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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 and biological exposure indices information

2022-10-27

You can now find workplace exposure standards (WES) and biological exposure indices (BEI) information by using the new substance search tool on our website.

Digitising the WES and BEI special guide provides easier access to this critical information for health and safety professionals and businesses who need it for assessing health risks in the workplace.

[Read More](#)

New Zealand Worksafe, 27-10-22

<https://www.worksafe.govt.nz/topic-and-industry/monitoring/workplace-exposure-standards-and-biological-exposure-indices/>

Approved safe work instruments for the fumigant ethanedinitrile (EDN)

2022-10-27

The Minister for Workplace Relations and Safety, Michael Wood, has approved two safe work instruments setting requirements under the Health and Safety at Work Act 2015 (HSWA) for work with the fumigant ethanedinitrile (EDN).

EDN is a potential replacement for many current uses of methyl bromide and has been approved as a fumigant for export logs and timber.

These safe work instruments are the first to set prescribed exposure standards and health monitoring requirements for a hazardous substance under the HSWA.

[Read More](#)

New Zealand Worksafe, 27-10-22

<https://www.worksafe.govt.nz/laws-and-regulations/safe-work-instruments/hazardous-substances/>

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Call for information on fluazinam

2022-10-27

We are seeking information on how fluazinam is used in Aotearoa New Zealand.

Fluazinam is an active ingredient commonly used to control fungal diseases in grapes, potatoes, vegetable brassicas, field tomatoes, and onions.

We established grounds for reassessment on 7 December 2021 based on significant new information about the effects of the substance. Fluazinam is currently going through a renewal process in the European Union.

This is an opportunity for all interested parties and stakeholders to provide us with information on how fluazinam products are manufactured, imported, sold, and applied. We also want to know the risks, benefits, and effects on human health and the environment that come from fluazinam products.

We want to hear from growers, agriculture workers, iwi/hapū representatives, suppliers, manufacturers, researchers, councils, members of the public, and anyone else who wants to participate.

The submission period closes on Monday 14 November 2022 at 11.59 pm.

Commonly named products containing fluazinam

- Agpro Fluazinam 500
- Apex
- Curalan
- Flick 500 SC Fungicide
- Florid
- Gem fungicide
- Nando
- Nexigro
- Nexus
- Ohayo 500 SC
- Pinnacle
- Preguard

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[Read More](#)

New Zealand EPA, 27-10-22

<https://www.epa.govt.nz/public-consultations/open-consultations/call-for-information-on-fluazinam/>

Reassessment of diazinon, fenamiphos and methamidophos

2022-10-11

The decision has been made on the modified reassessment of diazinon, fenamiphos, and methamidophos, and the decision is published.

The decision-making committee has revised the expiry of the time-limited approvals for the organophosphate pesticides methamidophos and fenamiphos, and declined the application to extend the approval timeframes for diazinon:

- approvals for substances containing fenamiphos or methamidophos expire: 1 July 2024
- the existing expiry date for diazinon approvals remains in place: 1 July 2028.

After the expiry date, these substances will no longer be able to be imported or manufactured in New Zealand.

The committee has recognised the importance of fenamiphos in biosecurity use. They consider that this use pattern presents lower risks than wide dispersal plant protection use patterns which they consider have higher risks compared to methamidophos plant protection products. Therefore, the committee decided to limit the use of fenamiphos during the extension period to biosecurity uses only. From 1 July 2023 the use of fenamiphos will only be permitted for biosecurity purposes in accordance with the Biosecurity Act 1993.

The decision considers protecting human health and the environment from the risks of ongoing use of diazinon, fenamiphos, or methamidophos. It also acknowledges the concerns from Māori and the wider public regarding the health and environmental effects of these substances, as well as the benefits provided by the use of these substances including the availability of alternative substances to replace them when the approvals expire.

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[Read More](#)

New Zealand EPA, 11-10-22

<https://www.epa.govt.nz/public-consultations/decided/diazinon-fenamiphos-and-methamidophos/>

Change to lead risk notifications

2022-10-17

The way to notify SafeWork SA of lead exposure has changed following the introduction of an electronic reporting system.

Businesses must notify SafeWork SA of any lead risk work within 7 days of the risk determination or if a determination is unable to be made.

This applies even if the work is short-term, such as abrasive blasting of lead paint from a structure.

The Work Health and Safety (Blood Lead Removal Levels) Variation Regulations 2019 reduced the notification levels of the allowable blood lead levels in workplaces and were agreed nationally.

Lead risk work is work that is likely to cause a worker's blood lead level to exceed:

- 5µg/dL (0.24µmol/L) for a female of reproductive capacity, or
- 20µg/dL (0.97µmol/L) for other cases.

There are two regulatory notifications to SafeWork SA in relation to Lead Risk Work:

1. Notification of Lead Risk Work
2. Notification of Removal of a Worker from Lead Risk Work.

Previously, both notifications were made via email submission of the relevant completed PDF form.

From 17 October 2022, the PDF notification forms will no longer be available on the SafeWork SA website and notification requirements will be made via submission of a completed electronic form, directly through the SafeWork SA website.

The single iApply form aims to streamline and make the notification process more user friendly, whilst reducing the number of incomplete or inappropriate notifications.

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Regulatory Update

NOV. 11, 2022

In 2021-22 SafeWork SA received 24 notifications of lead risk work and 43 notifications of removal of workers from lead risk work.

[Read More](#)

SafeWork SA, 17-10-22

<https://www.safework.sa.gov.au/news-and-alerts/news/news/2022/change-to-lead-risk-notifications>

Amendments to the HSNO Act

2022-11-04

The HSNO (Hazardous Substances Assessments) Amendment Bill, which has passed its final reading, will improve the process for assessing hazardous substances and make it more transparent.

Process changes from HSNO Amendment Bill

The package of amendments included in the Bill significantly improves our assessment processes, creating a safe new rapid pathway for approvals that draws on information from trusted international sources.

Introducing new substances that are safer and more environmentally friendly will be quicker and easier, while still being subject to comprehensive risk assessments.

Reassessments to change hazard classifications and controls for existing hazardous substances can be completed faster via a simplified process to align with a trusted international regulator.

During reassessments, we can also put in place additional rules for specific uses of a substance if there are significant concerns about the impacts on people and the environment.

Hazardous Substances and New Organisms (Hazardous Substances Assessments) Amendment Bill - NZ Legislation website

Using information from international regulators

Two new pathways for assessing new substances have been created:

We can approve a new substance via a rapid pathway if the same use has been approved by a trusted international regulator, unless it will have significant cultural, environmental and human health effects.

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NOV. 11, 2022

We can amend a hazard classification or control of an existing substance via a simplified modified reassessment to align with a trusted international regulator.

Criteria for selecting appropriate international regulators are included in the Bill, and we will develop a list of these regulators with input from a public consultation process.

[Read More](#)

EPA New Zealand, 04-11-22

<https://www.epa.govt.nz/industry-areas/hazardous-substances/hsno-amendment-bill/>

AMERICA

Bipartisan Bill Would Amend FIFRA To Provide Nine Months For Farmers To Adapt To Any New Restrictions On Pesticides

2022-10-21

On September 29, 2022, Representatives Jim Baird (R-IN) and Cindy Axne (D-IA) introduced the Farmers Deserve Notification Act (H.R. 9035). According to Baird's September 29, 2022, press release, the bill would prevent EPA from canceling, suspending, or enacting new restrictions on pesticides without first providing a 270-day advance notice in the Federal Register. If new data or science demand restrictions go into effect sooner, the 270-day requirement could be waived by a majority vote of the "independent FIFRA Scientific Advisory Panel."

[Read More](#)

JDSupra, 21-10-22

<https://www.jdsupra.com/legalnews/wrap-up-of-federal-and-state-chemical-8193947/>

Lawmakers and Public Health Advocates Call for Congress to Finally Ban Asbestos

2022-10-27

Days after ProPublica detailed dangerous working conditions at a chlorine plant that used asbestos until it closed last year, public health advocates

A law blocking the use of asbestos, a potent carcinogen, would be harder to overturn than a similar ban being considered by the EPA, advocates say.

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and two U.S. lawmakers are renewing calls for Congress to ban the carcinogen.

“American workers are dying from asbestos. It is way past time to end its use,” said Sen. Jeff Merkley, a Democrat from Oregon. “This ProPublica report confirms our worst fears: workers dealing with asbestos are often left vulnerable to this deadly, dangerous substance.”

Merkley and Rep. Suzanne Bonamici, D-Ore., are sponsoring the Alan Reinstein Ban Asbestos Now Act, which would permanently ban the importing and use of asbestos. The proposed legislation is named after Alan Reinstein, who died in 2006 from mesothelioma, a cancer caused by asbestos. Alan’s wife, Linda, co-founded the Asbestos Disease Awareness Organization, one of the leading nonprofits that has advocated for protecting the public from the dangers of asbestos.

Read More

ProPublica, 27-10-22

<https://www.propublica.org/article/asbestos-poisoning-ban-lawmakers-advocates-congress>

White House unveils cyber plan for chemical sector

2022-10-26

The White House announced on Wednesday its plan to expand its public-private cybersecurity partnership to include the chemical sector.

The Chemical Action Plan will push for higher cybersecurity standards across the sector, including improving visibility and threat detection for industrial control systems.

The plan will also guide the sector in assessing current cybersecurity standards over the next 100 days.

Under the plan, industry leaders will focus on securing high-risk chemical facilities from cyberattacks. The proposal also encourages information sharing between the government and the private sector as well as collaboration with sector owners and operators.

The new strategy will also support the continuation of chemical productions that are critical to the national and economic security of the country.

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Regulatory Update

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The announcement is the latest action from the Biden administration to secure critical sectors from cyber threats by strengthening cybersecurity standards.

Read More

The Hill, 26-10-22

<https://thehill.com/homenews/administration/3705395-white-house-unveils-cyber-plan-for-chemical-sector/>

Drinking Water Case Proceeds to Probe Fluoride Data, Court Says

2022-11-01

A federal court will allow a lawsuit to prohibit fluoride from drinking water to proceed to review new scientific evidence about the chemical’s potential to harm babies’ developing nervous systems.

Judge Edward M. Chen of the US District Court Northern District of California ruled on Friday that the case—filed in 2017 by Food & Water Watch and other advocacy groups—can proceed to review a scientific study and two summary evaluations of multiple fluoride health effects studies. The case has been on hold since April 2021.

The science the court wants to review includes a May 2022 unpublished, draft version of a federal health agency’s assessment of fluoride’s neurodevelopmental and other health effects. The court will obtain the National Toxicology Program’s draft health assessment via a protective order and not disseminate it “at this juncture,” Chen ruled.

The court will decide the timing of future expert disclosures and other actions after it’s reviewed the scientific evidence, he said.

The court’s desire to view the new science doesn’t indicate a conclusion about “the admissibility or weight of the evidence,” Chen said.

Diverse Groups Tracking

The lawsuit is being tracked by dental and other medical professionals that believe fluoride helps prevent cavities, as well as chemical law experts, and environmental health groups concerned about fluoride’s health effects. The case involves chemical legislation and challenges the 77-year old tradition of adding fluoride to drinking water as a public health measure.

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Regulatory Update

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The case was unique when filed, as it was the first to challenge the Environmental Protection Agency's dismissal of a citizen's petition authorized by the Toxic Substances Control Act (TSCA).

[Read More](#)

Bloomberg Law, 1-11-22

<https://news.bloomberglaw.com/environment-and-energy/drinking-water-case-proceeds-to-probe-fluoride-data-court-says>

Antibiotic resistance linked to these household products: University of Toronto

2022-11-01

The study, by Assistant Professor Hui Peng's research group in the department of chemistry in the Faculty of Arts & Science, was able to show that triclosan – a chemical often included in household items like hand soaps, toothpastes, and cleaning products to fight off bacteria – is the predominant antibiotic in Ontario sewage sludge.

The findings were published in the journal Environmental Science & Technology.

"Since there are so many different antibiotics in the sewage sludge, we were surprised to find that the majority of antibacterial activity of the sludge could be directly linked to triclosan alone," says Holly Barrett, a PhD candidate in the Peng group and lead author on the study.

The research was performed by investigating sewage sludge from Ontario's sewage treatment plants (STPs). As the study notes, STPs are a breeding ground for antibiotic resistant bacteria due to the diverse set of antibiotics that are found there. That's because after we rinse our household products down the drain, the antibiotic ingredients in those products are transported to STPs where they accumulate.

Among thousands of co-occurring chemicals in the sludge, triclosan was found to be the predominant antibacterial compound impacting E. coli.

Barrett notes in the study that antibiotic resistance is a growing concern. Antibiotic-resistant bacteria – also commonly known as "superbugs" – are strains of bacteria that are not killed by antibiotics. They are produced when continuous exposure to antibiotics causes bacteria to evolve over several generations to survive antibiotic effects. These bacteria can be very dangerous to humans, especially those with impaired immune systems.

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Regulatory Update

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Between 2014 and 2016, there were 700,000 deaths around the world attributed to antibiotic resistance.

