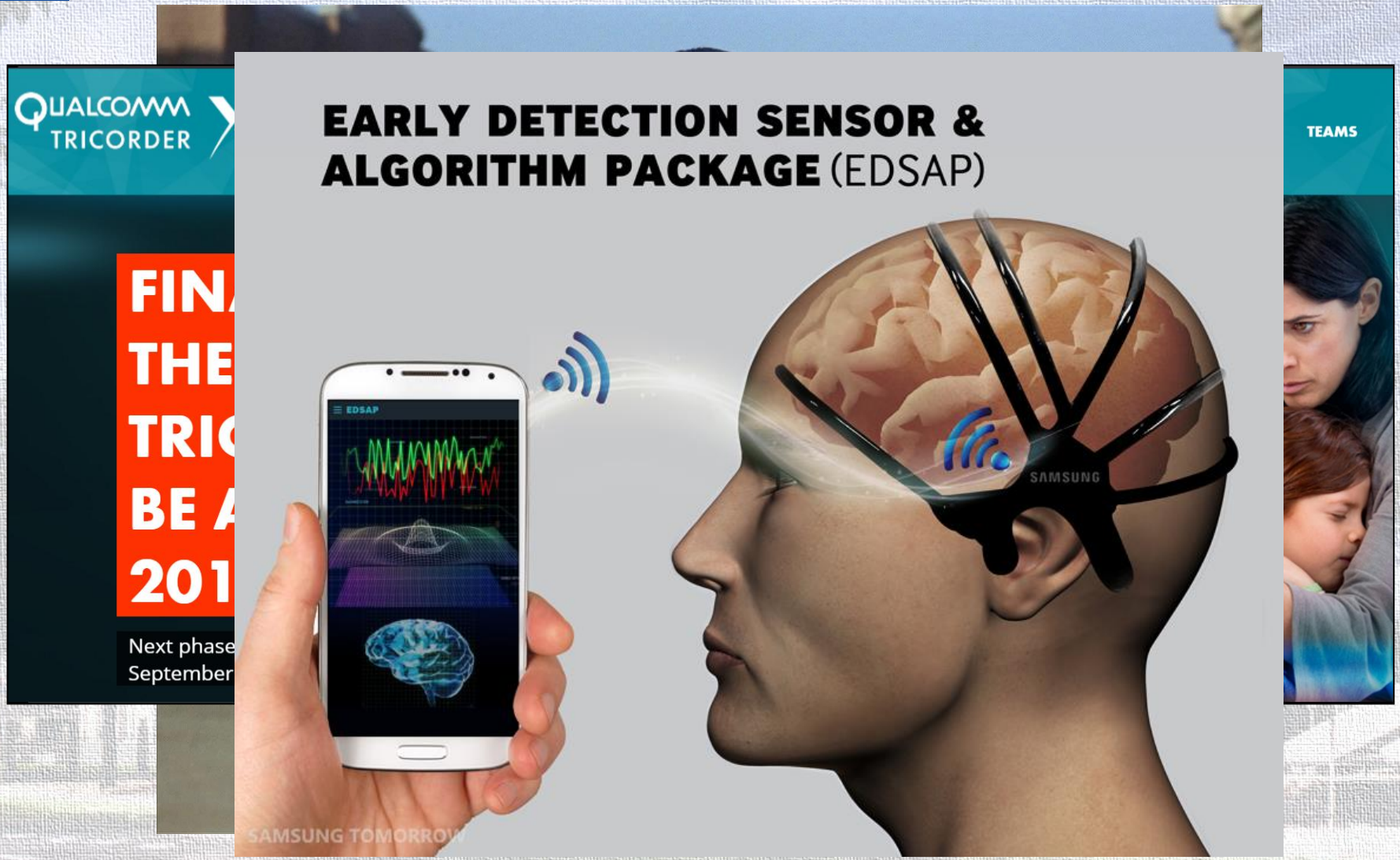


The Elusive Tricorder...

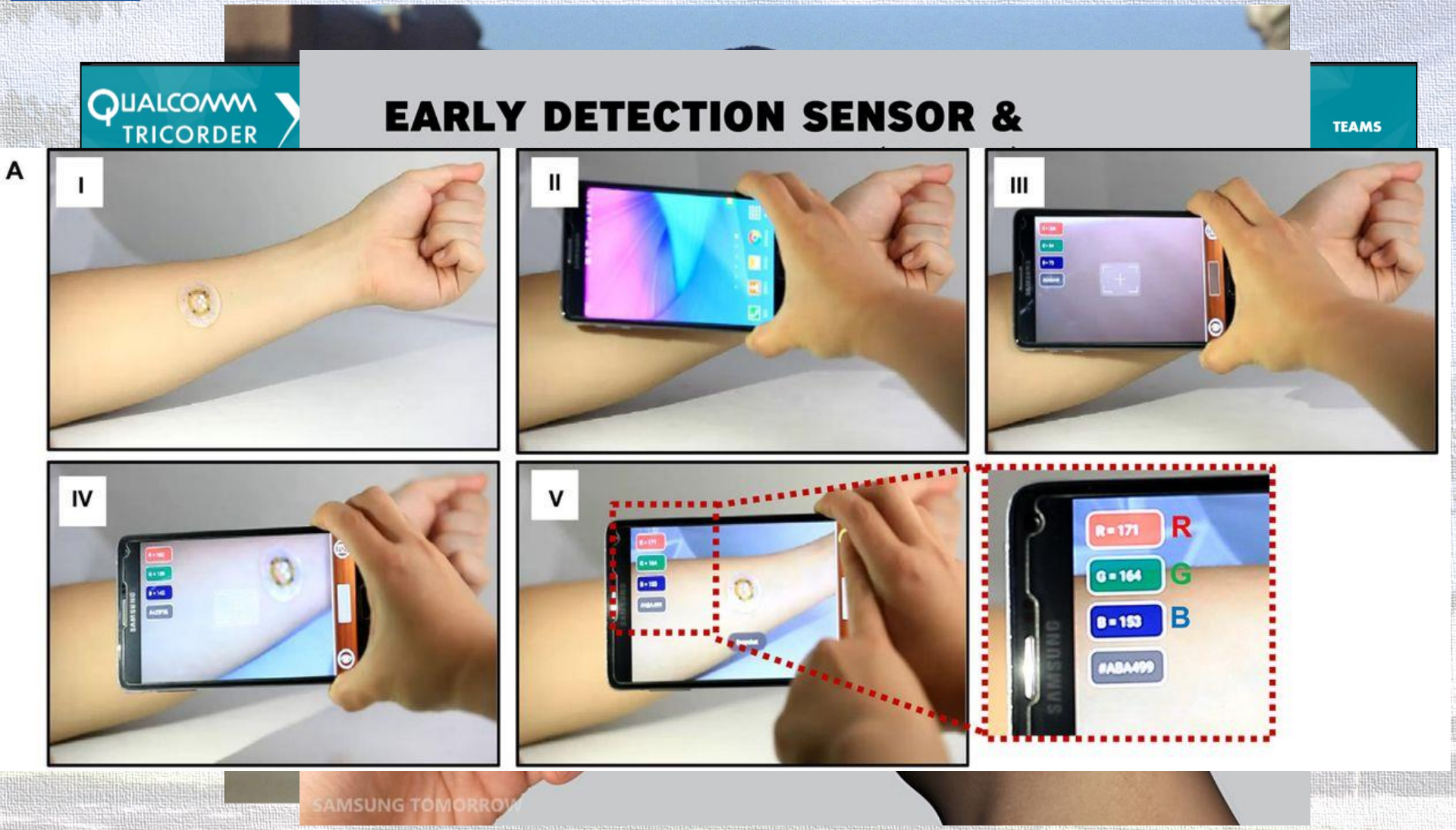
The Elusive Tricorder...



The Elusive Tricorder...



The Elusive Tricorder…



http://stm.sciencemag.org/content/8/366/366ra165

Mobile Laboratories

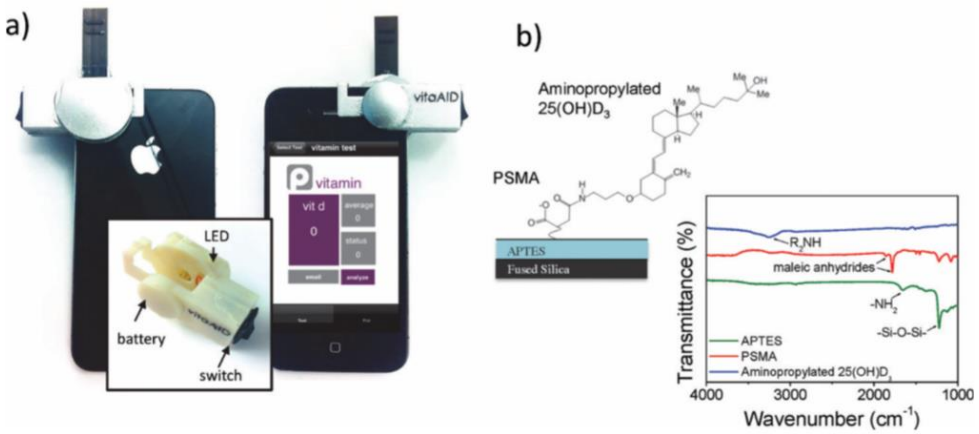


Fig. 1 a) vitaAID accessory on a iPhone with the inset showing the components of the accessory b) FT-IR spectra showing the chemical composition of the APTES, maleic anhydride and aminopropylated 25(OH)D_3 layers that constitute the detection area.

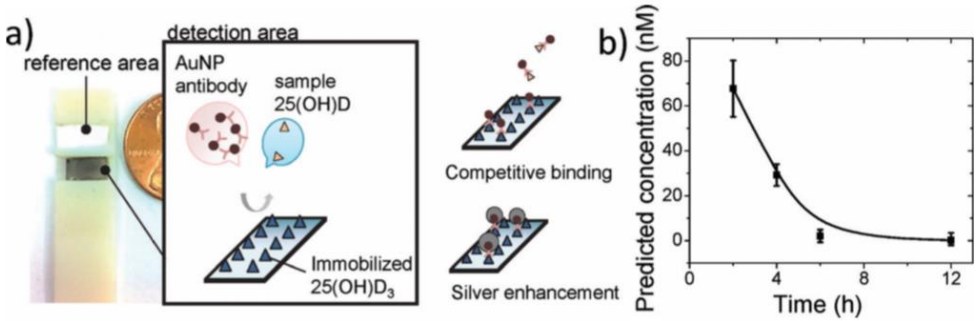


Fig. 2 a) Test strip and schematic of the gold nanoparticle-based immunoassay reaction on the detection area b) variation in predicted concentration at different AuNP-anti-25(OH)D_3 incubation times on the detection area for 0 nM sample 25(OH)D.

