CHEMWATCH

Bulletin Board

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GOSSIP

CURIOSITIES

TECHNICAL NOTES

ASIA PACIFIC

India Delays Quality Control Orders for 6 Fatty Acids

2023-04-27

Once implemented, the QCOs shall mandate manufacturer of the 8 chemicals to apply for Grant of License by Bureau of Indian Standard to use the Standard Mark.

Updates: On April 24, 2023, India's Department of Chemicals and Petrochemicals (DCPC) issued a Notification on the gazette regarding the delayed implementation of Quality Control Orders (QCOs) for 6 types of fatty acids.

Originally planned to be implemented this month, new implementation date is set out for the 6 chemicals as follows:

Goods or Articles	Titile of Indian Standard	Implementation Date
Lauric Acid	IS 10931:1984 Lauric Acid — Specification	October 24, 2023
Acid Oil	IS 12029:1986 Acid Oil — Specification	October 24, 2023
Palm Fatty Acids	IS 12067:1987 Palm Fatty Acids — Specification	October 24, 2023
Rice Bran Fatty Acids	IS 12068:1987 Rice Bran Fatty Acids — Specification	October 24, 2023
Coconut Fatty Acids	IS 12069:1987 Coconut Fatty Acids — Specification	October 24, 2023
Hydrogenated Rice Bran Fatty Acids	IS 12361:1988 Hydrogenated Rice Bran Fatty Acids — Specification	October 24, 2023

On April 27, 2022, India's Ministry of Chemicals and Fertilizers published Quality Control Orders (hereinafter referred as the Orders) for 8 chemicals, which will come into force 181 days after their promulgation in the Official Gazette.

The Orders do not apply to chemicals for export only. The chemical products conforming to the requirements of the Orders shall bear the Standard Mark under a license from the Bureau of Indian Standards. Any

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person who contravenes the provisions of the Orders shall be punished according to the Bureau of Indian Standards Act (BIS Act), 2016.

Read More

Chemlinked, 27-04-23

https://chemical.chemlinked.com/news/chemical-news/india-publishes-quality-control-orders-for-8-chemicals

Variation of Inventory listing following revocation of CBI approval - 4 May 2023

2023-05-04

The Executive Director varied the terms of the Inventory listings for the following chemicals because approval had been revoked for the proper names of the industrial chemicals to be treated as confidential business information (CBI). The terms of the listings as varied are:

CAS number	2919696-28-7
Chemical name	Titanium, bis(2,4-pentanedionato-.kappa.O2,.kappa.O4)bis(2-propanolato)-, reaction products with 1-ethenyl-1H-imidazole and hydrogenated 1-decene homopolymer
Molecular formula	Unspecified
Specific information requirements	Obligations to provide information apply. You must tell us within 28 days if the circumstances of your importation or manufacture (introduction) are different to those in our assessment.
Listing date	27 April 2023

CAS number	2919696-30-1
Chemical name	Molybdenum, borate neodecanoate oxo complexes, reaction products with 1-ethenyl-1H-imidazole and hydrogenated 1-decene homopolymer
Molecular formula	Unspecified
Specific information requirements	Obligations to provide information apply. You must tell us within 28 days if the circumstances of your importation or manufacture (introduction) are different to those in our assessment.

CAS number	2919696-30-1
Listing date	27 April 2023

Published date

4 May 2023

Read More

AICIS, 04-05-23

https://www.industrialchemicals.gov.au/news-and-notices/variation-inventory-listing-following-revocation-cbi-approval-4-may-2023

Review of guidelines for determining a minor use

2023-05-04

The Australian Pesticides and Veterinary Medicines Authority (APVMA) is reviewing its guidelines for determining a minor use, to ensure they remain fit for purpose in a modern regulatory environment.

Minor use permits are issued by the APVMA to allow for the legal use of agricultural and veterinary chemicals in situations where registration of the product would not produce sufficient economic return.

The APVMA has developed guidance to assist applicants in determining whether a particular use can be defined as a minor use. These guidelines were first developed in the early 2000s and have since received minimal updates. As the agricultural landscape has changed over time, crops that were once considered major may now command only a small market share, whereas previously minor crops may have seen a surge in popularity or value.

The APVMA is seeking public feedback on the guidance in its current form and input into factors that should be considered during the update. The closing date for submissions is 15 June 2023. More information on how you can make a submission is available on the APVMA website.

Once the new guidelines are developed, there will be a second round of public consultation and the APVMA will seek feedback on the new guidelines.

Questions about the project can be directed to enquiries@apvma.gov.au.

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APVMA, 04-05-23

http://apvma.gov.au/node/112466

Hong Kong: Increased penalties for breaching occupational safety and health requirements

2023-04-28

In Brief

On 28 April 2023, the Occupational Safety and Occupational Health Legislation (Miscellaneous Amendments) Ordinance 2023 ("Ordinance") took effect upon gazettal.

Employers who breach the statutory occupational safety and health requirements in Hong Kong will now be subject to significantly higher fines and imprisonment for up to two years.

Key Takeaways

The Ordinance seeks to enhance the deterrent effect of the occupational safety and health offenses under the Factories and Industrial Undertakings Ordinance (Cap. 59) (FIUO) and the Occupational Safety and Health Ordinance (Cap. 509) (OSHO) by increasing the maximum fines for certain offenses. The key changes introduced by the Ordinance include the following:

- The maximum liability of an employer that breaches the general duty under Section 6A FIUO and Section 6 OSHO to ensure its employees' health and safety at work has increased to a fine of HKD 3 million upon summary conviction, and to a fine of HKD 10 million upon indictment. Where the employer contravenes such general duty willfully and without reasonable excuse, the penalty on summary conviction is now HKD 3 million and imprisonment for 6 months and on conviction on indictment, HKD 10 million and two years' imprisonment.
- Where an employer is convicted on indictment, the court must consider the turnover of the employer's business and other financial information given by the employer in assessing the appropriate fine.
- Other less serious offenses relating to occupational safety and health committed by employers are also subject to heavier fines. These summary offenses can be broadly grouped into three categories.

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Global Compliance News, 28-04-23

https://www.globalcompliancenews.com/2023/05/06/https-insightplus-bakermckenzie-com-bm-employment-compensation-hong-kong-increased-penalties-for-breaching-occupational-safety-and-health-requirements_05022023/

AMERICA

Legislators condemn manufacturers that added sesame in response to allergy labeling law

2023-05-04

In recent years, the prevalence and severity of sesame allergies in the United States set policymakers on the course to make the seed a major allergen. This means its presence in products and even manufacturing facilities needs to be explicitly disclosed on product labels.

In 2021, the bill that led to this mandate, known as the FASTER Act, passed the Senate with unanimous consent and made it through the House of Representatives on a roll call vote of 415-11.

Sesame, a common ingredient in some baked goods, is unlike most of the other top allergens — milk, eggs, soy, wheat, peanuts, tree nuts, fish and shellfish. While it's easy to control where milk or nuts are, and an entire industry has grown around gluten-free products, sesame is small and scatters easily.

The law requires that if a product is sesame-free, the manufacturing facilities in which it is made must be carefully cleaned to avoid cross-contamination. Because of the challenges involved with taking that step, some manufacturers are now adding a small amount of sesame — either as seeds or a ground flour — to all products so that sesame is accurately disclosed as an ingredient on their labels.

"Given current production operations in hundreds of bakeries coupled with the existing FDA regulatory scheme (which essentially requires recalls for any products with traces of sesame, even if they have the 'may contain sesame' statement), including sesame and labeling it as an allergen is the most realistic and safest way to protect allergic consumers," Rasma Zvaners, ABA's vice president of regulatory and technical services, wrote in a blog post on the trade group's website last week.

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Advocacy groups and the legislators' letter say this practice is not following the spirit of the law, which was intended to prevent putting consumers at risk. The legislators' letter also notes that the ABA publicly agreed compliance would not be a problem after Biden signed the law in 2021.

Consumers who are used to dealing with sesame allergies know the brands and products to buy to avoid problems. When some manufacturers started adding sesame to their ingredient list in response to the law, some of these consumers were unaware and unintentionally purchased products that provoked allergic reactions.

Read More

Food Dive, 04-05-23

https://www.fooddive.com/news/legislators-condemn-sesame-allergen-added-bakers/649380/

Warehouses are afflicting air and noise pollution on millions of Americans

2023-05-03

Warehouses are cropping up all over the US thanks to e-commerce. That's bringing truck traffic and tailpipe emissions closer to neighborhoods and disproportionately afflicting communities of color.

With millions of Americans now living in close proximity to a warehouse, it's time to start treating these drab, feature-less buildings like pollution hotspots, says a recent report by the Environmental Defense Fund. Warehouses are quickly popping up all over the US, bringing truck traffic and tailpipe emissions with them. And yet there is no federal database to see where current or proposed warehouses are located, unlike other major sources of pollution like oil and gas facilities.

In the absence of federal data, the nonprofit Environmental Defense Fund (EDF) completed its own analysis of warehouses in the 10 states where they've gained tremendous ground recently. Over the past decade, warehouses have surpassed office spaces to become the most common type of commercial building in the US.

At least 15 million people, including more than a million children under the age of five, live within a half-mile of a warehouse, the Environmental Defense Fund (EDF) found. And a warehouse isn't your average neighbor. Warehouses often operate around the clock, bringing in a steady stream

of truck traffic and delivery vans. Communities of color were more likely to see one crop up in their backyard, according to the report, which suggests they're disproportionately dealing with the public health risks.

Read More

The Verge, 03-05-23

https://www.theverge.com/2023/5/3/23706826/warehouse-pollution-ecommerce-edf-report

Hundreds of gas plants could escape EPA climate rules

2023-05-03

About 1,000 natural gas-fired power plants that provide energy at periods of peak demand could be excluded from the toughest standards under EPA's upcoming carbon rules.

These plants are often located in urban areas, raising concern among some environmental advocates that the agency's climate rules on power plants could lead to increased pollution in low-income communities.

"That's a big concern with us, with what we think is going to come out in the new rules," said Shelley Robbins, project director at the nonprofit Clean Energy Group.

Read More

Climate Wire, 03-05-23

https://www.eenews.net/articles/hundreds-of-gas-plants-could-escape-epa-climate-rules/

Canada working towards zero plastic waste

2023-05-04

Canadian government plans to establish federal plastics registry and release regulatory framework for plastic packaging; aim to improve knowledge of plastic waste, value recovery, and pollution; measures are open for comment until May 18, 2023; NGO urges government to expand ban on non-recyclable plastic packaging and take further action.

On April 18, 2023, the Canadian government published a technical paper on its plans of moving forward with establishing a federal plastics registry to improve knowledge of plastic waste, value recovery, and pollution across the country. The registry will provide important information to

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inform future compliance promotion and enforcement activities and will help identify gaps in the plastics value chain where further government action may be required.

Currently, data collection requirements for extended producer responsibility (EPR) programs are inconsistent across Canada, making it difficult to measure their performance across the country. The federal plastics registry aims to standardize the data collected on such programs and provide useful information for stakeholders and the government. The data will be open and accessible to all Canadians, including researchers.

In addition to that, the Canadian government also released the regulatory framework paper on recycled content and labelling rules for plastics on April 18, 2023. The document provides a comprehensive and up-to-date overview of the regulatory approach that the government is proposing for the draft regulations that are currently being developed.

Read More

Food Packaging Forum, 04-05-23

https://www.foodpackagingforum.org/news/canada-working-towards-zero-plastic-waste

High Levels of Toxic Metals Found in Widely Consumed Drinks: Study

2023-05-05

A new study has found that some commonly consumed beverages such as fruit juice and artificial soda contain levels of toxic metals including arsenic, cadmium, and lead that exceed federal drinking water standards.

Researchers from Tulane University, Louisiana, measured 25 different toxic metals and trace elements in 60 soft beverages, including single fruit juice, mixed fruit juice, plant-based milk, artificial soda, and tea.

The drinks were purchased in New Orleans and are commercially available in supermarkets across the United States.

Researchers found that five of the 60 beverages tested contained levels of a toxic metal above federal drinking water standards.

Two mixed juices had levels of arsenic above the 10 microgram/liter standard. Meanwhile, a cranberry juice, a mixed carrot and fruit juice, and

an oat milk each had levels of cadmium exceeding the three parts per billion standard.

What Are Arsenic and Cadmium?

Arsenic is a naturally occurring tasteless, colorless, and odorless, chemical element that can be found in the environment, including in food and water, according to the Centers for Disease Control and Prevention (CDC). The element persists in the environment and does not deteriorate.

The U.S. Environmental Protection Agency (EPA) adopted a 10 parts per billion (ppb), or 10 microgram/liter standard for arsenic in public drinking water in 2001, replacing the old standard of 50 microgram/liter.

However, long-term exposure to high levels of arsenic can result in skin disorders, an increased risk for diabetes, high blood pressure, and several types of cancer, according to the CDC.

Cadmium, meanwhile, is another naturally occurring element used in products such as batteries, pigments, metal coatings, and plastics but also found in plant and animal foods, according to the CDC.

When consumed in large amounts, cadmium can cause stomach issues and when inhaled at high levels, it can lead to lung damage or death. Cadmium is considered a cancer-causing agent.

"Exposure to low levels of cadmium in air, food, water, and particularly in tobacco smoke over time may build up cadmium in the kidneys and cause kidney disease and fragile bones," the CDC notes.

Read More

NTD, 05-05-23

https://www.ntd.com/high-levels-of-toxic-metals-found-in-widely-consumed-drinks-study_917559.html

EUROPE

EU Vigorously Advances Animal Testing Alternatives, OECD 416 and UDS Removed

2023-04-28

The European Commission has recently published regulation (EU) 2023/464, which amends Annex Regulation (EC) No 440/2008, a set of

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test methods under the Registration, Authorization and Restriction of Chemicals (REACH) regulation.

In this amendment, a number of new OECD in vitro test methods are introduced while some old test methods are removed such as Two-Generation Reproduction Toxicity Study (OECD 416) and Unscheduled DNA Synthesis (UDS) Test with Mammalian Liver Cells in vivo (OECD 486), which promotes the application of in vitro test methods in the EU.

Based on this amendment, in the following article, we have summarized the significant changes in test methods based on the testing requirements of the REACH regulation.

1. Serious eye damage/eye irritation

OECD Test Guideline 467, Defined Approaches for Serious Eye Damage and Eye Irritation, is introduced. With OECD 467, categories of test chemicals can be made based on in vitro tests without conducting further in vivo tests in most cases. In the following flowchart, one of the methods from OECD 467 is given. When conducting tests, the physiochemical properties of test chemicals, such as water solubility, vapor pressure, Kow, the physical state of test chemicals, and surface tension, should be taken into account. With the combination of OECD 492 and OECD 437, category prediction of test chemicals can be made as Not classified, Category 1, or Category 2. One can also combine OECD 491 with OECD 437 to make category prediction of test chemicals as Not Classified, Category 1, or Category 2.

