CHEMWATCH

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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

Release of the 2021 food recall statistics

2022-05-02

FSANZ has released data on 2021 food recalls. A total of 80 recalls were conducted in the last calendar year, with almost half of these due to undeclared allergens.

Other reasons for recalls included microbial contamination (19), foreign matter (5) and incorrect labelling (3).

FSANZ collects and publishes annual data on Australian food recalls to identify trends and common issues in the food industry and help identify ways to prevent future incidents.

We've also published an analysis of annual food recall statistics for the last 10 years, including new data for 2021.

For all the statistics and more information, see our website:

- Food recall statistics
- Undeclared allergen food recall statistics

Read More

Food Standards Australia New Zealand, 2-05-22

https://www.foodstandards.gov.au/industry/foodrecalls/recallstats/Pages/default.aspx

FSANZ has released data on 2021 food recalls. A total of 80 recalls were conducted in the last calendar year, with almost half of these due to undeclared allergens.

China JiLin Province MPA published Adjustment of registration application items and materials for Class II medical devices

2022-05-19

China JiLin Province MPA published Adjustment of registration application items and materials for Class II medical devices, including in vitro diagnostic reagents.

Registration applicants should be declared in the registration of Class II medical device products submitted to the product development, production-related information on the quality management system. Do not need to submit a single medical device registration quality management system verification of the declaration information.

The registration items of the Class II medical device (including in vitro diagnostic reagents) registration certificate are changed to "For the information recording".

Read More

Chemycal, 19-05-22

https://chemycal.com/news/fdcc5b3a-021e-4502-beb8-9d0a66b4ae7c/Chiina_JiLin_Province_MPA_published_Adjustment_of_registration_application_items_and_materials_for_Class_II_medical_devices

FSANZ Proposal P1059 - Energy labelling on alcoholic beverages

2022-05-02

We recently started work on a new proposal to consider energy labelling on alcoholic beverages. This proposal follows preliminary work undertaken in 2021, including an evidence assessment and options analysis. Both reports are available on our website.

FSANZ will seek stakeholder views and input on this proposal, including through public consultation anticipated towards the end of 2022. For more information and to keep up to date as this work progresses, visit our website.

Read More

Food Standards Australia New Zealand, 2-05-22

https://www.foodstandards.gov.au/code/proposals/Pages/Proposal-P1059---Energy-labelling-on-alcoholic-beverages.aspx

AMERICA

Colorado legislature passes bill banning 'forever chemicals' in products

2022-05-12

Coloradans would no longer be able to sell or distribute a long list of products that contain so-called forever chemicals under a bill approved by the state's legislature this week.

Coloradans would no longer be able to sell or distribute a long list of products that contain so-called forever chemicals under a bill approved by the state's legislature this week.

The bill, which would restrict some products as early as Jan. 1, 2024, passed both chambers with bipartisan support and is now headed to Gov. Jared Polis's (D) desk.

On the list of products are carpets or rugs, cosmetics, fabric treatments, food packaging, juvenile products, oil and gas products, textiles furnishings and upholstered furniture, according to the bill.

Cookware that contains such compounds "in the handle of the product or in any product surface that comes into contact with food" would also need to disclose these ingredients on their product labels.

Forever chemicals — also known as per- and polyfluoroalkyl substances (PFAS) — are most notorious for their presence in jet fuel firefighting foams and industrial discharge, but they are also key ingredients in household products like those included in the Colorado ban.

There are thousands of types of PFAS, some of which are linked to testicular cancer, kidney cancer and a host of other illnesses. They earned the epithet "forever chemicals" due to their propensity to endure long-term in the human body and in the environment.

"Colorado has more PFAS sites than any other state, so I'm thrilled that we were able to overcome a number of hurdles and pass this bill," State Rep. Lisa Cutter (D), co-sponsor of the bill, told The Hill in a statement.

Read More

The Hill, 12-05-22

https://thehill.com/policy/equilibrium-sustainability/3486347-colorado-legislature-passes-bill-banning-forever-chemicals-in-products/

Missouri legislators weaken regulations for hazardous waste, 'advanced recycling'

2022-05-13

Legislation weakening Missouri's hazardous waste regulations and opening the door for "advanced recycling" will soon be on Gov. Mike Parson's desk.

Legislation weakening Missouri's hazardous waste regulations and opening the door for "advanced recycling" will soon be on Gov. Mike Parson's desk.

With just hours left before Friday's mandated end to the Missouri legislative session, the House took up and passed a bill stuck in conference committee negotiations that was vehemently opposed

by environmentalists and pushed by business groups and the plastics industry.

The legislation would bar Missouri from enacting hazardous waste rules that are any stricter than federal regulation, a provision that Senate Democrats filibustered for hours earlier in the session.

It would also allow advanced — or chemical — recycling facilities to operate without a solid waste permit. Critics worry the two policies will leave Missourians more vulnerable to being exposed to dangerous chemicals.

"I'm very very disappointed to see this dangerous bill pass at the 11th hour," said Sen. Jill Schupp, D-Creve Coeur.

Rep. Jeff Knight, R-Lebanon sponsored the legislation in the House and lauded passage of the advanced recycling bill.

"Anytime you can reduce regulations to invite some new industries into your state, I think you're heading in the right direction," he said.

The bill began in the House with only the advanced recycling language. Advanced recycling breaks down hard-to-recycle plastics, like films and wrappers that can't be processed mechanically. The hope is to increase the dismal rate of plastic recycling — less than 10% — and ease the burden on landfills.

Read More

Missouri Independent, 13-05-22

https://missouriindependent.com/2022/05/13/missouri-legislators-weaken-regulations-for-hazardous-waste-advanced-recycling/

New Legislation on PFAS May Affect Your Fire Suppression System

2022-05-19

Over the past few decades, the fire protection industry has been affected by national/international restrictions and bans on production of the chemicals used in fire suppression systems. The first and most notable event was the Montreal Protocol in 1992 that essentially halted the production of Halon, categorized as a class 1 ozone depleting substance and the most popular clean agent of its time.

Over the past few decades, the fire protection industry has been affected by national/international restrictions and bans on production of the chemicals used in fire suppression systems.

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Halon was targeted because of its high ozone-depleting potential (ODP). The search for a Halon replacement led many manufacturers to hydrofluorocarbons (HFCs). In terms of fire suppression, HFCs provided a viable replacement to Halon without the ODP. However, HFCs were soon to be regulated by the Kyoto Protocol of 1997 on greenhouse gas emissions.

With the ongoing concern over climate change substances and materials with high global warming potential have increasingly come under scrutiny from Congress and other international governing bodies. Consequently, on December 27, 2020, Congress passed the American Innovation and Manufacturing (AIM) Act.

The AIM Act quickly curtails the production and consumption of HFCs, provides strict oversight on any remaining use of HFCs, and encourages innovation for HFC-free technologies. In terms of fire suppression agents, HFC 125 (trade name: FE-25), and HFC 227ea (trade name: FM-200) are both directly and adversely affected in terms of production, usage, and handling.

Read More

Environment + Energy Leader, 19-05-22

https://www.environmentalleader.com/2022/05/new-legislation-on-pfas-may-affect-your-fire-suppression-system/

FDA Allows Hormone-Disrupting Phthalates in Food Packaging

2022-05-19

The Food and Drug Administration (FDA) today denied petitions submitted by health and environmental advocates in 2016 to ban phthalates from food packaging and food production equipment. Studies show that these toxic petrochemicals leach into food and drinks, causing serious harm to human health. Today's decision allows for phthalate contamination of food and drinks — ranging from infant formula to meat, milk, spices, and cooking oils — to continue, despite the fact that Congress determined more than a decade ago that several of these chemicals are too dangerous to use in children's toys. At the same time, FDA acknowledged that its safety assessment for food-contact uses of phthalates is out of date and requested new information from the public.

Phthalates interfere with hormone-regulated processes in the body and are linked to a range of health harms including birth defects, infertility,

The Food and Drug Administration (FDA) today denied petitions submitted by health and environmental advocates in 2016 to ban phthalates from food packaging and food production equipment.

miscarriage, breast cancer, diabetes, and asthma. Phthalates also harm the developing brain, leading to reduced IQ and attention and behavior disorders in children. Babies and young children are most vulnerable to harm from phthalates and suffer the greatest exposure. People of color in all age groups, as well as economically insecure people, also face higher risks of serious health problems from exposure to phthalates compared to the general population. Safer substitutes for these chemicals are readily available.

Read More

Earth Justice, 19-05-22

https://earthjustice.org/news/press/2022/fda-allows-hormone-disrupting-phthalates-in-food-packaging

EPA Revamps Legal 'Toolbox' to Reach Environmental Justice Goals

2022-05-27

The EPA on Thursday unveiled a review of dozens of existing laws it can use to better protect marginalized communities from pollution—a legal "toolbox" to help the agency make good on the Biden administration's broad environmental justice efforts.

The 191-page legal tools review, which has undergone its first update since 2011, reflects statutory changes both big and small that have been made since the Environmental Protection Agency's general counsel first published the Obama-era document.

Congress hasn't passed many far-reaching environmental statutes since the last update, with one big exception: a 2016 bipartisan revamping of the Toxic Substances Control Act giving the EPA more tools to speed up the slow pace of its chemical reviews and strengthening testing authority.

The detailed survey of statutes, "EPA Legal Tools to Advance Environmental Justice," puts more of a focus on tools that environmental justice advocates argue that the agency haven't always been wielded, including civil rights laws. The roadmap also reflects EPA Administrator Michael Regan's 2021 call to all employees to find more ways to integrate environmental equity in their work as the administration pushes to make environmental justice a key platform across agencies.

The EPA on Thursday unveiled a review of dozens of existing laws it can use to better protect marginalized communities from pollution.

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While the document is primarily written for internal use, it also could assist states authorized to enforce environmental law and regulations as well as environmental justice advocacy groups and industry attorneys.

The updated toolbox showcases "a wide range of legal authorities that EPA can deploy to ensure its programs and activities protect the health and environment of all people, no matter the color of their skin, their zip code, or how much money they have in their pocket," Regan wrote in the document's introduction.

Read More

Bloomberg Law, 27-05-22

https://news.bloomberglaw.com/product-liability-and-toxics-law/epa-revamps-legal-toolbox-to-reach-environmental-justice-goals

EUROPE

GB PPP new active substance: publication of HSE conclusion

2022-05-24

Applications for the first approval of new active substances in GB are regulated under retained Regulation (EC) No 1107/2009.

Applicant: BASF Agro B.V

Substance: Cinmethylin - herbicidal active substance for controlling the growth of annual grasses and several broadleaf weed species in cereals

Conclusion: HSE's conclusion is that the active substance is expected to meet the approval criteria

The risk assessment which underpins the conclusion has been subject to public consultation and independent scientific advice from the Expert Committee on Pesticides (ECP). The input provided through these processes has been considered by HSE when finalising the conclusion on this new active substance.

Read More

HSE Pesticides eBulletin. 24-05-22

https://www.hse.gov.uk/pesticides/pesticides-registration/active-substances-new/pawbsd-aatk-0239.pdf

Applications for the first approval of new active substances in GB are regulated under retained Regulation (EC) No 1107/2009.

Chemical migration into coffee, canned vegetables, and Indian curd

2022-05-13

In an article published on April 30, 2022, in the Journal of Hazardous Materials, Roman Cariou from Oniris, Nantes, France, and co-authors investigated non-intentionally added substances (NIAS) in coatings of vegetable cans.

For their study, Cariou et al. purchased 12 cans containing different vegetables in France. They analyzed the chemicals extracted from the can coatings with acetonitrile and that migrated into the canned food using non-targeted liquid chromatography-high resolution mass spectrometry (LC-HRMS). The scientists pinpointed over 125 substances. "Oligoesters, a diverse family of unwanted compounds arising from synthesis of polyesters, prevailed in the data set." The total oligoester concentration in drained vegetables was 330 µg/kg on average. Among the identified NIAS were also diglycidyl ether derivative (BADGE, CAS 1675-54-3) derivatives as well as phenolic oligomers and benzoguanamine derivates, which have not been described previously.

The authors emphasized that their results "support the fact that oligoesters are a major NIAS family of diverse combinations to which the French population is systematically exposed when consuming canned vegetables." Therefore, they consider a "proper risk assessment" on these NIAS essential.

In an article published on April 24, 2022, in the Journal of Food Science and Technology, Krushna Chapke and co-authors from Dairy Chemistry Division, NDRI, Karnal, India, analyzed the chemicals migrating from low-density polyethylene (LDPE) in Dahi, an ancient Indian curd.

The authors acquired LDPE-based Dahi packaging materials from five different Indian producers and performed extraction and migration experiments using six different solvents as well as Dahi and food simulant as specified by the Bureau of Indian Standards (BIS, IS 9845:1998), respectively. Subsequently, they subjected the samples to gas chromatography-mass spectrometry (GC-MS) to assess chemical concentrations and identities.

Researchers investigated non-intentionally added substances (NIAS) in coatings of vegetable cans.

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Read More

Food Packaging Forum, 13-05-22

https://www.foodpackagingforum.org/news/chemical-migration-into-coffee-canned-vegetable-and-indian-curd

INTERNATIONAL

UN takes first decisions on regulation of extra-large tank containers

2022-05-24

A UN working party on the transport of dangerous goods has taken its first decisions regarding the regulation of extra-large tank containers.

The decisions – on definition, shell thickness and pressure resistant closures – offer regulatory clarity for manufacturers and users.

Extra-large tank containers were developed in 2015 by Van Hool and BASF, and first used in 2017 at BASF's site in Ludwigshafen, Germany.

The tanks come in a range of sizes with the largest measuring 15.8 metres – two and a half times a conventional container – with a capacity of 73,000 litres.

The regulations for transport of dangerous goods by road (ADR) and rail (RID) were developed assuming a maximum capacity of around 36,000 litres, leading to questions over the need for additional legal provisions for them.

At the UN Economic Commission for Europe (Unece)'s Working Party on the Transport of Dangerous Goods (WP.15) in March, it was agreed the tanks would be defined as having a volume of more than 40,000 litres.

A spokesperson for Cefic, which proposed it, said: "New definitions and regulations in the RID regulation aim to ensure that safety levels are maintained in the future. The new definitions would also offer clarity and legal certainty for investors, leasing companies, manufacturers and users to invest in or use extra-large tank containers as their new system."

A minimum thickness for the shell was also agreed at WP.15: 3mm for a conventional and 4.5mm for an extra-large tank container.

A UN working party on the transport of dangerous goods has taken its first decisions regarding the regulation of extra-large tank containers.

Read More

Chemical Watch, 24-05-22

https://chemicalwatch.com/488851/un-takes-first-decisions-on-regulation-of-extra-large-tank-containers

FCCmigex DATABASE

2022-05-27

The novel Database on Migrating and Extractable Food Contact Chemicals (FCCmigex) systematically maps the scientific evidence of food contact chemicals (FCCs) that have been measured in migrates and extracts of food contact materials and articles. It was compiled by a team of researchers from the Food Packaging Forum together with colleagues from eight academic institutions. The scientists analyzed 1,210 scientific studies that resulted from a systematic literature search and passed a two-phase screening process. In total, the database contains more than 3,000 food contact chemicals and over 22,000 database entries.

All FCCs in the database were investigated either for their presence in food contact materials, or for their propensity to transfer into food under real-world conditions, thus making human exposure to these chemicals highly probable. Importantly, only one third of FCCs that were detected in these studies were previously known to be used in the manufacture of food contact materials. And of all the materials investigated, 60% of the studies were on plastics with 1,976 different chemicals detected.

The FCCmigex database is a product of the ongoing Food Contact Chemicals and Human Health (FCCH) Project led by the Food Packaging Forum. A peer-reviewed, open-access article in the scientific journal Critical Reviews in Food Science and Nutrition provides detailed information about the compilation of the database and summarizes some of the key information. All data are accessible via the interactive tool below.

