Volume 3 Number 2

The OPCW Science & Technology Monitor

A sampling of Science & Technology
Relevant to the Chemical Weapons Convention

15 April 2016

In this Issue

Welcome

Welcome to the *OPCW Science and Technology Monitor*, an occasional bulletin to provide updates on developments in science and technology across a broad spectrum of topics relevant to the CWC. Past issues are available from the Science and Technology section of the OPCW web-site.

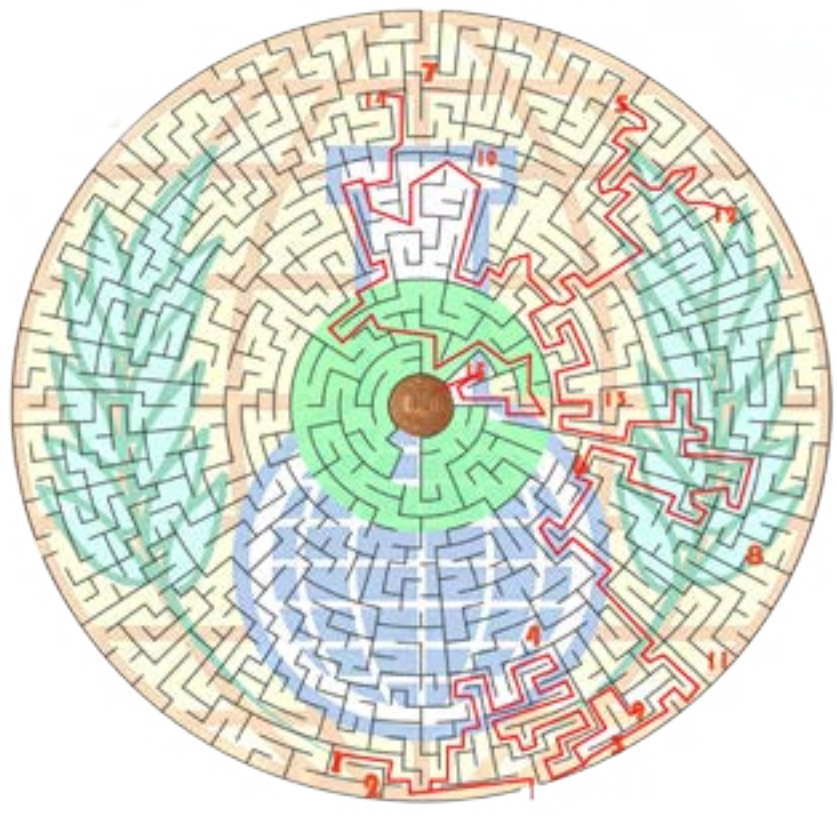

Nikolai Lunkov, David Ennals and Ronald I. Spiers in March 1975. Image courtesy of the UN.

Today's issue of the *S&T Monitor* goes to press the week of the forty-fourth anniversary of the Convention on the Prohibition of the Development, Production and Stock-piling of Bacteriological (Biological) and Toxin Weapons and on their Destruction which opened for signature on 10 April 1972. The Biological Weapons Convention (BWC), as it is generally referred to, is a true disarmament treaty, completely banning an entire class of weapons of mass de-struction. The BWC entered into force on 26 March 1975, has 174 States Parties and will hold its Eighth Review Con-ference in November of this year.

The S&T Puzzle

Last issue's S&T puzzle has apparently stumped our readership – no correct answers were received. For those that are curious, the answer is provided below. Puzzle standings remain at: VER 6, CTBTO 5, OSP 2, OCS 1, and INS 1.

To navigate last issue's maze: Enter at the bottom right, then collect in this order: (1) The Chemcial Weapons Convention (bonus), (9) the Chemical Agent Monitor, (3) the Gas Mask, (6) the Atropine Injector, (5) the Hazmat Suit and (12) the Barrels of VX. Bring the barrels to (14) the Field Deployable Hydrolysis System (details here!), then make your way to the center, pausing at (15) the Decontamination Shower. The other items you could have collected were: (2) The Hitchhiker's Guide to the Galaxy, by Douglas Adams, (4) a Stormtrooper Mask, (7) an Insulin Injector, (8) a Ghostbusters' Sensor, (10) Barrels of Salt, (11) Barrels of Caffeine and (13) Barrels of Ethanol. None of these of these, however, would help you win the prize!