Read More

CIRS, 28-04-23

https://www.cirs-group.com/en/chemicals/eu-vigorously-advances-animal-testing-alternatives-oecd-416-and-uds-removed

Commission proposes simplified, clearer and digital rules for detergents in the Single Market

2023-04-28

Today, the Commission proposed a revised Regulation on detergents that simplifies and future-proofs the current rules to better protect health and the environment, as well as ensure the better functioning of the Single Market for detergents. The revised rules cover new innovative products like detergents containing micro-organisms and sustainable new practices

like the refill sale of detergents. The new rules also introduce a digital labelling and a product passport for detergents and surfactants.

This proposal updates the existing rules in line with the objectives of the European Green Deal, the Chemicals Strategy for Sustainability and the recently adopted Commission Communication on the long-term competitiveness of the EU.

In particular, the proposal will:

- Simplify market rules by abolishing several requirements that have now become unnecessary or redundant: among those, such as: i) the obligation to provide an ingredient data sheet for hazardous detergents; ii) the obligatory intervention of approved laboratories that had to perform the tests under the Regulation; iii) the possibility to request a derogation for surfactants that do not meet the criterion of ultimate biodegradability; and iv) the obligation for manufacturers of detergents and surfactants to be established within the Union. Additionally, labels will also be simplified and streamlined to reduce the administrative burden for the detergents' industry and, at the same time, increase the understandability of labels by end-users.
- Introduce voluntary digital labelling: the proposal differentiates between pre-packaged products and products sold in a refill format. For pre-packaged products, economic operators may choose to move certain mandatory labelling information to a digital label, in combination with a physical one. And for products sold in a refill format, the possibility to provide all labelling information, except for dosage instructions for consumer laundry detergents, only digitally. The introduction of digital labelling will reduce burden and costs for industry and will provide further ease of use and awareness for consumers and professional users.
- Facilitate the sales of innovative safe products: the detergents sector has recently developed new innovative cleaning products that work on the action of micro-organisms. As these micro-organisms may present promising alternatives to harmful chemicals, the revised Regulation will introduce safety requirements for micro-organisms in detergents and the obligation for manufacturers to label the presence of micro-organisms in the detergents so that consumers are better informed. This will not only allow these products to move freely in the Single Market but also contribute to protecting health and the environment.
- Increase sustainability and safety through clear rules for refilled detergents: The proposal ensures that consumers receive the necessary information when buying refilled detergents. The proposal clarifies that refilled detergents are subject to the same rules as pre-packaged detergents. The proposal also introduces voluntary digital labelling for refilled detergents as a means of further facilitating this sustainable practice, which reduces the amount of packaging and packaging waste.

Read More

European Commission, 28-04-23

https://ec.europa.eu/commission/presscorner/detail/en/ip_23_2481

FPF submits feedback on packaging and packaging waste regulation

2023-04-07

Food Packaging Forum (FPF) responds to European Commission's call for feedback on the proposed packaging and packaging waste regulation (PPWR); FPF highlights aspects of food packaging and chemical safety that should be included in future versions; primarily (i) considering presence of hazardous chemicals in packaging materials meant to be recycled or reused, (ii) clearly defining compostable packaging and guaranteeing safety, and (iii) defining inertness

Members of the Food Packaging Forum (FPF) submitted feedback highlighting aspects of food packaging and chemical safety that FPF believes should be included in future versions of the packaging and packaging waste regulation (PPWR).

It is particularly important to consider food packaging in this process as, according to Eurostat, it makes up around 30% of overall household waste in the EU, and it strongly contributes to plastic littering (FPF reported). The revision of the PPWR is therefore an important opportunity for effective measures on hazardous components of food packaging. FPF's primary concerns are (i) the presence of hazardous chemicals in packaging materials meant to be recycled or reused, (ii) the definition of compostable packaging- it should include chemical safety and a time limit, and (iii) the current lack of a definition of inertness in the EU. A shortened version of the comment follows.

Read More

FPF, 27-04-23

https://www.foodpackagingforum.org/news/fpf-submits-feedback-on-packaging-and-packaging-waste-regulation

Labour plans new water regulator for England and Wales

2023-05-05

Party to propose creation of fresh bodies to tackle sewage outflows and flood risks

The Labour party is drawing up plans to create a new water regulator as it seeks to address public anger over the dumping of raw sewage in Britain's rivers, lakes and beaches. Under the proposals, a Labour government would merge most of the Environment Agency, the pollution watchdog, with the financial regulator Ofwat and the Drinking Water Inspectorate to create a new oversight body, according to people familiar with the plans.

The party would also create a separate flooding agency with the remnants of the Environment Agency to protect communities in England and Wales in the case of extreme weather events. With a general election expected next year and Labour showing strong gains in the local elections this week, there is growing focus on the party's policy agenda. Public outrage around the practice of water companies tipping raw sewage and storm water into Britain's waterways has become a political priority in recent months. The scandal has prompted widespread protests and led to beaches being closed for swimming several days last summer with a repeat expected this year. Ofwat regulates the water and sewerage industry in England and Wales, which is made up of privatised regional monopolies.

Read More

Financial Times, 05-05-23

https://www.ft.com/content/602a009b-6a41-4528-9804-22f7a5080cc3

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REACH committee votes to restrict intentional microplastics

2023-04-23

The Commission welcomes the positive vote of the EU countries on the REACH committee for its proposal to restrict microplastics that are intentionally added to products.

Issued under the European chemical legislation REACH, the Commission's proposal follows the European Chemicals Agency's findings that microplastics pose a risk to the environment that is not adequately controlled.

It is estimated that over 20 years, the proposed restriction would prevent the release in the environment of about half a million tonnes of microplastics, at an estimated total cost up to €19 billion. The proposal will now be subject to a 3-month scrutiny by the European Parliament and the Council before it can be adopted by the Commission.

Details

Publication date

27 April 2023

Author

Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs

Read More

European Commission, 27-04-23

https://single-market-economy.ec.europa.eu/news/reach-committee-votes-restrict-intentional-microplastics-2023-04-27_en

Janet's Corner

MAY. 12, 2023

At last, chemistry sets are perfectly safe

2023-05-12

At last, chemistry sets are perfectly safe.

https://www.smbc-comics.com/comic/chemistry

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Hazard Alert

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Phenanthrene

2023-05-12

Phenanthrene, also known as phenanthrin, is a polycyclic aromatic hydrocarbon (PAH) with three aromatic rings derived from coal tar. It has a chemical formula of $C_{14}H_{10}$, a molecular weight of 178.22, and exists as a colourless to white crystalline substance with a bluish fluorescence. It has a melting point of 100°C, a boiling point of 340°C, a density of 1.179 at 25°C. Phenanthrene is almost insoluble in water (1-1.6 mg/L), but is soluble in glacial acetic acid and a number of organic solvents including ethanol, benzene, carbon disulfide, carbon tetrachloride, diethyl ether, and toluene. [1,2]

USES [2,3]

Phenanthrene is used to make dyes, plastics and pesticides, explosives and drugs. In addition, it has been used to make bile acids, cholesterol and steroids. Phenanthrene can be used as a feed stock of carbon black. It is a raw material of phenanthrenequinone, which -is widely used in the synthesis of dyes, agrochemical and preservatives.

EXPOSURE SOURCES & ROUTES OF EXPOSURE [3]

Exposure Sources

Exposure to PAH including phenanthrene can occur via fumes from vehicle exhaust, coal, coal tar, asphalt, wildfires, agricultural burning and hazardous waste sites. In addition, exposure also occurs by breathing cigarette and tobacco smoke, eating foods grown in contaminated soil or by eating meat or other food that have been grilled. Grilling and charring food actually increases the amount of PAHs in the food. Occupational exposure also occurs for people working in a plant that makes coal tar, asphalt and aluminium, or that burns trash. Furthermore, exposure may also occur for people working in a facility that uses petroleum or coal or where wood, corn and oil are burned.

Routes of Exposure

One of the most common ways phenanthrene can enter your body is through breathing contaminated air. It can get into your lungs when you breathe it. If you work in a hazardous waste site where PAHs are disposed, you are likely to breathe phenanthrene and other PAHs. If you eat or drink food and water that are contaminated with PAHs, you could be exposed. Exposure can also occur if your skin comes into contact with contaminated

Phenanthrene, also known as phenanthrin, is a polycyclic aromatic hydrocarbon (PAH) with three aromatic rings derived from coal tar.

soil or products like heavy oils, coal tar, roofing tar or creosote where PAHs have been found. Creosote is an oily liquid found in coal tar and is used to preserve wood. Once in your body, the PAHs can spread and target fat tissues. Target organs include kidneys, liver and fat. However, in just a matter of days, the PAHs will leave your body through urine and faeces.

HEALTH EFFECTS [4]

Acute Health Effects

The following acute (short-term) health effects may occur immediately or shortly after exposure to phenanthrene:

- Contact can irritate the skin and eyes. If skin contaminated with Phenanthrene is exposed to sunlight a rash or skin burn may occur, sometimes with blisters.
- Inhaling Phenanthrene can irritate the nose and throat.

Carcinogenicity

- While phenanthrene has been tested, it is not classifiable as to its potential to cause cancer.

Other Effects

- Phenanthrene may cause a skin allergy. If allergy develops, very low future exposure can cause itching and a skin rash.

SAFETY

First Aid Measures [5]

- Eye Contact: Check for and remove any contact lenses. Immediately flush eyes with running water for at least 15 minutes, keeping eyelids open. Cold water may be used. Do not use an eye ointment. Seek medical attention.
- Skin Contact: After contact with skin, wash immediately with plenty of water. Gently and thoroughly wash the contaminated skin with running water and non-abrasive soap. Be particularly careful to clean folds, crevices, creases and groin. Cover the irritated skin with an emollient. If irritation persists, seek medical attention. Wash contaminated clothing before reusing.
- Serious Skin Contact: Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek immediate medical attention.

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- Inhalation: Allow the victim to rest in a well ventilated area. Seek immediate medical attention.
- Ingestion: Do not induce vomiting. Examine the lips and mouth to ascertain whether the tissues are damaged, a possible indication that the toxic material was ingested; the absence of such signs, however, is not conclusive. Loosen tight clothing such as a collar, tie, belt or waistband. If the victim is not breathing, perform mouth-to-mouth resuscitation. Seek immediate medical attention.

Workplace Controls & Practices [4]

Control measures include:

- Enclosing chemical processes for severely irritating and corrosive chemicals;
- Using local exhaust ventilation for chemicals that may be harmful with a single exposure; and
- Using general ventilation to control exposures to skin and eye irritants.

The following work practices are also recommended:

- Label process containers.
- Provide employees with hazard information and training.
- Monitor airborne chemical concentrations.
- Use engineering controls if concentrations exceed recommended exposure levels.
- Provide eye wash fountains and emergency showers.
- Wash or shower if skin comes in contact with a hazardous material.
- Always wash at the end of the workshift.
- Change into clean clothing if clothing becomes contaminated.
- Do not take contaminated clothing home.
- Get special training to wash contaminated clothing.
- Do not eat, smoke, or drink in areas where chemicals are being handled, processed or stored.
- Wash hands carefully before eating, smoking, drinking, applying cosmetics or using the toilet.

Personal Protective Equipment [5]

Gloves and Clothing

- Avoid skin contact with phenanthrene.

- Wear personal protective equipment made from material which can not be permeated or degraded by this substance.
- The recommended glove materials are Nitrile, Neoprene and Barrier® for Coal Tar Extract.
- The recommended protective clothing material for solid phenanthrene is Tyvek®, or the equivalent.
- All protective clothing (suits, gloves, footwear, headgear) should be clean, available each day, and put on before work.

Eye Protection

- Wear eye protection with side shields or goggles.
- If additional protection is needed for the entire face, use in combination with a face shield. A face shield should not be used without another type of eye protection.

Respiratory Protection

- Where the potential exists for exposure over 0.1 mg/m3, use a NIOSH approved respirator with an organic vapour cartridge and particulate N, R or P100 prefilters. Increased protection is obtained from full facepiece powered-air purifying respirators.
- Leave the area immediately if:
- While wearing a filter or cartridge respirator you can smell, taste, or otherwise detect phenanthrene,
- While wearing particulate filters abnormal resistance to breathing is experienced, or
- Eye irritation occurs while wearing a full facepiece respirator. Check to make sure the respirator-to-face seal is still good. If it is, replace the filter or cartridge. If the seal is no longer good, you may need a new respirator.
- Consider all potential sources of exposure in your workplace. You may need a combination of filters, prefilters or cartridges to protect against different forms of a chemical (such as vapour and mist) or against a mixture of chemicals.
- Where the potential exists for exposure over 1 mg/m3, use a NIOSH approved supplied-air respirator with a full facepiece operated in a pressure-demand or other positive-pressure mode. For increased protection use in combination with an auxiliary self-contained breathing apparatus or an emergency escape air cylinder.

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REGULATION

United States

The following exposure limits are for Coal Tar Pitch Volatiles:

- OSHA: The legal airborne permissible exposure limit (PEL) is 0.2 mg/m3 (as the Benzene soluble fraction) averaged over an 8-hour workshift.
- NIOSH: The recommended airborne exposure limit (REL) is 0.1 mg/m3 (as the Cylohexane extractable fraction) averaged over a 10-hour workshift.
- ACGIH: The threshold limit value (TLV) is 0.2 mg/m3 (as the Benzene soluble aerosol) averaged over an 8-hour workshift.

REFERENCES

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Antibiotics linked to higher triple-negative breast cancer death risk

2023-04-26

Effect on survival was not due to differences in cancer severity, the researchers found.

The risk increased substantially with the total number and types of antibiotics prescribed for each patient.

"Each additional antibiotic increased the risk of death between 5% and 18% relative to patients who weren't prescribed antibiotics," says Julia Ransohoff, a fellow in hematology and medical oncology at the Stanford School of Medicine and lead author of the study in Nature Communications.

"It is important to interpret these findings with caution, however. We can't let life-threatening infections go untreated. But this study suggests that we consider how best to treat them without raising the risk of cancer recurrence."

"These findings offer insight into the role of the immune system, and factors that may perturb its function, in fighting the most aggressive type of breast cancer," says senior author Allison Kurian, professor of medicine and of epidemiology and population health. "Gaining a better understanding of this process will be important to guide patient care."