Background

Food packaging and other food contact articles, such as processing equipment and kitchen utensils, can release chemicals into food. This process of chemical migration causes chronic human exposure to chemicals and can lead to adverse health effects. Until now, human exposure assessment for food contact chemicals (FCCs) has primarily focused on a few dozen chemicals of concern, such as bisphenols, phthalates, mineral oil hydrocarbons, and heavy metals. However, thousands of FCCs are intentionally added during the manufacture of food

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contact materials and articles and even more FCCs may be present in the final articles.

Search the FCCmigex Database

The freely available, interactive tool below allows you to use the FCCmigex database in an easily accessible and searchable way. We recommend using the Chrome, Brave, or Edge web browsers when using the tool. The Mozilla Firefox browser sometimes results in display errors.

Read More

Food Packaging Forum, 27-05-22

https://www.foodpackagingforum.org/fccmigex

A systematic evidence map to explore migrating and extractable food contact chemicals

New advice for using read-across

2022-05-06

ECHA's advice helps companies create robust and complete read-across adaptations for their substances, including those of unknown or variable composition, complex reaction products or biological materials (UVCBs). It covers changes to the REACH annexes that started to apply in January 2022.

Helsinki, 6 May 2022 – Companies are required to adequately justify and document the use of grouping and read-across in their registrations. They need to include robust study summaries for each study performed on a source substance which is used to provide information for the target substance. Their registrations also need to contain justifications and evidence for the read-across hypothesis.

The changes to the REACH annexes clarify the need for companies to give information on their substance compositions to demonstrate structural similarity. Establishing structural similarity is a prerequisite for performing grouping and read-across. For UVCBs, this is done based on the information that companies provide on the composition of their substances.

Companies also need to explain if the possible differences between the structures of the source and target substances have an impact on the prediction of hazardous properties. If the identification of all constituents is not technically possible or it is impractical, companies need to demonstrate structural similarity by other means and justify it.

Our Guidance on Information Requirements and Chemical Safety Assessment – Chapter R.6 is also being revised to reflect the changes. It is expected to be published later in 2022

Read More

ECHA, 6-05-22

https://echa.europa.eu/-/new-advice-for-using-read-across

SME registrants: check your company size

2022-05-04

If your company is micro, small or medium-sized, check that the company size you have claimed when registering your substance is correct and inform ECHA if you realise that the size was declared incorrectly. This can

ECHA's advice helps companies create robust and complete read-across adaptations for their substances.

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help you save up to EUR 19 900. Remember to also upload the required documents supporting your claim in REACH-IT.

Helsinki, 4 May 2022 - If you notice you have reported your company size incorrectly, inform us at:

sme-verification(at)echa.europa.eu by 31 May 2022.

We are continually initiating new verifications on the size of companies who have declared they are an SME at the time of their REACH registration.

By declaring and correcting your company size before we begin verifying it, you will not have to pay the administrative charge, but only the difference to the correct registration fee.

If we learn only after the verification process has started that you have claimed your size incorrectly, you will have to pay the difference to the correct fee and an administrative charge of up to EUR 19 900.

Help to determine and declare your company size correctly is available on our website.

We recommend regularly checking your REACH-IT accounts for any new messages and tasks and keeping your registrations and contact details up to date.

Read More

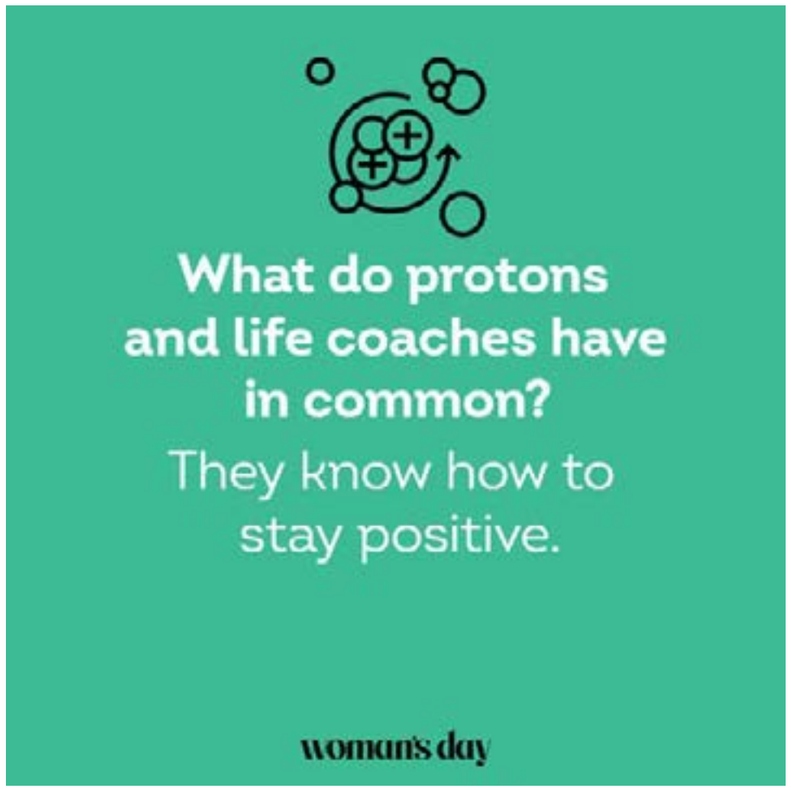
ECHA, 4-05-22

https://echa.europa.eu/pt/-/sme-registrants-check-your-company-size

If your company is micro, small or medium-sized, check that the company size you have claimed when registering your substance is correct.

Protons and Life Coaches

2022-06-03



https://www.womansday.com/life/a40024798/funny-science-jokes/

Selenium

2022-06-03

Selenium is a chemical element with symbol Se and atomic number 34.[1]

It is an odourless metalloid (an element which has both metallic and non-metallic properties). It can be a grey (the 'metallic' and most stable form), red or black solid. [2]

In nature selenium is usually combined with sulphide minerals or with silver, copper, lead, and nickel. [3]

USES [4]

Selenium has good photovoltaic and photoconductive properties, and it is used extensively in electronics, such as photocells, light metres and solar cells. The second largest use of selenium is in the glass industry: selenium is used to remove colour from glass, to give a red colour to glasses and enamels. The third main use is sodium selenite for animal feeds and food supplements. In addition, selenium can find applications in photocopying, in the toning of photographs. Its artistic use is to intensify and extend the tonal range of black and white photographic images. Other uses of selenium are in metal alloys such as the lead plates used in storage batteries and in rectifiers to convert AC current in DC current. Selenium is used to improve the abrasion resistance in vulcanised rubbers. Some selenium compounds are added to anti-dandruff shampoos.

SOURCES & ROUTES OF EXPOSURE

Sources of Exposure [4]

Selenium exposure takes place either through food or water, or through contact with soil or air that contains high concentrations of selenium. The exposure to selenium mainly takes place through food, because selenium is naturally present in grains, cereals and meat. Humans need to absorb certain amounts of selenium daily, in order to maintain good health. Food usually contains enough selenium to prevent disease caused by shortages. Selenium uptake through food may be higher than usual in many cases, because in the past many selenium-rich fertilisers have been applied on farmland. In addition, people that live near hazardous waste-sites will experience a higher exposure through soil and air. Selenium from hazardous waste-sites and from farmland will end up in groundwater or surface water through irrigation. This phenomenon causes selenium to end up in local drinking water, so that exposure to selenium through

Selenium is a chemical element with symbol Se and atomic number 34.[1]

water will be temporarily increased. People that work in metal industries, selenium-recovery industries and paint industries also tend to experience a higher selenium exposure, mainly through breathing. Selenium is released to air through coal and oil combustion. People that eat a lot of grains that grow near industrial sites may experience a higher exposure to selenium through food. Exposure to selenium through drinking water may be increased when selenium from hazardous waste disposals ends up in water wells. Exposure to selenium through air usually only occurs in the workplace.

Routes of Exposure [3]

- Inhalation (breathing) – Not a significant route of exposure for the general population, but is the primary route of exposure for selenium workers.
- Ingestion– Primary route of exposure for the general population via consumption of food.
- Dermal – Not a significant route of exposure to selenium.

HEALTH EFFECTS [5]

Acute Effects

Acute exposure of humans via inhalation to selenium compounds (selenium dioxide, hydrogen selenide) results primarily in respiratory effects. Acute inhalation exposure to elemental selenium dust results in irritation of the mucous membranes in the nose and throat, producing coughing, nosebleeds, dyspnea, bronchial spasms, bronchitis, and chemical pneumonia. Gastrointestinal effects including vomiting and nausea; cardiovascular effects; neurological effects such as headaches and malaise; and irritation of the eyes were reported in humans acutely exposed to selenium compounds via inhalation. Acute human exposure to selenium compounds via the oral route has resulted in pulmonary oedema and lesions of the lung; cardiovascular effects such as tachycardia; gastrointestinal effects including nausea, vomiting, diarrhoea, and abdominal pain; effects on the liver; and neurological effects such as aches, irritability, chills, and tremors. "Blind staggers" disease is a disease in livestock that results from acute consumption of plants high in selenium. It is characterised by impaired vision, aimless wandering behaviour, reduced consumption of food and water, and paralysis. Acute animal tests in rats, mice, and guinea pigs, have shown hydrogen selenide to have extreme toxicity from inhalation exposure, sodium selenite to have extreme toxicity

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from oral exposure, and elemental selenium to have low toxicity from oral exposure.

Chronic Effects

No information is available on the chronic effects of selenium in humans from inhalation exposure. In epidemiological studies of populations exposed to high levels of selenium in food and water, discoloration of the skin, pathological deformation and loss of nails, loss of hair, excessive tooth decay and discoloration, garlic odour in breath and urine, lack of mental alertness, and listlessness were reported. "Alkali disease" is a disease in livestock resulting from chronic consumption of high levels of selenium; it is characterised by hair loss, deformation and sloughing of the hooves, erosion of the joints of the bones, anaemia, and effects on the heart, kidney, and liver. EPA has not established a Reference Concentration (RfC) for selenium. The Reference Dose (RfD) for selenium is 0.005 milligrams per kilogram body weight per day (mg/kg/d) based on clinical selenosis in humans.

Selenium Deficiencies

Two diseases, "Keshan disease" and "Kashin-Beck disease" have been reported in humans in selenium-deficient populations in China. Keshan disease is characterised by heart failure, cardiac enlargement, abnormalities of EKG, and cardiogenic shock. Kashin-Beck disease, which occurs primarily in children between the ages of 5 and 13 years, is characterised by atrophy, degeneration, and necrosis of cartilage tissue. Some epidemiological studies have suggested that selenium deficiency may contribute to cardiovascular disease in humans. However, these studies are inconclusive due to confounding factors.

Reproductive/Developmental Effects

No information is available on the developmental or reproductive effects of selenium in humans. The consumption of high levels of selenium in the diet by pigs, sheep, and cattle has been shown to interfere with normal foetal development and to produce foetal malformations. Sodium selenate, administered in the drinking water to mice, did not result in birth defects, but did result in an increased incidence of foetal deaths and a high proportion of runts, while chronic exposure of mice to selenium in the diet has been shown to affect their fertility and to reduce the viability of the offspring of pairs that are able to breed.

Cancer Risk

In one study of workers exposed to selenium (form not specified) over a 26-year period, no statistically significant increase in cancer deaths was reported. Human studies have reported that patients with cancer, particularly gastrointestinal cancer, prostate cancer, or Hodgkin's lymphoma, had significantly lower selenium levels in the blood than healthy patients. Epidemiological studies that used the selenium concentration in crops as an indicator of dietary selenium have generally reported an inverse association between selenium levels and cancer occurrence. Animal studies have reported that selenium supplementation, as sodium selenate, sodium selenite, and organic forms of selenium, results in a reduced incidence of several tumour types. The only selenium compound that has been shown to be carcinogenic in animals is selenium sulphide, which resulted in an increase in liver tumours in rats and mice and lung tumours in female mice from oral exposure. Selenium sulphide is a pharmaceutical compound used in anti-dandruff shampoos and is very different than the inorganic or organic selenium compounds found in foods and the environment. EPA has classified elemental selenium as a Group D, not classifiable as to human carcinogenicity, and selenium sulphide as a Group B2, probable human carcinogen.

SAFETY [6]

First Aid Measures

- Eye Contact: Check for and remove any contact lenses. Do not use an eye ointment. Seek medical attention.
- Skin Contact: After contact with skin, wash immediately with plenty of water. Gently and thoroughly wash the contaminated skin with running water and non-abrasive soap. Be particularly careful to clean folds, crevices, creases and groin. Cover the irritated skin with an emollient. If irritation persists, seek medical attention. Wash contaminated clothing before reusing.
- Inhalation: Allow the victim to rest in a well-ventilated area. Seek immediate medical attention.
- Serious Inhalation: Evacuate the victim to a safe area as soon as possible. Loosen tight clothing such as a collar, tie, belt or waistband. If breathing is difficult, administer oxygen. If the victim is not breathing, perform mouth-to-mouth resuscitation. Seek medical attention.

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- Ingestion: Do not induce vomiting. Loosen tight clothing such as a collar, tie, belt or waistband. If the victim is not breathing, perform mouth-to-mouth resuscitation. Seek immediate medical attention.

Exposure Controls & Personal Protection

Engineering Controls

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

Personal Protective Equipment

The recommended personal protective equipment includes:

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

Personal Protection in Case of a Large Spill:

- Splash goggles;
- Full suit;
- Dust respirator;
- Boots;
- Gloves;
- A self-contained breathing apparatus should be used to avoid inhalation of the product.
- Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

REGULATION [2,6,7]

United States

- EPA Office of Drinking Water regulates the amount of selenium allowed in drinking water. Public water supplies are not allowed to exceed 50 ppb total selenium.
- FDA regulations allow a level of 50 ppb of selenium in bottled water.

- OSHA exposure limit for selenium compounds in the air for an 8-hour period is 0.2 mg selenium/m3.

Australia

- Australian Drinking Water Guidelines (NHMRC and ARMCANZ, 1996): Maximum of 0.01 mg/L
- Worksafe Australia has set the exposure standard for selenium compounds (excluding selenium hydride) to 0.2 milligram/m3 (TWA, as selenium). The exposure standard for selenium hydride and selenium hexafluoride is 0.05 ppm or 0.16 milligram/m3 (TWA, as selenium). Selenium and selenium compounds are classified as toxic by inhalation and if swallowed.

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Climate change means people are losing 44 hours of sleep per year

2022-05-20

Eco-anxiety is already causing people to lose sleep over climate change. Now, a global study has found that a warming planet is also affecting how long people sleep, and the problem will get significantly worse this century even if humanity manages to rein in its carbon emissions.

Our measurements of the impact of above-average night temperatures on sleep have previously been limited by being confined to single countries, lab studies or notoriously unreliable self-reporting of sleep.

To glean a better real-world picture, Kelton Minor at the University of Copenhagen, Denmark, took data from sleep-tracking wristbands used by 48,000 people in 68 countries between 2015 and 2017.

He and his colleagues then paired the sleep data with local weather data, revealing that unusually hot nights are causing people to fall asleep later, rise earlier and sleep less. Already, the evidence suggests that people are losing an average of 44 hours of sleep each year. By 2100, the researchers estimate people will lose 58 hours of sleep a year if emissions go unchecked. In a lower-emissions future, the figure drops to 50 hours.

Unusually hot nights are causing people to fall asleep later, rise earlier and sleep less

Minor and his team measured the level of sleep loss on unusually hot nights by comparing the data with a baseline of how much an individual sleeps normally. They also controlled for alternative possible explanations for sleep erosion, such as the weather and the season.

"This is the first planetary-scale evidence that warmer-than-average temperatures erode human sleep. We show that sleep erosion occurs primarily by delaying when people fall asleep," says Minor.

