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

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ASIA PACIFIC

Transition to GHS 7

2022-12-08

Australia is transitioning to the 7th Revised Edition of the GHS (GHS 7), which includes some changes to hazardous chemical classifications and precautionary statements.

Why are we transitioning?

Since 1 January 2017, we have used the 3rd revised edition of the GHS (GHS 3) to classify and label hazardous chemicals in Australia. We are now changing from GHS 3 to GHS 7.

Moving to GHS 7 in Australia will:

- match our key trading partners, who are also moving to GHS 7
- make sure classifications, labels and SDS use the more up-to-date classifications and hazard communication.

During the transition

The two-year transition to GHS 7 began on 1 January 2021 and will finish on 31 December 2022, giving manufacturers and importers time to implement the updated system.

Manufacturers and importers of hazardous chemicals

If you manufacture or import hazardous chemicals, you can currently use either GHS 3 or GHS 7 to make labels and SDS for hazardous chemicals.

You are also considered to be a manufacturer or importer of hazardous chemicals if you repackage or re-label hazardous chemicals products with your product name.

Suppliers of hazardous chemicals

If you supply hazardous chemicals, you can continue to supply chemicals that are classified and labelled under either GHS 3 or GHS 7.

Users of hazardous chemicals

You can continue to use chemicals that are classified and labelled under either GHS 3 or GHS 7, provided the chemical is manufactured or imported before 1 January 2023.

After the transition

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From 1 January 2023, only GHS 7 can be used to classify and label chemicals in Australia.

Manufacturers and importers of hazardous chemicals

If you are a manufacturer or importer of hazardous chemicals, you must only use GHS 7 to label and make SDS from 1 January 2023.

You do not have to re-label or dispose of any existing products. However, the SDS should comply with GHS 7 from 1 January 2023 even if the label doesn't.

You are also considered to be a manufacturer or importer of hazardous chemicals if you repackage or re-label hazardous chemicals products with your product name.

Suppliers of hazardous chemicals

If you are a supplier of hazardous chemicals, you should only accept stock which is classified, labelled and has a SDS prepared under GHS 7 from 1 January 2023.

You must not supply stock manufactured or imported from 1 January 2023 if it's not classified and labelled under GHS 7.

Users of hazardous chemicals

If you use hazardous chemicals, you should only accept new stock that is manufactured, classified and labelled under GHS 7 if they are manufactured or imported after 1 January 2023.

If the hazardous chemical is manufactured or imported before 1 January 2023, the product can be classified and labelled with either GHS 3 or GHS 7. This is the case even if you receive the product after 1 January 2023.

SDS should be compliant with GHS 7 from 1 January 2023 even if the label doesn't.

Progress on the GHS 7 transition in each jurisdiction

Each state and territory and the Commonwealth is adopting GHS 7 in their WHS laws.

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[Read More](#)

Safe Work Australia, 08-12-22

<https://www.safeworkaustralia.gov.au/safety-topic/hazards/chemicals/classifying-chemicals/transition-ghs7>

FSANZ annual report released

2022-11-30

The FSANZ 2021/22 Annual Report is available now on our website.

FSANZ achieved excellent results in the last financial year by working collaboratively with stakeholders, focussing on key priorities and upholding our organisational values.

We encourage you to read the annual report to get a full picture of all the good work FSANZ does in setting standards and supporting the bi-national food regulation system.

A big thanks to all our clients, stakeholders and partners for your contributions and support throughout 2021/22.

[Read More](#)

Food Standards News, 30-11-22

<https://mailchi.mp/3c81b4c0640d/food-standard-news-1300496?e=%5bUNIQID%5d#Website>

New FSANZ website on the way

2022-11-30

FSANZ is building a new website to better meet the needs and expectations of our users.

Our website is the primary gateway to agency services and tools, the Australia New Zealand Food Standards Code and food safety information.

Recent user testing found our current site does not adequately meet the needs of the public or new food sector entrants and is out of step with stakeholder perceptions of FSANZ as a modern food standards agency.

We're using this feedback to guide the development of a dynamic, contemporary and user-centred website that meets government digital service standards and the latest accessibility requirements.

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All of your favourite content and tools will be available on the new site, due for launch in the first half of 2023.

We'll keep you updated as work progresses. In the meantime, if you'd like to know more or put your hand up to participate in user acceptance testing, please email web.comments@foodstandards.gov.au.

[Read More](#)

Food Standards News, 30-11-22

<https://mailchi.mp/3c81b4c0640d/food-standard-news-1300496?e=%5bUNIQID%5d#Website>

China Releases New Standard for SVHCs and Restricted Chemicals in Automotive Industry

2022-11-31

Almost all SVHCs and restricted chemicals designated under REACH, as well as their application scope in metallic and non-metallic materials of auto parts are listed on the standard.

On October 31, China's Zhongguancun Inspection, Testing and Certification Industry Technology Alliance released a group standard T/ZTCA 011.1—2022 Automotive industry control of key chemical substances — Part 1: Application guidelines. The standard was developed and co-drafted by several industrial leaders, such as BMW Brilliance Automotive Ltd and BYD Auto, and prestigious universities and research institutes, which has drawn widespread attention. It will be adopted by relevant automotive enterprises involved in the drafting work and available for voluntary adoption by others. The standard takes effect on the same day it was released.

Background

In recent years, as more and more Chinese automotive enterprises march into the EU market for market share, they are increasingly constrained by technical trade barriers set up by REACH regulation - Registration, Evaluation, Authorization and Restriction of Chemicals. According to news published in 2020, a pilot project conducted by European Chemicals Agency (ECHA) examining imports of products into the EU has found that 23% of them were non-compliant with REACH and the Classification, Labeling and Packaging (CLP) regulations. Those found to be non-compliant (74%) mostly came from China, as well as from other Asia countries. With no industrial consensus on a consistent and reliable testing

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method for regulated chemicals, auto enterprises are faced with rising costs of legal compliance.

The formulation of T/ZTCA 011.1-2022 is set to provide general technical standards for the testing of REACH-controlled chemicals in automotive industry. It specifies the application scope of controlled chemicals in metallic and non-metallic materials of auto parts, including 222 substances of very high concern (SVHC) and 77 entries of restricted chemicals. Companies may adopt this standard as a testing reference and ensure safe use of these controlled chemicals to protect human health and environment.

[Read More](#)

Chemlinked, 31-11-22

<https://chemical.chemlinked.com/news/chemical-news/china-releases-new-standard-for-svhcs-and-restricted-chemicals-in-automotive-industry>

AMERICA

Drinking Water Regulations – Prohibition on Lead Use Rulemaking

2022-12-07

On Dec. 7, 2022, the comment period begins for Drinking Water Regulations – Prohibition on Lead Use rulemaking to update the safe drinking water rules to conform to EPA's final regulation entitled "Use of Lead Free Pipes, Fittings, Fixtures, Solder, and Flux for Drinking Water" (Lead Free Rule). 85 FR 54235 (Sept. 1, 2020). The comment period ends on Jan. 23, 2023.

Public Notice Information

ADEQ proposes to update the safe drinking water rules in A.A.C. Title 18, Chapter 4 to conform with the EPA's final regulation in 85 FR 54235 (Sept. 1, 2020).

The Notice of Proposed Expedited Rulemaking was filed with the Secretary of State's office and will be published in the Arizona Administrative Review

[Drinking Water Regulations – Prohibition on Lead Use Rulemaking](#)

[Public Comment Period](#)

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Dates: Dec. 7, 2022 – Jan. 23, 2023

[Read More](#)

ADEQ, 07-12-22

<https://www.azdeq.gov/notices/comment-period-begins-drinking-water-regulations-%E2%80%93-prohibition-lead-use-rulemaking>

Revealed: Nearly 100 potential PFAS-polluted sites in Pennsylvania, Ohio and West Virginia from fracking waste

2022-12-08

A new map reveals at least 97 new locations that could have been contaminated by the industry's use of "forever chemicals"

Waste from fracking wells that used PFAS – commonly known as "forever chemicals" – has been dumped at dozens of sites across Pennsylvania, Ohio and West Virginia — all of which could face contamination of soil, groundwater and drinking water as a result.

PFAS (per- and polyfluoroalkyl substances) have been used in hydraulic fracturing and other types of oil and gas wells across the U.S. for at least a decade.

Exposure to the chemicals, which are also used to make various consumer products nonstick and waterproof, is linked to health problems including kidney and testicular cancer, liver and thyroid problems, reproductive problems, lowered vaccine efficacy in children and increased risk of birth defects, among others.

Regulatory loopholes and a lack of transparency make it impossible to know how extensively the chemicals have been used in oil and gas production. In August, however, Environmental Health News (EHN), documented the first case of private drinking water contaminated with PFAS potentially linked to fracking wells, and in October EHN mapped the eight locations where operators have publicly disclosed the kind of PFAS they used in Pennsylvania fracking wells.

[Read More](#)

Environmental Health News, 08-12-22

<https://www.ehn.org/fracking-pennsylvania-pfas-2658837888.html>

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EPA Issues Guidance to States to Reduce Harmful PFAS Pollution

2022-12-06

New EPA memo provides direction under NPDES permitting program to restrict PFAS at their source

Today, the U.S. Environmental Protection Agency (EPA) released a memorandum to states that provides direction on how to use the nation's bedrock clean water permitting program to protect against per- and polyfluoroalkyl substances (PFAS). The guidance released today, which outlines how states can monitor for PFAS discharges and take steps to reduce them where they are detected, is part of the Agency's holistic approach to addressing these harmful forever chemicals under EPA's PFAS Strategic Roadmap.

This action is a critical step in EPA's efforts to restrict PFAS at their source, which will reduce the levels of PFAS entering wastewater and stormwater systems and ultimately lower people's exposure to PFAS through swimming, fishing, drinking and other pathways.

"EPA is following through on its commitment to empower states and communities across the nation to address known or suspected discharges of PFAS," said EPA Assistant Administrator for Water Radhika Fox. "Today's action builds upon successful and innovative efforts already used by several states to safeguard communities by using our Clean Water Act permitting program to identify and reduce sources of PFAS pollution before they enter our waters."

The memorandum, Addressing PFAS Discharges in National Pollutant Discharge Elimination System (NPDES) Permits and Through the Pretreatment Program and Monitoring Programs, will align wastewater and stormwater NPDES permits and pretreatment program implementation activities with the goals in EPA's PFAS Strategic Roadmap. The memo recommends that states use the most current sampling and analysis methods in their NPDES programs to identify known or suspected sources of PFAS and to take actions using their pretreatment and permitting authorities, such as imposing technology-based limits on sources of PFAS discharges. The memo will also help the Agency obtain comprehensive information through monitoring on the sources and quantities of PFAS discharges, informing other EPA efforts to address PFAS.

Several states have already demonstrated the benefits of leveraging their state administered NPDES permit programs to identify and reduce

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sources of PFAS before these forever chemicals enter treatment facilities and surface waters. Michigan, for example, is partnering with municipal wastewater treatment facilities to develop monitoring approaches to help identify upstream sources of PFAS. The state has been able to leverage that monitoring information to work with industries, such as electroplating companies, to substantially reduce PFAS discharges. North Carolina has also successfully leveraged its NPDES program to develop facility-specific, technology-based effluent limits for known industrial dischargers of PFAS. This memo urges states to replicate these approaches and use others noted in the memo to identify and reduce PFAS discharges.

This memo builds upon the agency's April 2022 memo to EPA Regions by expanding the audience to states and including new recommendations related to biosolids, permit limits, and coordination across relevant state agencies. The memo provides recommendations to NPDES permit writers and pretreatment coordinators, rooted in the successful use of these tools in several states, on monitoring provisions and analytical methods and the use of pollution prevention and best management practices. These provisions will help reduce PFAS pollution in surface waters as the Agency also works to promulgate effluent guidelines, finalize multi-laboratory validated analytical methods and publish water quality criteria that address PFAS compounds.

Read More

EPA, 06-12-22

<https://www.epa.gov/newsreleases/epa-issues-guidance-states-reduce-harmful-pfas-pollution>

How a dangerous stew of air pollution is choking the United States

2022-12-06

Fires and droughts in the western states are getting worse — and they're combining with industrial sources to threaten air quality and people's health.

In September 2020, the skies in Oregon turned crimson as dozens of wildfires scorched forests in the Cascade Mountains. In just three days, the blazes engulfed nearly 4,000 square kilometres — more than had burnt in Oregon during the previous 36 years combined.