[Read More](#)

EurekaAlert, 1-11-22

<https://www.eurekaalert.org/news-releases/969707>

EUROPE

EU/UK Regulatory Update: CMRs, NAMs to Replace Animal Tests and More

2022-10-26

Substances classed as carcinogenic, mutagenic or toxic to reproduction (CMR) are officially identified via the Classification, Labeling and Packaging (CLP) regulation; EU and Great Britain (GB) CLP Regulations were detailed in the September 2022 column. It is important to remember that CMR classifications are hazard classifications and do not consider the potency or strength of the substance or the exposure to it.

CMR substances are classified in the following categories under the CLP Regulations:

- 1A: Known to be CMR based on studies in humans;
- 1B: Presumed to be CMR based on animal studies; or
- 2: Suspected to be CMR based on limited evidence from animal or human studies.

Article 15 of both the EU Cosmetic Products Regulation (CPR) and the UK Cosmetics Regulation (UKCR) prohibits the use of CMR substances classified as 1A, 1B or 2 under Annex VI to the CLP regulations in cosmetic products, unless a specific exemption is granted. Article 15 applies only to harmonized classifications; self-classifications are not included in the EU and UK cosmetics regulations prohibition of CMRs.

Exemption conditions for CMR category 1A and 1B substances, are:

- Compliance with the food safety requirements;
- If there are no suitable alternative substances available;
- If the application is made for a particular use of the product category with a known exposure; or

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- If the substance has been evaluated and found to be safe for use in cosmetic products;

The exemption condition for CMR category 2 substances is:

- The substance has been evaluated and found to be safe for use in cosmetic products.

EU CMR Omnibus Regulation

In October 2010, the European Commission shared a working document with member states and industry stating that CMR substances classified by the EU CLP regulation would automatically become banned in cosmetics without the need for specific listing in Annex II of the CPR. This interpretation took effect on Dec. 1, 2010. The industry challenged this interpretation and in September 2016, the European Commission (EC) agreed that the risk management process will apply to CMR substances, so that annexes to the CPR must be updated following a classification in the EU CLP regulation.

Read More

Cosmetics & Toiletries, 26-10-22

<https://www.cosmeticsandtoiletries.com/magazine/article/22512508/cosmetics-toiletries-magazine-euuk-regulatory-update-cmrs-nams-to-replace-animal-tests-and-more>

Germany's wounded chemical industry causes concern in Berlin

2022-11-03

The chemical industry is tightly woven into Germany's industrial fabric, beginning with the invention of synthetic dyes in the late 1800s. Today, chemical products make up 10% of Germany's exports and the country is home to the world's largest chemicals company, BASF.

But while industries like steel, aluminium, and paper have so far been able to weather the energy crisis, the chemical sector has taken a bad hit.

Output in the chemical industry, which is embedded in many industrial processes ranging from fertilisers to plastics, decreased sharply in 2022. A November survey by the German chamber of industry and commerce found that more than 25% of chemical industry companies had scaled back production.

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The final straw came at the end of October when BASF announced it would "permanently" scale back its operations in Europe, citing rising energy costs and concerns over regulation.

For Germany's political leaders, the announcement came as a shock.

"Industry is part of the culture and the way we live in Germany," said Chancellor Olaf Scholz while on a visit to a BASF plant on 1 November.

The same day, Vice-Chancellor Robert Habeck was on a visit to the Wacker chemical plant in Saxony, which manufactures polysilicon used in solar panels. Until the energy crisis is fixed, "the state must ensure that the economic substance holds out," Habeck promised.

The chemical sector is particularly exposed to rising energy prices.

"The costs of electricity, oil and gas account for around 12% of production costs in the chemical industry," a proportion that rises to "more than 70%" for chemicals such as ammonia or chlorine, explains Wolfgang Große Entrup, CEO of the German chemical industry association VCI.

And over the last two years, "energy costs have more than quadrupled," he told EURACTIV.

Big chemical groups like BASF have so far been largely shielded from rising energy prices. Large companies, which have dedicated energy trading desks, can hedge their costs thanks to long-term purchasing strategies.

Wacker, for instance, still receives 50% of its energy through lower-price long-term contracts at its production site in Saxony.

Read More

Euractiv, 03-11-2022

<https://www.euractiv.com/section/economy-jobs/news/germanys-wounded-chemical-industry-causes-concern-in-berlin/>

The deteriorating state of Germany's chemical industry is causing concern at the highest political level, as the German government readies its €200 billion aid package for households and businesses.

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REACH Update

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Humane Society International calls for 'essential revisions' to EU REACH regulation

2022-10-26

Animal welfare charity Humane Society International has published a white paper outlining a proposal to revise the EU chemicals regulation REACH, aiming to modernise the framework and drive uptake of non-animal testing methods.

Published in Regulatory Toxicology and Pharmacology, the white paper outlined Humane Society International's proposal on how the EU's chemicals regulation REACH could be modernised to accelerate wider use of new approach methodologies (NAMs) and push ahead with a truly animal-free cosmetics testing future.

Animal testing on cosmetic products and ingredients had been banned in the EU since 2013 under the EU Cosmetics Regulation 1223/2009, following initial bans on testing for finished products in 2004 and ingredients in 2009. However, the European Chemicals Agency's (ECHA) REACH Regulation 1907/2006 still sometimes required animal data – particularly in instances like environmental impact and worker safety.

Since the EU ban, new approach methodologies (NAMs) had fast advanced in the field of cosmetics safety assessment and industry was now determined to push for wider acceptance of these methods under REACH, across all end points tested for safety or risk.

Writing in its white paper, Humane Society International said the adoption of the Chemicals Strategy for Sustainability (CSS) in 2020 that aimed to improve the quality, efficiency and speed of chemical hazard and risk assessments – part of the wider European Green Deal – offered the EU a "golden opportunity to accelerate a transition to animal-free safety".

Moving beyond a 'tick-box' approach

The authors said that whilst REACH had been created to protect human health and the environment with a central aim of doing so via alternatives to animal testing, it had "instead become a long 'tick-box' list of in vivo experiments" with questionable relevance to human health outcomes. And this was despite a clear global trend towards new approach methodologies (NAMs) in chemical safety assessment, they said.

As the EU looked to revise its chemicals regulation in light of the Chemicals Strategy for Sustainability (CSS), the authors said proposals presented so far had "significant negative animal welfare consequences",

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REACH Update

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hence the move by the Humane Society International to issue its own proposal.

"There is still time to correct the course of the ongoing REACH revision," the animal welfare charity said.

Humane Society International's proposal was split into three action areas: procedural, technical and structural.

Read More

Cosmetics Design Europe, 26-10-22

<https://www.cosmeticsdesign-europe.com/Article/2022/10/26/Humane-Society-International-REACH-revision-proposal-calls-for-ECHA-procedural-technical-and-structural-change>

Guidance for safe and sustainable chemicals and materials published

2022-10-26

Today the European Commission published a Strategic Research and Innovation Plan (SRIP) to accelerate the shift to safe and sustainable chemicals and materials. In order to boost the protection of people and the planet against hazardous substances, the SRIP highlights crucial research and innovation needs for this transition and guides funders in their investments.

In addition to listing the research and innovation needs for the whole life cycle of such chemicals and materials, SRIP also provides guidance on how to make the most of such R&I activities. The aim is to encourage and guide funders in EU, national and private financial programmes. It reflects the priorities of authorities, scientists and companies alike.

Mariya Gabriel Commissioner for Innovation, Research, Culture, Education and Youth, said:

"Protecting people and the planet calls for a strategic approach. We can harness a big economic opportunity by focusing on safe and sustainable chemicals and materials. European industry can gain a competitive advantage and win consumers' confidence by investing in such innovative solutions."

The Commission will refer to the SRIP in the upcoming Horizon Europe work programme 2023-2024 expected to be adopted before the end of

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the year, as an overarching strategy. In order to maximize SRIP's impact the Commission sets out a monitoring scheme for its implementation.

The zero-pollution ambition for a toxic-free environment is one of the four interlinked policy goals of the European Green Deal Underlining the role of research and innovation the Commission recently published a report on how Horizon 2020 project results help us to preserve biodiversity, while keeping land, water and air clean.

Read More

European Commission, 26-10-22

https://research-and-innovation.ec.europa.eu/news/all-research-and-innovation-news/guidance-safe-and-sustainable-chemicals-and-materials-published-2022-10-26_en

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Janet's Corner

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Biology

2022-11-11



Biologists are weird.

<https://www.smbc-comics.com/comic/biology>

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Hazard Alert

NOV. 11, 2022

Acrylamide

2022-11-11

Acrylamide (or acrylic amide) is a chemical compound with the chemical formula C_3H_5NO . Its IUPAC name is prop-2-enamide. It is a white odourless crystalline solid, soluble in water, ethanol, ether, and chloroform. Acrylamide can react violently when melting and when it is heated, acrid fumes may be released. It is incompatible with acids, bases, oxidising agents, iron, and iron salts. It decomposes non-thermally to form ammonia, and thermal decomposition produces carbon monoxide, carbon dioxide, and oxides of nitrogen. [1,2]

USES [1]

Acrylamide is prepared on an industrial scale by the hydrolysis of acrylonitrile by nitrile hydratase. Most acrylamide is used to synthesise polyacrylamides, which find many uses as water-soluble thickeners. These include use in wastewater treatment, gel electrophoresis (SDS-PAGE), papermaking, ore processing, and the manufacture of permanent press fabrics. Some acrylamide is used in the manufacture of dyes and the manufacture of other monomers. In addition, acrylamide has many other uses in molecular biology laboratories, including the use of linear polyacrylamide (LPA) as a carrier, which aids in the precipitation of small amounts of DNA. The majority of acrylamide is used to manufacture various polymers. These are used as binding, thickening or flocculating agents in grout, cement, sewage/wastewater treatment, pesticide formulations, cosmetics, sugar manufacturing, soil erosion prevention, ore processing, food packaging and plastic products. Polyacrylamide is also used in some potting soil.

SOURCES & ROUTES OF EXPOSURES [2]

Sources of Exposure

The primary source of exposure for the general population is ingestion of contaminated food. Acrylamide is formed in foods that are rich in carbohydrates when they are fried, grilled or baked. Starchy foods such as potato-based products typically contain the highest levels of acrylamide, whereas protein-based foods contain smaller amounts. Exposure can also occur in places near plastic and dye plants and drinking water may contain acrylamide. Furthermore, exposure may occur through inhalation of tobacco smoke (including second-hand smoke). Occupational exposure may occur in people involved in the production or use of acrylamide and

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acrylamide-containing products. Exposure may also occur in laboratories utilising polyacrylamide gels.

Routes of Exposure

The main routes of exposure to acrylamide are via inhalation, dermal adsorption and ingestion. When inhaled, acrylamide is readily and rapidly absorbed following inhalation and oral exposure, and somewhat less rapidly following dermal exposure. Once absorbed, acrylamide is widely distributed throughout the body. Acrylamide is rapidly metabolised; glycidamide is the principle toxicologically significant metabolite. It is then excreted from the body as metabolites in the urine.

HEALTH EFFECTS [3]

Acute Effects

Central and peripheral nervous system damage, with effects such as drowsiness and hallucinations, has been observed in humans acutely exposed to acrylamide through inhalation exposure. Acrylamide (when occurring as a monomer) is a potent neurotoxicant at low levels. Acute oral exposure to acrylamide has resulted in neurotoxic effects in rats and effects on the kidney in monkeys exposed by injection.

Chronic Effects

Chronic oral exposure to acrylamide has been observed to produce nerve damage, with effects such as numbness and weakness in the hands and legs, in humans and animals. Chronic dermal exposure may result in an exfoliative, reddish rash in humans. EPA has not established a Reference Concentration (RfC) for acrylamide. The Reference Dose (RfD) for acrylamide is 0.0002 milligrams per kilogram body weight per day (mg/kg/d) based on nerve damage in rats.

Reproductive/Developmental Effects

No information is available on the reproductive or developmental effects of acrylamide in humans. In one animal study, decreases in body weight and body weight gain and an increase in preimplantation loss were observed in rats orally exposed to acrylamide. In mice orally exposed to acrylamide, decreased sperm counts were reported.

Acrylamide (or acrylic amide) is a chemical compound with the chemical formula C_3H_5NO .

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Cancer Risk

Two studies have been carried out examining worker exposure to acrylamide and cancer mortality. EPA considers both of these studies to be inadequate to determine cancer risk due to the small populations studied and incomplete exposure data. In rats orally exposed to acrylamide, significantly increased incidences of tumours at multiple sites have been observed. These include mammary tumours, central nervous system tumours, thyroid follicular tumours, and uterine adenocarcinoma in female rats and thyroid follicular tumours and scrotal mesothelioma in males. EPA has classified acrylamide as a Group B2, probable human carcinogen.