Some groups are hit worse than others. Above-average heat at night had a larger impact on sleep loss for people in lower-income countries, women and older people. For those aged 65 and older, the effect on sleep of a 1°C increase in the minimum overnight temperature was at least twice that of younger age groups.

The researchers found that people failed to change their daily behaviour to cope with the lack of sleep, such as by taking a nap. People also failed to adapt across a season – for instance, by finding it easier to sleep on a warm night at the end of summer than on a warm night early in summer. "We don't find evidence that people are adapting well," says Minor.

It is possible that some of those living in higher-income countries are more likely to install air conditioning, which could be seen as a form of adaptation, but Minor says the findings in the study don't allow him to make this link definitively. Moreover, air conditioning's cost makes it out of reach for many and it can drive up emissions due to fossil fuel energy use.

Susan Clayton at the College of Wooster, Ohio, says the study's methodology is sound and includes a "very thorough" examination of other explanations. "The implications are clear: higher temperatures associated with climate change are already reducing the amount of sleep people get and are projected to do so even more. Since we know that lack of sleep can negatively impact mood, behaviour, health and cognitive functioning, this is concerning," she says.

Ivana Rosenzweig at King's College London says the study showcases the power of big data and aligns with previous work showing the colder it is, the better people sleep. But she points out: "The measured effect is small, mere minutes of sleep per night, or less than 3 per cent of total sleep time."

However, Minor says the type of person who chooses to wear a sleep-tracker may also be more likely to have access to other technologies that can curb the effect of hot nights on their sleep. For that reason, he says the team's estimates of climate change's impact on sleep are likely to be on the low side.

New Scienctist, 2 May 2022

https://www.newscientist

These dolphins might be self-medicating

2022-05-19

We're not the only creatures who pop a pill or slather on an ointment when we're ill or itchy. Chimpanzees swallow rough leaves to rid their intestines of parasites, for example, and some ants eat foods rich in hydrogen peroxide to expel fungal infections. Now, scientists might be adding dolphins to the list. Researchers have discovered that bottlenose dolphins in the Red Sea rub against corals and sponges that have medicinal properties, possibly to ward off pathogens that cause skin diseases.

"This is very valuable work," says Michael Huffman, a primatologist and expert on animal self-medication at Kyoto University who wasn't involved with the research. "I've long awaited a really solid study of self-medication in a marine animal species."

Animals rub against antibacterial corals and sponges, possibly to ward off skin infections

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Huffman has studied primate self-medication since the 1980s. He also collects information on instances of the phenomenon across the animal kingdom. But he says such behavior has been tough to study in the ocean because of the logistical challenges of observing animals at sea.

Enter Angela Ziltener, a wildlife biologist with the University of Zürich and the conservation nonprofit Dolphin Watch Alliance. Since 2009, Ziltener has scuba dived in Egypt's Red Sea among a population of 360 Indo-Pacific bottlenose dolphins (Tursiops aduncus), gaining their trust and observing their behavior up close.

Over the years, she noticed the animals rubbing up against certain corals and sponges. The behavior wasn't random: The dolphins rubbed their heads on some corals, scraped their bellies on others, and avoided some species altogether (see video, above). Adult dolphins would queue up to rub, whereas the younger members of the group watched closely and slowly began to mimic their actions.

It seemed like the dolphins were getting more than just a good back scratch, Ziltener says. Not only were they selecting specific corals, but as they rubbed, mucus coatings puffed off the corals and sponges, clouding the water and coloring the dolphins' skin. "They'd get yellowish or greenish," Ziltener says.

She thought the mucus might feel good or even help heal skin ailments. Past studies have shown dolphins are vulnerable to infections of poxvirus, which causes ringlike lesions on the skin, and fungal diseases such as lobomycosis, which causes cystlike nodules.

To find out whether coatings from the corals' mucus had medicinal properties, Ziltener teamed up with Gertrud Morlock, an analytical chemist at Justus Liebig University Giessen. The duo took tiny samples of mucus from the dolphins' three preferred rubbing surfaces: gorgonian coral (Rumphella aggregata), leather coral (Sarcophyton sp.), and a sponge (Ircinia sp.).

The researchers put the samples on ice and brought them to Morlock's lab, where they used a technique called high-performance thin-layer chromatography to analyze the mucus' chemical makeup. Similar to how black ink drawn on thin paper bleeds into many colored pigments when moistened with water, the coral mixtures could be separated out into their component parts when applied with chemicals to a special silica plate.

After separating the mucus into its component chemicals, the scientists tested those parts for 10 types of molecules that might have healing or medicinal activities. The corals and sponge coatings contained 17 different biologically active compounds that had antibacterial, antioxidative, or hormonal properties. Those chemicals could potentially treat skin conditions, the team reports today in iScience.

Showing the mucus has healing properties is a good first step, says Eric Angel Ramos, a marine biologist at Rockefeller University who wasn't involved with the work. To prove that the animals are truly self-medicating, however, "I'd want to see what kind of skin ailments these dolphins are experiencing, and if these corals actually improve their health," he says.

In his own studies, Ramos has seen bottlenose dolphins in Belize rub against certain corals, too. In light of the new findings, "I want to look back at my own observations," he says. The animals he's observed could be self-medicating, or they might just like the way the corals feel. "Dolphins love to touch and play with things," Ramos says. "They're like babies that way."

Science, 19 May 2022

https://science.org

Galaxies without dark matter perplex astronomers

2022-05-19

Astronomers think that galaxies cannot form without the gravitational pull of dark matter. So a trail of galaxies free of this mysterious material, with no obvious cause, would be a remarkable find. In a paper published in Nature on 18 May1, astronomers say they might have observed such a system — a line of 11 galaxies that don't contain any dark matter, which could all have been created in the same ancient collision. But many of their peers are unconvinced that the claim is much more than a hypothesis.

This kind of system could be used to learn about how galaxies form, and about the nature of dark matter itself. "If proven right, this could certainly be exciting for galaxy formation. However, the jury is still out," says Chervin Laporte, an astronomer at the University of Barcelona in Spain.

The finding centres on two galaxies described by Pieter van Dokkum at Yale University in New Haven, Connecticut, and his co-authors in 2018 and 2019. Their stars moved so slowly that the pull of dark matter was not needed to explain their orbits, so the team concluded that the galaxies contained no dark matter. The finding was controversial because the galaxies, named DF2 and DF4, seemed stable and different from the only

Researchers say a cosmic collision could have created two galaxies that don't contain the mysterious substance — but others cast doubt on the claim.

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other known dark-matter-free galaxies, which are new and short-lived, created in the arms of larger galaxies whose dark matter is being stripped by a neighbour. How DF2 and DF4 formed was a mystery.

Telltale trail

In the latest paper, van Dokkum's team not only connects the two unusual galaxies, but says their properties are consistent with them being formed in a high-speed collision, eight billion years ago, that also spawned more such structures. "This single explanation explains so many odd things about these galaxies," says van Dokkum.

The team borrowed its scenario from simulations originally created to explain unique features in larger-scale collisions between galaxy clusters. The researchers suggest that when two progenitor galaxies collided head on, their dark matter and stars would have sailed past each other; the dark matter would not have interacted, and the stars would have been too far apart to collide. But as the dark matter and stars sped on, gas in the space between the two galaxies' stars would have crashed together, compacted and slowed down, leaving a trail of matter that later formed new galaxies with no dark matter.

Next, the researchers looked for such galaxies in the line between DF2 and DF4. They identified between three and seven new candidates for dark-matter-free galaxies, as well as strange, faint galaxies at either end, which could be the dark matter and stars remaining from the progenitor galaxies. "It was staring you in the face once you knew what to look for," says van Dokkum.

If this picture proves to be true, it could help astronomers to understand how dark matter behaves, and to learn about the circumstances under which galaxies can form. Such a galactic collision might also be used as a "new laboratory" to understand whether dark matter interacts with itself, says Go Ogiya, an astronomer at Zhejiang University in Hangzhou, China.

Open questions

Although plausible, van Dokkum's model describes just one of a number of ways that these galaxies could have been made, says Priyamvada Natarajan, an astrophysicist at Yale who is not a member of van Dokkum's team. But it is intriguing and, crucially, makes testable predictions, she says.

Measurements of the precise distances and velocities of candidate galaxies could prove they are part of the same string and not just coincidentally

along the same line of sight, says Michelle Collins, an astronomer at the University of Surrey in Guildford, UK. "For me, whether this is a real line or not is a big open question."

Astronomers also need to measure the masses of the ghost galaxies at the ends of the line — the potential progenitor galaxies — to test whether they contain lots of dark matter, as the model predicts, adds Laporte.

Others question whether any exotic explanation is needed. Ignacio Trujillo, an astronomer at the Institute of Astrophysics of the Canary Islands in La Laguna, Spain, leads a team that proposes that DF2 and DF4 are closer to Earth than van Dokkum's measurements suggest, and therefore contain more dark matter than was at first apparent.

Astronomers also need to see a reliable simulation showing that the scenario van Dokkum's team describes is plausible, says Mireia Montes, an astronomer at the Space Telescope Science Institute in Baltimore, Maryland. "For now, there are a lot of assumptions, but those are not supported by any simulation," she says.

Nature, 19 May 2022

https://nature.com

PFAS chemicals do not last forever

2022-05-20

Once dubbed "forever chemicals," per-and polyfluoroalkyl substances, or PFAS, might be in the market for a new nickname.

That's because adding iodide to a water treatment reactor that uses ultraviolet (UV) light and sulfite destroys up to 90% of carbon-fluorine atoms in PFAS forever chemicals in just a few hours, reports a new study led by environmental engineering researchers at UC Riverside. The addition of iodide accelerates the speed of the reaction up to four times, saving energy and chemicals.

"Iodide is really doing some substantial work," said corresponding author Jinyong Liu, an assistant professor of chemical and environmental engineering. "Not only does it speed up the reaction but it also allows the treatment of a ten times higher concentrations of PFAS, even some very recalcitrant structures."

Liu's lab has been working on ways to destroy PFAS through photochemical reactions since 2017. The new method has already

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attracted interest from industry and Liu's group is partnering with companies to conduct pilot tests.

Synthetic chemicals known as PFAS contain multiple very strong carbon-fluorine bonds. Widespread use of these nonbiodegradable compounds in countless products since the 1940s has contaminated water supplies across America, with various negative health effects on human and animals. Because the carbon-fluorine bond is very hard to break, PFAS pass through most water treatment systems unchanged.

Photochemical degradation by UV light and sulfite (SO32–) is, to date, one the most effective ways to break PFAS down. The original process used a lot of electricity because the chemical reactions occurred slowly. It also left multiple carbon-fluorine bonds remaining in the degradation products, with unknown health effects.

Last year, the researchers reported that oxidation treatments before and after the UV/sulfite treatment can achieve almost 100% destruction of carbon-fluorine bonds in various major PFAS pollutants.

In the new work, the researchers added iodide to the UV/sulfite system to treat a particularly stubborn four-carbon PFAS molecule called perfluorobutane sulfonate (PFBS), which degrades poorly in the original UV/sulfite setting. The iodide accelerated the reaction and completely removed PFBS within 24 hours.

As expected, the UV/sulfite+iodide system also degraded other PFAS, such as the frequently reported eight-carbon PFOA and PFOS, with ease. The addition of iodide also enabled the system to destroy concentrated PFAS in brine solution, which is a practical challenge for groundwater remediation. Ion-exchange systems are used to clean the groundwater, but the PFAS chemicals captured in the resin need to be washed out and destroyed in a cost-effective way.

The paper, "Accelerated degradation of perfluorosulfonates and perfluorocarboxylates by UV/sulfite + iodide: reaction mechanisms and system efficiencies," is published in Environmental Science & Technology.

Phys Org, 20 May 2022

https://phys.org

Simple Gene Circuits Hint at How Stem Cells Find New Identities

2022-05-19

The human body contains more than 200 types of cells by most estimates, all descended from a single fertilized egg. The spindly cells of the skin, the gangly branching neurons, the plump fat cells, the exquisitely sensitive rods and cones of the eye — all of these are products of a long process of development, during which their physical forms altered beyond recognition. With few exceptions, however, all these cells carry the same genes as that fertilized egg. The only thing that changes from cell to cell is which genes are active.

But how do genetically identical cells get shunted into different identities? What happens at the molecular level to turn stem cells into skin cells, and why do they stay that way instead of morphing into muscle or fat?

Researchers have struggled to answer such questions, which are relevant to the development of all complex organisms, whether they are mustard plants, centipedes or blue whales. Early attempts at genetic models always lacked important aspects of what biologists saw in nature — not least a simplicity that would allow them to scale up to define multitudes of cell fates.

Now, a group of biologists at the California Institute of Technology with backgrounds in physics have reported in Science that they have devised a simple network of genes that gives rise to surprisingly complex, lifelike behaviors. It could represent an important advance in understanding how nature tells cells to differentiate.

By introducing a small number of engineered genes into cells and applying the right chemical cues, the researchers were able to direct the cells into seven different stable states, each distinguishable under the microscope by a different glowing color. The cells exhibited key properties associated with differentiated cells; for example, they were stably committed to being one type of cell, but they also exhibited a "memory" of their previous activity that affected their responses to new circumstances.

Mathematical models suggest that with just a few more genes, it might be possible to define hundreds of cellular identities, more than enough to populate the tissues of complex organisms. It's a finding that opens the door to experiments that could bring us closer to understanding how, eons ago, the system that builds us was built.

By introducing a small number of engineered genes into cells and applying the right chemical cues, the researchers were able to direct the cells into seven different stable states.

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The Limits of Mutual Repression

Developmental biologists have illuminated many tipping points and chemical signals that prompt cells to follow one developmental pathway or another by studying natural cells. But researchers in the field of synthetic biology often take another approach, explained Michael Elowitz, a professor of biology and bioengineering at Caltech and an author of the new paper: They build a system of cell-fate control from scratch to see what it can tell us about what such systems require.

More than 20 years ago, researchers at Boston University led by James Collins took a major step in that direction. In a Nature paper, they described an artificial cell control circuit they had inserted into Escherichia coli bacteria. The circuit could flip the cells between two states. The engineered cells glowed green as long as a gene that repressed production of the fluorescent pigment was turned off. However, if the scientists added one chemical to the cell's culture solution, the repressor gene was activated and the color disappeared. A dose of another chemical reversed the process by forcing a second repressor into action, bringing the green back.

These two states were stable: Until a chemical was added to trigger a change, a cell remained either glowing or dark. This stability recalled the behavior of cells in nature whose fates are permanently set by chemical commands issued during development. The key to the control system was that the two repressors repressed each other — when one was ascendant, the other was dormant.

This kind of mutual repression has been central to most cell control systems that biologists have devised since Collins' experiment. An elegant example is a system designed by Xiao Wang, an associate professor of biomedical engineering at Arizona State University, and his colleagues, presented in a 2017 paper. Using two mutually repressing transcription factors and two genes that activated themselves, they created a system capable of putting E. coli into four different states.

Mutual repression, however, can be complex to scale up. You can generate additional stable states by adding more genes, but each gene must then inhibit all of the others. Such an approach seemed cumbersome even for ambitious synthetic biology experiments, and nature clearly couldn't rely on such a brittle system to direct the development of cells in organisms.

Flexible, Adaptable and Robust

When Elowitz discussed this problem with Ronghui Zhu, a graduate student in his lab, they wondered whether there could be a simpler way to scale up. "A fundamental property of the natural system is that it is scalable. That was, I think, a key insight," said Elowitz. "You need a design that [doesn't require] that every time you add something, you have to reengineer everything that's already been put in."

They looked for a solution in nature, where transcription factor proteins have been seen binding together in pairs, or dimers. A transcription factor will sometimes bind to a copy of itself, and sometimes to a completely different factor. What it's bound to can radically alter a factor's abilities, allowing it to activate new genes or turning it off entirely. The permutations of these pairings form a network of possible states for a cell.