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For two weeks, the acrid air held residents hostage in their homes. The Oregon Health Authority documented a 38% increase in respiratory-related visits to hospital emergency departments during September 2020, compared with the previous month. It was “the worst two-week period I’ve ever experienced for air pollution anywhere — including India, China and Bangladesh”, says Perry Hystad at Oregon State University in Corvallis, who studies the health impacts of the worst air pollution worldwide.

One stark sign of the dangers could be seen in the air quality index (AQI) — a measure of particulate matter pollution (PM), ozone, carbon monoxide, sulfur dioxide and nitrogen dioxide. The US AQI scale runs from 0 to 500, and values more than 300 are considered hazardous to everybody. For two weeks in mid-September, during the most intense burning across Washington state, Oregon and California, the AQI was at 300 and above. The air monitors closest to the fires were shut off or knocked out. On the worst day, southeast of Salem, Oregon, the AQI surged past the scale’s limit; extrapolations by the Oregon Department of Environmental Quality estimate that it would have reached 642.

“These are AQI values that were unheard of” in the region until the past five years, says Dan Jaffe, an atmospheric chemist at the University of Washington in Seattle. Fine particulate pollution reached levels between 4 and 11 times the National Ambient Air Quality Standards (NAAQS) limit set by the US Environmental Protection Agency (EPA). And it didn’t stay in the West; the pollution travelled all the way to New England on the US east coast.

Read More

Nature, 06-12-22

<https://www.nature.com/articles/d41586-022-04333-9>

EUROPE

50,000 signatures: Create a national ban on PFAS

2022-11-29

In a short time, over 50,000 Danes have signed the Consumer Council Tænks proposal for a national ban on harmful PFAS substances. It should send a clear signal to the politicians about the need for action now, believes chairman Anja Philip.

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Several problematic fluorine substances, which come under the term PFAS, have a number of extremely harmful effects on our health and the environment. This knowledge has been known since the 1960s, yet the substances are still used in a number of consumer products such as paint, dental floss, cosmetics, rainwear and kitchenware.

The EU Commission has announced a ban on PFAS, but it is not yet known if and when, if any, it will come. In the worst case, it can take years.

In just a few months, over 50,000 Danes have shown their support for getting the harmful substances out of consumers’ everyday lives as soon as possible by signing the Consumer Council Tænks proposal for a national ban. A proposal that is also supported by six of the country’s leading researchers in the field.

“It is really critical that, with all the knowledge we have about the substances, we still see new products on the market that contain PFAS. Politicians simply cannot listen to the researchers’ and consumers’ clear call for a national ban any longer. We have known about the consequences of the dangerous so-called ‘forever chemicals’ for six decades. Now action must be taken,” says Anja Philip, chairman of the Consumer Council Tænks.

PFAS are often used because of their water, dirt and grease-repellent properties, but the substances accumulate in our blood, liver and kidneys and cause, among other things, increased risk of elevated cholesterol levels, liver damage, cancer and miscarriage. But the unwanted substances have also spread to the environment around us. Most recently, greatly increased concentrations of PFAS have been found in sea foam off the West Coast, and this is in all probability not a geographically isolated problem. Recently, PFAS were also found in Danish rainwater.

“We can see in our testing of products that there are alternatives to the problematic substances, so it is out of place that consumers and our environment should continue to be exposed to the many fluorine substances. We must have the tap turned off as soon as possible, where we can, and therefore the politicians must not hesitate to adopt a rapid national ban on PFAS in consumer products,” says Anja Philip.

Read More

Consumer Council Tænks, 29-11-22

<https://taenk-dk.translate.google.com/press/50000-underskrifter-lav-et-nationalt-forbud-mod-PFAS>

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EU bio-based, biodegradable & compostable plastics framework: can recommendations help control pollution?

2022-11-29

On 30 November, the European Commission will publish its Circular Economy Action Plan. It includes a framework indicating in which cases it makes sense to use bio-based, biodegradable or compostable plastics. Spoiler alert: applications should be extremely limited. Can these recommendations be of true help against plastic pollution?

This week, the European Commission is expected to publish a set of non-binding guidelines about how the market should use bio-based, biodegradable, and compostable plastics.

First of all, let's be clear: 'bio-plastic' is still... plastic. Bio-based plastics are simply sourced from biological resources rather than fossil material. Biodegradable plastic is most often fossil-based and relies on virgin materials. Even when designed to be biodegradable, these plastics often include the same toxic chemicals as conventional non-biobased and non-biodegradable plastic.

Unnecessary plastics, especially short-lived single-use items, must be eliminated. As for the remaining plastics, careful consideration is required to ensure they contribute to a circular plastics economy. Bio-based, biodegradable, and compostable plastics should be used for niche applications only – and have an extremely limited role in the economy.

To crack down on this kind of plastics, governments worldwide must introduce clear frameworks so as not to perpetuate linear consumption patterns.

The EU is just about to take a small step in this direction. What should the European Commission's proposal include to truly contribute to a more sustainable and circular plastics economy?

Read More

Ecostandard, 29-11-22

https://ecostandard.org/news_events/plastics-framework/

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France still exporting prohibited pesticides, despite landmark ban

2022-11-30

The French government has approved the export of more than 7,400 tonnes of banned pesticides so far this year, despite introducing a landmark law intended to prohibit the practice, a new Unearthed and Public Eye investigation has found.

Among these planned exports are 14 different chemicals that have been prohibited from use on farms across the European Union in order to protect human health or the environment.

They include notorious "bee-killing" neonicotinoid insecticides, banned from outdoor use in the EU to protect pollinators. They also include pesticides banned over human health concerns such as endocrine disruption and damage to DNA, and environmental concerns such as groundwater contamination and toxicity to wildlife.

The shipments were approved despite the French government passing a landmark law – the first of its kind in Europe – prohibiting the manufacturing and export of pesticides containing active ingredients that are banned in the EU. This law, known as the loi Egalim, came into force on 1 January this year.

However, Unearthed and Public Eye, a Swiss NGO, have identified major loopholes in the law and its implementing regulations. These are allowing manufacturers to continue exporting large quantities of banned pesticides from France.

Read More

Unearthed, 30-11-22

<https://unearthed.greenpeace.org/2022/11/30/france-still-exporting-prohibited-pesticides-despite-landmark-ban/>

Pow promises 'gold standards' on chemicals regulation as fears over impact of UK-REACH delays grow

2022-12-01

Environment minister Rebecca Pow has promised "the same gold standards as we've had in the EU" on chemicals regulation, after hearing concerns that further extensions to the UK's timeline for transitioning

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to a new model of regulation post-Brexit will see a weakening of environmental protections.

Pow addressed the Environmental Audit Committee on Wednesday with an update on the progress of UK Registration, Evaluation, Authorisation and restriction of Chemicals (REACH), which officials noted has been slow.

After leaving the EU, all substances manufactured in or imported to England, Scotland and Wales must be registered with the Health and Safety Executive (HSE), which is the agency for UK REACH. Applications registered while the UK was still in the EU were “grandfathered” under transitional provisions.

The deadline for registration data to be submitted to UK REACH was extended last year by former environment secretary George Eustice following industry pressure. This deadline is now set to be extended again by three years across the board.

Pow told EAC: “No-one is pretending that this has not been a complicated issue to tackle. I believe really positive progress has been made.”

Pow highlighted that so far 6,000 companies have completed their initial notifications, which covers 22,000 chemicals, and now the next stage is getting their data packages about these chemicals registered.

Pow also stressed that the overarching aim is the “same gold standards as we’ve had in the EU”, emphasising that this is the “highest level of protection for human health and for the environment”.

“That hasn’t changed at all, it remains an absolute priority, and similarly the principles remain the same. No data, no market,” she said.

Read More

ENDS, 01-12-22

<https://www.endsreport.com/article/1806913/pow-promises-gold-standards-chemicals-regulation-fears-impact-uk-reach-delays-grow>

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INTERNATIONAL

IEEE SA Working Group: Standard for Endocrine Disrupting Chemical Hazard Labelling

2022-12-12

This standard specifies the design of hazard labelling for known and suspected endocrine disrupting chemicals, with example implementations in a range of potential use cases, including labelling of chemicals, labelling of electrical and mechanical components, labelling of consumer products, labelling of food and drug preparations, and hazardous areas. Whether a use case merits or should require the application of this hazard labelling is not within the scope of this standard. This standard also describes a gradation of classes of risk which may be optionally displayed to inform about the particular level of a hazard. However, what substances, quantities, or concentrations may merit a particular risk classification is not within the scope of this standard. This standard is not intended to be applied within the domains of food and pharmaceuticals. However, packaging of food or pharmaceuticals that itself may contain endocrine disrupting chemicals remains in scope.

The next working group meeting is scheduled on 13 January 2023.

Read More

IEEE SA

<https://standards.ieee.org/ieee/3173/10968/>

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REACH Update

DEC. 16, 2022

Transforming ECHA into a champion for modern, animal-free safety science

2022-12-08

Congratulations, Dr. McGuinness, on your appointment as executive director of the European Chemicals Agency (ECHA).

ECHA plays a central role in the implementation of the European Union's legislation on chemicals, and biocidal products. Moreover, the agency's approach to this mandate will become ever more significant under the ambitious European Green Deal commitments and Chemicals Strategy for Sustainability (CSS).

In our changing geopolitical, social, economic and technological landscape, it is vital to conceive of ECHA's core mandates of ensuring safety, promoting replacement of animal testing, and enhancing competitiveness and innovation as connected rather than competing, and guided by a unifying vision and robust strategy to achieve the EU's laudable aims under the CSS.

It is vital to conceive of ECHA's core mandates of ensuring safety, promoting replacement of animal testing, and enhancing competitiveness and innovation as connected rather than competing.

The European Parliament has observed that "the European Food Safety Authority (EFSA) and the European Medicines Agency (EMA) have put in place strategies to actively reduce and replace animal testing, but the European Chemicals Agency (ECHA) still has to put in place a reduction and replacement strategy". Examples of ambitious targets for phasing out of animal tests and phasing in of new approach methods (NAMs) and next-generation risk assessment (NGRA) approaches in the chemical space have been articulated by Canada, South Korea, and the United States. They have also been requested by an overwhelming majority of MEPs and more than 1.4 million respondents to a recent European Citizens Initiative.

Now is the time for ECHA to develop an ambitious strategy, structures, systems and culture that remove barriers to the preferential use and acceptance of suitable NAM and NGRA approaches, consistent with EU law. As an ECHA-accredited stakeholder organization, Humane Society International/Europe (HSI) would welcome the opportunity to collaborate with the agency and interested parties on future-focused planning, capacity-building, and other solutions to support ECHA in fulfilling its legal obligations to protect humans and the environment while ensuring that animal testing is truly performed only as last resort.

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[Read More](#)

Politico, 08-12-22

<https://www.politico.eu/sponsored-content/transforming-echa-into-a-champion-for-modern-animal-free-safety-science/>

Technical completeness check

2022-12-07

ECHA carries out a technical completeness check on each incoming registration and PPORD notification as set out in Article 20(2) of the REACH Regulation. This is done to ensure that the dossiers include all the information that is required. The quality or adequacy of the provided data or justifications are not assessed as part of the completeness check.

Completeness checks are performed both on new registrations and updates of existing registrations. All the information in a dossier is checked, whether it is newly submitted or already part of the previous submission. The completeness check can only be successful if all the information in the dossier is complete.