Gut Microbiome's Role

The researchers studied 772 women diagnosed between January 2000 and May 2014 and treated at Stanford Health Care or Palo Alto Medical Foundation. They found that treatment with antimicrobials (a class of drugs that includes antibiotics to treat bacterial infections and antifungals to treat fungal infections) was associated with a decrease in the numbers of an immune cell called lymphocytes circulating in a patient's blood.

Lymphocyte numbers have been shown to correlate with response to treatment and overall survival in people with breast cancer. (Although the researchers studied total antimicrobial prescriptions, 99% of the women in the study who were prescribed antimicrobials received antibiotics.)

The researchers believe the link between antimicrobials and lymphocyte numbers lies in the gut. It's well established that antibiotic treatment, as well as chemotherapy, can be especially harsh on the bacteria that carpet our intestines—a population of tiny helpers known as the gut microbiome.

Triple-negative breast cancer patients who used antibiotics within three years of diagnosis have an increased risk of death, according to a new study.

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These bacteria not only help us digest food, but also affect many aspects of our health, including how our immune systems respond to emerging threats like infection or cancers.

"We've long known that the gut microbiome plays a role in shaping the immune system and that the immune system is pivotal in how people respond to cancers and chemotherapy," Ransohoff says. "We found a surprisingly strong and sustained increased risk of death in patients who had received multiple antimicrobials any time during the three years after their initial diagnosis."

The study has caveats. The women were diagnosed and treated before 2021, when the use of an immune-boosting therapy called immune checkpoint inhibitors for early-stage triple-negative breast cancer became routine. Also, triple-negative breast cancer is unique among breast cancer types. It is both more rare and more difficult to treat successfully than other breast cancers. But it is also more sensitive to attacks by the immune system, so it is unclear whether the association between antibiotics and poorer survival will translate to other types of breast cancer.

Triple-negative Breast Cancer Death Risk

This study is not the first to show that antibiotic use may affect cancer survival. A previous large study by researchers in Australia of more than 7,000 people with cancer found an association between antibiotic use in the six months prior to the patients' diagnosis and poorer survival. And antibiotic treatment correlates with increased tumor growth in several mouse models of breast cancer. Other studies have also hinted at an association between gut microbiome health and responses to cancer treatments.

But this study is the first to correlate antimicrobial use with both the number of circulating lymphocytes and overall cancer survival—and to do it at several time points after treatment.

"While other studies have suggested that the gut microbiome is different in cancer patients who do poorly versus those who do well, few have evaluated the upstream choices that patients and doctors can make to affect the microbiome," says senior author Ami Bhatt, associate professor of medicine and of genetics.

"This study helps connect some of the dots—finding that antibiotic use is linked to lower numbers of a type of circulating immune cell important to fight cancer. We still don't know if the microbiome is the critical

connecting factor between antibiotic use and cancer outcomes, but we suspect that it may be a key player."

Ransohoff and her colleagues used a database called Oncoshare, which integrates electronic health records and data from the California Cancer Registry. The women in the study were diagnosed with non-metastatic (stages 1 through 3) triple-negative breast cancer and were treated with chemotherapy and, if necessary, surgery.

Eighty-four percent of the women were prescribed antimicrobials at some point after their cancer diagnosis; 99% of these prescriptions were for antibiotics. The median follow-up time for the study was 104 months.

The researchers found that, over the course of the multiyear study period, 20% of the women who were not prescribed antimicrobials during the study died. In contrast, 23% of the women who had ever received antimicrobials died. There was no statistically significant difference in the risk of death from breast cancer between the average woman who did versus did not receive antimicrobials since diagnosis, suggesting that the risk associated with each prescription was small.

However, Ransohoff and her colleagues found that the risk of death from breast cancer increased not just with the total number of prescriptions a woman had received since diagnosis, but also with the number of unique drugs to which she was exposed (amoxicillin versus tetracycline, for example).

Antibiotic Exposure

The association between antimicrobial use and an increased risk of death lasted about three years after the women's cancer diagnoses; the risk gradually decreased in years four and five. Further analysis showed the association was not due to how sick the patients were when they received the drugs.

The data from Oncoshare didn't include information about the patients' gut microbiomes, which is usually obtained through fecal samples. But Ransohoff and her colleagues hope to design a new study that directly correlates gut microbiome composition with lymphocyte numbers and long-term cancer survival.

"We would love to look directly at the gut microbiome and see how antibiotic exposure shapes gut taxonomy," Ransohoff says. "But this study certainly raises the question of how our findings should impact clinical

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care of cancer patients." The researchers caution against applying the findings of the study of several hundred women to any one person.

"Patients should not panic if they were treated with antibiotics after a breast cancer diagnosis," Kurian says. "In any individual case, the risk increase is not large. But overall, these findings suggest a link between antibiotic use, the immune system and breast cancer survival, which warrants further study."

Researchers from the Palo Alto Medical Foundation Research Institute and UC San Francisco contributed to the work.

Funding for the study came from the National Institutes of Health, the Breast Cancer Research Foundation, the Susan and Richard Levy Gift Fund, the Suzanne Pride Bryan Fund for Breast Cancer Research, the Jan Weimer Junior Faculty Chair in Breast Oncology, the Regents of the University of California's California Breast Cancer Research Program, the BRCA Foundation, the G. Willard Miller Foundation, the Biostatistics Shared Resource of the Stanford Cancer Institute, Stand Up 2 Cancer, the V Foundation, and the Damon Runyon Cancer Research Foundation.

Futurity, 26 April 2023

https://futurity.org

Just Add Water – Stanford Researchers Have Discovered a Simple and Eco-Friendly Way To Make Ammonia

2023-04-29

Stanford researchers have found an environmentally friendly method of producing ammonia using small droplets of water and nitrogen sourced from the air.

Ammonia (NH_3) serves as the foundation for the creation of chemical fertilizers used for agricultural crops. For over 100 years, the global production of ammonia in large quantities has relied on the Haber-Bosch process. This industrial breakthrough has had a major impact on agriculture, enabling the feeding of a rapidly growing human population. However, the Haber-Bosch process is extremely energy-intensive, requiring high pressure levels of 80-300 atmospheres and temperatures ranging from 572-1000 F (300-500 C) to break nitrogen's strong bonds. Additionally, the steam-treatment of natural gas involved in the process contributes significantly to the release of carbon dioxide, a key contributor to climate change.

"We were shocked to see that we could generate ammonia in benign, everyday temperature-and-pressure environments with just air and water."

All told, to satisfy the current annual worldwide demand for 150 million metric tons of ammonia, the Haber-Bosch process gobbles up more than 2% of global energy and accounts for about 1% of the carbon dioxide emitted into the atmosphere.

In contrast, the innovative method debuted by the Stanford researchers requires less specialized circumstances.

"We were shocked to see that we could generate ammonia in benign, everyday temperature-and-pressure environments with just air and water and using something as basic as a sprayer," said study senior author Richard Zare, the Marguerite Blake Wilbur Professor in Natural Science and a professor of chemistry in the Stanford School of Humanities and Sciences. "If this process can be scaled up, it would represent an eco-friendly new way of making ammonia, which is one of the most important chemical processes that takes place in the world."

The new method also uses little energy and at a low cost, thus pointing a way forward to potentially producing the valuable chemical in a sustainable manner. Xiaowei Song, a postdoctoral scholar in chemistry at Stanford, is the lead author of the study, which was recently published in the Proceedings of the National Academy of Sciences.

New chemistry from blue-sky study

The new chemistry discovered follows in the footsteps of pioneering work by Zare's lab in recent years examining the long-overlooked and surprisingly high reactivity of water microdroplets. In a 2019 study, Zare and colleagues novelly demonstrated that caustic hydrogen peroxide spontaneously forms in microdroplets in contact with surfaces. Experiments since have borne out a mechanism of electric charge jumping between the liquid and solid materials and generating molecular fragments, known as reactive oxygen species.

Taking those findings further, Song and Zare began a collaboration with study co-author Basheer Chanbasha, a professor of chemistry at King Fahd University of Petroleum and Minerals in Saudi Arabia. Chanbasha specializes in nanomaterials for energy, petrochemical, and environment applications and came to Stanford as a visiting scholar last summer.

The research team zeroed in on a catalyst – the term for any substance that boosts the rate of a chemical reaction but is not itself degraded or changed by the reaction – that they suspected could help blaze a chemical pathway toward ammonia. The catalyst consists of an iron oxide, called

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magnetite, and a synthetic membrane invented in the 1960s that is composed of repeating chains of two large molecules.

The researchers applied the catalyst to a Graphite mesh that Song incorporated into a gas-powered sprayer. The sprayer blasted out microdroplets in which pumped water (H2O) and compressed molecular nitrogen (N2) reacted together in the presence of the catalyst. Using a device called a mass spectrometer, Song analyzed the microdroplets' characteristics and saw the signature of ammonia in the collected data.

Low-tech, low-energy ammonia synthesis

Zare and colleagues were very pleased with this result, especially in light of the relatively low-tech approach. "Our method does not require the application of any electrical voltage or form of radiation," said Zare.

From a broader chemistry perspective, the method is remarkable in that it uses three phases of matter: nitrogen as gas, water as liquid, and catalyst as solid. "To our knowledge, the idea of using gas, liquid, and solid all at the same time to cause a chemical transformation is a first of its kind and has a huge potential for advancing other chemical transformations," said Zare.

While promising, the ammonia production method revealed by Zare, Song, and Chanbasha for now is only at the demonstration stage. The researchers plan to explore how to concentrate the produced ammonia as well as gauge how the process could potentially be scaled up to commercially viable levels. While Haber-Bosch is only efficient when pursued at huge facilities, the new ammonia-making method could be portable and done on-site or even on-demand at farms. That, in turn, would slash the greenhouse gas emissions related to the transportation of ammonia from far-off factories.

"With further development, we're hoping our ammonia generation method could help address the two major looming problems of continuing to feed Earth's growing population of billions of people, while still mitigating climate change," said Zare. "We are hopeful and excited to continue this line of research."

Sci Tech Daily, 29 April 2023

https://scitechdaily.com

Multi-functional "superfoam" soaks up oil spills and kills bacteria

2023-04-28

Scientists at the University of Georgia have created a "superfoam" with two very valuable potential applications. It could be used not only to clean up oil spills, but also to keep infections from occurring at medical implant sites.

Developed by a team led by Assoc. Prof. Hitesh Handa, the three-dimensional material consists of a PDMS (polydimethylsiloxane) matrix which is augmented with graphene nanoplatelets and antibacterial copper microparticles. These additions give the foam a coarse, porous structure which is both hydrophobic (water-repelling) and oleophilic (oil-attracting).

When sponges made of the foam were placed in water polluted with oil, they adsorbed the oil while not taking in any of the water. Once that adsorbed oil had been removed from the foam, the sponges could be reused multiple times to take up more oil.

Along with oil, the sponges were also found to take in other non-polar water-polluting liquids such as chloroform, hydrochloric acid and other organic pollutants – leaving the water itself behind. And thanks to the presence of the copper microparticles, any bacteria making contact with the foam were killed.

With that functionality in mind, the scientists also envision thin layers of the material being applied to the surface of medical implants. The foam could then minimize the chances of infection by not only killing bacteria, but also repelling fluids such as blood.

"Current medical devices are prone to contamination," said Handa. "When you put any medical device into the body, proteins are the first thing to stick to a surface, and they act like a glue that allows blood or bacteria to adhere. So, if we can stop the protein adsorption, half the battle is won."

Finally, as an added bonus, the graphene nanoplatelets in the foam make it electrically conductive, boosting its potential uses.

Once adsorbed oil had been removed from the foam, the sponges could be reused multiple times to take up more oil.

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The research is described in a paper that was recently published in the journal ACS Applied Materials & Interfaces.

New Atlas, 28 April 2023

https://newatlas.com

An epic global study of moss reveals it is far more vital to Earth's ecosystems than we knew

2023-05-02

Mosses are some of the oldest land plants. They are found all over the world, from lush tropical rainforests to the driest deserts, and even the wind-swept hills of Antarctica.

They are everywhere; growing in cracks along roads and pathways, on the trunks of trees, on rocks and buildings, and importantly, on the soil.

Yet despite this ubiquity, we have a relatively poor understanding of how important they are, particularly the types of moss that thrive on soil.

New global research on soil mosses published today in Nature Geoscience reveals they play critical roles in sustaining life on our planet. Without soil mosses, Earth's ability to produce healthy soils, provide habitat for microbes and fight pathogens would be greatly diminished.

A global survey of soil mosses

The results of the new study indicate we have probably underestimated just how important soil mosses are.

Using data from 123 sites across all continents including Antarctica, we show that the soil beneath mosses has more nitrogen, phosphorus and magnesium, and a greater activity of soil enzymes than bare surfaces with no plants.

In fact, mosses affect all major soil functions, increasing carbon sequestration, nutrient cycling and the breakdown of organic matter. These processes are critical for sustaining life on Earth.

Our modelling revealed that soil mosses cover a huge area of the planet, about 9 million square kilometres – equivalent to the area of China. And that's not counting mosses from boreal forests, which were not included in the study.

Without soil mosses, Earth's ability to produce healthy soils, provide habitat for microbes and fight pathogens would be greatly diminished.

The strength of the effect mosses have on soil depends on their growing conditions. They have the strongest effect in natural low productivity environments, such as deserts. They are also more important on sandy and salty soils, and where rainfall is highly variable.

Not unexpectedly, mosses have the strongest effects on soils where vascular plants – those that contain specialised tissues to conduct water and minerals – are sparse.

An intimate connection

Mosses lack the plumbing that allows vascular plants to grow tall and pull water from beneath the soil. This keeps them relatively short, and means they develop an intimate connection with the uppermost soil layers.

Mosses are extremely absorbent and can attract airborne dust particles. Some of these particles are incorporated into the soil below. It is not surprising then that they have such a strong effect on soils.

Our modelling shows that, across the globe, mosses store 6.4 gigatonnes more carbon than soils without plant cover.

Losing just 15% of the global cover of soil mosses would be equivalent to global emissions of carbon dioxide from all land use changes over a year, such as clearing and overgrazing.

Not all mosses are equal

We also found some mosses are more effective at promoting healthy soils than others. Long-lived mosses tended to be associated with more carbon and greater control of soil pathogens.

The ability of mosses to provide ecosystem services and support a diverse community of microbes, fungi and invertebrates was strongest in locations with a high cover of mat- and turf-forming mosses such as Sphagnum, which are widely distributed in boreal forests.

Soils are a huge reservoir of soil pathogens, yet the soil beneath mosses had a lower proportion of plant pathogens. Mosses can help to reduce the pathogen load in soils. This ability may have originated when mosses evolved as land plants.