So Elowitz and Zhu worked out the math describing a system in which pairs of transcription factors inhibiting and promoting each other could control cell state. In their new system, each gene produces a transcription factor protein; these proteins bind together as dimers to exert an effect. If two copies of the same factor bind together, the resulting "homodimer" stimulates further protein production by the gene — a positive feedback loop. If a factor binds to a different factor to form a "heterodimer," however, the transcription factor is inactive.

What's clever about this arrangement is that once the activity or inactivity of a transcription factor gene is set, it tends to stay that way. The precise amounts of different dimer combinations can be fine-tuned to produce any desired pattern of gene activity. Significant environmental changes that affect the stability of the transcription factors can flip a cell from one state to another, but random small changes are shrugged off. This makes the control system flexible, adaptable and robust.

Much later, Elowitz, Zhu and their team decided to see whether they could actually build it in mammalian cells, a change from other labs' systems that were mainly built in E. coli. Drawing on a toolbox of transcription factor components assembled by their colleagues, they designed two that were active as homodimers but inactive as heterodimers. The model suggested that a control system built around these could put cells into three distinct states: one in which only the first gene was active, one in which only the second gene was active, and one in which both were active. Which state predominated would depend on the stability of the factor proteins and how likely they were to bind to each other. "The design gives you both combinatorial control and also enables one state to repress the other states," said Zhu.

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Of course, modeling is one thing; making something work in a living cell is another. "If you do a lot of mathematical modeling of biology, you always know that the models are a very rough approximation to what is going on in many cases, and it's often challenging to make them predictive," said Elowitz. The team was surprised, then, when Zhu introduced the genes for the initial test into hamster cells and the cells obediently morphed into a painterly pattern of green, red and yellow. The system, which they named MultiFate, seemed to work.

To see if it would scale as the model predicted, they added a third transcription factor, which brought the expected number of states up to seven. The cells obligingly developed a kaleidoscope of seven hues. If they were left undisturbed, the states persisted for over a month, echoing the stability of a natural system.

The researchers also observed how the cells responded to change. By altering the concentration of a chemical in the cells' environment, they could destabilize the transcription factor proteins; as predicted, this caused the cells to move between states. Intriguingly, though, the responses of the engineered cells were shaped in part by their histories. They switched states when the concentration of the chemical agent went from high to low — but when the concentration was raised again, they didn't just revert.

This behavioral asymmetry has a parallel in nature, where cells that live through a time of scarcity, for instance, may stay in a permanent state of hoarding energy. Resetting the environment doesn't wipe away the cell's experience.

Walking Through the Cellular Landscape

"It's extremely clever," said Ahmad Khalil, a professor at Boston University who co-authored a commentary about the Elowitz and Zhu paper for Science. "[It] demonstrates how you can walk through this landscape — reshape this landscape — of different states by just increasing or decreasing protein stability."

That's a profound accomplishment, because whatever process led to the seething complexity of enormous multicellular organisms today must have started off quite simple, and it very likely relied on something basic and mutable like protein stability. The system that Elowitz and Zhu described suggests that principles like these would have been sufficient to generate the great variety we see in nature.

Wang, who developed the E. coli system with four stable states, thinks it's telling that the researchers' modeling drew on nonlinear dynamics, a branch of mathematics that deals with systems that often have complex, surprising outcomes. "The whole gene regulation network is a nonlinear network," he said. And while nonlinearity can often lead to chaos, in biology it typically does not. "So there must be something else in there, some deep, deep principles and rules to make the thing so complex but also so robust."

"Theoretically, if you have a master network of eight transcription factors, you have the core machinery to have all the possibilities to form a human body," Wang added. Indeed, Elowitz and Zhu wrote in their MultiFate paper that with just 11 transcription factors, it should be possible to produce more than 1,000 steady states.

"On paper it's very scalable," Wang said. "But when you scale up, it needs to be cautious. In biology there is so much that's unknown. We might see something we don't expect."

Going forward, Khalil speculated, researchers could hope to use the MultiFate system to control real aspects of a cell's growth and change, and not just its color. Perhaps cells introduced into patients could be engineered to respond to their environment by following desirable developmental paths. If they sensed cancer, for example, they might develop in a diagnostically or therapeutically useful way. "It's a very cool notion," he said.

For Elowitz, the system is a doorway into understanding the teeming weirdness of biology as more than just a Rube Goldberg machine. The artist's whimsical contraptions, which performed simple tasks with the maximum number of steps, were "the perfect embodiment of the unevolvable design," he said — of something that does what it's meant to do but nothing else.

"Natural systems … may look like that superficially because we don't fully understand what's going on," he said. "Once we understand the right way to look at it, we can hopefully appreciate it as a simple design."

Quanta Magazine, 19 May 2022

https://quantamagazine.org

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Home testing for syphilis gains support in wake of COVID

2022-05-19

Global cases of sexually transmitted infections (STIs) have been on the rise in some countries. Even the COVID-19 pandemic — which locked down life in many ways — hasn't halted the trend. In April, the US Centers for Disease Control and Prevention reported that the first year of the pandemic saw 133,945 cases of syphilis, a 52% increase since 2016 (see 'Resurgence').

And this is probably an underestimate, the CDC says, given that health-care clinics had to limit in-person visits at the start of the pandemic, and STI surveillance programmes found their resources shifted elsewhere. The situation sparked a push for at-home tests for syphilis and other STIs.

Encouraged by the popularity of at-home tests for COVID-19, self-testing has been embraced by many, including policymakers and people in marginalized populations. In January, a California law went into effect that requires private health insurers to cover the cost of at-home STI testing. Supporters say that self-testing has the benefit of allowing individuals to collect samples in the privacy of their homes, free from any stigma that might be associated with attending clinics, and that it allows people from all backgrounds and income levels to test frequently.

With cases of sexually transmitted infections growing, researchers hope self-tests — made popular by the pandemic — could stem the tide.

But the shift could also have trade-offs — some of them similar to those experienced for COVID-19, cautions Shweta Patel, a gynaecologist at the University of Alabama at Birmingham. With at-home tests, people do not receive the counselling that comes with in-person testing, and public-health departments might lose valuable statistics. Users must report their own results, and perform their own contact tracing to inform others that they might be in need of testing, Patel says, and this doesn't always happen.

Still, during the pandemic, self-testing for COVID-19 proved to be useful, says Natalie Cramer, deputy executive director of programmes at the National Alliance of State and Territorial AIDS Directors in Washington DC. She adds that it's past time for a similar approach to be taken for STIs including syphilis and HIV. "I think we've all become more comfortable self-testing with COVID," Cramer says. "It's opened up both a need and a comfort level that folks have around it."

Anatomy of a pathogen

For around half a millennium, syphilis has been one of the most widely recognized — and feared — STIs. It spurred the development of the first drug dubbed a magic bullet (salvarsan, an arsenic-based compound, in 1910) and, since the advent of penicillin three decades later, has largely been considered curable. With proper condom use, disease transmission can be reduced to near zero. Left untreated, however, the disease can prove deadly, causing severe neurological issues, especially if transmitted at or before birth.

Detecting the disease, which is caused by the corkscrew-shaped bacterium Treponema pallidum, is easy enough, says Deborah Williamson, a microbiologist at the University of Melbourne in Australia, who has spent several decades studying syphilis. At a clinic, a health-care worker usually takes a blood sample and runs an assay to look for antibodies against the bacterial family that includes T. pallidum. If this assay is positive, the clinician runs further tests on the original sample to zero in on a diagnosis.

Only a small subset of tests, which require swabs of open sores or other regions of the body, actually look for the bacterium itself, whether searching for it under a microscope or identifying bits of its DNA or protein. Regardless of the method, however, if a person tests positive, treatment requires a physician's prescription, Patel says.

Testing goes DIY

When the COVID-19 pandemic arrived, clinic-based testing around the world took a hit. For instance, as rates of SARS-CoV-2 infection soared in New York City in the second quarter of 2020, STI testing sharply declined. Clinics restricted visits, and people hesitated to see physicians in spaces where they might contract COVID-19. STI transmission began to rise. Although necessary, these changes "created a perfect storm", says Jennifer Mahn, director of clinical and sexual health at the National Coalition of STD Directors in Washington DC.

But the pandemic also spawned a boom in at-home testing. Governments began promoting at-home COVID-19 testing as a way for people to check whether they might be contagious before travelling or socializing. A variety of studies showed that frequent self-testing, even with rapid antigen tests that could detect infections only when viral load was high, could aid the public-health response1,2. The move also made physicians, researchers and the public more comfortable about the accuracy and utility of home-testing kits in general.

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Proponents hope that the popularity of at-home COVID-19 testing will boost the use of and demand for at-home STI tests. Research shows that these could be popular. For instance, a study of men who have sex with men in Zimbabwe, first published in April 20213, showed that the participants were eager to self-test for syphilis.

At-home kits would go a long way towards helping these men access testing services, says study co-author Definate Nhamo, senior programmes manager at Pangaea Zimbabwe AIDS Trust in Harare. "They can get a result within 20–30 minutes and they do not need to endure some of the health-care providers' negative attitudes."

Test accuracy

In 2012, the US Food and Drug Administration approved its first at-home test for HIV, which detects antibodies against HIV-1 and HIV-2 in saliva. Users could get results in minutes, without having to send samples to a laboratory. The test was not as popular as first expected, and its price was high at US$40–$50. However, it inspired similar initiatives for other STIs: syphilis self-tests began appearing in the late 2010s.

Like their clinic-based counterparts, at-home syphilis tests detect antibodies against the family of bacteria that includes T. pallidum in a blood sample. But they require only a drop of blood, rather than a tubeful. They function like a hybrid between a blood-glucose check and a home pregnancy test.

Other self-administered syphilis tests ask users to take separate swabs of their mouth, anus and genitals, and send the samples to a clinical lab for analysis. These kits directly test for pieces of bacterial protein from T. pallidum, or for substances secreted by cells during syphilis infection. When used correctly, some tests can have sensitivities (true positive rates) and specificities (true negative rates) comparable to those of clinic-based tests — above 98%. Results, however, can take several days to receive, which makes them less useful for testing before every sexual encounter, says Weiming Tang, an infectious-disease epidemiologist at the University of North Carolina at Chapel Hill.

One drawback is that kits are often pricey, starting at $50, with some options costing over $100 — although some include tests for multiple STIs. Another drawback for the at-home tests that provide results within minutes is that clinical trials have found variabilities across different lots and users.

Self-test challenges remain

The push for syphilis self-testing is also creating public-health challenges that echo those from the COVID-19 pandemic. The accuracy of any at-home test depends on how well the user can collect the sample, Cramer says, whether it's a nasopharyngeal swab for SARS-CoV-2 or a genital swab for syphilis. Perhaps most concerning to some is that home tests lack the counselling and contact tracing that come with clinic-based tests, especially for STIs such as syphilis4.

Cramer says that although the results of self-testing aren't automatically uploaded to public-health databases, that might not cause such a big drop in reporting as expected. Many people whom she has seen use at-home tests wouldn't go to a clinic for testing anyway, so there would be no net loss in data where they are concerned. Furthermore, people still need to engage with the health-care system to receive treatment, which provides another opportunity to track infections and trace contacts. Some self-testing programmes send antibiotic prescriptions to people who test positive, without the need for a formal clinic visit. Overall, society is better off with at-home tests than without them, says Jen Hecht, executive director at Springboard HealthLab in Richmond, California.

Initiatives to promote the use of at-home syphilis test kits have picked up steam during the pandemic. In the United States, Hecht is trialling a programme to send free STI kits to people who sign up. Importantly, the programme also provides phone counselling and connects users with local public-health departments for follow-up and contact tracing.

"We're seeing quite a number of positive cases, which is indicating to us that we're reaching a group of people who really needed this kind of service," Hecht says. "We want to be able to make it as easy as possible for folks to access."

Nature, 19 May 2022

https://nature.com

Hydrogen production method opens up clean energy possibilities

2022-05-23

A new energy-efficient way to produce hydrogen gas from ethanol and water has the potential to make clean hydrogen fuel a more viable alternative for gasoline to power cars.

Using hydrogen as a fuel for cars is a promising but unrealized clean energy. Like an electric-powered car, a hydrogen fuel-cell powered car doesn't emit any harmful carbon dioxide.

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Washington State University researchers used the ethanol and water mixture and a small amount of electricity in a novel conversion system to produce pure compressed hydrogen. The innovation means that hydrogen could be made on-site at fueling stations, so only the ethanol solution would have to be transported. It is a major step in eliminating the need to transport high-pressure hydrogen gas, which has been a major stumbling block for its use as a clean energy fuel.

"This is a new way of thinking about how to produce hydrogen gas," said Su Ha, professor in the Gene and Linda Voiland School of Chemical Engineering and Bioengineering and corresponding author on the paper published in the journal, Applied Catalysis A. "If there are enough resources, I think it has a really good chance of making a big impact on the hydrogen economy in the near future."

Using hydrogen as a fuel for cars is a promising but unrealized clean energy. Like an electric-powered car, a hydrogen fuel-cell powered car doesn't emit any harmful carbon dioxide. Unlike an electric car, it can be filled up with hydrogen gas in minutes at hydrogen fueling stations.

Despite the promise of hydrogen technology, however, storing and transporting high-pressure hydrogen gas in fuel tanks creates significant economic and safety challenges. Because of the challenges, there is little hydrogen gas infrastructure in the U.S., and the technology's market penetration is very low.

In their work, the WSU researchers created a conversion system with an anode and a cathode. When they put a small amount of electricity into the ethanol and water mixture with a catalyst, they were able to electrochemically produce pure compressed hydrogen. Carbon dioxide from the reaction is captured in a liquid form.

Instead of having to transport hazardous hydrogen gas, the conversion method would mean that the existing infrastructure for transporting ethanol could be used and that the compressed hydrogen gas could be easily and safely created on-demand at gas stations.

"We're already using ethanol-containing gasoline at every gas station," said Ha. "You can imagine that an ethanol water mixture can be easily delivered to a local gas station using our existing infrastructure, and then using our technology, you can produce hydrogen that is ready to pump into a hydrogen fuel cell car. We don't need to worry about hydrogen storage or transportation at all."

The electrochemical system the team developed uses less than half the electricity of pure water splitting, another method that researchers have studied for de-carbonized hydrogen production. Instead of working hard to compress the hydrogen gas later in the process, the researchers used less energy by instead compressing the liquid ethanol mixture, thereby directly producing an already compressed hydrogen gas.

"The presence of the ethanol in water changes the chemistry," said graduate student Wei-Jyun Wang, a co-lead author on the paper. "We can actually do our reaction at a much lower electrical voltage than is typically needed for pure water electrolysis."

Their system also doesn't require an expensive membrane that other water splitting methods do. The resulting hydrogen from the electrochemical reaction is then ready for use.

"A process that offers a low-electrical energy cost alternative to water electrolysis and can effectively capture carbon dioxide while producing compressed hydrogen could have a significant impact on the hydrogen economy," said Jamie Kee, a Voiland School postdoctoral researcher and one of lead authors on the paper. "It's really exciting because there are a whole lot of aspects that play into improving the production methods of hydrogen."

The researchers are working to scale up the technology and operate it in a continuous manner. They also are working to make use of the carbon dioxide captured in the liquid.

Tech Xplore, 23 May 2022

https://techxplore.com

Gene-edited tomatoes could be a new source of vitamin D

2022-05-23

Tomatoes gene-edited to produce vitamin D, the sunshine vitamin, could be a simple and sustainable innovation to address a global health problem.

Researchers used gene editing to turn off a specific molecule in the plant's genome which increased provitamin D3 in both the fruit and leaves of tomato plants. It was then converted to vitamin D3 through exposure to UVB light.