[Read More](#)

ECHA, 07-12-22

<https://echa.europa.eu/technical-completeness-check>

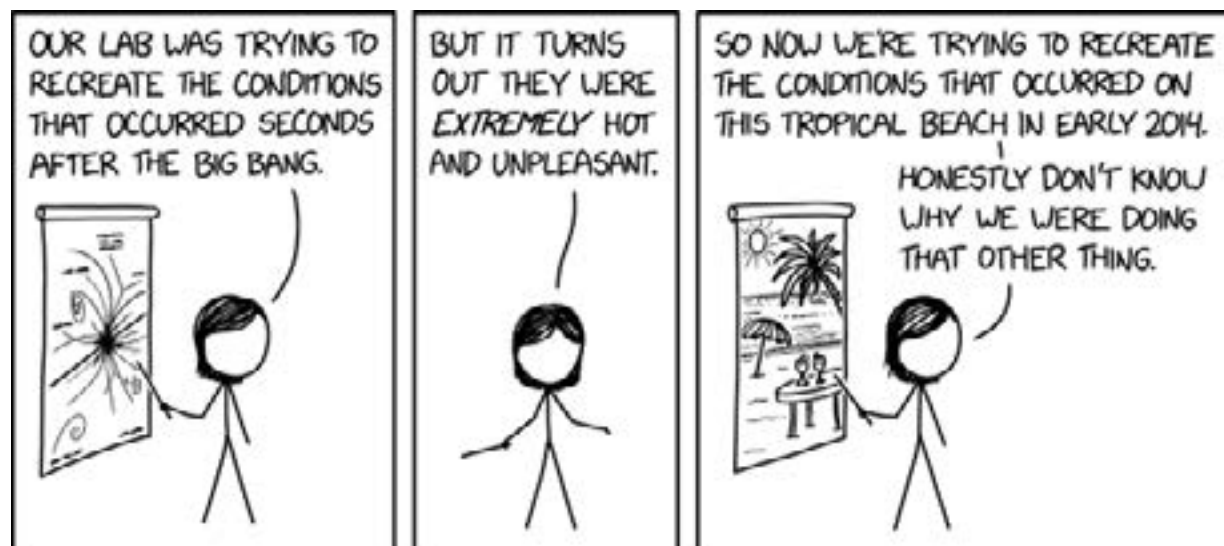
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Recreate the Conditions

2022-12-16

<https://xkcd.com/2511/>

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Hazard Alert

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Bromine

2022-12-16

Bromine is a chemical element with the symbol Br, an atomic number of 35, and an atomic mass of 79.904. It is in the halogen element group. [1] At ambient temperature bromine is a brownish-red liquid. It has a similarly coloured vapour with an offensive and suffocating odour. It is the only non-metallic element that is liquid under ordinary conditions, it evaporates easily at standard temperature and pressures in a red vapour that has a strong disagreeable odour resembling that of chlorine. Bromine is less active chemically than chlorine and fluorine but is more active than iodine; its compounds are similar to those of the other halogens. Bromine is soluble in organic solvents and in water. [2]

USES [2]

Bromine is used in industry to make organobromo compounds. A major one was dibromoethane an agent for leaded gasoline, before they were largely phased out due to environmental considerations. Other organobromines are used as insecticides, in fire extinguishers and to make pharmaceuticals. Bromine is used in making fumigants, dyes, flameproofing agents, water purification compounds, sanitises, medicinals, agents for photography and in brominated vegetable oil, used as emulsifier in many citrus-flavoured soft drinks.

ROUTES OF EXPOSURE

- Following the release of bromine into water, you could be exposed by drinking the contaminated water.
- If food becomes contaminated with bromine, you could be exposed by eating the contaminated food.
- Following release of bromine gas into the air, you could be exposed by breathing the fumes.
- Skin exposure to bromine could occur through direct contact with bromine liquid or gas.
- Bromine gas is heavier than air, so it would settle in low-lying areas.

HEALTH EFFECTS

Bromine is corrosive to human tissue in a liquid state and its vapours irritate eyes and throat. Bromine vapours are very toxic with inhalation. [2]

Bromine is a chemical element with the symbol Br, an atomic number of 35, and an atomic mass of 79.904.

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Acute Effects [3]

- Breathing bromine gas could cause you to cough, have trouble breathing, get a headache, have irritation of your mucous membranes (inside your mouth, nose, etc.), be dizzy, or have watery eyes.
- Getting bromine liquid or gas on your skin could cause skin irritation and burns. Liquid bromine that touches your skin may first cause a cooling sensation that is closely followed by a burning feeling.
- Swallowing bromine-containing compounds (combinations of bromine with other chemicals) would cause different effects depending on the compound. Swallowing a large amount of bromine in a short period of time would be likely to cause symptoms such as nausea and vomiting (gastrointestinal symptoms).
- Showing these signs and symptoms does not necessarily mean that a person has been exposed to bromine.

Chronic Effects [4]

Bromine is toxic to mucous membranes. The substance may be toxic to kidneys, liver, cardiovascular system, central nervous system (CNS) and thyroid. Repeated or prolonged exposure to the substance can produce target organs damage. Repeated or prolonged contact with spray mist may produce chronic eye irritation and severe skin irritation. Repeated or prolonged exposure to spray mist may produce respiratory tract irritation leading to frequent attacks of bronchial infection. Repeated exposure to a highly toxic material may produce general deterioration of health by an accumulation in one or many

human organs.

SAFETY

First Aid Measures [4]

- Eye Contact: Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. WARM water MUST be used. Get medical attention immediately.
- Skin Contact: In case of contact, immediately flush skin with plenty of water. Cover the irritated skin with an emollient. Remove contaminated clothing and shoes. Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention.

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- Serious Skin Contact: Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek immediate medical attention.
- Inhalation: If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention immediately.
- Serious Inhalation: Evacuate the victim to a safe area as soon as possible. Loosen tight clothing such as a collar, tie, belt or waistband. If breathing is difficult, administer oxygen. If the victim is not breathing, perform mouth-to-mouth resuscitation. WARNING: It may be hazardous to the person providing aid to give mouth-to-mouth resuscitation when the inhaled material is toxic, infectious or corrosive. Seek immediate medical attention.
- Ingestion: Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention if symptoms appear.

Exposure Controls/Personal Protection [4]

- Engineering Controls: Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapours below their respective threshold limit value. Ensure that eyewash stations and safety showers are proximal to the work-station location.
- Personal Protection: Face shield, full suit, vapour respirator (be sure to use an approved/certified respirator or equivalent), gloves and boots.
- Personal Protection in Case of a Large Spill: Splash goggles, full suit, vapour respirator, boots and gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

REGULATION

United States [5]

OSHA: The Occupational Safety & Health Administration has set the following Permissible Exposure Limits (PEL) for bromine:

- General Industry: 29 CFR 1910.1000 Z-1 Table -- 0.1 ppm, 0.7 mg/m³ TWA

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- Maritime: 29 CFR 1915.1000 Table Z-Shipyards -- 0.1 ppm, 0.7 mg/m³ TWA

ACGIH: American Conference of Governmental Industrial Hygienists has set a Threshold Limit Value (TLV) for bromine of 0.1 ppm, 0.66 mg/m³ TWA; 0.2 ppm, 1.3 mg/m³ STEL

NIOSH: The National Institute for Occupational Safety and Health has set a Recommended Exposure Limit (REL) for bromine of 0.1 ppm TWA; 0.3 ppm STEL

Australia [6]

Safe Work Australia: Safe Work Australia has set an 8-hour time weighted average concentration for bromine of 0.1 ppm or 0.66 mg/m³. In addition, the following 15-minute short-term exposure limit (STEL) has been set 0.3 ppm or 2 mg/m³.

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Custom 3D-printed joints may restore full movement to disabled fingers

2022-12-01

We hear a lot about artificial hips and knees, but finger joints? They do exist, but their fit and functionality is limited. Germany's Fraunhofer research group aims to change that, with artificial finger joints that are custom 3D-printed for each patient.

Quite often, when a finger joint is irreparably damaged due to arthritis or injury, doctors will simply fuse it together. Needless to say, doing so decreases that digit's dexterity.

Artificial finger joints are becoming more common, and typically take the form of either silicone or standard implants.

According to Fraunhofer, however, the silicone implants often come loose from the finger bones and have to be surgically reattached, while the standard implants are only made in certain sizes which don't restore a full range of movement to any one patient.

With these limitations in mind, five Fraunhofer branches are now collaborating on what is known as the FingerKit project.

In a system developed as part of that project, patients start by having the affected finger X-rayed. Custom AI-based software subsequently analyzes the two-dimensional images, and uses the information to create a 3D computer model for an artificial joint which is specifically suited to that finger.

The model then guides a 3D printer which builds the actual titanium implant. In a printing process called metal binder jetting, the implant is initially constructed one layer at a time, by applying a liquid binder to a titanium-particle powder. The resulting object is highly detailed but rather fragile, so it's subjected to a sintering process, which transforms the bonded particles into a sturdier solid material.

It's also possible to make the implants out of ceramics, via a slip casting process.

In either case, it is estimated that patients could be fitted with the custom joints up to 60% faster than is currently the case with standard implants, as the joints could be printed on location, soon after the X-rays were taken.

Quite often, when a finger joint is irreparably damaged due to arthritis or injury, doctors will simply fuse it together. Needless to say, doing so decreases that digit's dexterity.

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Fraunhofer is now seeking commercial partners to help bring the technology to market.

New Atlas, 1 December 2022

<https://newatlas.com>

Chemistry breakthrough creates usable products out of unrecyclable PVC

2022-11-30

Advances in chemistry continue to bring new materials into the realm of recyclability, and new work from a team at the University of Michigan has taken aim at one of the most problematic to reuse. The scientists have developed a method of converting waste PVC (polyvinyl chloride) into usable products, opening up some interesting new possibilities when it comes to this traditionally unrecyclable material.

PVC sits in the top handful of plastics in terms of production and volume, and is put to use in everything from piping and flooring, to shower curtains and clothes. Its recycling rate in the US, however, sits at zero, with efforts to recycle the material hindered by its toxic contents.

"PVC is the kind of plastic that no one wants to deal with because it has its own unique set of problems," said study first author Danielle Fagnani. "PVC usually contains a lot of plasticizers, which contaminate everything in the recycling stream and are usually very toxic. It also releases hydrochloric acid really rapidly with some heat."

Plasticizers are added to common plastics to improve their durability and flexibility, but some of them carry serious risks to human health, with BPA a particularly well-known example. Another is phthalates, known as "everywhere chemicals" due to their widespread use in everyday products, and which have been linked to endocrine disruption, childhood cancers and premature death.

The phthalates in PVC are one of the material's most harmful ingredients, and these, along with other plasticizers, leach out during conventional recycling that relies on heat treatment. This process also releases hydrochloric acid from the PVC, which can cause chemical burns and corrode recycling equipment.

Fagnani and her colleagues were therefore experimenting with ways of recycling PVC that don't rely on heat, which led to a novel electrochemistry technique with some exciting potential. The team used electrons to break

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down the carbon-chlorine bonds in the material, and by using one of the PVC plasticizers to mediate the process, were able to carefully control the release of hydrochloric acid.

"What we found is that it still releases hydrochloric acid, but at a much slower, more controlled rate," Fagnani said.

This allows the acid to be collected and used as a reagent for other chemical reactions, while the process also produces chlorine ions that can be used to chlorinate molecules for use in pharmaceutical and agricultural products. The method also leaves other materials behind that the scientists are trying to find uses for, so there is room for improvement, but they say the work shows how chemical recycling can be leveraged to give problematic materials a second life.

"It's a failure of humanity to have created these amazing materials which have improved our lives in many ways, but at the same time to be so shortsighted that we didn't think about what to do with the waste," said principal investigator Anne McNeil. "In the United States, we're still stuck at a 9% recycling rate, and it's only a few types of plastics. And even for the plastics we do recycle, it leads to lower and lower quality polymers. Our beverage bottles never become beverage bottles again. They become a textile or a park bench, which then ends up in a landfill."

The research was published in the journal Nature Chemistry.

New Atlas, 30 November 2022

<https://newatlas.com>

Simple urine test proposed as early diagnostic tool for Alzheimer's

2022-11-30

Alzheimer's is a slow-moving neurodegenerative disease. Decades can pass before clinical symptoms appear, and even when they do it's challenging to identify the disease in patients with mild cognitive impairment.

Clinicians currently lack a clear diagnostic tool to detect Alzheimer's. The disease is generally only formally diagnosed using cognitive or psychological measures, however, in some cases, advanced medical imaging can be used to detect certain pathological characteristics in the brain.

The recycling rate of PVC in the US sits at zero currently, but a new chemistry technique could change that.

The researchers suggest formic acid levels in urine could be a useful early-stage biomarker for Alzheimer's.

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A wide array of potential diagnostic tests are currently in various stages of development. Eye scans, blood tests, smartphone pupil tracking apps, and sniff tests have all been proposed to catch the disease before symptoms appear.

Now, in a new study published in *Frontiers in Aging Neuroscience*, researchers have proposed urine tests as a potential way to detect the disease. The researchers suggest formic acid levels in urine could be a useful early-stage biomarker for Alzheimer's.

Formic acid is a metabolic product of formaldehyde, a molecule that is toxic in high concentrations but also found in low levels in a healthy brain. Recent research has found endogenous formaldehyde may play a role in learning and memory, but high concentrations in the brain can result in cognitive deficits that resemble what is seen in Alzheimer's disease (AD).