Lab Chip, 2014,**14**, 1437-1442, DOI: 10.1039/C3LC51375K

Mobile Laboratories

Environ. Sci. Technol. (2015), *49* , 2977–2982
DOI: 10.1021/es505362x

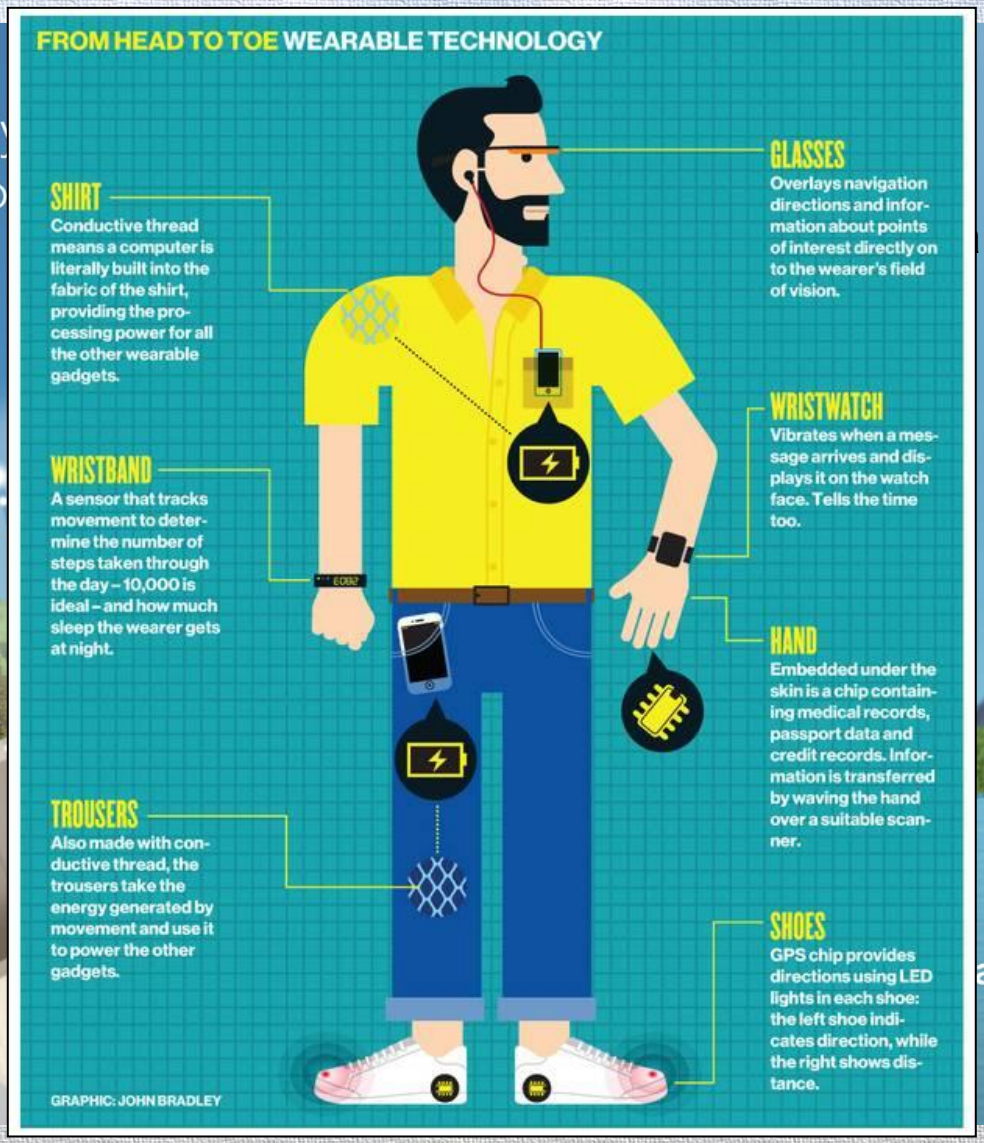
Mobile Laboratories

Environ. Sci. Tec
DOI: 10.1021/es

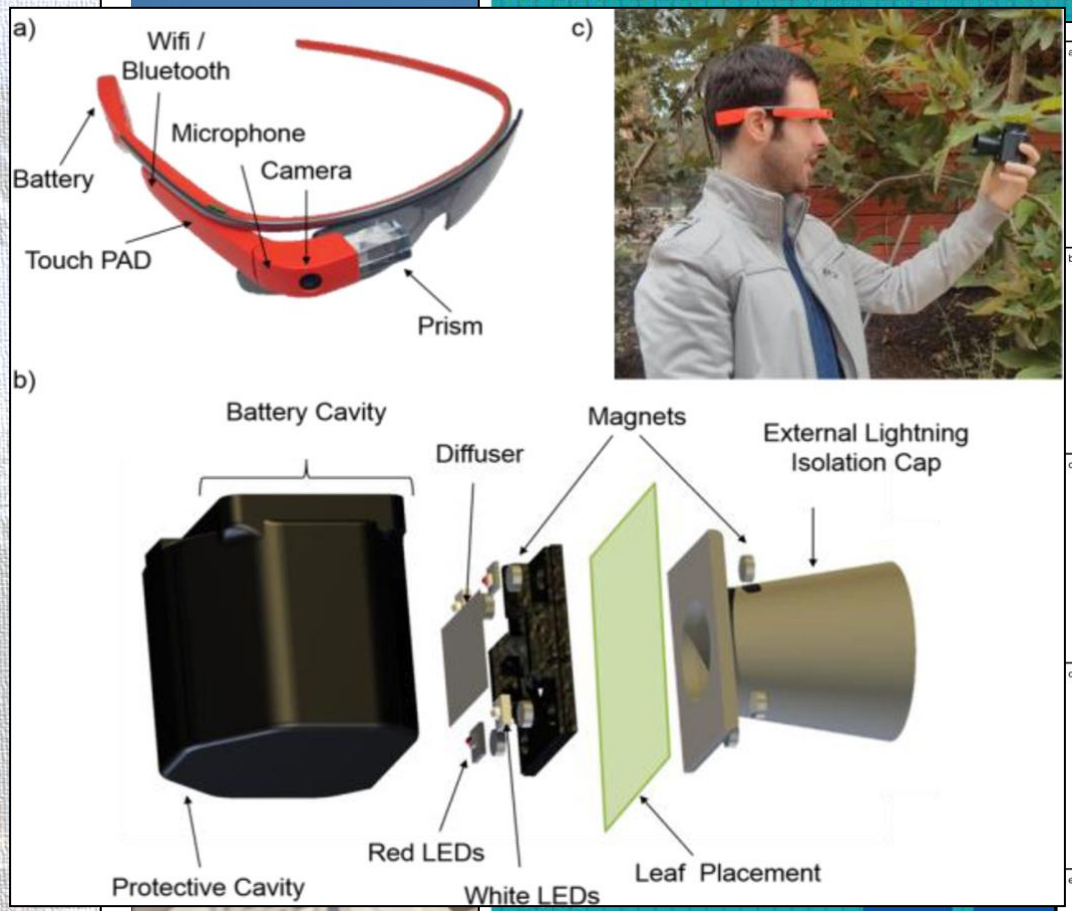
PLoS ONE (2015) 10(7): e0127706.
DOI:10.1371/journal.pone.0127706

Mobile Laboratories

Mobile Laboratories

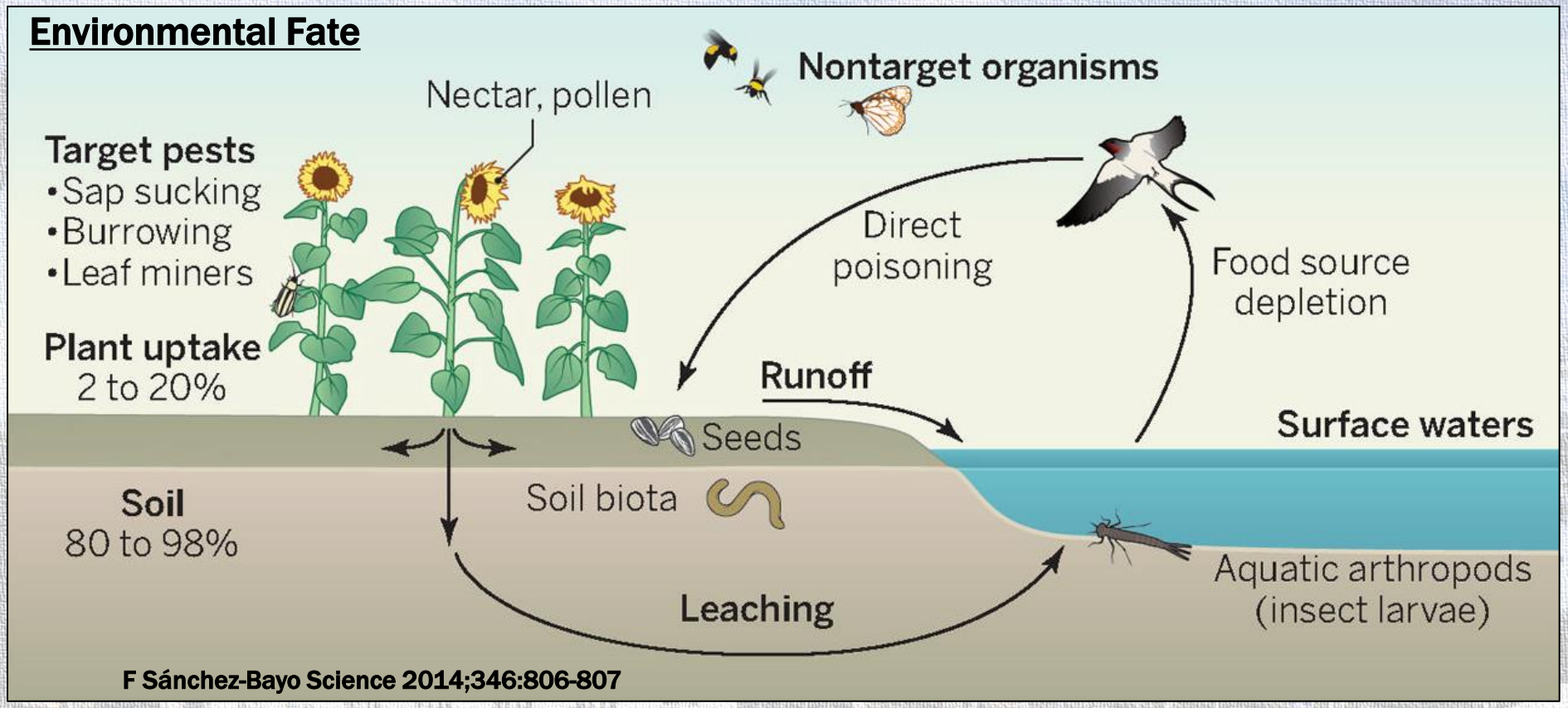


Mobile Laboratories



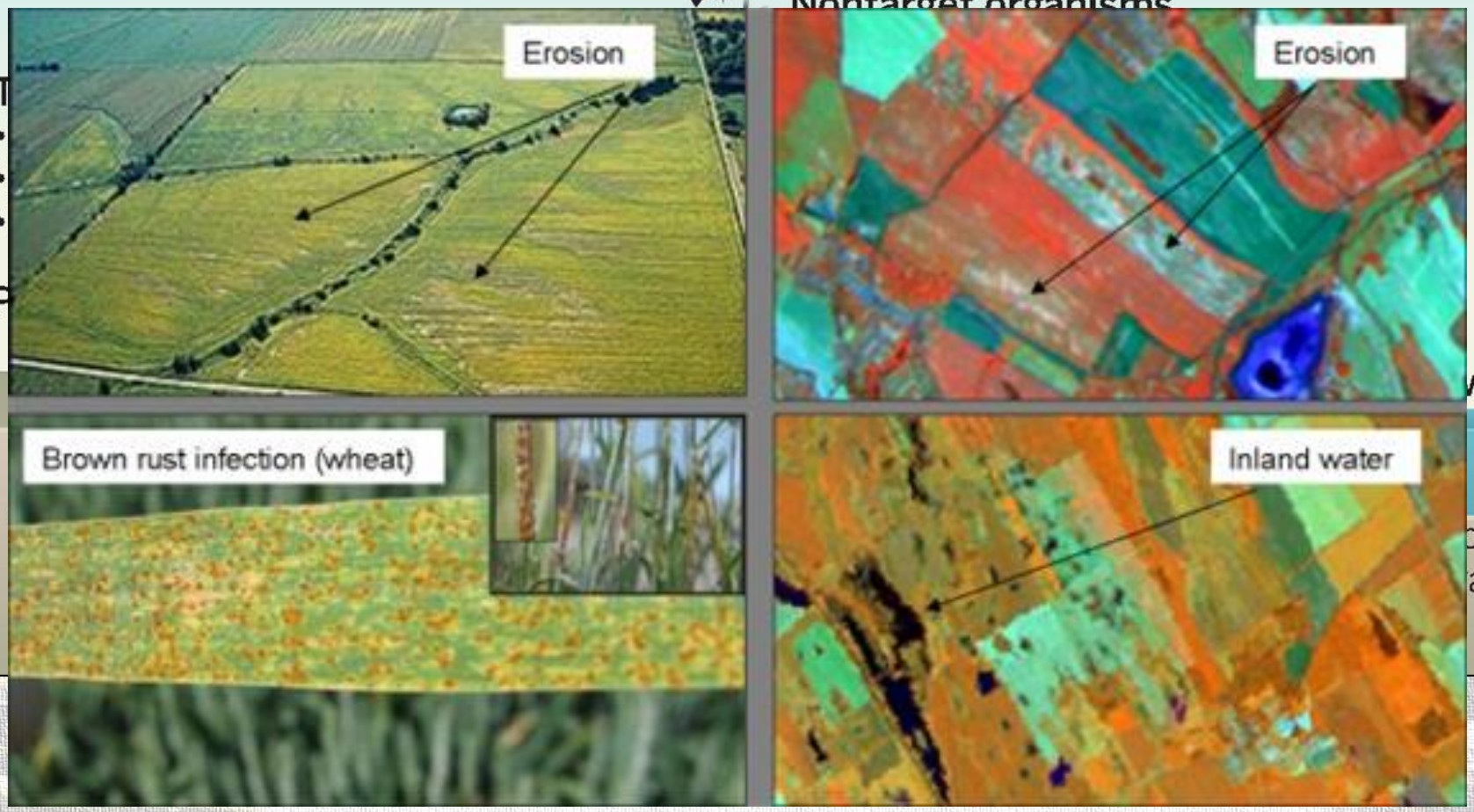
Lab Chip. 2015 Apr 7; 15(7): 1708–1716
www.ncbi.nlm.nih.gov/pmc/articles/PMC4366296/