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Vitamin D is created in our bodies after skin's exposure to UVB light, but the major source is food. This new biofortified crop could help millions of people with vitamin D insufficiency, a growing issue linked to higher risk of cancer, dementia, and many leading causes of mortality. Studies have also shown that vitamin D insufficiency is linked to increased severity of infection by COVID-19.

Tomatoes naturally contain one of the building blocks of vitamin D3, called provitamin D3 or 7-dehydrocholesterol (7-DHC), in their leaves at very low levels. Provitamin D3, does not normally accumulate in ripe tomato fruits.

Researchers in Professor Cathie Martin's group at the John Innes Centre used CRISPR-Cas9 gene editing to make revisions to the genetic code of tomato plants so that provitamin D3 accumulates in the tomato fruit. The leaves of the edited plants contained up to 600 ug of provitamin D3 per gram of dry weight. The recommended daily intake of vitamin d is 10 ug for adults.

When growing tomatoes leaves are usually waste material, but those of the edited plants could be used for the manufacture of vegan-friendly vitamin D3 supplements, or for food fortification.

"We've shown that you can biofortify tomatoes with provitamin D3 using gene editing, which means tomatoes could be developed as a plant-based, sustainable source of vitamin D3," said Professor Cathie Martin, corresponding author of the study which appears in Nature Plants.

"Forty percent of Europeans have vitamin D insufficiency and so do one billion people world-wide. We are not only addressing a huge health problem, but are helping producers, because tomato leaves which currently go to waste, could be used to make supplements from the gene-edited lines."

Previous research has studied the biochemical pathway of how 7-DHC is used in the fruit to make molecules and found that a particular enzyme Sl7-DR2 is responsible for converting this into other molecules.

To take advantage of this the researchers used CRISPR-Cas 9 to switch off this Sl7-DR2 enzyme in tomato so that the 7DHC accumulates in the tomato fruit.

They measured how much 7-DHC there was in the leaves and fruits of these edited tomato plants and found that there was a substantial increase in levels of 7-DHC in both the leaves and fruit of the edited plants.

"Forty percent of Europeans have vitamin D insufficiency and so do one billion people world-wide."

The 7-DHC accumulates in both the flesh and peel of the tomatoes.

The researchers then tested whether the 7-DHC in the edited plants could be converted to vitamin D3 by shining UVB light on leaves and sliced fruit for 1 hour. They found that it did and was highly effective.

After treatment with UVB light to turn the 7-DHC into Vitamin D3, one tomato contained the equivalent levels of vitamin D as two medium sized eggs or 28g tuna—which are both recommended dietary sources of vitamin D.

The study says that vitamin D in ripe fruit might be increased further by extended exposure to UVB, for example during sun-drying.

Blocking the enzyme in the tomato had no effect on growth, development or yield of the tomato plants. Other closely related plants such as aubergine, potato and pepper have the same biochemical pathway so the method could be applied across these vegetable crops.

Earlier this month the UK Government announced an official review to examine whether food and drink should be fortified with vitamin D to address health inequalities.

Most foods contain little vitamin D and plants are generally very poor sources. Vitamin D3 is the most bioavailable form of vitamin D and is produced in the body when the skin is exposed to sunlight. In winter and in higher latitudes people need to get vitamin D from their diet or supplements because the sun is not strong enough for the body to produce it naturally.

First author of the study Dr. Jie Li said that "the COVID-19 pandemic has helped to highlight the issue of vitamin D insufficiency and its impact on our immune function and general health. The provitamin D enriched tomatoes we have produced offer a much-needed plant-based source of the sunshine vitamin. That is great news for people adopting a plant-rich, vegetarian or vegan diet, and for the growing number of people worldwide suffering from the problem of vitamin D insufficiency."

Phys Org, 23 May 2022

https://phys.org

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Scientists Found an Animal That Walks on Three Limbs. It's a Parrot.

2022-05-17

Lovebirds, small parrots with vibrant rainbow plumage and cheeky personalities, are popular pets. They swing from ropes, cuddle with companions and race for treats in a waddling gait with all the urgency of toddlers who spot a cookie. But, along with other parrots, they also do something strange: They use their faces to climb walls.

Give these birds a vertical surface to clamber up, and they cycle between left foot, right foot and beak as if their mouths were another limb. In fact, a new analysis of the forces climbing lovebirds exert reveals that this is precisely what they are doing. Somehow, a team of scientists wrote in the journal Proceedings of the Royal Society B on Wednesday, the birds and perhaps other parrot species have repurposed the muscles in their necks and heads so they can walk on their beaks, using them the way rock climbers use their arms.

Lovebirds — and perhaps other species — seem to confound nature's strong preference for bilateral bodies.

Climbing with a beak as a third limb is peculiar because third limbs generally are not something life on Earth is capable of producing, said Michael Granatosky, an assistant professor of anatomy at the New York Institute of Technology and an author of the new paper.

"There is this very deep, deep set aspect of our biology that everything is bilateral" in much of the animal kingdom, he said. The situation makes it developmentally unlikely to grow an odd numbers of limbs for walking.

Some animals have developed workarounds. Kangaroos use their tails as a fifth limb when hopping slowly, pushing off from the ground with their posteriors the same way they push with their feet.

To see if parrots were using their beaks in a similar way, Dr. Granatosky and a graduate student, Melody Young, as well as their colleagues brought six rosy-faced lovebirds from a pet store into the lab. They had the birds climb up a surface that was fitted with a sensor to keep track of how much force they were exerting and in what directions. The scientists found that the propulsive force the birds applied through their beaks was similar to what they provided with their legs. What had started as a way to eat had transformed into a way to walk, with beaks as powerful as their limbs.

"For them to take their faces and integrate it into their stride cycle is pretty incredible," said Ms. Young, who noted that the birds' nervous systems

would have had to change to fit beak movement into the rhythm of walking.

Dr. Granatosky speculates that parrots may have evolved this ability because they, like woodpeckers and nuthatches, cannot hop up and down the trunks of trees. Parrots alternate their legs when they walk, rather than pushing off with both legs at once. So when it came to the challenge of moving vertically, they had to come up with something different, something that created the third limb that developmental biology could not provide to them.

How often parrots do this three-limbed walking in their daily lives is another question the researchers have. To get a sense of what role it plays in their behavior, Dr. Granatosky has dispatched students to make close observations of the green monk parakeets that live in the towering Gothic Revival-style gate of Green-Wood Cemetery in Brooklyn.

While the results have not yet been published, he hopes that the lovebirds and monk parakeets will help illuminate how parrots evolved such an unusual way of climbing and what changes they made to their bodies to do it.

The New York Times, 17 May 2022

https://nytimes.com

3D printing adds another dimension

2022-05-23

Smart materials are already part of our daily lives. From novelty mugs with thermochromic pigments that change colour when holding a hot drink, to photochromic prescription glasses' lenses that darken when the sun is out, to hydrogels that expand to soak up liquid in disposable nappies and period products. But these are only the tip of the iceberg in terms of what smart materials – that can sense information about the environment around them and then act accordingly – are predicted to achieve in the future.

According to a recent Royal Society report, smart materials on the way include window glass that changes porosity in response to humidity, clothing that adapts to environmental conditions and self-healing concretes. 'Animate materials could eventually have a transformative effect on all spheres of life,' the report authors wrote.

'The fourth dimension [is] time,' [Skylar Tibbits] tells Chemistry World. 'We are 3D printing things that then change over time – that reconfigure, that evolve, that adapt, that have agency.'

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The key point is that these are not autonomous systems comprised of sophisticated electronics and robotics. The ability to sense stimuli and respond appropriately is instead preprogrammed into the design of a single material.

Printing the future

Smart materials will need to jump many hurdles before they can reach their full potential, including how best to manufacture them. Over the past decade or so, increasing numbers of researchers have been exploring the potential of 3D printers for this purpose.

The use of 3D printers to produce smart materials is called 4D printing, a term coined by Skylar Tibbits, an architect and computer scientist at the Massachusetts Institute of Technology in the US, during a TED talk in 2013. 'The fourth dimension [is] time,' he tells Chemistry World. 'We are 3D printing things that then change over time – that reconfigure, that evolve, that adapt, that have agency.'

Using 3D printers for smart materials has many of the same advantages as it does for static objects, including the ability to make personalised, made-to-measure materials. Allowing access to types of materials that are impractical to produce any other ways is another. 'It is almost impossible to fabricate [our smart materials] using the commercial fabrication approach – or at least it would be extremely tedious,' explains Jerry Qi, a mechanical engineer from the Georgia Institute of Technology in the US.

This ease of manufacture also accelerates innovation. 'Previously, once you've designed a [smart] material, then you have to figure out how to fabricate it, which is going to take you probably half a year to achieve,' Qi says. It is now possible for researchers to get their hands on a new prototype within hours rather than months of designing it.

Printing lifestyle products

It is still early days for 4D printing and no smart materials made this way are yet in commercial use, although plenty of prototypes have been developed. One of Tibbits' early designs was a 4D printed shoe. His group printed a preprogrammed pattern of polymer ink onto a stretched piece of textile fabric. After the fabric was released from its stretch, the 2D shape immediately jumped up into the intended 3D shape. 'It's a jack-in-the-box effect,' explains Tibbits. He also used the same trick to produce a 4D printed dining table prototype designed to be flat-packed and then to

instantly spring up into the 3D shape once unpacked. For this table, an ink composed of polymer and sawdust was printed onto the fabric.

The Tibbits group has also created a 4D printed stretchy, inflatable silicone prototype material with tuneable stiffness in conjunction with the car manufacturer BMW. The smart material changes shape in response to the amount of air pumped into it. 'With BMW, we were looking at the future of the car interior [and investigating] how materials could morph and transform in the car based on pressure differential,' Tibbits says. A potential use is in car seats, enabling them to become softer or harder, or to provide greater lumbar support, without the need for complicated mechanical mechanisms, he adds.

To make its pneumatic material, Tibbits' group developed a novel type of 3D printing technology – rapid liquid printing. Unlike most 3D printing approaches, rapid liquid printing doesn't build up objects layer by layer. Instead, the liquid 3D object is printedinto a tank containing a gel, which suspends the object so it is not subject to gravity. The ink contains polymers that rapidly solidify once combined or when exposed to ultraviolet light. Rapid liquid printing overcomes some of the inherent shortcomings of 3D printing, namely size limitations and slow speed, says Tibbits. 'We can print high quality products at large scale, super fast.' The group is now exploring the use of this printing approach for a wide variety of smart materials.

Next generation stents

Unlike Tibbits, who is focused on 4D printing approaches to manufacturing lifestyle products, many other researchers who are championing this technology are concentrating on potential biomedical applications.

The use of 3D printers to produce personalised static objects is already becoming established in healthcare. Examples include personalised digital hearing aids that fit in the ear or soft earmoulds for behind-the-ear aids; 3D models of organs and other body parts on which to practice complicated surgeries; components of prosthetics that perfectly match a person's anatomy; and low-cost, made-to-measure implants such as jaws, hips and pieces of skull.

Devices that can change shape once inside the body are also already in use, but they are made using traditional manufacturing methods. Deployable stents, for example, have been used for treating heart attacks and angina since the 1990s. These cylinders of expandable metal mesh are

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guided through a patient's blood vessels while collapsed around a balloon on the end of a narrow wire. Once in the correct location, the balloon is inflated so that the mesh expands to fit the blood vessel wall.

Bioengineer Amir Zadpoor and his group at Delft University of Technology in the Netherlands are looking to 4D printing to make next generation deployable stents. The goal is to produce a smart polymer stent that self-expands at body temperature, therefore removing the need for a balloon-inflation system. Zadpoor's stents can be a standardised size or personalised for complex scenarios, including at junctions where two blood vessels diverge.

To make the 4D cylinders, the group built an add-on to attach to a commercially available fuse deposition modelling (FDM) printer. The add-on resembles a rolling pin and rotates during printing. When an object is printed on a rotating curved surface instead of a static flat one, its layers are oriented differently, affecting its shape-shifting behaviour. The cylinder now expands in diameter rather than in length, Zadpoor explains.

Origami-like tissue scaffolds

The Zadpoor group is also looking to use 4D printing to produce next-generation tissue engineering scaffolds. These structural scaffolds are implanted into patients to promote the regeneration of bone, muscle, neural and other tissue in situ. 3D printing has already proven itself to be a highly effective tool for producing personalised, highly porous metal lattices for this purpose.

4D printing offers the additional benefit of allowing the surfaces inside the metal lattice pores to be functionalised, Zadpoor says, which can't be done using traditional manufacturing methods. 'We can decorate these surfaces with very small geometrical features that we call nanopatterns,' he explains. The nanopatterns direct cells to become bone-forming cells and also act to reduce bacterial growth. 'These little spikes can behave like a knife and penetrate into bacteria and kill them in a mechanical way, and they can also modulate the behaviour of immune cells to kill bacteria,' Zadpoor adds.

An FDM printer is used to print a 2D layered structure that spontaneously folds into a 3D object when stretched. 'Smartness is incorporated into this material [design] so that once you trigger it using a stimulus, it goes into the required 3D shape,' says Zadpoor. Unlike the stents, these scaffolds are designed to change shape during the manufacturing process, rather than inside the body.

Mending a broken heart

At the George Washington University in Washington DC, US, bioengineer Grace Zhang and her group are also using 4D printing to make tools capable of supporting tissue regeneration in the body. 4D printed cardiac patches, that repair heart muscle damage caused by heart attacks, are among their efforts. The rhythm of heartbeat is controlled by heart muscle cells, or cardiomyocytes, and it has long been suggested that damaged hearts could be repaired with lab-grown cardiomyocytes, but integrating them efficiently has proven to be a major challenge. 'When a heart is beating it is really hard to keep the cells in the [desired] location long term,' explains Zhang.

Her group's 4D cardiac patches are preprogrammed to hold cardiomyocytes securely on the heart's surface. They are comprised of a gelatine-based ink andprinted using a custom-designed stereolithography3Dprinter. Gelatine is a hydrolysed form of collagen, a highly abundant protein in the body that serves as a scaffold for cells.By adjusting the degree of cross-linking in the different sections of its design, the patches are designed to reversibly change structure upon stretching so that they can expand and contract along with the heart. 'We design the patches so that they can perfectly attach without any glue over,' Zhang explains.

The first-generation cardiac patch has already been tested in mice with induced heart damage. The Zhang group placed the 4D printed patches loaded with lab-grown cardiomyocytes in the mice and observed that they were still in place and supporting heart-muscle formation four months later.

A second-generation 4D printed cardiac patch is also now in development, whereby the ability to self-curl,when triggered by near infrared light, has also been preprogrammed into the cross linkage pattern. This curling mechanism will further improve the patch's ability to grip onto the heart's surface, Zhang explains.

4D printed surgeons

Mechanical engineer Xuanhe Zhao and his group at the Massachusetts Institute of Technology in the US, meanwhile, are looking to apply 4D printing to stroke treatment. The researchers are aiming to improve the thrombectomy, a common stroke treatment whereby a thin wire – carrying drugs to break up clots or a device that pulls or sucks out clots – is inserted into a blood vessel in the leg and then manually guided, with

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the help of real-time x-ray imaging, through the body until it reaches the blockage.

4D printed wires could make this guiding process easier, says Zhao. His group's wires are designed his wire to change shape, and therefore direction, in response to a magnetic field. Magnets on the outside of the body could be used to direct the wire to travel through the blood vessels. The procedure could even be controlled remotely using a joystick, reducing the surgeon's radiation exposure, says Zhao. 'We are moving forward towards clinical application and FDA approval of this stroke robot,' he adds.

To make the wires, Zhao has designed an electromagnetic add-on that sits next to the nozzle of a commercially available FDM 3D printer. The ink is a soft polymer containing uniformly dispersed ferromagnetic microparticles, which permanently retain magnetism after exposure to a magnetic field. During printing, the electromagnet magnetises and aligns the ferromagnetic microparticles in the ink.