SAFETY [4]

First Aid Measures

- **Eye Contact:** Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Cold water may be used. Get medical attention.
- **Skin Contact:** In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Cover the irritated skin with an emollient. Cold water may be used. Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention immediately.
- **Serious Skin Contact:** Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek immediate medical attention.
- **Inhalation:** If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.
- **Serious Inhalation:** Evacuate the victim to a safe area as soon as possible. Loosen tight clothing such as a collar, tie, belt or waistband. If breathing is difficult, administer oxygen. If the victim is not breathing, perform mouth-to-mouth resuscitation. Seek medical attention.
- **Ingestion:** If swallowed, do not induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention immediately.

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Exposure Controls & Personal Protection

Engineering Controls

Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protection

- Splash goggles;
- Lab coat;
- Dust respirator (be sure to use an approved/certified respirator or equivalent);
- Gloves.

Personal Protection in Case of a Large Spill

- Splash goggles;
- Full suit;
- Dust respirator;
- Boots;
- Gloves;
- A self contained breathing apparatus should be used to avoid inhalation of the product.

Note: Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

REGULATION [4,5,6]

United States

OSHA: The United States Occupational Safety & Health Administration has set the following Permissible Exposure Limit (PEL) for acrylamides:

- General Industry: 29 CFR 1910.1000 Z-1 Table -- 0.3 mg/m³ TWA; Skin
- Maritime: 29 CFR 1915.1000 Table Z-Shipyards -- 0.3 mg/m³ TWA; Skin

ACGIH: The American Conference of Governmental Industrial Hygienists has set a Threshold Limit Value (TLV) for acrylamide of 0.03 mg/m³ TWA; Skin; Appendix A3 (Confirmed Animal Carcinogen with Unknown Relevance to Humans)

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NIOSH: The National Institute for Occupational Safety and Health has set a Recommended Exposure Limit (REL) for acrylamide of 0.03 mg/m³ TWA; Skin; Appendix A - Potential Occupational Carcinogen

Australia

Safe Work Australia: Safe Work Australia has set an 8-hour Time Average (TWA) exposure limit for acrylamide of 0.03 (mg/m³).

Europe

TWA: 0.3 (mg/m³) [United Kingdom (UK)] Inhalation

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4. <http://www.sciencelab.com/msds.php?msdsId=9927422>
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Fighting 'dicamba drift' can add amines to the air

2022-10-31

"Dicamba drift" can result in unintentional damage to neighboring plants. To prevent dicamba drift, other chemicals, typically amines, are mixed with dicamba to "lock" it in place and prevent it from volatilizing, or turning into a vapor that more easily moves in the atmosphere.

New research from the lab of Kimberly Parker, an assistant professor of energy, environmental, and chemical engineering at Washington University in St. Louis' McKelvey School of Engineering, demonstrates that these amines themselves volatilize, often more than dicamba itself.

Their findings appear in the journal *Environmental Science and Technology*.

The volatilization of amines when applied with dicamba may help explain the processes that cause dicamba drift. However, amines are used in other herbicides as well, including as glyphosate, the most-used herbicide in the world. Regardless of the herbicide, the researchers found that amines still volatilized.

If amines, themselves, are released into the atmosphere, they can have a negative impact on human health as they can form cancer-promoting substances. They also affect the climate and atmospheric chemistry. Because of their potential danger and prevalence, the scientific literature is full of research looking at the ways they are released into the atmosphere—except when it comes to their use in herbicide-amine formulations.

"Amines also undergo reactions to form particulate matter—tiny particles that can make their way into the body when inhaled," Parker says. "Those particles are also toxic and carcinogenic," and they carry consequences for atmospheric chemistry by affecting climate.

"Researchers have looked at industrial applications, animal operations, and environmental sources of amines, but no one has looked at herbicides at all, as far as we have seen, despite the fact that large quantities of herbicide-amine mixtures are being sprayed onto crops across the country," Parker says.

"We were really surprised to see that this source had been overlooked."

Her lab has done research into the use of amines with herbicides in agriculture. In those scenarios, the amines were added to stop the

An effort to contain "dicamba drift," the movement of the herbicide off crops through the atmosphere—can backfire, research shows.

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herbicide dicamba from volatilizing. The technique often was ineffective, however, and the dicamba wound up drifting to nearby crops.

First author Stephen Sharkey, a PhD student in Parker's lab, led that earlier research studying dicamba volatilization from dicamba-amine mixtures and wondered, "If the dicamba is volatilizing, what's happening to the amine that's supposed to be there stopping the volatilization process?"

To find out, Sharkey measured the change in the amount of amines present over time when mixed with different herbicides. The results? In all mixtures, the amines volatilized from the herbicide-amine mixtures. Sharkey also worked with the lab of Brent Williams, an associate professor of energy, environmental, and chemical engineering, to confirm that the amines were entering the gas phase from herbicide-amine mixtures by capturing amines from the air to measure.

In agricultural settings, Parker points out, amines are not only mixed with dicamba, but also with other herbicides, including 2,4-D and the widely used glyphosate.

In addition to experimentation, Sharkey also quantified the amount of amines that were actually entering the atmosphere, which required a bit of detective work. He used two separate data sets—estimated rates of herbicide applications and survey data from US farmers that showed which specific amines were used with different herbicides.

Sharkey concludes that herbicide use is responsible for the release of about 4 gigagrams (4,000 metric tons) of amines annually in the United States.

The findings came somewhat as a surprise to Parker, not only because the chemistry doesn't immediately suggest that amines volatilize in this way, but also for a more practical reason.

"There has been extensive work looking at the different ways in which amines enter the atmosphere," she says. "There has been a lot of effort put into understanding where amines come from, but research into its use with herbicides just wasn't considered before."

Support for the research came from the National Science Foundation and ACS-Petroleum Research Fund.

Futurity, 31 October 2022

<https://futura.orgt>

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Study finds blue whales eat some 10 million microplastic particles a day

2022-11-01

We know that marine animals of all sizes are inadvertently consuming plastics as they move through the ocean, but what does this diet look like for the largest of them all? To answer this question, scientists at Stanford University have analyzed the foraging habits of whales off the coast of California and found that blue whales take in an estimated 10 million pieces of plastic each day.

The study is a continuation of field research carried out by biologists and ocean scientists at Stanford that amounts to more than a decade of data on whales and their feeding habits. This involves drone observations, non-invasive tags and the use of small research vessels and sound waves to map dense gatherings of fish and krill in the whales' feeding areas.

For the first time, the researchers have now combined this information with measurements on microplastic concentrations in the water column off the coast of California. The new analysis showed that the whales do the majority of their feeding 50 to 250 m (164 to 820 ft) below the surface, where the highest concentrations of microplastics can be found in the open ocean.

But rather than slurping up the microplastics with seawater as they open their mouths and lunge after swarms of krill and fish, the scientists found the whales are consuming the fragments as they eat the prey itself. For blue whales, the largest creature on the planet with a diet heavy on krill, this means it is ingesting an estimated 10 million tiny pieces of plastic a day.

"They're lower on the food chain than you might expect by their massive size, which puts them closer to where the plastic is in the water," said study co-author Matthew Savoca. "There's only one link: The krill eat the plastic, and then the whale eats the krill."

As part of their analysis, the team also looked at the impacts on humpback whales, which feed primarily on herring and anchovies and were found to ingest an estimated 200,000 microplastic pieces a day. Fin whales, meanwhile, eat both krill and fish and are ingesting an estimated three to 10 million microplastic pieces a day. That the plastics are being consumed with the prey is a concern for the scientists, who are troubled by the unknown repercussions for the animals' nutrition.

The study is a continuation of field research carried out by biologists and ocean scientists at Stanford that amounts to more than a decade of data on whales and their feeding habits.

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“We need more research to understand whether krill that consume microplastics grow less oil rich, and whether fish may be less meaty, less fatty, all due to having eaten microplastics that gives them the idea that they’re full,” said lead author Shirel Kahane-Rapport. “If patches are dense with prey but not nutritious, that is a waste of their time, because they’ve eaten something that is essentially garbage. It’s like training for a marathon and eating only jelly beans.”

Learning more about the nutritional impacts of this microplastic pollution is among the next steps for the researchers, along with efforts to better understand the oceanic forces that lead to its accumulation in dense patches amid the whales’ prey.

“Understanding more about the basic biology of baleen whales and whale ecosystems through the use of new technologies like drones, biologging tags, and echosounders enable us to perform important translational research in sustainability and beyond,” said senior study author Jeremy Goldbogen.

The research was published in the journal Nature Communications.

New Atlas, 1 November 2022

<https://newatlas.com>

New Study Links Dementia to Metabolism

2022-11-02

Every three seconds, someone in the world is diagnosed with dementia. Even though dementia has no known cure, changes in the brain might take place years before dementia is identified.

Now, groundbreaking research from the Australian Centre for Precision Health at the University of South Australia has discovered a connection between metabolism and dementia-related brain measures, offering important new information about the disease.

Researchers examined data from 26,239 individuals in the UK Biobank and discovered that those with obesity-related liver stress, inflammation, or kidney stress had the greatest adverse effects in their brains.

In order to identify early risk factors for dementia, the research examined relationships between six different metabolic profiles and 39 cardiometabolic markers with measurements of brain volume, brain lesions, and iron accumulation from MRI brain scans.

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Negative MRI profiles with smaller hippocampal and grey matter volumes, higher burdens of brain lesions, and higher iron accumulation were more prevalent in those with metabolic profiles connected to obesity.

Dr. Amanda Lumsden, a researcher at UniSA, claims that the study deepens our knowledge of brain health.

“Dementia is a debilitating disease that affects more than 55 million people worldwide,” Dr. Lumsden says.

“Understanding metabolic factors and profiles associated with dementia-related brain changes can help identify early risk factors for dementia. In this research, we found that adverse neuroimaging patterns were more prevalent among people who had metabolic types related to obesity. These people also had the highest Basal Metabolic Rate (BMR) –how much energy your body requires when resting in order to support its basic functions – but curiously, BMR seemed to contribute to adverse brain markers over and above the effects of obesity.”

Senior Investigator, UniSA’s Professor Elina Hyppönen says the finding presents a new avenue for understanding brain health.

“This study indicates that metabolic profiles are associated with aspects of brain health. We also found associations with many individual biomarkers which may provide clues into the processes leading to dementia,” Prof Hyppönen says.

“The human body is complex, and more work is now needed to find out exactly why and how these associations arise.”

Sci Tech Daily, 2 November 2022

<https://scitechdaily.com>

Europe warming at double the rate of other continents

2022-11-03

Europe is the fastest-warming continent in the world, according to a newly released report from the World Meteorological Organization.

The State of the Climate in Europe report cites the loss of more than 25 metres of ice loss in alpine glaciers, and 20 metres of loss in Greenland (a Danish territory), as particularly responsible for the rise in ocean levels.

Climate change events were also responsible for more than US\$50 billion in damages.

Mitigation and transition efforts a positive in report, despite dire temperature predictions.

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In its statement releasing the report, the WMO described Europe as the “live picture” of a world burdened by warming climate. Since 1990, Europe’s temperatures have undergone an average rate of temperature increase of 0.5 degrees each decade.

That rate is twice as high as the next fastest warming continent.

The WMO points to high-impact weather and climate events – nearly 85% of which were floods and storms – as directly affecting around 510,000 people.

Extreme heat also took its toll, with provisional record temperatures experienced in southern Italy in August reaching 48.8°C. These temperatures influenced drought and low rainfall across the Mediterranean, leading to deadly wildfires that burned through three times the amount of land area than the region’s 15-year average up to 2020.

But are carbon emissions decreasing in Europe?

Fuel prices and the COVID-19 pandemic were major influences on the continent’s carbon emissions reduction, the WMO found.

A 31% decline in carbon emissions between 1990 and 2020 was recorded, although it’s expected to be far less in 2021 due to the relaxation of COVID-19 restrictions and altered fuel prices.

2021 also marked the introduction of EU legislation to make net zero by 2050 a legally-binding target for member nations.

Although temperature data provided by six datasets showed a decrease in 2021 from the preceding year, it still marked one of the 10 warmest years on record.

And observers will keenly await the release of next year’s 2022 appraisal, after record summer droughts and heatwaves heaped pressure on European nations.

Even now, regions across the continent are recording their hottest temperatures for November on record.

“[Europe] reminds us that even well-prepared societies are not safe from impacts of extreme weather events,” says WMO secretary-general Professor Petteri Taalas.

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“This year, like 2021, large parts of Europe have been affected by extensive heatwaves and drought, fuelling wildfires. In 2021, exceptional floods caused death and devastation.

“On the mitigation side, the good pace in reducing greenhouse gases emissions in the region should continue and ambition should be further increased. Europe can play a key role towards achieving a carbon neutral society by the middle of the century to meet the Paris Agreement.”

Future outlook

The release of the report comes ahead of the global climate change conference to be held in Egypt, where delegations from around the world convene to recalibrate efforts to address climate change.

Last year’s COP26 conference in Glasgow was criticised for scrubbing language to phase out coal from the final agreement. In its place came language to ‘phase down’ its use. Coal is the leading source of carbon emissions from energy use.

Similarly, several nations failed to renew important targets to reduce carbon emissions by the end of the decade, considered an important tipping point if net zero by 2050 is to be achieved.