Environmental Chemical Signatures



Environmental Chemical Signatures

Environmental Fate



http://www.tankonyvtar.hu/en/tartalom/tamop425/0027_DAI6/ch01s05.html

Environmental Chemical Signatures

Environmental Fate

http://www.tankonyvtar.hu/en/tartalom/tamop425/0027_DAI6/ch01s05.html

Environmental Chemical Signatures

Environmental Fate

r.hu/en/ om/tamop425/0027_DAI6/ch01s05.html

http://gamaya.com/

Environmental Chemical Signatures

Environmental Fate

Nontarget organisms

Erosion

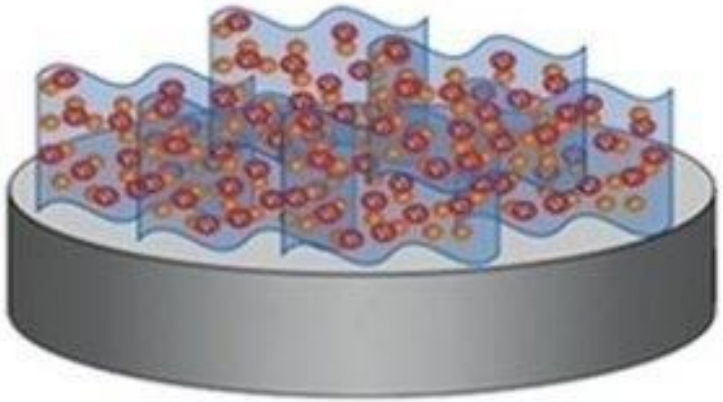
Erosion

GAMAYA

nutrient deficiency

http://gamaya.com/

Plant based biosensor for OP pesticides



Graphene nanosheets

Gold nanoparticles

Plant esterase

www.cen.acs.org/articles/93/web/2015/12/Potentially-Cheaper-Way-Test-Food.html

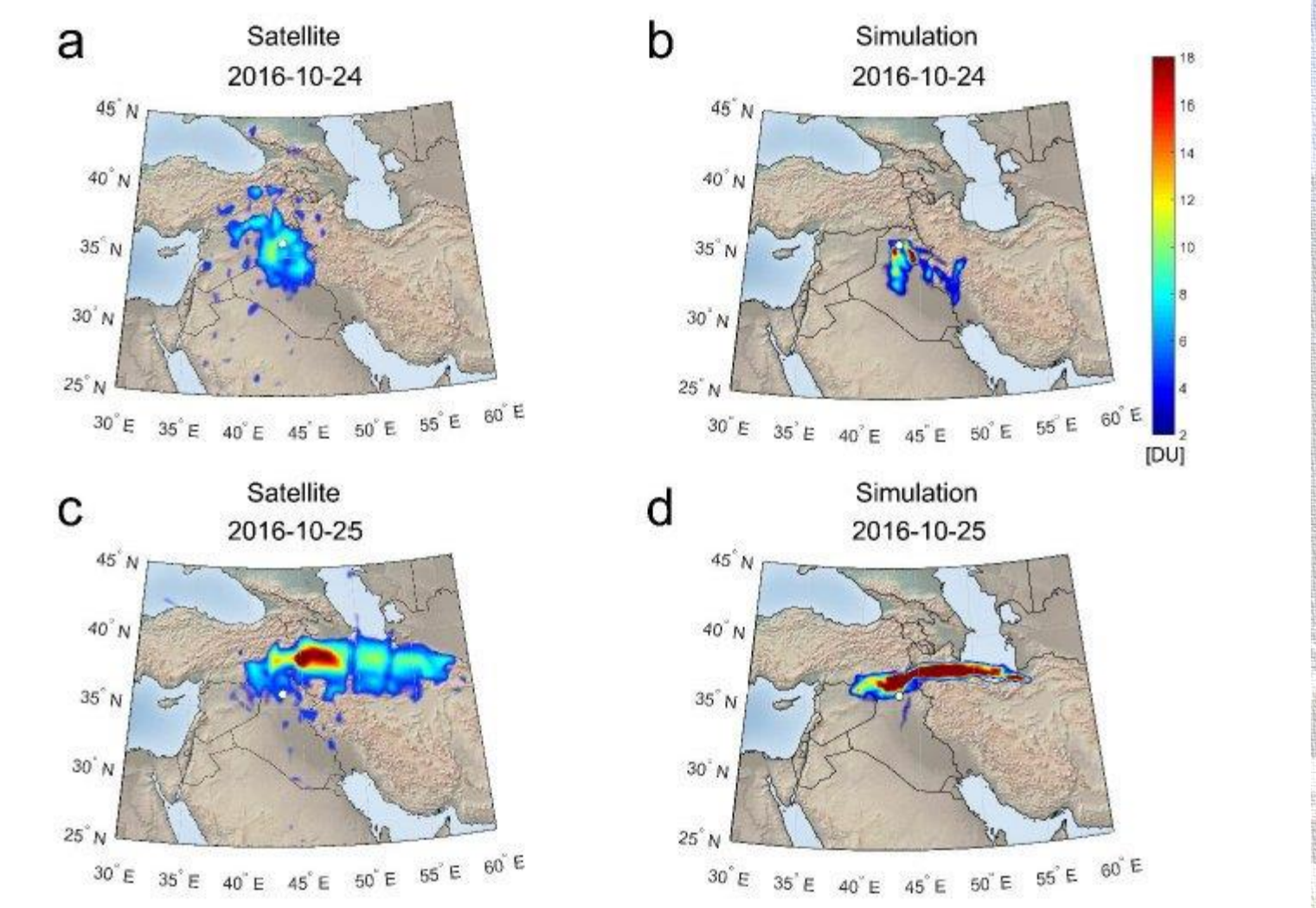
r.hu/en om/tamop425/0027_DAI6/ch01s05.html

If Plants Could Talk…

"The signs are that the bombs were made with the windows open but the net curtains taped to the walls to avoid being seen. The fumes had killed off the tops of plants just outside the windows"

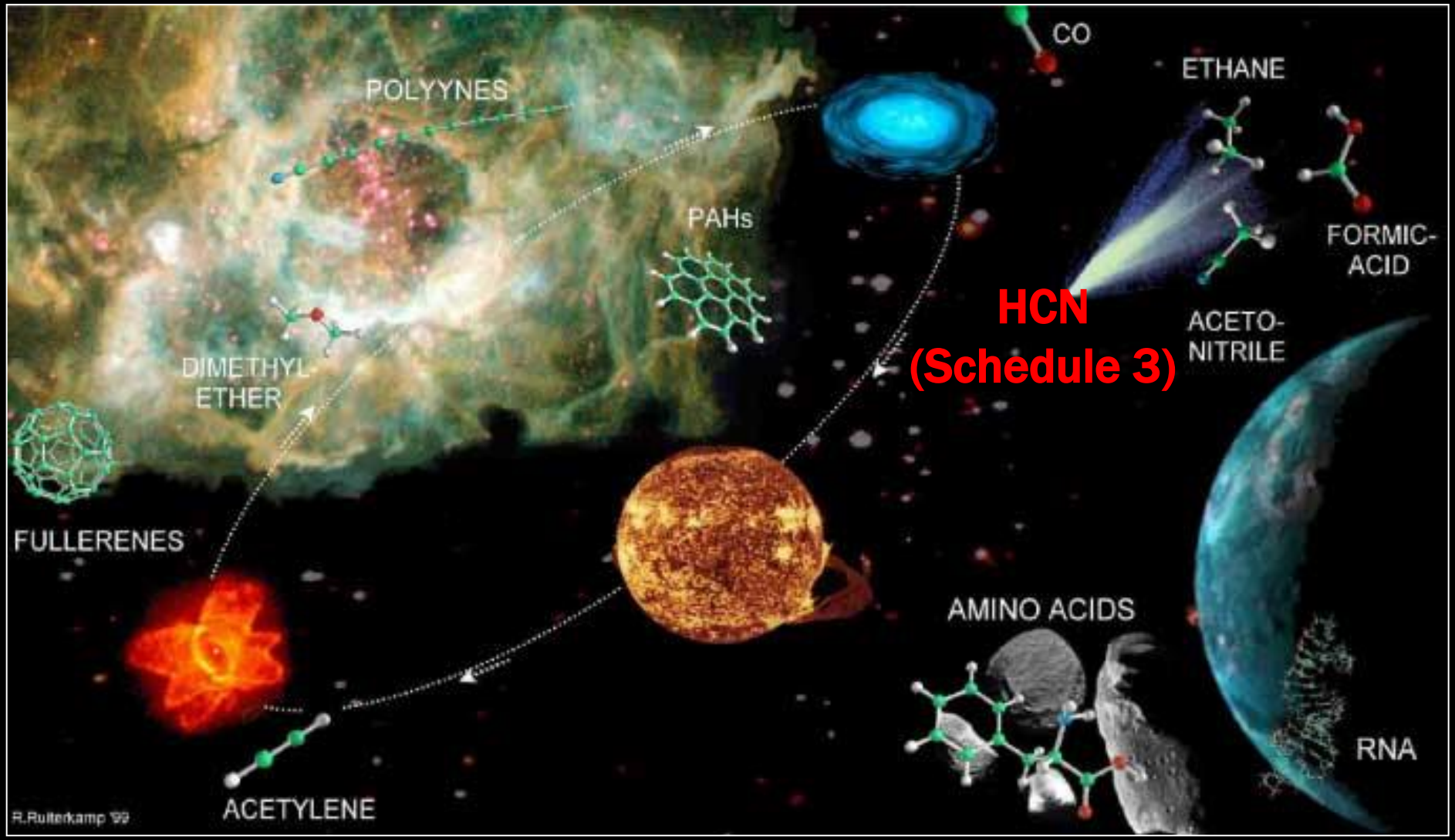
- Report of the Official Account of the Bombings in London on 7th July 2005

Monitoring Chemical Release by Satellite

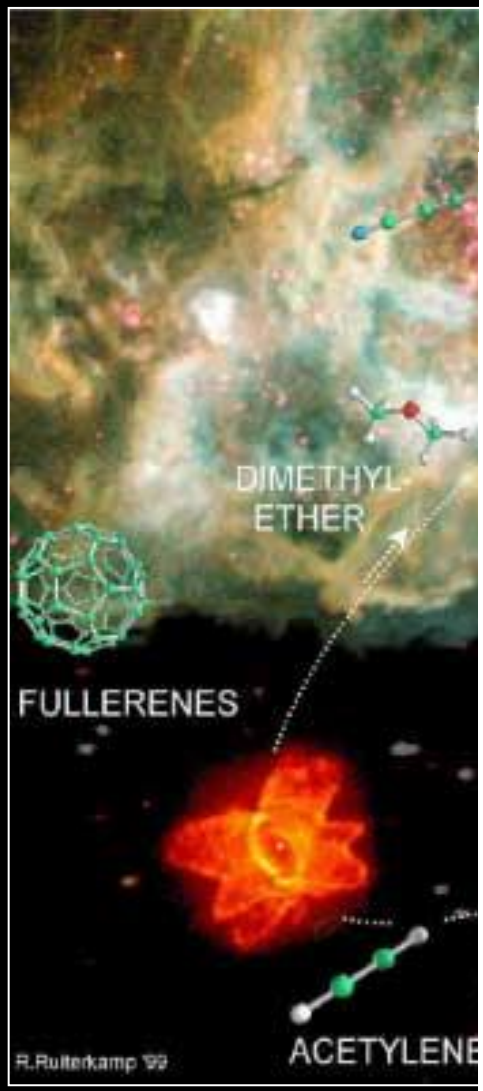


The 2016 Al-Mishraq sulphur plant fire: source and risk area estimation
https://arxiv.org/abs/1611.03837

Decades of Detecting (Bio)Chemicals Across The Universe!