A special group in the desert

A special type of moss flourishes in deserts. They either live hard (perennial mosses) or die young (annual mosses).

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Mosses in the family Pottiaceae are uniquely suited to life under dry and inhospitable conditions. Many have specialised structures that allow them to survive when water is scarce. These include boat-shaped leaves with long hairy tips that help to funnel water into the centre of the plant. Some mosses twist around their stem to reduce the area exposed to the sun and conserve moisture.

Desert mosses also protect the soil against erosion, influence how much water moves through the upper layers and even alter the survival chances of plant seedlings.

Other mosses have special moisture-absorbing cells (papillae) that swell up and provide them with a moisture reserve when conditions are dry.

Our global study showed that mat- and turf-forming mosses such as Sphagnum had the strongest positive effects on the diversity of microbes, fungi and invertebrates, and on critical services such as nutrient supply. Predictably, longer-lived mosses supported more soil carbon and had greater control of plant pathogens than short-lived mosses.

Protect the mosses

Overall, our work shows mosses influence important soil processes and function in the same way vascular plants do. Their effects may not be as strong, but their total cover means mosses are potentially as significant when summed across the whole globe.

But mosses are under increasing threats globally; disturbance by livestock, overharvesting, land clearing and even changing climates are the greatest threats.

We need a greater acknowledgement of the services that soil mosses provide for all life on this planet. This means greater education about their positive benefits, identifying and mitigating the main threats they face, and including them in routine monitoring programs.

Soil mosses are everywhere, but their future is far from secure. They are likely to play increasingly important roles as vascular plants decline under predicted hotter, drier and more variable global climates.

The Conversation, 2 May 2023

https://theconversation.com

Even BPA-free plastic particles can mess with your sex hormones, study finds

2023-04-28

When inhaled at moderate levels, plastic particles without dangerous additives appear to be able to disrupt sex hormones, according to a new study published by researchers at Rutgers University.

Previously, research suggested that chemical additives used to improve plastics, like bisphenol-A (or BPA), were potentially having all kinds of disruptive effects on human hormones. Alarming research into BPA spurred numerous manufacturers of goods with plastics in them to advertise them as "BPA-free."

Yet this new study suggests that even plastic without BPA can have comparable endocrine-disrupting effects.

"This is one of the first studies to show endocrine disrupting effects from a plastic particle itself, not based on exposure to the plasticizing chemical," said Phoebe Stapleton, assistant professor at the Rutgers Ernest Mario School of Pharmacy and senior author of the study published in Particle and Fiber Toxicology, in a media statement. "The other innovation was the method of exposure."

As explained by Stapleton, previous studies have injected animals with the particles being studied, or they've been fed to them. In their study, published in the journal Particle and Fibre Toxicology, the researchers found a way to successfully aerosolize the particles so they could see what happened to them when inhaled. Plastic is so pervasive in human environments that this is a common method of absorption into the body.

Stampleton and her colleagues used extremely fine, food-grade nylon powder to model the potential effect of extremely tiny, "nanoscale" particles or plastic. In their experiment, researchers placed the powder on a rubber pad and put the pad on top of a bass speaker. The pulse of the bass sent small particles into the air, which delivered them to the rats used in the experiment, who breathed them in. Twenty-four hours later, the researchers observed the potential toxicological effect of a one-day exposure. Researchers followed up to study the potential impact on pulmonary inflammation, cardiovascular function, systemic inflammation and endocrine disruption. They found an impairment in vascular function and a decrease in the levels of the reproductive hormone 17 beta-estradiol.

It's not just plastics with BPA: everyday plastic pollution could be endocrine-disrupting, too.

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"Unfortunately, there's very little that people can do to reduce exposure at the moment," Stapleton said. "You can be aware of your flooring, wear natural fibers and avoid storing food in plastic containers, but invisibly small plastic particles are likely in nearly every breath we take."

Many believe that the disruption of sex hormones delivered by the endocrine system could explain consistently declining fertility rates across the Western world. As Dr. Shanna Swan, a professor of environmental medicine and public health at Mount Sinai School of Medicine in New York City, previously told Salon, it is possible that the dramatic decrease in reproductive health over the last 40 years is partly because of our everyday exposure to chemicals that affect human hormones.

"An endocrine disruptor is a chemical that impacts the body's endogenous natural hormone function. And by impact, it could be increases, slows, or interferes with in various ways," Swan said. "The most profound way they do that is by disturbing prenatal development, so that the exposure to the pregnant woman early in pregnancy is going to have the biggest impact on later reproductive health and function in the offspring."

As Salon has previously reported, microplastics — meaning are plastic particles that are five millimeters or less across or in length — have polluted virtually every inch of the planet, from the deepest parts of the ocean to the most remote regions of the rainforest. Animals small and large constantly eat microplastics accidentally, which are sent up the food chain, while humans themselves ingest the rough equivalent of a credit card's worth of plastic each week.

Stapleton said it is tough for people to protect themselves from the damaging effects of plastics today.

"Unfortunately, there's very little that people can do to reduce exposure at the moment," Stapleton rued. "You can be aware of your flooring, wear natural fibers and avoid storing food in plastic containers, but invisibly small plastic particles are likely in nearly every breath we take."

Salon, 28 April 2023

https://salon.com

CATL unveils battery that may power electric airplanes and 1000km-range EVs

2023-05-03

At a recent Shanghai auto expo, the world's largest battery maker unveiled a battery it claimed could power electric aircraft or propel electric vehicles (EVs) beyond 1,000 kilometres on a single charge.

Chinese Amperex Technology Limited (CATL), which makes one-third of the world's EV batteries, shared few details about the technology but said it would start mass production later this year.

It was the latest in a series of big announcements for the industry, which is booming with the global shift to electrification.

Battery design has been likened to a gold rush, as researchers push the boundaries of materials chemistry and develop lighter, longer-lasting, safer, cheaper batteries that charge more quickly.

Better batteries mean more affordable cars, cheaper electricity for the home, and ways of travelling overseas without emitting tonnes of CO2.

"If you think about our electrified lives, if you took away batteries, none of this is possible," said Adam Best, a principal research scientist at CSIRO.

"But people don't think about batteries."

So, here's how battery technology has improved over the past decade, and where it's going in the future.

EVs clocking 1,000km per charge?

Since being developed about 50 years ago, the amount of energy these batteries store per kilogram, known as their specific energy, has incrementally improved.

From consumer electronics in the 1990s, their applications branched out into electric vehicles in 2006, and large-scale grid storage in 2012.

As the number of applications has increased, so have the types of lithium-ion batteries. One may be designed to be cheaper, another to hold more energy, and a third to recharge more quickly.

Although we often talk in general terms about EV batteries, different models and brands use different types, equivalent to the difference between a V8 performance engine and an economical four-cylinder.

Battery design has been likened to a gold rush, as researchers develop lighter, longer-lasting, safer, cheaper batteries that charge more quickly.

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Standard-range EVs, for instance, use a lithium-ion battery with a lithium-iron-phosphate (LFP) chemistry, while longer-range vehicles tend to use nickel-cobalt-aluminium, or nickel-cobalt-manganese.

The main measure of how much energy a battery holds is its specific energy, which is measured in watt-hours per kilogram.

Most EV batteries have a specific energy of under 300Wh/kg.

CATL says its new battery almost doubles that figure, with a specific energy of 500Wh/kg.

Unfortunately, the company has not released many other details, including what this battery would cost, how many times it can be recharged, or how much power it can produce (how fast the stored energy can be used).

CATL says the new design will go into mass production later this year and be used in civil aviation and road transport.

If the battery is as good as it claims, it will mean EVs can drive from Sydney to Melbourne on a single charge.

Or, since most people do not need that kind of range, it will mean smaller battery packs and cheaper EVs.

How to make a better battery

There are two elements to better battery design: chemistry and engineering.

Chemistry involves tweaking the component parts of the battery, while engineering is about the shape and structure of the battery itself.

Batteries store energy in the form of chemical potential. As the amount of energy they store goes up, so does the challenge of keeping them stable, Dr Best said.

"You're trying to have something that's electrochemically stable, thermally stable, and chemically stable. It has to be able to conduct ions at a range of different temperatures."

"These materials that have to do so many different things in concert with each other. It's really like a symphony, with all the parts playing its role."

Often, improvements are made by tweaking the materials of the cathode, anode or electrolyte to reduce weight, improve conductivity, or lower cost.

Improving one metric, however, often comes at the cost of another.

For instance, battery makers have developed a sodium-ion battery that does not use lithium and is therefore as much as half the price.

But it has a lower energy density, of about 200Wh/kg.

For its latest battery, CATL appears to have developed a type of highly conductive electrolyte gel, which saves on weight.

In a statement, it says the battery uses "condensed matter" as an electrolyte to improve the conductive performance of the cells, as well as "innovative" anode materials.

"CATL's condensed battery leverages highly conductive biomimetic condensed state electrolytes to construct a micron-level self-adaptive net structure that can adjust the interactive forces among the chains, thus improving the conductive performance of the cells."

What batteries are needed for flight?

The current crop of small aircraft outfitted with electric power systems operate at 250-270Wh/kg of specific energy.

For electric aviation to really take off, experts say this figure will need to be about 400–500Wh/kg.

But high specific energy isn't the only requirement for electric aviation batteries, according to John Fletcher, a professor of engineering at UNSW.

"You need a battery that can deliver power for take-off," he said.

"The kind of ratios of power that you need to take off and the power to cruise are about 3 to 1."

That is, an aviation battery needs to deliver about three times as much power to get a plane in the air as it does to keep it cruising.

Because CATL hasn't given more detail about its new battery, we don't know its power output.

It says it's partnering with several unnamed companies to use the new condensed matter batteries to develop electric passenger aircraft.

Where is battery development going next?

One of the most promising emerging technologies is solid-state batteries, which use a solid electrolyte material instead of the liquid or gel used in conventional lithium-ion batteries.

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A solid electrolyte drastically increases the battery's energy density, as well as safety, as it avoids the need for flammable solvents used in liquid electrolytes.

"Solid-state batteries will play a role in getting rid of those liquid phases that can … cause gas and catch fire," CSIRO's Dr Best said.

Late last year, NASA announced it had developed a solid-state battery with an energy density of 500Wh/kg

Meanwhile, SVOLT Energy, a division of China's Great Wall Motors, has created solid-state sulfide battery cells with an energy density of 350–400Wh/kg

There's also a lot of excitement about batteries that use the oxygen in air as a cathode, resulting in energy densities four times that of existing lithium-ion batteries.

In February, researchers at the Illinois Institute of Technology and US Department of Energy's Argonne National Laboratory announced they had developed a lithium-air battery with an energy density of up to 1200Wh/kg.

These batteries were a long way from being made commercially available, Dr Best said.

"The opportunity of lithium-air batteries is immense, but the chemistry of oxygen reacting with lithium is really difficult to control."

"This device would be an immense breakthrough if that was to work."

ABC News, 3 May 2023

https://abc.net.au

Mathematicians Solve a Knotty Mystery: How To Untangle a Worm Ball

2023-05-02

As anyone who has ever unwound a string of holiday lights or detangled a lock of snarled hair knows, undoing a knot of fibers takes a lot longer than tangling it up in the first place.

This is not so for a wily species of West Coast worm.

Found in marshes, ponds, and other shallow waters, California blackworms (Lumbriculus variegatus) twist and curl around each other by the

California blackworms tangle themselves up by the thousands, then separate in a split second. Their trick may inspire the design of self-detangling materials and fibers.

thousands, forming tightly wound balls over several minutes. In the face of a predator or other perceived threat, the worms can instantly untangle, disassembling the jiggly jumble in milliseconds.

Perplexed by how the wigglers can disentangle such elaborate knots so quickly, MIT mathematicians teamed up with biophysicists at Georgia Tech to study the worms' knotty behavior. Through experiments and mathematical modeling, the team has now pinned down the mechanism by which the worms tangle up and quickly unwind. Their findings, published today in Science, could inspire designs for fast, reversible, and self-assembling materials and fibers.

"We can take inspiration from these worms to think about how we might manipulate polymeric and filamentary systems," says Vishal Patil, a postdoc at Stanford University, who developed a mathematical model of the worms' behavior while a graduate student in MIT's Department of Mathematics. "One could think of engineering active woven fibers that could rearrange when they are clogged or a smart robot that could change its grasp by tangling and untangling."

Patil's co-authors on the study are Jörn Dunkel, professor of mathematics at MIT, and co-first author Harry Tuazon, along with Emily Kaufman, Tuhin Chakrabortty, David Qin, and M. Saad Bhamla at Georgia Tech.

Hooked on a tangle

Bhamla's group studies worms, insects, and other living organisms, and how their behavior can inspire the design of new devices and robotic systems. Tuazon, a PhD student in the lab, was observing California blackworms swimming in a laboratory aquarium when they were struck by the worms' remarkable tangling and untangling abilities.

The group has previously found that in nature, the worms tangle up as a protective and defensive mechanism. A large knot of worms can prevent interior worms from drying out in drought conditions. A ball of worms can also move as one, collectively crawling along the floor of a lake or pond. When they sense a predator, the worms can untangle in milliseconds, dispersing in many directions.

Wondering what the worms could be doing to get themselves out of such intricate configurations, Bhamla recalled a study by Dunkel and his group at MIT. In that work, the mathematicians devised a model that predicts a knot's stability, based on the twists and crossings of various knotted segments.

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"I saw this study and thought, my goodness, these mathematical principles could be suited to being applied to worms," says Bhamla, who reached out to Dunkel and Patil to see whether they could shed mathematical insight on the worms' knotting. Bhamla also sent the mathematicians a few videos taken in the lab of the tangling worms.

"When he showed us those videos, especially of the worms untangling, we were hooked," Patil says. "We know intuitively it's really difficult to untangle fibers. The fact that the worms were able to solve that showed that there was something interesting going on with these tangles that we wanted to work out mathematically."

Dance step

Dunkel and Patil adapted their mathematical codes on knot stability to worm tangling by first studying the behavior of a single worm. They watched Tuazon's recordings of one worm in a petri dish of water and observed that in response to a perceived threat such as a pulse of ultraviolet light, the worm suddenly corkscrewed, looping to the left, then quickly to the right, again and again.

"That recurrent figure-eight motion suggested to us an unweaving mechanism that could operate to untangle from a knot," Patil says.

The mathematicians then studied videos of two worms to see if any patterns in their motion guaranteed that the pair would tangle.

"If you just get two fibers together, it's not clear that they will braid around each other," Patil says. "Both the tangling and untangling were dynamics we wanted to unpack."