The WMO echoed the most recent Intergovernmental Panel on Climate Change forecasts that weather, climate and water disasters will increase in the future, and that Europe will experience temperature rises at rates exceeding global average increases.

Cosmos Magazine, 3 November 2022

<https://cosmosmagazine>

Dry Shampoo Added to List of Products Contaminated With Benzene

2022-11-02

Dry shampoo has joined the growing list of cosmetic and hygiene products that contain benzene, a known human carcinogen, according to an analysis from the independent laboratory Valisure.

Of 148 batches of dry shampoo spray from 34 different companies, 70% contained quantifiable levels of benzene. Some products contained up to 170 times the FDA-imposed benzene limit of 2 parts per million (ppm), Valisure found.

Findings represent the highest [benzene] levels found in a consumer product to date.

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For example, Not Your Mother's dry shampoo had a benzene concentration of up to 340 ppm. Other brands whose products contained benzene levels above the FDA limit included Paul Mitchell, Sun Bum, Batiste, Sebastian, and Redken, among others.

Valisure filed a citizen petition with the FDA Monday, requesting a recall of contaminated dry shampoo products. They also asked the agency to redefine and clarify benzene limits in cosmetics and other regulated products, noting that their findings represent the highest and most broadly detected levels of benzene that it has found in a consumer product to date.

"The detection of high levels of benzene in dry shampoos should be cause for significant concern since these products are likely used indoors, where benzene may linger and be inhaled for prolonged periods of time," David Light, CEO of Valisure, said in a press release.

"Unfortunately, it's not so surprising that we continue to see benzene in consumer products, especially in aerosol consumer products," Light told MedPage Today. While Valisure has detected benzene in other household products, Light said this assessment makes it much more evident that propellants in aerosol products are a potential source of benzene contamination.

Benzene, which is used primarily as a solvent in chemical and pharmaceutical industries, is known to cause leukemia or other blood disorders in humans. Trace levels of the carcinogen can be found in cigarette smoke, gasoline, glues, adhesives, cleaning products, and paint strippers. It is also a contaminant in the petroleum industry, the press release noted.

Dry shampoos often contain propellants such as butane, isobutane, or propane, which may all be sources of benzene contamination.

Valisure has previously detected unlawful levels of benzene in hand sanitizers, sunscreens, and spray deodorants. The high presence of the cancer-causing agent in these hygiene and cosmetic products is evidence that further industry and regulatory action is needed, Light said.

The company's analysis of dry shampoo products follows a voluntary recall from Unilever, which pulled several dry shampoo products due to elevated levels of benzene, including those from Dove, Nexxus, Suave, Bedhead, and TRESemmé. Valisure did not include any of these voluntarily recalled dry shampoo products in its petition.

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For their analysis, Valisure collaborated with Syft Technologies to conduct tests of benzene levels in the air after spraying dry shampoo products, using Selected Ion Flow Tube Mass Spectrometry (SIFT-MS) technology, which may be able to capture more benzene than previously used methods, Light said.

"I think that it is even more concerning that we may be underestimating -- pretty significantly -- the amount of benzene that we're finding," Light noted, adding that the SIFT-MS technology should be rapidly adopted to evaluate consumer spray products.

The FDA has alerted drug manufacturers to benzene contamination in recent months, clarifying that they should appropriately test their products for levels above 2 ppm. Light said that further action is needed to clarify the levels found in other consumer and household products.

"It's encouraging that there is progress in this space," he added. "But we still have, I think, quite a ways to go until we really fully address this problem and the risks that come from it."

Med Page Today, 2 November 2022

<https://medpagetoday.com>

Researchers find that 60% of home 'compostable' plastic doesn't fully break down and ends up in our soil instead

2022-11-03

In a UK-wide study, researchers have found that 60% of home-compostable plastics do not fully disintegrate in home compost bins, and inevitably end up in our soil. The study also found that citizens are confused about the labels of compostable and biodegradable plastics, leading to incorrect plastic waste disposal. These results highlight the need to revise and redesign this supposedly sustainable plastic waste management system.

Global plastic pollution remains one of the biggest environmental challenges of our time. A new OECD report shows that plastic consumption has quadrupled over the past 30 years. Globally, only 9% of plastic waste is recycled, while 50% ends up in landfills, 22% evades waste management systems, and 19% is incinerated.

Several countries have set targets to eliminate all single-use plastics and to make plastic packaging 100% recyclable, reusable, or compostable by 2025.

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In response to this pollution crisis, several countries have set targets to eliminate all single-use plastics and to make plastic packaging 100% recyclable, reusable, or compostable by 2025.

Compostable plastics are becoming more common as the demand for sustainable products grows. The main applications of compostable plastics include food packaging, bags; cups and plates, cutlery, and bio-waste bags. But there are some fundamental problems with these types of plastics. They are largely unregulated, and claims around their environmental benefits are often exaggerated.

Now, in a new study published in *Frontiers in Sustainability*, researchers at University College London have found that consumers are often confused about the meaning of the labels of compostable plastics, and that a large portion of compostable plastics do not fully disintegrate under home composting conditions.

(Un)compostable plastics

“Compostable plastic” describes a material that can undergo biological degradation in a compost site at a rate consistent with other known compostable materials, leaving no visible (toxic) residues.

However, compostable plastics are currently incompatible with most waste management systems. There exists no harmonized international standard for home compostable plastics. The fate of these plastics, when they are thrown away or sorted for recycling, is therefore either incineration or landfill.

“The typical fate of landfill or incineration is not usually communicated to customers, so the environmental claims made for compostable packaging can be misleading,” said corresponding author Danielle Purkiss.

The Big Compost Experiment

Purkiss and her colleagues designed a three-part citizen science study, The Big Compost Experiment, to investigate what the public thinks about home compostable plastics, how we deal with them, and whether they fully disintegrate in our compost.

First, participants from across the UK completed an online survey about opinions and behavior surrounding compostable plastics and food waste. Then, participants were invited to take part in a home composting experiment. Lastly, those who participated in part two were sent a request

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to search for traces of their chosen compostable plastic items in their composter. The researchers collected the data over a period of 24 months.

“Our study was created in response to feedback from the public and stakeholders from industry, policy, and third sector organizations, which highlighted many systemic issues in the manufacturing, use, and disposal of compostable plastic packaging,” explained Purkiss.

The results show a general willingness to make sustainable choices by buying compostable plastics. However, participants showed confusion about the labeling and identification of these plastics. Out of a randomized sample of 50 item images, the researchers found that 46% showed no identifiable home composting certification or standards labeling and 14% showed industrial composting certification.

“This shows that there is a current lack of clear labeling and communication to ensure that the public can identify what is industrially compostable or home compostable packaging, and how to dispose of it correctly,” said Purkiss.

But a more shocking result is that 60% of plastic certified as home compostable did not fully disintegrate in home compost bins.

“Compostable packaging does not break down effectively in the range of UK home composting conditions, creating plastic pollution,” Purkiss added. “Even packaging that has been certified as home compostable is not breaking down effectively.”

The participants indicated that they use their compost in their flower and vegetable gardens. As the results of the experiment show that the compost contains plastic that has not fully disintegrated, plastic inevitably ends up in soil of UK citizens.

The experiment also showed that compost bins are important sites for biodiversity, with pictures sent in by the participants showing 14 different categories of organisms such as fungi, mites, and worms.

Revising the system

The question remains whether compostable plastics serve as a solution to our widespread plastic pollution problem.

“Compostable plastics are potentially useful for products that are not suited to recycling due to contamination such as tea bags, fruit labels, take-away food packaging, and certain hygiene products. These products typically end up in landfill,” explained Purkiss.

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But the research shows that in this case, the better solution is to send compostable plastics to industrial composting facilities, where composting conditions are regulated.

“We have shown that home composting, being uncontrolled, is largely ineffective and is not a good method of disposal for compostable packaging,” said Purkiss.

Overall, there is a need for the revision and improvement of home compostable plastics. “The idea that a material can be sustainable is a widespread misconception. Only a system of production, collection, and reprocessing of a material can be sustainable,” concluded Purkiss.

Phys Org, 3 November 2022

<https://phys.org>

Breakthrough as scientists might have found a way to capture carbon emissions cheaply

2022-11-05

An international team of researchers has found a cheap and efficient substance that can remove carbon dioxide from the air.

It's a type of metal-organic framework (MOF): a class of chemicals that are well known for their carbon capture properties, but are typically not very scalable or durable.

This MOF, however, is made from readily available aluminium hydroxide and formic acid, and works in all but the most humid conditions.

It's called aluminium formate, or ALF.

“What makes this work exciting is that ALF performs really well relative to other high-performing CO₂ adsorbents, but it rivals designer compounds in its simplicity, overall stability and ease of preparation,” says Dr Hayden Evans, a chemist at the US National Institute for Standards and Technology (NIST), and lead author on a paper published in Science Advances.

“It is made of two substances found easily and abundantly, so creating enough ALF to use widely should be possible at very low cost.”

Carbon capture is something of a problem child in decarbonisation: while there's plenty of technology that does it well, much of it is too expensive for polluters to install on power stations. “Put it all together, you need some kind of wonder material,” says Evans.

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“Here, we've managed to tick every box except stability in very humid conditions. However, using ALF would be inexpensive enough that a drying step becomes a viable option.”

According to Evans, ALF would cost less than one US dollar per kilogram.

The researchers tested ALF in simulated exhaust streams from coal-fire power stations, finding it selectively stuck to CO₂, avoiding other gases.

Their analytical work showed that – like other MOFs – ALF looks like a cage filled with holes at a molecular level. CO₂ molecules are just big enough to fit into the holes and get trapped.

The researchers are now interested in seeing whether the captured CO₂ could then, possibly, be converted into formic acid to make more ALF, leading to a cyclic process.

“There is a great deal of research going on nowadays into the problem of what to do with all the captured CO₂,” says Evans.

“It seems possible that we could eventually use solar energy to split hydrogen from water, and then combine that hydrogen with the CO₂ to make more formic acid.

“Combined with ALF, that's a solution that would help the planet.”

While the material is scalable, it's not yet possible to use at scale.

Engineers need to figure out how to make large amounts, and coal-fired plants would need to have infrastructure in place to dehumidify the air first – but Evans says that the cost of this wouldn't be prohibitive.

Cosmos Magazine, 5 November 2022

<https://cosmosmagazine.com>

AlphaFold's new rival? Meta AI predicts shape of 600 million proteins

2022-11-01

When London-based artificial-intelligence (AI) company DeepMind unveiled predicted structures for some 220 million proteins this year, the trove covered nearly every protein from known organisms in DNA databases. Now, another tech giant is filling in the 'dark matter' of the protein universe.

Microbial molecules from soil, seawater and human bodies are among the planet's least understood.

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Researchers at Meta (formerly Facebook, headquartered in Menlo Park, California) have used AI to predict the structures of some 600 million proteins from bacteria, viruses and other microorganisms that haven't been characterized.

"These are the structures we know the least about. These are incredibly mysterious proteins. I think they offer the potential for great insight into biology," says Alexander Rives, the research lead of Meta AI's protein team.

The scientists generated the predictions — described in a 1 November preprint¹ — using a 'large language model', a type of AI that can predict text from just a few letters or words.

Normally, language models are trained on large volumes of text. To apply them to proteins, Rives and his colleagues instead fed the AI sequences of known proteins, which can be written down as a series of letters, each representing one of 20 possible amino acids. The network then learnt to fill in the sequences of proteins in which some of the amino acids were obscured.

Protein 'autocomplete'

This training imbued the network with an intuitive understanding of protein sequences, which contain information about their shapes, says Rives. A second step — inspired by DeepMind's pioneering protein-structure-predicting AI, AlphaFold — combines such insights with information about the relationships between known protein structures and sequences, to generate predictions.

Meta's network, called ESMFold, isn't quite as accurate as AlphaFold, Rives' team reported earlier this year², but it is about 60 times faster at predicting structures for short sequences, he says. "What this means is that we can scale structure prediction to much larger databases."

As a test, the researchers unleashed their model on a database of bulk-sequenced 'metagenomic' DNA from environmental sources such as soil, seawater and the human gut and skin. The vast majority of the entries — which encode potential proteins — come from single-cell organisms that have never been isolated or cultured and are unknown to science.

In total, the team predicted the structures of more than 617 million proteins. The effort took just two weeks (by contrast, AlphaFold can take minutes to generate a single prediction). The structures are freely available for use, as is the code underlying the model, says Rives.

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Of the 617 million predictions, the model deemed more than one-third to be high quality, such that researchers can have confidence that the overall protein shape is correct and, in some cases, can discern atomic-level details. Millions of these structures are entirely unlike anything in the databases of protein structures determined experimentally, or any of AlphaFold's predictions from known organisms.

A large chunk of the AlphaFold database is made up of structures that are nearly identical to each other, whereas metagenomic databases "should cover a large part of the previously unseen protein universe", says Martin Steinegger, a computational biologist at Seoul National University. "There's a big opportunity now to unravel more of the darkness."