Decades of Detecting (Bio)Chemicals Across The Universe!



3 Prospects for Observing Civilisation Destruction
http://arxiv.org/ftp/arxiv/papers/1507/1507.08530.pdf

Death Channel	Detection Method	Signature of Active Civilisation	Signature of Dead Civilisation	Detection Timescale (yr)
Nuclear Detonation	Gamma ray detection, Transit spectroscopy	Y	Y	0-5 years
Bioterrorism	Transit spectroscopy	Y	Y	1-30 years
Grey Goo	Transit spectroscopy and photometry	N	Y	>1,000 years
Stellar Pollution	Asteroseismology, stellar abundance studies	Y	Y	>100,000 years (depending on stellar convection)
Planetary Pollution	Transit spectroscopy (IR)	Y	Y	10-100,000 years
Orbital Pollution (Kessler Syndrome)	Transit spectroscopy and photometry	Y	Y	<100,000 years
Total Planetary Destruction	Debris Disk Imaging (IR)	Y	Y	<100,000 years

Hyperspectral Images and Chemical Sensing: Satellites not required

AVAILABLE SENSORS

DR1000

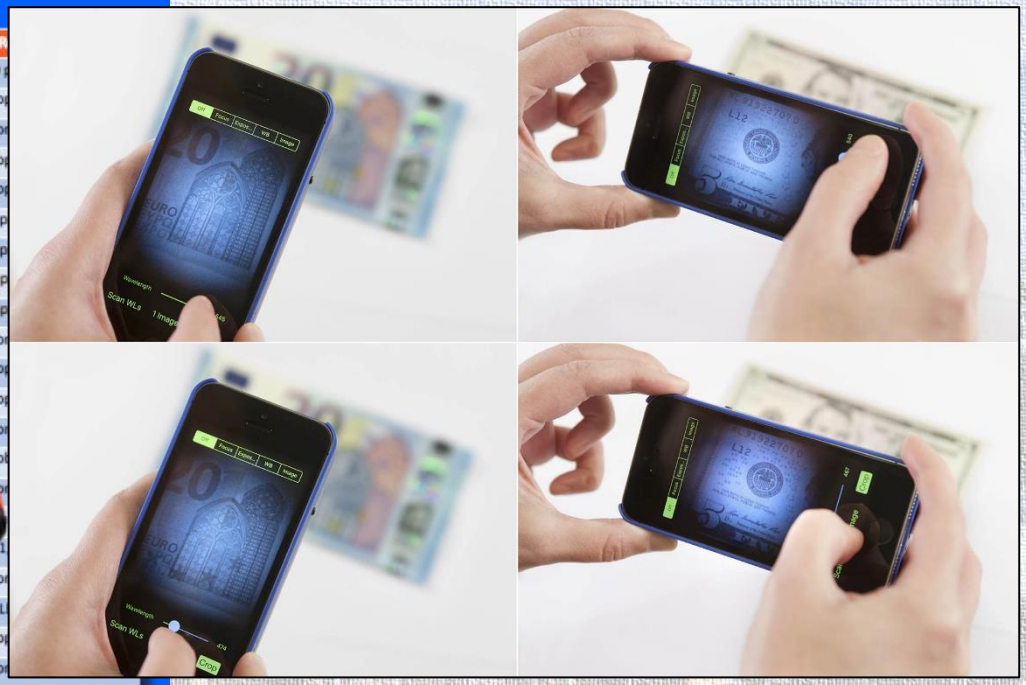
Sensor ID	Chemical	Range	Lowest Detection	Resolution (ppm)
CD1	Carbon Dioxide - High Concentration	5,000 to 900,000 ppm	5000 ppm	100 ppm
CD2	Carbon Dioxide - Low Concentration	0-5000ppm	0 ppm	15 ppm
CO1	Carbon Monoxide (low Concentration)	500 ppm	15 ppm	5 ppm
CO2	Carbon Monoxide (high concentration)	10000 ppm	250 ppm	20 ppm
C11	Chlorine	20 ppm	200 ppb	20 ppb
E1	Ethylene Oxide	0-100 ppm	1 ppm	0.1 ppm
H1	Hydrogen	0-5000 ppm	1 ppm	0.8 ppm
HCL1	Hydrogen Chloride	100 ppm	0.1 ppm	0.1 ppm
HCY1	Hydrogen Cyanide	100 ppm	0.1 ppm	0.1 ppm
AM1	Ammonia	100 ppm	0 ppm	1 ppm
ON1	Ozone and Nitrogen Dioxide	O3- 20; NO2- 20 ppm	0 ppb	15 ppb
PH1	Phosphine (low Concentration)	10 ppm	0 ppm	30 ppb
PH2	Phosphine (high Concentration)	2000 ppm	5 ppm	2 ppm
HS1	Hydrogen Sulfide (low Concentration - ppb)	1 ppm	3 ppb	1 ppb
HS2	Hydrogen Sulfide (high Concentration - ppm)	2000 ppm	1 ppm	1 ppm
NO1	Nitrogen Oxide	100	0 ppm	0.1 ppm
CH1	Carbon Monoxide and Hydrogen Sulfide	CO 0-1000, H2S 0 - 100 ppm	0 ppm	CO 1, H2S 0.25 ppm
E2	Ethanol	0-500 ppm	0 ppm	1 ppm
MT1	Methane (LEL)	0-100% LEL	0 ppm	1% LEL
NC1	Nitric Oxide (low Concentration)	20 ppm	0 ppm	80 ppb
NC2	Nitric Oxide (High Concentration)	5000 ppm	0 ppm	1 ppm
ND1	Nitrogen Dioxide (Low Concentration)	20 ppm	0 ppm	0.02 ppm
ND2	Nitrogen Dioxide (high Concentration)	200 ppm	0 ppm	0.1 ppm
O1	Oxygen	0-20%	0 ppm	0.10%
O2	Oxygen	0-100%	0 ppm	1%
PD1	Total VOCs (ppb) - PID	50 ppm (isobutylene)	0 ppm	1 (ppb isobutylene)
PD2	Total VOCs (ppm) - PID	300 ppm (isobutylene)	1 ppm	0.1 (ppm isobutylene)
SD1	Sulfur Dioxide (high Concentration)	2000 ppm	0 ppm	2 ppm
SD2	Sulfur Dioxide (low Concentration)	20 ppm	0 ppb	20 ppb
FM1	Formaldehyde	10 ppm	0.01 ppm	0.01 ppm
PM 1-10	Particulate PM 1, 2.5, 10	0-10,000 Particles/Sec	PM 1	N/A

Hyperspectral Images and Chemical Sensing: Satellites not required

AVAILABLE SENSORS

DR1000

Sensor ID	Chemical	Range	Lowest Detection	R
CD1	Carbon Dioxide - High Concentration	5,000 to 900,000 ppm	5000 ppm	100
CD2	Carbon Dioxide - Low Concentration	0-5000ppm	0 ppm	15
CO1	Carbon Monoxide (low Concentration)	500 ppm	15 ppm	5
CO2	Carbon Monoxide (high concentration)	10000 ppm	250 ppm	20
C11	Chlorine	20 ppm	200 ppb	20
E1	Ethylene Oxide	0-100 ppm	1 ppm	0.1
H1	Hydrogen	0-5000 ppm	1 ppm	0.8
HCL1	Hydrogen Chloride	100 ppm	0.1 ppm	0.1
HCY1	Hydrogen Cyanide	100 ppm	0.1 ppm	0.1
AM1	Ammonia	100 ppm	0 ppm	1
ON1	Ozone and Nitrogen Dioxide	O3- 20; NO	0 ppb	15
PH1	Phosp	ration)	10	30
PH2	Ph	on)	2	2
HS1		ion - ppb)		
HS2				
NO				
C				1
				1
				1%
NC				80
NC2				1
ND1			ppm	0.02 ppm
ND2	Nitr		0 ppm	0.1 ppm
O1	Oxygen	-20%	0 ppm	0.10%
O2	Oxygen	0-100%	0 ppm	1%
PD1	Total VOCs (ppb)	50 ppm (isobutylene)	0 ppm	1 (ppb isobutylene)
PD2	Total VOCs (ppm) - P	300 ppm (isobutylene)	1 ppm	0.1 (ppm isobutylene)
SD1	Sulfur Dioxide (high Concentration)	2000 ppm	0 ppm	2 ppm
SD2	Sulfur Dioxide (low Concentration)	20 ppm	0 ppb	20 ppb
FM1	Formaldehyde	10 ppm	0.01 ppm	0.01 ppm
PM 1-10	Particulate PM 1, 2.5, 10	0-10,000 Particles/Sec	PM 1	N/A