Surprisingly, they found that the worms tangled up by moving in the same helical motion as untangling. The only difference seemed to be that the two worms tangled by looping in one direction for a longer stretch of time before switching to loop in the other direction, whereas the single worm switched directions quickly, looping left, then right, and back again.

The scientists suspected that the worms tangled and untangled based on how fast they switched their looping direction. The team incorporated these new parameters of helical motion and the speed of loop switching into their existing knot model, which they then used to simulate the behavior of hundreds of computer-generated worms.

"It's a very minimal model, in which each worm basically runs its own program of helical movements, and how fast they switch directions,"

Dunkel says. "You can think of them as having two gears: a slow gear, which allows them to tangle, and a fast gear, which lets them untangle."

The team simulated numerous scenarios of worm-like fibers and found those that were slower to switch looping directions indeed tangled up in large balls. Fibers that switched quickly from one direction to the other were able to disentangle from a knot.

When they compared their simulations with ultrasound images of actual worms taken at Georgia Tech, the group discovered the pattern of movements in both were the same. Vishal and Dunkel's mathematical description, involving helical motion and looping speed, accurately predicted the worms' tangling, and fast untangling.

"We realized this simple dance," Bhamla says. "The biological circuit is the same. But it's like the dance music changed, from a slow waltz to Elvis hip-hop, and they suddenly untangle."

"This study is about the behavior of worms, but it turns out they can be a model system for engineering filamentary matter," Patil says. "How worms use this tangled state is unique, but we can extract design principles, and engineer systems, based on how we now understand tangles work."

Sci Tech Daily, 2 May 2023

https://scitechdaily.com

Case report: Magic mushrooms may induce lasting improvements in color-blind vision

2023-05-03

Researchers at the Department of Psychiatry and Psychology, Center for Behavioral Health, Neurological Institute at the Cleveland Clinic in Ohio have authored a case report on the positive effects of psilocybin on color blindness.

Published in the journal Drug Science, Policy and Law, the researchers highlight some implications surrounding a single reported vision improvement self-study by a colleague and cite other previous reports, illustrating a need to understand better how these psychedelics could be used in therapeutic settings.

Past reports have indicated that people with color vision deficiency (CVD), usually referred to as color blindness, experience better color vision after using lysergic acid diethylamide (LSD) or psilocybin (magic mushrooms).

There is no treatment to correct color blindness, although there have been attempted workarounds.

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There is a lack of scientific evidence for these claims, as researching the effects of these drugs has been highly restricted.

Color vision depends on a cluster of three types of photoreceptors known as cones—red, green, and blue sensing retinal photoreceptors with light-sensitive pigments. If one or more of these pigments is missing, the result is color blindness. Red-green CVD, which results in difficulties distinguishing between red and green, is typically an inherited condition caused by X chromosome-linked recessive mutations in genes coding for components of cones. It is the most common type of CVD, occurring in 8% of men and 0.5% of women.

People with color blindness can only perceive around 10% of hues and color variations compared with normal color vision, with some forms having no ability to distinguish red and green.

Life with color blindness can be difficult; aside from making the occasional wardrobe color mistakes, it can make maps and infographics indecipherable, disguise the ripeness of fruits or freshness of meat in the fridge, and can restrict career choices where color sight is an advantage or required, such as airline pilot, graphic artist and textile and paint-related jobs.

There is no treatment to correct color blindness, although there have been attempted workarounds. One of the more accessible options for some specific types of color blindness is glasses with special lenses, like the ones made by EnChroma, which selectively filter out wavelengths of light at the point where red and green frequencies overlap for a person with color blindness, making the two distinct.

In the current case, a subject with red-green CVD (mild deuteranomalia) self-administered the Ishihara Test to quantify the degree and duration of color vision improvement after using 5 g of dried psilocybin magic mushrooms. Self-reported Ishihara Test data from the subject revealed partial improvement in CVD, peaking at 8 days and persisting for at least 16 days post-psilocybin administration.

In previous experiences that led to the more controlled self-experiment, the subject reported using MDMA once, psilocybin mushrooms twice, oral LSD five times, and inhaling DMT (dimethyltryptamine) seven times. After these prior episodes of psychedelic use, the subject had noted improvement in color vision persisting for months.

Before mushroom ingestion, the subject self-administered the Ishihara Test, a series of graphics composed of a mosaic of dots varying in color, hue and size. The cards of the test are designed to hide test images from someone with color blindness that would be clearly visible to someone with color vision. For example, a graphic of red and green dots might have the number "3" composed of only red dots, clearly apparent to most but invisible to the color-blind individual.

During this baseline test, the subject reported scoring 14 on plates 1–21, indicating mild red-green blindness, with an additional set of four cards indicating deuteranomalia, a version of CVD that makes greens look more reds.

While the subject reported intensification of colors under the acute effects of psilocybin, the score showed only slight improvement to 15 at 12 hours post-administration. By 24 hours post-mushroom administration, the score reached 18, one above the cut-off of 17 required by the Ishihara Test for the classification of normal color vision. The score peaked at 19 on day eight and was still tuned into the range of normal vision four months later.

The researchers suggest it is likely that psychedelic-induced visual phenomena result primarily from alterations in brain activity rather than their direct effects on the retina and peripheral eye. Based on the time delay between psilocybin and color vision, the mushroom may have catalyzed a learning process around color interpretation, possibly altering the connectivity between visual regions.

Interestingly, though not in the case report, filtered wavelength glasses, like EnChroma, do not work instantly. It takes around 15 minutes to an hour for the effect of the filtering to "turn on" and the newly separated waves to be interpreted by the brain, also suggesting that a brain learning process is required.

Despite color blindness typically resulting from a genetic defect, the report authors say that if this single use of psilocybin can produce long-lasting partial improvements in color vision, it raises the possibility of psilocybin inducing durable alterations in visual processing in some people. The authors conclude that future research in this area should determine whether psilocybin-induced improvement occurs in more severe cases,

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explore the relationship of psilocybin dosage to improvement and investigate the underlying mechanism of this curious phenomenon.

Medical Xpress, 3 May 2023

https://medicalxpress.com

'A good day': FDA approves world's first RSV vaccine

2023-05-03

The US Food and Drug Administration (FDA) has approved GSK's vaccine against respiratory syncytial virus (RSV) for use in people aged 60 years and older. This is the first RSV vaccine to gain approval anywhere in the world, and researchers are celebrating.

"It's a very big deal to have options available to prevent RSV disease," says Barney Graham, senior adviser for global-health-equity trials at Morehouse School of Medicine in Atlanta, Georgia.

RSV usually causes mild symptoms similar to those that arise during a common cold. But for older people, it can be deadly. According to the US Centers for Disease Control and Prevention (CDC), each year RSV kills approximately 6,000 to 10,000 adults in the United States who are 65 years or older, and sends 60,000 to 160,000 to hospital. People in this age group with comorbidities such as chronic obstructive pulmonary disease, asthma or congestive heart failure are especially at risk.

Green light from US regulatory agency for GSK's jab caps off a decades-long quest.

The FDA approved GSK's RSV vaccine, to be sold as Arexvy, on the basis of phase III clinical-trial data submitted by the pharmaceutical company, which is based in London. Those data showed that the shot reduced the risk of people aged 60 and older developing lower respiratory tract disease from RSV by 82.6% and that of developing severe disease by 94.1%. The results were published in February in The New England Journal of Medicine1.

The approval is "a tremendous opportunity to help address a really important public-health need", says Leonard Friedland, vice-president and director of scientific affairs and public health for GSK's US vaccines division.

A life's work

The FDA expedited the approval of GSK's vaccine last November, during a period when the United States was grappling with a 'tripledemic' of people with RSV, influenza or COVID-19 flooding hospitals.

The technology underlying the RSV vaccine has been almost 60 years in the making. In the 1960s, during a clinical trial of an RSV vaccine, two of the participating children died and 80% ended up in hospital2. Understanding what had happened and finding a solution became Graham's life's work. "The first 20 years were spent primarily working out how to make a vaccine that could be safe," he says.

The original vaccine contained an inactivated RSV virus. Eventually, the vaccine-research community pivoted its strategy.

In 2008, Graham teamed up with Jason McLellan and Peter Kwong at the US National Institutes of Health in Bethesda, Maryland, and others to investigate the structural biology of RSV. Over time, they learnt that the virus used protein F, a molecule on its surface, to infect human cells. With this knowledge, protein-based RSV vaccines could be developed that would introduce the molecule into cells to produce an immune response.

But the team eventually found that early jabs of this type had been designed around the wrong form of protein F, a 'postfusion' version that arises after the virus and cell have already joined. The researchers discovered a way to instead target the correct form of protein F, which hasn't yet fully fused with any cell and was found to elicit neutralizing antibodies. They published their findings in 20133.

Their work paved the way for companies such as GSK, Pfizer and Moderna to develop the RSV vaccines in the pipeline today. "This is my lifetime's work. It's very gratifying to see this finally happening," Graham says. "It's a good day for RSV."

The race continues

After the approval of GSK's vaccine, scientists hope others will follow. "There are many patients all around the world who can benefit from vaccination," Friedland says.

The pharmaceutical firm Pfizer, based in New York City, has also developed a protein-based RSV vaccine for people aged 60 and older that the FDA is expected to approve later this month. Biotechnology company Moderna in Cambridge, Massachusetts, has an mRNA-based vaccine for preventing RSV in adults in the same age group under expedited review at the agency.

Moreover, an FDA advisory panel will convene on 18 May to consider the safety and effectiveness of Pfizer's RSV vaccine for pregnant people. During a phase III clinical trial, pregnant people who received the jab

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gave birth to newborn babies who were then monitored for illness. The vaccine reduced the risk of infants up to 90 days old having a severe lower respiratory tract illness from RSV by 81.8%4. The FDA will decide whether to approve the vaccine by August.

Like older adults, babies are at high risk from RSV. "RSV seems like a harmless thing," but it's not, says Mina Suh, a scientist at the company EpidStrategies who is based in Irvine, California, that evaluates epidemiological studies. Each year, 58,000 to 80,000 children in the United States who are aged 5 years and under are hospitalized because of RSV and 100 to 300 die, according to the CDC.

Newborn babies' immune systems don't respond robustly to many vaccines, so it is challenging to give them shots directly. To protect infants, Pfizer opted to immunize pregnant people a few months before they gave birth. Their bodies make the antibodies that are transferred to their newborn.

But before this next tranche of vaccines is approved, GSK's jab will move ahead. It is expected to be approved in Europe soon. And the next step in the US process is for the CDC's Advisory Committee on Immunization Practices to weigh in. The panel will recommend who can receive the GSK jab, how it is given and when it will it be available to the public. The committee's next meeting is in June. This is an important step, Friedland says. "Vaccines don't save lives. It's vaccination that does."

Nature, 3 May 2023

https://nature.com

For billions of years, rivers connected continents to the sea. Then we came along.

The Oceans Are Missing Their Rivers

2023-05-03

Gazing out from the eighth floor of a hotel in Georgetown, Guyana, the broad expanse of the Atlantic Ocean was a muddy brown. Only a thin rim of blue on the horizon showed the ocean's true color; the rest swirled with sediment emerging from the mouth of the Essequibo River.

In a rhythm that's pulsed through epochs, a river's plume carries sediment and nutrients from the continental interior into the ocean, a major exchange of resources from land to sea. More than 6,000 rivers worldwide surge freshwater into oceans, delivering nutrients, including nitrogen and phosphorus, that feed phytoplankton, generating a bloom of life that in turn feeds progressively larger creatures. They may even influence ocean

currents in ways researchers are just starting to understand. But today, in rivers around the world, humans are altering this critical phenomenon.

In many places, the great culprit is the dam: a wall of concrete and stone bisecting a river, diverting its energy and water to human use. There are 58,000 "big dams"—50 feet high or taller—around the globe, with another 3,700 more planned, mostly in lower-income countries in Asia and South America.

Rising seas deservedly get headlines, but sinking land is an equally grave problem.

Many of the harms caused by dams are well-documented. They block fish passage and starve subsistence fishers; radically alter natural river regimes and aquatic creatures' lifecycles; and flood forests, wetlands, villages, and historical sites. (They're also less climate-friendly1 and reliable2 than is widely believed.) Now scientists are describing another impact that has received relatively little attention but appears to also be profound: Dams block sediment-carrying river pulses into the ocean.

Researchers used satellite data to estimate sediment changes over the past 40 years in 414 rivers around the world and found that dams in the global north—North America, Europe, and Asia—blocked 49 percent of sediment delivery to coasts.3 That finding, which was published last year in the journal Science, is even more striking when considering the frenzy of dam-building that occurred during the 1970s. The study's early 1980s baseline likely already showed a significant departure from the rivers' natural states.

"Humans have built structures that have drastically outstripped the impacts of climate change in many ways," says Evan Dethier, an oceanographer at Bowdoin College and the study's lead author.

Sediment plays vital roles in river and coastal systems. When rivers overflow onto their floodplains, water slows, dropping silt that shapes its flows and nourishes vegetation growing amidst the channels. The sediment also brings nutrients to the floodplain, helping to jumpstart algae blooms that in turn feed phytoplankton and juvenile fish. At the sea's edge, sediment continually rebuilds coastal land otherwise eroded by ocean waves. Rising seas deservedly get headlines, but sinking land is an equally grave problem for people living in river deltas now starved of sediment.4

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The stories of rivers and the sediment they carry don't end there. The ocean is turbulent, which can cause its currents to meander back and forth, like streams do on land. Meanders become unstable, forming eddies, where strong currents meet weak ones, and where freshwater meets denser, often colder, saltwater. When rivers enter oceans, they form a plume of freshwater that can extend 80 miles offshore; the resulting collision of freshwater and saltwater, their differences in temperature, and the sediment they carry, generate eddy trains, like a conga line of eddies, which impact larger ocean circulation patterns.

Researchers led by Annalisa Bracco, an oceanographer at the Georgia Institute of Technology, investigated these dynamics in a study of the plume created by the Mekong River, the 12th-longest river in the world.5 It flows nearly 3,000 miles from its headwaters in the Tibetan Plateau through China, Myanmar, Thailand, Laos, Cambodia, and Vietnam before reaching the South China Sea.

More than 150 dams have been built in the Mekong River basin, including 13 on the river's mainstem, and more than 100 additional dams are planned. To understand how they may affect the South China Sea, Bracco's team created a computational model of the Mekong plume's effects on the sea's circulation today. Then they simulated how the plume will behave if more dams are built, dramatically reducing the Mekong's annual mean flow and its seasonal cycle.