To explore the hypothesis that formic acid concentrations in urine can be a biomarker of Alzheimer's disease, the researchers recruited almost 600 subjects at various stages of cognitive decline. The cohort was divided into five groups, from a cognitively healthy group to a group with clinically diagnosed Alzheimer's.

Overall, the researchers found formic acid concentrations were measurably higher in all four cognitively impaired groups compared to the healthy control. The study also found formic acid levels correlated with declining scores on psychological tests measuring cognition.

When the researchers added blood tests for Alzheimer's biomarkers to the mix, they found the diagnostic accuracy increased further, allowing for predictions of disease staging.

It is important to note this is just preliminary research, so lots more work will be needed to validate these findings before a clinical urine test becomes commonly available. Nevertheless, the promising findings point to not only a very simple early screening test for Alzheimer's but also provides clues to a novel degenerative mechanism at play in the disease.

"Using these urine biomarkers can significantly promote the popularity of early screening for AD, which can improve advice on diagnosis, treatment, and lifestyle for people at risk for AD," the researchers conclude. "In-depth research on these biomarkers will also help to explore the mechanisms and potential treatments of AD. Dynamic changes in urinary formaldehyde and urinary formic acid suggest another new metabolic disorder in AD pathogenesis."

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The new study was published in the journal *Frontiers in Aging Neuroscience*.

New Atlas, 30 November 2022

<https://newatlas.com>

Traffic Pollution Has Been Associated With an Increased Risk of Dementia

2022-12-02

According to a meta-analysis recently published in *Neurology*, the medical journal of the American Academy of Neurology, higher exposure to a certain type of traffic-related air pollution known as particulate matter may be connected to an increased risk of dementia. Researchers focused on fine particulate matter, or PM2.5, which is made up of airborne pollutants with a diameter of fewer than 2.5 microns. The meta-analysis examined all available studies on the relationship between air pollution and dementia risk.

"As people continue to live longer, conditions like dementia are becoming more common, so detecting and understanding preventable risk factors is key to reducing the increase of this disease," said study author Ehsan Abolhasani, MD, MSc, of Western University in London, Canada. "Since a report by the World Health Organization showed that more than 90% of the world population is living in areas with higher than recommended levels of air pollution, our results provide more evidence for enforcing regulations for air quality and accelerating the transition from fossil fuels to sustainable energies."

17 studies were analyzed by the researchers for the meta-analysis. Participants had a minimum age of 40. More than 91 million individuals took part in all the studies. 5.5 million of them, or 6%, developed dementia.

Age, sex, smoking, education level, and other variables that may increase or decrease a person's risk of dementia were taken into account in the studies.

Researchers analyzed the rates of exposure to air pollution for those with and without dementia and discovered that those without dementia had a lower average daily exposure to fine particulate matter air pollutants. The U.S. Environmental Protection Agency (EPA) considers average yearly exposures up to 12 µg/m³ to be safe.

Dementia is a general term referring to the impaired ability to remember, think, or make decisions, which interferes with doing everyday activities.

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Researchers found that the risk of dementia increased by 3% for every one microgram per cubic meter ($\mu\text{g}/\text{m}^3$) increase of fine particulate matter exposure.

“While our meta-analysis does not prove that air pollution causes dementia, it only shows an association, our hope is these findings empower people to take an active role in reducing their exposure to pollution,” Abolhasani said. “By understanding the risk of dementia through exposure to air pollution, people can take steps to reduce their exposure such as using sustainable energy, choosing to live in areas with lower levels of pollution, and advocating for reduced traffic pollution in residential areas.”

They also looked at nitrogen oxides, which form smog, nitrogen dioxide, and ozone exposure, but did not find significantly increased risk when these other classes of pollutants were considered alone.

A limitation of the meta-analysis was the small number of studies available on this specific topic. Abolhasani said more studies are needed.

Sci Tech Daily, 2 December 2022

<https://scitechdaily.com>

Giant magma plume reveals Mars may not be a dead planet after all

2022-12-06

Mars is usually considered a geologically dead planet, but a new study challenges that idea. Multiple lines of evidence reveals a giant plume of magma is forcing its way up through the Red Planet’s mantle and producing seismic activity in one particular region of the surface.

After a volcanically active youth, Mars seems to have calmed down in middle age. But apparently it still knows how to party sometimes – NASA’s InSight lander has detected as many as 1,300 “marsquakes” in its four years of operation. Most of these seem to be coming from a region called Cerberus Fossae, which is made up of a network of fissures.

Exactly what’s causing the activity in this area remained unknown, but here on Earth there are usually two possibilities – plate tectonics, involving the movement of chunks of planetary crust rubbing against each other, and mantle plumes, which are big bubbles of magma rising from deep within the planet. And since Mars definitely doesn’t have plate tectonics,

“Mars was most active 3 to 4 billion years ago, and the prevailing view is that the planet is essentially dead today.”

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scientists at the University of Arizona investigated whether mantle plumes might be responsible.

“We have strong evidence for mantle plumes being active on Earth and Venus, but this isn’t expected on a small and supposedly cold world like Mars,” said Jeff Andrews-Hanna, co-author of the study. “Mars was most active 3 to 4 billion years ago, and the prevailing view is that the planet is essentially dead today.”

To find out, the team examined the region around the fissures of Cerberus Fossae – a large plain called Elysium Planitia – for features that, on Earth, indicate the presence of mantle plumes. As the magma rises, the crust is uplifted and stretched, and eventually an eruption occurs that forms large, flat volcanic plains.

Elysium Planitia already seems to be a volcanic plain, so that’s one item ticked off the list immediately. The team found that the surface has already been raised by over a mile, and measurements of the gravity field in the area indicate that it’s driven by something deep within the planet. The floors of impact craters in the area are also tilted in one direction, suggesting the uplift has occurred since the craters formed.

The team applied a tectonic model to the region, and found it was unable to account for the features observed. The only explanation, they conclude, is a gigantic mantle plume measuring around 4,000 km (2,500 miles) wide.

“In terms of what you expect to see with an active mantle plume, Elysium Planitia is checking all the right boxes,” said Broquet. “This mantle plume has affected an area of Mars roughly equivalent to that of the continental United States. Future studies will have to find a way to account for a very large mantle plume that wasn’t expected to be there.”

Not only does the find raise questions about what we thought we knew about the Red Planet’s formation and evolution, but it could have major implications for life on Mars. The warmth of the magma could drive chemical reactions of the kind that can potentially sustain microbes deep underground.

The research was published in the journal Nature Astronomy.

New Atlas, 6 November 2022

<https://newatlas.com>

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Spray uses virus-filled microbeads to kill harmful bacteria on food

2022-12-05

While it would be great if there were a simple method of eradicating all the harmful bacteria present on food, dousing that food in antibiotics certainly wouldn't be the way to go. A new spray, however, uses food-safe viruses that kill such bacteria.

Developed by scientists at Canada's McMaster University, the spray consists of microgel beads of viruses known as bacteriophages. Although the latter are harmless to humans, they kill and eat bacteria. And importantly, certain bacteriophages prey on certain types of bacteria – they don't just indiscriminately kill all bacteria, harmful and beneficial alike.

Building upon previous research by the same group, the process for producing the beads begins with the creation of a liquid solution made up of bacteriophages and a crosslinking organic compound called glutaraldehyde.

That solution is deposited onto a two-layer thin polymer film – the bottom base layer is solid, whereas the top template layer consists of a honeycomb-like grid of tiny holes.

Next, the solution-filled film is placed in a vacuum for 10 minutes, then left in a cool, humid environment for two days. Over this time, the glutaraldehyde causes all the individual bacteriophages in each honeycomb hole to self-assemble into linked nanofilament networks, thus forming a gelatinous bead in that hole.

When the top layer of the film is subsequently peeled off, the microgel beads can be harvested from the exposed base layer. Each bead is about 20 microns wide, and contains approximately half a million bacteriophages. In this collective form, the viruses are considerably more robust than they would be on their own.

"They link together like microscopic Lego pieces," said one of the lead scientists, Prof. Zeinab Hosseinidou. "This organized natural structure makes them much more durable and easier to package, store and use."

In lab tests, the bead spray thoroughly eradicated E. coli bacteria on tainted lettuce and meat within nine hours of application. The scientists state that if other types of bacteriophages were used, the spray could also kill harmful bacteria such as Salmonella and Listeria.

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It is hoped that the spray could ultimately be utilized when processing and packaging foods, or even when growing fresh produce. The technology could additionally have medical applications, being used to kill bacteria in infected wounds.

A paper on the research – which was co-led by Assoc. Prof. Tohid Didar and grad student Lei Tian – was recently published in the journal Nature Communications.

New Atlas, 5 December 2022

<https://newatlas.com>**New Catalyst Can Turn a Smelly Gas Byproduct Into a Cash Cow**

2022-12-03

Engineers and scientists at Rice University have developed a sweet way for petrochemical refineries to transform a smelly byproduct into cash.

Hydrogen sulfide gas has the distinct odor of rotting eggs. It frequently emanates from sewers, stockyards, and landfills, but it is especially problematic for refineries, petrochemical plants, and other industries. Thousands of tons of the noxious gas are produced annually as a byproduct of processes that remove sulfur from petroleum, natural gas, coal, and other products in these places.

Naomi Halas, a Rice engineer, physicist, and chemist, and colleagues describe a process that uses gold nanoparticles to convert hydrogen sulfide into sulfur and high-demand hydrogen gas in a single step in a study that was recently published in the journal ACS Energy Letters. Even better, the one-step process only needs light as its source of energy. Co-authors of the study include Hossein Robotjazi of Syzygy Plasmonics, Emily Carter of Princeton University, and Peter Nordlander of Rice University.

"Hydrogen sulfide emissions can result in hefty fines for industry, but remediation is also very expensive," said Halas, a nanophotonics pioneer whose lab has spent years developing commercially viable light-activated nanocatalysts. "The phrase 'game-changer' is overused, but in this case, it applies. Implementing plasmonic photocatalysis should be far less expensive than traditional remediation, and it has the added potential of transforming a costly burden into an increasingly valuable commodity."

Each molecule of hydrogen sulfide gas (H₂S) contains two hydrogen atoms and one sulfur atom. Each molecule of clean-burning hydrogen

A catalyst activated by light converts hydrogen sulfide into hydrogen energy in one step.

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gas (H₂), the primary commodity of the hydrogen economy, contains two hydrogen atoms. Halas' team sprinkled the surface of grains of silicon dioxide powder with tiny islands of gold in the new study. Each island was a gold nanoparticle 10 billionths of a meter in size that interacted strongly with a certain wavelength of visible light. These plasmonic reactions create "hot carriers," which are short-lived, high-energy electrons capable of driving catalysis.

In the study, Halas and co-authors used a laboratory setup and showed a bank of LED lights could produce hot carrier photocatalysis and efficiently convert H₂S directly into H₂ gas and sulfur. That's a stark contrast to the established catalytic technology refineries use to break down hydrogen sulfide. Known as the Claus process, it produces sulfur but no hydrogen, which it instead converts into water. The Claus process also requires multiple steps, including some that require combustion chambers heated to about 1,500 degrees Fahrenheit.

The plasmonic hydrogen sulfide remediation technology has been licensed by Syzygy Plasmonics, a Houston-based startup company with more than 60 employees, whose co-founders include Halas and Nordlander.

Halas said the remediation process could wind up having low enough implementation costs and high enough efficiency to become economical for cleaning up nonindustrial hydrogen sulfide from sources like sewer gas and animal wastes.

"Given that it requires only visible light and no external heating, the process should be relatively straightforward to scale up using renewable solar energy or highly efficient solid-state LED lighting," she said.

Sci Tech Daily, 3 December 2022

<https://scitechdaily.com>

Antarctica is changing, and wildlife and weeds could be on the way

2022-12-01

Only a tiny portion of Antarctica — less than 1 per cent — is permanently ice-free.

Yet that's where the bulk of its unique plants, mosses, lichens, algae, invertebrates and animals manage to survive.

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But that's all changing. Between now and the end of the century, thousands of square kilometres of permanently ice-free habitat is going to open up on the continent, even under moderate climate change.

In general, growing seasons will get longer, more precipitation will fall as rain, more fresh meltwater will be released, average temperatures will become milder, and extreme weather events, like elsewhere, are likely to become more intense.

Put that all together, and what you get is a transformation of parts of the world's most untouched environment.