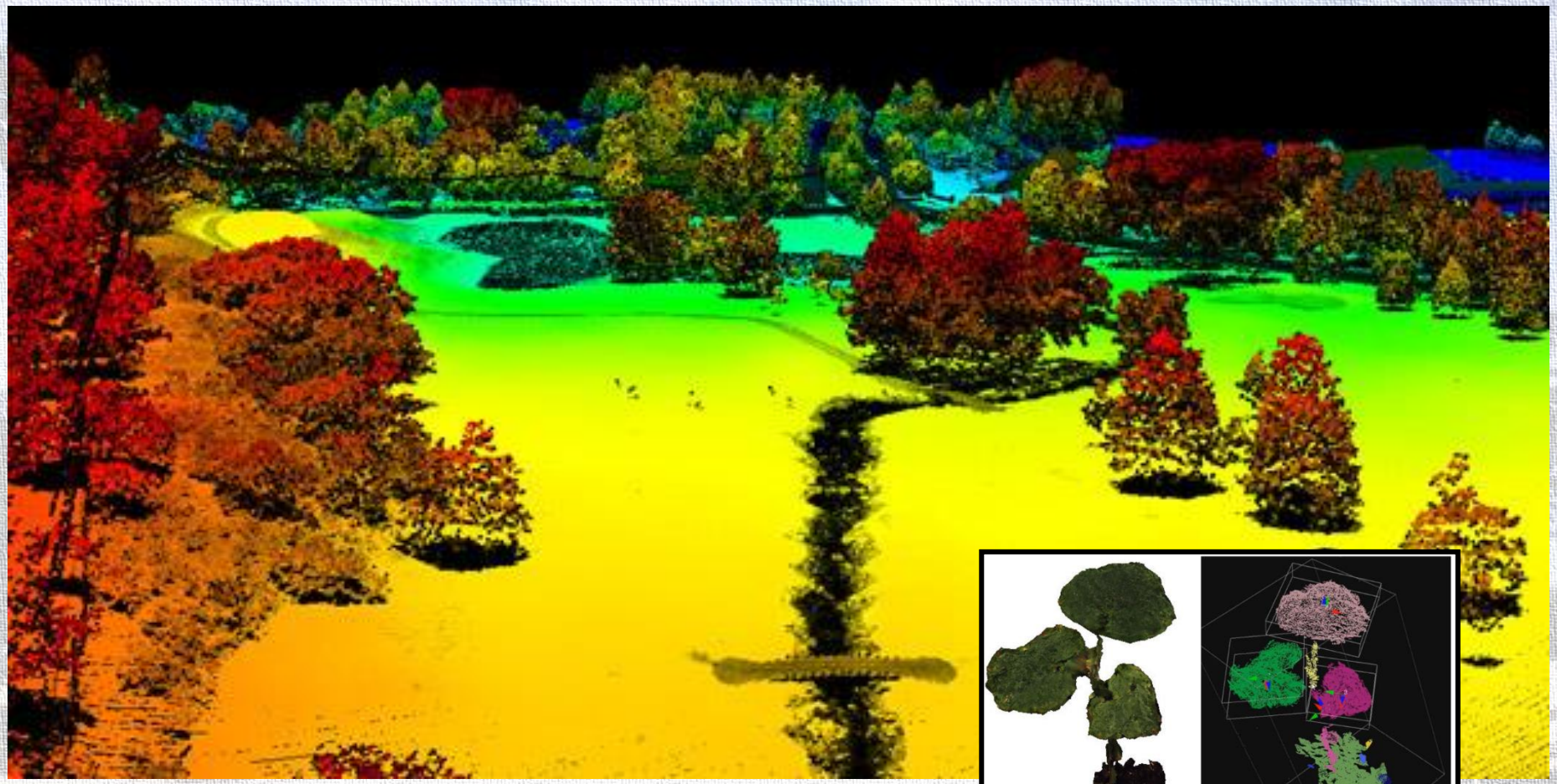


http://www.vttresearch.com/

https://www.parrot.com/fr/solutions-pro/parrot-sequoia#parrot-sequoia-

Integrated Data Streams

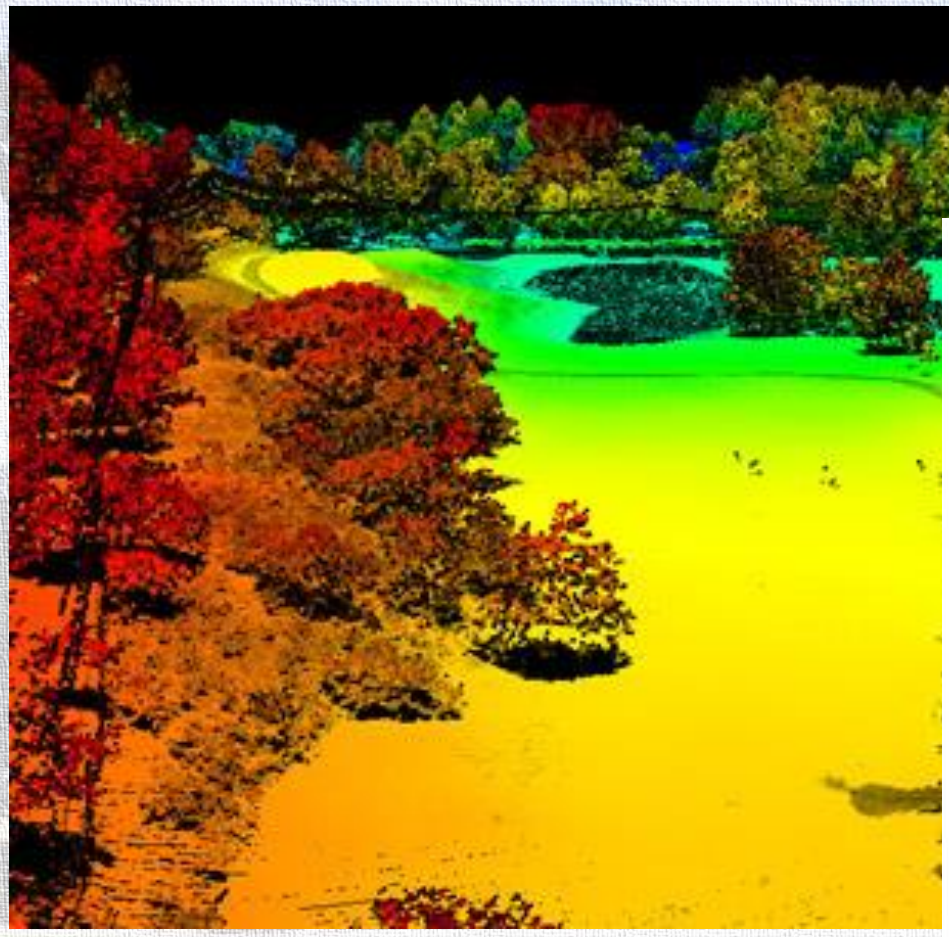
(3D and visual images, sensor data, spectral data, external databases)

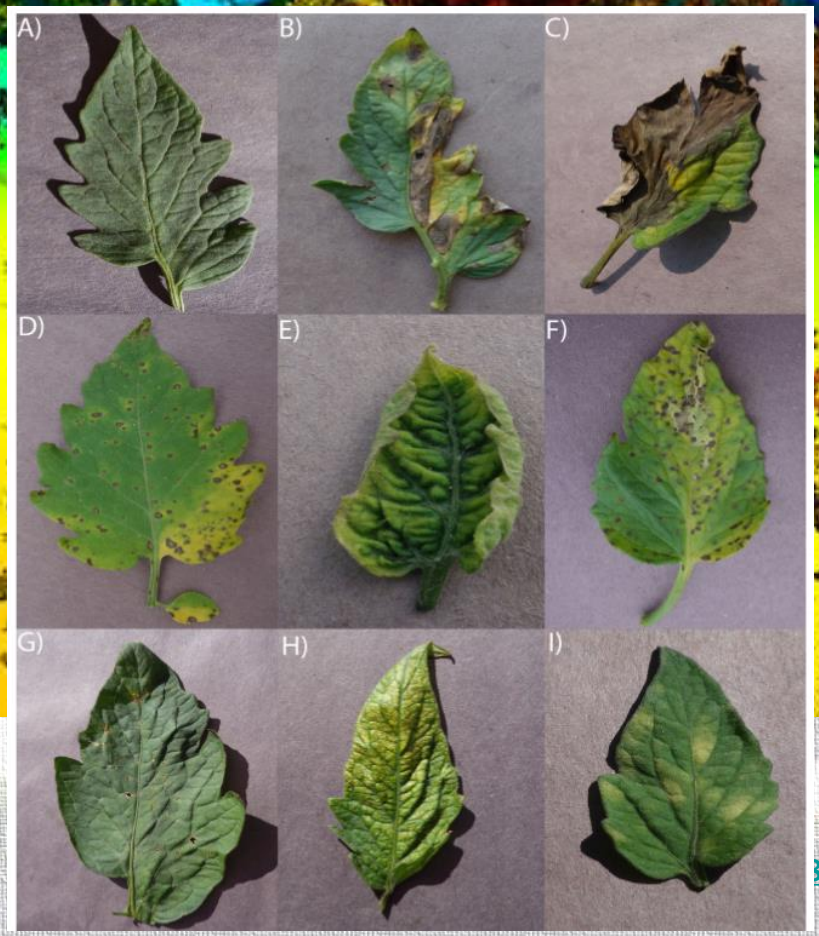


http://www.mdpi.com/1424-8220/15/8/18587/htm

Integrated Data Streams

(3D and visual images, sensor data, spectral data, external databases)



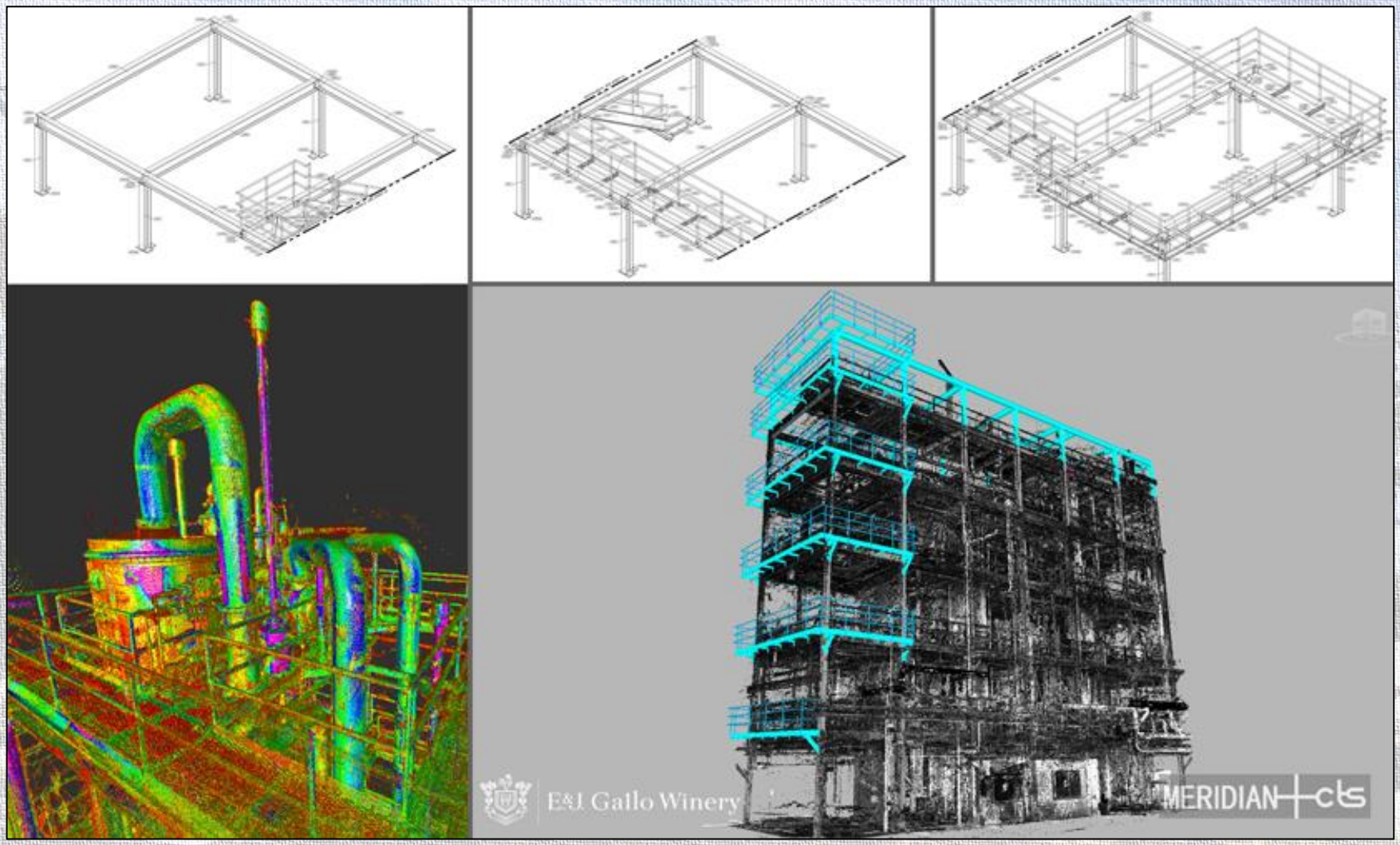


An open access repository of images on plant health to enable the development of mobile disease diagnostics