The Zhao group has previously used the same add-on to create a variety of 2D patterns that fold into complex 3D shapes under the control of handheld magnets. 'With 4D printing you programme these magnetic software robots into very complex structures to achieve many functions,' Zhao explains.

Fundamental advances

Not everyone working on 4D printing currently has applications in mind; many are working to achieve fundamental advances that others can then take forward for applications. Among Qi and his Georgia Tech group's endeavours are 4D printed materials with multiple layers of composite shape memory polymers. The researchers use two polymers with mismatched polarity and tightly control their spatial distributions within each layer. This means that when the material is soaked in water or acetone, one polymer swells more than the other and the material bends in a very precise manner.

The printer they use for this work is a custom-made digital light processing (DLP)-style 3D printer. In DLP printers, the resin is cured using rapid light-triggered polymerisation, which makes them much faster than FDM printers, Qi explains. He also recently developed a machine learning model that eliminates the need for trial and error in the material's pattern design. Qi can rapidly and accurately produce a composite material pattern based on just a hand-drawn picture of the desired end product shape.

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Polymer chemist Tao Xie and his group at Zhejiang University in Hangzhou, China, are also using a custom-made DLP 3D printer to make smart materials containing multiple polymers. It is a modular process with a different polymer in each module. The 3D modules are printed as patterned 2D films. 'The fabrication process can be done in less than a minute,' says Xie. The pattern is preprogrammed to do serve two different purposes. First, it directs the transformation of the 2D film into a 3D object as it dries. Second, it allows the 3D object to change shape when exposed to an environmental trigger.

To create more complex shape-shifting materials, the 3D modules are stacked on top of each other and heated to permanently fuse together. 'It's like Lego,' Xie says, adding that this modular approach to 4D printing drastically expands the structural complexity possible for shape-shifting materials. Smart modular materials the group has created so far include a three-layered cylinder that deforms in a controlled manner when heated.

4D printing technology has rapidly evolved since its conception to allow rapid prototyping of a wide variety of shape-shifting materials, but there are still hurdles to overcome before its use becomes mainstream and it is able to produce smart materials on a commercial scale.

Standardisation, according to Tibbits, is one such issue. 'If we look at the field of 4D printing, everyone's doing it differently; they all have different materials, machines and software, and they are all testing their systems in different ways,' he says. To ensure safety and reliability, the community needs to come up with a set of shared standards for testing and analysing these smart materials, he explains.

The biggest challenge of all for 4D printed materials, however, may be one of mindset: how to integrate activity into a world that is used to its materials being static. 'Normally, engineering is about trying to make structures and bridges that do not change shape – most materials out there trying to be super stable and not move,' says Tibbits. 'This is going the complete opposite direction and aiming to use materials that are as active as possible, and we're not really used to that.'

Chemistry World, 23 May 2022

https://chemistryworld.com

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Curiosities

Does turmeric's reputation translate into real health benefits?

2022-05-22

While Kamal Patel was probing through the reams of user data on examine.com – a website that calls itself "the internet's largest database of nutrition and supplement research" – before a planned revamp later this year, he discovered that the most searched-for supplement on the website was curcumin, a distinctive yellow-orange chemical that is extracted from the rhizomes of turmeric, a tall plant in the ginger family, native to Asia.

Patel concluded that this was probably because of curcumin's purported anti-inflammatory properties. "An astounding number of people experience inflammation or have inflammation-related health conditions, and curcumin and fish oil are two of the most researched supplements that can sometimes help," he says.

This consumer interest in curcumin hasn't gone unnoticed by the "wellness" industry. Besides its use in pill supplements, curcumin is increasingly being incorporated into cosmetic products that claim to help treat acne and eczema, prevent dry skin, and even slow down the ageing process. Some reports predict that the global curcumin market size could reach $191m (£156m) by 2028.

The doses of curcumin required to give benefit are very high – typically about 1,000mg a day

The ground rhizomes of the turmeric plant are commonly found in curry powder, but turmeric has also been part of Ayurvedic medicine – a traditional Indian system of treatment – for centuries, and at some point in the last decade turmeric worked its way out of the spice cupboard and took its place at the forefront of the western wellness industry. "As part of the general concept of Ayurvedic medicine and wellness, it's increased in popularity in lockstep with yoga and meditation," says Patel.

Turmeric has become the wellness industry's new cure-all. It has been subject to all kinds of wild and wonderful health claims, including the ability to relieve allergies, prevent cancer, improve heart health, reverse cognitive decline, cure depression and increase longevity.

As with any dietary supplement, separating the hype and the truth is not straightforward, since not all the claims about turmeric are complete hyperbole. Most are based on the curcumin turmeric contains, which has been shown to be a potent anti-inflammatory and antioxidant.

Clinical trials show that curcumin, present in the spice, may help fight osteoarthritis and other diseases, but there's a catch – bioavailability, or how to get it into the blood

This is where it gets more complicated. The proportion of curcumin in turmeric is just 3%, by weight. The scientific studies that have made positive health associations use either pure curcumin or turmeric extract that has been designed to contain mostly curcumin. The doses of curcumin required to give benefit are very high – typically about 1,000mg a day. So despite what manufacturers might claim, consuming turmeric shots and lattes or adding a little extra spice to your meals will not come close to reaching the necessary dose. Some turmeric products have even been found to be contaminated with heavy metals such as lead, which can have adverse effects on your health.

But there is genuine interest from scientists around the world in curcumin's potential as a natural treatment for a whole range of chronic illnesses. The most convincing evidence so far relates to its ability to relieve joint pain in people with osteoarthritis, an area of medicine where there is a huge unmet need owing to the limitations of non-steroidal anti-inflammatory drugs (NSAIDs).

"Osteoarthritis is the most prevalent joint disease worldwide," says Kristopher Paultre, assistant professor of orthopaedics and family medicine at the University of Miami. "NSAIDs have been a staple in treatment but are not without their drawbacks including gastrointestinal, cardiac and renal issues when used chronically."

But this is just one area of investigation. There are 70 clinical trials around the world that are either active or seeking patients, and are looking at the potential of curcumin to treat chronic kidney disease, cognitive decline, inflammatory bowel syndrome (IBS), macular degeneration, and even to slow down the progression of various forms of cancer.

Advances in drug-delivery techniques

In the mid 1990s, Jack Arbiser and Nancy DeMore were young researchers at Harvard Medical School exploring new treatment options for cancer, when they came across some research suggesting that curcumin could inhibit the growth of different types of cancer cells in a test tube.

Intrigued by this, they went on to find that curcumin could prevent the formation of new blood vessels, a process called angiogenesis, which all tumours require to sustain themselves.

"Together we showed that curcumin inhibits angiogenesis," says DeMore. "We were very excited about this initial finding. There have since been several studies using curcumin in clinical trials in patients with pancreatic

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cancer, breast cancer, and multiple myeloma showing that there is some biologic effect."

However, when scientists moved from testing curcumin in the lab to testing it on humans, there was a catch – one that has dogged curcumin ever since. The compound has notoriously poor bioavailability – the rate at which the body absorbs a substance – making it nearly impossible to get sufficiently high concentrations of curcumin into the blood through oral supplementation alone. This, along with the commercial difficulties of patenting natural products, meant that scientific interest in curcumin soon waned, and would remain in the doldrums for more than a decade.

But in recent years, advances in drug delivery techniques have renewed interest in curcumin. Nanoparticle systems are being explored as ways of potentially getting high doses of curcumin to tumours. Some research has shown that combining curcumin with piperine – a compound found in black pepper – can enhance its absorption into the blood, although it still remains to be proven whether this can help yield benefit in humans. While there are now a whole variety of off-the-shelf supplements that combine curcumin and piperine, there are still challenges for scientists looking to use it medically. One of these is that piperine has been shown to inhibit a variety of enzymes that aid in metabolising drugs, and it remains to be seen whether this could cause an increased risk of side-effects in patients also taking prescription medicines.

In the world of sport, curcumin has gained a reputation as an aid to muscle rehabilitation

"The problem of curcumin's absorption has been enthusiastically addressed by a number of supplement companies and researchers," says Wyatt Brown, a researcher at examine.com. "They typically do this by packaging it in highly absorbable lipids of various types so that more of it gets into the body."

This has been accelerated by a drive for more natural alternatives to painkillers, but also by the fact that in the world of sport, curcumin has gained a reputation as an aid to muscle rehabilitation. Scientists at Northumbria University are planning a clinical trial to study this, while in the US, Paultre is already witnessing the rise of curcumin as a sports supplement.

"Curcumin has seen a significant increase in use in athletics for recovery post-workouts and after games," he says. "The idea is the same as with osteoarthritis and the goal is to reduce inflammation. We tend to avoid

chronic NSAID use in athletes due to side-effects. The evidence seems to be positive, but once again there is still work to be done."

Potential new delivery methods have sparked interest once again in curcumin's potential anti-cancer properties, with various researchers keen to explore its uses in patients in the early stages of the disease, as an add-on treatment to more conventional cancer drugs.

DeMore, now a professor of surgery at the Medical University of South Carolina, has returned to studying curcumin after a near 20-year gap, launching a clinical trial to see whether breast cancer patients taking a formulation of curcumin specially designed to enhance its absorption into the blood experience a decrease in tumour proliferation.

At the same time, oncologists at the University of Rochester Medical Center in New York state are running a trial to see whether curcumin supplemented with piperine can halt disease progression in patients with low-grade prostate cancer, and prevent them from requiring more aggressive treatment.

In both cases, scientists are keen to emphasise that these trials are very much in the exploratory stage, and even if they produce positive results, far more proof will be needed before curcumin can be officially recommended for cancer patients. For example, even if the data from DeMore's study shows that curcumin appears to reduce the rate at which tumours are growing, it would then require a full randomised control trial – where curcumin is compared against a placebo – to prove that it can actually prolong survival or prevent tumour recurrence in cancer patients who have been through chemotherapy.

"The problem is that many of these natural products have not been through the traditional clinical trials to evaluate whether or not they truly are effective," says DeMore. "If our trial shows benefits, it would allow us to write grants to fund further randomised controlled clinical studies."

Paultre says it is positive that further independent trials are being funded for curcumin because much of the research on the compound has been acquired through small studies that have been financed by the nutraceutical industry, which has created a perception of curcumin as a miracle cure. "Current studies still have a lot of potential bias in them," he says. "Nutraceuticals do not have much regulatory oversight, and companies want to make a profit. There is always concern for bias in these studies, which produce amazing results with a specific product."

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While there is ongoing interest in curcumin across a whole spectrum of diseases, there is a lack of concrete evidence for its benefits for conditions such as cognitive decline, IBS, or chronic pain beyond osteoarthritis, while Wyatt describes any claims that curcumin could meaningfully reduce the risk of cardiovascular disease as "speculative".

But there are hopes that the anti-inflammatory properties of curcumin could offer benefits for depression. Laura Fusar-Poli, a psychiatry researcher at the University of Catania, Italy describes a number of theories, including that curcumin may be able to restore levels of serotonin in the brains of depressed patients and a possible modulatory effect on the brain-gut axis. But to date, evidence of any of this in humans remains scarce.

Paultre is hoping that the current interest in curcumin will help develop a gold-standard way of delivering it into the body as well as agreements on the best dose to use, which could all make it easier for scientists to quantify its benefits in future.

"The problem is that there is no consensus on appropriate curcumin levels for therapeutic effect," he says. "Additionally, with so many formulations out there, there are no studies comparing the bioavailability of each one. It's a bit like the wild west in this regard. Therefore though there is evidence of curcumin being helpful in some conditions, there is still a lot of work to be done."

The Guardian, 22 May 2022

https://theguardian.com

The Biggest Carbon Sink of All

2022-05-19

One of the brightest hopes for sequestering carbon lies in the darkest place on earth: the abyssal depths of the deep ocean. For millennia, dead plants and animals have sunk to the bottom of the sea, where they form sediment that eventually turns into rock (and sometimes fossil fuels).

Some climate researchers think we can now accelerate this natural process and clean up our modern carbon mess by deliberately sinking millions of tons of seaweed and fish.

But is carbon sinking the climate equivalent of sweeping dirt under the rug? Our knowledge of deep-sea ecosystems is still sketchy; and even if

Can we bury our CO2 problem at the bottom of the ocean?

the carbon math works out, the logistics of sinking carbon could disrupt the marine systems we rely on for food, transport, and recreation.

A Natural Solution As Vast As The Problem

1. Sinking seaweed. A 2016 paper in Nature Geoscience estimated that marine macroalgae—aka seaweed or kelp—could store around 175 million tons of carbon each year, either by burying it in coastal sediments or exporting it to the deep sea. In 2020, the Energy Futures Initiative, a climate tech non-profit, published a report that found marine carbon dioxide removal could one day sequester CO2 at a billion ton scale, thanks to the sheer amount of available space in the ocean and the absence of land use complications.

2. Just add water (and money). There seem to be no major technical barriers to farming seaweed, which can grow at almost 3 centimeters an hour. Several start-ups are already experimenting with growing or moving coastal kelp far out to sea, where it would settle to the ocean floor instead of washing up on shore. Running Tide is using carbon buoys to suspend kelp "microforests" above deep water: when the buoys are deflated, the kelp naturally sinks. Pull to Refresh wants to use semi-autonomous solar-powered vessels to grow and sink its carbon-sucking seaweed.

3. Scaling back on industrial fishing. Gaël Mariani, a marine ecologist at the University of Montpelier has calculated that big fish like tuna also sink to the seafloor when they die—and that global fishing has interrupted that natural process to the tune of 730 million tons of CO2 since 1950. Letting the big ones get away can be a win for carbon.

The Numbers Are Still Murky

1. The science ebbs and flows. The 2016 Nature paper estimated that a square kilometer of seaweed absorbs around 50 tons of carbon. But when University of Tasmania scientist John Barry Gallagher ran the numbers, he was surprised to find that kelp forests are actually a net source of carbon. He calculates that tiny sea creatures feeding on seaweed breathe out their own CO2, meaning a square kilometer of kelp actually emits an average of 20 tons. His helpful article from March suggests more research is needed before we scale up seaweed farms.

2. The detail is in the weeds. In this excellent MIT Technology Review article from last year, James Temple attempts to untangle the prospects for kelp carbon removal. He notes that scholars worry about a billion-ton blue carbon effort blocking the paths of marine mammals, disrupting

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local ecosystems, interfering with shipping, and encroaching on protected areas and indigenous territories.

3. Don't sink it, eat it. Any discussion of kelp is complicated by its growing popularity as a climate-friendly agricultural foodstuff, biofuel and replacement for plastics. These reduce the world's carbon footprint but are only carbon-neutral solutions: recycling carbon dioxide already in the atmosphere rather than permanently removing it. To sink and sequester the kelp instead, a generous carbon price (or other incentive) would be needed to make it a more attractive option.

What To Keep An Eye On

1. Early experiments. Running Tide has already deployed about 1600 kelp buoys, and you can now buy its "carbon-negative" oysters online.

2. Kelp Coins. Whether you consider "a unique, serialized digital security token comprising a forward contract on a ton of seaweed" to be a great way of building natural capital based on marine permaculture, or another example of cryptocurrency gone mad, it will be interesting to see what happens to the Kelp Coin's $200 face value when it matures (at a so-far unspecified point in the future).

3. Public and political pushback. In 1990, protestors managed to prevent a seaweed farm intended to produce nori for the then-hottest food trend of sushi from going ahead in Washington State. Permitting is still a big issue for kelp cultivation—although Washington recently advanced a bill to streamline regulation.

Anthropocene Magazine, 19 May 2022

https://anthropocenemagazine.org

Can sniffer dogs really detect COVID almost as well as a PCR test? Turns out they can

2022-05-20

Dogs have an exceptional sense of smell. We take advantage of this ability in many ways, including by training them to find illicit drugs, dangerous goods and even people.