Sergey Ovchinnikov, an evolutionary biologist at Harvard University in Cambridge, Massachusetts, wonders about the hundreds of millions of predictions that ESMFold made with low confidence. Some might lack a defined structure, at least in isolation, whereas others might be non-coding DNA mistaken for protein-coding material. "It seems there is still more than half of protein space we know nothing about," he says.

Leaner, simpler, cheaper

Burkhard Rost, a computational biologist at the Technical University of Munich in Germany, is impressed by the combined speed and accuracy of Meta's model. But he questions whether ESMFold really offers an advantage over AlphaFold's precision when it comes to predicting proteins from metagenomic databases. Language-model-based prediction methods — including one developed by his team³ — are better suited to quickly determining how mutations alter a protein's structure, which is not possible with AlphaFold. "We will see structure prediction become leaner, simpler, cheaper, and that will open the door for new things," he says.

DeepMind doesn't currently have plans to include metagenomic structural predictions in its database, but hasn't ruled out adding them to future releases, according to a company representative. But Steinegger and his collaborators have used a version of AlphaFold to predict the structures of some 30 million metagenomic proteins. They are hoping to find new kinds of RNA virus by looking for previously unknown forms of the viruses' genome-copying enzymes.

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Steinegger sees trawling biology's dark matter as the obvious next step for such tools. "I do think we will quite soon have an explosion in the analysis of these metagenomic structures."

Nature, 1 November 2022

<https://nature.com>

Inflammasome pathway links COVID and Parkinson's

2022-11-03

The paper identifies a potential future risk for neurodegenerative conditions in people who've had COVID-19, but also a possible treatment.

"We studied the effect of the virus on the brain's immune cells, 'microglia' which are the key cells involved in the progression of brain diseases like Parkinson's and Alzheimer's," says study author Trent Woodruff, professor at the University of Queensland's School of Biomedical Sciences.

"Our team grew human microglia in the laboratory and infected the cells with SARS-CoV-2, the virus that causes COVID-19. We found the cells effectively became 'angry', activating the same pathway that Parkinson's and Alzheimer's proteins can activate in disease, the inflammasomes."

Study author and professor Eduardo Albornoz Balmaceda says triggering the inflammasome pathway sparked a 'fire' in the brain, which begins a chronic and sustained process of killing off neurons.

"It's kind of a silent killer, because you don't see any outward symptoms for many years," Albornoz Balmaceda says. "It may explain why some people who've had COVID-19 are more vulnerable to developing neurological symptoms similar to Parkinson's disease."

The researchers found the spike protein of the virus was enough to start the process and was further exacerbated when there were already proteins in the brain linked to Parkinson's.

"So if someone is already pre-disposed to Parkinson's, having COVID-19 could be like pouring more fuel on that 'fire' in the brain," Woodruff says. "The same would apply for a predisposition for Alzheimer's and other dementias that have been linked to inflammasomes."

But the study also indicates a potential treatment.

The researchers administered a class of inhibitory drugs which are currently in clinical trials with Parkinson's patients.

COVID-19 activates the same inflammatory response in the brain as Parkinson's disease, new research in human cells and mice suggests.

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"We found it successfully blocked the inflammatory pathway activated by COVID-19, essentially putting out the fire," Albornoz Balmaceda says. "The drug reduced inflammation in both COVID-19-infected mice and the microglia cells from humans, suggesting a possible treatment approach to prevent neurodegeneration in the future."

Woodruff says that while the similarity between how COVID-19 and dementia diseases affect the brain was concerning, it also meant a possible treatment was already in existence.

"Further research is needed, but this is potentially a new approach to treating a virus that could otherwise have untold long-term health ramifications."

The study appears in the journal *Molecular Psychiatry*.

Futurity, 3 November 2022

<https://futura.org>

Experimental breast cancer vaccine passes first human trials

2022-11-06

A new paper in the journal *JAMA Oncology* has reported the results of a decade-long Phase 1 human trial testing an experimental breast cancer vaccine. The novel treatment was found to be "very safe" and a larger Phase 2 trial is now underway testing efficacy.

Up to 30% of breast cancers involve the overproduction of a protein called human epidermal growth factor receptor 2 (HER2). These HER2-positive cancers are often more aggressive than other types of breast cancer, growing faster and being more likely to reoccur.

For the last couple of decades one of the more effective clinical treatments for this type of breast cancer has been a monoclonal antibody therapy designed to block the activity of HER2 on tumor cells. However, researchers have long been working on vaccines that can train the immune system to target these HER2-positive tumor cells.

These kinds of cancer vaccines are not designed to be preventative vaccines that stop cancers from appearing in the first place. Instead, these are known as therapeutic vaccines, given to patients after they are diagnosed with a cancer in the hopes they help the immune system better seek and destroy certain tumors.

A therapeutic vaccine being trialed is designed to help the immune system better target breast cancer by homing in on a certain protein over-expressed by tumors.

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In this instance researchers are working with what is called a DNA vaccine. These vaccines deliver DNA blueprints for the production of certain proteins into the nucleus of a cell. That protein is then produced by the cell, triggering an immune response. The vaccine being tested prompts cells to produce a specific fragment of the HER2 protein.

This Phase 1 trial began 20 years ago, slowly enrolling 66 patients with advanced HER2-positive breast cancer. Three different dose levels were tested, with the primary goal of the trial to evaluate the long-term safety of the vaccine. Because HER2 proteins can be found on other cell types in the body, the researchers planned a 10-year follow-up for each participant to make sure there were no lingering problems of immune activity against healthy tissue.

“The results showed that the vaccine was very safe,” said lead author on the new study Mary Disis. “In fact, the most common side effects that we saw in about half the patients were very similar to what you see with COVID vaccines: redness and swelling at the injection site and maybe some fever, chills and flu-like symptoms.”

The trial was not geared to evaluate how effective the experimental vaccine is at treating breast cancer. But Disis did point out promising early signs of efficacy, with 80% of the treated trial participants surviving the full 10-year follow-up. Disis said only around 50% of patients with advanced HER2 breast cancer would generally be expected to survive more than five years, so it's likely the vaccine is working.

A Phase 2 trial is currently underway, testing the vaccine's efficacy in a larger cohort of HER2-positive patients. That trial kicked off a few years ago and only has a two-year follow-up period. So preliminary results could start coming within the next couple of years.

“If the results of the new randomized-controlled Phase 2 trial of the vaccine are positive, it will be a strong signal for us to rapidly move forward to a definitive phase III trial,” Disis added. “I have high hopes that we're close to having a vaccine that can effectively treat patients with breast cancer.”

The new study was published in JAMA Oncology.

New Atlas, 6 November 2022

<https://newatlas.com>

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It's electric! Technique could clean up mining of valuable rare earth elements

2022-11-01

Electric cars, wind turbines, and LED lighting all help keep the environment clean, but making them can be a dirty business. The high-performance magnets in motors and generators and the glowing phosphors in LEDs and flat screens all depend on substances called rare earth elements (REEs). And capturing REEs from the clay deposits in which many are found requires leaching agents that pollute soil and groundwater.

Now, a Chinese group has developed—and tested on tons of soil—an approach called electrokinetic mining that relies on electric currents to free the REEs, sharply reducing the need for polluting chemicals. The strategy, described this week in *Nature Sustainability*, could be “a game changer, providing that it is feasible at a large scale,” says Anouk Borst, a geologist at KU Leuven.

Despite their name, REEs are fairly abundant in Earth's crust. It's just hard to find deposits that are economical to mine. Heavy REEs—those with high atomic numbers, including dysprosium, yttrium, and terbium—are most commonly extracted from masses of clay formed through eons of weathering of igneous rocks such as granite. In these “ion-adsorption” deposits, the elements are adsorbed—or stuck—to the surface of clay particles. They are usually extracted by pumping large quantities of ammonium sulfate or a similar solution into the ground. The leachate pulls REEs from the clay and percolates down to bedrock, where it is collected for processing.

All that can contaminate water and soil, not to mention lay waste to large tracts of land. And roughly 80% of the world's supply of heavy REEs come from ion-adsorption deposits in southern China and adjacent parts of Myanmar, where environmental regulations are poorly enforced and illegal mining is common. (The light REEs—cerium, neodymium, and praseodymium—are typically found in hard rock and are mined in a different way.)

Gaofeng Wang of the Chinese Academy of Sciences's Guangzhou Institute of Geochemistry (GIG) and his colleagues thought electrokinetic technology might offer a cleaner alternative. The approach, in which electrodes on the top and bottom of a volume of soil induce an electric field, speeding the movement of the leaching agent and the ions it

Current methods to extract key ingredients for green technologies require polluting chemicals

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extracts, is already used in soil remediation and has been proposed for copper and gold mining. It has “the real potential to outperform traditional mining techniques in terms of efficiency, environmental impacts, and economics,” says Riccardo Sprocati, a specialist in the technology at the Technical University of Denmark.

The Chinese team started with a bench-top experiment, then scaled up to 20 kilograms of material, and finally moved to a field test at an actual ion-adsorption deposit, trying the technique on a 14-ton hunk of clay. The method extracted a higher percentage of the REEs more quickly than conventional leaching and needed less ammonium sulfate. It also left the soil cleaner and reduced contaminating elements in the leachate, which could simplify processing. The team calculates that the process could cut mining costs by about two-thirds.

Gareth Hatch, a rare earths expert at the Strategic Materials Advisory, a consulting firm in Manchester, England, notes that whether the technique can be scaled up “remains to be seen.” The group’s next test will include about 2000 tons of soil, where they will try “to optimize operating conditions,” says geochemist Hongping He, director of GIG and co-author on the paper. They will divide the site into sections to keep the electric current and voltage low enough to avoid harming surrounding soil, vegetation, or fauna, He says. And they have struck an agreement with a major rare earth supplier to test the process on an even larger scale.

“As with all mining methods, it will still impact the environment,” says Henning Prommer, an environmental engineer at the University of Western Australia, Perth, whose group has worked on applying electrokinetic mining to gold and copper. But, he says, “Given the crucial role that REEs play in our ambitions for a renewable energy infrastructure, any reduction in the environmental impact of mining is welcome.”

Science, 1 November 2022

<https://science.org>

Completely Changing Current Ways of Thinking – New Breakthrough Could Lead to Better Cancer Treatments

2022-11-02

Scientists funded by Cancer Research UK have found that cancer cells ‘hijack’ a process used by healthy cells to spread throughout the body, completely changing current ways of thinking about cancer metastasis.

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The researchers from the Cancer Research UK Cambridge Institute at the University of Cambridge discovered that blocking the NALCN protein’s activity in mice with cancer cells triggers metastasis.

The study, which was recently published in the journal Nature Genetics, also found that this process is not just present in cancer. Unexpectedly, when NALCN was removed from mice that did not have cancer, the healthy cells in those animals began to migrate out from their original tissue and join with other organs.

They discovered, for example, that healthy pancreatic cells moved to the kidney and became healthy kidney cells. This indicates that metastasis is not an abnormal process unique to cancer, as previously thought, but rather a normal process employed by healthy cells that tumors have exploited to travel to other areas of the body and form metastases.

Group Leader for the study and Director of the Cancer Research UK Cambridge Centre, Professor Richard Gilbertson, said: “These findings are among the most important to have come out of my lab for three decades. Not only have we identified one of the elusive drivers of metastasis, but we have also turned a commonly held understanding of this on its head, showing how cancer hijacks processes in healthy cells for its own gains. If validated through further research, this could have far-reaching implications for how we prevent cancer from spreading and allow us to manipulate this process to repair damaged organs.”

Despite being one of the main causes of death in cancer patients, metastasis has remained incredibly difficult to prevent, largely because researchers have found it hard to identify key drivers of this process which could be targeted by drugs. Now that they have identified NALCN’s role in metastasis, the team is looking into various ways to restore its function, including using existing drugs on the market.

Lead researcher on the study and Senior Research Associate at the Cancer Research UK Cambridge Institute, Dr. Eric Rahrman, said: “We are incredibly excited to have identified a single protein that regulates not only how cancer spreads through the body, independent of tumor growth, but also normal tissue cell shedding and repair. We are developing a clearer picture on the processes that govern how cancer cells spread. We can now consider whether there are likely existing drugs which could be repurposed to prevent this mechanism from triggering cancer spreading in patients.”

Scientists have found that cancer cells ‘hijack’ a process used by healthy cells to spread throughout the body, completely changing current ways of thinking about cancer metastasis.

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Cancer Research UK's Director of Research, Dr. Catherine Elliott, said: "Once cancer has spread from the first tumor, it is harder to treat because we are looking at multiple sites in the body and working with new tumors that may be resistant to treatment. Discovering that a cancer has spread is always devastating news for patients and their families and so we are delighted to have supported this incredible research which may one day allow us to prevent metastasis and turn cancer into a much more survivable disease."

Sci Tech Daily, 2 November 2022

<https://scitechdaily.com>

Are bananas really 'radioactive'? An expert clears up common misunderstandings about radiation

2022-11-04

The simple mention of the word "radiation" often evokes fear in people. For others, it's fun to think a little exposure to radiation could turn you into the next superhero, just like the Hulk.