https://arxiv.org/abs/1511.08060

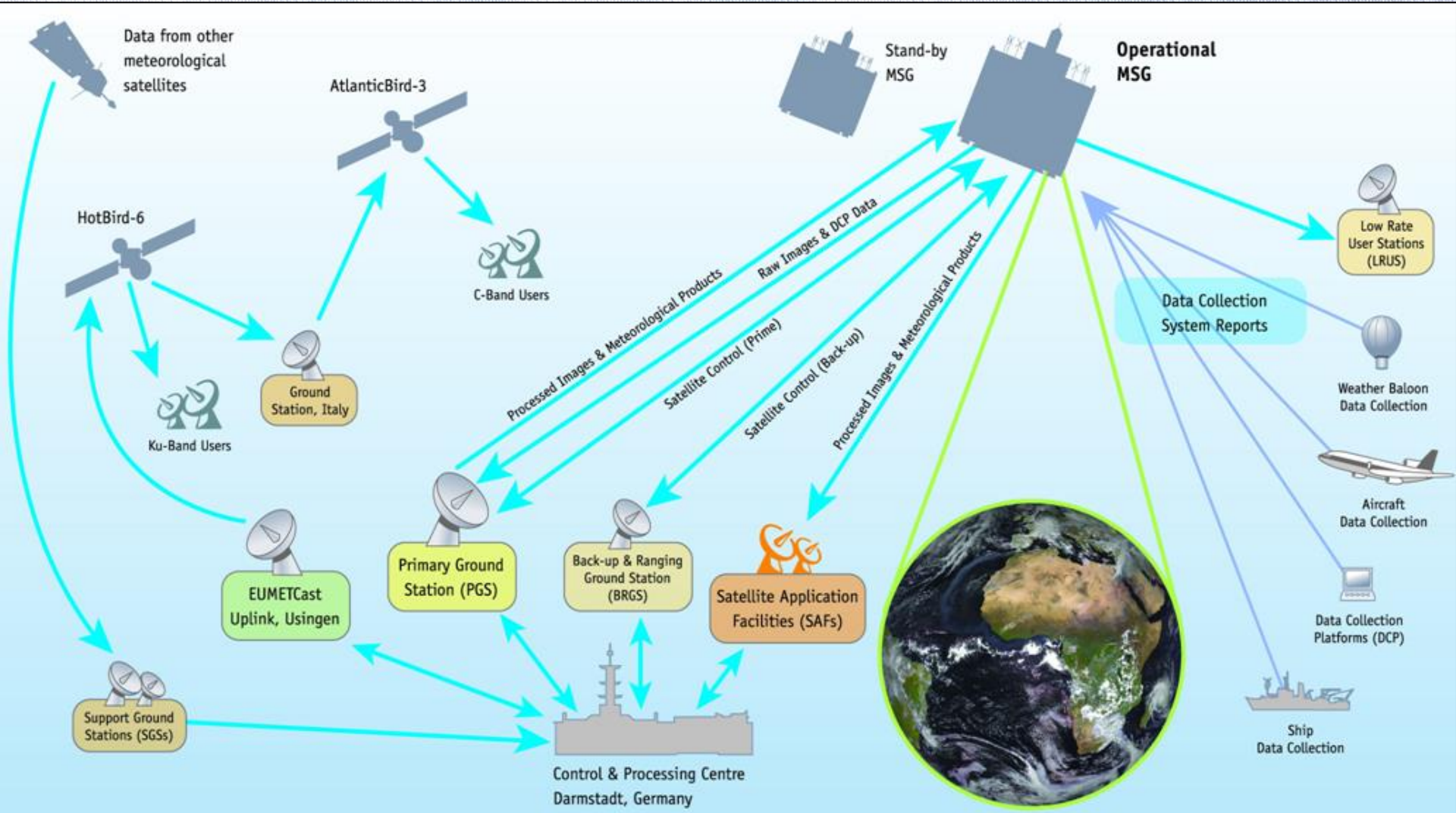
37/htm

Imaging of Complex Structures

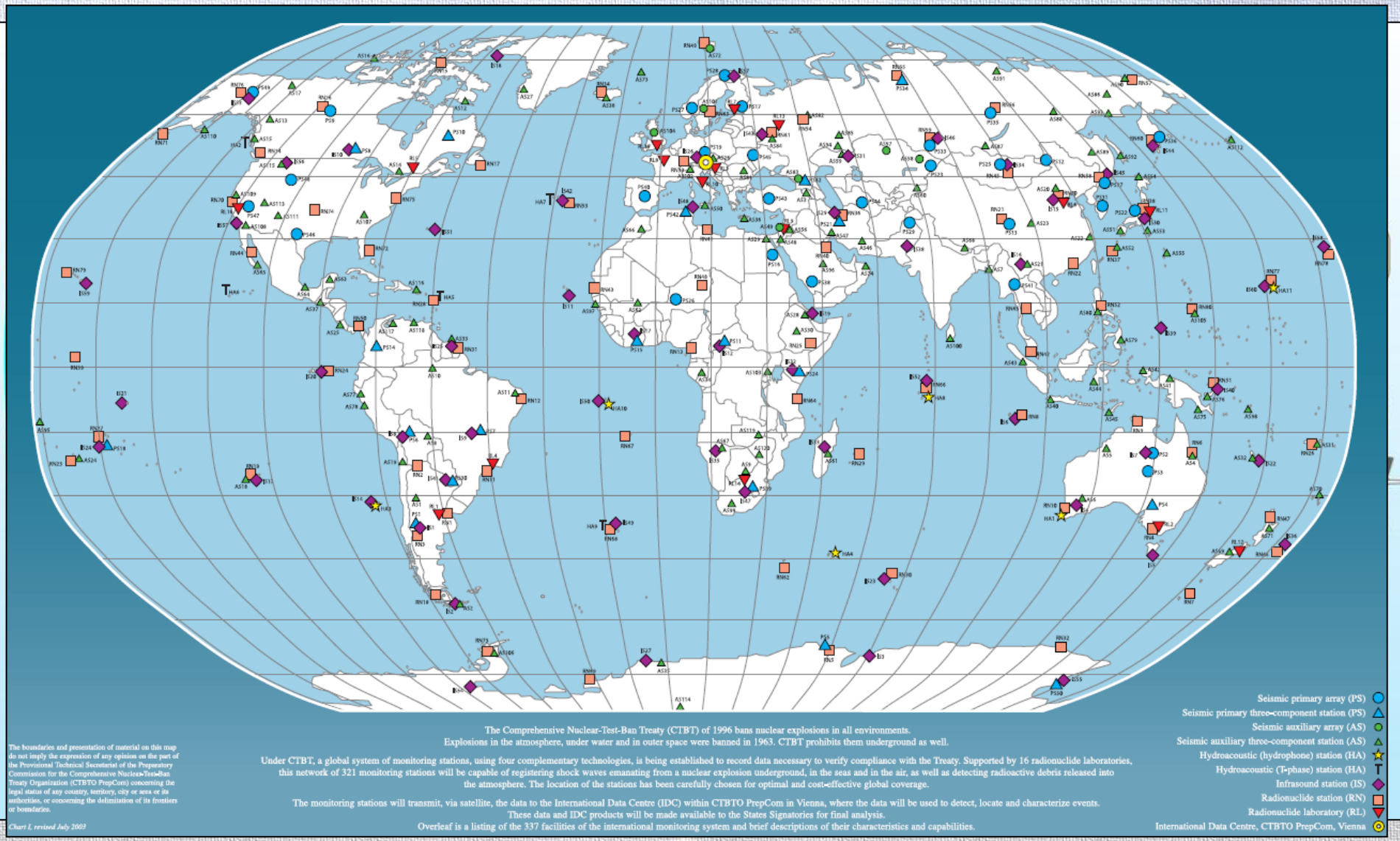


Imaging of Complex Structures and a capability to Inspect

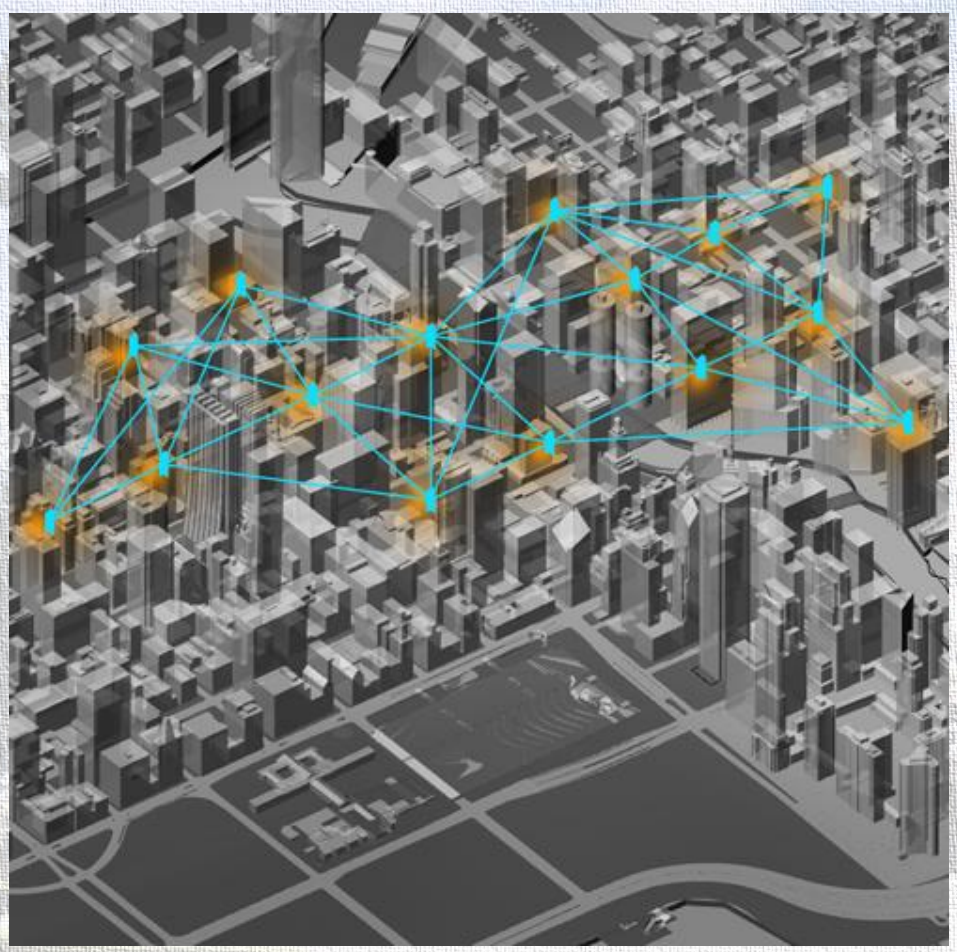
Data Collection on Global Scale



Data Collection on Global Scale

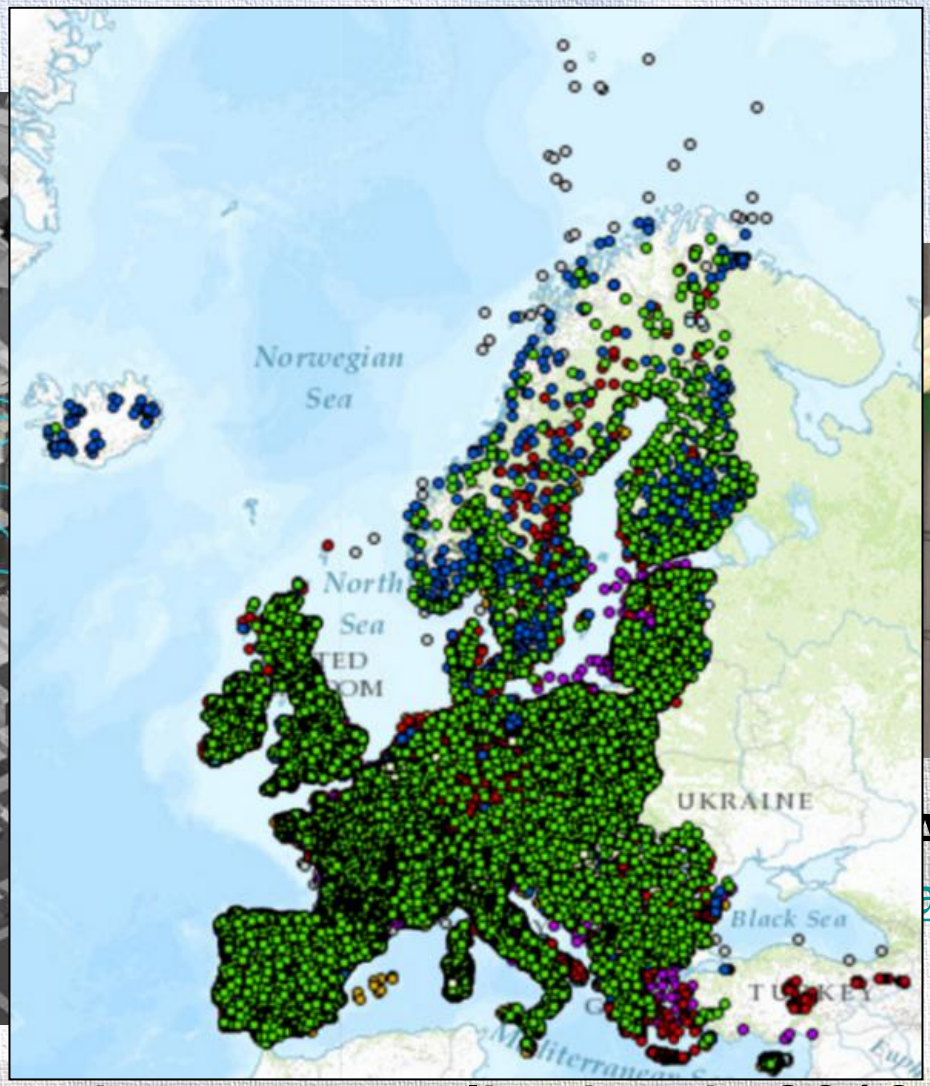


Data with Chemical (and Biological) Relevance is Collected too



The Array of Things