"You really get a different transport," Bracco says. Because freshwater is less dense than saltwater, water from the plume tends to remain at the surface, where it is more easily moved by wind. If the Mekong's plume is diminished, winds will need more energy to move seawater, slowing the velocity of currents, she says.

Bracco's team found that, in the South China Sea, summer monsoon winds drive currents northeast, carrying nutrients, food, and warmer temperatures with them. Future dams would make the eddy train falter, weakening the movement of northward currents and decreasing the marine ecosystem's productivity.

Bracco recounts a time when she was on a boat, measuring ecosystem changes along the river plume. "You see the plankton that emerges and blooms following the impact of the river water," she says. That, in turn, feeds larger species. "If you change the river drastically and it's not bringing in the plume anymore, you prevent the ecosystem from having that bloom."

Dams are less climate-friendly and reliable than is widely believed.

Glen Gawarkiewicz, a physical oceanographer at Woods Hole Oceanographic Institution who studies the Northwest Atlantic, notes that eddy trains carry sediments from river plumes across continental shelves into ocean basins, and fish concentrate at these nutrient fronts. "Reduced eddies could mean fewer nutrients getting into ocean basins. And in Southeast Asia, fish are very important for protein, and culturally," Gawarkiewicz says. Fishing in the South China Sea already sparks diplomatic controversies, he says, and changes in nutrient circulation may trigger new conflicts.

While Bracco's findings about the likely decline of ocean productivity in the South China Sea are sobering, she cautions that the dynamics she observed are not universal. "There's nothing that happens in the same way everywhere," she says. For example, the Mississippi River's plume is not changing the direction of currents in the Gulf of Mexico. "The Loop Current, which is the main oceanic current into the Gulf of Mexico, is just so big and so strong." (Of course, the Mississippi plume has another well-documented impact: Nutrient overload from agricultural runoff creates a vast dead zone every year.)

Nevertheless, it's difficult to accurately assess wider impacts because today's climate models—the only tools available for predicting Earth system behaviors decades into the future—are too low-resolution to accurately show the effect of river plumes. The oceanic turbulence Bracco tracked in the South China Sea, which influences the structure of eddies and currents, occurs on a scale of one to two kilometers. Most climate models have a resolution of 50 to 100 kilometers. At that coarse resolution, turbulence from river plumes doesn't register. When existing models attempt to account for freshwater delivery from major rivers, they "mix that water in a way that's very different from reality," says Bracco.

Gawarkiewicz notes a related issue. In his own studies of how freshwater gets into the deep ocean, he's found that "there are lots of surprises to it. The dynamics are very complicated." Interactions among wind and water, tidal mixing, the presence and intensity of sunshine, and eddy motions all affect what happens. But climate models generally use just one variable—the density difference between the fresh river plume and the salty sea—to stand in for all these factors.

Human-induced changes in the quantity, quality, and timing of river plumes may have other still-unpredictable impacts on the ocean. Building dams isn't the only way that humans are changing river plumes. Rather

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than holding back sediment, sometimes people cause vast amounts of excess sediment to be released.

The study documenting the dramatic reduction in sediment delivery to coasts in the global north found the opposite problem in the global south. Coasts in South America, Africa, and Oceania now receive 36 percent more sediment than they did four decades ago, largely because of runoff and erosion caused by deforestation to make way for palm oil, soy, sugarcane, and mining.

During the past decade, the Gulf of Mexico and the Caribbean Sea have experienced a troublesome explosion of sargassum seaweed; Bracco thinks it will ultimately prove related to deforestation-induced runoff bringing excess sediment into the Amazon River's plume.

Most ocean impacts caused by human changes to river plumes are likely local, says Bracco, rather than global. But with dams already blocking two-thirds of large rivers worldwide and thousands more planned, those local impacts could affect ocean life just about everywhere—and we're only beginning to reckon with them.

Nautilus, 3 May 2023

https://nautil.us

The Unexpected Evolutionary Key of Blinking

2023-04-27

Blinking is vital for the eye's health and function. It serves multiple purposes such as keeping the eyes clean, safeguarding them, and even conveying nonverbal cues. However, the origin of blinking is still a mystery. To shed light on this subject, a team of researchers from the Georgia Institute of Technology, Seton Hill University, and Pennsylvania State University conducted a study on the mudskipper, a unique amphibious fish that primarily lives on land. The study aimed to understand why blinking is a fundamental behavior for life on land.

Despite being only distantly related to tetrapods, a group that encompasses humans and other four-legged vertebrates, researchers believed studying the fish could unlock how blinking evolved as these animals began to move on land.

The research team, which included several undergraduates, published their findings in the Proceedings of the National Academies of Science.

"By comparing the anatomy and behavior of mudskippers to the fossil record of early tetrapods, we argue that blinking emerged in both groups as an adaptation to life on land," said Tom Stewart, an assistant professor at Penn State and an author of the paper. "These results help us understand our own biology and raise a whole set of new questions about the variety of blinking behaviors we see in living species."

Breaking Down Blinking

Mudskippers blink by sucking their eye downward into their eye socket. The evolution of this behavior did not require the evolution of a lot of new parts such as new muscles or special glands, though. Instead, mudskippers use their existing set of eye muscles in a new way.

"This is a very exciting result because it demonstrates that the evolution of a new, complex behavior can be achieved using a relatively rudimentary set of structures," said Brett Aiello, a former postdoctoral fellow in the Agile Systems Lab and now an assistant professor at Seton Hill.

Next, the research team set out to determine why mudskippers blink. In a series of experiments, they found that mudskippers blink for three main functions: to wet, clean, and protect the eye. These functions are also why humans and other land-dwelling vertebrates blink.

Blinking isn't just a unique research question, but also an important mechanism to understand.

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"We find that a single behavior can be deployed to accomplish three complex, distinct functions," said Aiello. "These results not only help humans understand our own history, but also help us reevaluate the adaptations necessary for major transitions in the evolutionary history of vertebrates, like moving from water to land."

Blinking isn't just a unique research question, but also an important mechanism to understand, according to Saad Bhamla, an assistant professor in Georgia Tech's School of Chemical and Biomolecular Engineering and author on the paper.

"We all blink without thinking, and understanding why we blink is just such a beautiful puzzle right in front of our eyes," Bhamla said. "Through our research on mudskippers and by conducting biophysical and morphological analyses, we expose how blinking serves a multitude of functions for adapting to life out of water."

Engaging Undergraduates

To explore such open-ended questions, the researchers engaged the Vertically Integrated Projects (VIP) program, which allows undergraduates to conduct long-term, large-scale research projects as part of their coursework at Georgia Tech.

"The structure of the VIP course empowers students to really lean on their own creativity and drive the project in the directions that are most exciting to them," said Aiello. "It helps our students gain the ability to solve unknown problems on the ground as they arise — a lot of people become scientists to push research somewhere where nobody else has tried to go before."

The VIP structure is inherently multidisciplinary. While Aiello is a biologist, most students were engineers and brought their respective expertise. Manognya Sripathi was a biomedical engineering major with a minor in computer science and offered her unique experience to the mudskipper problem.

"I used my computer science skills to gather raw data and analyze and plot them using programs like MATLAB or Python," Sripathi said. "I also used engineering skills to help build the experimental equipment, allowing us to apply engineering methods to study a biological problem in a unique way."

Moving Beyond Mudskippers

The research didn't just expand knowledge of mudskippers — it also contributed to each student's future aspirations. For example, Kendra Washington's trajectory was influenced by the two semesters she spent in the lab.

"VIP drew me closer to the programming and device areas of my biomedical engineering major and solidified why I picked up a computer science minor," she said. "I continued to pursue that fusion through later internships and research, and now work with hemodynamic monitoring. But in a sense, I still help characterize physiology through programming."

VIP also expanded the students' knowledge and scientific experience which has propelled them far beyond the lab. Hajime Minoguchi, a biomedical engineering graduate, now works as a systems integration research and development engineer thanks to his experience in the class.

"Working in an interdisciplinary team like this has allowed me to learn how to understand and communicate ideas between disciplines, which allowed me to be a more well-rounded engineer," Minoguchi said. "My work requires a thorough understanding of biology, electrical circuitry, software, firmware, mechanical interactions, and physics. This VIP experience was instrumental for me in being successful at my current job."

The research is far greater than the sum of its parts and brings a greater understanding of evolution, noted Simon Sponberg, an associate professor in the School of Physics and the School of Biological Sciences.

"Blinking is a reflection of a bigger question," Sponberg said. "How did major evolutionary transitions occur that enabled organisms to inhabit basically every environment on this planet? What we learned is you don't need the evolution of a lot of specialized musculature or glands; evolution can tinker with the structures that are already there, allowing them to be used in a new way and for a new behavior."

Sci Tech Daily, 27 April 2023

https://scitechdaily.com

Mushrooms and their post-rain, electrical conversations

2023-04-28

Certain fungi play a critical role in the ecological sustenance of forest trees. Ectomycorrhizal fungi are one such example. Commonly found on pine, oak, and birch trees, ectomycorrhizal fungi form a sheath around the outside of tree roots, and their mycelial body develops into vast

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underground networks that absorb vital nutrients from the soil and transfer it to the trees.

Scientists have been studying the possibility of electrical signal transfer between mushrooms and across trees via the mycelial networks. It is thought that fungi generate electrical signals in response to external stimuli and use these signals to communicate with each other, coordinating growth and other behavior. It has even been hypothesized that these signals can be used to help transfer nutrients to plants and trees.

Still, current scientific evidence remains sparse. Moreover, many studies have been limited to the laboratory, failing to recreate what happens in the wild.

Now, a group of researchers has recently headed to the forest floor to examine small, tan-colored ectomycorrhizal mushrooms known as Laccaria bicolor. Attaching electrodes to six mushrooms in a cluster, the researchers discovered that the electrical signals increased after rainfall. Details of their research were reported in the journal Fungal Ecology on March 14, 2023.

"In the beginning, the mushrooms exhibited less electrical potential, and we boiled this down to the lack of precipitation," says Yu Fukasawa from Tohoku University, who lead the project along with Takayuki Takehi and Daisuke Akai from the National Institute of Technology, Nagaoka College, and Masayuki Ushio from the Hakubi Center, Kyoto University (presently at the Hong Kong University of Science and Technology). "However, the electrical potential began to fluctuate after raining, sometimes going over 100 mV."

The researcher correlated this fluctuation with precipitation and temperature, and causality analysis revealed that the post-rain electric potential showed signal transport among mushrooms. This transport was particularly strong between spatially close mushrooms and demonstrated directionality.

"Our results confirm the need for further studies on fungal electrical potentials under a true ecological context," adds Fukasawa.

Phys Org, 28 April 2023

https://phys.org

Scientists have been studying the possibility of electrical signal transfer between mushrooms and across trees via the mycelial networks.

Intravenous Mistletoe Shows Potential As Cancer Therapy

2023-04-27

While the phase I trial was meant to evaluate the drug's safety, the researchers also documented improved quality of life and some disease control among study participants with advanced and treatment-resistant cancers.

Mistletoe extract has been widely used to support cancer therapy and improve quality of life, but there has been a lack of clinical trials and data to support its use. Researchers at the Johns Hopkins Kimmel Cancer Center completed what is believed to be the first phase I trial of intravenous Helixor M in the United States, aimed at determining dosing for subsequent clinical trials and to evaluate safety.

The findings from the small study, led by Channing Paller, associate professor of oncology, appear in the journal Cancer Research Communications.

Mistletoe extract, or ME, known as Helixor M, was studied in 21 patients with advanced and treatment-resistant cancers of various types. The phase I trial used dose escalation to determine the maximum dose that patients could safely tolerate. ME was delivered intravenously three times per week until disease progression or until toxicity. The study concluded that dose to be 600 milligrams of ME.

The median follow-up duration on mistletoe was 15.3 weeks. Stable disease was observed in five patients and lasted, on average, for 15 weeks. Tumors in three participants decreased in size and remained stable for two to five months; however, this did not meet official criteria for partial response. Patients also reported overall improved quality of life via a questionnaire. The most common side effects reported were fatigue, nausea, and chills, and they were noted as manageable.

"Intravenous mistletoe demonstrated manageable toxicities with disease control and improved quality of life in this group of patients, who had already received multiple cancer therapies," says Paller, who adds that additional phase II studies in combination with chemotherapy are the next step, pending additional funding.

In addition, Paller says that laboratory research to better decipher ME's mechanisms are needed, as the cytokines (cell-signaling proteins) measured in this study are preliminary and hypothesis generating.

In a small study, intravenous mistletoe extract shows promise as a cancer therapy.

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Mistletoe extract is a semi-parasitic plant with several active ingredients that, in preclinical studies, appear to directly cause the death of tumor cells and stimulate an immune response. It has been used in Europe for several decades as a complementary medicine approach to cancer treatment alone or in combination with chemotherapy and radiation therapy, but it has not been evaluated in clinical trials.

Mistletoe extract is not currently FDA approved for cancer treatment in the US but is listed in the Homeopathic Pharmacopoeia and is offered in integrative care clinics.

Futurity, 27 April 2023

https://futurity.org

How close are we to reading minds? A new study decodes language and meaning from brain scans

2023-05-02

The technology to decode our thoughts is drawing ever closer. Neuroscientists at the University of Texas have for the first time decoded data from non-invasive brain scans and used them to reconstruct language and meaning from stories that people hear, see or even imagine.

In a new study published in Nature Neuroscience, Alexander Huth and colleagues successfully recovered the gist of language and sometimes exact phrases from functional magnetic resonance imaging (fMRI) brain recordings of three participants.

Technology that can create language from brain signals could be enormously useful for people who cannot speak due to conditions such as motor neurone disease. At the same time, it raises concerns for the future privacy of our thoughts.

Language decoded

Language decoding models, also called "speech decoders", aim to use recordings of a person's brain activity to discover the words they hear, imagine or say.

Until now, speech decoders have only been used with data from devices surgically implanted in the brain, which limits their usefulness. Other decoders which used non-invasive brain activity recordings have been able to decode single words or short phrases, but not continuous language.

Until now, speech decoders have only been used with data from devices surgically implanted in the brain, which limits their usefulness.

The new research used the blood oxygen level dependent signal from fMRI scans, which shows changes in blood flow and oxygenation levels in different parts of the brain. By focusing on patterns of activity in brain regions and networks that process language, the researchers found their decoder could be trained to reconstruct continuous language (including some specific words and the general meaning of sentences).

Specifically, the decoder took the brain responses of three participants as they listened to stories, and generated sequences of words that were likely to have produced those brain responses. These word sequences did well at capturing the general gist of the stories, and in some cases included exact words and phrases.

The researchers also had the participants watch silent movies and imagine stories while being scanned. In both cases, the decoder often managed to predict the gist of the stories.