So researchers have painted a picture of what that is going to look like, publishing their analysis in *Global Change Biology*.

March of the penguins?

"Some penguin species are going to win, but others are going to lose," said co-author Justine Shaw from Securing Antarctica's Environmental Future, at the Queensland University of Technology.

Gentoo penguins are already advancing into new habitats as ice retreats in Western Antarctica, as are Adelie penguins on Beaufort Island and king penguins on sub-Antarctic South Georgia, the analysis stated.

This is a really important point.

Antarctic soils buried under ice for millennia are typically nutrient-poor and incapable of supporting much life.

But penguin poo, or "guano", is packed with nutrients like nitrogen and phosphorous, as well as trace metals.

In that way, penguins act as ecosystem engineers — as they advance into freshly uncovered habitats, they help ready the soil for things like plants, lichen and mosses to move in.

So much so that vegetation growth on newly exposed soil can betray the location of ancient penguin colonies, which existed during previous periods of warming.

Scientists are able to use soil analysis to confirm those locations.

"You look and say, 'why is there a big moss bed here?'" Dr Shaw said.

"Ice can melt and expose an ancient penguin colony, where you have nutrients locked away in that soil."

Thousands of square kilometres of Antarctica will become ice free between now and the end of the century

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But it's not all good news for penguins. Some like the emperor penguin depend on sea ice for breeding and feeding.

"The emperor penguin is looking like it's really not going to cope well with climate change. It doesn't occur anywhere else in the world."

Will we see trees on Antarctica?

There are currently only two species of flowering plant native to Antarctica — Antarctic hair grass and Antarctic pearlwort.

Both are thought to have colonised Antarctica multiple times over tens of thousands of years, via wind and animals from South America.

But if penguins and shorebirds are priming more ice-free areas for vegetation, could we see trees move onto the continent?

"Certainly not in our lifetime. We don't have trees on the sub-Antarctic islands yet," Dr Shaw said.

It's not just the harsh conditions keeping trees at bay either.

"The Southern Ocean is a pretty massive barrier," she said. Seeds would have to remain viable after crossing that vast body of saltwater in order to establish themselves in Antarctica.

But some non-native plants and invertebrates have managed to make it. So how have they done it?

"Where we've already had weeds and invasive species in Antarctica is where people have been," Dr Shaw said.

In fact, many non-native species have hitchhiked with humans to Antarctica, and it's thought that 11 invertebrates and plants have managed to establish themselves in the past.

Again though, because of the harsh conditions, they haven't managed to spread far and eradication has been generally successful.

But as more ice-free areas expand and the distance between them shrinks, what we're likely to see is increased connectivity — the ability for species to move between and colonise new habitats.

And while that means some native species will spread out, it also increases the risk of pests getting a foothold — especially as human traffic rises.

Rats have decimated shorebirds on sub-Antarctic islands

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A 2012 study found that visitors to Antarctica, including researchers, carried on average more than nine seeds per person attached to their clothing.

And mammals have managed to hitchhike their way to sub-Antarctic islands.

It's not impossible that something like rats could, in the future, wreak havoc in Antarctica.

"It's a long way off," Dr Shaw said.

"[But] when we look at the sub-Antarctic islands — Macquarie Island, Heard Island — we've seen invasive mammals on those islands and we've seen the damage they do.

"They're a great testament to why we should have tight security in Antarctica."

Even without the introduction of pests to the white continent, glaciologist Felicity McCormack from Monash University said retreating ice could allow some native species to outcompete others.

"We could see that some species potentially benefit from changes in ice-free areas, but that could lead to an overall decrease in biodiversity," said Dr McCormack, who wasn't involved in the analysis.

"We don't tend to associate biodiversity with Antarctica, but it's crucial just like everywhere else on Earth.

"I think there's a real imperative to do what we can to prevent further warming now."

The guiding principle, according to Dr Shaw, is that we should be trying to prevent extinctions.

"This is the last true wilderness in the world. If we can't stop species going extinct in Antarctica, that's pretty depressing."

ABC News, 1 December 2022

<https://abc.net.au>

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Paper-thin solar cell can turn any surface into a power source

2022-12-09

MIT engineers have developed ultralight fabric solar cells that can quickly and easily turn any surface into a power source.

These durable, flexible solar cells, which are much thinner than a human hair, are glued to a strong, lightweight fabric, making them easy to install on a fixed surface. They can provide energy on the go as a wearable power fabric or be transported and rapidly deployed in remote locations for assistance in emergencies. They are one-hundredth the weight of conventional solar panels, generate 18 times more power-per-kilogram, and are made from semiconducting inks using printing processes that can be scaled in the future to large-area manufacturing.

Because they are so thin and lightweight, these solar cells can be laminated onto many different surfaces. For instance, they could be integrated onto the sails of a boat to provide power while at sea, adhered onto tents and tarps that are deployed in disaster recovery operations, or applied onto the wings of drones to extend their flying range. This lightweight solar technology can be easily integrated into built environments with minimal installation needs.

“The metrics used to evaluate a new solar cell technology are typically limited to their power conversion efficiency and their cost in dollars-per-watt. Just as important is integrability—the ease with which the new technology can be adapted. The lightweight solar fabrics enable integrability, providing impetus for the current work. We strive to accelerate solar adoption, given the present urgent need to deploy new carbon-free sources of energy,” says Vladimir Bulović, the Fariborz Maseeh Chair in Emerging Technology, leader of the Organic and Nanostructured Electronics Laboratory (ONE Lab), director of MIT.nano, and senior author of a new paper describing the work.

Joining Bulović on the paper are co-lead authors Mayuran Saravanapavanantham, an electrical engineering and computer science graduate student at MIT; and Jeremiah Mwaura, a research scientist in the MIT Research Laboratory of Electronics. The research is published today in *Small Methods*.

Slimmed down solar

They are one-hundredth the weight of conventional solar panels, generate 18 times more power-per-kilogram, and are made from semiconducting inks.

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Traditional silicon solar cells are fragile, so they must be encased in glass and packaged in heavy, thick aluminum framing, which limits where and how they can be deployed.

Six years ago, the ONE Lab team produced solar cells using an emerging class of thin-film materials that were so lightweight they could sit on top of a soap bubble. But these ultrathin solar cells were fabricated using complex, vacuum-based processes, which can be expensive and challenging to scale up.

In this work, they set out to develop thin-film solar cells that are entirely printable, using ink-based materials and scalable fabrication techniques.

To produce the solar cells, they use nanomaterials that are in the form of a printable electronic inks. Working in the MIT.nano clean room, they coat the solar cell structure using a slot-die coater, which deposits layers of the electronic materials onto a prepared, releasable substrate that is only 3 microns thick. Using screen printing (a technique similar to how designs are added to silkscreened T-shirts), an electrode is deposited on the structure to complete the solar module.

The researchers can then peel the printed module, which is about 15 microns in thickness, off the plastic substrate, forming an ultralight solar device.

But such thin, freestanding solar modules are challenging to handle and can easily tear, which would make them difficult to deploy. To solve this challenge, the MIT team searched for a lightweight, flexible, and high-strength substrate they could adhere the solar cells to. They identified fabrics as the optimal solution, as they provide mechanical resilience and flexibility with little added weight.

They found an ideal material—a composite fabric that weighs only 13 grams per square meter, commercially known as Dyneema. This fabric is made of fibers that are so strong they were used as ropes to lift the sunken cruise ship *Costa Concordia* from the bottom of the Mediterranean Sea. By adding a layer of UV-curable glue, which is only a few microns thick, they adhere the solar modules to sheets of this fabric. This forms an ultra-light and mechanically robust solar structure.

“While it might appear simpler to just print the solar cells directly on the fabric, this would limit the selection of possible fabrics or other receiving surfaces to the ones that are chemically and thermally compatible with all the processing steps needed to make the devices. Our approach

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decouples the solar cell manufacturing from its final integration," Saravanapavanantham explains.

Outshining conventional solar cells

When they tested the device, the MIT researchers found it could generate 730 watts of power per kilogram when freestanding and about 370 watts-per-kilogram if deployed on the high-strength Dyneema fabric, which is about 18 times more power-per-kilogram than conventional solar cells.

"A typical rooftop solar installation in Massachusetts is about 8,000 watts. To generate that same amount of power, our fabric photovoltaics would only add about 20 kilograms (44 pounds) to the roof of a house," he says.

They also tested the durability of their devices and found that, even after rolling and unrolling a fabric solar panel more than 500 times, the cells still retained more than 90 percent of their initial power generation capabilities.

While their solar cells are far lighter and much more flexible than traditional cells, they would need to be encased in another material to protect them from the environment. The carbon-based organic material used to make the cells could be modified by interacting with moisture and oxygen in the air, which could deteriorate their performance.

"Encasing these solar cells in heavy glass, as is standard with the traditional silicon solar cells, would minimize the value of the present advancement, so the team is currently developing ultrathin packaging solutions that would only fractionally increase the weight of the present ultralight devices," says Mwaura.

"We are working to remove as much of the non-solar-active material as possible while still retaining the form factor and performance of these ultralight and flexible solar structures. For example, we know the manufacturing process can be further streamlined by printing the releasable substrates, equivalent to the process we use to fabricate the other layers in our device. This would accelerate the translation of this technology to the market," he adds.

Tech Xplore, 9 December 2022

<https://techxplore.com>

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We have a genuine fusion energy breakthrough

2022-12-13

Researchers at the National Ignition Facility in Livermore, California, home of the world's most powerful laser, announced on Tuesday that they crossed the critical threshold in their pursuit of fusion power: getting more energy out of the reaction than they put in.

This is 1) a massive scientific advancement, and 2) still a long, long (long) way off from harnessing fusion, the reaction that powers the sun, as a viable source of abundant clean energy. On December 5, the team fired 192 laser beams at a tiny fuel pellet, producing slightly more energy than the lasers put in, "about 2 megajoules in, about 3 megajoules out," said Marvin Adams, deputy administrator for defense programs at the National Nuclear Security Administration, at a press conference Tuesday.

To make fusion something that could actually produce electricity for the power grid, it can't just inch over the ignition finish line; it has to blow past it. This announcement is an important incremental advance, but the breakthrough doesn't go far enough to be of practical use. Because NIF itself is a research laboratory, its technology is not intended to produce power. So designing a fusion reactor to harness this new approach will be its own engineering challenge.

NIF is part of Lawrence Livermore National Laboratory, operated by the US Department of Energy. "This is what it looks like for America to lead, and we're just getting started," Energy Secretary Jennifer Granholm said on Tuesday.

The Financial Times first revealed on Sunday that a fusion breakthrough announcement was imminent.

Nuclear fusion refers to the reaction where the nuclei of tiny atoms like hydrogen and helium collide and stick together, generating immense heat, which could, in theory, be used to make electricity. That's in contrast to the fission reaction used in conventional nuclear power plants, where large atoms like uranium are split apart. The trouble for fusion is that the nuclei are positively charged and thus repel each other. To get them to overcome their opposition, you have to get them moving really, really fast in a confined space and create a high-energy state of matter known as plasma.

Scientists have struggled for decades to do this. There are two main approaches: One is to compress a tiny pellet of fuel with powerful lasers,

That fusion announcement is worth getting hyped about, but practical fusion is still a long way off.

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which is NIF's strategy. The other is to heat up plasma to temperatures hotter than the sun and contain it with magnets. This is how ITER, the world's largest fusion project, currently under construction in southern France, will generate the reaction.

The sun and other stars can pull this off because they have enough matter to generate immense gravity, which accelerates and confines atoms to create fusion reactions that produce the light and heat we can experience from millions of miles away.

Here on Earth, humanity has actually known how to produce fusion since 1952 — in thermonuclear weapons. Scientists have been able to produce fusion in laboratories as well, but only intermittently, and at great energy expense: Imagine using a blowtorch to light a match. The slow progress in pursuit of fusion has also made it a struggle to get adequate research funding, which in turn hampered progress.

In 1997, the National Academy of Sciences established ignition as the goalpost for fusion at NIF. It defined ignition as "gain greater than unity," meaning more energy out of the fuel target than the amount of laser energy hitting it.

For months, scientists at NIF have gotten tantalizingly close. About a year ago, they said they were about 70 percent of the way there. "We're on the threshold of ignition," Tammy Ma, a plasma physicist at NIF, told Vox in January 2022.

Now they've crossed that line.

"This result clearly surpasses that mark leaving no question that they achieved fusion ignition in the laboratory," said Carolyn Kuranz, a plasma physicist at the University of Michigan, in an email.