https://arrayofthings.github.io/

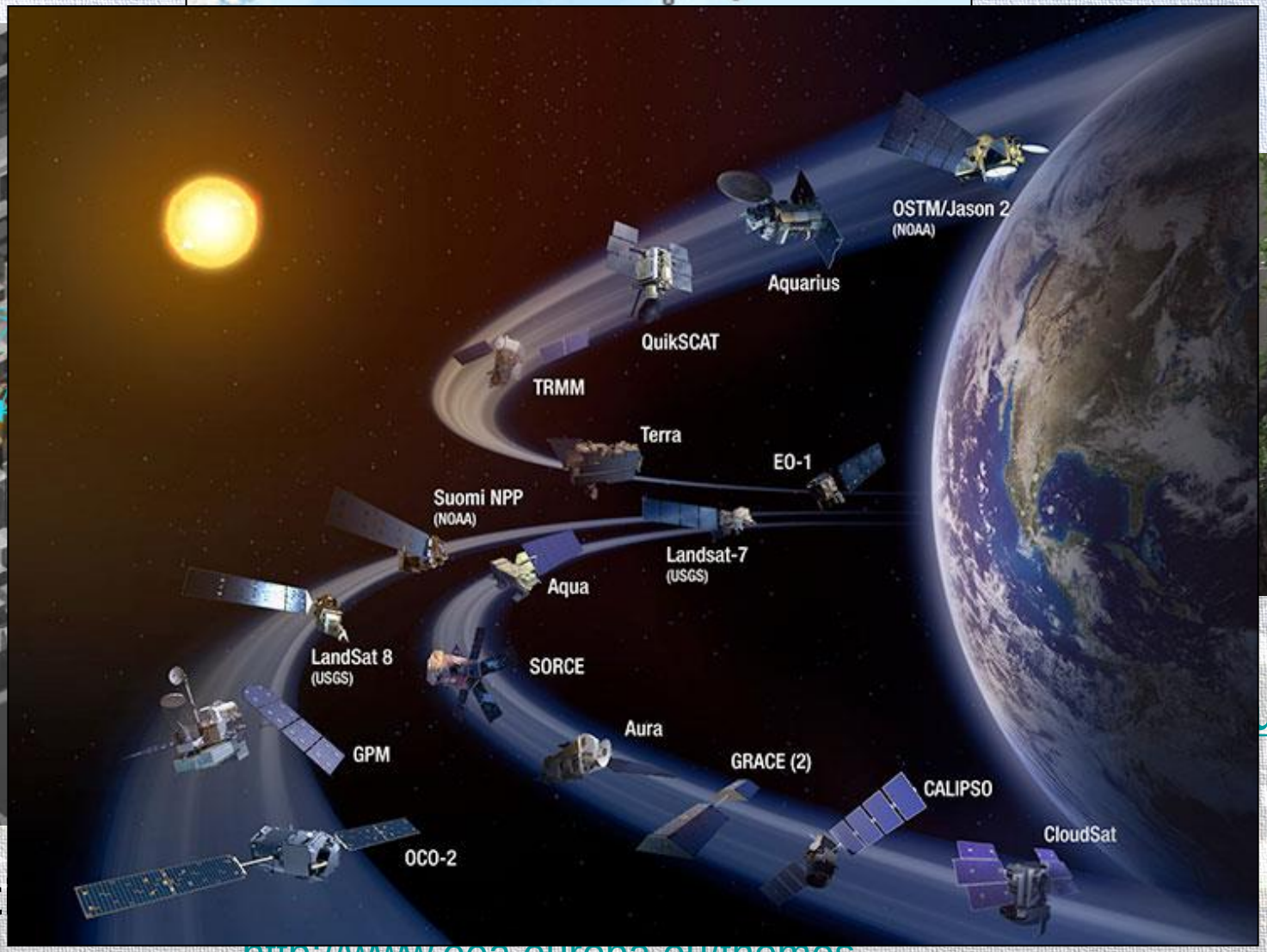
Data with Chemical (and Biological) Relevance is Collected too



Array of Things
ayofthings.github.io/

Stations reporting water quality data in 2016 in the EU
http://www.eea.europa.eu/themes

Data with Chemical (and Biological) Relevance is Collected too



ub.io/

Stat

http://www.eea.europa.eu/themes

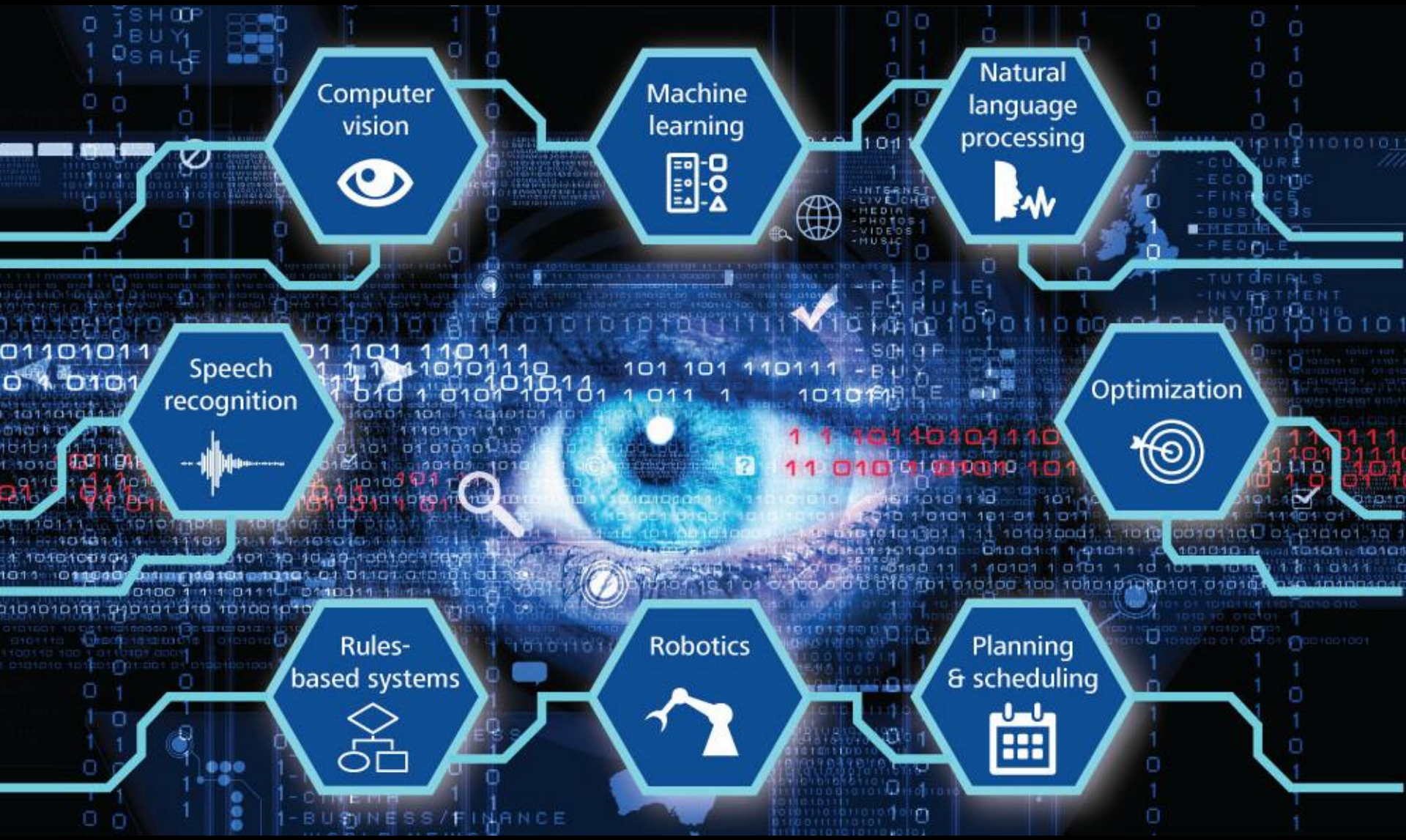
Data with Chemical (and Biological) Relevance is Collected too

Stat

http://www.eea.europa.eu/themes

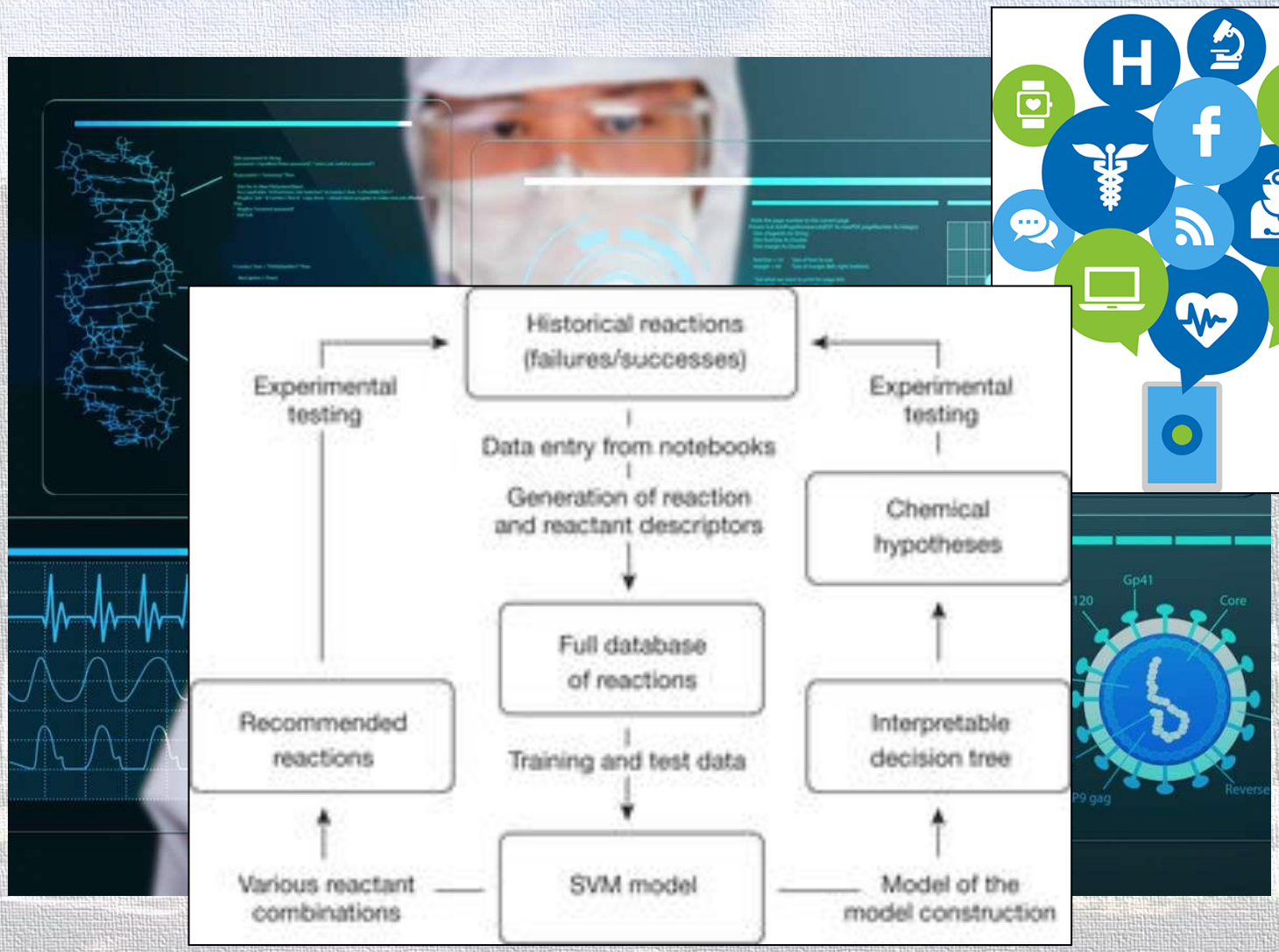
The Value is the Data

To Make Use of it All, Data Streams Must be Harnessed and Integrated



Artificial Intelligence, Chemistry, Life Sciences and Medicine

Artificial Intelligence, Chemistry, Life Sciences and Medicine

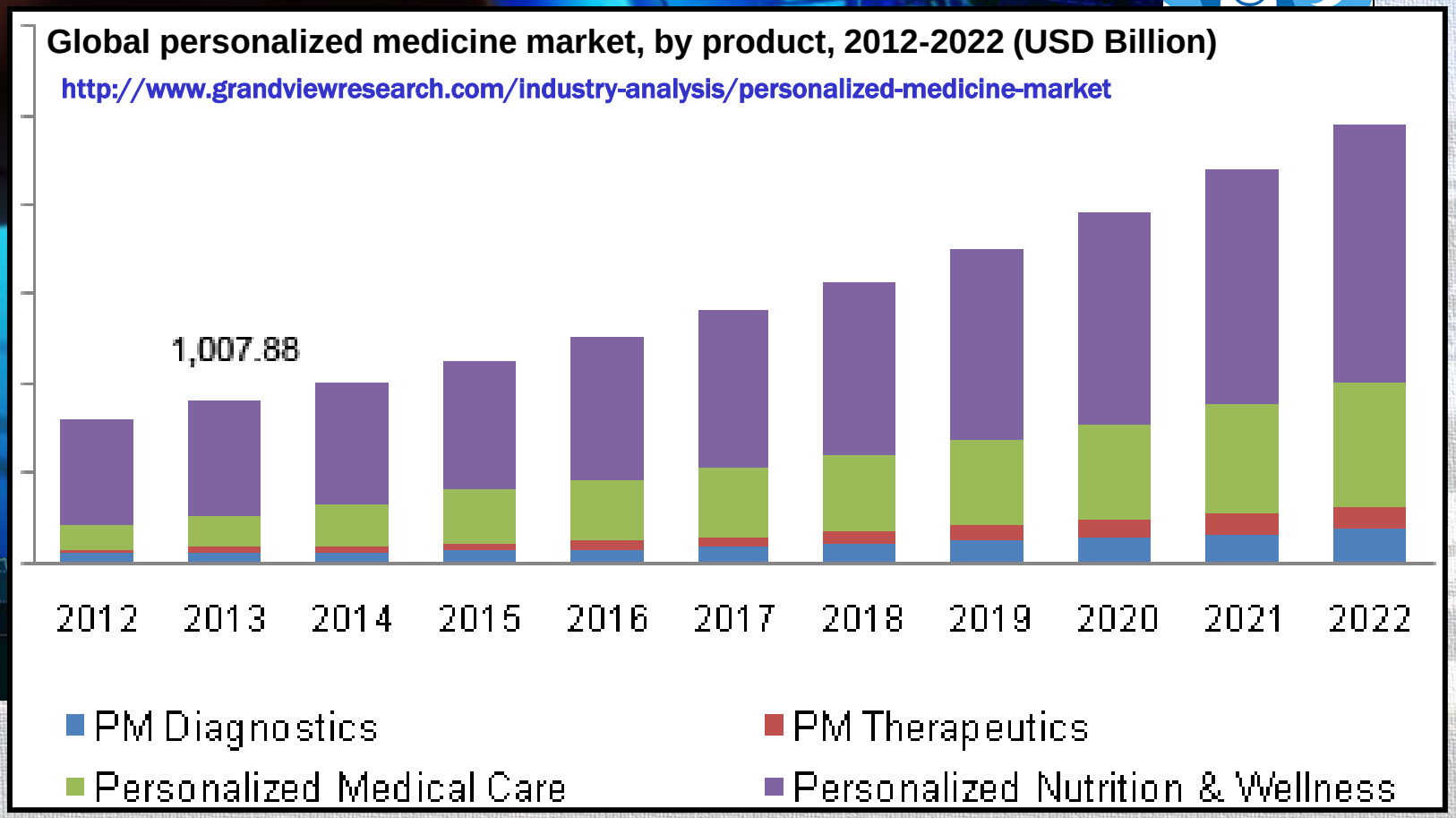


http://www.nature.com/nature/journal/v533/n7601/full/nature17439.html

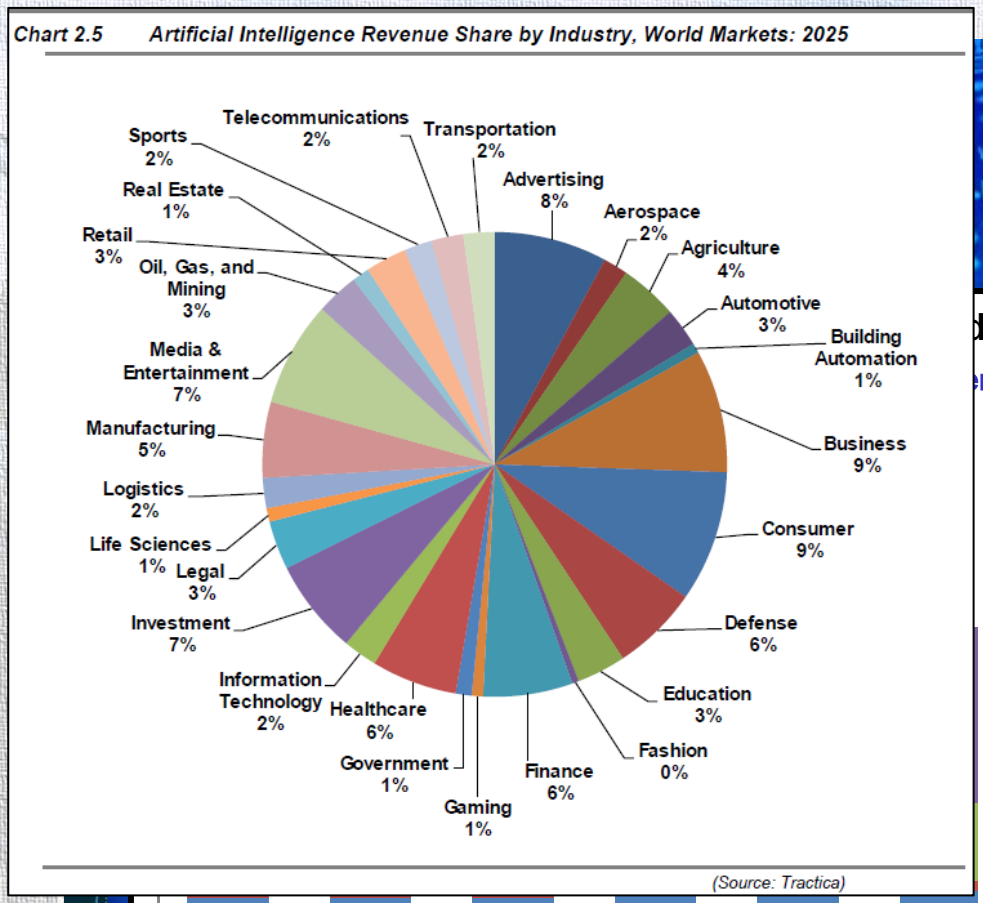
Artificial Intelligence, Chemistry, Life Sciences and Medicine

http://www.nature.com/nature/journal/v533/n7601/full/nature17439.html

Artificial Intelligence Chemistry, Life Sciences and Medicine

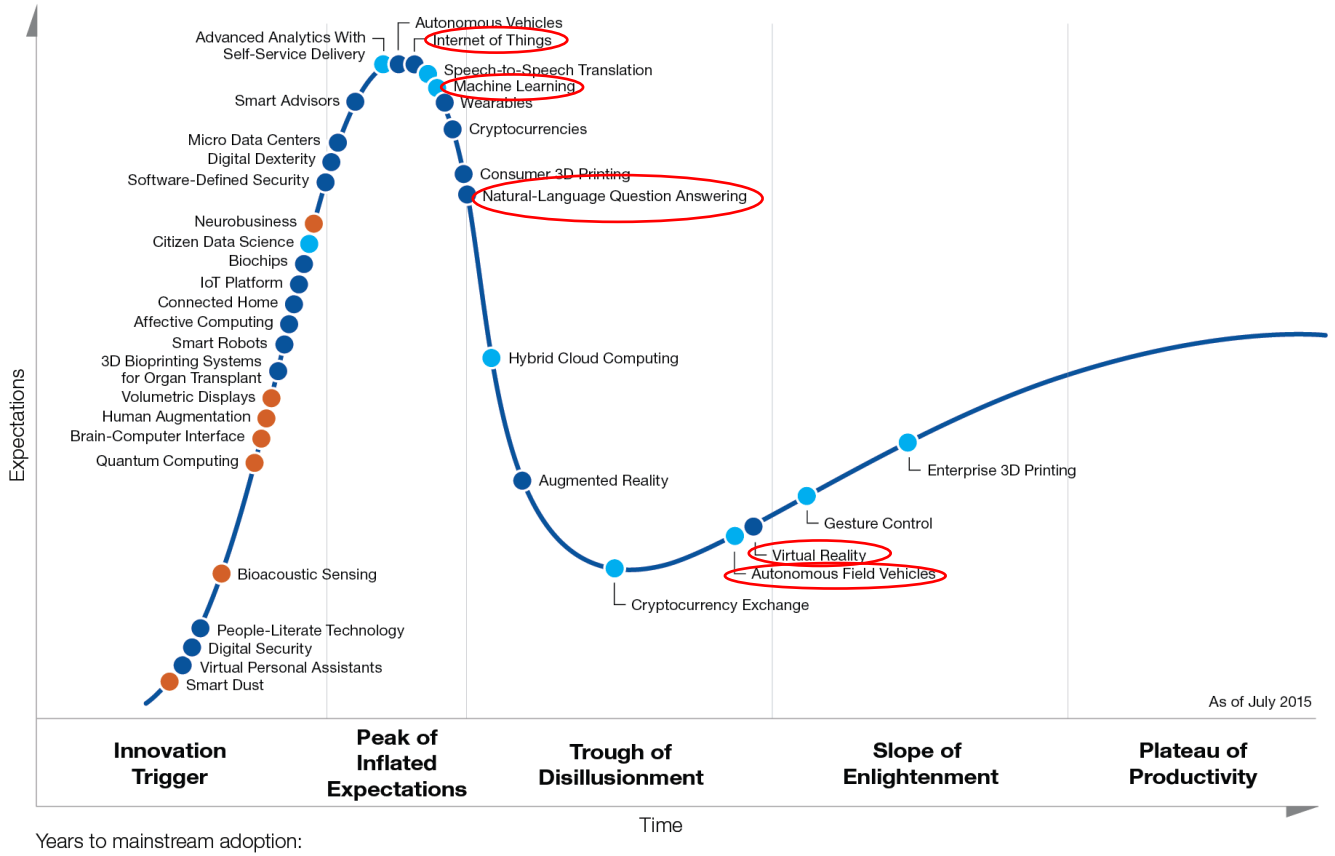


Artificial Intelligence, Chemistry, Life Sciences and Medicine



Beneficial or Challenging: How Much of This Should we Really Believe?

Emerging Technology Hype Cycle



Years to mainstream adoption:

less than 2 years | 2 to 5 years | 5 to 10 years | more than 10 years | obsolete before plateau

gartner.com/SmarterWithGartner

Gartner

OPCW Scientific Advisory Board
2017 Emerging Technology Workshop

- **In support of report to Fourth Review Conference**
- **Co-organised with IUPAC**
  - **EU Funding**
- **Participation from experts in**
  - Recognizing (bio)chemical change (environment, process, etc.)
  - Mobile and wearable technologies
  - Point-of-care technologies
  - Sample collection and analysis
  - Artificial intelligence in the chemical sciences
- **More to follow…**