For example, one user thought "I don't have my driver's licence yet", and the decoder predicted "she has not even started to learn to drive yet".

Further, when participants actively listened to one story while ignoring another story played simultaneously, the decoder could identify the meaning of the story being actively listened to.

How does it work?

The researchers started out by having each participant lie inside an fMRI scanner and listen to 16 hours of narrated stories while their brain responses were recorded.

These brain responses were then used to train an encoder – a computational model that tries to predict how the brain will respond to words a user hears. After training, the encoder could quite accurately predict how each participant's brain signals would respond to hearing a given string of words.

However, going in the opposite direction – from recorded brain responses to words – is trickier.

The encoder model is designed to link brain responses with "semantic features" or the broad meanings of words and sentences. To do this, the system uses the original GPT language model, which is the precursor of today's GPT-4 model. The decoder then generates sequences of words that might have produced the observed brain responses.

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The accuracy of each "guess" is then checked by using it to predict previously recorded brain activity, with the prediction then compared to the actual recorded activity.

During this resource-intensive process, multiple guesses are generated at a time, and ranked in order of accuracy. Poor guesses are discarded and good ones kept. The process continues by guessing the next word in the sequence, and so on until the most accurate sequence is determined.

Words and meanings

The study found data from multiple, specific brain regions – including the speech network, the parietal-temporal-occipital association region, and prefrontal cortex – were needed for the most accurate predictions.

One key difference between this work and earlier efforts is the data being decoded. Most decoding systems link brain data to motor features or activity recorded from brain regions involved in the last step of speech output, the movement of the mouth and tongue. This decoder works instead at the level of ideas and meanings.

One limitation of using fMRI data is its low "temporal resolution". The blood oxygen level dependent signal rises and falls over approximately a 10-second period, during which time a person might have heard 20 or more words. As a result, this technique cannot detect individual words, but only the potential meanings of sequences of words.

No need for privacy panic (yet)

The idea of technology that can "read minds" raises concerns over mental privacy. The researchers conducted additional experiments to address some of these concerns.

These experiments showed we don't need to worry just yet about having our thoughts decoded while we walk down the street, or indeed without our extensive cooperation.

A decoder trained on one person's thoughts performed poorly when predicting the semantic detail from another participant's data. What's more, participants could disrupt the decoding by diverting their attention to a different task such as naming animals or telling a different story.

Movement in the scanner can also disrupt the decoder as fMRI is highly sensitive to motion, so participant cooperation is essential. Considering these requirements, and the need for high-powered computational

resources, it is highly unlikely that someone's thoughts could be decoded against their will at this stage.

Finally, the decoder does not currently work on data other than fMRI, which is an expensive and often impractical procedure. The group plans to test their approach on other non-invasive brain data in the future.

The Conversation, 2 May 2023

https://theconversation.com

Rust in the Brain: Iron's Surprising Role in Alzheimer's Uncovered

2023-05-01

What if amyloid beta plaques aren't the main cause of Alzheimer's disease? There is a growing body of evidence that iron in the brain may play a role in Alzheimer's disease. Lending weight to that idea, a new imaging probe has for the first time shown that in the same regions of the brain where the amyloid beta plaques associated with Alzheimer's occur, there is also an increase in iron redox, meaning the iron in these regions is more reactive in the presence of oxygen. Their imaging probe could yield even more details about the causes of Alzheimer's and help in the search for new drugs to treat it.

A team from The University of Texas at Austin and the University of Illinois at Urbana-Champaign published a study on the new imaging technique and findings in Science Advances.

"The link between iron redox and Alzheimer's disease has been a black box," said Yi Lu, corresponding author and professor of chemistry at UT Austin. "The most exciting part to me is that we now have a way to shine light into this black box so that we can begin to understand this whole process in much more detail."

About a decade ago, scientists discovered ferroptosis, a process in the body that is dependent on elevated iron levels, leads to cell death and plays a key role in neurodegenerative diseases, such as Alzheimer's. Using magnetic resonance imaging on living Alzheimer's patients, scientists have observed that these patients tend to have elevated iron levels in the brain, although that method doesn't differentiate between different forms of iron. Together, these findings suggested that iron might play a role in destroying brain cells in Alzheimer's patients.

This breakthrough could provide new insights into the role of iron in Alzheimer's and guide the development of new treatments targeting iron redox changes.

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For the new study, the researchers developed DNA-based fluorescent sensors that can detect two different forms of iron (Fe2+ and Fe3+) at the same time in cell cultures and in brain slices from mice genetically modified to mimic Alzheimer's. One sensor glows green for Fe2+ and the other glows red for Fe3+. This is the first imaging technique that can simultaneously detect both forms of iron in cells and tissue while also indicating their quantity and spatial distribution.

"The best part about our sensor is that we can now visualize the changes of Fe2+ and Fe3+ and their ratios in each location," said Yuting Wu, a co-first author of the study and a postdoctoral researcher in Lu's lab at UT Austin. "We can change one parameter at a time to see if it changes the plaques or the oxidative states of iron."

That ability could help them better understand why there is an increased ratio of Fe3+ to Fe2+ in the location of amyloid beta plaques and whether increased iron redox is involved in forming the plaques.

Another key question is whether the iron redox is directly involved in cell death in Alzheimer's, or simply a byproduct. The researchers plan to explore this question in Alzheimer's mice. If further research determines that iron and its redox changes indeed cause cell death in Alzheimer's patients, that information could provide a potential new strategy for drug development. In other words, perhaps a drug that change the ratio Fe3+ to Fe2+ could help protect brain cells. The new imaging probe could be used to test how well drug candidates work at changing the ratio.

To develop the sensors, the scientists first hired a commercial lab to produce a library of 100 trillion short DNA strands, through a chemical process called oligonucleotide synthesis. They then conducted a screening process to find those strands that recognize — or in chemistry parlance "bind tightly to and conduct a catalytic reaction with" — a specific form of iron and not any other forms. To complete the sensors, other components were added including molecules called fluorophores that glow in a specific color when the probe recognizes the specific form of iron.

Sci Tech Daily, 1 May 2023

https://scitechdaily.com

Did 'deleted' bits of genetic info make us human?

2023-05-01

What the human genome is lacking compared with the genomes of other primates might have been as crucial to the development of humankind as

what has been added during our evolutionary history, according to a new study.

The new findings, published in the journal Science, fill an important gap in what is known about historical changes to the human genome. While a revolution in the capacity to collect data from genomes of different species has allowed scientists to identify additions that are specific to the human genome—such as a gene that was critical for humans to develop the ability to speak—less attention has been paid to what's missing in the human genome.

For the new study, researchers used an even deeper genomic dive into primate DNA to show that the loss of about 10,000 bits of genetic information—most as small as a few base pairs of DNA—over the course of our evolutionary history differentiates humans from chimpanzees, our closest primate relative. Some of those "deleted" pieces of genetic information are closely related to genes involved in neuronal and cognitive functions, including one associated with the formation of cells in the developing brain.

These 10,000 missing pieces of DNA—which are present in the genomes of other mammals—are common to all humans, researchers find.

The fact that these genetic deletions became conserved in all humans, the authors say, attests to their evolutionary importance, suggesting that they conferred some biological advantage.

"Often we think new biological functions must require new pieces of DNA, but this work shows us that deleting genetic code can result in profound consequences for traits make us unique as a species," says Steven Reilly, an assistant professor of genetics at Yale University School of Medicine and senior author of the paper.

The paper was one of several published in Science from the Zoonomia Project, an international research collaboration that is cataloging the diversity in mammalian genomes by comparing DNA sequences from 240 species of mammals that exist today.

In their study, the Yale team found that some genetic sequences found in the genomes of most other mammal species, from mice to whales, vanished in humans. But rather than disrupt human biology, they say, some of these deletions created new genetic encodings that eliminated elements that would normally turn genes off.

Information "deleted" from the human genome may be what made us human, research shows.

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The deletion of this genetic information, Reilly says, had an effect that was the equivalent of removing three characters—"n't"—from the word "isn't" to create a new word, "is."

"[Such deletions] can tweak the meaning of the instructions of how to make a human slightly, helping explain our bigger brains and complex cognition," he says.

The researchers used a technology called Massively Parallel Reporter Assays (MPRA), which can simultaneously screen and measure the function of thousands of genetic changes among species.

"These tools have the capability to allow us to start to identify the many small molecular building blocks that make us unique as a species," Reilly says.

Researchers at Yale and the Broad Institute of MIT and Harvard led the study.

Futurity, 1 May 2023

https://futurity.org

Forest fungi overheard talking to each other after rain showers

2023-05-02

Whether they're hacking the brains of bugs or mining for gold, fungi are craftier than we give them credit for. Now researchers in Japan have studied how forest mushrooms communicate with each other, and found that they're mostly chatty when it rains.

Ectomycorrhizal fungi don't just grow as capped stalks above ground – they form vast networks of roots that stretch out underground and absorb key nutrients from the soil to feed themselves and other plants in a symbiotic relationship.

But this mycelial network also seems to be used for communication between stalks and neighboring plants, coordinating growth or warning of insects or disease. Intriguing as it is, scientific study of the phenomenon has been patchy, and often limited to lab tests.

So for the new study, researchers at Tohoku University in Japan conducted field tests on a type of ectomycorrhizal fungi known as Laccaria bicolor, small tan-colored mushrooms that grow on forest floors. The team

Researchers noticed that the electrical signals fluctuated over time, and seemed to correlate with changes in temperature and moisture.

attached electrodes to six of the mushrooms in a cluster and measured the electrical signals they passed between each other.

They noticed that the electrical signals fluctuated over time, and seemed to correlate with changes in temperature and moisture. In fact, the signals spiked after rainfall, and were found to be stronger between mushrooms that were closer together.

"In the beginning, the mushrooms exhibited less electrical potential, and we boiled this down to the lack of precipitation," said Yu Fukasawa, lead researcher on the study. "However, the electrical potential began to fluctuate after raining, sometimes going over 100 mV."

The team says these findings indicate the need for future studies investigating electrical communication between fungi in real-world locations.

The research was published in the journal Fungal Ecology.

New Atlas, 2 May 2023

https://newatlas.com

The surprising appliance that could make solar panels easier to produce and recycle

2023-04-27

The rise of solar power in the last decade has been a climate success story. But solar power comes with a dark side. As solar farms grow around the world, so does the problem of tons of waste panels in the future.

Researchers in Australia have now come up with a technique that could not only make solar panels easier to recycle, and also make them less expensive to manufacture. And all it takes is a kitchen microwave.

Most solar panels today are made of silicon. During their manufacture, the silicon is heated at temperatures above 900°C in a furnace to change its properties. This burns a lot of energy and adds cost. Zapping silicon in microwave ovens instead would not only be faster and more energy efficient, it also makes the panels easier to recycle at the end of their working life, the Australian team reports in a paper published in Applied Physics Letters.

Microwaves could process silicon solar cells using less time and energy than high-temperature furnaces, while also making panels easier to disassemble and recycle.

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The world's solar capacity went from 1.4 gigawatts in 2000 to 760 gigawatts in 2020, and solar power now generates almost 4 percent of the world's electricity, according to the International Energy Agency.

Solar panels typically last about 30 years. Studies predict that around 8 million metric tons of these panels will reach the end of their lives by 2030. That number will go up to 80 million metric tons by 2050.

Most of these panels, which contain toxic lead that can leach out, end up in landfills. Besides the potential environmental hazard, this is also a waste of resources because the panels contain valuable materials. Only the European Union mandates panel recycling as of now. But current recycling technologies are limited and energy-intensive.

Binesh Puthen Veettil of Macquarie University and colleagues devised a cheaper, less energy-intense way to both make and recycle solar panels. The team bought a kitchen microwave and added heat-proofing so it could handle very high temperatures. They found that microwaves could heat and process the silicon in solar cells nearly as efficiently as a furnace. Microwave radiation selectively heats silicon, leaving the rest of the panel of glass, plastic and aluminum largely unaffected.

As an added bonus, microwaving also softened the plastic, making it easier to peel off, and freeing the solar cell and glass for recycling. The plastic coating is designed to protect the panel from moisture, but is difficult to remove. "Until now it made economic sense to just dump the panels in the landfill," said Veettil in a press release. "In the rare instances when they are recycled, you crush the panels, heat them to about 1400°C and wash them with chemicals to remove the plastic—a highly energy-demanding process."

The researchers have a patent pending for the microwave-based recycling process. They are now working on further improvements with plans to commercialize it.

Anthropocene, 27 April 2023

https://antropocenemagazine.com

Smaller, cheaper, safer: The next generation of nuclear power, explained

2023-05-01

Inside the Transient Reactor Test Facility, a towering, windowless gray block surrounded by barbed wire, researchers are about to embark on a mission to solve one of humanity's greatest problems with a tiny device.

Next year, they will begin construction on the MARVEL reactor. MARVEL stands for Microreactor Applications Research Validation and EvaLuation. It's a first-of-a-kind nuclear power generator, cooled with liquid metal and producing 100 kilowatts of energy. By 2024, researchers expect MARVEL will be the zero-emissions engine of the world's first nuclear microgrid here at Idaho National Laboratory (INL).

"Micro" and "tiny," of course, are relative. MARVEL stands 15 feet tall, weighs 2,000 pounds, and can fit in the trailer of a semi-truck. But compared to conventional nuclear power plants, which span acres, produce gigawatts of electricity to power whole states, and can take more than a decade to build, it's minuscule.

For INL, where scientists have tested dozens of reactors over the decades across an area three-quarters the size of Rhode Island, it's a radical reimagining of the technology. This reactor design could help overcome the biggest obstacles to nuclear energy: safety, efficiency, scale, cost, and competition. MARVEL is an experiment to see how all these pieces could fit together in the real world.

"It's an applications test reactor where we're going to try to figure out how we extract heat and energy from a nuclear reactor and apply it — and combine it with wind and solar and other energy sources," said Yasir Arafat, head of the MARVEL program.

The project, however, comes at a time when nuclear power is getting pulled in wildly different directions.

Germany just shut down its last nuclear reactors. The US just started up its first new reactor in 30 years. France, the country with the largest share of nuclear energy on its grid, saw its nuclear power output decline to the lowest levels since 1988 last year. Around the world, there are currently 60 nuclear reactors under construction, with 22 in China alone.

But the world is hungrier than ever for energy. Overall electricity demand is growing: Global electricity needs will increase nearly 70 percent by 2050 compared to today's consumption, according to the Energy Information

The nuclear industry's big bet on going small.

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Administration. At the same time, the constraints are getting tighter. Most countries in the world, including the US, have now committed to zeroing out their net impact on the climate by the middle of the century.

To meet this energy demand without worsening climate change, the US Energy Department's report on advanced nuclear energy released in March said "the U.S. will need ~550–770 [gigawatts] of additional clean, firm capacity to reach net-zero; nuclear power is one of the few proven options that could deliver this at scale."

The US government is now renewing its bets on nuclear power to produce a steady stream of electricity without emitting greenhouse gases. The Bipartisan Infrastructure Law included $6 billion to keep existing nuclear power plants running. The Inflation Reduction Act, the US government's largest investment in countering climate change to date, includes a number of provisions to benefit nuclear power, including tax credits for zero-emissions energy.

"It's a game changer," said John Wagner, director of INL.

The tech sector is jumping in, too. In 2021, venture capital firms poured $3.4 billion into nuclear energy startups. They're also pouring money into even more far-out ideas, like nuclear fusion power. Public opinion has also started moving. An April Gallup poll found that 55 percent of Americans favor and 44 percent oppose using nuclear energy, the highest levels of support in 10 years.

But nuclear energy is still facing some long-running headwinds. It's the one power source whose operating costs have actually increased over time. Recent construction efforts have run years behind schedule and billions of dollars over budget. Most reactors still rely on enriched uranium, a pricey fuel to mine and process. Finding a place to store nuclear waste remains a problem. The workforce needed to build and operate plants has withered, due to the decades between reactor builds. And now, with rising interest rates, it's more expensive to finance ambitious energy projects.

Can the nuclear energy industry invent its way out of its toughest problems?

Advocates certainly hope so, and the potential for nuclear energy to meet the challenge of climate change is immense. Many new nuclear power technologies are now in design and testing phases. But one of the most promising strategies for nuclear is to go big by going small.

The new generation of nuclear power, explained

Splitting atoms is the largest source of greenhouse gas-free electricity in the US and the second-largest in the world behind hydropower. Nuclear fission produces 10 percent of the world's electricity. The US has the largest nuclear reactor fleet in the world, with 92 reactors across 53 power plants in 28 states.

The current crop of nuclear reactors use a variety of different design approaches, tailored to their specific needs. That helped these power plants better fit into the power grids when they were initially built, but it made it harder for them to adapt to changing demands and for newer plants in other places to learn from them.

To understand what sets the new reactor designs apart, it helps to know how earlier designs worked. Generally, civilian nuclear reactors are divided into "generations" that refined the technology, economics, and safety with each iteration.

The first generation of reactors were proofs of concept, according to Jess Gehin, associate director for nuclear science and technology at INL. From there, they scaled up in size and added safety features to make them more usable in the real world, forming the second generation. The bulk of the world's operating nuclear reactors right now are second-generation designs. They are also the foundation of most business models and the basis for nuclear energy regulations.

More recent third-generation reactors advance this with improved safety features. "Several of those have been built that actually start moving away from the active safety systems to more passive systems," Gehin said. The recently opened reactor at the Vogtle Electric Generating Plant in Georgia is a design called AP1000. It's considered a generation three-plus reactor that uses fewer moving parts than conventional designs and can cool off on its own should something go wrong. "You can go 72 hours without any operator interaction," Gehin said.

Fourth-generation reactors are now in the works. Unlike current reactors that mainly use water to control the reaction and to stay cool, these designs use other materials like liquid metal, pressurized gas, and molten salt. The advantage is that they can reach higher operating temperatures, which can lead to greater efficiency. Industrial processes like steel production could also draw on that extra heat.

Many fourth-generation designs can also use cheaper, lower-grade nuclear fuels. That's one of the approaches being developed by TerraPower, a nuclear company founded by investor Bill Gates. Some fourth-generation

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designs can even use waste from other reactors. They can also integrate equipment that allows them to ramp up and down more readily to scale with energy demands.

These combined effects improve the economics of nuclear power, streamlining the overall process from reducing fuel costs to generating power more effectively to reducing waste and to improving safety.

Nuclear can do more than generate electricity

Some of the most significant advances in nuclear energy, however, may not be in the reactors themselves. Their biggest benefits could come from rethinking how they fit into the existing power infrastructure.

The Energy Department has suggested that hundreds of sites for coal power plants, which are rapidly shutting down across the country, could be repurposed for nuclear energy. The advantage is that they already have many of the necessary permits and the equipment to plug into the power grid, saving some of the startup costs of a new plant.

Most conventional reactors are optimized to run flat out, with a steady output of energy. But demand on the power grid varies widely as lights switch on in the evening or heaters turn on during the day. While some nuclear power plants can ramp up and down, it's not always easy. Windy and sunny days can also mean that there's a surfeit of cheap electrons from renewables and undercut nuclear electricity on price. And since nuclear plants have high fixed costs even when they're turned down, they prefer to stay up and sell as much of their electricity as possible.

Now, engineers are planning nuclear reactors with this capricious demand in mind. "New reactors are designed to be dispatchable and flexible," said Christine King, director of the Gateway for Accelerated Innovation in Nuclear at INL.

One idea is to integrate energy storage. Molten salt, for instance, can be used to store heat from a nuclear reactor for hours at a time and dispatch it as needed. Another approach is to use the heat from a reactor not just to boil water but to provide industrial heat to factories. Researchers are also designing reactors that can produce hydrogen when they have excess power, which in turn can run fuel cells in cars or put electrons back on the grid.

Electricity from nuclear power plants doesn't necessarily have to feed into the power grid either, according to King. It can instead power dedicated processes like capturing carbon dioxide directly from the air. Capturing

this carbon dioxide is a highly energy-intensive process, though, and nuclear could provide the requisite power without making the problem worse. That captured carbon could then serve as a building block for synthetic fuels, particularly for sectors that are hard to electrify, like aviation and shipping.

It's hard to build anything these days

The virtues of advanced nuclear reactors are all great in theory. In practice, building anything big is really, really hard.

Bent Flyvbjerg, a professor at the IT University of Copenhagen and a professor at the University of Oxford, recently co-authored a book called How Big Things Get Done. It examines why so many major infrastructure projects like high-speed trains, IT systems, and even home renovations run behind schedule and over budget. Often, these problems arise from a failure of planning, inadequate expertise, political pressure, and limited experience.

Nuclear energy brings even more unique challenges. One is that the technology itself is evolving, so it's difficult to learn from past efforts to build reactors. Nuclear regulators also built their rules around second-generation designs. So as engineers come up with new ways to split atoms, nuclear observers also have to come up with new standards to make sure they're safe. The back-and-forth between developers and regulators adds another layer of complexity to the design process.

And anytime there's a problem with a nuclear power plant anywhere, regulators step up their scrutiny. "Once they had adapted to a certain set of standards, they would be raised because there was a nuclear incident or accident," Flyvbjerg said.

Most existing commercial reactors also don't scale up and down easily, so they have to start with bigger, more expensive designs at the outset. That means they have to recover that cost over decades, but if utilities get their electricity demand forecasts wrong, then nuclear power plants end up having to raise their prices or lose money. With new reactors being built for the first time, there's little experience to draw on. Builders often encounter unanticipated problems that require more money and resources to fix.

The Vogtle Plant was nearly six years behind schedule, and its cost was almost double its initial budget of $14 billion, for example. Utilities in South Carolina abandoned a $9 billion effort to build two AP1000 reactors in 2017. If you're an investor or a public utility, it's enough to grind your

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molars into dust. Developing fourth-generation reactors stands to be an even more expensive, time-consuming process.

But there are some potential ways to chip away at these monumental challenges. One way is for governments to step in and provide research support to these new designs and test them out.

For the nuclear industry, the hot new strategy is to scale down with small modular reactors, or SMRs. Rather than building huge, customized reactors on site, companies like NuScale are developing smaller reactors, on the order of 10 to 50 megawatts, that can be built in factories and trucked or shipped around the world. The standardized designs could save costs. And by starting small and scaling up, they could meet a variety of use cases.

This approach has already caught eyes around the world. The US Navy already operates more than 200 small nuclear reactors to power submarines and aircraft carriers. The test is to see whether the business case makes sense on land. China and Russia are already running SMRs, and 19 countries are developing them. Canadian Prime Minister Justin Trudeau said in April that Canada is making "a return to nuclear, which we're very very serious about, and investing in some of the small modular reactors." One of NuScale's first commercial SMR plants in the world is now planned in Romania in 2028.

"This is the right experiment to be doing," Flyvbjerg said.

And with designs like MARVEL, researchers are investigating even smaller reactors that can power remote communities, back up renewables, or provide emergency power after a disaster. As reactors get smaller, though, the question is how many it will take in order to achieve economies of scale.

"A lot of learning has to do with how many you build," said Gregory Nemet, a professor at the University of Wisconsin Madison and author of How Solar Energy Became Cheap.

Technologies like wind turbines, photovoltaic panels, and lithium-ion batteries saw huge price drops in part because it was easy to build a lot of them, so small improvements in performance had big ripple effects. If smaller nuclear reactors could achieve even a fraction of these cost declines, they could finally push the cost curve of nuclear power in the other direction.

It's not clear how much advanced nuclear will cost

Balancing the books may prove to be a bigger obstacle for nuclear power than splitting the atom.

A new report from the National Academy of Engineering says the economics of nuclear power "is perhaps the largest challenge to the commercial success of advanced reactors." Advanced nuclear reactors are especially tricky to game out.

"Let me just say that anyone making estimates of what it will cost to produce electricity from these power plants has got to have a whole series of embedded assumptions, there's a lot of uncertainty," said Richard Meserve, a former chair of the nuclear regulatory commission and a co-author of the report, during a briefing about the report.

Another big issue is that most countries still don't have a long-term solution for dealing with nuclear waste, which can remain hazardous for hundreds of years. It's a huge technical and political problem.

And while there is more demand for clean energy, interest rates are rising, making it more expensive to borrow money to build anything, let alone financially risky novel reactors. INL's Wagner noted that US reactor construction halted in the '80s due in part to high interest rates at the time. "When interest rates go to 10, 12, 15 percent, what happens? You've got cost overruns," he said.

At the same time, the world is about to overrun its carbon budget and overshoot the goal of limiting warming to less than 2.7 degrees Fahrenheit (1.5 degrees Celsius) this century.

The US has now committed to cutting its greenhouse gas emissions in half by 2030 compared to 2005 levels. It's unlikely that new nuclear power plants will make much progress toward that goal, now less than seven years away. But the US and more than 130 countries in the world want to eliminate their contributions to climate change entirely by 2050. That goal demands far cleaner, more abundant, and reliable energy than we have now.

Nuclear could help the world achieve this. It's a risky and expensive investment, but the foundations for this future have to be laid now.

Vox, 1 May 2023

https://vox.com

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New study identifies pathway to non-addictive pain relief

2023-05-03

While opioids like fentanyl and oxycodone are among the most powerful painkillers known to modern medicine, they are also extremely addictive and therefore, increasingly hard to get – even for those suffering from severe pain. A new finding may offer hope to pain patients in the form of powerful painkillers that lack the most hard-to-handle side effects of current options.

In seeking to block pain, pharmacologists long ago figured out that compounds that work on the opioid receptors on nerve cells work the best. However, as the current opioid crisis illustrates, these drugs are highly addictive. Our nerves have two types of opioid receptors and the most addictive drugs target the mu receptors. Seeking to find alternatives to these medications, scientists focused on the other receptors, known as kappa. But drugs that work on these pathways come with their own side effects, most notably, hallucinations.

Still, because addiction isn't an issue, working with the kappa receptors has held promise. Now, researchers at the Washington University School of Medicine (WashU Medicine) and the University of Health Sciences & Pharmacy in St. Louis, have figured out that there is more than one type of kappa receptor. More importantly, they discovered that while they can all offer some pain relief, they don't all cause hallucinations.

The current finding joins other research that is seeking to replace opioids with safer options.

The key lies in a group of signaling compounds known as G proteins. When encountered by the kappa opioid receptors, these proteins activate different pathways. With further testing, the research team believes that they will be able to sort out which pathways provide relief from pain without triggering hallucinations. Once that puzzle is sorted out, it is theoretically possible to create painkillers that would work as well as the best opioids, without carrying along their harmful side effects.

"All of these proteins are similar to one another, but the specific protein subtypes that bind to the kappa receptor determine which pathways will be activated," said principal investigator Tao Che, an assistant professor of anesthesiology at WashU Medicine. "We have found that the hallucinogenic drugs can preferentially activate one specific G protein but not other, related G proteins, suggesting that beneficial effects such as pain relief can be separated from side effects such as hallucinations. So we expect it will be possible to find therapeutics that activate the kappa

receptor to kill pain without also activating the specific pathway that causes hallucinations."

The current finding joins other research that is seeking to replace opioids with safer options. A 2018 study, for example, found success with a non-addictive painkiller in non-human primates, while a more recent effort discovered that three older antibiotics were effective in combating neuropathic pain in mice. There may even be hope that using a compound in tarantula venom could one day lead to non-addictive painkillers. Considering that over 70,000 deaths from opioids other than methadone were reported across the United States alone in 2021, any compound that can bring relief to patients without causing addiction or other serious mental health effects would be a welcome addition to the current state of pain management.

The research has been published in the journal, Nature.

New Atlas, 3 May 2023

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(NOTE: OPEN YOUR WEB BROWSER AND CLICK ON HEADING TO LINK TO SECTION)

CHEMICAL EFFECTS

Geospatial pattern of topsoil pollution and multi-endpoint toxicity in the petrochemical area of Augusta-Priolo (eastern Sicily, Italy)

Alleviation of arsenic toxicity in pepper plants by aminolevulinic acid and heme through modulating its sequestration and distribution within cell organelles

Comparison of biomarkers of exposure among US adult smokers, users of electronic nicotine delivery systems, dual users and nonusers, 2018-2019

ENVIRONMENTAL RESEARCH

Occurrence of persistent and mobile chemicals and other contaminants of emerging concern in Spanish and Portuguese wastewater treatment plants, transnational river basins and coastal water

Microplastic pollution in lakeshore sediments: the first report on abundance and composition of Phewa Lake, Nepal

Examination of the environmental behavior of phosphogypsum with the application of lab-scale experiment

PHARMACEUTICAL/TOXICOLOGY

Incorporation of Fast-Elimination Chemicals in Hair Is Governed by Pharmacokinetics-Implications for Exposure Assessment

OCCUPATIONAL

Benchmark dose estimation among benzene-exposed workers in China: Based on quantitative multi-endpoint genotoxicity assessments

Safety culture and perception of warning signs of chemical hazards among hospital cleaning workers: a cross-sectional study

Occupational exposure to pesticides: DNA damage in horticulturist from Nativitas, Tlaxcala in Mexico