The S&T Puzzle

For this edition of the puzzle, we ask you to find a series of simple phrases. We give you symbols of chemical elements and a series of images; it is up to you to match the name of the element with one of the images to produce the phrase. As an example, if the element symbol were **Pb** (lead), the matching image would be the one on the right, to create the phrase "**lead paint**".

The person who finds the most correct phrases wins the prize: your choice of requesting a featured topic, designing a puzzle or receiving a beverage hand selected by the Science Policy Adviser. Send answers by email. Let the games begin!

He
Si
C
S
Cu
Au
U
Pt
Ag
W
NaCl
Fe
H
Li
Sn















Science Fun

Another Easter has come and gone, leaving us with the spoils of an egg hunt! Whether made from chocolate or awesomely decorated and hardboiled, our offices ended up with no shortage of the protein packed gelatinous ovals; inspiring us to explore the science fun of chicken eggs!

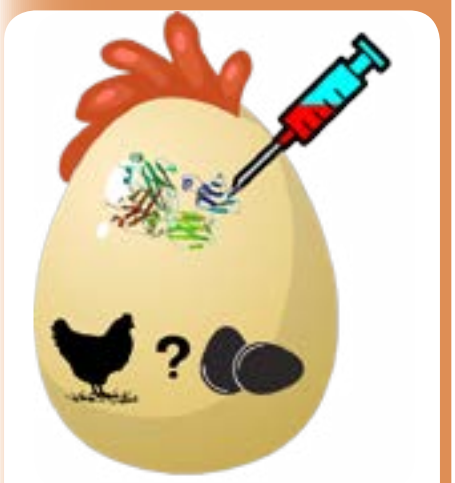


Image by Puja Mody.

Did you know, there are an estimated 4.93 billion egg laying hens in the world, each capable of producing over 300 eggs/year? That's right, world-wide production capacity comes to about 1.48 trillion eggs per annum! Perhaps a bit too many to try and hide for the next egg hunt.

Eggs are one of the most versatile culinary ingredients; they are enjoyed boiled, scrambled, fried or poached, and can be used as a binder and more in cooking and baking. Eggs can even be used to entertain your friends while learning about science, have you ever squeezed an egg into a bottle or dissolved the shell to create a bouncing egg? These are but two of the many experiments you can try in your own kitchen! If you do decide to experiment at home, please cook with caution to avoid toxic gas!

A chicken egg has three main components: a calcium carbonate shell, the egg white

News and Updates

Recent reports and publications:

2016 R&D Global Funding Forecast.

Nature Index looks at science in Japan.

Preventing disease through healthy environments: a global assessment of the burden of disease from environmental risks, a report from the WHO.

WIPO statistics on international intellectual property filings in 2015.

Future generations, a look at whether researchers today consider the world of tomorrow - and why they should, from Nature.

TWAS Plus, news and opportunities from The World Academy of Sciences, January 2016 Issue.

Evaluation of the results of the Thirty-Eighth Official OPCW Proficiency Test and the status of the Designated Laboratories.

Report on the performance of the revised methodology for site selection of chemical production facilities for CWC inspection.

Emerging Security Challenges in the spring 2016 issue of Connections.

Chemical safety and security resources from the American Chemical Council, the American 15.

Science and education tools and resources:

Online tutorials on chemical weapons non-proliferation from nti.org.

Web widget, an online tool for sharing research data.

Neuro-computing tools available for all to use from the Human Brain Project.

Do you want to be a rocket scientist? There is an App for that (and even more where that came from).

Some News from the World of Science & Technology:

From the weeks of 28 February – 5 March; 6 – 12, 13 – 19 and 20 - 26 March; 27 March – 2 April; and 3 – 9 April 2016 in chemistry.

Legacy Chemical Munitions

Our previous issue highlighted sea-dumped chemical weapons and the issues they have raised; it is not only ocean depths however, that conceal chemical arsenals from historical conflicts. Unexploded munitions are still found on historical battlefields and there are abandoned chemical munitions buried in the ground or submerged in lakes and streams in several regions of the world. Former World War I battlefields where unexploded chemical munitions might be found (lewisite and mustard agent in particular) are known in Belgium and France (where there are still "no go zones"); and China has received considerable attention for the abandoned World War II chemical weapons that have been found there (with excavation and

Warning sign on the shore of Walker Lake, Nevada, USA.
Image courtesy of Kelapstick.

or albumen which is made up of 90% water and 10% protein, and the egg yolk made up of cholesterol and fatty acids such as oleic acid. The colours of the components are themselves important analytical tools: the colour of the yolk is indicative of a hen's diet, and pinkish or iridescent egg whites warn of spoilage (that's an important health tip, don't eat iridescent eggs!). Of course, if the eggs are really rotten, smell more than colour might give it away!

Egg whites contain long folded protein chains that denature during cooking, the result is an unwrapping of the proteins and a solidification of the egg! Scientists found a solution to this problem, demonstrating that it is actually possible to "unboil" an egg and refold the proteins; a discovery that received the Ig Nobel Prize in Chemistry for 2015! Speaking of boiled eggs: Did you know, the world record for most hard-boiled eggs peeled and eaten in 1 minute is six? Or that the record for most hardboiled eggs consumed, 141 in eight minutes, was set in 2013?

In addition to all the food and fun that chicken eggs have to offer, they can also have biotechnological applications. Eggs can be used to produce both viruses, and vaccines. For flu vaccines, influenza virus is actually injected into the egg where it rapidly multiplies over 72 hours, after which a complex process involving inactivation and break-up of the virus occurs, ultimately stimulating an immune response. Egg yolks are also a source for IgY antibodies; antibodies that have use for treating animal diseases and toxin detection! In the technology sector, eggs have even inspired 3D printed IOT devices for wildlife conservation

clean-up projects underway at a number of sites). The reports we cite here are by no means comprehensive (we have, for example, come across reports concerning regions in Central Europe, Germany, Iraq and Russia and realise there are other known and suspected cases), but they highlight the environmental risks as well as the health and safety concerns of legacy weapons.

Artillery Shell on Kubbar Island, Kuwait. Image courtesy of Tom Oates.

Buried chemical munitions pose clear hazards from the leakage and environmental fate of toxic chemicals (arsenic species have been well studied in this context). Environmental impact of these munitions might even result from methods of disposal: burning arsenic containing munitions in open pits for example, has spread arsenic into soils, prompting a need for more environmentally benign procedures. As the focus of our work is chemical agents, we often overlook that there are additional environmental consequences from the materials and explosives found in legacy munitions (both chemical and conventional); each with their own associated environmental fate. Even bullets can leave a mark through lead contamination at firing ranges. As a consequence, we have seen reports of munition-related ecological risk assessment and "greener munitions".

There can also be social consequences to the presence of legacy chemical weapons, resulting for example from risk of exposure to general civilian populations when buried munitions are accidentally found or handled by improperly prepared responders. In addition to civilian safety, there must be ways to ensure the safety of those involved in disposal activities.

While there are proven methods for disposal of chemical agents, (with comprehensive reviews on the subject available), circumstances of location and the conditions of the abandoned munitions may require approaches and technologies tailored to a specific mission. We sometimes see reports of interesting and novel approaches as well, for example the use of micromotorized particles. Facilities where chemical agents were produced, stored and tested also require clean-up (an example of a former UK chemical warfare agent production and research site is described in a 2010 report on contaminated industrial site remediation). The containers used for storage and any materials exposed to chemical agents also require appropriate treatments.

Scanning for dangerous residue at the abandoned site of CDE Nancekuke, UK (Image courtesy of J. Baylis and D. Allenby) and examining an unexploded WWII munition in Bütgenbach, Belgium (Image courtesy of Grenz-Echo).

As mechanisms of environmental fate and transport are characterized, we may find opportunities to use a variety of samples types (plants for example) to identify both presence and previous use of chemical agents (this potential has been demonstrated with nerve agents). Opportunities for bioremediation of contaminated environments may present themselves as well: for example, the uptake (details here) and transformation of explosive chemicals by plants is known.

Analytical methods for finding burial locations, detecting munitions and distinguishing chemical from non-chemical munitions (as age and degradation can hide identifying markings) are crucial to the clean-up of legacy weapons. The methods employed in this work include x-ray and neutron activation analysis of shells, headspace-trap GC/MS for detecting chemical agents in soil and real-time air monitoring systems. Equally important are methods that simultaneously

and video games for studying camouflage.

We end this edition of Science Fun with one of the most important conundrums of our time. The ever evasive question: which came first, the Chicken? Or the Egg? For your consideration, we offer two views. Since the production of eggs requires a specific protein (ovocledidin-17) found in chicken ovaries, some say that perhaps it was the chicken that came first. Others, however, argue the answer can only be the egg; an egg containing a genetic mutation that hatched into a chicken and was borne to parents that were "almost, but not quite, chickens"!

Upcoming S&T Related Events

OPCW Calendar of Events October to December 2015

15 April 2016
Meeting of the Expert Working Group on Green Chemistry
OPCW Headquarters
The Hague, The Netherlands

18 – 22 April 2016
23rd Session of OPCW SAB
OPCW Headquarters
The Hague, The Netherlands

26 – 27 April 2016
BWC Preparatory Committee for the Eighth Review Conference
Geneva, Switzerland

2 May – 10 June 2016
2016 Spring ConfChem: Science, Disarmament, and Diplomacy in Chemical Education: The Example of the Organisation for the Prohibition of Chemical Weapons.
A virtual Conference
Papers will be posted on a weekly basis followed by online questions and comments.

detect chemical agents and their environmental degradation products. Methods are also needed for detecting buried and sunken munitions. Data collected from clean-up operations can also produce information with forensic value: for example, the ability to identify chemical agents used by different branches within an armed forces through distinguishable impurity profiles. Moving to modern conflict zones, the use of media monitoring (and perhaps social media) has been suggested as a way to ensure we don't lose track of where unexploded munitions (of any kind) may be located – potentially allowing us to remove a future hazard.

Microbiomes

Microbial diversity on a person's skin. Image courtesy of Bouslimani et al.

We all know that our bodies coexist with a multitude of microbial species, have you ever thought about just how diverse that multitude truly is? Would a map of your microbial diversity appear as in the image at left? What about inside your body, where the diversity of gut bacteria is thought to collectively contain at least 100 times as many genes as the human genome. It has been said that we are actually "supraorganisms" made up of thousands of species of microbes interacting with our human cells. Just how many microbes do you carry with you? Perhaps you have heard that there are 10 times more bacterial cells on your body than human cells? It turns out that is not actually true, it is much closer to 1:1; that's still quite a large amount of bacteria if you consider a human is made up of between one trillion and 10 quadrillion cells! The collection of microbes in and on our bodies (our microbiota) define the human microbiome.

There should be no surprise that as a supraorganism of interacting human and microbial cells, your health (both physical and mental) and response to medication might be influenced by your personal microbiome. This has created many new opportunities for healthcare (especially personalized medicine). Studies have shown higher risk for babies to develop asthma if levels of certain gut bacteria are low (details here); and how microbes that influence human cell division may also induce cancer, while other microbes may actually provide opportunities to treat it (details here).

Proportion of microbial vs human genes in the human body. Image courtesy of AMNH.

The human gut microbiota contains at least 160 different microbial species that vary with sex, ethnicity, age and diet. These gut microbes influence digestion and absorption of nutrients into our bodies, influence our immune system and can even influence brain development. Linkages between gut and brain affect blood-brain-barrier permeability, as well as brain development and behaviour.

In medical research, the possibility for linkages to the gut microbiome are being explored with obesity (is there a causal relationship?), allergies, arthritis, intestinal disorders, visceral pain, cardiovascular disease (details here), central nervous system disorders and even autism spectrum disorders. The gut microbiome has also been shown to be a source for therapeutic targets.

Fecal transplants, where gut microbiota of a healthy individual are transferred into the intestine of an unhealthy person, have been used sporadically for over 50 years in applications such as the treatment of Clostridium difficile infection (details here). If you are healthy, you can donate some of your own microbiome to help others. Other applications include controlling the microbiome for treating depression (clinical trials are underway).

Children, especially infants, may not have a fully developed microbiome, requiring further understanding of the benefits and side effects of using microbiome-altering treatments. The

2 – 4 May 2016
International Day for the Foundation of the Organisation for the Prohibition of Chemical Weapons ("Chemical Safety and Security in a Technologically Evolving World")
OPCW Headquarters
The Hague, The Netherlands

5 May 2016
Science Diplomacy 2016
Washington DC, USA

26 – 28 May 2016
23rd Symposium on Chemical and Science Education
TU Dortmund, Germany

30 May – 3 June 2016
European Space Solutions
The Hague, The Netherlands

1 – 2 June 2016
CBRNeConvergenceAsia
Tokyo, Japan

6 – 9 June 2016
2016 BIO International Convention
San Francisco, CA, USA

7 – 8 June 2016
5th Internet of Things Event
High Tech Campus Eindhoven, The Netherlands

8 – 10 June 2016
12th International Symposium on Protection against Chemical and Biological Warfare Agents
Stockholm, Sweden

9 – 11 June 2016
ECSITE Annual Conference 2016
Graz, Austria

20 – 22 June 2016
OPCW SAB Workshop on Chemical Forensics
Helsinki, Finland

gut microbiome of a newborn can be influenced by delivery method and maternal stress, studies on pre-term births have indicated a temporal component to microbiome development, and antibiotic use during critical phases of infant development can produce long-term metabolic consequences and increased risk of certain allergies.

Influencing and controlling microbiomes has much broader applications than human health, with many opportunities recognized for solving real-world problems through microbial symbioses. Plant microbiomes can improve the resilience of crops to unfavorable climates, promote drought resistance, reduce dependence on fertilizers and pesticides, and restrict access of pathogens; with biotechnology start-up companies already inspired! Microbial communities might influence oil extraction from shale rock or be used as a living (and non-toxic) dye.

The use of meta-genomics allows the characterization of complete microbial communities, in effect the ability to measure the microbiome of not just individual humans, but whole urban environments. Yes, even cities and transportation systems have their own unique microbiomes (studies that can really get people talking and inspire art).

Having maps of microbial communities (and having the ability to recognize specific organisms that are unique to certain locations) has applications in investigations, identifying the geographic source of dust particles, tracking the route of disease transmission (details here), tracking microbiological change due to natural events (such as a hurricane) and actually identifying individuals by their "gut print" (raising new privacy concerns).

The benefit from understanding microbiomes has prompted a call for a global microbiome initiative. In regard to human health, the Human Microbiome Project just might lead to a change in the way we practice medicine.

Ricin

Ricin, a Type II ribosome-inactivating protein (RIP), is the only protein toxin listed in the Schedules of the Chemical Weapons Convention and is infamous for centuries of accidental and intentional poisonings. The toxin has been weaponised in past military programmes, implicated in assassinations (there is that very famous case involving an umbrella), appeared in TV shows and has received considerable attention in the context of bioterrorism.


Ricinus communis fruit. Image courtesy of Wikimedia.

Ricin produces its toxic effects through ribosome inactivation, which prevents protein synthesis and induces cell death; a process with potential use in chemotherapy (Anticancer Immunotoxin Therapy). Ricin is composed of two subunits (A and B chains) linked through a disulphide bond. The A chain is responsible for inhibiting protein synthesis, while the B chain enables the protein to gain entry into a cell (for which there are a number of mechanisms). The median lethal dose (LD_{50}) is dependent on route of exposure, with the LD_{50} for aerosol or injected exposure about 1000 times lower than an oral dose (~20 vs. ~20,000 µg/kg).

The toxin is naturally produced in the seeds of the castor bean plant, *Ricinus communis*; the same seeds that provide castor oil and its derivatives; chemicals with a market size expected to reach 1.81 Billion US Dollars by the year 2020. Current worldwide production of castor seeds is estimated at over one-million metric tonnes per year. The oil is used in lubricants, cosmetics, paints and more, and to produce biofuels (including biodiesel from raw castor oil). Castor meal leftover from oil extraction is even used to feed livestock (provided it is detoxified).

Concerns about ricin and bioterrorism have initiated considerable efforts for developing detection methods; these efforts have produced recommendations for the use of mass-spectrometry and immunological assays (methods often used in combination for ricin analysis), characterized reference materials and protocols for inter-laboratory proficiency tests. Detection of the toxin

22 – 24 June 2016
Industrial Technologies 2016
Amsterdam, The Netherlands

13 July 2016
"Science for Diplomats" at EC-82
Report on Chemical Forensics Workshop
OPCW Headquarters, The Hague, Netherlands

11 – 16 July 2016
AAAS-TWAS Course on Science Diplomacy 2016
Trieste, Italy

18 – 22 July 2016
The International Conference on Pure and Applied Chemistry (ICPAC 2016)
"Emerging Trends in Chemical Sciences"
Flic en Flac, Mauritius

8 – 12 August 2016
BWC Preparatory Committee for the Eighth Review Conference (continued)
Geneva, Switzerland

15 – 20 August 2016
24th IUPAC International Conference on Chemistry Education (ICCE 2016)
Kuching, Malaysia
Abstract submission open until 30 April for a CWC Symposium at ICCE2016!

21 – 25 August 2016
252nd American Chemical Society National Meeting & Exposition
Philadelphia, PA, USA

4 – 7 September 2016
52nd Congress of the European Societies of Toxicology (EUROTOX2016)
Istanbul, Turkey

4 – 8 September 2016
6th International IUPAC Conference On Green Chemistry
Venice, Italy

4 – 9 September
Asser Institute Summer Programme on Disarmament and Non-Proliferation of Weapons of Mass Destruction in a Changing World
The Hague, The Netherlands

11 - 16 September 2016
6TH EuCheMS Congress
Seville, Spain

29 – 30 September 2016
Science and Policy-Making: towards a new dialogue
Brussels, Belgium

in food matrices and biomedical samples are of particular interest. The effects of the food matrix and storage conditions are an important aspect of this work, as is the development of methods to improve sample throughput. Other efforts have focused on the development of biosensors and microfluidic devices for point of care detection. With a variety of aptamers and monoclonal antibodies developed for toxin detection, a broad range of detection technologies have been reported, such as paper and aptamer based electrochemical devices, "chemical tongues", piezoresistive microcantilevers, immuno–PCR assays (this can involve antibody coated beads), surface plasmon resonance based systems (including those with nanoparticle enhancement) and nanoparticle based colorimetric systems.

Vaccines to protect against ricin poisoning have also generated interest. RiVAX™ and RVEc™ have successfully completed Phase I clinical trials and further development of vaccines is ongoing. The assessment and engineering of antibodies that neutralise ricin (mAb 4C13 for example), represents another active field of study. Cocktails that can neutralise ricin and other toxins simultaneously, the use of pulsed electric fields to neutralise ricin in mice and natural compounds that can inhibit biological toxins in food matrices, have also been reported.

With the concerns raised regarding bioterrorism and applications in biomedicine (chemotherapy and countermeasures) research on ricin and other toxins will only continue into the foreseeable future – interesting developments are sure to follow!

Stuck in a Bubble? Online Echo Chambers

For the final feature, we look to an issue that comes up often – with all the information we have access to, and all of the online tools that "find" information for us, is there a danger of bias?

We live in a world that connects us to a continually expanding pool of information, bringing opportunities to acquire and share both knowledge and experience with others across the globe. With so much information available, there comes a challenge to avoid becoming trapped within a space where only similar opinions and viewpoints are found - for if those opinions are misinformed, how would we know? Such spaces, which can actually result from the way in which we access information, are known as "Echo Chambers" or "Filter Bubbles".

How do these spaces form? First, navigating and smoothening our experience across the vast unstructured information space requires algorithms and curating tools (e.g. Google). These tools work by selecting websites through criteria such as interconnected links, filtering "spam" and reviewing previously searched or downloaded content to give the users the most relevant results. Similarly, social networks (e.g. Facebook) use algorithms to notice from whom and to what types of posts users respond to with interest. Next, these websites provide users with additional tools to define the types of information they want to see, which reduces their exposure to other types of information. An unintended consequence can be that internet users find themselves seeing a single viewpoint or interpretation of the information being accessed (this becomes a particular issue of concern in political campaigns and discussions of issues of global concern).

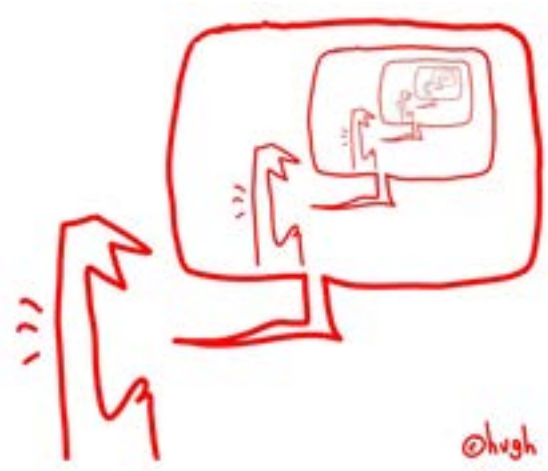


Image courtesy of Tara Hunt and Hugh Macleod.

The positive side is that we find the information we think is most useful to us; the negative is that content can become limited to our own or similar viewpoints that only serve to reinforce our opinions. This is confirmation bias, which can contribute to the spreading and reinforcement of biased information (details here). This phenomena is not exclusive to the internet as has been evidenced in some policy networks; the internet does however, provide an ideal means for it to spread with examples reported from Blogs, on Facebook and on Twitter.

The digital wildfires that can result from the spread of online misinformation have been identified as a geopolitical risk. There is certainly the risk of propagating conspiracy theories,

25 – 28 October 2016
24th Session of OPCW SAB
OPCW Headquarters
The Hague, The Netherlands

7 – 25 November 2016
BWC Eighth Review Conference
Geneva, Switzerland

6 – 8 December 2016
CHAINS 2016, the Dutch chemistry conference
The Netherlands

Crowdsourcing

Have ideas on how to create a minimally invasive technology capable of monitoring drug levels and biomarkers of toxicity in real-time? Here is a challenge for you!