In recent years, a dog's sense of smell has also been used in the medical field. These remarkable animals can be trained to sniff out cancer, diabetes, and extraordinarily, epileptic seizures before they occur.

These remarkable animals can be trained to sniff out cancer, diabetes, and extraordinarily, epileptic seizures before they occur.

Early in the pandemic the possibility of using dogs to sniff out COVID was explored in a few countries. And although the results of these early trials surpassed most people's expectations, many questions remained. These included how well these findings would stand up to more rigorous scientific scrutiny and how well dogs would perform outside the artificial environment of the research laboratory.

In the past week we have moved closer to answering these questions, with an article published in BMJ Global Health, which found dogs could detect COVID almost as well as PCR tests, in some circumstances.

What did the researchers test?

This article reported the results of two studies. In both studies, four dogs were tested to see how well they detected COVID from skin swabs taken from people with or without COVID (according to the gold-standard test, PCR).

These dogs didn't just come off the streets; they had already had a significant amount of training in sniffing out drugs, dangerous goods or cancer.

The first study

In the first study, the researchers looked at whether the dogs could identify COVID in the skin swabs of 420 volunteers, 114 of whom had tested positive to COVID by PCR.

The study was rigorous, with various precautions against the results being compromised. This included an elaborate study protocol that involved a number of separate assistants and a dog handler. None of them knew whether the sample was from someone with COVID, so they could not influence the outcome, intentionally or unintentionally.

The dogs detected COVID with a sensitivity of 92% (which refers to their ability to correctly identify those with infection) and a specificity of 91% (their ability to correctly identify those without infection).

Although there was some variation between dogs, they all performed exceptionally well. There are no significant disclaimers here, this was a great result.

The second study

The second study was important as its goal was to see how well the dogs could do in the messiness of the real world. This real-life trial involved the

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dogs sniffing 303 incoming passengers at Helsinki-Vantaa International Airport in Finland. Each passenger also took a PCR test.

The dogs matched the PCR results in 296 out of 303 (98%) of the samples and they correctly identified the swabs as negative in 296 out of 300 (99%) samples.

The important consideration in interpreting this result is this happened during airport screening, a situation where you wouldn't expect many people to test positive.

In this type of low-prevalence environment, you want dogs to be able to screen passengers with a high "negative predictive value". That is, you want the dogs to be able to identify people who are not carrying the virus to differentiate them from those who may be carrying it. Then you would carry out confirmatory PCR testing on that last group.

In an environment where the prevalence of COVID is around 1%, such as an airport, the researchers estimated the "negative predictive value" for dogs screening for COVID to be 99.9%. That is, the dogs would be expected to correctly exclude 99.9% of passengers as having COVID. This is another fantastic result.

Low tech and instant

In a world where we rely on expensive technological solutions, there is something reassuring about finding a low-tech option for screening COVID.

Importantly, however, the study highlights dogs are quick to train for this task and are ideal for screening in high-throughput settings, such as airports, given how accurate they are and the fact they give instant results.

Although nothing should surprise us about our closest friend, another incredible outcome from this study was the suggestion the dogs may have been able to distinguish between the variants of SARS-CoV-2, the virus that causes COVID.

While other possible explanations cannot be excluded, the performance of the dogs seemed to drop with the emergence of the Alpha variant. This was attributed to the dogs being able to identify a difference between this variant and the wild-type virus on which they were originally trained.

These studies confirm nothing could be further from the truth when we say you can't teach an old dog new tricks.

The Conversation, 20 May 2022

https://theconversation.com

Farm vehicles are now heavier than most dinosaurs: Why that's a problem

2022-05-17

What does a modern combine harvester and a Diplodocus have in common? One answer, it seems, may be their big footprints on the soil. A new study led by researchers from Sweden and Switzerland has found that the weight of farming machinery today is approaching that of the largest animals to have ever roamed the Earth—the sauropods.

Depicted as the giant, friendly "veggiesaurus" in the movie "Jurassic Park," sauropods were the biggest of the dinosaurs. The heaviest were thought to weigh in at around 60 metric tons—similar to the weight of a fully laden combine harvester. Tractors and other machinery used on farms have grown enormously heavier over the past 60 years as intensive, large-scale agriculture has become widespread. A combine harvester is almost ten times heavier today than it was in the 1960s.

The weight of animals or machines matters because soils can only withstand so much pressure before they become chronically compacted. They may not look it, but soils are ecosystems containing fragile structures—pores and pathways which allow air to circulate and water to reach plant roots and other organisms. Tires, animal hooves and human feet all apply pressure, squashing the pores, not just at the surface but deeper down too.

Soil compaction can cut plant growth and harvests, and increase the risk of floods as water runs off the land and reaches waterways more quickly. The scientists involved in the new study took a look at how much compaction is being caused by these giant farming machines and compared it with the sauropods who lived over 66 million years ago. They found both to be big culprits of compaction.

Under pressure

The study points out that as the weight of farm machinery has grown, tire sizes have ballooned too, adjusting the area of contact between the vehicle with the soil to reduce the pressure on the surface and help avoid

Soils can only withstand so much pressure before they become chronically compacted. They may not look it, but soils are ecosystems containing fragile structures.

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sinking. It seems that animals evolved with a similar strategy—increasing foot size with weight to help avoid sinking into the soil.

Overall, pressure at the soil surface has remained fairly constant as farm machinery has gained weight. But the authors suggest that stresses on the soil continue to increase below the surface and penetrate deeper as vehicles (or animals) get heavier. Farm machinery today (and the sauropods of the past) are now so heavy that they irreparably compact soil below the first 20 cm, where it isn't tilled. Aside from restricting how deep the roots of crops can grow to seek water and nutrients further down in the soil, this can also create low-oxygen conditions that are not good for plants or the organisms they share the soil with.

Where did the dinosaurs go for dinner?

This creates a "sauropod paradox," as the researchers call it. The dinosaurs and the loads transmitted through their feet were so large that they would have likely caused significant subsurface damage to soils wherever they roamed, potentially destroying the soil's ability to support the plants and ecosystems they would have relied on as their food source.

The image of sauropods roaming widely and foraging freely as depicted by Jurassic Park seems unlikely, as they would have had an unsustainable influence on their environment. So how did they survive?

The scientists behind the study speculate that they may have kept to well-trodden paths, limiting their impact while browsing the canopy with their long necks. How exactly a sauropod could live in equilibrium with the soil remains a mystery for now.

Big food for thought

A more pressing conundrum is how to reconcile soil compaction by farming vehicles with sustainable food production today. The risk of soil compaction varies with the type of machinery and the way it's used, as well as the type of soil and the moisture bound up in it.

The study estimates that 20% of croplands globally are at high risk of losing productivity because of subsoil compaction by modern agricultural vehicles, with the highest risks in Europe and North America where it's relatively moist and there are more large farms using the largest machines. Clearly, this is an issue in arable landscapes, but the problem also extends to grasslands where silage is baled, and urban landscapes where the movement of construction vehicles on green space is not well controlled.

The authors call for design changes to machinery to help maintain the soil's structure. We suggest another option. To reduce their impact on the soil, we could reduce the need for such large machines in the first place by growing food using smaller machines on smaller parcels of land, particularly in high-risk zones. Finding ways to break up vast monoculture landscapes makes sense for many other reasons. For example, wildflower field margins, hedgerows and trees can help sequester carbon, manage water quality and support biodiversity.

Soil can only withstand so much pressure—whether from compaction or other threats such as continual harvesting, erosion or pollution. Humans must act to reduce pressures on soils, or we risk going the way of the dinosaurs.

Phys Org, 17 May 2022
https://phys.org

Did NASA find a mysterious doorway on Mars? No, but that's no reason to stop looking

2022-05-23

For the past ten years, NASA's Curiosity rover has been trundling around the surface of Mars, taking photos in its quest to understand the history and geology of the red planet and perhaps even find signs of life.

Last week it took a photo which appeared to show a doorway carved into the rock. It's the sort of thing that on Earth might indicate an underground bunker, such as an air-raid shelter.

Seeing is not always believing

At first sight, the picture is totally convincing. At second sight, maybe not. The passage seems to go in only a short way before the steeply descending roof meets the floor.

And then those killjoys at NASA tell us its only about 45 cm high. Still, who said Martians had to be the same height as us? But then geologists point out several straight-line fractures can be seen in this site, and the "doorway" is where they happen to intersect.

Such a pity. It would have been so exciting if it had been a real doorway. Instead it joins the face on Mars, the spoon on Mars, the cube on the Moon, and all the other things seen in photos from space that turn out not to be as exciting as we thought.

The sad fact is that when presented with an unclear or unfamiliar image, humans try to turn it into a familiar-looking object. Scientists call our tendency to do this "pareidolia".

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Faces in the clouds

Worse, the "doorway" joins the even longer list of wacky images like the cornflake that looks like Australia, the cats that look like Hitler, and so on. And who hasn't seen a face in the clouds?

The sad fact is that when presented with an unclear or unfamiliar image, humans try to turn it into a familiar-looking object. Scientists call our tendency to do this "pareidolia".

It's easy to understand why it happens. We likely evolved this tendency because spotting important things like predators or faces, even when the light is poor or they are partly obscured, gave us an advantage. And getting false positives – seeing a predator where there is none – is better than not seeing a predator who then eats you.

No signs of life

Reasonable explanations won't deter the conspiracy theorists who say the doorway really is evidence of life on Mars, and maintain that scientists are engaged in some sort of cover-up.

If I were trying to do a cover-up, I wouldn't be releasing the photos! So a conspiracy doesn't seem very likely.

But there's also a lesson here for serious searchers for alien life. As astronomer Carl Sagan said, extraordinary claims require extraordinary evidence.

Following this maxim, scientists seeking evidence of extra-terrestrial life demand much stronger evidence, than, say, someone looking for a geological formation. And despite decades of searching for evidence of life on Mars, we have found nothing.

It is still possible there may once have been life on Mars. We may yet find some fossilised relics of ancient cellular life. But suddenly finding an artefact such as a doorway, or a spoon, seems unlikely.

The bigger picture

There's a similar story with the broader search for extra-terrestrial intelligence (SETI). For years, SETI scientists have been searching the skies for signals from other civilisations, but so far we have found nothing. But nearly all our searches have been on the nearest few stars, and so in a sense the search has barely started.

Meanwhile, we continue to be bombarded with photos purporting to show UFOs (Unidentified Flying Objects) or UAP (Unidentified Aerial Phenomena).

The vast majority of these photos are probably fakes, or mistaken photos of familiar objects such as weather balloons. But as scientists, we must keep an open mind. In among the rubbish, perhaps there may be one or two photos or videos that really could stretch our current knowledge.

The problem is that if someone presents me with a photo purporting to show a flying saucer, I know that the odds overwhelmingly favour it being a fake, and so I'm likely to dismiss it rather than wasting my time examining it carefully. But supposing I'm wrong?

Similarly, when we see a doorway, or a face, or a spoon, on Mars, it's all too easy to dismiss it out of hand. But we must remain alert to the possibility that one day we might find archaeological evidence of past life on Mars.

Admittedly, this seems very unlikely. But not impossible. It would be a terrible loss if, among all our careful searching through the data, we missed the thing we had been searching for because it was too easily dismissed as a trick of the light.

The Conversation, 23 May 2022

https://theconversation.com

Haptics device creates realistic virtual textures

2022-05-21

Technology has allowed us to immerse ourselves in a world of sights and sounds from the comfort of our home, but there's something missing: touch.

Tactile sensation is an incredibly important part of how humans perceive their reality. Haptics or devices that can produce extremely specific vibrations that can mimic the sensation of touch are a way to bring that third sense to life. However, as far as haptics have come, humans are incredibly particular about whether or not something feels right, and virtual textures don't always hit the mark.

Now, researchers at the USC Viterbi School of Engineering have developed a new method for computers to achieve that true texture—with the help of human beings.

Haptics or devices that can produce extremely specific vibrations that can mimic the sensation of touch are a way to bring that third sense to life.

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Called a preference-driven model, the framework uses our ability to distinguish between the details of certain textures as a tool in order to give these virtual counterparts a tune-up.

The research was published in IEEE Transactions on Haptics by three USC Viterbi Ph.D. students in computer science, Shihan Lu, Mianlun Zheng and Matthew Fontaine, as well as Stefanos Nikolaidis, USC Viterbi assistant professor in computer science and Heather Culbertson, USC Viterbi WiSE Gabilan Assistant Professor in Computer Science.

"We ask users to compare their feeling between the real texture and the virtual texture," Lu, the first author, explained. "The model then iteratively updates a virtual texture so that the virtual texture can match the real one in the end."

According to Fontaine, the idea first emerged when they shared a Haptic Interfaces and Virtual Environments class back in Fall of 2019 taught by Culbertson. They drew inspiration from the art application Picbreeder, which can generate images based on a user's preference over and over until it reaches the desired result.

"We thought, what if we could do that for textures?" Fontaine recalled.

Using this preference-driven model, the user is first given a real texture, and the model randomly generates three virtual textures using dozens of variables, from which the user can then pick the one that feels the most similar to the real thing. Over time, the search adjusts its distribution of these variables as it gets closer and closer to what the user prefers. According to Fontaine, this method has an advantage over directly recording and "playing back" textures, as there's always a gap between what the computer reads and what we feel.

"You're measuring parameters of exactly how they feel it, rather than just mimicking what we can record," Fontaine said. There's going to be some error in how you recorded that texture, to how you play it back."

The only thing the user has to do is choose what texture matches best and adjust the amount of friction using a simple slider. Friction is essential to how we perceive textures, and it can vary between the perceptions of person to person. It's "very easy," Lu said.

Their work comes just in time for the emerging market for specific, accurate virtual textures. Everything from video games to fashion design is integrating haptic technology, and the existing databases of virtual textures can be improved through this user preference method.

"There is a growing popularity of the haptic device in video games and fashion design and surgery simulation," Lu said. "Even at home, we've started to see users with those (haptic) devices that are becoming as popular as the laptop. For example, with first-person video games, it will make them feel like they're really interacting with their environment."

Lu previously did other work on immersive technology, but with sound—specifically, making the virtual texture even more immersive by introducing matching sounds when the tool interacts with it.

"When we are interacting with the environment through a tool, tactile feedback is only one modality, one kind of sensory feedback," Lu said. "Audio is another kind of sensory feedback, and both are very important."

The texture-search model also allows for someone to take a virtual texture off of a database, like the University of Pennsylvania's Haptic Texture Toolkit, and refine them until they get the result they want.

"You can use the previous virtual textures searched by others, and then based on those, you can then continue tuning it," Lu said. "You don't have to search from scratch every time."

This especially comes in handy for virtual textures that are used in training for dentistry or surgery, which need to be extremely accurate, according to Lu.

"Surgical training is definitely a huge area that requires very realistic textures and tactile feedback," Lu said. "Fashion design also requires a lot of precision in texture in development, before they go and fabricate it."

In the future, real textures may not even be required for the model, Lu explained. The way certain things in our lives feel is so intuitive that fine-tuning a texture to match that memory is something we can do inherently just by looking at a photo, without having the real texture for reference in front of us.

"When we see a table, we can imagine how the table will feel once we touch it," Lu said. "Using this prior knowledge we have of the surface, you can just provide visual feedback to the users, and it allows them to choose what matches."

Tech Xplore, 21 May 2022

https://techxplore.com

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Manufacturers getting to grips with airless tyres

2022-05-22

Airless tyres that never go flat or need to be inflated: It's a decades-long dream that manufacturers hope to turn into a reality soon, but for truck drivers first.

The challenges that the technology faces were put on display at a Goodyear test track in Luxembourg, where a group of journalists put a Tesla equipped with airless tyres through its paces.

Instead of being filled with air, the tyres have a web of spokes that keep the wheels firm and give them a see-through look.

The thin layer of rubber gripping the asphalt has a gargantuan physical challenge to meet: supporting the weight of the car and absorbing shocks as well as standard pneumatic tyres for thousands and thousands of kilometres.

That challenge is being overcome: the tyre's rubber and plastic structure resisted the huge stress as the car banked into the track's tight turns.

The ride is smooth but the grip is not as good as on conventional tyres—and they are noisier.

The tyres were tested for 120,000 kilometres (75,000 miles) at speeds of up to 160 kph in both scorching temperatures as well as snow, said Michael Rachita, who heads up Goodyear's efforts to develop airless tyres.

"The most obvious advantage is that it's puncture proof," said Rachita.

"It will never run flat, you could drive over any nail and expect not to lose performance," he added.

Rachita said airless tyres will also be maintenance free for drivers as they will never need to check and adjust air pressure.

He said a second generation of airless tyres that are lighter, quieter and roll better are in the works.

Gradual transition seen

Michelin has released the Tweel, but it is for construction vehicles rather than cars where the demands in terms of driving performance are much greater.

Instead of being filled with air, the tyres have a web of spokes that keep the wheels firm and give them a see-through look.

The French firm has also unveiled the Uptis which it is developing with US car manufacturer General Motors, and which it hopes can make the jump from auto shows to showrooms next year.

Its researchers are working on a cocktail of fibreglass and resin to hold the rubber onto the honeycomb structure of the new tyre.

But Michelin's CEO Florent Menegaux doesn't expect airless tyres to squeeze out regular tyres anytime soon.

The challenges that the technology faces were put on display at a Goodyear test track in Luxembourg, where a group of journalists put a Tesla equipped with airless tyres through the paces.

"We're going continue to have air tyres for several decades," he said.

Goodyear, which submitted its first patent on airless tyre technology in 1982, has recently put its foot down on the accelerator in terms of research and development.

The US firm aims to have a maintenance-free and long-lasting airless tyre for cars by the end of the decade.

It already has an early version for shuttle buses and automated delivery vehicles on university campuses.

Bridgestone also hopes to have an airless tyre ready within a decade, having already tested early versions on utility vehicles.

Other manufacturers are more sceptical that airless tyres will ever offer comparable shock absorption as traditional tyres and the noise can be reduced sufficiently.

"They aren't a viable solution and I don't expect they will become one," a Continental researcher, Gerrit Bolz, said at a tyre convention in 2017.

Environmental benefits, economic concerns

But independent researcher Ulf Sandberg at the Swedish National Road and Transport Research Institute, which is working on an airless tyre for trucks, believes they will eventually become a viable alternative.

"I believe that sooner or later airless tyres could take over," he told AFP.

"If rolling resistance is reduced by 50 percent, it would increase the range of vehicles by 25 percent, and could be extremely valuable" for

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car manufacturers, particularly for electric vehicles where range is a key concern.

Airless tyres could prove to be environmentally beneficial as they could last the entire lifetime of most vehicles and could then be recycled or retreaded for a second life.

But manufacturers may not be burning rubber to bring airless tyres to market because they also pose threats to their business model, said Sandberg.

A switch to airless tyres would strand the manufacturing equipment used for pneumatic tyres, a heavy cost for the companies to bear.

Given the longevity of the airless tyres, companies would be making less of them.

Goodyear's vice president for product development in Europe, Xavier Fraipont, acknowledged that airless tyres requires a "rethinking our business model, of rethinking our manufacturing".

Yet the possibility of gaining a lead on competitors or being left behind by an affordable and high-performing airless tyre for the consumer market keeps their research rolling forward.

Tech Xplore, 22 May 2022

https://techxplore.com

Why do my armpits smell? And would using glycolic acid on them really work?

2022-05-24

You showered this morning, are wearing fresh clothes and having an otherwise normal day, when suddenly you notice that stench.

Why do our armpits smell, and why more at some times than others?

It all comes down to an oily secretion from special glands beneath our skin, which are very prevalent under the armpits, and more active at certain times.

And despite what you might have heard on Instagram or TikTok, wiping under your arms with glycolic acid is not the best long-term solution.

The oily paste

It all comes down to an oily secretion from special glands beneath our skin, which are very prevalent under the armpits, and more active at certain times.

The main sweat glands (called "eccrine" sweat glands) covering most of our body secrete primarily water, which is odourless and evaporates to cool us down.

However, our body is also equipped with a second type of sweat gland, called "apocrine sweat glands".

They're mostly around areas with lots of hair follicles, such as the armpits and groin. These glands secrete an oily compound, and become more active in response to stress, fear, anxiety, pain, and sexual stimulation.

Initially odourless, this oily secretion provides great food for bacteria living on our skin.

The bacteria convert this sweat into fatty acids, and compounds that produce scents, giving off an odour with smell traces reminiscent of onion, cumin, and rotten meat.

The type of bacteria is relatively consistent between people, but the balance between each type can be different.

Genetics play a prominent role in how we smell.

And because our apocrine glands respond to emotions, our thoughts and lifestyle can influence on their activity.

Even some foods, such a lot of red meat, can alter the smell.

For both men and women, underarm hair can also cause a more prominent smell.

But what's the role of this smell?

Apocrine sweat glands don't generally activate until puberty, which is why body odour isn't really a concern when we're young.

The scent also changes with the production of hormones.

For example, during the menstrual cycle, the most "attractive" smell occurs around the time of ovulation, when women are most fertile. However, the sexual function of body odour doesn't appear to play a major role in humans.

Nonetheless, there may be some social relevance to our unique scent. Newborn babies can recognise their mother's armpit smells a few weeks after delivery, and mothers can distinguish the smell of their own baby by about three weeks.

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How to avoid the odour?

Our sweat gland secretions are odourless, so the longer the bacteria on our skin have to process the oils, the more scented compounds they can produce.

That's why showering every day helps reduce odour.

Antiperspirants reduce the amount of sweat released by the glands. This is usually due to ingredients such as aluminium, which form a temporary blockage in the glands.

Deodorants work to mask the odours with stronger, pleasant scents. They often also contain alcohols or ingredients that can turn your skin slightly acidic, or make the area less hospitable to bacteria.

Choose clothing wisely. If your skin is moist for a long time it gives bacteria a chance to grow. Clean clothes that allow for good airflow can help keep you smelling fresher for longer during the day.

Caffeine, some medications, as well as some illicit drugs such as methamphetamine, MDMA, heroin and cocaine can increase sweating, which will affect body odour.

What about antiperspirants and glycolic acid?

You may have heard antiperspirants containing aluminium could cause cancer. The Cancer Council has called this a myth and a rumour, with no scientific studies specifically linking the use of these products to cancer.

Nonetheless, it is wise to consider the cosmetics or chemicals we put on our skin. If you find your antiperspirant or deodorant is causing irritation or rashes, try a product with different ingredients or consult a doctor.

A recent trend on Tik Tok and Instagram suggests using glycolic acid (often used as an exfoliant for the face) on the armpits to reduce smell.

Theoretically, adding this chemical to your armpit will alter the environment under the arms. This can inhibit bacteria growth, and assist to reduce body odour. However, it could irritate the skin, particularly under the arms where there is a lot of friction, and especially if the area was recently shaved.

It will also not inhibit the amount you sweat.

Glycolic acid straight from the bottle will not act for long, as sweat from the armpits will dilute and neutralise its activity. This means even if it works temporarily, you'll likely be back to your odorous ways pretty soon.

If you're aiming to avoid chemical products, the best steps to an odour-free life are the obvious ones. Shower daily with soap (and dry off thoroughly), wear breathable fabrics (like cotton, linen or moisture-wicking sportswear), keep your clothes clean, reduce stress and limit your caffeine intake.

The Conversation, 24 May 2022

https://theconversation.com

Metal-lifespan analysis shows scale of waste

2022-05-26

Metals might be the foundation of the modern economy, but that doesn't mean they stick around.

A study looking at the economic lifetimes of 61 commercially used metals finds that more than half have a lifespan of less than 10 years. The research, published on 19 May in Nature Sustainability1, also shows that most of these metals end up being disposed of or lost in large quantities, rather than being recycled or reused.

Billions of tonnes of metal are mined each year, and metal production accounts for around 8% of all global greenhouse-gas emissions. So, recycling more metal could help to lower its environmental impacts, says co-author Christoph Helbig, an industrial ecologist at the University of Bayreuth in Germany.

"The longer we use metals, the less we need to mine," says Helbig. "But before we can identify how to close those loops, we need to know where they are."

The fact that the economy haemorrhages metals is well documented, says Thomas Graedel, an industrial ecologist at Yale University in New Haven, Connecticut. Losses can occur at any stage of a metal's lifespan. Some metals are dug up as by-products during mining but are never made into products. Others are lost during use when components or machinery break apart, or are converted into other substances, such as fertilizers, that are ultimately dispersed into the environment. But the study found that waste and recycling — when metals end their lives in landfill or at recycling plants — accounted for 84% of cumulative metal loss globally.

Mining metals has a rising environmental cost. But high losses and low recycling rates mean that many last only a short time.

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Most previous studies that attempted to quantify these losses looked at individual metals without examining the wider context, says Graedel. Helbig and his colleagues amassed and compared data from several industries to see how long different metals stayed useful, how they were lost and whether they were likely to be recycled.

They found that for many metals, only a small proportion is recycled (see 'Scrap metal'). Exceptions include gold, which stays in use for centuries and can be repurposed many times, as well as iron and lead. Several metals that have been designated 'critically important' in the European Union and the United States have high rates of loss and low rates of recycling. These include cobalt, a key component of aircraft engines and lithium-ion batteries, and gallium, which has a crucial role in semiconductors used in mobile phones and other devices.

One way to boost recycling would be to mandate that new products are made with reused metal, says Helbig. For example, the European Union is considering introducing a requirement that some types of battery be made using recycled lithium, nickel, cobalt and lead.

Recycling alloys — mixtures of two or more metals — can be technologically and economically challenging, points out Philip Nuss, an industrial ecologist at the German Environmental Agency in Dessau-Roßlau. Still, giving metals a second, third or even fourth life is essential for building sustainable economies, Helbig says.

Nature, 26 May 2022

https://nature.com

When self-driving cars crash, who's responsible? Courts and insurers need to know what's inside the 'black box'

2022-05-25

The first serious accident involving a self-driving car in Australia occurred in March this year. A pedestrian suffered life-threatening injuries when hit by a Tesla Model 3 in "autopilot" mode.

In the U.S., the highway safety regulator is investigating a series of accidents where Teslas on autopilot crashed into first-responder vehicles with flashing lights during traffic stops.

The decision-making processes of "self-driving" cars are often opaque and unpredictable (even to their manufacturers), so it can be hard to determine who should be held accountable for incidents such as these.

Manufacturers and developers of AI-based systems like self-driving cars may not be able to foresee and control everything the "autonomous" system does, but they can take measures to reduce risks.

However, the growing field of "explainable AI" may help provide some answers.

Who is responsible when self-driving cars crash?

While self-driving cars are new, they are still machines made and sold by manufacturers. When they cause harm, we should ask whether the manufacturer (or software developer) has met their safety responsibilities.

Modern negligence law comes from the famous case of Donoghue v Stevenson, where a woman discovered a decomposing snail in her bottle of ginger beer. The manufacturer was found negligent, not because he was expected to directly predict or control the behavior of snails, but because his bottling process was unsafe.

By this logic, manufacturers and developers of AI-based systems like self-driving cars may not be able to foresee and control everything the "autonomous" system does, but they can take measures to reduce risks. If their risk management, testing, audits and monitoring practices are not good enough, they should be held accountable.

How much risk management is enough?

The difficult question will be "How much care and how much risk management is enough?" In complex software, it is impossible to test for every bug in advance. How will developers and manufacturers know when to stop?

Fortunately, courts, regulators and technical standards bodies have experience in setting standards of care and responsibility for risky but useful activities.

Standards could be very exacting, like the European Union's draft AI regulation, which requires risks to be reduced "as far as possible" without regard to cost. Or they may be more like Australian negligence law, which permits less stringent management for less likely or less severe risks, or where risk management would reduce the overall benefit of the risky activity.

Legal cases will be complicated by AI opacity

Once we have a clear standard for risks, we need a way to enforce it. One approach could be to give a regulator powers to impose penalties (as the ACCC does in competition cases, for example).

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Individuals harmed by AI systems must also be able to sue. In cases involving self-driving cars, lawsuits against manufacturers will be particularly important.

However, for such lawsuits to be effective, courts will need to understand in detail the processes and technical parameters of the AI systems.

Manufacturers often prefer not to reveal such details for commercial reasons. But courts already have procedures to balance commercial interests with an appropriate amount of disclosure to facilitate litigation.

A greater challenge may arise when AI systems themselves are opaque "black boxes." For example, Tesla's autopilot functionality relies on "deep neural networks," a popular type of AI system in which even the developers can never be entirely sure how or why it arrives at a given outcome.

'Explainable AI' to the rescue?

Opening the black box of modern AI systems is the focus of a new wave of computer science and humanities scholars: the so-called "explainable AI" movement.

The goal is to help developers and end users understand how AI systems make decisions, either by changing how the systems are built or by generating explanations after the fact.

In a classic example, an AI system mistakenly classifies a picture of a husky as a wolf. An "explainable AI" method reveals the system focused on snow in the background of the image, rather than the animal in the foreground.

How this might be used in a lawsuit will depend on various factors, including the specific AI technology and the harm caused. A key concern will be how much access the injured party is given to the AI system.

The Trivago case

Our new research analyzing an important recent Australian court case provides an encouraging glimpse of what this could look like.

In April 2022, the Federal Court penalized global hotel booking company Trivago $44.7 million for misleading customers about hotel room rates on its website and in TV advertising, after a case brought on by competition watchdog the ACCC. A critical question was how Trivago's complex ranking algorithm chose the top ranked offer for hotel rooms.

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The Federal Court set up rules for evidence discovery with safeguards to protect Trivago's intellectual property, and both the ACCC and Trivago called expert witnesses to provide evidence explaining how Trivago's AI system worked.

Even without full access to Trivago's system, the ACCC's expert witness was able to produce compelling evidence that the system's behavior was not consistent with Trivago's claim of giving customers the "best price."

This shows how technical experts and lawyers together can overcome AI opacity in court cases. However, the process requires close collaboration and deep technical expertise, and will likely be expensive.

Regulators can take steps now to streamline things in the future, such as requiring AI companies to adequately document their systems.

The road ahead

Vehicles with various degrees of automation are becoming more common, and fully autonomous taxis and buses are being tested both in Australia and overseas.

Keeping our roads as safe as possible will require close collaboration between AI and legal experts, and regulators, manufacturers, insurers, and users will all have roles to play.

Tech Xplore, 25 May 2022

https://techxplore.com

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Genotoxicity Associated with 131 I and 99m Tc Exposure in Nuclear Medicine Staff: A Physical and Biological Monitoring Study

Experimental Study on the Detection of Hazardous Chemicals Using Alternative Sensors in the Water Environment

Determination of cytotoxicity following oxidative treatment of pharmaceutical residues in wastewater

ENVIRONMENTAL RESEARCH

An Interactive Online App for Predicting Diabetes via Machine Learning from Environment-Polluting Chemical Exposure Data

Chemical Mixtures in Household Environments: In Silico Predictions and In Vitro Testing of Potential Joint Action on PPARγ in Human Liver Cells

Environmental Health Needs Among Latinas in Cleaning Occupations: A Mixed Methods Approach

Environmental Occurrence and Predicted Pharmacological Risk to Freshwater Fish of over 200 Neuroactive Pharmaceuticals in Widespread Use

Integrated Framework for Identifying Toxic Transformation Products in Complex Environmental Mixtures

PHARMACEUTICAL/TOXICOLOGY

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OCCUPATIONAL

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