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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

AICIS industrial chemicals regulatory news

2020-10-30

We're now four months into our new scheme, and I'm four weeks into my new role as Acting Executive Director of AICIS. I'd like to thank my predecessor, Dr Brian Richards, for his incredible commitment and leadership during his eight-year tenure. We wish him well in retirement.

As we head towards the end of this calendar year, a key priority is improving our efficiency and developing our IT systems so that more of our processes are online.

With that in mind, our **annual declaration** and **post-introduction declaration** forms will be available on [AICIS Business Services](#) in the next IT release slated for the end of November. This is an essential part of our new scheme and I know many introducers have been inquiring about these features. Although every introducer must submit an annual declaration form, it is only required to be submitted at the end of the registration year.

It's also encouraging to see our stakeholders successfully using our existing suite of online services. To illustrate this point, we've already received about **170 pre-introduction reports** through the Business Services portal.

Many stakeholders have asked questions or requested advice on aspects of the new scheme, so we've published a series of online guides to walk you through the process of [categorising your chemical importation and manufacture](#) and [categorising chemical introductions that have been assessed overseas](#); plus a host of [extra resources to help you categorise your introduction](#). We continue to work on guidance based on your comments, so please keep giving us your feedback.

Full Article

Australian Government Department of Health, 30 October 2020

<https://www.industrialchemicals.gov.au/help-and-guides/extra-resources-help-you-categorise-your-introduction>

This is an essential part of our new scheme and I know many introducers have been inquiring about these features.

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A list of chemicals added to the Inventory 5 years after issue of assessment certificate

2020-10-29

The following industrial chemicals have been added to the Australian Inventory of Industrial Chemicals in accordance with section 82 of the Industrial Chemicals Act 2019 because 5 years have passed since the assessment certificates for the industrial chemicals were issued.

Chemical Name	Decanedioic acid, polymer with 11-aminoundecanoic acid and 4,4 -methylenebis[2-methylcyclohexanamine]
Molecular Formula	(C15H30N2.C11H23NO2.C10H18O4)x
Specific information requirements	Obligations to provide information apply. You must tell us within 28 days if the circumstances of your importation or manufacture (introduction) are different to those in our assessment.
Listing date	21 October 2020
CAS Number	1353573-37-1
Chemical Name	1,7-Naphthalenedisulfonic acid, 4-amino-5-hydroxy-3-[2-(5-hydroxy-1,7-disulfo-2-naphthalenyl)diazenyl]-6-[2-(4-nitro-2-sulfo-phenyl)diazenyl]-, sodium salt (1:5),
coupled with diazotized 2-amino-5-[2-(4-sulfo-phenyl)diazenyl] benzenesulfonic acid, sodium salts	
Molecular Formula	Unspecified
Specific information requirements	Obligations to provide information apply. You must tell us within 28 days if the circumstances of your importation or manufacture (introduction) are different to those in our assessment.
Listing date	26 October 2020
CAS Number	1673536-21-4
Chemical Name	2,5-Furandione, polymer with 1-dodecene, C8-14-alkyl C9-11-alkyl esters

The following industrial chemicals have been added to the Australian Inventory of Industrial Chemicals in accordance with section 82 of the Industrial Chemicals Act 2019 because 5 years have passed since the assessment certificates for the industrial chemicals were issued.

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Chemical Name	Decanedioic acid, polymer with 11-aminoundecanoic acid and 4,4 -methylenebis[2-methylcyclohexanamine]
Molecular Formula	Unspecified

Industrial Chemicals, 29 October 2020

<https://www.industrialchemicals.gov.au/news-and-notice/chemicals-added-inventory-5-years-after-issue-assessment-certificate-29-october-2020>

28 substances are added to China IECSC list

2020-10-28

28 Substances are added into the List of Existing Chemical Substances in China. Among them, 18 substances are registered under MEP Order No. 7 while other 10 substances are registered under SEPA Order No. 17.

These 28 substances will be managed as existing substances after inclusion.

CIRS has added the 28 substances into the Asia-Pacific Chemical Inventory Search System (APCISS). If you would like to know whether substances are listed in IECSC, please go to CIRS's APCISS system.

Full Article

CIRS, 28 October 2020

<http://www.cirs-reach.com/news-and-articles/28-Substances-are-Added-to-China-IECSC-List.html>

AMERICA**TSCA Section 21 petition seeks section 4 test rule for 54 PFAS**

2020-10-29

On October 14, 2020, a coalition of non-governmental organizations (NGO) petitioned the U.S. Environmental Protection Agency (EPA) under Section 21 of the Toxic Substances Control Act (TSCA) to request that EPA require health and environmental effects testing on 54 per- and polyfluoroalkyl substances (PFAS). The petition seeks issuance of a rule

Among them, 18 substances are registered under MEP Order No. 7 while other 10 substances are registered under SEPA Order No. 17.

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or order under TSCA Section 4 compelling The Chemours Company (Chemours) to fund and carry out this testing under the direction of a panel of independent scientists. EPA acknowledged receipt of the petition, noting that TSCA Section 21 provides that the EPA Administrator shall either grant or deny a petition within 90 days (January 11, 2021, in this case) after the date of filing. If the Administrator grants the petition, the Administrator shall promptly commence an appropriate proceeding. If the Administrator denies the petition, the Administrator shall publish the reasons for such a denial in the *Federal Register*. EPA states that the petition is under review by the Office of Pollution Prevention and Toxics (OPPT). The petition was filed by the following non-profit public health, environmental, and environmental justice groups based in North Carolina -- Center for Environmental Health, Cape Fear River Watch, Clean Cape Fear, Democracy Green, the NC Black Alliance, and Toxic Free NC.

According to the petition, the Fayetteville chemical manufacturing facility, located on the Cape Fear River upstream of Wilmington, North Carolina, "has long been a major producer and user of PFAS under the ownership of E. I. DuPont de Nemours & Company, Inc. (DuPont) and, since 2015, Chemours, a DuPont spinoff." The petition states that several of these PFAS have been identified in drinking water sources serving over a quarter of a million people in the Cape Fear watershed, in human blood, and in environmental media. Petitioners have identified a total of 54 PFAS (not including legacy substances) that they claim are attributable to the Chemours facility and have been detected in environmental media and/or people in the Cape Fear River watershed.

The petition acknowledges that under a consent order between EPA and Chemours, GenX compounds have undergone some toxicological testing but states that available studies are incomplete. According to the petition, there is also some testing underway on a small number of other PFAS under a North Carolina consent order, but these studies are limited in scope. The petition states that no health or environmental effects testing has been conducted on the remainder of the 54 PFAS, and for all 54 substances, there are insufficient data to determine risks to the exposed population and the surrounding ecosystem and to set risk reduction targets and other protective measures.

Full Article

The National Law Review, 29 October 2020

<https://www.natlawreview.com/article/tsca-section-21-petition-seeks-section-4-test-rule-54-pfas>

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TURI calls for information on carbon nanotubes and carbon nanofibers

2020-10-28

According to the [Toxics Use Reduction Institute's \(TURI\) website](#), the Toxics Use Reduction Act (TURA) Program in Massachusetts has received a petition to list carbon nanotubes (both single-walled and multi-walled) and carbon nanofibers. The TURA Science Advisory Board (SAB) is beginning the process of reviewing these substances and seeks additional information from stakeholders. SAB's primary role is to consider petitions to add or delete chemicals from the TURA list and make recommendations to TURI accordingly.

Massachusetts enacted TURA in 1989. TURA established a Toxic or Hazardous Substance List, often referred to as the [TURA list](#). Companies subject to TURA are required to file an annual Toxics Use Report that identifies:

- Every TURA-listed chemical the company manufactures, processes, or otherwise uses above applicable thresholds;
- All production processes and products that use one or more listed chemicals; and
- The amount of each listed chemical generated as byproduct (wasted), shipped in product, and released to the environment.

Full Article

Nano and other emerging chemical technologies blog, 28 October 2020

<https://nanotech.lawbc.com/2020/10/turi-calls-for-information-on-carbon-nanotubes-and-carbon-nanofibers>

EUROPE**Before implementing new plastic bottle legislation, European Commission should review Finland's longstanding return scheme**

2020-10-18

The increasing amount of plastic pollution in our oceans and seas is one of the greatest environmental challenges of our time. With such a widespread and global problem, solutions require common legislation.

The TURA Science Advisory Board (SAB) is beginning the process of reviewing these substances and seeks additional information from stakeholders.

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One achievement of the previous legislature was the conclusion of the Directive 2019/904, which aims to reduce the impact of certain single-use plastic products on Europe's maritime environment. I will examine this from the perspective of a Member State with a long history of recycling plastic bottles.

Finland is known for its unique deposit-based recycling system. 92 percent of all plastic bottles, together with their caps, are currently recycled. A deposit encourages consumers to return empty bottles and cans for recycling, thus preventing it from ending up in nature or in mixed waste. In return, citizens redeem €280m each year in return pledges.

There are also incentives for companies, as participating in the return system means avoiding packaging tax. First launched in the 1950s with the recycling of glass bottles in the Helsinki Olympics in 1952, the system nowadays recycles virtually all glass bottles in Finland. In 1996, the system started to cover aluminium cans, and in 2008 PET-based bottles.

PALPA, the non-profit company in charge of the return system is owned by large retailers and breweries. In January 2020, I asked the European Commission to clarify a specific conflict between Finland's recycling system and the new requirements of the Directive on single-use plastic. The problem is that the recently approved Directive requires plastic caps and lids to remain attached to the container during use (Article 6).

Full Article

The Parliament Magazine, 18 October 2020

<https://www.theparliamentmagazine.eu/news/article/rational-implementation-of-single-use-plastics>

Chemicals strategy for sustainability — Towards a toxic-free environment

2020-10-14

The European Commission (EC) has published the chemicals strategy for sustainability, published on Oct. 14, 2020. The document lays out more than 50 wide-ranging actions that will directly impact the industry and are listed for completion by 2024.

The document lays out more than 50 wide-ranging actions that will directly impact the industry and are listed for completion by 2024.

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Full Document

European Commission, 14 October 2020

<https://ec.europa.eu/environment/pdf/chemicals/2020/10/Strategy.pdf>

Aircraft air quality and transport's virus-risk in focus

2020-10-26

Air quality on flights is due to improve if the European Union agrees to back new safety standards. The fresh push for cleaner air comes as transport companies struggle to convince passengers their services are low risk in the ongoing spread of the coronavirus.

New standards developed by the European Committee on Standardisation (CEN) over the course of the last five years aim to prevent plane passengers from being exposed to engine oil and hydraulic fumes during flight.

A majority of aircraft compress air in their engines and then pump it into the plane, in order to preserve cabin pressures. This causes low-level contamination with engine fumes, which can reach higher levels if planes are not maintained properly.

This has been standard operating procedure on commercial airliners for more than 60 years.

Representatives from the airline and manufacturing industries, passenger groups, and trade unions collaborated on the standard. In a statement, they said that it "represents what can be accomplished when experts from every side of the issue collaborate within a structured and balanced framework".

The new criteria would ensure that ventilation systems flood aircraft cabins with enough air so as to prevent the build-up of odors or contaminants, such as carbon dioxide, and sets a minimum airflow rate to achieve that.

CEN still needs to finalize the standard, which the European Commission, Parliament, and European Aviation Safety Agency (EASA) must then also approve in order for it to become binding.

"We believe that the new standard provides a world-beating reference on how to manage the issue of contaminated air on aircraft and [...] stands above current standards regulation," the statement added.

This has been standard operating procedure on commercial airliners for more than 60 years.

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The Commission could decide to adopt it into the bloc's existing aviation regulations if officials conclude that the standard will help regulate the single market more effectively. It would also likely satisfy 'better regulation' policy-making, as the work has essentially been done already.

Full Article

EURACTIV, 26 October 2020

<https://www.euractiv.com/section/transport/news/aircraft-air-quality-and-transport-virus-risk-in-focus/>

Boosting circularity: How the industry is driving sustainability

2020-10-27

The European Union is betting big on circular economy initiatives that boost recycling and reuse while decreasing resource consumption. But ambitious policies need industry buy-in to work and they appear to be getting it already.

In March, the European Commission published the Circular Economy Action Plan, a package of initiatives that aims to double the EU's use of recycled material this decade, increase GDP and contribute to the bloc's climate agenda.

Among the raft of measures, the Commission wants to incentivise manufacturers to design products that last longer and can be recycled or reused, but also grant consumers a "right to repair" for their purchases.

The plan tackles a number of sectors, including electronics, plastics, buildings, packaging, batteries and textiles, the latter of which is among the biggest consumers of raw materials and a significant greenhouse gas emissions producer.

At a virtual event organised by EDANA, an association group for the nonwoven industry, Paola Migliorini, a senior Commission official who has oversight of the action plan, described how ratcheting up circularity will have an across-the-board impact.

"We are using way too many resources in respect to what we have available. Three times that one planet can give. This creates up to 90% of biodiversity loss. By 2050, waste generated could increase to 70%," she warned.

"We are using way too many resources in respect to what we have available. Three times that one planet can give..."

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Migliorini also explained how the strategy aims to extend eco-design principles beyond energy-intensive products and implement a "digital product passport" that will give recyclers and consumers vital information about an item's composition.

In terms of textiles, the Commission intends to make sure EU countries collect waste textiles separately by 2025 so that they can be recycled or reused to a greater extent than they are currently.

The EU executive is also working on an Extended Producer Responsibility scheme (EPR) for textiles, under which producers would be tasked with making sure their products are disposed of in the correct manner.

EPRs are designed to incentivise producers to make their products easier to recycle or reuse, as they are held financially or physically responsible for their fate. The Commission's textile EPR is still on the drawing board and a list of products still needs to be finalised.

Full Article

EURACTIV, 27 October 2020

<https://www.euractiv.com/section/circular-economy/news/boosting-circularity-how-the-industry-is-driving-sustainability/>

INTERNATIONAL

Transportation of COVID-19 vaccine

2020-10-29

Air cargo plays a key role in the distribution of vaccines through well-established temperature-sensitive distribution systems, using cutting-edge technology and procedures.

This capability will prove crucial to the quick and efficient transport of COVID-19 vaccines once available. This will naturally require careful planning by every segment in the entire cargo supply chain to ensure full preparedness when vaccines for COVID-19 are approved and ready for distribution.

To guarantee the quality of the product, vaccines must be handled and transported in line with international regulatory and manufacturers' requirements, at controlled temperatures, and without delay.

This capability will prove crucial to the quick and efficient transport of COVID-19 vaccines once available.

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Priorities for developing capacity and resources for vaccine distribution include:

- The availability of temperature-controlled facilities and appropriate equipment—maximizing the use or re-purposing of existing infrastructure and minimizing temporary builds;
- The availability of staff trained to handle time and temperature-sensitive vaccines; and
- The development of robust monitoring capabilities to ensure the integrity of the vaccines is maintained

Full Article

IATA, 29 October 2020

https://www.iata.org/en/programs/cargo/pharma/vaccine-transport/?utm_source=Pardot&utm_medium=Email&utm_campaign=M-CBS-Vaccine-2020

UNEP: Export of used cars to developing world creating significant enviro

2020-10-28

Millions of used cars, vans and minibuses exported from Europe, the United States and Japan to the developing world are of poor quality, contributing significantly to air pollution and hindering efforts to mitigate the effects of climate change, according to a new report by the UN Environment Programme (UNEP).

The report shows that the three largest exporters of used vehicles—the European Union (EU), Japan, and the United States of America (USA)—exported 14 million used light duty vehicles (LDVs) worldwide between 2015 and 2018. The EU was the largest exporter with 54% of the total followed by Japan (27%) and the USA (18%). Some 80% went to low- and middle-income countries, with more than half going to Africa.

Used Vehicles and the Environment - A Global Overview of Used Light Duty Vehicles: Flow, Scale and Regulation, the first report of its kind, calls for action to fill the current policy vacuum with the adoption of harmonized minimum quality standards that will ensure used vehicles contribute to cleaner, safer fleets in importing countries.

The fast-growing global vehicle fleet is a major contributor to air pollution and climate change; globally, the transport sector is responsible for nearly a quarter of energy-related global greenhouse gas emissions. Specifically,

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vehicle emissions are a significant source of the fine particulate matter (PM2.5) and nitrogen oxides (NOx) that are major causes of urban air pollution.

Full Article

Green Car Congress, 28 October 2020

<https://www.greencarcongress.com/2020/10/20201028-unep.html>

The EU was the largest exporter with 54% of the total followed by Japan (27%) and the USA (18%).

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REACH Update

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Recyclers told of dual post-Brexit chemicals rules

2020-10-27

Plastics Recyclers Europe (PRE) has warned that, from 1 January 2021, companies that import or export waste plastic must meet both EU and UK rules for the registration, evaluation, authorisation and restriction of chemicals (REACH).

It said in [a briefing](#) on the legislative changes following Brexit that “anyone producing, selling or distributing chemicals in the UK and the EU will therefore need to follow both UK REACH and EU REACH rules”.

It said: “When a UK-based recycler exports its product to the EU, it will need to be covered by an EU REACH registration.”

The exact nature of the UK’s chemicals regulation regime, and any co-operation with the European Chemicals Agency (ECHA), will ultimately depend on negotiations that are still in progress.

Under UK plans, the Health and Safety Executive (HSE), working with Defra, will take an equivalent role to that of the ECHA

Full Article

MRW, 27 October 2020

<https://www.mrw.co.uk/news/recyclers-told-of-dual-post-brexit-chemicals-rules-27-10-2020/>

Tracking chemicals of concern in products—SCIP database ready for use

2020-10-28

Industry can now submit information on substances of very high concern in their articles to ECHA’s SCIP database. The aim is to make recycling of products safer and improve information about dangerous chemicals in products.

Helsinki, 28 October 2020 – The SCIP database was launched today and companies can submit data on substances of very high concern (SVHCs) in their articles. The Waste Framework Directive requires companies to submit their data as of 5 January 2021. Consumers and waste operators can access and use the data from February 2021 onwards.

“We need to know more about the hazardous chemicals in products so that they can be safely recycled. This is key for a better circular economy

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and essential to make the EU Green Deal work. The increased knowledge protects workers, citizens and the environment, helps consumers make safer choices and encourages industry to replace hazardous chemicals with safer ones. We call on industry to start submitting the data to us now and we stand ready to support them,” says Bjorn Hansen, ECHA’s Executive Director.

The database has been developed in close cooperation with stakeholders and a dedicated IT user group of more than 60 members. Based on industry feedback, the database includes mechanisms that simplify the work for companies. For example, a system-to-system submission function helps companies submit notifications in an automated way. It also allows them to work together so they can submit notifications by referring to data that has already been submitted.

For support, companies can consult the material published on ECHA’s website or contact ECHA’s helpdesk. A webinar on SCIP, including a demo of the tools and new features, will take place on 19 November.

Full Article

ECHA, 28 October 2020

<https://echa.europa.eu/fr/-/tracking-chemicals-of-concern-in-products-scip-database-ready-for-use>

IUCLID 6.5 is available

2020-10-28

Every October, a new major release of IUCLID is published and made available to all users. Major releases contain not only fixes and improvements but also changes to the IUCLID format.

The IUCLID team has implemented, in the new version of the IUCLID format, the latest changes of the OECD Harmonised Templates, a revised Classification and Labelling format in accordance with the latest updates of the CLP regulation and revision of the Globally Harmonised System. In addition, the relevant modifications have been made to the SCIP and PCN formats in order to comply with the agreed information requirements for submissions to the SCIP database and the Poison Centres in Europe. Updates specified by Australia and New Zealand have also been made in order to support the implementation of IUCLID in both OECD member countries. Finally, the 2019 prototype of the format extension to make possible Pesticides submissions in Europe has evolved into a first official

Updates specified by Australia and New Zealand have also been made in order to support the implementation of IUCLID in both OECD member countries.

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version of IUCLID for these dossier types, under the supervision of an EFSA technical group.

On the software features side, some evolutions can be noted too, particularly the move towards the web interface of IUCLID which is accelerating its pace with the abandonment of the classic interface availability by default. There will still be a possibility to continue accessing and using the classic interface in the next months though, following the instructions published on the IUCLID website. This solution was made possible by the progress in reducing the gap between the two interfaces, for example by proposing a more efficient way of managing datasets or by proposing advanced import options.

You can access the full release notes and download the new version from the IUCLID website. ECHA cloud services users will see their installations automatically upgraded the week of the release. We will hold a webinar, on the 11th of November, where we will present this new release in more detail.

Full Article

ECHA, 28 October 2020

https://iuclid6.echa.europa.eu/fi/view-article/-/journal_content/title/iuclid-6-5-is-available

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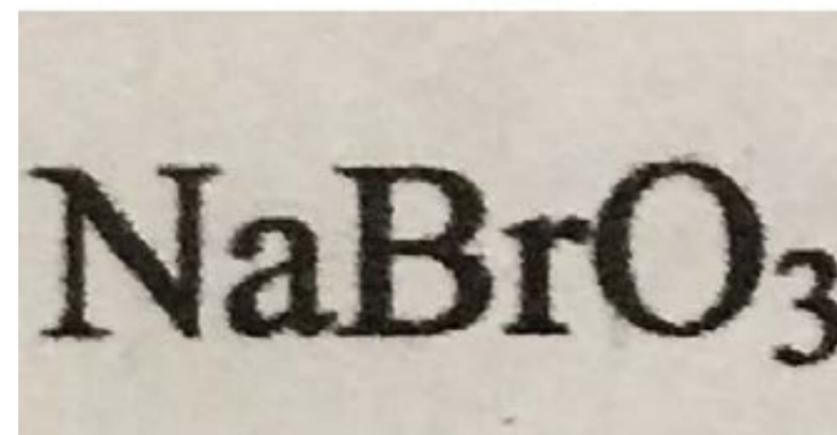
Janet's Corner

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Hey do you like chemistry?

2020-11-06

Hey do you like chemistry?



https://www.pinterest.com.au/pin/57561701477352956/?nic_v2=1a1YYTDXG

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Hazard Alert

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Benzoic Acid

2020-11-06

Benzoic acid, aka benzoate or E210, is a colourless organic crystalline solid, with the chemical formula of C_6H_5COOH . It has a faint but pleasant odour and is soluble in water. [1,2,3]

USES [2,4]

Benzoic acid is used across various applications in a range of industries. It is used as an antimicrobial preservative in food and beverages. It is also used in the manufacture of plastics, dyes, insect repellents and various other cosmetics. Benzoic acid is an ingredient in the industrial production of phenol.

ROUTES OF EXPOSURE [5]

- Routes of exposure include inhalation and skin/eye contact.

HEALTH EFFECTS

Benzoic acid poisoning affects a range of systems, including the integumentary and respiratory systems.

Acute Effects [4]

Severity of symptoms depend on the level and type of exposure.

Inhalation of the acid may result in irritation of the respiratory tract, resulting in coughing, red itching eyes, runny nose and eyes and a sore throat. For those who already have impaired respiratory functions, inhalation of this acid may cause further damage. Ingestion of benzoic acid may be fatal. Skin contact could result in dermatitis, characterised by swelling and redness. The acid could also cause systemic injury if it gets into the bloodstream. Eye contact could result in ocular lesions.

Chronic Effects [5]

Chronic exposure to benzoic acid is toxic to multiple body systems. Long term exposure to the acid can result in disease of the airway, including difficulty breathing. Limited research has found that long-term occupational exposure to this acid can result in cumulative health effects. Symptoms can be activated by a variety of environmental triggers, including smoke, perfume, and exhaust.

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Hazard Alert

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~h1Safety

First Aid Measures [5]

- Ingestion: DO NOT induce vomiting, and contact a medical professional IMMEDIATELY.
- Skin contact: Remove all contaminated clothing, footwear and accessories. Do not re-wear clothing until it has been thoroughly decontaminated. Immediately rinse affected areas with plenty of soap and water. For the different types of burns, read the SDS on benzoic acid. Contact a doctor immediately.
- Eye contact: Flush eyes (including under the eyelids), with fresh running water for at least 15 minutes. Removal of contact lenses should only be done by skilled personnel. Contact a medical professional immediately. For thermal burns, DO NOT remove contact lens. Pad both eyes, making sure the dressing does not touch the injured eye.
- Inhalation: If the person inhales fumes, remove them from the contaminated site. Protheses, such as false teeth, should be removed prior to first aid procedures, as they may block airways. Perform CPR if you are qualified and if the patient is unconscious and not breathing. Use a one-way valve and mask if possible. Immediately contact a medical professional.
- General: Never administer anything by mouth to an unconscious, exposed person.

Exposure Controls/Personal Protection [7]

- Engineering controls: Emergency eyewash fountains and quick-drench areas should be accessible in the immediate area of the potential exposure. Ensure there is adequate ventilation.
- Personal protection: Safety glasses with side shields or chemical goggles, protective and dustproof clothing, gloves, a P.V.C apron and an appropriate mask or dusk respirator. Do not wear contact lenses as they could absorb chemicals in the air. Wear impervious shoes. Other protection could overalls. For specifications regarding other PPE, follow the guidelines set in your jurisdiction.

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Hazard Alert

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REGULATION [6]

Germany:

A Time Weighted Average (TWA) concentration limit of 0.5mg/m³ for benzoic acid has been set.

Australia [6]

There is no TWA set for benzoic acid in Australia.

REFERENCES

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2. <https://www.britannica.com/science/benzoic-acid>
3. <https://pubchem.ncbi.nlm.nih.gov/compound/Benzoic-acid>
4. Jr.chemwatch.net
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Scientists make digital breakthrough in chemistry that could revolutionize the drug industry

2020-10-24

In June, the U.S. government purchased the vast majority of world's supply of remdesivir—a FDA-approved antiviral treatment for Covid-19—for July through September. Gilead, the company that makes the compound, recently announced that it would meet international demand by the end of October. Yet all along, digital instructions for whipping up a batch of the nearly 400-atom molecule at the push of a button have been sitting on Github, an online software repository, freely available to anyone with the hardware needed to execute the chemical “program.”

A dozen such chemical computers or “chemputers” sit in the University of Glasgow lab of Lee Cronin, the chemist who designed the bird's nest of tubing, pumps, and flasks, and wrote the remdesivir code that runs on it. He's spent years dreaming of a future where researchers can distribute and produce molecules as easily as they email and print PDFs, making not being able to order a drug as archaic as not being able to locate a modern text.

“If we have standard way of discovering molecules, making molecules, and then manufacturing them, suddenly nothing goes out of print,” he says. “It's like an ebook reader for chemistry.”

Cronin and his colleagues described their machine's capability to produce multiple molecules last year, and now they've taken a second major step toward digitizing chemistry with an accessible way to program with the machine. Their software turns academic papers into chemputer-executable programs that researchers can edit without learning to code, they announced earlier this month in *Science*. And they're not alone. The team represents one of dozens of groups spread across academia and industry all racing to bring chemistry into the digital age, a development that could lead to safer drugs, more efficient solar panels, and a disruptive new industry.

The Cronin team hopes their work will enable what they describe as “Spotify for chemistry”—an online repository of downloadable recipes for important molecules that they say could help developing countries more easily access medications, enable more efficient international scientific collaboration, and even support the human exploration of space.

“The majority of chemistry hasn't changed from the way we've been doing it for the last 200 years. It's very manual, artisan driven process,”

“It's like an ebook reader for chemistry.”

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says Nathan Collins, the chief strategy officer of SRI Biosciences, a division of SRI International, a research company developing another automated chemistry system that's not involved in the Glasgow research. "There's billions of dollars of opportunity there."

At the heart of Cronin's new work lies what he calls a chemical description language or XDL (the "X" is pronounced "kai" after the first letter in the Greek word for chemistry). XDL is to the "chemputer" as HTML is to a browser—it tells the machine what to do. The group has also created software called SynthReader that scans a chemical recipe in peer-reviewed literature — like the six-step process for cooking up remdesivir — and uses natural language processing to pick out verbs like "add," "stir," or "heat;" modifiers like "dropwise;" and other details like durations and temperatures. The system translates those instructions into XDL, which directs the chemputer to execute mechanical actions with its heaters and test tubes.

One of the framework's strengths, according to Cronin, is that chemists can edit the chemical protocol in plain English. This feature lets researchers operate the machine with little training, and, crucially, harness their chemistry expertise to spot bugs in the code. Chemputer crashes can be serious affairs. "The human will always need to be there to make sure you don't have a dumpster on fire," he says.

The researchers tested the system, and no dumpsters burned. The group reported extracting 12 demonstration recipes from the chemical literature, such as the numbing anesthetic lidocaine, all of which the chemputer carried out at efficiencies similar to those of human chemists.

Robotic transformation of chemistry

Cronin built a company called Chemify to sell the chemistry robots and XDL package, although he's also posted free instructions online for building and programming the machine. And already the device is making inroads in the chemical world. In May of 2019, the group installed a prototype at the pharmaceutical company GlaxoSmithKline.

"The chemputer as a concept and the work [Cronin]'s done is really quite transformational," says Kim Branson, the global head of artificial intelligence and machine learning at GSK. The company is exploring various automation technologies to help it make a wide array of chemicals more efficiently, but Cronin's work in particular, Branson says, may let GSK "teleport expertise" around the company. Once a chemist designs a

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promising molecular recipe, rather than writing up a report or teaching a colleague, they'll just press the share button.

Researchers say that while Chemify isn't the most sophisticated automated chemistry platform, it might be the most accessible. It's built around the traditional tools of beakers and test tubes and functions in the step-by-step "batch" paradigm that chemists have used for centuries. Cronin also intends it to be universal: compatible with any batch chemistry robot. Researchers with their own machines just need tell the software what parts they have and give it figures like how hot their heater can go.

Other groups are betting on a more dramatic break from chemistry's roots. At SRI, Collins oversees the development of a platform called AutoSyn, which uses an alternative approach called "flow" chemistry. Rather than mixing up a batch of one substance in one beaker, and then moving it to another flask, in flow chemistry reactions play out continuously. Chemicals stream together in tubing, react there, and get carried off. With more than 3,000 pathways, AutoSyn, which Collins and colleagues described in a publication in June, can recreate almost any kind of liquid based reaction.

Doing chemistry in flow requires specialized hardware and extra effort to translate chemical procedures from their batch descriptions, but that investment buys an "exquisite" control over aspects like heat transfer and mixing, Collins says. If machines like AutoSyn can automatically run hundreds of subtle variations on a published reaction, the detailed datasets they generate could highlight the best way to make a chemical.

The literature may be a good place to start, but many published experiments have flaws. Collins estimates that chemists spend 30% to 70% of their time just working out missing details in known reactions. "[A reaction] is written up by someone who sits down and bases it on their notes from something they were doing the day before, or maybe something they did six months ago," he says.

While AutoSyn and the Chemputer are both able to reproduce the majority of published reactions today, the next step will be making the machines reliable and "Apple groovy," as Cronin puts it. Collins says that AutoSyn used to need an engineer to keep it functioning for more than half of its runs, but now needs fixing less than 10% of the time. Eventually, he hopes, users will troubleshoot the system over the phone.

"This is still a very new science," he says. "It's started to explode really in the last 18 months."

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One force driving that explosion has been the Defense Advanced Research Projects Agency (DARPA). It's wrapping up a four-year program called Make-It, of which both the Chemputer and AutoSyn are alumni. The long-term goal of the program's manager, Anne Fischer, is to speed up the discovery of useful molecules, which has historically involved a lot of waiting around while chemists laboriously smithed atoms into novel configurations. "The slow step is always making and testing the molecules," she says.

But now that Make-It has helped produce robotic tools to build molecules like the Chemputer, AutoSyn, and others, she's directing a new DARPA program, Accelerated Molecular Discovery, that looks to the next stage: developing smarter software to tell the robots what molecules to make, and how to make them.

"We're now trying now to harness what we've done in Make-It and expand it out so we can teach computers how to discover new molecules," she says.

The secret to doing so, many believe, is machine learning. And some machines capable of rudimentary chemical learning are well underway. Connor Coley, a chemist at MIT, is a member of a team that last year paired an automated flow chemistry system with an algorithm to direct it. The algorithm trained on databases of hundreds of thousands of reactions and was able to predict recipes for new products. "It tries to understand, based on those patterns, what kind of transformations should work for new molecules it's never seen before," Coley said.

He stresses that the system has a long way to go. Its predictions were based on similar molecules and human chemists needed to flesh out details missing from the machine-generated outline. Nevertheless, the work supported the notion that software can come up with useful recipes.

MIT is collaborating with more than a dozen chemical and pharmaceutical companies to advance its molecule-predicting algorithms, and some companies have already put the software to use. Juan Alvarez, the Assistant Vice President of computational and structural chemistry at Merck, says that Coley's machine learning algorithm is one of a variety of chemistry prediction tools that the company has made available to its internal researchers. "It's absolutely being deployed to impact our timeline today," he says.

While each group approaches automation from a different angle, they're all tackling the same problem. A near infinite diversity of

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possible molecules exist—some of which are surely life-saving drugs or revolutionary new materials—but precious few human beings have the specialized skillset to analyze, make, and test these compounds.

They aim to keep those rare skills from going to waste. In some ways the work of chemists still resembles the work of scribes, who once painstakingly copied and corrected the writings of others. Researchers like Cronin hope that with the chemical equivalents of the printing press, word processor, and autocorrect in hand, tomorrow's chemists will spend less time recreating, and more time composing.

"It's not about replacing chemists," Fischer says. "It's about giving chemists the tools to allow them to implement and apply the chemistry and allow them to be creative high-level thinkers."

cnbc.com, 24 October 2020

<https://www.cnbc.com>

Scientists find new way to 'upcycle' plastic into valuable liquid

2020-10-24

Everyone knows how much damage plastics are doing to the environment, from the plastics comprising the Great Pacific garbage patch to the microplastics infesting the ocean, to landfill sites that are overflowing with plastic waste. Some types of plastics can be recycled, but the resulting products are often low-quality and not that useful. This means that only a small percentage of all the plastic we create and use ends up being recycled.

Now, chemists from the University of California Santa Barbara and other universities have come up with a new way to recycle plastic into something more valuable, which could help reduce the plastic waste with which we currently pollute the environment.

The method involves approaching plastics on the molecular level. Plastics are made up of chains of carbons which can be combined in all sorts of ways to create different types of plastic. Instead of melting down plastics, which results in lower-quality products at the end, the chemists have found a way to chop up the carbon chains without using a massive amount of heat or giving off nasty emissions.

Lead author Susannah Scott wrote about the research for the academic news website The Conversation, describing how the process for breaking

This process essentially turns waste plastics into a liquid by cutting the carbon chains that the plastic is composed of.

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down plastics works: "The process we have developed does not require high temperatures, but instead depends on tiny amounts of a catalyst containing a metal that removes a little hydrogen from the polymer chain," she wrote. "The catalyst then uses this hydrogen to cut the bonds that hold the carbon chain together, making smaller pieces."

This process essentially turns waste plastics into a liquid by cutting the carbon chains that the plastic is composed of. The resulting liquid is valuable as it contains molecules called alkylbenzenes, which are solvents and are used in detergent products.

The method has been tested on polyethylene, one of the most common types of plastics which is found in things like food packaging, construction materials, and waterproof coatings. The researchers were able to use a "one-pot process" with a small amount of heat to break down the polyethylene into a useful product.

The process has only been demonstrated on a small scale so far, but the researchers are hopeful it could be adapted to process large amounts of plastic within the next few years. The research is published in the journal Science.

digitaltrends.com, 10 October 2020

<https://www.digitaltrends.com>

EU compliance commits to major crackdown on non-compliance

2020-10-23

The European Commission has pledged a 'zero tolerance' approach to non-compliance under its new chemicals strategy for sustainability, in which it sets a series of measures to combat the issue.

The move, outlined in a communication document, follows earlier calls from member states and NGOs for greater adherence to the rules and increases pressure on an industry that is now facing mandatory deadlines to update REACH dossiers.

The wide-ranging strategy says "stepping up" implementation and enforcement of chemicals legislation is "urgently needed" and makes several commitments to address this.

One action that will have a direct impact on industry is the Commission's pledge to "strengthen the principles of 'no data, no market' and the

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'polluter-pays' under REACH, in particular by requiring compliance of all registration dossiers and revoking the registration numbers in case of non-compliance".

In response, Cefic said providing quality data in REACH dossiers is of "utmost priority" for industry and pointed out that it had already begun a major voluntary initiative to improve dossiers, with 190 companies having signed up to date.

Meanwhile, Tatiana Santos, policy manager at NGO the European Environmental Bureau (EEB), said the best way to strengthen the 'no data, no market' principle "is not to allow any chemical on the market without data to guarantee it can be used safely – 'no data, no market' should be interpreted as 'no proper data, no market'".

It is crucial, she added, that Echa does not grant a registration number to chemicals "for which it is not 100% clear that all necessary data to assess safety has been provided". The agency should also check dossiers and revoke registration numbers of non-compliant companies.

"We believe the best way to apply the 'polluter pays' principle in this context is to increase registration fees. This would reinforce Echa's capacity to perform adequate dossier evaluations and support Echa and member state competent authorities to perform substance evaluations when needed."

Enforcement

In the chemicals strategy, the Commission has pledged to target known areas of high risk of non-compliance, in particular online sales, imported articles, classification and labelling and restrictions.

Less than a month before the strategy's release, the results of an EU-wide enforcement project found almost a quarter of EU imports to have contravened REACH and CLP rules.

The Commission promised to propose carrying out audits in member states, "where relevant, to ensure compliance and enforcement of chemicals legislation, in particular REACH, and use infringement procedures as necessary".

The EU executive will also ensure a "harmonised EU-wide response and coordinated exchange of information on enforcement" by strengthening the use of relevant Commission IT platforms.

'no data, no market' should be interpreted as 'no proper data, no market'.

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Cefic welcomed the proposals, adding it is “crucial” they “have ‘teeth’ and are backed by tangible measures” to be taken to prevent non-compliance.

“We strongly believe that no product should enter the EU if it is not compliant with the EU regulations [...] policy makers and enforcement authorities must ensure that existing measures are enforced and availability of tools should be assessed.”

Ms Santos said it is important that the Commission develops clear guidance to combat the “general lack of coherence” among member state sanctions for the same infringements.

She also called for recommendations to “truly apply” the zero tolerance approach. “We have seen over decades that the preferred option by the enforcement authorities is ‘soft’ measures, while the levels of compliance have not improved, showing that these ... were clearly insufficient to ensure compliance.”

A Commission spokesperson declined to comment directly on the ‘zero tolerance’ approach, but added that the steps “over the coming months are to define more precisely the implementation of the actions” outlined in the strategy.

chemicalwatch.com, 23 October 2020

<https://www.chemicalwatch.com>

Why it's getting harder to mine gold

2020-10-28

For 1,000 days, the caravan stood with banners and placards pinned to its side: “We are not afraid. This is our land. This is our home. We will die for it.” Irish flags flutter in the wind. This is the anti-gold mine protest site set up by a group of locals in County Tyrone, Northern Ireland.

With 460 million-year-old veins of gold strewn hither and thither in the rock deep underfoot, the prospect of a mine in Curraghinalt, in a remote corner of the Sperrin mountains, has been talked about for decades – but it has never yet materialised. A recent application by a mining company to extract the seams of precious metal, has brought the prospect closer still. If successful, the firm says it could bring new jobs and money to the area. But many here want to keep things the way they are.

The question now hovering over the rolling Sperrins is, what is more valuable: keeping the gold in the ground, or taking it out?

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“I devote all my time to this campaign, I just feel it’s our future,” says Fidelma O’Kane, a retired social worker and lecturer who is concerned about the potential environmental impacts of the mine.

“My main worry is that the water will be poisoned, the air will be poisoned, the land will be contaminated – and ultimately people’s health will suffer,” she adds, explaining that she would never accept a mine, of any kind, in this area.

The company hoping to extract precious metals here, Dalradian Gold, says that it has put in place a swathe of environmental safeguards, and promises several economic benefits for locals. Still, the online planning proposal for the mine has attracted tens of thousands of comments, mostly negative, and a public inquiry will now take place to decide what will happen next.

Heralded by some as a potential boon for Northern Ireland, where jobs and investment opportunities stagnated during the 30-year period of conflict known as the Troubles, experts say Curraghinalt could become home to the largest gold mine in the UK, were it to go ahead.

The question now hovering over the rolling Sperrins is, what is more valuable: keeping the gold in the ground, or taking it out?

This query could hardly be voiced at a more pivotal moment. The price of gold rocketed during the pandemic, spurring renewed interest in excavation projects and even an illegal mining boom in parts of the Amazon rainforest. Yet gold is proving ever-more difficult to release from the ground. The technical challenges may be well known, but environmental protests and local politics are less predictable. At what point does mining gold stop being worth the effort?

Last year, global gold production fell by 1%, the first decline in a decade, according to the World Gold Council, which promotes the gold industry. Some analysts argue we have reached “peak gold” – which means that the maximum rate of extraction has passed and the production of gold will continue to fall until, eventually, mining for it shall cease entirely.

However, demand for the stuff shows no sign of slowing down.

“It’s kind of a perfect storm,” says Matt Miller, vice president of equity research at CFRA Research, an investment analysis company. “Or, a better way to say it is, the fundamentals for gold may never be stronger than they are now.”

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According to CFRA, about half of the world's gold, excluding that still buried in the ground, is used in jewellery. As for the other half, one quarter is held by central banks and a final quarter is owned by private investors or used in industry.

Miller is among those who believe we have reached peak gold. The price of a single ounce of the glittering yellow metal breached \$2,000 (£1,550) this summer and still rests comfortably above \$1,900 (£1,470). Twenty years ago, the same ounce would sell for less than a quarter of that amount. The latest surge, following the emergence of Covid-19, has been linked to weakening currencies, including the US dollar. Governments are borrowing huge sums to pay for their pandemic response plans and printing money to fill the gap, say analysts, which means that the value of currency has become more volatile. Gold on the other hand is viewed as a stable asset, of which there are finite amounts, meaning that investors deem it trustworthy.

But Covid-19 has also caused disruption to gold mining operations themselves and supply is not likely to bounce up to meet rising demand any time soon. As such, the gold mining industry is actually sitting on the makings of a "major crisis", argues Miller.

"My view is that gold demand will continue to trend upwards," he says. "More and more of that is going to come from the recycling, which basically means that gold is trading hands."

He predicts that recycling old jewellery, coins or even the seemingly miniscule amounts of gold in the circuit boards of electronic devices, will become an increasingly significant source of the metal in the future. CFRA's data suggests that around 30% of the world's gold supply in the past 20 years was actually recycled, not mined. Refineries that recycle "scrap" gold – old jewellery, coins and bars – do use toxic chemicals and energy in their processes, but some environmental impacts may be much lower than mining. One recent study of gold refineries in Germany found that, kilogram for kilogram, the production of 99.99% pure gold via recycling was 300 times less carbon intensive than mining it from underground or open pit mines.

This means that obtaining one kilogram of recycled gold would produce 53kg of CO2 equivalent – but to mine a kilogram of the same material would cause 16 tonnes of CO2 equivalent to be emitted. Recycling scrap gold from electronics fell in between the two but was still better than mining – at one tonne of CO2 equivalent for every kilogram of gold turned out.

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Like any large-scale industrial operation, gold mining can also have local effects on the environment. Public opposition to gold mines in some parts of the world has become a barrier to gold production, says Miller. Such resistance does not only exist in Tyrone. Take the Pascua-Lama mine in Chile, for instance. After years of protests from local activists on environmental grounds, the project was halted by regulators.

But where gold mines have become established, they can become giant operations. The world's largest produce many tonnes of gold annually and the biggest of them all, Nevada Gold Mine in the US, churns out more than 100 tonnes every year. Even smaller gold mines can support the livelihoods of many people within the communities that bloom around them. Take the city of Val d'Or (Valley of Gold) in Quebec, Canada. There's been a town there ever since gold was discovered in 1923. Various other metals including copper and lead are now also extracted in the area and a surplus of mining jobs has attracted people to Val d'Or in recent years. The town's ice hockey team, the Foreurs, even has a mascot with a hard hat named "Dynamit" – a reference to the dynamite used to blast away rock in mining.

Political barriers

As for Curraghinalt, it was bloodshed that kept the gold in the ground for many years. During the Troubles, several political and sectarian groups in Northern Ireland turned to violence, carrying out shootings and bombings, for example. So when one company eyed the potential for a mine at Curraghinalt in the 1980s, it struggled to obtain a permit for explosives, given the security risks of keeping them on-site at the time.

But a decade later, Curraghinalt seemed to promise a more hopeful future, remembers Adrian Boyce, professor of applied geology at Scottish Universities Environmental Research Centre. