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*** While Chemwatch has taken all efforts to ensure the accuracy of information in this publication, it is not intended to be comprehensive or to render advice. Websites rendered are subject to change.**

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ASIA PACIFIC

Workplace exposure standards open for public comment until 30 April

2019-05-02

Safe Work Australia have been seeking comments on the recommended values for respirable crystalline silica and respirable coal dust. The agency is currently evaluating the Workplace exposure standards for airborne contaminants to ensure they are based on the highest quality evidence and supported by a rigorous scientific approach. Safe Work Australia will be seeking comments on the draft evaluation reports and recommendations for the workplace exposure standards (WES) throughout 2019, beginning with respirable crystalline silica and respirable coal dust. In particular, technical comments regarding:

- the toxicological information and data that the value is based upon, and
- the measurement and analysis information provided.

Go to the Safe Work Australia consultation platform Engage to provide your comments on the draft evaluation reports and recommendations for respirable crystalline silica and respirable coal dust. Feedback will be considered when making final recommendations regarding the workplace exposure standards. The draft evaluation reports and recommendations for the remaining chemicals on the Workplace exposure standards for airborne contaminants, as well as additional chemicals that are being considered for inclusion on this list, will be released throughout 2019.

Safe Work Australia, 3 April 2019

<http://www.safeworkaustralia.gov.au>

Updates to the Permissible Ingredients Determination for listed medicines

2019-05-02

An updated version of the Therapeutic Goods (Permissible Ingredients) Determination was registered on the Federal Register of Legislation (FRL) in April 2019. The updated determination is titled the Therapeutic Goods (Permissible Ingredients) Determination (No. 1) 2019. A total of 16 changes have been made in the updated Determination. These changes include:

- Addition of 8 new ingredient entries; and

Safe Work Australia have been seeking comments on the recommended values for respirable crystalline silica and respirable coal dust.

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- Changes to 8 existing ingredient entries, including making requirements clearer and less restrictive.

New ingredients

- C11-13 alkane
- cetearyl nonanoate
- dimeticonol/propylsilsesquioxane/silicate crosspolymer
- disodium lauril sulfosuccinate
- methyl heptanoate
- polyglyceryl-2 caprate
- polyquaternium-4
- resveratrol

Changed ingredients

Ingredient	Reason for update
BRASSICA CAMPESTRIS/ALEURITES FORDI OIL COPOLYMER	Update to ingredient name
BRILLIANT BLUE FCF	Less restrictive requirements
MAGNESIUM GLYCINATE DIHYDRATE	Correction of error
METHYL SALICYLATE	Correction of error
NEOPENTYL GLYCOL DIOCTANOATE	Less restrictive requirements
POLYVINYL ACETATE	Less restrictive requirements
SORBITOL	Correction of error
STREPTOCOCCUS SALIVARIUS	Less restrictive requirements

TGA, 30 April 2019

<http://www.tga.gov.au/>

Protecting Victorian Workers from Deadly Silica Dust

2019-05-02

The Victorian Labor Government will launch an unprecedented compliance and enforcement blitz targeting over 300 high-risk workplaces – focusing on stonemasonry workshops to prevent the deadly lung disease silicosis. The comprehensive action plan, unveiled by Premier Daniel Andrews and Minister for Workplace Safety Jill Hennessy, includes:

- A state-wide ban on uncontrolled dry cutting of materials that contain crystalline silica dust;

The Victorian Labor Government will launch an unprecedented compliance and enforcement blitz targeting over 300 high-risk workplaces – focusing on stonemasonry workshops to prevent the deadly lung disease silicosis.

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- Free health screening for Victoria's 1400 stonemasons;
- A tough new compliance code for businesses working with silica;
- An awareness campaign to highlight the risks of working with engineered stone.

Silica dust is a hazardous substance impacting workers in construction, mining and quarrying. Stonemasons are at higher risk due to the cutting and polishing of artificial stone benchtops which contain high concentrations of silica. Banning dry cutting of materials containing crystalline silica will dramatically reduce the risk of workers developing silicosis as wet cutting reduces the likelihood of harmful exposure to silica dust. The Labor Government is also leading a push to develop a national silicosis strategy and reduce the Australian silica workplace exposure standard from 0.1 mg/m³ to 0.02 mg/m³ over an eight-hour day. The Labor Government will also hold a summit for GPs and medical specialists, and education seminars for those in the stonemasonry industry and health sector in August. Silicosis is a proclaimed disease, meaning workers or dependents of a worker with silicosis are entitled to compensation without having to prove that work contributed to the disease. WorkSafe received 28 claims for silica-related conditions in 2018 and 15 workers have died from the disease since 1985. The Labor Government has also requested WorkSafe examine ways for improving access to compensation for workers with silicosis, including expediting compensation claims for lost wages and pain and suffering. WorkSafe will also review the list of proclaimed diseases for stonemasons and those working with engineered stone with a view to adding lung cancer and auto-immune diseases that can occur from silica exposure.

Premier of Victoria, 1 May 2019

<https://www.premier.vic.gov.au>

Hydrofluorocarbon permits

2019-05-02

New Zealand's Environmental Protection Authority (EPA) have issued a reminder that applications for special permits for the import of hydrofluorocarbons close on 1 July 2019, and 1 September 2019 for grandparented permits. From 1 January 2020, all imports, transshipments, and exports of specified hydrofluorocarbons will require a permit from the EPA. You need to apply in 2019 for these permits. If you export hydrofluorocarbons in the calendar year (from 2020 onwards) you may be eligible for an exporter's import permit to replace the quantity exported.

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Export permits, exporter's import permits, import permits for recycled hydrofluorocarbons, and exemptions for transshipments may be applied for in 2020.

NZ EPA Hazardous Substances Newsletter, April 2019

<http://www.epa.govt.nz>

China Consults on General Program of Technical Guidelines for Environmental Health Risk Assessment

2019-05-02

On 19 April 2019, the Chinese Ministry of Ecology and Environment (MEE) issued a notice to seek public feedback on the *General Program of Technical Guidelines for Environmental Health Risk Assessment*, aiming to guide and regulate the environmental health risk assessment work and protect the public health. The consultation is set to end on 22 May this year. Environmental health risk assessment is an important foundation for environmental management. It can help governments to address the root cause of environmental hazards and proactively manage environmental pollutants with high health hazards, thus enabling great improvements to be made to ecological and environmental management. The General Program is positioned as a master plan guiding the institutional framework for environmental health risk assessment. Following the principle of ensuring "scientific, conservative, up-to-date, and traceable" practices, it applies to assessment of risks to human health from exposure to chemicals in the environment. According to the document, the procedure of environmental health risk assessment majorly contains six steps. The General Program provides detailed requirements for risk assessors in performing every one of the six phases in environmental health risk assessment. For example, in developing an assessment program, risk assessors should first identify several factors, including the objective, scope, category, content of assessment, methodology for collecting data, and quality control requirements. It should also be noted that some procedures and requirements are developed referring to relevant technical documents released by authorities of other countries as well as international organizations like the WHO. Further information is available at: [MEE Notice](#)

Chemlinked, 30 April 2019

<http://chemlinked.com/en/news>

On 19 April 2019, the Chinese Ministry of Ecology and Environment (MEE) issued a notice to seek public feedback on the General Program of Technical Guidelines for Environmental Health Risk Assessment

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AMERICA

EPA Takes Next Step in Review Process for Herbicide Glyphosate, Reaffirms No Risk to Public Health

2019-05-02

The United States Environmental Protection Agency (EPA) is taking an important step in the agency's review of glyphosate. As part of this action, EPA continues to find that there are no risks to public health when glyphosate is used in accordance with its current label and that glyphosate is not a carcinogen. The agency's scientific findings on human health risk are consistent with the conclusions of science reviews by many other countries and other federal agencies. While the agency did not identify public health risks in the 2017 human health risk assessment, the 2017 ecological assessment did identify ecological risks. To address these risks, EPA is proposing management measures to help farmers target pesticide sprays on the intended pest, protect pollinators, and reduce the problem of weeds becoming resistant to glyphosate. "EPA has found no risks to public health from the current registered uses of glyphosate," said EPA Administrator Andrew Wheeler. "Today's proposed action includes new management measures that will help farmers use glyphosate in the most effective and efficient way possible, including pollinator protections. We look forward to input from farmers and other stakeholders to ensure that the draft management measures are workable, realistic, and effective." "If we are going to feed 10 billion people by 2050, we are going to need all the tools at our disposal, which includes the use the glyphosate," U.S. Secretary of Agriculture Sonny Perdue said. "USDA applauds EPA's proposed registration decision as it is science-based and consistent with the findings of other regulatory authorities that glyphosate does not pose a carcinogenic hazard to humans." Glyphosate is the most widely used herbicide in U.S. agriculture and has been studied for decades. Glyphosate is used on more than 100 food crops, including glyphosate-resistant corn, soybean, cotton, canola and sugar beet. Non-agricultural uses include residential areas, aquatic areas, forests, rights of way, ornamentals and turf. Once the Federal Register notice publishes, the public will be able to submit comments on EPA's proposed decision at www.regulations.gov in docket # EPA-HQ-OPP-2009-0361. Public comments will be due 60 days after the date of publication in Federal Register. EPA's responses to the comments received on the draft ecological and human health risk assessments and the benefits assessment will be in the docket. For more information about glyphosate, including the proposed interim decision

The EPA's scientific findings on human health risk are consistent with the conclusions of science reviews by many other countries and other federal agencies.

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and supporting documents, visit: <https://www.epa.gov/ingredients-used-pesticide-products/glyphosate>. The glyphosate draft risk assessments and supporting documents can be found at: <https://www.epa.gov/ingredients-used-pesticide-products/draft-human-health-and-ecological-risk-assessments-glyphosate>.

U.S EPA, 30 April 2019

<http://www.epa.gov>

U.S. EPA Issues Proposed Rule for Ignitable Liquid Determinations

2019-05-02

Recently, the United States Environmental Protection Agency (EPA) requested public comment on a proposed rule regarding ignitable liquids under the Resource Conservation and Recovery Act (RCRA). The current regulation requires test methods mandating the use of mercury-containing thermometers, references out of date standards, and contains certain ambiguous language for which guidance was issued. The proposed rule updates test methods for determining whether a waste is an ignitable hazardous waste and codifies previously issued guidance. Comments must be received on or before 3 June 2019. The EPA does not expect the other parts of this proposed action (*i.e.*, changes to aqueous alcohol exclusion, addition of sampling guidelines for multiphase mixtures, and technical edits) to affect any entity because they do not create new requirements or change existing requirements. Under RCRA, solid waste is "any garbage, refuse, sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, including solid, liquid, semisolid, or contained gaseous material..." The EPA considers certain of these wastes hazardous – those that generators determine exhibit ignitability, corrosivity, reactivity, or toxicity or that are specifically listed by the EPA. It is several aspects of the ignitability classification regulations that EPA is addressing in the proposed rule:

- Existing regulations require the use of Test Methods for Evaluating Solid Waste: Physical/Chemical Methods (SW-846) Methods 1010A (Pensky-Martens) or Method 1020B (Setaflash) for flash point testing and Methods 0010, 0011, 0020, 0023A, or 0051 for air sampling and stack emissions. These Methods required the use of mercury thermometers. Methods 1010A and 1020B incorporate by reference certain American Society for Testing Materials (ASTM) standards which

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are no longer current. Method 1010A incorporates ASTM D 93-79 and D 93-80 (issued in 1979 and 1980) whereas the current ASTM D 93-16 standard was published in 2016. Method 1020B incorporates ASTM D 3278-78 (from 1978) while the current standard was last edited in 1996 and confirmed in 2011. Further, both ASTM D 93 and ASTM D 3278 standards were developed for use with petroleum products. Under the proposed rule, updated test methods allow for both digital and non-mercury liquid in glass flash point detection methods. Updated SW-846 Methods 0010, 0011, 0020, 0023A, and 0051 are incorporated by reference. The EPA has worked with the ASTM International Committee on Waste Management to develop test method standards specifically for waste, and these new standards, ASTM D 8175-18 ("Test Method for Finite Flash Point Determination of Liquid Wastes by Pensky-Martens Closed Cup Tester") and ASTM D 8174-18 ("Test Method for Finite Flash Point Determination of Liquid Wastes by Small Scale Closed Cup Tester") are incorporated into the updated SW-846 Methods 1010B and 1020C. Generators and laboratories should choose to use the test method that is most suitable to their needs. The EPA may require transition to the newer Methods and Standards at some point, but, at this time, the use of the older Methods and Standards will still be permissible, allowing effected entities to transition to the newer Methods and Standards on their own schedule. The public is encouraged to comment on whether immediate transition should be required.

- Existing regulations are somewhat unclear regarding aqueous solutions containing low amounts of alcohol, and reference Department of Transportation (DOT) regulations that are no longer current. The intent of the aqueous solutions exclusion was to exclude from ignitability classification those solutions that will not sustain combustion because of their high water content. Guidance has clarified this somewhat. Under the proposed rule, the EPA will rephrase this exclusion as "other than a solution containing less than 24 percent of any alcohol or combination of alcohols (except if the alcohol has been used for its solvent properties and is one of the alcohols specified in EPA Hazardous Waste No. F003 or F005) by volume and at least 50 percent water by weight." The EPA notes that water content may be quantified in different ways including SW-846 Methods 9000 and 9001, as appropriate. The above phrasing for the exclusion may allow for the inadvertent exclusion of wastes that are ignitable due to non-alcohol components. The public is encouraged to comment on any known waste streams for which this could be the case, how these are currently

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managed, and any hazards or lack thereof associated with the waste or its handling.

- Existing guidance on multi-phase waste specifies that testing should be done on each phase to the extent possible. The EPA has proposed pressure filtration (SW-846 Method 1311) to confirm that a waste does not contain liquid. Under the proposed rule, Codified language will indicate that multi-phase waste is to be separated into its different liquid and solid phases to the extent possible before then testing each phase for ignitability. The EPA suggests SW-846 Methods 9095B or 1311 to confirm that a waste does not contain liquid. The public is encouraged to comment regarding the determination of free liquids.
- Existing regulations reference DOT regulations that are obsolete. Under the proposed rule, Regulations will now reference ASTM E 681-85 ("Standard Test Method for Concentration Limits of Flammability of Chemicals (Vapors and gases).") as the modified DOT regulations require, mirror DOT requirements, and remove references to the Bureau of Explosives as this is no longer the delegated authority.

How will this impact me?

Consider whether your state already has an authorised RCRA program. The proposed rule, if finalised, would be required only in states that do not yet have final authorisation of their base RCRA programs as these changes in the rule are neither considered more nor less stringent, nor are broader in scope than the previous regulations. Authorised states may, but are not required to, adopt the changes in the rule. If you are a generator of waste or a laboratory, consider adjusting testing procedures as soon as reasonably possible as the use of mercury thermometers will no longer be accepted at some point (possibly as soon as this rule is finalised). If already following EPA guidance for aqueous solutions and multi-phase wastes, the codification of these will likely have minimal impact. If not following the guidance, now is the time to move toward that goal. Similarly, if following DOT regulation, the update to EPA references may have minimal effect.

Further information is available at: The full proposed rule and supplementary information can be found at [FR Doc. 2019-05878](#).

Product Supply Chain Intelligence, 22 April 2019

<https://psi.ul.com/en/>

Agency Asks for Public Input on Draft Interim Recommendations for Addressing Groundwater Contaminated with PFOA and PFOS

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EPA Takes Important Step Under PFAS Action Plan

2019-05-02

The United States Environmental Protection Agency (EPA) released draft interim guidance for addressing groundwater contaminated with perfluorooctanoic acid (PFOA) and/or perfluorooctane sulfonate (PFOS) for public review and comment. This is a key component of the agency's PFAS Action Plan. These draft recommendations will help protect human health in communities across the country by providing clear and consistent guidance on addressing PFOA and PFOS in groundwater under federal clean-up programs. This information has been requested by other federal agencies and the states and could be used by other federal, state and tribal clean-up programs. "Today, we are delivering on one of our most important commitments under the PFAS Action Plan," said EPA Administrator Andrew Wheeler. "This interim guidance will support actions to protect the health of communities impacted by groundwater that contains PFOA and PFOS above the 70 parts per trillion level, and is a potential source of drinking water. This is a critical tool for our state, tribal, and local partners to use to address these chemicals." EPA developed this guidance based on the agency's current scientific understanding of PFAS toxicity, including the agency's PFOA and PFOS health advisories. The recommendations may be revised as new information becomes available. EPA has opened a docket for a 45-day public comment period. The draft guidance describes EPA's interim recommendations for screening levels and preliminary remediation goals (PRGs) to inform final clean-up levels for PFOA and/or PFOS contamination of groundwater that is a current or potential source of drinking water. To view the draft guidance and to learn how to submit comments, visit <https://www.epa.gov/pfas>.

U.S EPA, 25 April 2019

<http://www.epa.gov>

US Chemical Safety Board urges review of hydrofluoric acid regulations

2019-05-02

The United States Chemical Safety and Hazard Investigation Board has called on the US Environmental Protection Agency to review its regulation of hydrofluoric acid. One-third of the nation's 150 petrochemical refineries use HF to produce high-octane gasoline. The CSB's [April 24 statement](#) urges the EPA to re-examine and update a 1993 study to determine the effectiveness of existing risk management program requirements

The United States Chemical Safety and Hazard Investigation Board has called on the US Environmental Protection Agency to review its regulation of hydrofluoric acid.

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as well as the viability of using inherently safer alkylation technologies in refineries. "In the last 4 years, the CSB has investigated two refinery incidents where an explosion elevated the threat of a release of HF," CSB interim executive Kristen Kulinowski says. "Refinery workers and surrounding community residents are rightly concerned about the adequacy of risk management for the use of hazardous chemicals like HF." HF is a highly toxic chemical that can seriously injure or cause death at concentrations as low as 30 ppm, the CSB says. The CSB's recommendation follows its accident investigations at an ExxonMobil refinery in California and a Husky Energy refinery in Wisconsin. After the California accident, the South Coast Air Quality Management District began examining HF regulations and alternatives. That effort is ongoing, a South Coast AQMD spokesperson says. EPA officials say it is reviewing the CSB's request.

Chemical & Engineering News, 28 April 2019

<http://pubs.acs.org/cen/news>

EUROPE

New meta-analysis of glyphosate-based plant protection products does not alter the assessment of the active substance

2019-05-02

If used properly and for its intended purpose, glyphosate is not carcinogenic. This was the conclusion arrived at by the German Federal Institute for Risk Assessment (BfR) and numerous other national and international authorities. A new meta-analysis in which already published studies are evaluated collectively does not alter the assessment of the BfR. In the meta-analysis, Luoping Zhang, University of California, Berkeley, and her team pursued the question of whether people who used plant protection products containing glyphosate (such as farmers and gardeners) had an increased risk of contracting Non-Hodgkin Lymphoma (NHL), a form of lymph node cancer. To this end, the scientists evaluated updated data from the "Agricultural Health Study" (AHS), a large-scale cohort study, and five case control studies. The researchers' analysis concluded that people who had the greatest exposure to plant protection products containing glyphosate contracted NHL more often than persons with lower or no exposure. This result is supported, in the view of the authors, by previous experiments with animals and "mechanistic" studies in which the causes were sought. It is suggested

If used properly and for its intended purpose, glyphosate is not carcinogenic.

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that there is a “compelling” link between the uptake of glyphosate-based plant protection products and an increased risk of NHL. The BfR has a different opinion. Although the meta-analysis with its reference to glyphosate-based plant protection products is interesting from a scientific point of view, it involves great uncertainty: It could not be determined with sufficient accuracy in the studies how much glyphosate the study participants were actually exposed to. It should also be taken into account that according to the current state of knowledge, farmers in the USA can come in closer contact with plant protection products containing glyphosate (e.g. because larger areas are treated or because it is often sprayed from aircraft). Several of the case-control studies used by Zhang and colleagues found an increase in the NHL risk. These studies should only be given very limited consideration, however, when assessing the active substance glyphosate, as no distinction can be made between glyphosate and the various co-formulants contained in the products that were spread. Furthermore, it was not taken sufficiently into account in several studies that the farmers were possibly exposed to other plant protection products too.

Even though the meta-analysis presents a weak connection between the uptake of glyphosate-based plant protection products and the risk of NHL, this result involves considerable uncertainty in the corresponding studies. When all of the findings are viewed together, therefore, a causal connection between exposure to (contact with) the active substance glyphosate and the occurrence of NHL has still not been substantiated, in the view of the BfR. In concurrence with the International Agency for Research on Cancer (IARC), the BfR established “limited evidence” of a connection between exposure to glyphosate-based plant protection products and Non-Hodgkin Lymphomas (NHL) in an overall assessment of the epidemiological data made in August 2015. In the conclusion of the peer reviews and final expert meeting, this connection was evaluated as providing “very limited evidence” in the assessment of the European Food Safety Authority (EFSA). In addition to the CLH dossier (harmonised classification and labelling), the European Chemicals Agency (ECHA) conducted its own assessment of the epidemiological studies and confirmed that several case control and meta-studies show a weak connection between exposure to glyphosate-based plant protection products and NHL. The Risk Assessment Committee (RAC) of the European Chemicals Agency (ECHA) concluded in 2017, however, that the criteria for classification as carcinogenic are not satisfied in the overall view of epidemiological examinations. The publication “Exposure to Glyphosate-Based Herbicides and Risk for Non-Hodgkin Lymphoma: A Meta-Analysis

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and Supporting Evidence” by Luoping Zhang et al. (2019), presents an analysis of already published epidemiological studies. Zhang and colleagues (2019) analysed the connection between the occurrence of NHL and high exposure to glyphosate-based herbicides (GBH) in the Agricultural Health Study (AHS). High exposure to GBH is understood here to be exposure which is high in a group comparison. Zhang et al. (2019) identify high exposure in the AHS study on the basis of the cumulative exposure of users. As the BfR does not have any comparable information on applications in the European Union (EU), a comparison with the customary exposure of users in the EU is not currently possible. The AHS recorded data from plant protection product users in the US states Iowa and North Carolina. It is assumed that exposure was representative of these regions of the USA and the study period.

The BfR does not have any reliable information, however, on whether the quantities of GBH used in the USA and Europe are comparable. The BfR is assuming that the treated area per user is higher in the USA than in Europe and that other application techniques (e.g. per aircraft) are also used. Based on the data from five case-control studies from Sweden, France, Canada and the USA, as well as the newly updated results of the US-American AHS (Andreotti et al., 2018), the analysis conducted by Zhang et al. shows an increase of approx. 41% in the relative risk of the occurrence of NHL with high as opposed to lower GBH exposure (statistical uncertainty range: 13% to 75%). The strength of this connection is of the same magnitude as in previously published meta-analyses (Chang & Delzell, 2016; IARC, 2015; Schinasi & Leon, 2014) and equates to roughly 6 additional NHL cases a year per 100,000 highly exposed persons (e.g. farmers, uncertainty range: 2 to 11 cases). Because several scientifically justifiable analysis scenarios were considered, it was possible to reduce the uncertainty of the estimation compared to previous meta-analyses. A reduction of the uncertainty when recording exposure and cases of disease in the underlying studies is not possible by means of the study by Zhang et al. (2019). Separate review of the analysed studies is not suitable for showing a connection between exposure to GBH and NHL. A comprehensive assessment of the study by Andreotti et al. (2018) in the context of all existing epidemiological studies based on the meta-analysis by Zhang et al. (2019) therefore complements the estimation of the BfR of 27 November 2017 of the separately reviewed publication by Andreotti et al. (2018). The BfR estimates, therefore, that high GBH exposure could pose a moderately elevated risk of NHL. The causality of this connection cannot be substantiated by the available data, however. This is due to various reasons, such as the imprecise recording of exposure

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and the extent of exposure through the incorrect use of GBH and possible parallel exposure to other herbicides (which were not recorded in the same way in all studies). It must also be taken into consideration that the EU active substance assessment as well as classification and labelling in line with the CLP regulation relate to the technical active substance. In the epidemiological studies, however, exposure to GBH was recorded as a matter of course. For this reason, no reliable statement can be made on the basis of the epidemiological studies as to whether the effects in question were caused by the active substance glyphosate or by co-formulants in the formulations, and/or enhancement of the glyphosate effects through co-formulants (the BfR already remarked in Addendum 1 to the RAR (2015) that sometimes significantly higher toxicity of GBH was detected compared to the pure active substance). To reduce the great uncertainties of the epidemiological data requires the acquisition of additional data within the scope of an independent epidemiological study under user conditions in Europe. The BfR recommends the planning, funding and conducting of a study of this kind in Europe so that reliable statements can be made. This epidemiological study should contain an as precise as possible characterisation of exposure to plant protection products as it exists in Europe. On the basis of the provisional estimation, the BfR concludes that the existence of a connection between exposure to GBH and NHL has become more plausible compared to the previous estimation, although the causality of the connection has still not been substantiated. To satisfy the criteria of the CLP regulation for classification as carcinogenic, however, these findings would have to be supported by other studies. Viewed overall, therefore, it would not be appropriate at the moment from a German point of view for the European authorities responsible for classification and labelling to look into the matter once again. Moreover, the BfR suggests that the comparability of the authorised forms of use of GBH, including the quantities used and frequency of use in the USA and Europe, be reviewed. It could perhaps then be evaluated on this basis to what extent the above-mentioned estimations of additional NHL cases among highly exposed users can be transferred to the situation in the EU. More information on this topic at the BfR website: https://www.bfr.bund.de/en/a-z_index/glyphosate-193962.html

BfR, 3 April 2019

<http://www.bfr.bund.de>

The European Chemical Industry Council (CEFIC) have welcomed the European Chemicals Agency's (ECHA) report 'Mapping the Chemical Universe to Address Substances of Concern'.

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Cefic's Reaction To ECHA's Integrated Regulatory Strategy Report

2019-05-02

The European Chemical Industry Council (CEFIC) have welcomed the European Chemicals Agency's (ECHA) report 'Mapping the Chemical Universe to Address Substances of Concern'. Cefic actively participates in ECHA's initiatives to map substances with the aim of identifying those which may require additional information and immediate regulatory action. Cefic, together with other associations, has worked with ECHA and EU member state representatives to screen some 1,000 substances towards creating an inventory of all plastic additives on the EU market and validate their properties. Regulators in EU member states can now use this inventory as a starting point to decide which substances should be prioritised for risk assessment. Such a collaborative model could be used to map other groups of substances. CEFIC will also discuss with ECHA how we can contribute to their work checking data for 2,700 substances from the so-called "uncertain area" to help identify substances of potential concern and facilitate their risk assessment. Having a list of those substances available will help the industry to prioritise the review and updates to relevant REACH dossiers.

CEFIC, 19 April 2019

<http://www.cefic.org>

Sweden and France propose ban on over a thousand allergenic substances in textiles and leather

2019-05-02

Sweden and France are proposing an EU ban on more than a thousand allergenic substances used in items such as clothing and shoes. According to the proposal, textile and leather items sold to consumers should not contain these substances at levels above certain content thresholds. "We want to protect all consumers from being affected by skin allergies. These days it is difficult to avoid exposure to allergenic substances that may be present in textiles and leather. Once you have developed a skin allergy, it is a life-long problem," says Helena Dorfh, a risk manager with the Swedish Chemicals Agency. The Swedish Chemicals Agency and the French agency ANSES have jointly drawn up the proposal for an EU ban. The proposal was recently submitted to the European Chemicals Agency, ECHA. Nearly a hundred of the more than one thousand substances covered by the proposal can currently be present in commercially-available textile and

Sweden and France are proposing an EU ban on more than a thousand allergenic substances used in items such as clothing and shoes.

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leather goods. "The proposal includes many more allergenic substances than those that can currently be present in textiles and leather, and in this way will prevent the use of other allergenic substances in textile and leather in the future. The aim is to create robust protection for the consumer against all substances that can cause skin allergies," says Helena Dorf. The Swedish Chemicals Agency and ANSES estimate that four to five million EU citizens have allergies to chemicals that are present in textiles and leather, and it is thought that between 45,000 and 180,000 people in the EU develop an allergy to these chemicals every year. The European Chemicals Agency, ECHA, will now consider the Swedish-French proposal and give companies, organisations and the public an opportunity to express their views as part of a public consultation. This will be followed by a decision process that may result in a decision by the EU Commission on a ban within just over two years. [Read the proposal on the website of the European Chemicals Agency \(ECHA\)](#)

KEMI, 26 April 2019

<https://www.kemi.se/en/>

France, Hungary the Netherlands and Sweden will jointly carry out the next assessment of glyphosate

2019-05-02

EU Member States have agreed that France, Hungary, the Netherlands, and Sweden will be jointly responsible for the next evaluation of the active substance glyphosate used in plant protection products. Approvals for active substances used in plant protection products shall, according to the legislation, be reviewed periodically. Normally, the evaluation of such an application is made by a single Member State which is appointed as Rapporteur Member State (RMS). Due to the extensive documentation for glyphosate, the European Commission has proposed that a group of Member States jointly should act as RMS for the next evaluation of the substance. This proposal from the European Commission has now been supported by the EU Member States in a vote in the Standing Committee on Plants, Animals, Food and Feed (SCoPAFF). At the same time, the Standing Committee voted in favour of amending Commission Implementing Regulation (EU) 844/2012 to allow such an approach. The competent authorities in France, Hungary, the Netherlands and Sweden have all agreed to be part of the rapporteur group, called "The Assessment Group on Glyphosate (AGG)". The upcoming review of glyphosate in the EU starts on 15 December 2019, when interested applicant(s) must submit an application for renewed approval. The complete documentation to be

EU Member States have agreed that France, Hungary, the Netherlands, and Sweden will be jointly responsible for the next evaluation of the active substance glyphosate used in plant protection products.

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assessed should be submitted by the applicant(s) within the subsequent six months. By June 2021, the AGG will present a draft renewal assessment report to the European Food Safety Authority (EFSA). The report will then be reviewed by other Member States and will be made publicly available for comments by stakeholders. Based on the peer review and overall data, EFSA will adopt a conclusion on whether glyphosate can still be expected to meet the approval criteria set out in the EU Plant Protection Products Regulation. Finally, the European Commission will prepare a decision whether or not the approval of glyphosate should be renewed, which will be submitted to a vote in the SCoPAFF. A decision on the renewal or non-renewal of approval for glyphosate should be made no later than December 2022, when the current approval period for glyphosate expires. [Read further and updated information \(also on the assessment process\) at the European Commission website](#)

KEMI, 15 April 2019

https://www.kemi.se/en

REACH Update

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ECHA seeks comments on workplace exposure limits for 2 substances

2019-05-03

On 17 April 2019, the European Chemicals Agency (ECHA) published a call for comments and evidence on workplace exposure limits for 2 new substances. The agency is seeking evidence on properties related to scientific evaluation of health-based exposure limits at the workplace for:

- Diisocyanates; and
- Lead and its compounds

Further information is available at: <https://echa.europa.eu/oels-ccc-current-consultation>

ECHA, 17 April 2019

<http://echa.europa.eu>

On 17 April 2019, the European Chemicals Agency (ECHA) published a call for comments and evidence on workplace exposure limits for 2 new substances.

ECHA publishes 16 New Testing Proposals

2019-05-03

On 26 April 2019, the European Chemicals Agency (ECHA) published 16 new testing proposals. Details of the new proposals are as follows:

Name	EC Number	CAS Number	Deadline for submitting information	Hazard endpoint for which vertebrate testing was proposed
2-Propyn-1-ol, reaction product with 1-2.5 moles of oxirane	941-793-1	-	10/06/2019	Reproductive toxicity (pre-natal developmental toxicity)
3-(trimethoxysilyl)propylamine	237-511-5	13822-56-5	10/06/2019 10/06/2019	Reproductive toxicity (extended one-generation reproductive toxicity study) Reproductive toxicity (pre-natal developmental toxicity)
3-trimethoxysilylpropyl methacrylate	219-785-8	2530-85-0	10/06/2019	Reproductive toxicity (pre-natal developmental toxicity)

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<u>Name</u>	<u>EC Number</u>	<u>CAS Number</u>	<u>Deadline for submitting information</u>	<u>Hazard endpoint for which vertebrate testing was proposed</u>
Biphenyl-4,4'-diol	202-200-5	92-88-6	10/06/2019 10/06/2019	Reproductive toxicity (extended one-generation reproductive toxicity study) Reproductive toxicity (pre-natal developmental toxicity)
Ethylenediamine, propoxylated	500-035-6	25214-63-5	10/06/2019 10/06/2019	Reproductive toxicity (extended one-generation reproductive toxicity study) Reproductive toxicity (pre-natal developmental toxicity)
Isobutyric acid, monoester with 2,2,4-trimethylpentane-1,3-diol	246-771-9	25265-77-4	10/06/2019 10/06/2019 10/06/2019	Reproductive toxicity (extended one-generation reproductive toxicity study) Reproductive toxicity (pre-natal developmental toxicity) Sub-chronic toxicity (90-day): oral
Perfluamine	206-420-2	338-83-0	13/05/2019 13/05/2019 13/05/2019 13/05/2019	Genetic toxicity in vivo (In vivo Mammalian Alkaline Comet Assay) Genetic toxicity in vivo (Mammalian Erythrocyte Micronucleus Test) Reproductive toxicity (extended one-generation reproductive toxicity study) Reproductive toxicity (pre-natal developmental toxicity)
Propylidynetrimethyl trimethacrylate	221-950-4	3290-92-4	10/06/2019	Reproductive toxicity (extended one-generation reproductive toxicity study)

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Name	EC Number	CAS Number	Deadline for submitting information	Hazard endpoint for which vertebrate testing was proposed
Reaction mass of 2-(3,4-dimethyl-1H-pyrazol-1-yl)succinic acid and 2-(4,5-dimethyl-1H-pyrazol-1-yl)succinic acid	940-877-5	-	13/05/2019 13/05/2019	Reproductive toxicity (pre-natal developmental toxicity) Sub-chronic toxicity (90-day): oral
Strontium neodecanoate	812-724-1	106705-37-7	10/06/2019	Reproductive toxicity (pre-natal developmental toxicity) Note: testing proposed with [Strontium oxide] (EC 215-219-9)
Zinc, O,O-mixed (iso-Bu), (iso-Pr), (pentyl) phosphorodithioate	820-225-5	101747-77-7	10/06/2019 10/06/2019 10/06/2019	Reproductive toxicity (extended one-generation reproductive toxicity study) “ Note: testing proposed with [Phosphorodithioic acid, mixed O,O-bis(iso-Bu and pentyl) esters, zinc salts] (EC 270-608-0) Reproductive toxicity (pre-natal developmental toxicity) “ Note: testing proposed with [Phosphorodithioic acid, mixed O,O-bis(iso-Bu and pentyl) esters, zinc salts] (EC 270-608-0) Sub-chronic toxicity (90-day): oral “ Note: testing proposed with [Phosphorodithioic acid, mixed O,O-bis(iso-Bu and pentyl) esters, zinc salts] (EC 270-608-0)

Further information is available at: <https://echa.europa.eu/information-on-chemicals/testing-proposals/current>

ECHA, 26 April 2019

<http://echa.europa.eu>

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Safer Chemicals – ECHA Conference

2019-05-03

On 21-22 May 2019, the European Chemicals Agency (ECHA) will be holding a free conference on Safe Chemicals. The conference offers an insight into the current priorities in EU chemicals regulation after the final REACH registration deadline. Register now for two days packed with practical advice, discussion and networking. Further information is available at: [More](#)

ECHA, April 2019

<http://echa.europa.eu>

On 21-22 May 2019, the European Chemicals Agency (ECHA) will be holding a free conference on Safe Chemicals.

Janet's Corner

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Research Solidified

2019-05-03

www.benitaepstein.com

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"Our research is solidified,
but our funding has vaporized."

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Sodium Hypochlorite

2016-10-18

Sodium hypochlorite is a chemical compound with the formula NaClO. [1] It is a clear, slightly yellowish solution with a characteristic odour. Sodium hypochlorite is unstable. Chlorine evaporates from the solution and when heated, the sodium hypochlorite disintegrates. This also happens when sodium hypochlorite comes in contact with acids, sunlight, certain metals and poisonous and corrosive gasses, including chlorine gas. It is a strong oxidator and reacts with flammable compounds and reductors. Sodium hypochlorite solution is a weak base that is inflammable.[2]

USES [2]

Sodium hypochlorite is used on a large scale. For example in agriculture, chemical industries, paint- and lime industries, food industries, glass industries, paper industries, pharmaceutical industries, synthetics industries and waste disposal industries. In the textile industry sodium hypochlorite is used to bleach textile. It is sometimes added to industrial wastewater. This is done to reduce odours. Hypochlorite neutralises sulphur hydrogen gas (SH) and ammonia (NH₃). It is also used to detoxify cyanide baths in metal industries. Hypochlorite can be used to prevent algae and shellfish growth in cooling towers. In water treatment, hypochlorite is used to disinfect water. In households, hypochlorite is used frequently for the purification and disinfection of the house.

Sodium hypochlorite is a chemical compound with the formula NaClO.

SOURCES AND ROUTES OF EXPOSURE

Sources of Exposure [3]

- Exposure to sodium hypochlorite can occur at low levels if you use disinfectants like household bleach.
- Exposure may also occur when swimming in pools where it has been added to kill bacteria.
- Drinking water from public drinking water supplies where sodium hypochlorite is added to kill bacteria can also be a source of exposure.
- Workers employed in occupations where sodium hypochlorite is used to bleach paper and textiles may be subject to slightly higher levels of exposure.

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Routes of Exposure [4]

The main routes of sodium hypochlorite is via ingestion, contact with the skin and eyes and inhalation of gases.

HEALTH EFFECTS [5]

Acute Exposure

Symptoms of sodium hypochlorite exposure may be immediate, or may be delayed for several hours.

Inhalation

The toxicity of sodium hypochlorite solution by inhalation is predominantly due to the mixing of bleach with acids and the release of highly irritant gases. Metabolic acidosis may occur in rare cases following significant inhalation of sodium hypochlorite. Mixing sodium hypochlorite with acids releases chlorine gas, although in most cases the concentration of chlorine liberated are not sufficient to cause adverse health effects. In rare cases, inhalation of chlorine gas, produced from mixing sodium hypochlorite with acid causes immediate burning of the throat and lungs, eye and nose irritation, chest tightness, coughing, sore throat, wheezing and dyspnoea. In severe cases, bronchospasm, pneumonitis, upper airway oedema, pulmonary oedema or oedema of the glottis may develop. Mixing sodium hypochlorite with ammonia-based solutions results in the formation of monochloramine and dichloramine, both of which are respiratory irritants. In most cases respiratory irritation occurs immediately, followed by a latent period of 5 minutes to 15 hours, after which time breathlessness and bronchospasm may occur. In most cases symptoms are usually resolved in 1 – 4 weeks [5, 8]. However, in some instances pulmonary damage may lead to long-term Reactive Airways Dysfunction Syndrome (RADS), a chemical irritant-induced type of asthma following an acute respiratory exposure to an irritant gas. In addition, Acute Respiratory Distress Syndrome (ARDS), as a result of pneumonitis, has been reported in patients following inhalation of chlorine following the mixing of bleach and other hydrochloric acid.

Ingestion

At low concentrations (up to 10 %), such as those used for household bleach, sodium hypochlorite is a mild to moderate irritant that rarely produces necrosis or significant mucosal injury. Ingestion is not expected to cause severe or permanent damage of the gastrointestinal tract and

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recovery is usually rapid. At higher concentrations (> 10 %) it is corrosive. The critical pH for corrosivity is thought to be 12.5. Ingestion of small volumes (up to 200 ml in adults; 50 ml in children) of sodium hypochlorite solution (< 10 %) usually causes minimal health effects. In some cases it may cause burns to the mouth, throat, oesophagus and stomach, pharyngeal pain and inflammation, gastrointestinal irritation, nausea and vomiting. Dysphagia, stridor, drooling, abdominal pain and dyspnoea may also occur. Severe irritation is uncommon unless contact is prolonged or a large volume is ingested. Ingestion of large amounts (approximately 300 ml in adults; 100 ml in children) of sodium hypochlorite (< 10 %) or more concentrated sodium hypochlorite (> 10 %) may cause corrosive oesophagitis, haematemesis, abdominal and retrosternal pain, diarrhoea and, in some cases, malaena and metabolic acidosis, although symptoms other than vomiting do not strongly correlate with the amount of sodium hypochlorite ingested. In rare cases, the gastrointestinal mucosa may become haemorrhagic, ulcerated and perforated, leading to shock. Hypernatraemia, hyperchloraemia, hypotension and cardiovascular collapse may rarely develop after ingestion of extremely large volumes of sodium hypochlorite (volumes not stated). Aspiration of sodium hypochlorite or aspiration of contaminated vomit may occur. This secondary source of pulmonary exposure may lead to ARDS.

Dermal/Ocular exposure

Sodium hypochlorite itself is corrosive and may irritate the skin or cause burning pain, inflammation and blisters. Skin damage may not be immediately apparent and may continue to develop over time. Ocular exposure to household bleach can cause mild irritation and temporary discomfort if eyes are washed immediately [1]. Irritation becomes more severe and prolonged if eyes are not washed. More concentrated solutions can cause pain, blepharospasm, lacrimation, conjunctivitis, photophobia, necrosis and chemosis of the cornea, clouding of the cornea, iritis, cataract formation and retinitis.

Chronic Effects

Dermal/Ocular exposure

Chronic dermal exposure to sodium hypochlorite solution may cause skin irritation.

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Carcinogenicity

No data were available from studies in humans on the carcinogenicity of hypochlorite salts and there was inadequate evidence for the carcinogenicity of hypochlorite salts in experimental animals. Overall, the IARC assigned hypochlorite salts to Group 3, i.e. compounds that are not classifiable as to their carcinogenicity in humans.

Reproductive and developmental toxicity

There are no data indicating that sodium hypochlorite, without severe maternal toxicity, is associated with adverse effects on reproductive function, pregnancy or lactation in humans.

SAFETY [6]

First Aid Measures

- Ingestion: Rinse mouth with water immediately. If swallowed DO NOT induce vomiting. Give a 1-3 glasses of water to drink. If vomiting occurs, place victim head lower than hips to prevent vomiting entering lungs. Seek immediate medical assistance or contact the Poisons Information Centre immediately.
- Eye: Hold eyelids apart and flush the eye continuously with running water. Continue flushing until advised to stop by the Poisons Information Centre or a doctor, or for at least 15 minutes.
- Skin: If spilt on large areas of skin or hair, immediately drench with running water and remove clothing. Continue to wash skin and hair with plenty of water (and soap if material is insoluble) until advised to stop by the Poisons Information Centre or a doctor.
- Inhaled: Remove victim from further exposure. Remove contaminated clothing and loosen remaining clothing. Allow patient to assume most comfortable position and keep warm. Keep at rest until fully recovered. Seek medical attention if effects persist.
- Advice to Doctor: Treat symptomatically. Can cause corneal burns. Delayed pulmonary oedema may result.

Exposure Controls & Personal Protection

Engineering Control Measures

- Ensure ventilation is adequate and that air concentrations of components are controlled below quoted Exposure Standards.

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- If inhalation risk exists, use with local exhaust ventilation or while wearing air supplied mask.
- Keep containers closed when not in use.

Personal Protective Equipment

- Wear overalls, face shield, elbow-length impervious gloves, splash apron and rubber boots.
- Always wash hands before smoking, eating, drinking or using the toilet.
- Wash contaminated clothing and other protective equipment before storage or re-use.
- If risk of inhalation exists, wear air supplied respirator meeting the requirements of AS/NZS 1715 and AS/NZS 1716.

REGULATION

United States [7]

- NIOSH: The National Institute for Occupational Safety and Health recommends an airborne recommended exposure limit (REL) of 0.5ppm for sodium hypochlorite for any 15 min work period.
- AIHA: The American Industrial Hygiene Association recommends a workplace environmental exposure level (WEEL) of 2mg/m³ for sodium hypochlorite for a 15 min work period.

Australia [6]

No value assigned for this specific material by the National Occupational Health and Safety Commission. However, Exposure Standard(s) for decomposition product(s): Chlorine: Peak Limitation = 3 mg/m³ (1 ppm).

Peak Limitation - a ceiling concentration which should not be exceeded over a measurement period which should be as short as possible but not exceeding 15 minutes. These Exposure Standards are guides to be used in the control of occupational health hazards. All atmospheric contamination should be kept to as low a level as is workable. These exposure standards should not be used as fine dividing lines between safe and dangerous concentrations of chemicals. They are not a measure of relative toxicity.

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Gossip

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Amorphous materials will be used in medical and industrial applications

2019-04-16

Amorphous solids have an internal structure made of interconnected structural blocks. These blocks can be similar to the basic structural units found in the corresponding crystalline phase of the same compound. Almost all known systems, including water or metallic alloys, can become amorphous under certain conditions. In particular, such alloys can show outstanding physical and mechanical properties, such as strength, electric conductivity, and corrosion resistance. "Combining quantum mechanics and statistical physics with machine learning and Big Data can help find new solutions in physics and materials science," says project head Anatolii Mokshin. "We can now find out many physical properties of a compound just by knowing its chemical composition. We can calculate properties under extremely high temperature or pressure not yet obtainable through actual experiment. This is a part of our approach in this project." In this particular paper, Dr. Mokshin's group studied the influence of supercooling on the structure and morphology of the crystalline nuclei arising and growing within a liquid metallic film. It was found that the liquid metallic film at the temperatures corresponded to low supercooling levels crystallises into a monocrystal, whereas a polycrystalline structure forms at deep supercooling levels. The temperature dependence of critical size of the crystalline nuclei contains two distinguishable regimes with the crossover temperature, which appears due to the specific geometry of the system.

EurekAlert, 8 April 2019

<http://www.eurekalert.org>

Detecting pollution with a compact laser source

2019-04-16

Researchers at EPFL have come up with a new middle infrared light source that can detect greenhouse and other gases, as well as molecules in a person's breath. The compact system, which resembles a tiny suitcase, contains just two parts: a standard laser together with a photonic chip measuring a few millimetres across. The research is detailed in an article published in Nature Communications. The mid-infrared spectrum is especially useful for scientists because, at this wavelength range, light can detect particles that play an important role in the environment and in human health. Until now, however, infrared laser systems have proven

"Combining quantum mechanics and statistical physics with machine learning and Big Data can help find new solutions in physics and materials science."

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difficult to transport because they involve complex, damage-prone hardware. The new technology, developed by researchers at EPFL, could be a game-changer. The team took a commercially available fibre laser and combined it with a micrometre waveguide chip to reliably generate light waves in the mid-infrared spectrum. They then added a spectrometer to demonstrate the potential of this light source, successfully detecting the presence and concentration of acetylene, a colourless and highly flammable gas.

How does it work?

The system uses a compact and robust fibre laser that emits light in a specific wavelength range. The beam is directed through a waveguide, measuring one micrometre (0.001 mm) across and half a millimetre long, which can alter the frequency of the light as it passes through. The system produces light in the mid-infrared spectrum, retaining 30% of the original signal strength. The researchers can even tune the wavelength of the light by adjusting the waveguide's geometry. "This device sets a new benchmark for efficiency," says Davide Grassani, one of the authors of the paper. "This is the first time anyone has created a fully integrated spectroscopic laser source. It does away with the painstaking process of precisely aligning all the parts in a conventional laser system." The breakthrough came after the team refined key aspects of the system's design – the waveguide geometry and material, and the wavelength of the original laser source. "Coming up with such a simple yet efficient and sturdy system involved a lot of design work," says Camille Brès, project coordinator and head of the Photonic Systems Laboratory, part of EPFL's School of Engineering.

On-chip spectroscopy

This advancement paves the way for miniaturised mid-IR technologies – a wavelength range that scientists rarely get to work with. "Once we've developed the system further, we could well see on-chip detectors that scientists can easily carry out into the field," adds Brès.

EurekAlert, 4 April 2019

<http://www.eurekalert.org>

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Current methods may inadequately measure health impacts from oil, natural gas extraction

2019-04-16

An examination of peer-reviewed studies published over six years on hazardous air pollutants associated with the extraction of oil and natural gas finds that measurements of hazardous air pollutant concentrations near operational sites have generally failed to capture levels above standard health benchmarks; yet, the majority of studies continue to find poor health outcomes increasing as distance from these operations decreases. While it is unclear why there is a gap in the evidence between environmental sampling and health-based studies, the current review provides insights into methodological shortcomings that may help explain this discrepancy. Authors state that current health benchmarks may not provide accurate risk estimates from the broad range of pollutants associated with oil and natural gas development, and fail to adequately address potential risks associated with long-term, chronic, lower levels of exposure or from a mixture of chemicals. Further, a failure of sampling methods to properly account for degradation and dispersion of pollutants, or inappropriate sampling timeframes that may not capture peak emission periods that are characteristic of oil and natural gas extraction, may also contribute to the current gap in the literature. The authors call for additional investigations of emissions using measurements and research that incorporate appropriate timeframes and proximity to oil and gas extraction on health impacts from chronic, low-level ambient hazardous air pollutant exposures, among others. Energy demands have increased over several decades as technical innovations have led to more extraction of oil and natural gas, making the United States one of the world's leading producers of petroleum and natural gas hydrocarbons. Several hazardous air pollutants such as benzene, toluene, and ethyl-benzene are listed by the Environmental Protection Agency as known or suspected carcinogens, or that carry other health effects, have been measured at elevated concentrations around oil and natural gas extraction sites. During the study, the researchers reviewed 37 peer-reviewed journal articles published between Jan. 1, 2012 and Feb. 28, 2018. One focused on Poland and the rest on the U.S. This review will help guide future research on air quality near oil and natural gas development sites by highlighting future research priorities. It may also bring insights into possible exposures of communities near oil and natural gas development and storage sites such

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as Aliso Canyon in Los Angeles' Porter Ranch, where there was a major methane leak that affected the community.

EurekaAlert, 8 April 2019

<http://www.eurekaalert.org>

To upgrade quantum computers, researchers look to materials science

2019-04-16

Quantum computers promise to simulate complex chemistry that can't be modelled on conventional computers. But today's quantum computers use error-prone hardware and don't yet live up to this potential. So, materials scientists and quantum engineers are working to improve the basic hardware element of quantum computers, called the qubit. They are developing better manufacturing recipes and control equipment for the leading technologies: superconducting qubits and trapped-ion qubits. They're developing technologies based on that old standby, silicon. And they're envisioning less error-prone qubits based on new quantum materials that exhibit weird effects. As she walks around the lab of Rigetti Computing, quantum engineer Sabrina Hong strains to make her voice heard over a loud pumping noise. It's the heartbeat of helium refrigerators cooling down the Berkeley, California-based start-up's quantum computers. To perform optimally, these machines need to run below $-273.14\text{ }^{\circ}\text{C}$ (10 mK)—colder than outer space. Whoosh, supercold liquid helium is pumped in. Whoosh, warmed helium is pushed out. "I love that sound," Hong says. It means the company's two commercial quantum computers are up and running, at the ready for customers. Rigetti and other firms in the quantum computing business, including IBM and Google, allow customers to access their machines over the cloud and perform calculations. The pumping sound also means that the machines are ready for Hong and other engineers on the Rigetti team. She wants to improve quantum computers' performance and would like to try out some test chips fabricated using new circuit recipes. For decades, theoretical physicists and computer scientists have been compiling evidence that quantum computers will eventually leave our current top-of-the-line supercomputers in the dust. Among other things, they predict that quantum computers should be able to simulate complex chemical systems that conventional computers cannot. The machines, they believe, will elucidate the energetic states of magnetic materials, superconductors, and catalysts and speed up the process of developing new materials. At this point, however, researchers have yet to use a quantum computer to

Scientists need to improve the basic elements of quantum circuits—qubits—to push their machines to the next level of quantum weirdness

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solve a chemistry problem—or any problem—that a classical computer can't tackle. So far, they've simulated only simple molecules. For instance, Maryland-based start-up IonQ has modelled a water molecule, and IBM has tackled beryllium hydride. Quantum computers have been limited to simple problems because of their hardware. The basic elements of quantum circuits, called qubits (for quantum bits), are still highly error prone. Truly useful quantum computers will probably need millions of robust qubits, a far cry from the tens of qubits operating in today's machines. And if the ones we have today are misfiring, there's no hope of a million-qubit system calculating anything with certainty. So, scientists and engineers like Hong are shouldering the responsibility of building a better qubit.

What's A Qubit Anyway?

The word qubit has two meanings, one physical and one conceptual. Physically, it refers to the individual devices that are used to carry out calculations in quantum computers. Conceptually, a qubit is like a bit in a regular computer. It's the basic unit of data in a quantum circuit. In classical computers, bits are represented as a 1 or a 0. Physically, this binary data system manifests in switches called transistors. When current flows through a transistor, that's a 1, and when it doesn't, that's a 0. Similarly, qubits have energy states that can be represented as a 1 or a 0 when they're measured. But until they're measured, they are in a superposition of states—0, 1, or many places in between. And their states are connected, or entangled, with those of other qubits. It's because of this quantum in-between that a quantum computer could theoretically store and process a lot more information than a conventional computer, which uses a binary system. "A qubit uses quantum mechanical phenomena to do things with information you can't otherwise do," says Brad Blakestad, a program manager for quantum computing at the Intelligence Advanced Research Projects Activity (IARPA).

Qubits 101

You aren't alone if you don't completely understand qubits. Here's a primer. One common type of physical qubit is the nuclear spin of a trapped ion. The spin of the ion's nucleus can be either up, which could represent 0, or down, which could represent 1. Before it's measured, however, it could theoretically be in a multitude of spin states. Researchers use electrical fields, lasers, or other inputs to set the state of each qubit in a circuit. Then they perform some quantum logic operations using the qubits to carry out an algorithm. Finally, they measure the qubits again

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to find the output of the algorithm. But the quantum states of qubits are fragile. A single stray photon, a tiny vibration, or a slight variation in temperature, and a qubit's state can be thrown out of whack, causing it to give a wrong answer. Qubits also have a penchant for eavesdropping. They can pick up on signals intended for their neighbours and change their state. Physical qubits are "much more sensitive to noise" than transistors in regular circuits, Blakestad says. The ability to hold a quantum state is called coherence. The longer the coherence time, the more operations researchers can perform in a quantum circuit before resetting it, and the more sophisticated the algorithms that can be run on it. To reduce errors, quantum computers need qubits that have long coherence times. And physicists need to be able to control quantum states more tightly, with simpler electrical or optical systems than are standard today. A quantum computer will need about 200 or so perfect qubits to perform chemical simulations that are impossible on classical computers, says Maud Vinet, an engineer with CEA-Leti, a French electronics research institute. Because qubits are so prone to error, though, these systems are likely to require redundancy, with tens or perhaps hundreds of faulty qubits doing the work of one ideal qubit that gives the right answer. These so-far-theoretical ideal qubits are often called "logical qubits" or "error-corrected qubits." "I can go and make 1,000 [nonideal] qubits for you tomorrow, but that's not a useful processor," says Jerry Chow, manager of experimental quantum computing at IBM's Thomas J. Watson Research Centre. "It doesn't make sense to increase the number of qubits before you improve your error rates." Because qubits are currently error prone, scientists have a hard time figuring out whether a qubit correctly gave them a 0 state or whether it incorrectly gave them a 0 state because it was disturbed by some noise. Scientists are getting better at detecting these errors, but correcting for them is still extremely difficult, Blakestad says. He directs IARPA's LogiQ Program, which aims to create a logical qubit and prove that error correction is possible. Under LogiQ, four teams have been charged with demonstrating a logical qubit by 2021. (An IARPA representative said the agency does not disclose funding numbers.) Teams led by IBM and the Delft University of Technology are working on superconducting qubits, and teams led by Duke University and the University of Innsbruck are working on trapped-ion qubits. These two qubit designs have shown the most promise in these early days of quantum computing. Both are close to being able to perform a calculation that's currently impossible for classical computers, a feat called quantum supremacy, Blakestad says. In Europe, scientists are taking a similar approach of not putting all their eggs in a basket that holds one type of qubit. In October 2018, the European Union announced a €1 billion, 10-year Quantum Flagship initiative that will fund

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20 projects in its first 3 years during a “ramp up” phase. “Here in Europe, we are funding superconducting qubits and ions on the same level,” plus basic research on other types of qubit designs, says Tommaso Calarco, director of the Institute for Complex Quantum Systems at Ulm University. It’s too early to focus research funding and industrial development on any one technology, he adds, because it’s not at all clear which will be the winner. Blakestad agrees. What looks most promising today, he says, may have nothing to do with the technology that’s in the lead 10 years from now. “I think that’s very much still up in the air.”

Muffling the Noise

“There are probably about 20 suggested ways of creating qubits for quantum computers, with varying degrees of success,” says Clarina dela Cruz, science coordinator for the Quantum Materials Initiative at the Oak Ridge National Laboratory (ORNL). At the recent American Chemical Society Spring 2019 National Meeting in Orlando, Florida, dela Cruz described how her team uses ORNL’s neutron source, the brightest in the world, to characterise quantum materials. Because so many existing and proposed qubits store information in spin states, she says, magnetism is the most important property to study. Neutron beams can be used as a kind of microscope for studying the magnetic properties of materials. Discovering quantum materials requires physicists, chemists, and materials scientists to work together, dela Cruz says. Materials scientists search databases for structures that match physicists’ predicted quantum materials and then seek the advice of chemists. Most of the time, she says, the chemists say something like, “That cannot be stabilised—try another element here.” Once a potential quantum material is made, researchers can use neutron-scattering experiments to study its structure and how it responds to a range of temperatures, changing magnetic and electrical fields, and other parameters. To prove that they’ve made a qubit, researchers have to extensively characterize all the possible states of their devices and figure out how to switch them with a high level of control, she adds. “Materials science is a huge component of increasing the performance of our circuits,” says Corey Rae McRae, a quantum physicist and postdoctoral researcher at the University of Colorado Boulder and the Boulder arm of the National Institute of Standards and Technology. McRae works on superconducting qubits, which are circuits incorporating multiple devices. First, they include simple devices made from aluminium or niobium—both of which are superconducting at cryogenic temperatures. These are integrated with electron-tunnelling devices made by sandwiching the same metals around insulators. Superconducting

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qubits can be switched between two energy levels—representing 0 and 1—with microwave pulses. Scientists handle these types of qubits with great care to eliminate all possible sources of noise. First, they are kept extremely cold in helium refrigerators like the ones in Rigetti's labs. And engineers use only the most delicate microwave pulses to interact with them—they typically apply only a single photon, McRae says. At these low temperatures and photon levels, one of the noisiest things is the insulating material in the device itself. Typically made of aluminium oxide, the insulator can act like an antenna, absorbing microwave pulses rather than allowing them to transmit quantum states and, in effect, muddying the information encoded in those pulses. McRae wants to minimise the loss of these microwave pulses. She is designing chips that blow up the qubit, separating all the parts on the same wafer so that losses can be measured from each one individually. Then their individual losses can be added up. McRae and others are also using similar methods to test alternative materials.

At Rigetti, Hong and other engineers are testing how slight changes in manufacturing affect the coherence times of the company's superconducting qubits. She says making a good interface between the underlying silicon wafer and the device's metal layer, usually aluminium, is a particular focus. "You can almost double the coherence time" by making clean interfaces, she says. The company is also honing the control electronics used to generate and carry microwave signals to individual qubits. Proponents of superconducting qubits like the fact that they can be created using equipment and materials already used to fabricate conventional computer chips, with few alterations. Meanwhile, researchers working on the other leading class of qubits, trapped ions, boast that their qubits don't need to be manufactured at all: nature makes them just right. "Every ion is the same. There's no synthesis to worry about," says Kenneth Brown, a chemist and quantum engineer at Duke University. Brown is the leader of a \$15 million National Science Foundation project to build a programmable ion-trap quantum computer. He's also a consultant to IonQ. The qubits in these devices are individual trapped ions, floating in empty space. Ion traps apply electromagnetic fields to suspend ions in a vacuum and use lasers to cool them down. Unlike a superconducting quantum computer, the entire system does not need to be extremely cold—just the individual ions. Researchers use lasers to manipulate the nuclear spin of the atom, and photodetectors to measure it. A common ion choice is the ytterbium isotope $^{171}\text{Yb}^+$, whose nuclear spin is relatively impervious to magnetic fields, protecting it from noise. In one experiment by Kihwan Kim at Tsinghua University, a $^{171}\text{Yb}^+$ qubit held its state for about 10

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min, a record coherence time, and an eternity in the quantum world (Nat. Photonics 2017, DOI: 10.1038/s41566-017-0007-1). The issue with trapped-ion qubits is control. It's straightforward to load ions into a trap, but addressing them individually with a laser is difficult. According to Brown, scientists can so far individually control only 20 or 30 ion qubits at once. The necessary optics to split laser beams to greater numbers of ions, for instance, are still being developed.

Making It Weirder

Computers based on superconducting circuits or ions floating in a vacuum are already pretty strange. Some researchers see promise in even weirder quantum materials that might approach the ideal qubit. In particular, researchers are excited about a class of qubits that might one day be made from so-called topological materials. Storing information in superpositions of quantum states, as is done in existing qubits, is "great but very susceptible to decoherence and loss," says Michael Manfra, a materials scientist at Purdue University. The problem, he says, is that the leading designs store quantum information in a physical place—in one electron, for example. Topological materials store information nonlocally, in large clouds of electrons. If one electron in the cloud changes state, no matter. The rest of the group will maintain. "You do your best from the get-go to build a system that is tone deaf to the noise in the environment," Manfra says. Changing the quantum state of a topological material—all the electrons in its cloud—requires such a large input that it's unlikely to happen by chance. Therefore, when the state of a qubit of this kind is measured, researchers can, in theory, have much more confidence that the answer is correct. Researchers, however, are still figuring out how to make and use topological materials, let alone fashion a topological qubit, Manfra says. Topological materials are rare in nature, and those materials that do exist are difficult to work with. Strontium ruthenate, for instance, is brittle and obtainable only in small amounts—not good qualities for an electronic device. So Manfra and other researchers are investigating combinations of easy-to-work-with materials that, together, exhibit emergent topological physics. One design uses cryogenically cooled devices made by frosting the semiconductor indium arsenide with superconducting aluminium. This combo mimics the physics of a topological semiconductor, Manfra explains. Although Manfra, who is collaborating with Microsoft, is excited by this work, he cautions that no one has made a topological qubit yet. But he's optimistic. He thinks it's possible researchers will demonstrate a topological qubit "in a couple years."

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Back To Silicon

If a topological qubit can be made and lives up to its theoretical potential, it may make error correction easier—and quantum computers might need far fewer qubits than researchers have assumed. But given what's been experimentally demonstrated so far, many physicists are not counting on this. They expect that running complex, error-corrected applications such as chemical simulations will require thousands or perhaps millions of nonideal qubits. Some are sceptical that ion traps, superconducting qubits, and other designs will be amenable to that sort of scaling. This focus on scale has led some quantum engineers back to the material beloved by computer geeks the world over: silicon. Today's computer chips are made up of billions of silicon-based transistors, integrated and controlled with metal wiring and manufactured at tremendous scales. Silicon transistors are powerhouses of binary computation. But very similar device designs can coax quantum effects from the same set of materials—with an isotopic twist. Silicon spin qubits are built using wafers made from pure ^{28}Si because it is "quiet." The isotope has no nuclear spin, which cuts down on noise and improves coherence times. In this quiet environment, researchers can excite individual electrons and carefully control them. Researchers either add dopants such as phosphorus atoms—one of the approaches being pursued by a team at the University of New South Wales led by physicist Michelle Simmons—or apply voltages to trap single excited electrons in ^{28}Si quantum dots, an approach being taken by Intel and CEA-Leti. Traditional transistors use metal gates layered with dielectrics to switch small patches of silicon between conducting and insulating states to represent 1 and 0. Silicon qubits can use the same gates and dielectrics to control individual electrons. By applying electric fields, researchers can switch the spin of a confined electron from up to down and back again. The CEA-Leti group demonstrated a silicon spin qubit in 2016 (Nat. Commun., DOI: 10.1038/ncomms13575), and since then, silicon spin qubits have become a more popular research area. However, neither that group nor any others have been able to get large numbers of silicon qubits working together to perform basic quantum logic. "Silicon qubits are compelling but behind as a technology," says James Clarke, director of quantum hardware at Intel; his team is developing both silicon and superconducting qubits. When asked whether manufacturing conditions for silicon qubits need to be even more stringent than those for making conventional silicon transistors, CEA-Leti's Vinet says, "You're pressing where it's painful—we don't know." This qubit design is still being characterized, and Vinet says researchers are still gathering data about how these qubits behave. Clarke's team at Intel is

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trying to speed up this research. At the American Physical Society Meeting in Boston earlier this year, Clarke described Intel's strategy. Instead of testing one chip at a time in a helium refrigerator, Intel's team has worked with Finnish equipment makers Bluefors and Afore to build a cryogenic probe station that can characterise an entire 300 mm wafer of spin qubit chips simultaneously. Even though today's quantum hardware is far from ideal, Peter Love, a physicist and quantum information scientist at Tufts University, still believes that we'll soon reach quantum supremacy. "It's very easy to imagine a 49-qubit device becoming impossible to simulate with a classical computer," he says. However, quantum supremacy is a moving target—the prospect has been a goad to classical programmers, who keep making their simulations better. A particularly devastating takedown published in July 2018 by 18-year-old Ewin Tang showed that classical computers can carry out one of the major classes of algorithms that had been held up as a sterling example of something only quantum computers would be able to perform (arXiv 2018, arXiv:1807.04271). She was an undergrad at the University of Texas at Austin at the time and is now a PhD student in theoretical computer science at the University of Washington. But qubit designs are getting better too. At the moment, state-of-the-art quantum computers capable of performing calculations use tens of qubits. Google claims to be able to control 72 superconducting qubits with low error rates; other companies' claims are more modest, in the range of 20 to 50 of the devices. The next landmark is to get around 100 qubits working together in a chip or device and then combine many of these systems to make bigger, more complex ones. "The first system that makes that breakthrough will be the main platform for a long time," Duke's Brown predicts. But there's no telling which platform that will be. Many designs have been proposed. And it's possible that ion traps and superconducting qubits will run into some major roadblock on the way to larger systems, one no one has anticipated. "If those don't work," Love says, "there's a list to go down" for other solutions.

Chemical & Engineering News, 12 April 2019

<http://pubs.acs.org/cen/news>

New step for better chemical decontamination

2019-04-16

An industrial chemical accident. An attack with a chemical warfare agent. Either of these situations can leave many people in acute need of decontamination. Until recently, the US government's decontamination protocol for first responders dealing with people exposed to most types

Victims wipe themselves with dry, absorbent materials

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of liquid chemicals had two major steps. First, affected people would strip off their clothes and walk through a spray of cold water provided by two fire trucks hooked up to a fire hydrant. Next, victims would take a warm, soapy shower set up in a tent. Now, citing evidence in a peer-reviewed study, the US Department of Health and Human Services (HHS) has added a new step to its decontamination guidance for chemical incidents (Ann. Emerg. Med. 2018, DOI: 10.1016/j.annemergmed.2018.06.042). It calls for exposed people to first wipe themselves off with dry, absorbent materials, such as paper towels or diapers, before they pass through the water spray. The main reason for this new step, dubbed dry decontamination, is time. "If you've got something which can kill you very quickly, the sooner you can get it off the skin and hair, the better," says Robert P. Chilcott, a University of Hertfordshire toxicologist and lead author of the study. Responders may need 10–20 min to set up the water spray, called a pipe-and-ladder system. The warm shower system takes even longer to install and get operational. The dry process is also impressively effective. A team led by Chilcott found that dry wiping, when performed under the instruction of a first responder, can remove 70–99% of a liquid contaminant from a person's body. The research, conducted under contract with HHS's Biomedical Advanced Research and Development Authority (BARDA), involved a 2017 exercise conducted at the University of Rhode Island. Researchers applied a chemical warfare agent simulant to 80 volunteers who role-played as casualties. Local firefighters acted as first responders and led the volunteers through various combinations of decontamination procedures, including dry wiping. Dry decontamination provides several other benefits besides speed and effectiveness. For one, it helps prevent hypothermia. "The water that comes out of a fire hydrant is less than 10 °C," Chilcott says. "It's cold." Having wet, cold people wait for a shower isn't ideal, especially when outdoor temperatures are low, Chilcott explains. Wiping gives people a way to help themselves while both the spray and shower systems are readied so they can move quickly from cold to warm. In addition, dry decontamination minimises potential exposure of first responders and medical personnel, Chilcott points out. And it cuts back on the accumulation of hazardous material in the subsequent decontamination steps, says Rick Bright, director of BARDA. HHS is spreading the word about the new dry-wiping step. The department recently integrated the dry decontamination step into guidance for first responders called Primary Response Incident Scene Management. Plus, HHS and the University of Hertfordshire crafted a tool to help first responders determine which approaches to decontamination will work best in a particular situation. Called the Algorithm Suggesting Proportionate Incident Response Engagement, or ASPIRE, this tool is

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integrated with the new decontamination guidance in a mobile app called the Wireless Information System for Emergency Responders, or WISER. Chilcott warns, however, that “dry decontamination isn’t a universal panacea. It only works for liquid contaminants.”

Chemical & Engineering News, 12 April 2019

<http://pubs.acs.org/cen/news>

Governments pursue chemical recycling

2019-04-16

Local officials are beginning to opt for the chemical conversion of plastics into fuels as a means of processing difficult plastic waste. The City of Phoenix is working with Salt Lake City–based start-up Renewlogy to build a conversion plant. And the British firm Plastic Energy has a deal to build plants using its technology in West Java, Indonesia. Renewlogy, which has pyrolysis technology for converting waste plastics into fuels, will form a joint venture with a local waste management firm to build its plant. The plant will process plastics coded 3 through 7—materials such as polystyrene and polypropylene that aren’t mechanically recycled as widely as polyethylene terephthalate and high-density polyethylene, which are coded 1 and 2, respectively. The plant will have the capacity to process about 10 metric tons per day of the material into 60 barrels of liquid fuel. Phoenix officials say their plan is a reaction to National Sword, a Chinese government policy that stopped the import of US plastics for sorting and disposal. “During a time when cities are giving up on recycling, Phoenix is again leading the way,” says Mayor Kate Gallego. Separately, the government of West Java has signed an agreement under which Plastic Energy will build five facilities that transform plastic into fuel in a process the firm calls thermal anaerobic conversion. Indonesia is one of the world’s leading sources of plastic waste because of its lack of waste management infrastructure. Plastic Energy already operates two plants in Spain. In December, it signed an agreement with Sabic to build a plant in the Netherlands that will provide feedstock for Sabic’s chemical plants. Jan Dell, a chemical engineer whose organisation, the Last Beach Cleanup, works with investors and environmental groups on projects to reduce plastic pollution, has her doubts about chemical recycling. “The economic realities of cheap new plastic production and low-cost oil and gas production make chemical recycling processes economically uncompetitive and impractical at commercial scale,” she says. “Labor, transport, and processing costs for collecting, sorting, and recycling plastic

Projects in the US and Indonesia opt to turn hard-to-process materials into fuels

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make it more costly than new plastic or new oil." Such initiatives distract from the need to reduce consumption of single-use plastics, Dell adds.

Chemical & Engineering News, 11 April 2019

<http://pubs.acs.org/cen/news>

Army scientists lead the way to produce tools for engineering biomolecules

2019-04-16

Army scientists have discovered how to build novel synthetic biomolecule complexes that they believe are a critical step towards biotemplated advanced materials. Their work was recently featured in the March issue of Nature Chemistry. A team of researchers from the U.S. Army Combat Capabilities Development Command's Army Research Laboratory, the Army's corporate research laboratory also known as ARL, and The University of Texas at Austin's Department of Molecular Biosciences, combined pairs of oppositely charged synthetic proteins to form hierarchical ordered, symmetrical structures through a strategy they termed as "supercharged protein assembly." Dr. Jimmy Gollihar, a synthetic biology research scientist at ARL, along with University of Texas at Austin professors, Drs. Andrew Ellington and David W. Taylor, Jr., collaborated on this discovery. The researchers said synthetic protein units had their surface charge artificially augmented to create either a positively or negatively charged protein unit to create supercharged proteins. This feature allowed the team to create self-assembled structures that are driven by charge alone. As a demonstration of this capability, the team used computational modelling to design two fluorescent proteins, one super positive and the other super negative. Gollihar explained that when the team synthesised and mixed the oppositely supercharged fluorescent proteins, it resulted in well-ordered aggregates. "Our simple charged proteins assembled into well-ordered structures in a manner that has not been observed in nature," Gollihar said. "These protomers are aggregates of two oppositely charged pairs of fluorescent proteins. Once the protomers form, they can be reversibly assembled by altering the ionic strength or pH of the solution. At very low ionic strength, the proteins assemble into structures that are larger than bacterial cells." Gollihar indicated this begins to address questions on how protein structures can be engineered into templates for advanced materials. "Biology is exceptional at Angstrom-level scales that current manufacturing methods cannot access," he said. "By studying the self-assembly and functionalization at this level, it should prove possible to manufacture

Army scientists have discovered how to build novel synthetic biomolecule complexes that they believe are a critical step towards biotemplated advanced materials.

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nanoscale materials for a host of Army-relevant applications. He said synthetic biology is a key technology area that has disruptive potential to shape how the Army will fight and win in the future operational environment. "These efforts will be followed by attempts to engineer protein structures with unique properties suitable for Army applications such as bio-enabled sensing and functional coatings," Gollihar said. "The ready assembly of this structure suggests that combining oppositely supercharged pairs of protein variants may provide broad opportunities for generating novel architectures via otherwise unprogrammed interactions." This foundational work will continue, expanding in scale and composition, as part of Transformational Synthetic biology for Military Environments, or TRANSFORME, one of ARL's essential research programs. "TRANSFORME is about programmable control of biological processes allowing not only expeditionary capabilities in multi-domain operation, but also adaptation at operational tempo, a pace that can define a country's dominance in battle," said Dr. Dimitra Stratis-Cullum, program manager for TRANSFORME.

EurekAlert, 15 April 2019

NRL develops laser processing method to increase efficiency of optoelectronic devices

2019-04-16

Scientists at the U.S. Naval Research Laboratory discovered a new method to passivate defects in next generation optical materials to improve optical quality and enable the miniaturisation of light emitting diodes and other optical elements. "From a chemistry standpoint, we have discovered a new photocatalytic reaction using laser light and water molecules, which is new and exciting," said Saujan Sivaram, Ph.D., lead author of the study. "From a general perspective, this work enables the integration of high quality, optically active, atomically thin material in a variety of applications, such as electronics, electro-catalysts, memory, and quantum computing applications." The NRL scientists developed a versatile laser processing technique to significantly improve the optical properties of monolayer molybdenum disulphide (MoS₂) -- a direct gap semiconductor -- with high spatial resolution. Their process produces a 100-fold increase in the material's optical emission efficiency in the areas "written" with the laser beam. According to Sivaram, atomically thin layers of transition metal dichalcogenides (TMDs), such as MoS₂, are promising components for flexible devices, solar cells, and optoelectronic sensors due to their high optical absorption and direct band gap. "These semiconducting materials

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are particularly advantageous in applications where weight and flexibility are a premium," he said. "Unfortunately, their optical properties are often highly variable and non-uniform making it critical to improve and control the optical properties of these TMD materials to realize reliable high efficiency devices." "Defects are often detrimental to the ability of these monolayer semiconductors to emit light," Sivaram said. "These defects act as non-radiative trap states, producing heat instead of light, therefore, removing or passivating these defects is an important step towards high efficiency optoelectronic devices." In a traditional LED, approximately 90 percent of the device is a heat sink to improve cooling. Reduced defects enable smaller devices to consume less power, which results in a longer operational lifetime for distributed sensors and low-power electronics. The researchers demonstrated that water molecules passivate the MoS₂ only when exposed to laser light with an energy above the band gap of the TMD. The result is an increase in photoluminescence with no spectral shift. Treated regions maintain a strong light emission compared to the untreated regions that exhibit much a weaker emission. This suggest that the laser light drives a chemical reaction between the ambient gas molecules and the MoS₂. "This is a remarkable achievement," said Berend Jonker, Ph.D., senior scientist and principal investigator. "The results of this study pave the way for the use of TMD materials critical to the success of optoelectronic devices and relevant to the Department of Defence mission."

EurekAlert, 15 April 2019

<http://www.eurekalert.org>

Low-calorie sweetener derived from lactose gets manufacturing boost from yeast

2019-04-16

The quest to satisfy the sweet tooth without adding to the waistline has a new weapon in its arsenal: a strain of yeast that can metabolise lactose, the sugar in dairy products, into tagatose, a natural sweetener with less than half the calories of table sugar. Yong-Su Jin, a University of Illinois professor of food science and human nutrition, led the research team that engineered the yeast strain, which produces tagatose in much larger quantities than traditional enzymatic manufacturing techniques and could help make tagatose a cost-effective alternative to sugar or high-fructose corn syrup. The researchers published their work in the journal Nature Communications. "Tagatose is a sweetener that exhibits almost identical tastes and textures of sucrose, or table sugar. However, tagatose

The researchers added genes that direct the yeast's own metabolism to produce tagatose.

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has many fewer calories than sucrose—about 40% of sucrose,” Jin said. “In addition, it does not increase blood glucose levels as much as sucrose or fructose. The glycaemic index of tagatose is 3, which is much lower than that of sucrose, 68, and fructose, 24. As such, tagatose carries a lower risk for developing Type 2 diabetes and other diseases caused by rapid and repeating glucose increases in blood.” In spite of its benefits, tagatose has a high manufacturing cost that has kept it from wide commercial use, Jin said. Although it is naturally present in fruits and dairy products, the concentrations are too low to isolate tagatose effectively. The traditional manufacturing method involves a multi-step enzymatic process that turns galactose—a component of lactose—into tagatose. Unfortunately, the enzyme reaction is so inefficient that only 30 percent of galactose is converted into tagatose, forcing manufacturers to use an expensive process to remove the tagatose from the galactose mixture. Jin’s team used the internal machinery of yeast cells as tiny tagatose factories, much like how ethanol manufacturers use yeast to produce fuel from corn. The researchers engineered a strain of yeast that produces tagatose from lactose by making two genetic tweaks. First, they took out a gene that let the yeast use galactose as cellular fuel during lactose metabolism. Second, they added two genes that convert galactose into tagatose. Thus, when the yeast is fed lactose, its own metabolism drives it to produce a solution that is 90 percent tagatose—much higher than the 30 percent yield from traditional manufacturing. Yeast reactors also operate on much larger scales than enzyme-based ones, which could allow for efficient mass production of tagatose, Jin said. “Another advantage is that our yeast-based process can use whey indirectly. Whey is an inevitable by-product of the cheese and Greek yogurt manufacturing processes as a raw material,” Jin said. “Due to the recent popularity of Greek yogurt, the disposal of whey is an issue in the dairy industry. We hope our process can be used to resolve the surplus whey problem. As our yeast fermentation-based approach allows a higher product ratio and the direct use of inexpensive dairy waste, we expect that the production cost of tagatose can be significantly reduced.” Next, the researchers will explore using their yeast-based approach to manufacture other products from lactose. “We showed that lactose can be efficiently and rapidly utilised by engineered yeast. With further metabolic engineering, we can produce other valuable products from the lactose abundant in whey, using our engineered yeast strain,” Jin said.

Phys.org, 15 April 2019

<http://phys.org>

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Researchers characterize molecular scissors for plastic waste

2019-04-16

A research team from the University of Greifswald and Helmholtz-Zentrum-Berlin (HZB) has solved the molecular structure of the enzyme MHETase at BESSY II. MHETase was discovered in bacteria, and together with a second enzyme, PETase, is able to break down the widely used plastic PET into its basic building blocks. This 3D structure already allowed the researchers to produce a MHETase variant with optimized activity in order to use it, together with PETase, for a sustainable recycling of PET. Plastics are extremely versatile and almost eternally durable. But this is also a problem, because after only about 100 years of producing plastics, plastic particles are now found everywhere—in groundwater, in the oceans, in the air, and in the food chain. Around 50 million tonnes of the industrially important polymer PET are produced every year. Just a tiny fraction of plastic is currently recycled via expensive and energy-consuming processes that yield either downgraded products or depend in turn on adding 'fresh' crude oil. In 2016, a group of Japanese researchers discovered a bacterium that grows on PET and partially feeds on it. They found that the bacterium possesses two special enzymes, PETase and MHETase, that digest PET plastic polymers. PETase breaks down the plastic into smaller PET building blocks, primarily MHET, and MHETase splits this into the two basic precursor building blocks of PET, terephthalic acid and ethylene glycol. Both components are valuable for synthesising new PET without the addition of crude oil for a closed sustainable production and recovery cycle. In April 2018, the structure of PETase was finally solved independently by several research groups. The Diamond Light Source was also involved in the experiments. However, PETase is only part of the solution. It is equally important to characterize the structure of the second enzyme, MHETase. "MHETase is considerably larger than PETase and even more complex. A single MHETase molecule consists of 600 amino acids, or about 4000 atoms. MHETase has a surface that is about twice as large as the surface of PETase and has therefore considerably more potential for optimisation toward decomposition of PET," explains biochemist and structural biologist Dr. Gert Weber from Helmholtz-Zentrum Berlin and Freie Universität Berlin. During an interim professorship at the University of Greifswald, Weber contacted the biotechnologist Prof. Uwe Bornscheuer at the Institute of Biochemistry, who was already involved with plastic-degrading enzymes. Together, they developed the idea of solving the structure of MHETase and then using this insight to optimise the enzyme for applications in PET recycling. To do this, they first had to extract the

A research team from the University of Greifswald and Helmholtz-Zentrum-Berlin (HZB) has solved the molecular structure of the enzyme MHETase at BESSY II.

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enzyme from bacterial cells and purify it. Within this collaboration, the teams succeeded in obtaining the complex three-dimensional architecture of MHETase at BESSY II, the synchrotron source at HZB in Berlin. "In order to see how MHETase binds to PET and decomposes it, you need a fragment of plastic that binds to MHETase but is not cleaved by it," explains Weber. A member of Weber's prior research team in Greifswald, Dr. Gottfried Palm, cut up a PET bottle, chemically decomposed the PET polymer and synthesised a small chemical fragment from it that binds to MHETase but can no longer be cleaved by it. From this 'blocked' MHETase, tiny crystals were grown for structural investigations at the HZB. "The structural investigations enabled us to watch MHETase virtually 'at work' and develop strategies for how to optimise this enzyme," explains Weber. "Thanks to the joint research group format, we have the means to offer beamtime access on the highly demanded BESSY II MX beamlines for measurements very quickly at any time," says Dr. Manfred Weiss, who is responsible for the BESSY II MX beamlines. The three-dimensional architecture of MHETase actually displays some special features: enzymes such as MHETase bind to their target molecule first before a chemical reaction occurs. For breakdown of a molecule you need a tailor-made enzyme: "We can now exactly localise where the MHET molecule docks to MHETase and how MHET is then split into its two building blocks terephthalic acid and ethylene glycol," says Weber. However, neither PETase nor MHETase are particularly efficient. "Plastics have only been around on this scale for a few decades—even bacteria with their rapid successions of generations and rapid adaptability have not managed to develop a perfect solution through the evolutionary process of trial and error over such a short time," explains Weber. "Thanks to the clarification of the structure of this very important enzyme, we have now also been able to plan, produce and biochemically characterise variants that show significantly higher activity than natural MHETase and are even active against another intermediate product of PET degradation, BHET," adds Uwe Bornscheuer. In future, Uwe Bornscheuer will work on systematically optimising the enzymes PETase and MHETase for their task—the decomposition of PET. Gert Weber plans to supplement these studies with further work on biological structures in order to systematically develop plastic-digesting enzymes for environmental applications. Access to the measuring stations and the IT infrastructure of HZB is indispensable for this. Producing these kinds of enzymes in closed biotechnological cycles, for example, could be a way to really break down PET plastics and other polymers into their basic building blocks. This would also be the key to ideal recycling and a long-term solution to the plastic waste problem: production of plastic would be a

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closed cycle and no longer dependent on crude oil. The study is published in Nature Communications.

Phys.org, 12 April 2019

<http://phys.org>

Best in snow: New scientific device creates electricity from snowfall

2019-04-16

UCLA researchers and colleagues have designed a new device that creates electricity from falling snow. The first of its kind, this device is inexpensive, small, thin and flexible like a sheet of plastic. "The device can work in remote areas because it provides its own power and does not need batteries," said senior author Richard Kaner, who holds UCLA's Dr. Myung Ki Hong Endowed Chair in Materials Innovation. "It's a very clever device -- a weather station that can tell you how much snow is falling, the direction the snow is falling, and the direction and speed of the wind." The researchers call it a snow-based triboelectric nanogenerator, or snow TENG. A triboelectric nanogenerator, which generates charge through static electricity, produces energy from the exchange of electrons. Findings about the device are published in the journal Nano Energy. "Static electricity occurs from the interaction of one material that captures electrons and another that gives up electrons," said Kaner, who is also a distinguished professor of chemistry and biochemistry, and of materials science and engineering, and a member of the California NanoSystems Institute at UCLA. "You separate the charges and create electricity out of essentially nothing." Snow is positively charged and gives up electrons. Silicone -- a synthetic rubber-like material that is composed of silicon atoms and oxygen atoms, combined with carbon, hydrogen and other elements -- is negatively charged. When falling snow contacts the surface of silicone, that produces a charge that the device captures, creating electricity. "Snow is already charged, so we thought, why not bring another material with the opposite charge and extract the charge to create electricity?" said co-author Maher El-Kady, a UCLA postdoctoral researcher of chemistry and biochemistry. "While snow likes to give up electrons, the performance of the device depends on the efficiency of the other material at extracting these electrons," he added. "After testing a large number of materials including aluminium foils and Teflon, we found that silicone produces more charge than any other material." About 30 percent of the Earth's surface is covered by snow each winter, during which time solar panels often fail to operate, El-Kady noted. The

Researchers have designed a new device that creates electricity from falling snow, a first. The device is inexpensive, small, thin and flexible like a sheet of plastic.

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accumulation of snow reduces the amount of sunlight that reaches the solar array, limiting the panels' power output and rendering them less effective. The new device could be integrated into solar panels to provide a continuous power supply when it snows, he said. The device can be used for monitoring winter sports, such as skiing, to more precisely assess and improve an athlete's performance when running, walking or jumping, Kaner said. It also has the potential for identifying the main movement patterns used in cross-country skiing, which cannot be detected with a smart watch. It could usher in a new generation of self-powered wearable devices for tracking athletes and their performances. It can also send signals, indicating whether a person is moving. It can tell when a person is walking, running, jumping or marching. The research team used 3-D printing to design the device, which has a layer of silicone and an electrode to capture the charge. The team believes the device could be produced at low cost given "the ease of fabrication and the availability of silicone," Kaner said. Silicone is widely used in industry, in products such as lubricants, electrical wire insulation and biomedical implants, and it now has the potential for energy harvesting.

Science Daily, 15 April 2019

<http://www.sciencedaily.com>

The right polymers for the job

2019-04-16

One of the most promising clean energy technologies just got even better. Researchers from the University of Delaware have developed the most powerful, durable hydroxide exchange membrane fuel cell components on record, which they recently described in the journal *Nature Energy*. The key ingredient? Membranes made from poly(aryl piperidinium) polymers. Fuel cells work by converting chemical energy into electricity, and they are a promising source of power for eco-friendly vehicles. A few fuel cell vehicles already exist on the market, including the Toyota Mirai, the Honda Clarity and the Hyundai Nexo, and more fuel cell cars are under development worldwide. The fuel cells in automobiles require the use of an expensive catalyst material, usually platinum, to hasten the chemical reactions inside. These are called proton membrane exchange fuel cells, and they contain membranes made of a fluorinated polymeric material. For nearly two decades, Yushan Yan, Distinguished Engineering Professor of Chemical and Biomolecular Engineering, has been working to develop fuel cells that don't require platinum catalysts and instead employ cheaper metals, such as silver or nickel. These fuel cells contain

Researchers have developed the most powerful, durable hydroxide exchange membrane fuel cell components on record.

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hydroxide exchange membranes, which shift the environment within fuel cells from acidic -- the current standard -- to alkaline. The membrane of the fuel cell is what determines the pH inside. "We can make components much cheaper by switching from proton exchange membrane fuel cells to hydroxide exchange membrane fuel cells," said Yan. In order to make these membranes, Yan has been on a quest to develop optimal, scalable materials. For this project, Yan enlisted the expertise of another electrochemistry expert at UD -- Bingjun Xu, assistant professor of chemical and biomolecular engineering. Hydroxide exchange polymers consist of a long chain, or backbone, and a side chain with a positively charged ion, or cation. In Yan's past work, the side chains used in hydroxide exchange membranes contained very large positively cations, which made them stable but hindered their conductivity. The backbone material, on the other hand, was inexpensive, but not sufficiently stable. "The question was: how do you create a new polymer that is stable both for the organic cation and the backbone at the same time, with a small cation?" said Yan. Using poly(aryl piperidinium) polymers, the team developed hydroxide exchange membranes and ionomers with favourable properties, including good ion conductivity, chemical stability, mechanical robustness, gas separation and selective solubility. When the team tested these materials in a system with only a very small amount of platinum, the fuel cells fed with air had a peak power density of 920 milliwatts per square centimetre and operated in a stable manner at a current density of 500 milliamperes per square centimetre for 300 hours in air at 95 degrees Celsius. These are the best power and stability stats yet for a hydroxide exchange membrane at above 90 degrees Celsius and the closest anyone has come to the 5000 operating hours that would be required to use this technology in a car. The team developed a family of polymers, making this technology versatile. "There are a lot of knobs we can turn to deliver different properties," said Yan. "This is a platform technology." The paper's first author is research associate Junhua Wang, who has been working on this project since 2011. "For this discovery to be made, he had to be very patient," said Yan. "He is a wonderful scientist, very creative and diligent." The UD team also included research associate Yun Zhao, postdoctoral associates Brian P. Setzler, Santiago Rojas-Carbonell, Lan Wang, Keda Hu; doctoral student Lin Shi and adjunct professor Shimshon Gottesfeld. They also collaborated with three colleagues from Elbit Systems Limited, a fuel cell company based in Israel. The research is based on work supported by the U.S. Department of

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Energy, Advanced Research Projects Agency-Energy under Award No. DE-AR00000771.

Science Daily, 11 April 2019

<http://www.sciencedaily.com>

Using bacteria to protect roads from deicer deterioration

2019-04-16

Tiny bacteria could soon be chipping in to keep roads from chipping away in the winter, according to Drexel University researchers who are looking into new ways to make our infrastructure more resilient. Chemicals, like calcium chloride -- commonly called "road salts" -- are used to prevent the ice formation and snow accumulation that can lead to dangerous travel conditions. But they are also known culprits behind potholes and road surface deterioration. This degradation is caused by the chemicals reacting with the concrete and the water in ice and snow to form an expansive compound that can break down concrete by generating internal expansions and distresses. The deleterious compound, called CAOXY -- short for calcium oxychloride -- can also wedge out chunks of concrete as it infiltrates the road surface before freezing and thawing. In their research, recently published in the journal *Construction and Building Materials*, Yaghoob Farnam, PhD, Christopher Sales, PhD, and Caroline Schauer, PhD, researchers in Drexel's College of Engineering, show how mixing a bit of bacteria into concrete can curtail the formation of CAOXY. The pair arrived at their theory while studying a strain of bacteria called *Sporosarcina pasteurii*. *S. pasteurii* is rather unusual because it is able to induce the chemical reaction that creates calcium carbonate, a substance often referred to as "nature's cement." Only a few types of bacteria are able to pull off this trick, called microbial induced calcium carbonate precipitation, or "biomineralisation," but you can see their work in the mineral depositions that form limestone and marble. Over the last decade bacteria like *S. pasteurii* have been studied as a way to repair cracks in statues and concrete infrastructure, and, more recently, as an environmentally sustainable option for making bricks. But the Drexel researchers realized that one of the bacteria's other talents might also be quite useful for preventing those cracks from forming in the first place. "We were actually looking at the end product of a chemical reaction involving these bacteria -- calcite -- but we came to realise that the way they produce it could be quite useful when it comes to diverting the reaction that turns road salt into a road-deteriorating compound," Farnam said. "We knew the bacteria

Special bacteria that help form limestone and marble could soon have a new job on a road crew. Recent research shows how the bacteria, called *Sporosarcina pasteurii*, can be used to prevent the road degradation caused by ice-melting salt.

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require calcium chloride to produce the calcite, which is a harmless compound. So, if we could work out a way to have the bacteria present when the calcium chloride road salt hits the concrete it could interact with the bacteria and curtail the reaction that causes road degradation." To test their theory, Sales and Farnam made a series of concrete samples using the type of cement commonly used in roads and added a mixture of *S. pasteurii* and the nutrients they need to survive to some of the samples. After 28 days of exposure to a solution of calcium chloride -- simulating one month of road treatment in the winter -- they performed a series of tests on the samples to determine their structural integrity and measure the amount of CAOXY present. Looking at both the acoustic vibrations and the development of micropores in the mortar sample, which are both ways of quantifying the strength of the sample, the researchers found that the concrete made with the bacteria mixture experienced almost no deterioration after exposure to the calcium chloride. In addition, the levels of CAOXY were much lower in the bacteria-laden samples, as a result of the microbial induced calcium carbonate precipitation. And the presence of calcium carbonate suggests that the bacteria's interaction could also be used to strengthen the road surface, though this application would require more research, according to the team. "The bacteria are capable of changing the micro-environment around them," Sales said. "Specifically, they create a high pH environment by converting the chemicals in the nutrient slurry into a weak base, ammonia. This environment promotes the precipitation of calcium ions and carbonate ions into calcium carbonate-- rather than the formation of CAOXY." Because the bacteria occur in nature and are non-pathogenic, they would be an environmentally safe solution to the problem of road deterioration. Sales and Farnam are hoping to push this work to the next level by collaborating with local and national departments of transportation for additional testing and development.

Science Daily, 9 April 2019

<http://www.sciencedaily.com>

Fuel cell advance a breath of fresh air

2019-04-16

Fuel cells combine oxygen with an external fuel source, a similar process to the heat and light-yielding transformation that occurs in fire. Yet fuel cells perform those chemical reactions without burning. That's why fuel cells can generate energy with significantly more efficiency than combustion. Instead, fuel cells operate somewhat like batteries, consisting of two electrodes separated by an electrolyte, which is a material that

Fuel cells combine oxygen with an external fuel source, a similar process to the heat and light-yielding transformation that occurs in fire.

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transports ions. One of the electrodes splits oxygen gas from the air into individual atoms, which can then be transported and combined with fuel. Importantly, splitting oxygen frees up electrons that can move through a circuit as current to power homes or devices. This oxygen-splitting takes place at a component called the cathode. But oxygen gas is fairly stable and therefore reluctant to split. And efforts to drive the reactions efficiently at lower temperatures with compatible materials have been challenging, in part because researchers truly don't know the atomic scale details of the chemical reactions that take place at the cathode. "Previously, researchers really didn't understand what the rate-limiting steps are for how oxygen comes onto a surface, splits and enters a material," says Yipeng Cao, the lead student on the study. In order for oxygen to enter the cathode, the gas molecule must split into two atoms. Then each atom must encounter a structure called a vacancy, which is a little molecular gap at the surface of the material that allows oxygen to enter. Understanding this process is difficult because it happens at the top atomic layers of the cathode, whose chemistry can be quite different from the bulk of the material. "Measuring composition and vacancy chemistry at those top two layers is extremely challenging," says Morgan. That's why he and colleagues turned to computer simulations. As leading experts in molecular modelling, they combined density functional theory and kinetic modelling to gain atomic-level insight into the reactions occurring on the top two layers of the cathode. The team determined that splitting is not the rate-limiting step in the studied material. They learned that what's limiting fuel cell efficiency is the way in which oxygen atoms find and enter vacancies at the surface. Material with more vacancies, therefore, could potentially make fuel cells much more efficient. "This could allow for materials design in a way that was very hard to do before," says Morgan. The researchers focused on one particular material, a model compound for many common fuel cell cathodes called lanthanum strontium cobaltate. They're planning to expand the analysis to include other materials soon. The findings could have impact beyond fuel cells, too. Materials that exchange oxygen with the environment have numerous applications, including in water splitting, CO₂ reduction, gas separation, and electronic components called memristors. "I think we have a much better handle on how to control the oxygen exchange process," says Morgan. "It's early, but this could open the door to a broadly applicable design strategy for controlling oxygen exchange." This research was supported by grants

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from the U.S. Department of Energy (DESC0001284) and National Science Foundation (OCI-1053575).

Science Daily, 9 April 2019

<http://www.sciencedaily.com>

Characterisation of 'hidden' dioxins from informal e-waste processing

2019-04-16

A research team in Ehime University characterised the complex composition of chlorinated, brominated and mixed halogenated dioxins as well as their major precursors in soils from e-waste burning and dismantling areas in Agbogbloshie (Accra, Ghana), a major hub of informal e-waste processing in Africa. The findings were published on February 22, 2019 in *Environmental Science & Technology*. E-waste, or Waste Electrical and Electronic Equipment (WEEE), refers to end-of-life products such as communication devices, consumer electronics and home appliances. E-waste contains substantial amounts of valuable metals to recycle, but is also considered as hazardous waste due to the presence of toxic substances such as heavy metals and many various plastic additives. A large volume of these hazardous waste materials has been recycled inappropriately, and treated informally in Asian and African developing countries using primitive methods such as circuit board heating and open burning of wires. These informal recycling activities have led to serious environmental pollution caused by the emission of not only contaminants contained in e-waste but also unintentionally formed secondary toxic chemicals. Dioxin-like compounds, or simply dioxins, are a group of unintentional contaminants generated during informal processing of e-waste with a wide range of potential toxic effects. However, assessment of the environmental and health impacts of dioxins from e-waste is challenging due to their complex composition. Chlorinated dioxins including polychlorinated dibenzo-p-dioxins and dibenzofurans are combustion by-products of polyvinyl chloride (PVC) used in wire coating. Lesser-known brominated dioxins are thermal degradation products of brominated flame retardants (BFRs), which are plastic additives designed to prevent accidental fires. Mixed brominated/chlorinated dioxins are also generated during e-waste burning, but have not been well characterised because of the difficulties in analysing their large number. The research team in Ehime University used special analytical methods based on two-dimensional gas chromatography (GC×GC) and time-of-flight mass spectrometry (ToFMS) to conduct a comprehensive profiling of

Investigation of the complex mixture of chlorinated, brominated and mixed halogenated dibenzofurans and diphenyl ethers released from open e-waste burning in Ghana

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halogenated contaminants in the soils collected near e-waste burning and dismantling areas. Polybrominated and mixed halogenated dibenzofurans (PBDFs and PXDFs) were the major dioxins detected. Their composition profiles suggest that PBDFs were generated from polybrominated diphenyl ethers (PBDEs), a group of flame retardants commonly found in e-waste plastics; and PXDFs mainly from PBDFs through successive bromine-to-chlorine exchange. High concentrations of PXDFs in e-waste burning areas indicate that these "hidden" dioxins may contribute substantially to the total toxicity of the e-waste-derived dioxin mixture, and need to be included in future environmental and human exposure risk assessment.

EurekaAlert, 13 April 2019

<http://www.eurekaalert.org>

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Identifying the grass pollen that gets up your nose

2019-04-17

Scientists could be a step closer to providing more precise pollen forecasts to the 25% of the UK population who live with either asthma or hay fever. This follows the first results of a major three-year project to analyse airborne grass pollen. The first year's findings, published in *Nature Ecology & Evolution*, have shown that it is not just the overall 'load' of grass pollen in the air that could cause those particularly bad days for asthma and hay fever sufferers. Days which see increased asthma attacks or intense hay fever could be related to the release of pollen from particular grass species. Current pollen 'counts' and forecasts assess the whole load of pollen in the air, and, while scientists can distinguish between the pollen created by individual tree and weed species, it has proven virtually impossible for the current forecast methods to visually identify different grass pollens. Step forward metabarcoding, a technique which enables scientists to automatically identify any fragments of material caught in a sample of air, water or soil, by recognising and matching its unique DNA 'barcode'. For the first time, grass pollens collected over the course of one allergy season have been analysed using this high-tech method. This has enabled the team to start investigating links between certain pollen types and those days on which plant allergy sufferers and people with asthma are most affected. Prof Simon Creer, of Bangor University, who is leading the research explains: "I'm a hay fever sufferer myself, and I know that on some days, despite a high pollen forecast, I can be less affected than on other days when the forecast appears to be lower. This led me and others to wonder whether it's the high load of pollen alone that causes the problem, or whether the different grass pollens cause different levels of reaction." Dr Georgina Brennan, from Bangor University who analysed the aerial pollen "environmental DNA" with Dr Caitlin Potter from the University of Aberystwyth and the National Botanic Garden Wales, added: "Bringing a range of specialists together has enabled us to find initial answers. Our task is now to develop a clearer picture of where the pollen comes from, how it moves through the air and how different types of pollen can be linked to allergies." Dr Ben Wheeler of University of Exeter said: "We are now investigating datasets on hospital admissions and GP prescriptions for certain pharmaceutical products to identify correlations between healthcare data and increases in particular grass pollens. With these new insights into pollen characterization, we are focusing on future implications for pollen warnings and self-care strategies." Dr Rachel McInnes from the UK Met Office added: "Leading on from this new environment DNA research, we are currently developing maps of where

Scientists could be a step closer to providing more precise pollen forecasts to people who live with asthma or hay fever.

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these species of allergenic grasses are located in the UK. When combined with aerial modelling approaches being developed with Prof. Carsten Skjøth at the University of Worcester, the approaches could be used to improve our pollen forecast in the future."

Science Daily, 8 April 2019

<http://www.sciencedaily.com>

Antioxidants protect cells from harmful water contaminant

2019-04-17

Antioxidants such as vitamin C could help reduce harmful effects from hexavalent chromium, according to a new study performed with human cells. The contaminant, which is often produced by industrial processes, was featured in the biographical movie Erin Brockovich. Federal data from nationwide drinking water tests show that the compound contaminates water supplies for more than 200 million Americans in all 50 states. The concentration of hexavalent chromium that is safe for drinking water is now under review by the U.S. Environmental Protection Agency. "This is the first study to use human cells to test the effects of hexavalent chromium and protection by antioxidants," said Tim Mayotte, an undergraduate student at Olivet Nazarene University who performed the study. "If the new findings are further validated and go on to clinical trials, it might be possible to treat at-risk water sources with antioxidants like vitamin C to lower the risk for cancer caused by hexavalent chromium." Mayotte will present this research at the American Society for Biochemistry and Molecular Biology annual meeting during the 2019 Experimental Biology meeting to be held April 6-9 in Orlando, Fla. In a study designed to find out whether antioxidants might prevent cell toxicity, the researchers exposed two types of human cells to various concentrations of hexavalent chromium. They observed toxic effects for both cell types at 200 parts per billion (ppb) or higher concentrations of hexavalent chromium. However, this toxicity could be blocked by vitamin C at 10 parts per million (ppm) or the antioxidant epigallocatechin gallate at 15 (ppm). Epigallocatechin gallate is the primary antioxidant found in green tea. In other experiments, the researchers saw DNA mutations in bacteria exposed to 20 ppb or more of hexavalent chromium. However, these mutations didn't occur when the bacteria were also treated with 20 ppm of vitamin C. The new findings reveal that an oxidative mechanism is likely responsible for the contaminant's toxicity, which could be prevented

Findings could lead to treatment that reduces health risks from exposure to hexavalent chromium

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by treating the water with antioxidants. These results could help inform water quality monitoring and regulation.

Science Daily, 8 April 2019

<http://www.sciencedaily.com>

Zapping elderly brains with electricity improves short-term memory—for almost an hour

2019-04-17

To read this sentence, you hold the words in your mind for a few seconds until you reach the period. As you do, neurons in your brain fire in coordinated bursts, generating electrical waves that let you hold information for as long as it is needed. But as we age, these brain waves start to get out of sync, causing short-term memory to falter. A new study finds that jolting specific brain areas with a periodic burst of electricity might reverse the deficit—temporarily, at least. The work makes “a strong case” for the idea that out-of-sync brain waves in specific regions can drive cognitive aging, says Vincent Clark, a neuroscientist at the University of New Mexico in Albuquerque, who was not involved in the research. He adds that the brain stimulation approach in the study may result in a new treatment for age-related deficits in working memory. Working memory is “the sketchpad of the mind,” allowing us to hold information in our minds over a period of seconds. This short-term memory is critical to accomplishing everyday tasks such as planning and counting, says Robert Reinhart, a neuroscientist at Boston University who led the study. Scientists think that when we use this type of memory, millions of neurons in different brain areas communicate through coupled bursts of activity. “Cells that fire together, wire together,” Reinhart says. But despite its critical role, working memory is a fragile cognitive resource that declines with age, Reinhart says. Previous studies had suggested that reduced working-memory performance in the elderly is linked to uncoupled activity in different brain areas. So, Reinhart and his team set out to test whether recoupling brain waves in older adults could boost the brain’s ability to temporarily store information. To do so, the researchers used jolts of weak electrical current to synchronize waves in the prefrontal and temporal cortex—two brain areas critical for cognition—and applied the current to the scalps of 42 healthy people in their 60s and 70s who showed no signs of decline in mental ability. Before their brains were zapped, participants looked at a series of images: an everyday object, followed briefly by a blank screen, and then either an identical or a modified version of the same object. The goal was to spot whether the two images were

A new study finds that jolting specific brain areas with a periodic burst of electricity might reverse the deficit—temporarily, at least.

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different. Then the participants took the test again, while their brains were stimulated with a current. After about 25 minutes of applying electricity, participants were on average more accurate at identifying changes in the images than they were before the stimulation. Following stimulation, their performance in the test was indistinguishable from that of a group of 42 people in their 20s. And the waves in the prefrontal and temporal cortex, which had previously been out of sync in most of the participants, started to fire in sync, the researchers report today in *Nature Neuroscience*. No such effects occurred in a second group of older people who received jolts of current that didn't synchronize waves in the prefrontal and temporal cortex. By using bursts of current to knock brain waves out of sync, the researchers also modulated the brain chatter in healthy people in their 20s, making them slower and less accurate at spotting differences in the image test. "This is a very nice and clear demonstration of how functional connections underlie memory in younger adults and how alterations ... can lead to memory reductions in older adults," says Cheryl Grady, a cognitive neuroscientist at the Rotman Research Institute at Baycrest in Toronto, Canada. It's also the first time that transcranial stimulation has been shown to restore working memory in older people, says Michael O'Sullivan, a neuroscientist at the University of Queensland in Brisbane, Australia. But whether brain zapping could turbocharge the cognitive abilities of seniors or help improve the memories of people with diseases like Alzheimer's is still unclear: In the study, the positive effects on working memory lasted for just under an hour—though Reinhart says that's as far as they recorded in the experiment. The team didn't see the improvements decline toward the end, so he suspects that the cognitive boost may last for longer. Still, researchers say much more work has to be done to better understand how the stimulation works. Clark is optimistic. "No pill yet developed can produce these sorts of effects safely and reliably," he says. "Helping people is the ultimate goal of all of our research, and it's encouraging to see that progress is being made."

Science, 8 April 2019

<http://www.science.com>

Humane Society Successfully Campaigns to End Pesticide Test on Dogs

2019-04-17

On 12 March, the Humane Society of the United States released a report based on an undercover investigation of a lab in Michigan contracted by Dow Agrosiences (now Corteva Agriscience) to conduct toxicity

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testing on dogs. Just days later, on 18 March, Corteva announced it had ended a test of a fungicide on dogs and would attempt to rehome the animals. But what appeared to be a swift victory for the Humane Society was, in fact, the product of a months-long campaign on two continents. Kathleen Conlee, the vice president for animal research issues at the Humane Society, says the undercover investigation was carried out last summer by a Humane Society employee hired by Charles River Laboratories in Mattawan, Michigan, a facility contracted by Corteva to perform testing. The society's aim was "to educate the public about the use of dogs in toxicity testing of various products," Conlee says, but in addition to gathering details such as the conditions the dogs were kept in, the tests run on them, and the deaths of most of them by euthanasia, the investigator learned that 36 beagles were part of a one-year fungicide toxicity test that was slated to end with the animals' euthanasia in July 2019. After the investigation finished, Conlee tells *The Scientist*, her organisation began negotiating with Corteva to end the one-year fungicide test and release the dogs. After learning that the company was conducting the test in order to get a product approved for use in Brazil, the society worked with its sister organisation, Humane Society International, to try to get assurance from Brazil that the experiment was not necessary for approval, Conlee says. Humane Society International was able to get an official letter from Brazilian authorities confirming that the one-year test was not required, but Corteva asked for a more specific assurance that its product approval would not be affected, Conlee says. At that point, in mid-March this year, the Humane Society decided to release its report on its undercover investigation to the public, complete with photos and video of the dogs used in the fungicide test and other experiments; it was widely covered in local media, and on some national outlets such as CBS News. The same day, Corteva tweeted, "Once the industry receives confirmation that this test is no longer required, we will cease testing immediately and make every effort to rehome the animals." Six days later, it announced it had received the official confirmation it sought from Brazilian authorities and ended the test. "I do think the public pressure helped move that waiver process and move the company in securing that waiver more quickly," Conlee says. (Corteva did not respond to multiple requests for comment on this story, except by sending a previously released statement on the beagles' rehoming.) Cindy Buckmaster, the chair of Americans for Medical Progress, a group that performs public outreach on the need for animal research, writes in an email to *The Scientist* that Corteva's apparent concession that the fungicide test was not scientifically necessary "raises questions about why this particular phase of testing was commissioned in the first place. . . . I do not support the use of animals in research of any

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kind whenever it is determined that their involvement is not scientifically justified. And I believe this to be true of the research community, in general." Buckmaster says that in some experiments, dogs remain the best choice for studying specific biological processes. "For example, dogs are important in studies of specific features of cardiovascular disease because the anatomy and neural conduction properties of canine hearts most closely resemble human cardiac anatomy and function, relative to other animals. . . . Dogs are chosen for similar reasons for toxicology studies and their predictive value in testing designed to protect public health and safety has been demonstrated clearly for decades." Conlee concedes that "research is definitely a tougher issue to tackle [than toxicity testing] as far as alternatives." But she argues that technologies such as computational modelling already present a viable alternative to toxicology testing on animals, and points to the recent refusal of Vanda Pharmaceuticals to conduct an FDA-requested dog trial as the type of action the Humane Society wants to encourage. Eventually, she says, "if we start investing in technology . . . we're going to get there with replacing dogs in those more-challenging situations."

The Scientist, 8 April 2019

<http://www.the-scientist.com>

California Bill Banning Small Plastic Bottles at Hotels Advances

2019-04-17

A Bill banning hotels from providing small bottles of personal care products advanced recently in California amid concern that the containers are wasteful and environmentally unfriendly. Assembly Bill 1162 advanced in a 6-3 vote, with two members abstaining, in the National Resources Committee. Introduced in February by assembly members Mark Stone and Ash Kalra, the bill would prohibit any lodging establishment from providing small plastic bottles of shampoo, conditioner, bodywash, lotion or other personal care products in a guest room, any space within a guest room or any area that is shared by the public and guests. The ban includes hotels, motels, resorts, bed and breakfasts and vacation rentals and applies to plastic bottles smaller than 12 ounces that are "intended to be non-reusable." The measure would not apply to hospitals, nursing homes, retirement communities, schools or long-term rentals. The bill would go into effect 1 January 2023, and authorise a state or local agency to inspect accommodations to enforce the ban. Upon first violation of the bill, the accommodation would receive a written warning and the Natural

The bill would prohibit accommodations from providing guests with small plastic bottles of personal care products because of environmental concerns.

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Resources Committee recommended that subsequent violations result in fines of up to \$2,000. Kalra said that all options must be considered when it comes to reducing waste and pollution. Collectively, he said, small plastic bottles represent a “sizeable amount of waste,” KSWB-TV reported. “The amount of plastic produced is increasing exponentially, and we must consider all options to reduce this pollution from entering our waste streams,” Kalra said. “While it may not appear to be a problem on an individual level, small plastic bottles that are less than 12 ounces represent a sizeable amount of waste collectively that the state must address.” In December, the Santa Cruz Board of Supervisors passed a similar ordinance, banning single-use plastic bottles of personal care products in hotel and motel rooms.

U.S News, 12 April 2019

<https://www.usnews.com>

After a decade of research, here’s what scientists know about the health impacts of fracking

2019-04-17

Fracking has been linked to preterm births, high-risk pregnancies, asthma, migraine headaches, fatigue, nasal and sinus symptoms, and skin disorders over the last 10 years, according to a new study. Fracking, also known as hydraulic fracturing, is a process of extracting oil and gas from the Earth by drilling deep wells and injecting a mixture of liquids and chemicals at high pressure. The study, which was published in the Oxford Research Encyclopedia of Global Public Health in February, looked at several hundred scientific articles about the community and health impacts of fracking. The researchers focused on the design of those studies to ensure that the ones they included in their study were scientifically valid, then summarised what’s been learned about the industry in the last decade. “What we found pushes back against the narratives we often hear that say we don’t know enough about the health impacts yet,” Irena Gorski, co-author of the study and an environmental epidemiology doctoral candidate at the Johns Hopkins Bloomberg School of Public Health, told EHN. “We have enough evidence at this point that these health impacts should be of serious concern to policymakers interested in protecting public health,” Gorski said. She added that, while they found a number of documented health impacts, the ones with the most evidence for concern are negative impacts on pregnancy and birth outcomes. Evidence suggests women living closer to fracking have increased odds of having a baby with lower-than-average birth weight; of having a high-risk

Fracking has been linked to preterm births, high-risk pregnancies, asthma, migraine headaches, fatigue, nasal and sinus symptoms, and skin disorders over the last 10 years, according to a new study.

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pregnancy; or having a baby with a low infant health index. "We were looking for repeat findings," Gorski said, "and there are six studies on birth outcomes, which each found associations between adverse outcomes and unconventional natural gas development." Gorski and her colleagues also investigated the extent to which the studies they reviewed included metrics like the proximity of wells to residents, the phase of fracking the wells were in at the time of the study (active drilling versus ongoing production, for example), and the likelihood that non-fracking activities impacted their findings. "In these epidemiological studies, researchers do a lot to control for bias and consider all the confounding factors that could lead them to find false associations, and they adjust for them to minimise the impact on their findings," Gorski explained. "Basically, they're trying to see if their findings go away if they eliminate certain factors. In the studies we included, they're finding that they don't, which adds to the evidence that this is a concern for public health." The researchers noted in the study that it's still too early to study some health impacts, like cancer and neurodegenerative diseases, because they take a long time to develop. The researchers also looked at studies on the industry's effects on drinking water, air pollution, land use, earthquakes, and climate change to assess how those impacts might also affect health. They found evidence that water pollution, air pollution, and soil contamination caused by the industry have been linked to adverse health impacts through both exposure to toxic chemicals released during fracking, and through increased stress and anxiety caused by the increased light, noise, and truck traffic associated with fracking. They also found some surprising evidence of the industry's effect on climate change. "As a fossil fuel, natural gas extraction and use is contributing to climate change, of course," Gorski said, "but before conducting this study, I didn't realise the amount of evidence we have that it may be even worse than coal." She pointed to several studies suggesting that if fugitive emissions of methane from the equipment used to transport and store natural gas exceed more than 3 percent, natural gas use would have a greater climate change impact than coal. She also said there's evidence to suggest that the industry's methane emissions well exceed that 3 percent. "We included this in our study because climate change has its own contributions to health impacts," she added. "These indirect impacts will take longer to appear than the direct health impacts, but they have the potential to be significant." The impacts of climate change on health include heat-related illness and death, increased respiratory diseases, increases in insect-borne diseases, increased mental health impacts from forced migration and civil conflict, and health impacts from severe weather events. A separate forthcoming study, slated for publication in the journal *Ecological Economics*, found

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that ethnic minorities, especially African Americans, disproportionately live near fracking wells. Gorski said we should require more evidence of the industry's societal benefits, as opposed to requiring more evidence of its negative impacts, to determine the pace of expansion for the industry. "Some people are pushing for new studies on exactly how exposure happens in order to believe the evidence that these health impacts exist," Gorski said. "That's something scientists can potentially tease out, but we already know these health impacts exist, and I think there's already more than enough evidence for policymakers to take action."

Environmental Health News, 12 April 2019

<http://www.environmentalhealthnews.org/>

Study finds potential link between antimicrobial resistance and climate change

2019-04-17

While still too early to tell for sure, new research suggests that the growth in antimicrobial resistance may be linked to the onset of climate change. Medical health professionals are seriously worried about the growing number of reported cases of antimicrobial resistance (AMR). This comes after decades of misuse and the pharmaceutical industry's lack of urgency or ability to find and manufacture new antibiotics. Now, research presented at the recent European Congress of Clinical Microbiology and Infectious Diseases in Amsterdam may have found the first link between antimicrobial resistance and another potentially devastating issue: climate change. The study was conducted at the Institute of Infection Control and Infectious Diseases at the University Medical Centre Göttingen and Hannover Medical School in Germany. The possibility that AMR and climate change might be linked first gained attention when it was noticed that AMR increased with rising temperatures in the US. This latest research, however, investigated whether this also held up in Europe, with a diverse range in healthcare systems. This involved an observational study among 30 countries with data on the prevalence of carbapenem-resistant *Pseudomonas aeruginosa* (CRPA), *Klebsiella pneumoniae* (CRKP), multiresistant *Escherichia coli* (MREC) and Methicillin-resistant *Staphylococcus aureus* (MRSA) over a period of six years. Lead author of the study, Prof Simone Scheithauer, and the rest of her team then ran statistical analysis and computer modelling to see if there were any links between AMR and seasonal temperature, including potential socioeconomic and health system-related confounders.

While still too early to tell for sure, new research suggests that the growth in antimicrobial resistance may be linked to the onset of climate change.

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'AMR is a serious threat to communities worldwide'

The team found strong associations of CRKP, MREC and MRSA with the warm season mean temperature, which had a higher contribution to MRSA variance than outpatient antimicrobial drug use. Additionally, a rise in CRPA was significantly associated with the warm season change in temperature. "Our study identified a novel association between AMR and climatic factors in Europe," the authors wrote in the study, yet to be peer-reviewed. "These results reveal two aspects: climatic factors significantly contribute to the prediction of AMR in different types of healthcare systems and societies, while climate change might increase AMR transmission, in particular carbapenem resistance." Speaking to Newsweek, Scheithauer stressed that these were early results, but they raise serious concerns about the existence of a link between AMR and climate change. "At this stage we cannot make any recommendations for the future. We need further research to know more about this potential association. We need to monitor future developments and collect additional data," she said. "The increase of AMR is a serious threat to communities worldwide, and this is known to everyone."

Silicon Republic, 15 April 2019

<https://www.siliconrepublic.com>

Daimler: New emissions cheating software discovered — report

2019-04-17

German automaker Daimler on Sunday faced fresh allegations of emissions cheating after revelations about a previously unknown manipulation software were made public. The country's vehicle regulator has begun a formal investigation after discovering a new device in the company's Mercedes-Benz model GLK 220 CDI, the Bild am Sonntag newspaper reported. According to Bild, the investigation is focusing on another "illegal defeat device" installed in around 60,000 vehicles produced between 2012 and 2015 with the exhaust emission standard 5. Bild reported that regulators discovered the controversial software in late 2018. It said further emissions tests with a GLK model then confirmed their suspicion. The paper said the European Union's emissions limit of 180 milligrams of nitrogen oxide per kilometre was clearly exceeded once the software was deactivated during the tests.

Software has been updated

An unknown "illegal defeat device" was found in one of the carmaker's Mercedes models, a German newspaper reports. The country's auto sector is struggling to restore its reputation following the Dieselgate scandal.

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Bild said the newly-discovered cheating software had been subsequently removed secretly during software updates by Daimler. The Stuttgart-based carmaker confirmed a probe was underway by the Federal Motor Transport Authority (KBA). A spokesman told the German news agency Deutsche Presse-Agentur that the company had been in talks with the KBA for months. "We fully cooperate with the Federal Motor Transport Authority and are reviewing the facts," Daimler said in a statement. "In the course of the hearing proceedings, we will present our view to KBA." German automakers are struggling to move on from the Dieselgate scandal, which first erupted in September 2015, when Volkswagen admitted to secretly installing software in 500,000 US vehicles to cheat government exhaust emissions tests. The scandal is believed to have affected about 11 million cars worldwide, cost the company some \$25 billion (€22 billion) in fines and compensation, and caused significant damage to VW's reputation. Other German auto brands — Audi, BMW, Daimler, Mercedes-Benz and Porsche — were also implicated and subsequently carried out their own recalls.

Huge European recall

Last year, Daimler was ordered to recall nearly 800,000 vehicles across Europe, including 280,000 in Germany, that were found to be fitted with emissions cheating software. The company is carrying out the recalls of the diesel versions of the Mercedes C-Class, Vito and GLC models to install a new version of its engine management software. Daimler is also potentially facing a big fine over the diesel scam; German prosecutors said in February they had opened a "fine procedure" against the firm.

DW, 14 April 2019

<http://www.dw.com>

Firefighters demand crackdown on toxic dump 'death traps'

2019-04-17

Firefighters are calling for emergency laws to jail, fine and sue operators responsible for illegally stockpiling toxic chemical waste that causes industrial fires, warning that dump sites are "death traps" for emergency services personnel. The call from the United Firefighters Union comes as firefighters report falling ill after battling huge industrial blazes in Campbellfield this month and West Footscray in 2018 that have been linked to massive illegal waste dumping operations. Firefighters who

Firefighters are calling for emergency laws to jail, fine and sue operators responsible for illegally stockpiling toxic chemical waste that causes industrial fires, warning that dump sites are "death traps" for emergency services personnel.

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were at both scenes have suffered lung infections, nosebleeds, rashes and memory loss after exposure to the highly toxic smoke and debris produced by the burning of solvents, paints, inks and other unknown chemicals. The fires burned for days, forcing the closure of schools, businesses and creating widespread contamination in local waterways. The West Footscray factory fire is one of the biggest blazes the city has seen since the Coode Island disaster of the early 1990s, authorities say. In a letter to Premier Daniel Andrews, UFU Victorian secretary Peter Marshall has called for those responsible for creating the stockpiles to be held "fully accountable both in criminal sanctions and civil penalties". "Our firefighters are being forced to attend fires that amount to a premeditated ambush," he wrote. "The threat of imprisonment should be real and prosecuting bodies should have a 'pro-charge' policy to ensure that prosecutions are initiated in all circumstances where a fire occurs involving toxic chemicals that have, in any way, been illegally produced, sold, transported, stored or disposed of." Adrian Lovelace and Frances Egan were among the hundreds of firefighters exposed to toxic fumes and contamination at the West Footscray industrial blaze. The letter details the UFU's concern that current laws are unworkable or poorly enforced, often leading to only "modest" financial penalties against businesses and do not hold individuals accountable. An Andrews government spokesman confirmed the proposed measures would be considered to ensure rogue operators are held to account. "Victorians have a right to expect that the management of hazardous and industrial waste is done to the highest standard," the spokesman said. "Earlier this year the government announced we'd look at bringing in tougher penalties for those caught illegally storing dangerous goods, to make it clear to rogue operators that this will not be tolerated." As revealed by The Age last recently, the government will spend \$5.5 million to introduce electronic tracking of chemical waste in July. The Environment Protection Authority currently uses a mix of electronic and paper waste transport certificates – with up to 100,000 paper certificates received each year. The UFU is also asking for legislation that would allow injured firefighters or their families to sue "perpetrators" for compensation. It will launch a public awareness campaign this week, which includes a call for members of the public and businesses to "dob in a dumper" to Crime Stoppers. More than 700 firefighters were involved in the massive operations to fight the blazes at West Footscray in August, 2018 and the Campbellfield premises of waste disposal business Bradbury Industrial Services on April 5. Both fires are now under investigation by the arson squad and Victoria's coroner. The illicit dump at the West Footscray warehouse was controlled by Wallan-based businessman Graham Leslie White, who has since been linked to eight other stockpiles

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in Campbellfield and Epping that contained up to 19 million litres of chemical waste. Mr White is currently serving a six-month prison sentence after he was caught in possession of an arsenal of dangerous firearms as part of an unrelated criminal investigation. In March, Bradbury Industrial Services was caught by environment regulators stockpiling three times the amount of chemicals permitted under its licence. Fire broke out as the stockpile was being reduced, injuring a worker and forcing others to flee the scene. The business has since been linked to four dump sites in Craigieburn and Campbellfield that hold up to 11 million litres of illicitly-stored waste. CFA acting chief officer Gavin Freeman said the welfare of CFA firefighters and the community was of paramount importance. "CFA works closely with EPA, WorkSafe and other agencies on major hazardous incidents across the state and to help stop the illegal storage and dumping of toxic material," Mr Freeman said. An MFB spokeswoman said it was also working with the EPA and Worksafe to proactively target the illegal storage of dangerous goods. "MFB agrees that the full force of the law should be brought to bear on companies who wilfully ignore legislation and regulations designed to ensure the safe storage of dangerous goods," the spokeswoman said.

The Age, 15 April 2019

<http://www.theage.com.au>

New 'added sugars' labelling could save money and improve health

2019-04-17

The United States Food and Drug Administration's new mandatory rules requiring labels on all packaged foods and drinks to indicate the presence of so-called added sugars could have substantial health and cost saving benefits in the United States over the next two decades, a new study suggests. Using a computer model, researchers determined that the labelling policy, which is set to go into effect between 2020 and 2021, might prevent nearly 1 million cases of heart disease and diabetes, according to the report published in *Circulation*. "Our study is the first to estimate the potential health and cost-saving benefits of the FDA's added sugar labelling," said study co-author Renata Micha, a research associate professor at the Friedman School of Nutrition Science and Policy at Tufts University. "We found that, over the next 20 years, the impact of the FDA's added sugar labelling to nudge consumer choices could save nearly 1 million cases of cardiovascular disease and type 2 diabetes, \$31 billion in net healthcare costs, and \$62 billion in societal costs." If the labelling

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spurred the food industry to reduce the amount of sugar used in its products, that could result in even bigger benefits, Micha said. For their computer models, the researchers used data from the National Health and Nutritional Examination Survey (NHANES), which each year involves a nationally representative sample of about 5,000 people. In particular, the researchers looked at 24-hour dietary intake forms completed on two separate occasions by adults ages 30 to 84. Among the assumptions made in the modelling was the impact labelling would have on sugar consumption. Micha and her colleagues estimated that people would decrease added sugar intake by 6.8 percent because of the labelling. In an analysis of what would happen if companies reformulated their products as a result of the labelling, the researchers assumed an additional 8.25 percent decrease in added sugar intake. Those sugar reduction estimates came from "real world studies where the presence of a label on a product led to positive consumer responses," Micha said in an email. "As with any medical or public health intervention, our estimates represent average population effects; for any given individual there may be larger or smaller changes." A model with just consumer behaviour changes and no industry reformulations in response to the label changes predicted 354,400 fewer cases of cardiovascular disease, 599,300 fewer diabetes cases, \$31 billion saved in healthcare costs and \$61.9 billion saved in societal costs. When the researchers ran the model with both the label change and the reformulation of products, the result was 708,800 fewer cases of cardiovascular disease, 1.2 million fewer cases of diabetes, \$57.6 billion saved in healthcare costs and \$113.2 billion saved in societal costs. Micha suspects that the second scenario is a real possibility with the new labelling. "Our work and that of others, including recent experience with trans-fat labelling in the U.S., suggests that mandating labelling of added sugar content would stimulate the food industry to reduce sugar in their products," Micha said. "Some companies are already reformulating their products to reduce added sugar content, partly driven by the consumer's demand for healthier products." Experts welcomed the new study for providing a window on how new labelling might impact health and healthcare costs. "Overall, I think it's an important study," said Dr. Rekha Kumar, an endocrinologist at NewYork-Presbyterian and Weill Cornell Medicine and medical director of the American Board of Obesity Medicine. "What I think is the biggest assumption is that people will know how to read the food labels and will actually read them." The other big assumption is that people "will understand the correlation of added sugars with long term cardio metabolic health," Kumar said. "For many, the connection is not immediate." Consumers may need more education to make that connection, said Shelley Kendra, clinical manager of food and nutrition

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services at Magee-Women's Hospital at the University of Pittsburgh Medical Centre. "My hope is that the findings will turn out to be correct," Kendra said. "With cardiovascular disease and diabetes continuing to rise it would be great if a simple thing like changing food labels could help. But I think there definitely has to be an education piece involved."

Reuters Health, 16 April 2019

<http://www.reuters.com/news/health>

Female firefighters' health needs often unaddressed

2019-04-17

Women firefighters, particularly in North America, are less likely to have access to female-specific personal protective equipment and appropriate strength training and conditioning support, according to a new study. In addition, women reported numerous counts of sexism on the job, and others talked about logistical issues such as sanitary conditions and toilet facilities, especially when tackling fires for several hours, researchers wrote in *Women's Health Issues*. "Little research has been undertaken on female firefighters, yet there are clearly some very specific questions that need answering that are often overlooked as the vast majority of staff are male," said senior study author Alan Richardson of the University of Brighton in Eastbourne, UK. About six percent of firefighters worldwide are female, he said, and the numbers are increasing. Previous studies have identified high rates of cancer, musculoskeletal injuries, post-traumatic stress disorder and suicide among women firefighters, as well as pregnancy complications. "Hopefully more and more young girls will see this as a future career path," he told Reuters Health by email. "However, we need to better understand any potential risks and ensure that specific needs are catered for effectively." Richardson's team surveyed 840 female firefighters from 14 countries, including the UK, U.S., Canada, Australia and mainland Europe, in 2018. They asked about general health and well-being, role-specific health concerns, gender-related issues and available exercise facilities. Seventy-five percent of female firefighters in the U.S. and Canada said they don't have access to female-specific personal protective equipment. Although the numbers are better in the UK, about a third of women don't have a full female kit. Women firefighters also identified a lack of strength training and conditioning support or lack of gym access. About half said they'd like further support and guidance on fitness and training. In addition, about 45 percent of North American respondents reported heat illnesses and lower back and limb injuries, double the proportion in the UK and three times higher than in mainland Europe. "Given these women

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risk their lives for their communities, the fact that they suffer from these two addressable negative outcomes is unfortunate,” said Christopher Haddock of the National Development and Research Institute in New York. Haddock, who wasn’t involved with this study, has researched women firefighters’ health in the U.S. “I believe that women firefighters are often pressured to not address their unique concerns for fear of being labelled as a ‘whiner’ or wanting special accommodations,” he told Reuters Health by email. “We should all want to support women firefighters and ensure they have proper training and equipment.” Nearly 40 percent of women surveyed thought their menstrual cycle and menopause affected work, and 36 percent were concerned about their ability to meet future job demands due to hot flashes, fatigue, changes in bone and muscle strength and embarrassment in a male-dominated environment. Only 16 percent felt confident they could fill the role after age 60. Firefighters are routinely exposed to traumatic and life-threatening events, and they are generally resilient to the effects of trauma exposure and other occupational stressors due to factors such as camaraderie and a sense of purpose, said Ian Stanley of Florida State University in Tallahassee, Florida, who has studied job stress among women firefighters but wasn’t involved in this study. Stanley has found that more severe post-traumatic stress disorder symptoms lead to a higher risk of suicide in these women. “It is important to acknowledge,” he added, “that a nontrivial proportion of firefighters, including women firefighters, experience immense suffering as a result of trauma exposures and other occupation stressors.”

Reuters Health, 13 April 2019

<http://www.reuters.com/news/health>

Newly discovered life forms inside our bodies profoundly affect our health – and provide a glimpse of the vast and mysterious biological “dark matter” within us

We contain microbes so deeply weird they alter the very tree of life

2019-04-17

Eric Baptiste is on a hunt for life, but not as we know it. He doesn’t think we have to sift through Martian soils or trawl lunar oceans to find these entities. His hunting ground is far closer to home: the human body. “Biology is full of surprises,” says Baptiste, an evolutionary biologist at the Pierre and Marie Curie University in Paris. “Since we have not yet exhaustively sampled all the DNA in the world, there is still room for finding rare, strange creatures.” A realist might say that Baptiste’s mission is doomed to fail. After all, we are in the 2010s, not the 1710s. It is unthinkable that biologists can unearth new divisions of life on Earth – let alone make those discoveries in the intimately familiar environment of

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the human body. They would be wrong. Recent research shows that our bodies are home to microbes unlike anything science has encountered before – some so alien that they are rewriting the tree of life. What's more, this microbial "dark matter" could be having a profound effect on our health, for better and worse. The body is home to some 39 trillion microbes, which outnumber our 30 trillion human cells. Our skin has a billion bacteria per square centimetre. Earlier this year, a study found that as many as 2000 different species can thrive in the human gut – although a smaller subset of these live in or on any one individual. For years we assumed these microbes were harmful, but we now know that many of them are actually our allies, closely linked with our health and well-being (see "The human zoo"). Thanks to new technology, we can now study them in unprecedented detail. Until a few decades ago, microbiologists had to grow microbes in the lab before they could identify and study them. However, the vast majority of microbes can't be cultured this way, seriously limiting the scope of our understanding. Today, we can get around this problem using metagenomic sequencing, a technique used to identify microbes from their DNA – in a sample of human faeces, for instance – even if the microbes won't grow in culture. Once snippets of DNA have been identified, we can use software to reconstruct whole genomes from those fragments. Thanks to this approach, every month seems to bring a new discovery of previously unknown microbes living in or on us. Occasionally, these are truly unexpected. In 2013, for example, a team led by Jillian Banfield at the University of California, Berkeley, and Ruth Ley at Cornell University in New York discovered evidence that our guts are home to a completely new group of organisms – and that they are related to cyanobacteria, a well-known type of microbe critical to the evolution of complex life. The team named these newly found microbes Melainabacteria, after the nymph of dark waters from Greek mythology.

The facilitators of life

The connection of Melainabacteria to cyanobacteria was intriguing: the latter are, as far as we know, the only organisms ever to develop a form of photosynthesis that generates oxygen as a by-product (plants have this ability only because they incorporated cyanobacteria into their cells). This innovation transformed the planet's atmosphere and paved the way for complex life. But how cyanobacteria have evolved has been a bit of a mystery, largely because we have struggled to find related microbes. Melainabacteria plug that gap. They have already helped microbiologists and geologists to argue that oxygen-generating photosynthesis evolved relatively late in the history of life. What's more,

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they may play an important role in human health too. A 2018 study revealed that people with Parkinson's disease have fewer Melainabacteria in their gut than those without the condition. The microbes might protect us by outcompeting cyanobacteria, which generate neurotoxins, for nutrients and preventing them from gaining a toehold. This finding hints at something important about human microbiomes: they are complex ecosystems containing a range of microbes interacting with one another. This diversity is plucked from all three of the major branches, or domains, of the tree of life. The cyanobacteria, for instance, belong to the bacterial domain. Our bodies are also home to microbes that look superficially like bacteria but actually belong to a distinct domain called the archaea, commonly found in extreme environments such as hot springs. The body was once thought to be an unlikely habitat for these simple organisms, but last year a team reported that archaea are as abundant as bacteria in the human appendix and nasal passages. Our bodies also play host to a huge number of microbes – including fungi – from the domain of complex, eukaryotic life that also contains animals and plants. But is it possible that within us lie completely new life forms, microbes that don't fit within these three known domains? Bapteste has reason to believe so. In 2015, he and his colleagues sifted through gene sequences from faecal samples and found DNA that was so unusual it hinted at the existence of a mysterious fourth domain of life. The work is some way from solid proof that our bodies are home to such weird organisms, but one recent discovery suggests the idea isn't as far-fetched as it might sound. Back in 2010, a team exploring the life forms living in our mouths – the human oral microbiome – found genetic material belonging to two rare groups of bacteria, known simply as TM7 and SR1. These had first been found a few years earlier in a peat bog and in river sediment, respectively. By 2013, a group had pieced together essentially complete TM7 genomes from a wastewater treatment plant. Another team, led by Banfield, had done the same for TM7 and SR1 microbes living in groundwater. They discovered that all of the genomes were curiously small – roughly a quarter of the size of the genome of *Escherichia coli* bacteria, which are commonly found in the gut and the wider environment. As a consequence of being so small, the genomes seemed to lack some genes thought to be essential for independent life. This could mean they belonged to bacteria that survive only in intimate symbiosis with other cells that give them what they can't make themselves. Since then, we have learned a lot more about these odd bacteria. In 2015, Banfield's team used electron microscopy to show that some are so small that they are on the cusp of being impossible. Individual cells tend to be no more than a few hundred nanometres in length, which is about as small as biologists have calculated cells can be and still

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function. The same year brought even more unexpected news. Banfield and her colleagues studied almost 800 bacteria with small genomes (including TM7 and SR1). They realised that the bacteria belonged on a single evolutionary branch, which was given the working name of the Candidate Phyla Radiation (CPR). What's more, the CPR branch was a staggeringly stout one: Banfield and her colleagues suspect that the CPR account for as much as half of bacterial diversity. The upshot is that we really do seem to have a newly recognised set of very unusual microbes in our bodies. "We think it's a new player ... these ultra-small bacteria with tiny genomes that we're just learning about," says Jeffrey McLean at the University of Washington in Seattle. They may not be distinct enough to qualify as a fourth domain, but the CPR "subdomain" has revolutionised our picture of the tree of life and profoundly affected our thinking about human microbiomes.

Updated tree of life

There are, in fact, three different types of CPR bacteria that we know of in the human body – TM7, SR1 and a third called GN02. So far, they have been found in the human mouth, gut and vagina and on the skin. Now we know they existed in Neanderthals too. Studies of mineral deposits taken from 48,000-year-old Neanderthal teeth found several strains of CPR bacteria, including one called TM7x. What exactly are these bacteria doing? An answer is beginning to emerge, and it isn't good news. CPR bacteria usually comprise no more than 1 per cent of microbiome populations, but can be far more abundant in people with certain illnesses, including inflammatory bowel disease. In people with severe gum disease, 20 per cent of the oral microbiome may be composed of CPR bacteria. But are these mystery microbes actually causing these health woes? To answer that, McLean and Xuesong He, now at the Forsyth Institute in Cambridge, Massachusetts, decided to take a closer look. In 2015, they led a team that managed to grow a strain of TM7 taken from the human mouth, making it possible to study the microbes' biology and behaviour under the microscope. This strain – TM7x – remains the only CPR bacterium that has been successfully cultured to date.

A cloak of parasites

It wasn't easy. McLean and He's team found they could only grow TM7x in a co-culture that also included a strain of another oral bacterium called *Actinomyces odontolyticus*, which can itself cause inflammatory disease if it becomes overabundant in our microbiomes. Studying the cultures under the microscope revealed why the two must be grown together:

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the tiny TM7x cells are parasites that bind themselves to the surface of the larger *A. odontolyticus* bacteria. This kind of microbe-on-microbe parasitism has been seen elsewhere in nature, but never before within us. "Having a bacterium parasitise another bacterium in our bodies is a new finding," says McLean. "The bacteria are so small that they are on the cusp of being impossible"

But even though McLean and He have evidence that TM7x can kill *A. odontolyticus* cells, the parasitic relationship is a strange and complex one. Intriguingly, when *A. odontolyticus* are parasitised by TM7x, they gain the ability to dodge detection by our immune system. This might help explain the link between CPR bacteria and conditions including gingivitis and inflammatory bowel disease. These are caused by bacteria that are standard components of the healthy human microbiome, but that overwhelm our immune system if they become too abundant. Perhaps being parasitised by CPR microbes gives certain bacteria the ability to avoid detection by our immune system and helps them become abundant enough to increase inflammation – although that is an idea that hasn't yet been tested, says McLean. "The discovery of the CPR bacteria was a big surprise," says Baptiste – and it is one with big possible implications. After all, if we have only just realised that our microbiomes are home to a previously unknown subdomain of life, who knows what additional life forms may be lurking within us. Baptiste is realistic, and recognises that identifying them will take time and won't be easy. "Finding novelty is always far more difficult than finding more of the creatures we already know," he says. "It's going to be a long quest."

New Scientist, 10 April 2019

<http://www.newscientist.com/>

Airborne microplastics found atop France's remote Pyrenees mountains

2019-04-17

Microscopic fragments of plastic have invaded the farthest reaches of the sea, from the depths of the Mariana Trench to the freezing waters off Antarctica. Now, researchers have found that such microplastics have polluted the Pyrenees mountains, expanding plastic's dominion to previously unknown heights. Prior studies have shown that microplastics, which can be ingested and inhaled by humans—and which may lead to reproductive issues in some marine molluscs—can rise up into the atmosphere and drop back to solid ground in the cities they come from.

Researchers have found that such microplastics have polluted the Pyrenees mountains, expanding plastic's dominion to previously unknown heights.

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But scientists thought these plastics couldn't travel very far from their urban sources. To find out just how far they can go, the researchers collected particles falling from the sky in dust, rain, and snow for 5 months at the Bernadouze meteorological station in the Pyrenees mountains in southwestern France—100 kilometres from the nearest city. To their horror, the authors found plastics, predominantly the kind from the single-use packaging used in shipping. From their sample, they determined that each day, an average of 365 plastic particles sifted down from above into the square meter surface of the collection device. If comparable quantities of airborne microplastic fall across the rest of the country, the researchers estimate roughly 2000 tons of plastic blanket France each year, they report today in *Nature Geoscience*. Computer simulations corroborated the notion that the plastic fragments, films, and fibres collected could have originated in cities, suggesting the microplastics floated at least 100 kilometres before falling back to Earth. But researchers say these tiny particles may travel much farther. Dust particles from the Sahara Desert, for example, have been found in the Pyrenees, even though they are twice as large and twice as heavy as the microplastics found in the study. Pieces of plastic small enough to sail into the atmosphere are virtually impossible to clean up, say the researchers, suggesting the only viable solution is to produce less in the first place. Until then, the researchers plan to keep up their detective work—tracking the airborne microplastics all the way back to their source.

Science, 15 April 2019

<http://sciencemag.org/>

'First' 3-D print of heart with human tissue, vessels unveiled

2019-04-17

Scientists in Israel unveiled a 3D print of a heart with human tissue and vessels on Monday, calling it a first and a "major medical breakthrough" that advances possibilities for transplants. While it remains a far way off, scientists hope one day to be able to produce hearts suitable for transplant into humans as well as patches to regenerate defective hearts. The heart produced by researchers at Tel Aviv University is about the size of a rabbit's. It marked "the first time anyone anywhere has successfully engineered and printed an entire heart replete with cells, blood vessels, ventricles and chambers," said Tal Dvir, who led the project. "People have managed to 3D-print the structure of a heart in the past, but not with cells or with blood vessels," he said. But the scientists said many challenges

Scientists in Israel say they have produced the first 3D print of a heart with human tissue and vessels, calling it a "major medical breakthrough" even though they are a long way off from creating the first hearts suitable for transplant

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remain before fully working 3D printed hearts would be available for transplant into patients. Journalists were shown a 3D print of a heart about the size of a cherry, immersed in liquid, at Tel Aviv University on Monday as the researchers announced their findings, published in the peer-reviewed journal *Advanced Science*. Researchers must now teach the printed hearts “to behave” like real ones. The cells are currently able to contract, but do not yet have the ability to pump. Journalists were shown a 3D print of a heart about the size of a cherry, immersed in liquid, at Tel Aviv University

Then they plan to transplant them into animal models, hopefully in about a year, said Dvir. “Maybe, in 10 years, there will be organ printers in the finest hospitals around the world, and these procedures will be conducted routinely,” he said. But he said hospitals would likely start with simpler organs than hearts. In its statement announcing the research, Tel Aviv University called it a “major medical breakthrough”. Cardiovascular disease is the world’s leading cause of death, according to the World Health Organization, and transplants are currently the only option available for patients in the worst cases. But the number of donors is limited and many die while waiting. When they do benefit, they can fall victim to their bodies rejecting the transplant—a problem the researchers are seeking to overcome. Their research involved taking a biopsy of fatty tissue from patients that was used in the development of the “ink” for the 3D print. First, patient-specific cardiac patches were created followed by the entire heart, the statement said. Using the patient’s own tissue was important to eliminate the risk of an implant provoking an immune response and being rejected, Dvir said. “The biocompatibility of engineered materials is crucial to eliminating the risk of implant rejection, which jeopardises the success of such treatments,” said Dvir. Challenges that remain include how to expand the cells to have enough tissue to recreate a human-sized heart, he said. Current 3D printers are also limited by the size of their resolution and another challenge will be figuring out how to print all small blood vessels. But while the current 3D print was a primitive one and only the size of a rabbit’s heart, “larger human hearts require the same technology,” said Dvir. 3D printing has opened up possibilities in numerous fields, provoking both promise and controversy. The technology has developed to include 3D prints of everything from homes to guns.

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<http://medicalxpress.com>

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How your gut might modify your mind

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The idea that our guts may influence our mental health is not new, but in the past 15 years, it has gotten renewed attention from scientists. Amid the hype, researchers are beginning to solidify the connection between our gut microbiomes and our brains with studies mainly in mice. Questions remain about how gut-brain communication happens and whether it can be used therapeutically. But scientists say this field is still in its early days and are optimistic that we'll find answers. Anytime you touch a grimy handrail in the subway station or walk barefoot through the sand on a beach, you might be tempted to think that the skin we use to touch and feel is the largest interface with our surroundings. But you would be wrong; our guts are much bigger. Curled up inside us, our intestines have a surface area of around 32 m², or 344 ft². Put another way, the intestines of an average adult occupy the same area as a small studio apartment in New York City. But instead of housing a stressed-out Manhattanite, a human's gut hosts trillions of microbes. Our intestinal walls absorb and interact with all the molecules we ingest, but so do these microscopic chemists that live inside us. They take the nutrients in and then pump out a raft of new chemicals. This community of bugs is diverse and relatively stable—an ecosystem of bacteria, viruses, and fungi. In exchange for raw materials and shelter, the microorganisms, collectively known as the microbiome, feed and protect their hosts. But the influence of our microbial community doesn't stop there. Studies have shown that our microbiome may play a role in mental health and neurological conditions such as autism, epilepsy, and depression by interacting with our nervous system and even releasing molecules that can perhaps make their way to the brain. More research and trials are needed to understand how the gut and the brain are linked, but researchers suggest that their findings might one day lead to treatments for neuropsychiatric disorders.

Possible pathways

The mechanisms connecting the gut and brain are still unclear, but here are some of the most popular ideas.

1. Microbes interact with immune cells in the gut, prompting the cells to make cytokines that circulate from the blood to the brain.
2. Microbes interact with gut cells called enteroendocrine cells that produce neuroactive molecules and peptides. These molecules interact with the vagus nerve, which sends signals to the brain.

The microbes that live in your body might be influencing your behaviour.

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3. Microbes in the gut produce neurotransmitters and metabolites like butyrate. These circulate to the brain, where some of them are small enough to cross the blood-brain barrier, and others alter cell activity at the barrier itself.
4. In 2018 researchers at the University of Alabama at Birmingham reported at a meeting that they had found gut bacteria in human brain tissue. The study has not yet been published, and sceptics abound, but it suggests that microbes might somehow be making their way into the brain.

Source: Adapted from *Front. Integr. Neurosci.* 2013, DOI: 10.3389/fnint.2013.00070.

Feeling It In Your Gut

Doctors have been wondering about the links between digestion and mental health since the 19th century. Inspired by famed scientist Louis Pasteur, who speculated in 1885 that animals lacking bacteria would die, European doctors began investigating the significance of microbes located in the digestive system. Perhaps, the doctors suggested, "toxins" produced by microbes in the gut were poisoning the minds of their patients. This area of study became hugely popular for a few decades before being discredited, and medical science moved on. Until as recently as 2004, the suggestion that bacteria in the human gut could be a factor in mental health was regarded with suspicion. In that year, Nobuyuki Sudo's group at Kyushu University, in Japan, reported that the bodies of so-called germ-free mice reacted strongly to stress compared with those of non-germ-free mice (*J. Physiol.* 2004, DOI: 10.1113/jphysiol.2004.063388). Germ-free mice are lab animals raised in an isolated environment so they have no microorganisms living inside or on them. While the paper didn't immediately gain much attention, since then, evidence has slowly been mounting that intestinal microbiota are linked to mood, behaviour, and cognition. Among scientists, the report is now viewed as the start of a new field of research: the study of the gut-brain connection. In 2005, John F. Cryan, a neurobiologist with expertise in how stress affects the brain, joined the faculty at University College Cork, which was already home to many researchers interested in stress and its role in the gut—specifically, how it is involved in irritable bowel syndrome. By 2009, Cryan's group published a study showing that when young rat pups were separated from their mothers, the stress early in life could lead to long-term changes in the animals' microbiomes (*Biol. Psychi.* 2009, DOI: 10.1016/j.biopsych.2008.06.026). "It was just one of, like, 10 different measures we took to really prove that stress was a whole-body syndrome," Cryan says.

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So, to begin with, the finding didn't particularly stand out in the crowd, but it did get Cryan thinking. He began to search the literature for other links between stress and the gut microbiome and found the 2004 paper from the Japanese team. At that point, he says, the paper was still not very well known, but it helped him make some connections. His own team had shown that stress affects the microbiome in mice. The Japanese team had shown that the microbiome affects how mice deal with stress. Cryan and his team investigated the link further. In 2011, they reported that when a probiotic bacterium known to influence the immune system, *Lactobacillus rhamnosus* JB-1, was given to a mouse, the animal's stress behaviours decreased and its brain chemistry changed (Proc. Natl. Acad. Sci. U.S.A. 2011, DOI: 10.1073/pnas.1102999108). Mice with a severed vagus nerve did not get the same benefits when given *L. rhamnosus* JB-1, however. "That was a big kind of breakthrough moment for us in relation to this field," Cryan says.

What Happens In Vagus

The vagus nerve is like a superhighway between the gut and the brain. One of the 12 major nerves that directly connect the body to the brain, its name comes from the Latin for "wandering," because it links dozens of parts of the body to the medulla oblongata, a grape-sized bit of tissue in humans that's located at the base of the brain. With all its connections, the vagus nerve gives us a sense of how our bodies are doing. "Sometimes you just feel good; sometimes we feel crappy. That is your vagus nerve telling you what's going on," Cryan explains. When Cryan's lab fed *L. rhamnosus* JB-1 to laboratory mice in 2011, the animals produced less stress-induced corticosterone in their bodies and displayed fewer anxiety- and depression-related behaviours. Feeding the mice, the bacteria also changed the amount of a particular type of protein receptor produced in different parts of the brain. This receptor binds to the neurotransmitter γ -aminobutyric acid (GABA). The exact mechanism by which the gut microbiome interacts with the vagus nerve isn't known. But, Cryan says, the fact that these changes didn't happen in animals that had their vagus nerve cut is evidence that it is definitely involved in communicating between the gut microbiome and the brain. Other researchers have also noticed the vagus nerve's link between the gut and the brain. Around 2015, Mauro Costa-Mattioli and his colleagues at Baylor College of Medicine were investigating a link between a mother's diet and the development of autism in her children when they inadvertently stumbled into gut microbiome research. "Obesity is a big issue here in the US," Costa-Mattioli explains. "And there are epidemiological studies that actually

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showed that if the mom is obese, there is a higher possibility of the offspring developing autism." Costa-Mattioli's team fed female mice a high-fat diet to make them obese before they got pregnant and then examined the behaviour of their offspring after they were born. They found that mice from obese mothers displayed one of the symptoms of autism spectrum disorders—namely, problems with social interaction. Or at least they did initially. Once the animals were weaned, the control animals and the experimental mice were put in the same housing. Four weeks later, all the mice were interacting normally. "Of course, we scratched our brains for months trying to figure out what was going on," Costa-Mattioli recalls. Eventually, the researchers realized that the maternal diet induced a shift in the offspring's microbiome. But mice typically eat one another's poop. So, putting the two groups together in the same housing meant the mice ingested each other's microbiota, and the asocial mice became social. Sequencing the DNA of the bugs in the guts of the animals before and after mixing the groups pointed to this explanation. "To make a long story short, what we discovered is that the maternal diet eliminates a particular bacterium, *Lactobacillus reuteri*, in the offspring," Costa-Mattioli explains. Reintroducing the bacterium, either by intervention from the scientists or by the mice eating poop, reverses the social deficit. The scientists also found that the bacterium sends signals from the gut to the brain via the vagus nerve, increasing production of the hormone oxytocin, which promotes social bonding (Cell 2016, DOI: 10.1016/j.cell.2016.06.001).

Bugs As Drugs?

Of course, any discussion of how diet might influence the microbiome and thus alter mental health naturally leads to the idea of therapeutics. In 2013, Cryan coined the term psychobiotic to describe a medication containing live bacteria or their metabolic products that might confer a mental health benefit on humans. In fact, many argue that psychobiotics have been around for a long time and that physicians have already been using them without even realising it. Since the early 1900s, neurologists have known that putting children with epilepsy on a specific diet can reduce their seizures. This so-called ketogenic diet is low in carbohydrates and high in protein and fat. But scientists have never really understood how it works. Elaine Hsiao, a microbiologist at the University of California, Los Angeles, suspected that the answer might lie in the gut microbiome. In 2018, she showed that two particular types of gut bacteria thrive in mice feasting on a ketogenic diet (Cell 2018, DOI: 10.1016/j.cell.2018.04.027). Hsiao and her team think these bugs might be providing their hosts with building blocks for neurotransmitters such as GABA. In the brain, GABA

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acts like a sort of brake for brain cells, reducing the activity of neurons and keeping networks properly balanced. "This discovery has the potential to impact the many conditions that are associated with alterations in GABA and shown to be modified by the ketogenic diet," Hsiao says. She lists epilepsy, Alzheimer's disease, Parkinson's disease, autism, anxiety, and schizophrenia as potential conditions to target. To test whether the ketogenic diet could benefit people with these other conditions and bring treatments to the market, Hsiao started a company, Bloom Science. Across town at the California Institute of Technology, scientists have started up another firm, Axial Biotherapeutics, that hopes to develop psychobiotics too. In 2016, microbiologist Sarkis K. Mazmanian and colleagues pinpointed short-chain fatty acid signalling as mediating some of the gut's effects on the brain (Cell 2016, DOI: 10.1016/j.cell.2016.11.018). Using mouse models of Parkinson's disease, the researchers found that giving the mice microbes taken from the guts of people with Parkinson's made the animals' symptoms worse. The same happened if the mice were given short-chain fatty acid metabolites from the bugs.

From Mice To Humans

But not everyone is convinced that scientists should even be discussing treatments at this stage. Katarzyna B. Hooks, a computational biologist at the University of Bordeaux, believes that a lot of the claims linking the gut and the brain overreach. Although she sees the field as having promise, Hooks thinks it's too soon to expect a magic bullet treatment. Hooks recently co-authored a critique of the field (Behav. Brain Sci. 2018, DOI: 10.1017/S0140525X18002133). In the review article, Hooks, Bordeaux neuroscientist Jan-Pieter Kopsman, and Maureen A. O'Malley, who studies the philosophy of microbiology at the University of Sydney, argue that links between the gut microbiome and the brain have been accepted without enough investigation and scepticism. "It would be fair to say that we are simply sceptical about the idea of psychobiotics," Hooks says of herself and her co-authors. "The relationship between gut microbial metabolism and mental health is a controversial topic in microbiome research," says Jeroen Raes of KU Leuven. "Gut microbiome-brain communication has mostly been explored in animal models, with human research lagging behind." And anyone paying attention to the field of brain science knows that observations in mice aren't always reproduced in humans. With the rise of DNA sequencing, however, researchers like Raes can now begin to focus on humans. In February, Raes's group announced that, via sequencing, it had identified specific groups of microorganisms that positively or negatively correlate with mental health in humans

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(Nat. Microbiol. 2019, DOI: 10.1038/s41564-018-0337-x). Using samples from more than 1,000 participants in the Flemish Gut Flora Project, the authors found that two bacterial genera, Coprococcus and Dialister, were consistently depleted in individuals with depression. While studying Coprococcus and Dialister, the team noticed these bacteria harbor genes coding for butyrate, a short-chain fatty acid that is known to have antidepressive properties. But as Bordeaux's Konsman points out, Raes's work does not demonstrate how butyrate-producing bacteria in the gut might influence depression. Just because those bacteria have genes coding for butyrate doesn't mean the genes are being expressed and butyrate is being produced, he says. And even if it is produced, the fatty acid or its metabolites would need to cross both the gut barrier and the brain barrier to affect brain processes directly. What Raes's paper does show, Konsman and Hooks say, is a correlation between the population of the gut microbiome and depression. "It's correlation," which isn't certainty, Cryan says, "but it's a really good start." Cryan agrees with critics who argue that more human research is needed to firmly establish a gut-brain connection, but he is also firm in his belief that animal models still have a role to play. "We're really at the beginning of figuring all of this out. And it's easier to do that in mice where we control the diet and we control the repertoire of chemicals that are present," he says. Studies become much more complex when you move to humans, Cryan adds, "and I think that's where we're going to see a lot of the hurdles, in interindividual differences." Mouse populations in the lab can be rather homogeneous, but human populations are anything but. It's incredibly appealing to think that adjustments to diet or your gut microbiome could help treat neurological disease. That may be why the field has attracted so much public attention. But researchers urge caution. "The main thing is that we have to be careful of the hype," Cryan says. Some companies, he says, will use studies such as the ones discussed in this article, without an understanding of the mechanisms connecting gut and brain and without clinical trials, to sell their probiotic supplements for treating diseases such as depression. "There's a lot of snake oil" surrounding the field, he says. "We have to be really careful about that." For his part, Costa-Mattioli stresses that he is working on basic science rather than immediately thinking about drugs and therapeutics. For instance, he doesn't think the parents of autistic children should buy over-the-counter probiotics, believing they will be a solution. But perhaps one day, he suggests, treatments might have a microbial component. "I always tell my students, 'Don't oversell the stories, but, yes, be enthusiastic when you can be because this is amazing.' I could never imagine in my wildest dreams that a bacteria would be able to make animals more social." He says he always welcomes his critics to present him

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with an alternative scenario or explanation for his findings. "I think that what we need is more time," he says. "And time will tell."

Chemical & Engineering News, 8 April 2019

<http://pubs.acs.org/cen/news>

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