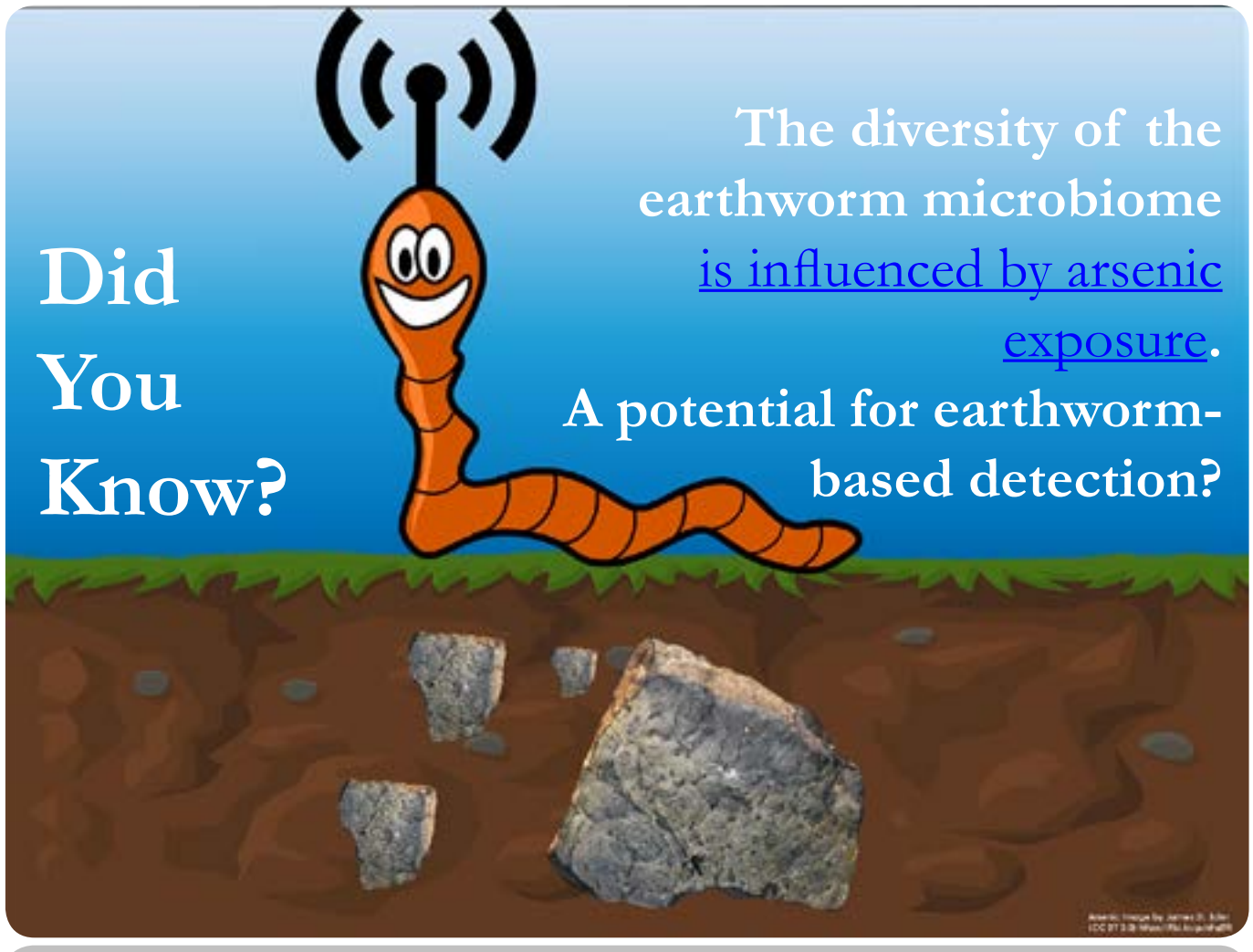
Recognizing pills with a smartphone, want to design an algorithm for the Pill Image Recognition Challenge?

Play videogames to learn about how eyes function!

Take a look at crowdsourcing of Fukushima radiation.

depriving certain communities of feedback from alternate perspectives, and in relation to science communication, echo chambers could serve to widen knowledge gaps between scientific and non-scientific audiences. Yet, like so many concerns in our world, it has been pointed out that there is little to no need to worry, and some published studies overestimate online ideological segregation.

Those that are online trying to understand things holistically and avoid only hearing one side of an argument are advised to question how broadly their message travels, seek diversity and remain aware that every possible online engagement can create a new customized experience. Next time you click, share, like or hover over an online article, think about all the associations that may have taken place to bring you to that information and ask yourself, am I in a bubble? Finally, for those that are truly concerned, you might consider search engines that let you opt out of personalized search results!



Questions, ideas, comments, suggestions, want to make a contribution, or be added to the mailing list? Please contact us through the OPCW Office of Strategy and Policy (OSP). For more frequent updates, Visit us on the web or follow us on Twitter at @OPCW_ST.