But is it true basically everything around us is radioactive, even the food we eat? You may have heard bananas are mildly radioactive, but what does that actually mean? And despite us not being superheroes, are human bodies also radioactive?

What is radiation?

Radiation is energy that travels from one point to another, either as waves or particles. We are exposed to radiation from various natural and artificial sources every day.

Cosmic radiation from the Sun and outer space, radiation from rocks and soil, as well as radioactivity in the air we breathe and in our food and water, are all sources of natural radiation.

Bananas are a common example of a natural radiation source. They contain high levels of potassium, and a small amount of this is radioactive. But there's no need to give up your banana smoothie – the amount of radiation is extremely small, and far less than the natural "background radiation" we are exposed to every day.

Artificial sources of radiation include medical treatments and X-rays, mobile phones and power lines. There is a common misconception that

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artificial sources of radiation are more dangerous than naturally occurring radiation. However, this just isn't true.

There are no physical properties that make artificial radiation different or more damaging than natural radiation. The harmful effects are related to dose, and not where the exposure comes from.

What is the difference between radiation and radioactivity?

The words "radiation" and "radioactivity" are often used interchangeably. Although the two are related, they are not quite the same thing.

Radioactivity refers to an unstable atom undergoing radioactive decay. Energy is released in the form of radiation as the atom tries to reach stability, or become non-radioactive.

The radioactivity of a material describes the rate at which it decays, and the process(es) by which it decays. So radioactivity can be thought of as the process by which elements and materials try to become stable, and radiation as the energy released as a result of this process.

Ionising and non-ionising radiation

Depending on the level of energy, radiation can be classified into two types.

Ionising radiation has enough energy to remove an electron from an atom, which can change the chemical composition of a material. Examples of ionising radiation include X-rays and radon (a radioactive gas found in rocks and soil).

Non-ionising radiation has less energy but can still excite molecules and atoms, which causes them to vibrate faster. Common sources of non-ionising radiation include mobile phones, power lines, and ultraviolet rays (UV) from the Sun.

Is all radiation dangerous? Not really

Radiation is not always dangerous – it depends on the type, the strength, and how long you are exposed to it.

As a general rule, the higher the energy level of the radiation, the more likely it is to cause harm. For example, we know that overexposure to ionising radiation – say, from naturally occurring radon gas – can damage human tissues and DNA.

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We also know that non-ionising radiation, such as the UV rays from the Sun, can be harmful if the person is exposed to sufficiently high intensity levels, causing adverse health effects such as burns, cancer, or blindness.

Importantly, because these dangers are well known and understood, they can be protected against. International and national expert bodies provide guidelines to ensure the safety and radiation protection of people and the environment.

For ionising radiation, this means keeping doses above the natural background radiation as low as reasonably achievable – for example, only using medical imaging on the part of the body required, keeping the dose low, and retaining copies of images to avoid repeat exams.

For non-ionising radiation, it means keeping exposure below safety limits. For example, telecommunications equipment uses radiofrequency non-ionising radiation and must operate within these safety limits.

Additionally, in the case of UV radiation from the Sun, we know to protect against exposure using sunscreen and clothing when levels reach 3 and above on the UV index.

Radiation in medicine

While there are clear risks involved when it comes to radiation exposure, it's also important to recognise the benefits. One common example of this is the use of radiation in modern medicine.

Medical imaging uses ionising radiation techniques, such as X-rays and CT scans, as well as non-ionising radiation techniques, such as ultrasound and magnetic resonance imaging (MRI).

These types of medical imaging techniques allow doctors to see what's happening inside the body and often lead to earlier and less invasive diagnoses. Medical imaging can also help to rule out serious illness.

Radiation can also help treat certain conditions – it can kill cancerous tissue, shrink a tumour or even be used to reduce pain.

So are our bodies also radioactive? The answer is yes, like everything around us, we are also a little bit radioactive. But this is not something we need to be worried about.

Our bodies were built to handle small amounts of radiation – that's why there is no danger from the amounts we are exposed to in our normal

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daily lives. Just don't expect this radiation to turn you into a superhero any time soon, because that definitely is science fiction.

The Conversation, 4 November 2022

<https://theconversation.com>

New 'smart tattoos' tackle tech challenges of on-skin computing

2022-11-03

Personal computing has gotten smaller and more intimate over the years—from the desktop computer to the laptop, to smartphones and tablets, to smart watches and smart glasses.

But the next generation of wearable computing technology—for health and wellness, social interaction and myriad other applications—will be even closer to the wearer than a watch or glasses: It will be affixed to the skin.

On-skin interfaces—sometimes known as “smart tattoos”—have the potential to outperform the sensing capabilities of current wearable technologies, but combining comfort and durability has proven challenging. Now, members of Cornell's Hybrid Body Lab have come up with a reliable, skin-tight interface that's easy to attach and detach, and can be used for a variety of purposes—from health monitoring to fashion.

Doctoral student and lab member Pin-Sung Ku is lead author of “SkinKit: Construction Kit for On-Skin Interface Prototyping,” which was presented in September at UbiComp '22, the Association for Computing Machinery's international joint conference on pervasive and ubiquitous computing.

“We've been working on this for years, and I think we've finally figured out a lot of the technical challenges,” said Cindy (Hsin-Liu) Kao, assistant professor of human centered design in the College of Human Ecology, and the study's senior author. “We wanted to create a modular approach to smart tattoos, to make them as straightforward as building Legos.”

SkinKit—a plug-and-play system that aims to “lower the floor for entry” to on-skin interfaces, Kao said, for those with little or no technical expertise—is the product of countless hours of development, testing and redevelopment, she said.

Kao's lab is also very conscious of cultural differences generally, and she thinks it's important to bring these devices to diverse populations.

On-skin interfaces—sometimes known as “smart tattoos”—have the potential to outperform the sensing capabilities of current wearable technologies.

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“People from different cultures, backgrounds and ethnicities can have very different perceptions toward these devices,” she said. “We felt it’s actually very important to let more people have a voice in saying what they want these smart tattoos to do.”

Fabrication is done with temporary tattoo paper, silicone textile stabilizer and water, creating a multi-layer thin film structure the group calls “skin cloth.” The layered material can be cut into desired shapes—for their study, the researchers used three-quarter-inch squares, with male-female cutting lines so the pieces can be tessellated (joined together)—and fitted with miniaturized flexible printed circuit board modules to perform a range of tasks.

“The starting point was to find a suitable form factor, and then to make it scalable,” Ku said. “And the way we scale it is through the tessellation pattern. So then the user can design a circuit and then customize the layout by putting multiple modules together.”

One of the benefits of their design, Ku said, is the reusability component.

“The wearer can easily attach them together and also detach them,” he said. “Let’s say that today you want to use one of the sensors for certain purposes, but tomorrow you want it for something different. You can easily just detach them and reuse some of the modules to make a new device in minutes.”

To test SkinKit, the researchers first recruited nine participants with both STEM and design backgrounds to build and wear the devices. Their input from the 90-minute workshop helped inform further modifications, which the group performed before conducting a larger, two-day study involving 25 participants with both STEM and design backgrounds.

Devices designed by the 25 study participants addressed: health and wellness, including temperature sensors to detect fever due to COVID-19; personal safety, including a device that would help the wearer maintain social distance during the pandemic; notification, including an arm-worn device that a runner could wear that would vibrate when a vehicle was near; and assistive technology, such as a wrist-worn sensor for the blind that would vibrate when the wearer was about to bump into an object.

Other applications were for social, fashion and athletic training purposes.

Kao said members of her lab, including Ku, took part in the 4-H Career Explorations Conference over the summer, and had approximately 10 middle-schoolers from upstate New York build their own SkinKit devices.

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“I think it just shows us a lot of potential for STEM learning, and especially to be able to engage people who maybe originally wouldn’t have interest in STEM,” Kao said. “But by combining it with body art and fashion, I think there’s a lot of potential for it to engage the next generation and broader populations to explore the future of smart tattoos.”

Tech Xplore, 3 November 2022

<https://techxplore.com>

Astronomers discover closest black hole to Earth

2022-11-04

Black holes are the most extreme objects in the universe. Supermassive versions of these unimaginably dense objects likely reside at the centers of all large galaxies. Stellar-mass black holes—which weigh approximately five to 100 times the mass of the sun—are much more common, with an estimated 100 million in the Milky Way alone.

Only a handful have been confirmed to date, however, and nearly all of these are “active”—meaning they shine brightly in X-rays as they consume material from a nearby stellar companion, unlike dormant black holes which do not.

Astronomers using the Gemini North telescope on Hawai’i, one of the twin telescopes of the International Gemini Observatory, operated by NSF’s NOIRLab, have discovered the closest black hole to Earth, which the researchers have dubbed Gaia BH1. This dormant black hole weighs about 10 times the mass of the sun and is located about 1,600 light-years away in the constellation Ophiuchus, making it three times closer to Earth than the previous record holder, an X-ray binary in the constellation of Monoceros.

The new discovery was made possible by making exquisite observations of the motion of the black hole’s companion, a sun-like star that orbits the black hole at about the same distance as the Earth orbits the sun.

“Take the solar system, put a black hole where the sun is, and the sun where the Earth is, and you get this system,” explained Kareem El-Badry, an astrophysicist at the Center for Astrophysics | Harvard & Smithsonian and the Max Planck Institute for Astronomy, and the lead author of the paper describing this discovery.

“While there have been many claimed detections of systems like this, almost all these discoveries have subsequently been refuted. This is the

“Take the solar system, put a black hole where the sun is, and the sun where the Earth is, and you get this system.”

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first unambiguous detection of a sun-like star in a wide orbit around a stellar-mass black hole in our galaxy.”

Though there are likely millions of stellar-mass black holes roaming the Milky Way Galaxy, those few that have been detected were uncovered by their energetic interactions with a companion star. As material from a nearby star spirals in toward the black hole, it becomes superheated and generates powerful X-rays and jets of material. If a black hole is not actively feeding (i.e., it is dormant) it simply blends in with its surroundings.

“I’ve been searching for dormant black holes for the last four years using a wide range of datasets and methods,” said El-Badry. “My previous attempts—as well as those of others—turned up a menagerie of binary systems that masquerade as black holes, but this is the first time the search has borne fruit.”

The team originally identified the system as potentially hosting a black hole by analyzing data from the European Space Agency’s Gaia spacecraft. Gaia captured the minute irregularities in the star’s motion caused by the gravity of an unseen massive object. To explore the system in more detail, El-Badry and his team turned to the Gemini Multi-Object Spectrograph instrument on Gemini North, which measured the velocity of the companion star as it orbited the black hole and provided precise measurement of its orbital period.

The Gemini follow-up observations were crucial to constraining the orbital motion and hence masses of the two components in the binary system, allowing the team to identify the central body as a black hole roughly 10 times as massive as our sun.

“Our Gemini follow-up observations confirmed beyond reasonable doubt that the binary contains a normal star and at least one dormant black hole,” elaborated El-Badry. “We could find no plausible astrophysical scenario that can explain the observed orbit of the system that doesn’t involve at least one black hole.”

The team relied not only on Gemini North’s superb observational capabilities but also on Gemini’s ability to provide data on a tight deadline, as the team had only a short window in which to perform their follow-up observations.

“When we had the first indications that the system contained a black hole, we only had one week before the two objects were at the closest separation in their orbits. Measurements at this point are essential to

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make accurate mass estimates in a binary system,” said El-Badry. “Gemini’s ability to provide fast-turnaround observations was critical to the project’s success. If we’d missed that narrow window, we would have had to wait another year.”

Astronomers’ current models of the evolution of binary systems are hard-pressed to explain how the peculiar configuration of Gaia BH1 system could have arisen. Specifically, the progenitor star that later turned into the newly detected black hole would have been at least 20 times as massive as our sun.

This means it would have lived only a few million years. If both stars formed at the same time, this massive star would have quickly turned into a supergiant, puffing up and engulfing the other star before it had time to become a proper, hydrogen-burning, main-sequence star like our sun.

It is not at all clear how the solar-mass star could have survived that episode, ending up as an apparently normal star, as the observations of the black hole binary indicate. Theoretical models that do allow for survival all predict that the solar-mass star should have ended up on a much tighter orbit than what is actually observed.

This could indicate that there are important gaps in our understanding of how black holes form and evolve in binary systems, and also suggests the existence of an as-yet-unexplored population of dormant black holes in binaries.

“It is interesting that this system is not easily accommodated by standard binary evolution models,” concluded El-Badry. “It poses many questions about how this binary system was formed, as well as how many of these dormant black holes there are out there.”

“As part of a network of space- and ground-based observatories, Gemini North has not only provided strong evidence for the nearest black hole to date but also the first pristine black hole system, uncluttered by the usual hot gas interacting with the black hole,” said NSF Gemini Program Officer Martin Still.

“While this potentially augurs future discoveries of the predicted dormant black hole population in our Galaxy, the observations also leave a mystery

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to be solved—despite a shared history with its exotic neighbor, why is the companion star in this binary system so normal?”

Phys Org, 4 November 2022

<https://phys.org>

A Caustic Shift Is Coming for the Arctic Ocean

2022-11-02

Imagine, for a moment, that you are standing on a pier by the sea, grasping, somewhat inexplicably, a bowling ball. Suddenly you lose your grip and it tumbles down into the waves below with a decisive plonk. Now imagine that the bowling ball is made of gas—carbon dioxide, to be specific, compressed down into that familiar size and weight. That’s approximately your share, on a rough per capita basis, of the human-caused carbon emissions that are absorbed by the sea every day: Your bowling ball’s worth of extra CO₂, plus the 8 billion or so from everyone else. Since the Industrial Revolution, the oceans have sucked up 30 percent of that extra gas.

The reason so much CO₂ ends up in the oceans is because that molecule is extremely hydrophilic. It loves to react with water—much more than other atmospheric gasses, like oxygen. The first product of that reaction is a compound called carbonic acid, which soon gives up its hydrogen ion. That’s a recipe for a caustic solution. The more hydrogen ions a solution has, the more acidic it is, which is why as the CO₂ in Earth’s atmosphere has increased, its water has gotten more acidic too. By the end of the century, models predict the oceans will reach a level of acidity that hasn’t been seen in millions of years. Prior periods of acidification and warming have been linked with mass die-offs of some aquatic species, and caused others to go extinct. Scientists believe this round of acidification is happening much faster.

That change is striking hardest and fastest in the planet’s northernmost waters, where the effects of acidification are already acute, says Nina Bednaršek, a researcher at Slovenia’s National Institute of Biology. She studies pteropods, tiny sea snails that are also known as “sea butterflies” due to their translucent, shimmering shells that look uncannily like wings. But scoop those snails from Arctic waters, and a close look at their exoskeletons reveals a duller reality. In more corrosive water, the once-pristine shells become flaked and pock-marked—a harbinger of an early death. Those critters are “the canary in the coal mine,” as Bednaršek puts it—a critical part of the food chain that supports bigger fish, crabs, and

Scientists have already begun to observe the ecological effects of acidifying oceans on sea life. The changes ahead may be more drastic.

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mammals, and a sign of coming distress for more species as the oceans become more caustic.

The icy Arctic waters are a special case for several reasons, says Wei-Jun Cai, an oceanographer at the University of Delaware. One is that the ice is melting. It typically acts as a lid on the water underneath it, preventing the exchange of gasses between the atmosphere and the ocean. When it’s gone, the water sucks up the extra CO₂ in the air above it. Plus, that meltwater dilutes compounds that could neutralize the acid. And then it usually just sits there, failing to mix much with the deeper water below. That results in a pool of water near the surface that’s extra acidic. In a study recently published in the journal *Science*, Cai’s team looked at data from Arctic seafaring missions between 1994 and 2020 and concluded that acidification was happening at three to four times the rate of other ocean basins. “Acidification would be fast, we knew. But we didn’t know how fast,” Cai says. The culprit, they surmise, is the rapid decrease in the range of summer ice over those years. Between 1979 and 2021, the end-of-summer ice shrank by an average of 13 percent per decade.

It’s tricky, though, to put specific numbers on the acidification rates across the entire Arctic seascape. In some places, the water is shallow and mixes heavily with meltwater and freshwater from the surrounding continents. In other places, it’s deeper and is currently locked in with ice all year. Ideally, researchers want to have a window into everything: data that’s consistent from year to year, covering a wide territory and varied seasons, capturing the sometimes decades-long churn of ocean currents. Short-term timing matters immensely as well, as local conditions can change drastically on a week-to-week basis depending on factors like the activity of phytoplankton, which may briefly bloom in an area during the summer and suddenly suck up some of the extra CO₂. But it’s tough to get data up there. Scientists studying acidification, like Cai, are peering through a narrow periscope—in his case, relying on summertime voyages across a relatively small portion of the sea, which is still mostly ice-locked.

But there are other ways of deciphering the bigger trends. James Orr, a senior scientist at France’s Atomic Energy Commission, uses global climate models that track trends in ocean salinity, temperature, and the movement of biological forces in the water, such as algae. Then his team can make predictions about where acidification is headed. In a study that recently appeared in *Nature*, Orr and his coauthors found that those models suggest by the end of this century, the usual seasonal pattern of ocean acidity may be turned on its head. Algae blooms normally reduce acidity during the summer. But as the ice melts and shrinks back weeks weeks

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earlier than before, instead of offering a reprieve, summertime is poised to become the period of highest acidity all year. For Orr, that was a startling conclusion. "We thought it would be quite boring, that could be up to a month's shift in the pattern," he says. "But it could be up to six months."

While ocean acidity alone is bad news for many Arctic organisms, Orr points out that the most severe impacts are likely to come from the confluence of many climate-related factors—especially rising water temperatures. Seasonal shifts have the potential to make those effects all the more potent, adds Claudine Hauri, an oceanographer at the University of Alaska, Fairbanks, who wasn't involved in the research. "We have moved on to realizing that ocean acidification doesn't happen on its own," she says. "We have warming. We have decreased salinity. We have less oxygen. Now suddenly there are experiments that show organisms that don't care about acidification alone do care if there are temperature increases too."

At a recent workshop held by the Alaska Ocean Acidification Network, a regional group of experts, an array of results from crab and fish researchers illustrated the wide-ranging effects of changing water. In sum: It's complicated, because the animals themselves are complicated. A species like the king crab may live for decades and progress through many life stages, each of which is best suited for a particular type of aquatic chemistry. It only takes one developmental disruption—of growth as a larva, or during shell-building or reproduction—to throw off the whole lifecycle. Meanwhile, certain species of fish, like Pacific cod, have seen their ability to swim compromised in more acidic water. Others have lost their hearing. Some species seem to do just fine.

A key to better understanding the ecological effects of ocean acidity is learning more about where it is happening, and with what intensity. Even with more attention on acidification, and with more of the Arctic open to research boats as the ice melts, the challenges and expenses of crewed research voyages remain. As an alternative, Hauri's team has been working on an autonomous sub, called the Carbon Seaglider, since 2014. The hot pink vessel, designed to dive 3,000 feet under the surface, is equipped with sensors to pick up CO₂ and methane concentrations. The first research expedition will be launched in February in the Gulf of Alaska, in the Northern Pacific. If all goes well, Hauri imagines a fleet of them sailing further north in the Arctic for years to come.

Wired, 2 November 2022

<https://wired.com>

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Cup lids inspire new way for drones to sense danger

2022-11-03

The study, published in the journal *Advanced Intelligent Systems*, is among the first demonstrations of a metamaterial that uses its shape to learn how to adapt to its surroundings on its own.

Unlike humans and other living beings, autonomous vehicles lack ways to filter out information they don't need, which slows their response time to changes in their environment.

"There's this problem called 'data drowning.' Drones cannot use their full flight capability because there is just too much data to process from their sensors, which prevents them from flying safely in certain situations," says Andres Arrieta, an associate professor of mechanical engineering at Purdue University with a courtesy appointment in aeronautical and astronautical engineering.

Dome-covered surfaces that can sense their surroundings would be a step toward enabling a drone's wings to feel only the most necessary sensory information. Because it only takes a certain minimum amount of force to invert a dome, forces below this threshold are automatically filtered out.

A specific combination of domes popped up and down at certain parts of the wing, for example, could indicate to the drone's control system that the wing is experiencing a dangerous pressure pattern. Other dome patterns could signify dangerous temperatures or that an object is approaching, Arrieta says.

It may seem strange that an invertible dome could give memory cues to a drone wing for dangerous conditions, but humans and animals also use unrelated concepts to recognize relationships. This learning strategy is called associative memory. When you have forgotten the name of a place, for example, you might use a detail such as the color of a building to remember it. Recalling a partial version of the memory allows you to construct a much more complete version of that memory.

Arrieta's lab investigates ways that an engineered material's shape could help it to compute and process information. His lab frequently takes inspiration from how spiders and other animals use their anatomical shapes to sense and understand the world around them.

For decades, electronics have been designed to save and retrieve images by encoding information in patterns of black or white pixels as zeroes or ones. Because a dome can adopt only two states—popped up or popped

The oddly satisfying small domes that you press on your soda's to-go cup lid may one day save a winged drone from a nosedive.

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down—these states can act like zeroes and ones to create spatial patterns for building associative memory.

Arrieta and his team showed in the study that when a certain level of force inverts a dome, sensors embedded into the flat part of a metamaterial sheet surrounding the dome detect the change in shape.

An electrical signal then triggers a memory device called a memristor to make a record of the force and where it was detected on the sheet. With each instance of an inverted dome, the metamaterial learns to remember the pattern that a certain level of force creates on its surface.

In practice, a drone wing would be able to quickly recall a pattern associated with a dangerous condition because the metamaterial keeps a record of all its “partial memories” from inverted dome patterns as a single “complete memory” that these patterns create altogether.

Based on this study, the researchers believe that the metamaterial wouldn't need to “buffer” to recall information that it stores within itself over time. Since the metamaterial can be manufactured with existing methods, these domes can easily cover a large surface area like a drone's wing, Arrieta says.

Next, the researchers will test how the material responds to its surroundings based on information it learns from the domes. Arrieta anticipates that it will be possible to build a drone wing using this material design in the next three to five years.

Additional coauthors are from the University of Tennessee, Knoxville and Purdue. The Defense Advanced Research Projects Agency, the National Science Foundation, and the Indiana Space Grant Consortium funded the work.

Futurity, 3 November 2022

<https://futura.org>

Physicists Create First Quasiparticle Bose-Einstein Condensate – The Mysterious “Fifth State” of Matter

2022-11-05

Physicists have created the first Bose-Einstein condensate — the mysterious “fifth state” of matter — made from quasiparticles. These are entities that do not count as elementary particles, although they can still have elementary-particle properties such as charge and spin.

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For decades, it was unknown whether quasiparticles could undergo Bose-Einstein condensation in the same way as real particles, and it now appears that they can. This discovery is set to have a significant impact on the development of quantum technologies including quantum computing.

A paper describing the process of creation of the substance, which was achieved at temperatures just a tiny bit above absolute zero, was published recently in the journal *Nature Communications*.

Bose-Einstein condensates are sometimes described as the fifth state of matter, alongside solids, liquids, gases, and plasmas. Theoretically predicted in the early 20th century, Bose-Einstein condensates, or BECs, were only created in a lab as recently as 1995. They are also perhaps the strangest state of matter, with a great deal about them remaining unknown to science.

BECs occur when a group of atoms is cooled to within billionths of a degree above absolute zero. Researchers commonly use lasers and “magnet traps” to steadily reduce the temperature of a gas, typically composed of rubidium atoms. At this ultracool temperature, the atoms barely move and begin to exhibit very strange behavior. They experience the same quantum state — almost like coherent photons in a laser — and start to clump together, occupying the same volume as one indistinguishable “super atom.” The collection of atoms essentially behaves as a single particle.

Currently, BECs remain the subject of much basic research, and for simulating condensed matter systems, but in principle, they have applications in quantum information processing. Quantum computing, still in early stages of development, makes use of a number of different systems. But they all depend upon quantum bits, or qubits, that are in the same quantum state.

Most BECs are fabricated from dilute gases of ordinary atoms. But until now, a BEC made out of exotic atoms has never been achieved.

Exotic atoms are atoms in which one subatomic particle, such as an electron or a proton, is replaced by another subatomic particle that has the same charge. Positronium, for example, is an exotic atom made of an electron and its positively charged anti-particle, a positron.

An “exciton” is another such example. When light hits a semiconductor, the energy is sufficient to “excite” electrons to jump up from the valence level

For decades, it was unknown whether quasiparticles could undergo Bose-Einstein condensation in the same way as real particles, and it now appears that they can.

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of an atom to its conduction level. These excited electrons then flow freely in an electric current — in essence transforming light energy into electrical energy. When the negatively charged electron performs this jump, the space left behind, or “hole,” can be treated as if it were a positively charged particle. The negative electron and positive hole are attracted and thus bound together.

Combined, this electron-hole pair is an electrically neutral “quasiparticle” called an exciton. A quasiparticle is a particle-like entity that does not count as one of the 17 elementary particles of the standard model of particle physics, but that can still have elementary-particle properties like charge and spin. The exciton quasiparticle can also be described as an exotic atom because it is in effect a hydrogen atom that has had its single positive proton replaced by a single positive hole.

Excitons come in two flavors: orthoexcitons, in which the spin of the electron is parallel to the spin of its hole, and paraexcitons, in which the electron spin is anti-parallel (parallel but in the opposite direction) to that of its hole.

Electron-hole systems have been used to create other phases of matter such as electron-hole plasma and even exciton liquid droplets. The researchers wanted to see if they could make a BEC out of excitons.

“Direct observation of an exciton condensate in a three-dimensional semiconductor has been highly sought after since it was first theoretically proposed in 1962. Nobody knew whether quasiparticles could undergo Bose-Einstein condensation in the same way as real particles,” said Makoto Kuwata-Gonokami, a physicist at the University of Tokyo and co-author of the paper. “It’s kind of the holy grail of low-temperature physics.”

The researchers thought that hydrogen-like paraexcitons created in cuprous oxide (Cu₂O), a compound of copper and oxygen, were one of the most promising candidates for fabricating exciton BECs in a bulk semiconductor because of their long lifetime. Attempts at creating paraexciton BEC at liquid helium temperatures of around 2 K had been made in the 1990s, but failed because, in order to create a BEC out of excitons, temperatures far lower than that are needed. Orthoexcitons cannot reach such a low temperature as they are too short-lived. Paraexcitons, however, are experimentally well known to have an extremely long lifetime of over several hundred nanoseconds, sufficiently long to cool them down to the desired temperature of a BEC.

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The team managed to trap paraexcitons in the bulk of Cu₂O below 400 millikelvins using a dilution refrigerator, a cryogenic device that cools by mixing two isotopes of helium together and which is commonly used by scientists attempting to realize quantum computers. They then directly visualized the exciton BEC in real space by the use of mid-infrared induced absorption imaging, a type of microscopy making use of light in the middle of the infrared range. This allowed the team to take precision measurements, including the density and temperature of the excitons, that in turn enabled them to mark out the differences and similarities between exciton BEC and regular atomic BEC.

The group’s next step will be to investigate the dynamics of how the exciton BEC forms in the bulk semiconductor, and to investigate collective excitations of exciton BECs. Their ultimate goal is to build a platform based on a system of exciton BECs, for further elucidation of its quantum properties, and to develop a better understanding of the quantum mechanics of qubits that are strongly coupled to their environment.

Sci Tech Daily, 5 November 2022

<https://scitechdaily.com>

Modified blood cells deliver antibiotics to kill dangerous bacteria

2022-11-03

Drugs given to the whole body can be too much of a shotgun approach, damaging cells that aren’t meant to be targeted. A new study has found that cloaking drugs inside red blood cells could help guide powerful but toxic antibiotics to target bacteria.

Bacteria are increasingly developing resistance to our best antibiotics, leaving doctors with fewer and fewer treatment options. In many cases, we’re down to our last-resort drugs, such as those that induce severe side effects within the body.

But there may be ways to target these drugs more precisely. A few years ago scientists at McMaster University in Canada developed what they called “super-human red blood cells” – essentially, they pull out the innards of normal blood cells and stuff them full of drugs instead. When the hybrid blood cells are injected back into the body, they theoretically should be able to carry the drug payload safely, without the immune system attacking them.

A new study has shown that modified blood cells can help carry antibiotics to drug-resistant bacteria selectively.

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In the new study, the team tackled a remaining problem – how do you get the hybrid blood cells to home in on the desired target? They coated the outside of the blood cells in an antibody that targeted the bacteria species they were trying to kill, which makes them accumulate around the bugs and deliver their drug payload more precisely.

The researchers tested the drug delivery system with an antibiotic called Polymyxin B (PmB), which is effective at killing bacteria that are resistant to other drugs. But that comes at a cost to healthy cells, with the potential for kidney damage, neurological problems, and other serious side effects. As such, it's considered a last-resort antibiotic.

In cell culture tests in vitro, the team loaded the blood cells with PmB and targeted them to drug-resistant *E. coli*. They found that the cells had a loading efficiency of around 90%, and were effective in delivering PmB to the bacteria in levels high enough to kill them. To test the targeting, the team also exposed a different bacterium, *Klebsiella aerogenes*, to the hybrid cells coated with *E. coli* antibodies, and found that they were insufficient to kill the bugs. That, the team says, shows that the selective targeting works.

The researchers say that this approach has a number of advantages. Not only does it keep the drug payload from affecting healthy cells, but because red blood cells have a long lifespan of around 120 days, they have plenty of time to reach the targeted sites. The technique could also reduce the number of doses required and the amount of drug per dose.

"Essentially, we are using red blood cells to conceal this antibiotic within so it can no longer interact or harm healthy cells as it passes through the body," said Hannah Krivic, lead author of the study. "We designed these red blood cells so they could only target bacteria we want them to target."

The team says that future work will investigate the technique's potential for delivering drugs across the blood-brain barrier to the brain to help treat neurological diseases such as Alzheimer's.

The research was published in the journal *ACS Infectious Diseases*.

New Atlas, 3 November 2022

<https://newatlas.com>

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The Mysteries of the Astronaut Microbiome

2022-11-02

Space poses some dangers for humans, from black holes to the heat death of the universe. But as humanity considers long-haul space travel, there are other, smaller potential hazards that some researchers say may deserve more attention: microbes from Earth.

Astronauts face numerous known health problems in space, including a loss in bone density, muscle atrophy, and psychological issues. And on Earth, researchers are increasingly discovering how the various bacteria and other microorganisms that live inside and outside of people — the human microbiome — affect physical and mental health.

Space, of course, is an entirely different environment from Earth, with high radiation levels and microgravity. Although the science is far from certain, these vast differences may cause unexpected changes in the microbiome of astronauts. In turn, this could result in a range of health problems, which may be more pronounced on long-haul stints in space, like traveling to another planet.

Still, the implications of a disrupted microbiome are poorly understood, even on Earth, said David Pearce, a bioscience researcher at Northumbria University and author of a 2022 paper exploring how a trip to Mars might affect microbes in the gut — which makes the range of related illnesses and diseases in space difficult to predict. And direct research is limited because only around 600 people have ever been to space. Those who have taken the trip don't typically stay long, as the average length of a trip to the International Space Station is about six months. And some researchers aren't yet convinced there's enough evidence suggesting the human microbiome will change much in space at all.

All the same, many researchers, including Pearce, are trying to figure out whether or not astronauts will enter a state in which their microbiome changes in adverse ways, called dysbiosis. "Because they're going to be away for a long time, will that dysbiosis become a significant problem," he said, "or lead to them having health impacts that impair their ability to function?"

Researchers try to understand the possible effects of space on the microbiome in two places: terrestrial settings that are similar in some way to those experienced in space, or in space itself. In an example of the former, Norberto González-Juarbe, a principal investigator with the astronaut microbiome research group at J. Craig Venter Institute's

The human microbiome has been linked to digestion, depression, and more. How might space travel change it?

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Infectious Diseases and Genomic Medicine Group, is looking at the microbiomes of researchers who work in the Concordia and Neumayer stations in Antarctica. He said that these locations mimic, in part, what astronauts experience in space, particularly the darkness, confinement, and limited human contact.

The team plans to analyze samples from the researchers at these stations to see how the microbial composition of their gastrointestinal tracts changes, and how their immune systems react to the space station-like conditions. According to González-Juarbe, early results show shifts in gut microbes, and the team is currently looking at the immunological data. He expects to publish the results by the end of this year.

As for studies conducted in space, there are a few. One 2019 study, for instance, compared the microbiomes of astronaut Scott Kelly and his twin brother, Mark, after the former went to the ISS for nearly a year starting in 2015. The study posited that Scott Kelly's microbiome did indeed change in space. For him, this included a reduction in bacteria called Bacteroidetes, the dysregulation of which has been linked to neurological, immune system, and metabolic issues, as well as increase in Firmicutes, a type of bacteria that can help break down certain starches and fibers.

In 2019, another study from the J. Craig Venter Institute looked at nine astronauts who spent between 6 and 12 months on the ISS. The astronauts collected samples from various patches of their skin, noses, and tongues. The astronauts also collected stool, blood, and saliva, along with samples from various surfaces in the station and its water reservoir.

Back on Earth, the study authors extracted and sequenced the DNA from the samples to see how the astronauts' microbiomes changed over time. The study found that various skin microbes, including types of Gammaproteobacteria, decreased in number, which the authors theorize could contribute to the common phenomenon of rashes and skin hypersensitivity among astronauts in space. The findings also suggested that the astronaut's gastrointestinal microbiome changed, and that two types of bacteria — Akkermansia and Ruminococcus, which seem to play important roles in maintaining mucus integrity in the digestive tract and in breaking down carbohydrates — saw a five-fold decrease.

Gut microbiome changes can impact the metabolism of food, bone health, and even cognition, said González-Juarbe, who was not part of the 2019 study. Longer stints in space — like the 18 months to Mars and back — would likely compound these issues. "The saying, 'You are what you eat,' is

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kind of true," he said. "Changes in the overall microbiome will have effects on your overall brain health, and your cognitive health."

Not everyone is convinced that the human microbiome changes in space, however. Existing studies have too few subjects to draw any conclusions, according to Jack Gilbert, a professor of pediatrics at the University of California San Diego and biology section head for the Scripps Institution of Oceanography. "With so few people up there," he added, "doing any studies with any statistical rigor is so hard."

Gilbert is also skeptical of the Kelly twin study: "We have lots of twin studies we compared over time on Earth, and they all show significant deviations from each other."

Potentially more concerning for human health in space are microbes that could escape the body and become more dangerous, Gilbert said. A 2019 study by Gilbert and his colleagues suggests this might be the case. In March 2016, astronauts in the ISS collected samples from the station's dining room table. Six days later, the samples were brought back to Earth. Gilbert and his team then isolated the microbes in the sample, selected two strains of the fungus *Fusarium oxysporum*, and sequenced their genes.

The team then compared the isolated fungi samples to 62 other strains and found that the genetics from the ISS samples differed from those of their terrestrial counterparts. The team also subjected small worms called nematodes to both samples. They found that some of the microbes that had come from the ISS killed more of these worms.

Gilbert said that it's possible fungus becomes more pathogenic in response to the harshness of space, although his team is working on a new study to help clarify that connection. Microbes prefer warm, moist areas, like the environment inside the human body. So, microbes that escape from that habitat onto the cold, dry surfaces — also subject to radiation and a lack of gravity — can pick up new survival skills over generations, he said. "Unfortunately," he added, "some of those survival strategies are associated with things like antibiotic resistance or enhanced virulence against humans."

Gilbert noted that astronauts chosen to go to space are often incredibly healthy, so the chances of them getting sick from one of these rogue microbes is small. However, if someone on a long trip to Mars has a weakened immune system from food poisoning or exhaustion, he added, they could be infected by "these hardcore, Mad Max survivors."

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The existing research on the human microbiome in space leaves plenty of unknowns, according to all of the researchers who spoke to Undark. For instance, Nicole Buckley, team leader with the European Space Agency's SciSpacE — or science of space environment — program noted that it's difficult to say if any ailments in space, like loss of sleep, are caused by microbial disruptions, or if the microbes are just contributing or reacting to other ailments.

Also unclear, so far, is how researchers can restabilize a person's microbiome in space, should it be thrown out of whack to the point of illness, Pearce said. For example, fecal transplant — which involves transplanting beneficial bacteria from the stool of a healthy donor into someone who is ill — can help restore immune functions for people with certain diseases. But because microbiomes are so complex, "it's not like administering a drug that has an outcome," he said. "You're administering an organism that may become established and have a desirable outcome, or it may not become established and not have the outcome you're hoping for."

Some of the researchers noted, however, that fairly simple changes could make a difference for astronauts. González-Juarbe said that providing fresh fruits and vegetables and high-fiber foods can foster microbes that produce short-chain fatty acids in the stomach, which helps support the immune system. Buckley noted that pre- and probiotic foods could also help in this area.

Astronauts in space do have access to freeze-dried foods, according to an email from Grace Douglas from NASA's Advanced Food Technology Project, which have "normal levels of food-relevant microorganisms," but are processed to avoid containing any pathogens. Astronauts also receive small amounts of fresh fruits and vegetables via resupply missions. Still, according to Buckley, a healthy microbiome requires limiting processed foods and even more fresh fruits and vegetables and high-fiber foods.

The ESA is currently working on a study in which they provide compounds found in human breast milk called oligosaccharides, a linked group of carbohydrates, to the diets of researchers staying at the Concordia research station in the Antarctic for more than a year. These compounds are believed to be important in creating healthy microbiomes in babies. The study will test the oligosaccharides' impact on the researchers' microbiomes, immune systems, and mood.

There are still other fields that need to be explored that could further science's understanding of space's effect on the human microbiome. For

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instance, there's a need for more information about individual astronauts and their microbial equilibriums, what causes their microbiomes to become stable or unstable, Pearce said.

Pearce added that astronauts may encounter familiar opportunistic pathogens — microbes that are usually benign, but can become dangerous when a person's immune system weakens, among other factors — like those responsible for MRSA, which is found in 2 percent of people. But there could be "unknown unknowns" in this area, he said: microbes that humans will carry into space that have the undiscovered potential to become pathogenic.

Right now, there's also no telling how the human microbiome would change on a long trip to Mars, compared to a relatively short stay on the ISS, Pearce said. But considering the timescale of spaceflight to the red planet — which NASA plans for the late 2030s or early 2040s — scientists have plenty of time to better understand the role the microbiome may play for astronauts' health, he added. Until then, Pearce said that researchers should continue using the means available to them, whether they're terrestrial studies that mimic space, studies in space itself, or simply tests that aim to better understand the microbiome of humans that are safely on the ground. "There's no one way we're going to get an answer for this," he said.

Undark, 2 November 2022

<https://undark.org>

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