Troy Carter, a plasma physicist at the University of California Los Angeles, explained that while NIF has achieved a massive breakthrough, it's still short of what's needed. As the National Academy of Sciences pointed out, the key metric is the fusion energy gain factor, also called "Q." This is the ratio of the power used to start and maintain a fusion reaction compared to the power produced. A gain of 1 means the reaction has broken even. The latest announcement at NIF shows a gain of roughly 1.5, meaning the reaction has become energy-positive.

But that's only if you define the energy input narrowly to the laser energy hitting the fuel target. If you measure from the total amount of energy needed to charge up and fire the laser, about 300 megajoules, the recent

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results are still far short. To actually produce more energy from fusion than the laser requires from the power grid, you would need a gain of 100 or more.

Another limitation is that NIF can only fire a few laser shots per day, and the amount of electricity required can sometimes cause blackouts at the lab. To run an actual fusion reactor, you'd need to fire about 10 shots per second.

The fuel itself could also stand to burn more efficiently. "The NIF shot only burned a small fraction of the fuel in the capsule," Carter said in an email. "If you can find a way to burn up more fuel, the gain goes up substantially."

That will involve tweaking the tiny fuel pellet to get more of the laser energy directed toward compressing atoms.

As for the laser, NIF is using dated technology that has a lot of room for improvement. The lasers are only about 1 percent efficient in terms of turning electricity to laser light, while more modern designs can be 20 percent efficient. "The NIF is built on 1980s laser technology," said Kim Budil, director of the Lawrence Livermore National Laboratory, during a press conference.

Still, achieving ignition is a critical milestone and an important signal that scientists are on the right track. Carter said it "provides more justification for an aggressive push to develop and deploy fusion energy as quickly as we can, with the hope of impacting climate change!"

Vox, 13 December 2022

<https://vox.com>

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There's more magma under Yellowstone than we thought—but don't panic

2022-12-02

In a corner of Yellowstone National Park in northwestern Wyoming, lies the Yellowstone Caldera, a crater situated over Yellowstone's super volcano. The volcano has produced three Earth-shattering eruptions over the past 2.1 million years, with the most recent occurring about 640,000 years ago. The caldera is about 30 by 45 miles wide.

Fears of the doomsday scenario of what would happen if this volcano were to erupt in the present day have sparked debate and worry about what is going on beneath the feet of the millions of tourists who visit the park every year. The scientists who study the volcano say we will receive decades worth of warnings that an eruption is about to happen, likely won't occur for thousands of years, and the volcano is not overdue for an eruption.

While there is no current risk of an eruption, the ground surrounding the ominous spot also seems to have a lot of magma. A new study published yesterday in the journal *Science* finds that the caldera's magma reservoir contains more melted rock than scientists once believed and at depths that fueled past eruptions. But do not panic—this doesn't mean that an eruption will be happening any time soon, according to the study's authors.

Predicting volcanic eruptions is difficult, partially because it is hard or impossible to really see what is going on beneath a volcano's surface. One of the key issues for better assessing the hazards of a volcanic eruption is getting a handle on just how much magma is below the surface and where it is located. Since Yellowstone's magmatic system remains active, questions persist about the volume and distribution of melt (the hot liquid base of the magma) and how that compares with the conditions before eruptions in the past.

These new findings may help scientists improve their models of this volcano to better understand the risk and signs of eruption.

Previous studies have produced images of what the subsurface below Yellowstone looks like, and show that the magma reservoir is located in the mid to upper crust. However, some recent observations from seismometers in the region show that the degree of partial melt could actually be much higher.

More magma under Yellowstone's super volcano doesn't mean an eruption is happening anytime soon.

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Since seismic waves move slower through areas with more melted rock, the team analyzed the seismic data recorded near Yellowstone over the past 20 years to help estimate the proportion of melted rock that is in the shallower magma reservoir. This analysis used supercomputers that modeled the waves in 3D to get a more complete view of the reservoir.

They found that the reservoir has 16 to 20 percent melted rock on average, compared with the older estimate of around nine percent. It's possible that the reservoir has about 383 cubic miles of melted rock—a great deal larger than the previous estimate of roughly 215 cubic miles.

Kari Cooper, a geochemist and geologist from the University of California, Davis who authored a commentary on the new study, writes that depending on how the magma is distributed, there might be enough for a smaller eruption, but the study shows that there's currently not enough for a catastrophic eruption. She adds that the study improves our ability to understand what's going on beneath Yellowstone.

So, we repeat: do not panic.

Popular Science, 2 December 2022

<https://popsci.com>

Young star clusters know when it's time to stop growing

2022-11-30

Stars love personal growth, but even they have limits. A new composite image from NASA and the European Space Agency (ESA) illustrates how the youngest members of a cluster in the Milky Way can exert "self control" in a process known as "stellar feedback."

The action takes place in RCW 36, a cloud of mostly hydrogen ions located 2,900 light-years away from Earth. A group of stars is emerging from super-hot gas there—and leaving a strange pair of voids in its wake. The formation is also pulled together by dense, cool gas, giving it an hourglass-like appearance.

With data collected from the Chandra X-ray Observatory, APEX telescope, and the now-retired SOFIA and Herschel space instruments, a team of international researchers dove into RSW 36's deserted regions. They learned that the ring of freezing gas (estimated at -430 to -410 degrees Fahrenheit) is being pushed out by the pressure of sizzling atoms in the middle (estimated at 3.6 million degrees Fahrenheit). Radiation from the natal stellar bodies also helped clear out raw materials from both sides

A colorful X-ray and infrared image shows new members of the Milky Way exerting "self control."

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of the cloud. "This process should drastically slow down the birth of new stars, which would better align with astronomers' predictions for how quickly stars form in clusters," NASA explained in a blog post this week.

The pressure and plasma coming out of the hotspots are called "stellar winds," and act similar to a galactic power washer. The scientists observing RSW 36 think the cold gas could be moving upward of 30,000 miles per hour, which means it'd be cleaning out 170 Earths worth of mass per year. At that rate, the cloud could be free of any fertile bits in the next 1 to 2 million years.

The team's findings, which were published in *The Astrophysical Journal* in August 2022, indicate that the ruthless "stellar feedback" strategy could be seen elsewhere in the Milky Way and cosmos. Lucky for us, NASA and ESA has the tools to catch the stars red-handed.

Popular Science, 30 November 2022

<https://popsci.com>

Why does lightning zigzag? At last, we have an answer to the mystery

2022-12-02

Everyone has seen lightning and marvelled at its power. But despite its frequency – about 8.6 million lightning strikes occur worldwide every day – why lightning proceeds in a series of steps from the thundercloud to the earth below has remained a mystery.

There are a few textbooks on lightning, but none have explained how these "zigzags" (called steps) form, and how lightning can travel over kilometres. My new research provides an explanation.

The intense electrical fields in thunderclouds excite electrons to have enough energy to create what are known as "singlet delta oxygen molecules". These molecules and electrons build up to create a short, highly conducting step, which lights up intensely for a millionth of a second.

At the end of the step, there is a pause as the build-up happens again, followed by another bright, flashing leap. The process is repeated again and again.

An increase in extreme weather events means lightning protection is increasingly important. Knowing how a lightning strike is initiated means

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we can work out how to better protect buildings, aeroplanes and people. Also, while the use of environmentally friendly composite materials in aircraft is improving fuel efficiency, these materials increase the risk of lightning damage, so we need to look at additional protection.

What leads up to a lightning strike?

Lightning strikes happen when thunderclouds with an electric potential of millions of volts are connected to the earth. A current of thousands of amps flows between the ground and the sky, with a temperature of tens of thousands of degrees.

Photographs of lightning reveal a host of details not observed by the naked eye. Usually there are four or five faint "leaders" coming from the cloud. These are branched and zigzag on an irregular path towards the earth.

The first of these leaders to reach the earth initiates the lightning strike. The other leaders are then extinguished.

Fifty years ago, high-speed photography revealed still more complexity. The leaders progress downwards from the cloud in "steps" about 50 metres long. Each step becomes bright for a millionth of a second, but then there is almost complete darkness. After a further 50 millionths of a second another step forms, at the end of the preceding step, but the previous steps remain dark.

Why are there such steps? What is happening in the dark periods between steps? How can the steps be electrically connected to the cloud with no visible connection?

The answers to these questions lie in understanding what happens when an energetic electron hits an oxygen molecule. If the electron has enough energy, it excites the molecule into the singlet delta state. This is a "metastable" state, which means it is not perfectly stable – but it usually doesn't fall into a lower energy state for 45 minutes or so.

Oxygen in this singlet delta state detaches electrons (required for electricity to flow) from negative oxygen ions. These ions are then replaced almost immediately by electrons (which carry a negative charge) again attaching to oxygen molecules. When more than 1% of the oxygen in the air is in the metastable state, the air can conduct electricity.

So the lightning steps occur as enough of the metastable states are created to detach a significant number of electrons. During the dark part

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of a step, the density of metastable states and electrons is increasing. After 50 millionths of a second, the step can conduct electricity – and the electrical potential at the tip of the step increases to approximately that of the cloud, and produces a further step.

The excited molecules created in previous steps form a column all the way to the cloud. The whole column is then electrically conducting, with no requirement of an electric field and little emission of light.

Protecting people and property

The understanding of lightning formation is important for the design of protection for buildings, aircraft and also people. While it is rare for lightning to hit people, buildings are hit many times – especially tall and isolated ones.

When lightning hits a tree, sap inside the tree boils and the resulting steam creates pressure, splitting open the trunk. Similarly, when lightning hits the corner of a building, water from rain that has seeped into the concrete boils. The pressure blasts off the whole corner of the building, creating the risk of deadly collapses.

A lightning rod invented by Benjamin Franklin in 1752 is basically a thick fencing wire attached to the top of a building and connected to the ground. It is designed to attract lightning and earth the electric charge. By directing the flow through the wire, it saves the building from being damaged.

These Franklin rods are required for tall buildings and churches today, but the uncertain factor is how many are needed on each structure.

Furthermore, hundreds of structures are not protected, including shelter sheds in parks. These structures are often made from highly conductive galvanized iron, which itself attracts lightning, and supported by wooden posts.

The new version of Standards Australia for lightning protection recommends such shelters be earthed.

The Conversation, 2 December 2022

<https://theconversation.com>

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Scared of Shots? A Wearable Robot Can Improve Your Experience

2022-12-06

While most of us cannot live without our cell phones, robots may soon become indispensable companions. It certainly seems so based on the recent experiments conducted by researchers in Japan, who developed a hand-held soft robot that can improve the experience of patients while undergoing potentially unpleasant medical procedures, such as injections.

Public health officials realized that some individuals just fear needles, which led to lower vaccination rates, during the campaign to promote vaccination against COVID-19. Despite extensive research into the issues of patient anxiety and anxiety during medical procedures, there is still a need to test and put into practice solutions to help patients.

In a recent study published in Scientific Reports, researchers at the University of Tsukuba created a wearable soft robot for patients to use during treatments in an attempt to ease pain. The research participants who wore the robot felt less discomfort during tests when they were exposed to a mild heat stimulus than those who did not.

“Our results suggest that the use of wearable soft robots may reduce fear as well as alleviate the perception of pain during medical treatments, including vaccinations,” says senior author Professor Fumihide Tanaka.

The scientists’ soft, fur-covered robot, Reliebo, was meant to be connected to the participant’s hand and had miniature airbags that could inflate in response to hand movements. The researchers examined its effectiveness under various conditions depending on the participant’s hand clenching, while applying the painful heat stimulus to the other arm that was not holding the robot.

The researchers also measured the levels of oxytocin and cortisol (which are biomarkers for stress) from the patient’s saliva samples. Additionally, subjective pain ratings were recorded using an assessment scale, and a survey test was conducted to evaluate the patients’ fear of injections and psychological state before and after the experiments.

The researchers found that holding the robot helped relieve the experience for patients regardless of the experimental conditions used, and speculated that the feelings of well-being that can be created by human touch may have also been activated by the robot.

“It is well known that interpersonal touch can reduce pain and fear, and we believe that this effect can be achieved even with nonliving soft robots.”

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“It is well known that interpersonal touch can reduce pain and fear, and we believe that this effect can be achieved even with nonliving soft robots,” states Professor Tanaka. This may be useful when actual human contact is not feasible, such as during pandemics. Future versions of the robot might use a controlled gaze or even AR (augmented reality) technologies to help build a connection with the patient or distract them from pain perception in various situations.

Sci Tech Daily, 6 December 2022

<https://scitechdaily.com>

Flash of light as bright as a quadrillion Suns dazzles astronomers

2022-12-01

Astronomers have spotted an incredibly bright flash of light beaming halfway across the universe. The strange light was estimated to throw off more light than one quadrillion Suns, and in an ironic twist came from one of the darkest objects possible.

The Zwicky Transient Facility (ZTF) is an observatory that watches large swathes of the sky at once, keeping an eye out for transient events – pulsing lights like supernovae or moving objects like comets. And on February 11 this year it spotted an absolute doozy, as an incredibly bright spot of light flared up in an area where there’d been nothing the night before. Astronomers roughly calculated that it was brighter than a quadrillion Suns.

Over the next few days, telescopes from all over the world were trained on the light, studying it in X-ray, ultraviolet, optical and radio, to find out what could possibly be throwing off that much energy. And in a new study, scientists report the most likely candidate.

The signal, known as AT 2022cmc, seems to have originated from a black hole located about 8.5 billion light-years away. In what’s called a tidal disruption event (TDE), this supermassive monster has devoured an unlucky star that wandered too close, flinging some of its matter away to form a burst of light. While TDEs have been observed plenty of times in the past, this is the brightest and most distant one ever detected.

So how did it get so bright? Some TDEs can form relativistic jets – matter from the dying star is thrown into powerful beams and accelerated to 99.99% of the speed of light. When these jets just so happen to be

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pointing directly at Earth, they can appear much brighter than usual. That’s thanks to the Doppler effect, where wavelengths of light are pushed closer together as they approach a viewer.

But even that isn’t enough to explain the extent of this unprecedented brightness, the team says. The black hole must be in the midst of a hyper-feeding frenzy.

“It’s probably swallowing the star at the rate of half the mass of the Sun per year,” said Dheeraj Pasham, co-author of the study. “A lot of this tidal disruption happens early on, and we were able to catch this event right at the beginning, within one week of the black hole starting to feed on the star.”

The team says that more TDEs are expected to be observed in future as more powerful telescopes begin scouring the skies more regularly.

The research was published in the journal Nature Astronomy. The team describes the work in the video below.

New Atlas, 1 December 2022

<https://newatlas.com>

Men are slowly losing their Y chromosome, but a new sex gene discovery in spiny rats brings hope for humanity

2022-12-06

The sex of human and other mammal babies is decided by a male-determining gene on the Y chromosome. But the human Y chromosome is degenerating and may disappear in a few million years, leading to our extinction unless we evolve a new sex gene.

The good news is two branches of rodents have already lost their Y chromosome and have lived to tell the tale.

A new paper in Proceedings of the National Academy of Science shows how the spiny rat has evolved a new male-determining gene.

How the Y chromosome determines human sex

In humans, as in other mammals, females have two X chromosomes and males have a single X and a puny little chromosome called Y. The names have nothing to do with their shape; the X stood for “unknown”.

The good news is two branches of rodents have already lost their Y chromosome and have lived to tell the tale.

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The X contains about 900 genes that do all sorts of jobs unrelated to sex. But the Y contains few genes (about 55) and a lot of non-coding DNA – simple repetitive DNA that doesn't seem to do anything.

But the Y chromosome packs a punch because it contains an all-important gene that kick-starts male development in the embryo. At about 12 weeks after conception, this master gene switches on others that regulate the development of a testis. The embryonic testis makes male hormones (testosterone and its derivatives), which ensures the baby develops as a boy.

This master sex gene was identified as SRY (sex region on the Y) in 1990. It works by triggering a genetic pathway starting with a gene called SOX9 which is key for male determination in all vertebrates, although it does not lie on sex chromosomes.

The disappearing Y

Most mammals have an X and Y chromosome similar to ours; an X with lots of genes, and a Y with SRY plus a few others. This system comes with problems because of the unequal dosage of X genes in males and females.

How did such a weird system evolve? The surprising finding is that Australia's platypus has completely different sex chromosomes, more like those of birds.

In platypus, the XY pair is just an ordinary chromosome, with two equal members. This suggests the mammal X and Y were an ordinary pair of chromosomes not that long ago.

In turn, this must mean the Y chromosome has lost 900–55 active genes over the 166 million years that humans and platypus have been evolving separately. That's a loss of about five genes per million years. At this rate, the last 55 genes will be gone in 11 million years.

Our claim of the imminent demise of the human Y created a furore, and to this day there are claims and counterclaims about the expected lifetime of our Y chromosome – estimates between infinity and a few thousand years

Rodents with no Y chromosome

The good news is we know of two rodent lineages that have already lost their Y chromosome – and are still surviving.

The mole voles of eastern Europe and the spiny rats of Japan each boast some species in which the Y chromosome, and SRY, have completely

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disappeared. The X chromosome remains, in a single or double dose in both sexes.

Although it's not yet clear how the mole voles determine sex without the SRY gene, a team led by Hokkaido University biologist Asato Kuroiwa has had more luck with the spiny rat – a group of three species on different Japanese islands, all endangered.

Kuroiwa's team discovered most of the genes on the Y of spiny rats had been relocated to other chromosomes. But she found no sign of SRY, nor the gene that substitutes for it.

Now at last they have published a successful identification in PNAS. The team found sequences that were in the genomes of males but not females, then refined these and tested for the sequence on every individual rat.

What they discovered was a tiny difference near the key sex gene SOX9, on chromosome 3 of the spiny rat. A small duplication (only 17,000 base pairs out of more than 3 billion) was present in all males and no females.

They suggest this small bit of duplicated DNA contains the switch that normally turns on SOX9 in response to SRY. When they introduced this duplication into mice, they found that it boosts SOX9 activity, so the change could allow SOX9 to work without SRY.

What this means for the future of men

The imminent – evolutionarily speaking – disappearance of the human Y chromosome has elicited speculation about our future.

Some lizards and snakes are female-only species and can make eggs out of their own genes via what's known as parthenogenesis. But this can't happen in humans or other mammals because we have at least 30 crucial "imprinted" genes that work only if they come from the father via sperm.

To reproduce, we need sperm and we need men, meaning that the end of the Y chromosome could herald the extinction of the human race.

The new finding supports an alternative possibility – that humans can evolve a new sex determining gene. Phew!

However, evolution of a new sex determining gene comes with risks. What if more than one new system evolves in different parts of the world?

A "war" of the sex genes could lead to the separation of new species, which is exactly what has happened with mole voles and spiny rats.

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So, if someone visited Earth in 11 million years, they might find no humans – or several different human species, kept apart by their different sex determination systems.

The Conversation, 6 December 2022

<https://theconversation.com>

Non-Invasive Laser Light Therapy Could Improve Short-Term Memory by Up to 25 Percent

2022-12-08

Laser light therapy, which is non-invasive, could improve short-term, or working memory in people by up to 25 percent according to new research demonstrated by scientists at the University of Birmingham in the UK and Beijing Normal University in China.

Called transcranial photobiomodulation (tPBM), the treatment is applied to an area of the brain known as the right prefrontal cortex. This area is widely recognized as important for working memory. In their experiment, the research team demonstrated how working memory improved among research participants after just several minutes of treatment. They were also able to track the changes in brain activity using electroencephalogram (EEG) monitoring during treatment and testing.

Previous research studies have shown that laser light treatment will improve working memory in mice. Additionally, human studies have shown tPBM treatment can improve accuracy, speed up reaction time, and improve high-order functions such as attention and emotion.

However, this is the first study to confirm a link between tPBM and working memory in humans.

Dongwei Li, a visiting PhD student in the University of Birmingham's Centre for Human Brain Health, is co-author on the paper. He said: "People with conditions like ADHD (attention deficit hyperactivity disorder) or other attention-related conditions could benefit from this type of treatment, which is safe, simple and non-invasive, with no side-effects."

In the study, scientists at Beijing Normal University carried out experiments with 90 male and female participants aged between 18 and 25. Participants were treated with laser light to the right prefrontal cortex at wavelengths of 1064 nm, while others were treated at a shorter wavelength, or treatment was delivered to the left prefrontal cortex. To

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rule out the placebo effect, each participant was also treated with a sham, or inactive, tPBM.

After tPBM treatment over 12 minutes, the participants were asked to remember the orientations or color of a set of items displayed on a screen. The participants treated with 1064 nm laser light to the right prefrontal cortex showed clear improvements in memory over those who had received the other treatments. While participants receiving other treatment variations were able to recall between 3 and 4 of the test objects, those with the targeted treatment were able to remember between 4 and 5 objects.

Data, including from electroencephalogram (EEG) monitoring during the experiment was analyzed at the University of Birmingham and showed changes in brain activity that also predicted the improvements in memory performance.

The researchers do not yet know precisely why the treatment results in positive effects on working memory, nor how long the effects will last. Further research is planned to investigate these aspects.

Professor Ole Jensen, also at the Centre for Human Brain Health, said: "We need further research to understand exactly why the tPBM is having this positive effect, but it's possible that the light is stimulating the astrocytes – the powerplants – in the nerve cells within the prefrontal cortex, and this has a positive effect on the cells' efficiency. We will also be investigating how long the effects might last. Clearly, if these experiments are to lead to a clinical intervention, we will need to see long-lasting benefits."

Sci Tech Daily, 8 December 2022

<https://scitechdaily.com>

Say hello to the toughest material on Earth

2022-12-08

The team, led by researchers from Lawrence Berkeley National Laboratory (Berkeley Lab) and Oak Ridge National Laboratory, published a study describing their record-breaking findings in Science on Dec. 1, 2022. "When you design structural materials, you want them to be strong but also ductile and resistant to fracture," said project co-lead Easo George, the Governor's Chair for Advanced Alloy Theory and Development at ORNL and the University of Tennessee. "Typically, it's a compromise between these properties. But this material is both, and instead of becoming brittle at low temperatures, it gets tougher."

Scientists have measured the highest toughness ever recorded, of any material, while investigating a metallic alloy made of chromium, cobalt, and nickel.

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CrCoNi is a subset of a class of metals called high entropy alloys (HEAs). All the alloys in use today contain a high proportion of one element with lower amounts of additional elements added, but HEAs are made of an equal mix of each constituent element. These balanced atomic recipes appear to bestow some of these materials with an extraordinarily high combination of strength and ductility when stressed, which together make up what is termed “toughness.” HEAs have been a hot area of research since they were first developed about 20 years ago, but the technology required to push the materials to their limits in extreme tests was not available until recently.

“The toughness of this material near liquid helium temperatures (20 kelvin, -424 Fahrenheit) is as high as 500 megapascals square root meters. In the same units, the toughness of a piece of silicon is one, the aluminum airframe in passenger airplanes is about 35, and the toughness of some of the best steels is around 100. So, 500, it’s a staggering number,” said research co-leader Robert Ritchie, a senior faculty scientist in Berkeley Lab’s Materials Sciences Division and the Chua Professor of Engineering at UC Berkeley.

Ritchie and George began experimenting with CrCoNi and another alloy that also contains manganese and iron (CrMnFeCoNi) nearly a decade ago. They created samples of the alloys then lowered the materials to liquid nitrogen temperatures (around 77 kelvin, or -321 F) and discovered impressive strength and toughness. They immediately wanted to follow up their work with tests at liquid helium temperature ranges, but finding facilities that would enable stress testing samples in such a cold environment, and recruiting team members with the analytical tools and experience needed to analyze what happens in the material at an atomic level took the next 10 years. Thankfully, the results were worth the wait.

Peering into the crystal

Many solid substances, including metals, exist in a crystalline form characterized by a repeating 3D atomic pattern, called a unit cell, that makes up a larger structure called a lattice. The material’s strength and toughness, or lack thereof, come from physical properties of the lattice. No crystal is perfect, so the unit cells in a material will inevitably contain “defects,” a prominent example being dislocations -- boundaries where undeformed lattice meets up with deformed lattice. When force is applied to the material -- think, for example, of bending a metal spoon -- the shape change is accomplished by the movement of dislocations through the lattice. The easier it is for the dislocations to move, the softer the material

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is. But if the movement of the dislocations is blocked by obstacles in the form of lattice irregularities, then more force is required to move the atoms within the dislocation, and the material becomes stronger. On the flip side, obstacles usually make the material more brittle -- prone to cracking.

Using neutron diffraction, electron backscatter diffraction, and transmission electron microscopy, Ritchie, George, and their colleagues at Berkeley Lab, the University of Bristol, Rutherford Appleton Laboratory, and the University of New South Wales examined the lattice structures of CrCoNi samples that had been fractured at room temperature and 20 K. (For measuring strength and ductility, a pristine metal specimen is pulled until it fractures, whereas for fracture toughness tests, a sharp crack is intentionally introduced into the sample before it is pulled and the stress needed to grow the crack is then measured.)

The images and atomic maps generated from these techniques revealed that the alloy’s toughness is due to a trio of dislocation obstacles that come into effect in a particular order when force is applied to the material. First, moving dislocations cause areas of the crystal to slide away from other areas that are on parallel planes. This movement displaces layers of unit cells so that their pattern no longer matches up in the direction perpendicular to the slipping movement, creating a type of obstacle. Further force on the metal creates a phenomenon called nanotwinning, wherein areas of the lattice form a mirrored symmetry with a boundary in between. Finally, if forces continue to act on the metal, the energy being put into the system changes the arrangement of the unit cells themselves, with the CrCoNi atoms switching from a face-centered cubic crystal to another arrangement known as hexagonal close packing.

This sequence of atomic interactions ensures that the metal keeps flowing, but also keeps meeting new resistance from obstacles far past the point that most materials snap from the strain. “So as you are pulling it, the first mechanism starts and then the second one starts, and then the third one starts, and then the fourth,” explained Ritchie. “Now, a lot of people will say, well, we’ve seen nanotwinning in regular materials, we’ve seen slip in regular materials. That’s true. There’s nothing new about that, but it’s the fact they all occur in this magical sequence that gives us these really tremendous properties.”

The team’s new findings, taken with other recent work on HEAs, may force the materials science community to reconsider long-held notions about how physical characteristics give rise to performance. “It’s amusing because metallurgists say that the structure of a material defines its

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properties, but the structure of the NiCoCr is the simplest you can imagine -- it's just grains," said Ritchie. "However, when you deform it, the structure becomes very complicated, and this shift helps explain its exceptional resistance to fracture," added co-author Andrew Minor, director of the National Center of Electron Microscopy facility of the Molecular Foundry at Berkeley Lab and Professor of Materials Science and Engineering at UC Berkeley. "We were able to visualize this unexpected transformation due to the development of fast electron detectors in our electron microscopes, which allow us to discern between different types of crystals and quantify the defects inside them at the resolution of a single nanometer -- the width of just a few atoms -- which as it turns out, is about the size of the defects in deformed NiCoCr structure."

The CrMnFeCoNi alloy was also tested at 20 kelvin and performed impressively, but didn't achieve the same toughness as the simpler CrCoNi alloy.

Forging new products

Now that the inner workings of the CrCoNi alloy are better understood, it and other HEAs are one step closer to adoption for special applications. Though these materials are expensive to create, George foresees uses in situations where environmental extremes could destroy standard metallic alloys, such as in the frigid temperatures of deep space. He and his team at Oak Ridge are also investigating how alloys made of more abundant and less expensive elements -- there is a global shortage of cobalt and nickel due to their demand in the battery industry -- could be coaxed into having similar properties.

Though the progress is exciting, Ritchie warns that real-world use could still be a ways off, for good reason. "When you are flying on an airplane, would you like to know that what saves you from falling 40,000 feet is an airframe alloy that was only developed a few months ago? Or would you want the materials to be mature and well understood? That's why structural materials can take many years, even decades, to get into real use."

Sci Tech Daily, 8 December 2022

<https://scitechdaily.com>

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Why do some dogs chase squirrels? Study finds genetic links to canine quirks

2022-12-08

Is your dog scared by a plastic bag flapping in the wind? When a stranger comes to the door, does it bark, hide or look for you? Does it chase squirrels?

A study that combined 46,000 answers to these and other questions with DNA sequences from more than 4,000 dogs — including domestic and wild canines — has pinpointed genetic variants linked to characteristic dog behaviours.

It is a Herculean effort to untangle the complicated genetics woven by hundreds of years of dog breeding, and to catalogue the genetic changes — many of them involved in neurodevelopment — behind the behavioural characteristics of different breeds.

"There are about 350 dog breeds recognized in the world, and each one is a different story," says geneticist Elaine Ostrander at the US National Human Genome Research Institute in Bethesda, Maryland, and an author of the study, which is published on 8 December in *Cell*. "You can't just group them together like you can humans."

Each of those unique histories has left its footprint in the genomes of specific breeds. Some breeds are heavily influenced by one particular male that did well in a dog show and had its sperm frozen and widely distributed. Others might have been influenced in a different way: for example, the populations of some large dog breeds decreased dramatically during times of war or famine, when there was not enough food to feed them. Sometimes breeders then mixed different canine lineages in an effort to reintroduce characteristics lost to the remaining population.

Dog DNA

The complexity of these stories makes it difficult to trace the genetic origins of behavioural traits, so Ostrander and her colleagues decided to scrap conventional breed categories and instead use DNA sequences to group dogs into genetic lineages. The team analysed DNA from almost 4,300 dogs, including 2,800 purebreds spanning 226 officially recognized breeds. The approach — which also included DNA from mixed-breed dogs, semi-feral dogs and wild canids from four continents — yielded ten distinct lineages.

Mapping the genetics created by centuries of breeding could inform studies of the biological basis for human behaviour.

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From there, Ostrander and her colleagues turned to the behavioural surveys collected from the owners of more than 46,000 purebred dogs to map behavioural traits to the lineages. Members of the terrier lineage, for example, tended to show predatory behaviour and aggression towards other dogs, whereas toy dogs tended to be nervous.

An analysis of DNA sequences associated with those behaviours identified a number of variants linked with the development of the nervous system. For example, variants that were common in sheepdogs — bred for their herding instincts — pinpointed a molecular pathway involved in forming connections between nerve cells. Previous studies have shown a link between two genes involved in this pathway and behaviour in which female mice gather their pups tightly together, suggesting that herding could have evolutionary roots in maternal actions to protect offspring.

The results are an exciting advance in understanding the relationships between dog lineages, says geneticist Elinor Karlsson at the University of Massachusetts Chan Medical School in Worcester. Earlier this year, Karlsson published data showing that breed is a poor predictor of an individual dog's behaviour.

"It's been a real struggle in dog genetics," she says. "This is starting to move beyond the idea of comparing one breed to another breed, and towards really looking at how behaviour maps onto the ancestry of dogs."

Bigger variations

This study focused on small changes in DNA sequences, such as single-letter changes and small deletions or insertions of DNA. Future studies might look at other forms of genetic variation, such as larger deletions or rearrangement of chromosome segments, says canine geneticist Adam Boyko at Cornell University in Ithaca, New York.

As such studies continue to map the genetics underlying dog behaviour, one hope is that the results could inform research into neurodiversity and the biological basis for human behaviours, Boyko says. "It gives human researchers the ability to start generating hypotheses that you wouldn't otherwise be able to have in the absence of this great model."

Given that dogs and humans often share a home, such studies could be useful in understanding how environment shapes disease risk. "At the end of the day, dogs and humans are probably more similar to each other than

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they are different, if you look at the whole spectrum of animal evolution," says Karlsson. "We can totally understand each other for most things."

Nature, 8 December 2022

<https://nature.com>

Mind-Blowing New Hypothesis: Gravity May Cause Irritable Bowel Syndrome

2022-12-11

According to a new theory from researchers out of Cedars-Sinai Medical Center, gravity may be the cause of irritable bowel syndrome (IBS), the most common gastrointestinal disorder.

Brennan Spiegel, MD, MSHS, director of Health Services Research at Cedars-Sinai and author of the hypothesis, explains that IBS—and many other conditions—could result from the body's inability to manage gravity.

"As long as there's been life on Earth, from the earliest organisms to Homo sapiens, gravity has relentlessly shaped everything on the planet," said Spiegel, who is also a professor of Medicine. "Our bodies are affected by gravity from the moment we're born to the day we die. It's a force so fundamental that we rarely note its constant influence on our health."

The hypothesis, published in the American Journal of Gastroenterology, describes how the intestines, spine, heart, nerves, and brain evolved to manage gravity.

Irritable bowel syndrome (IBS) is a collection of symptoms that occur together, including repeated pain in your abdomen and changes in your bowel movements, which may be diarrhea, constipation, or both. With IBS, you have these symptoms without any visible signs of damage or disease in your digestive tract.

"Our body systems are constantly pulled downward," Spiegel noted. "If these systems cannot manage the drag of gravity, then it can cause issues like pain, cramping, lightheadedness, sweating, rapid heartbeat and back issues—all symptoms seen with IBS. It can even contribute to bacterial overgrowth in the gut, a problem also linked to IBS."

The underlying mechanism of IBS has been puzzling researchers since it was first described over a century ago. While the disorder affects up to

New hypothesis unifies several contrasting theories that may help explain the underlying cause of IBS.

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10% of the world's population, experts still aren't sure exactly how or why it develops.

There are, however, several contrasting theories that explain its clinical features. One is that IBS is a gut-brain interaction disorder; evidence shows that neuromodulators and behavioral therapies are effective. Another theory holds that IBS is driven by abnormalities in the gut microbiome, which can be managed with antibiotics or low fermentable diets.

Other theories suggest that abnormalities in motility, gut hypersensitivity, abnormal serotonin levels, or a dysregulated autonomic nervous system cause IBS.

"There's such a variety of explanations that I wondered if they could all be simultaneously true," said Spiegel. "As I thought about each theory, from those involving motility, to bacteria, to the neuropsychology of IBS, I realized they might all point back to gravity as a unifying factor. It seemed pretty strange at first, no doubt, but as I developed the idea and ran it by colleagues, it started to make sense."

The most common symptoms of IBS are pain in your abdomen, often related to your bowel movements, and changes in your bowel movements. These changes may be diarrhea, constipation, or both, depending on what type of IBS you have.

Gravity can compress the spine and decrease one's flexibility. It can also cause organs to shift downward, moving from their proper position. The abdominal contents are heavy, like a sack of potatoes that we're destined to carry our entire lives, Spiegel explained.

"The body evolved to hoist this load with a set of support structures. If these systems fail, then IBS symptoms can occur along with musculoskeletal problems," Spiegel said.

Some people have bodies that are more capable of carrying the load than others. For example, some have "stretchy" suspension systems that cause the intestines to droop down. Others have spinal issues that cause the diaphragm to sag or the belly to protrude, leading to a compressed abdomen.

These factors might trigger motility problems or bacterial overgrowth in the gut. This may also help explain why physical therapy and exercise is effective for IBS because these interventions strengthen the support systems.

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The gravity hypothesis, however, also goes beyond the intestines.

"This hypothesis is very provocative, but the best thing about it is that it is testable. If proved correct, it is a major paradigm shift in the way we think about IBS and possibly treatment as well." — Shelly Lu, MD

"Our nervous system also evolved in a world of gravity, and that might explain why many people feel abdominal 'butterflies' when anxious," said Spiegel. "It's curious that these 'gut feelings' also occur when falling toward Earth, like when dropping on a roller coaster or in a turbulent airplane. The nerves in the gut are like an ancient G-force detector that warns us when we're experiencing—or about to experience—a dangerous fall. It's just a hypothesis, but people with IBS might be prone to over-predicting G-force threats that never occur."

Some people are more resilient to G-forces than others. For example, one person may raise their hands and grin while dropping on a roller coaster while another grits their teeth and groans. The first person is amused while the second feels threatened, revealing a spectrum of what Spiegel calls "G-force vigilance."

Another contributor that may play a role is serotonin, a neurotransmitter that may have evolved in part to manage gravity across body systems. Serotonin is necessary for mood elevation, both metaphorically and literally, noted Spiegel. Without it, people also would not be able to stand up, maintain balance, circulate blood, or pump intestinal contents against gravity.

"Dysregulated serotonin may be a form of gravity failure," Spiegel said. "When serotonin biology is abnormal, people can develop IBS, anxiety, depression, fibromyalgia, and chronic fatigue. These may be forms of gravity intolerance."

Further research is needed to test this approach and the possible treatments.

"This hypothesis is very provocative, but the best thing about it is that it is testable," said Shelly Lu, MD, the Women's Guild Chair in Gastroenterology and director of the Division of Digestive and Liver Diseases at Cedars-Sinai. "If proved correct, it is a major paradigm shift in the way we think about IBS and possibly treatment as well."

Sci Tech Daily, 11 December 2022

<https://scitechdaily.com>

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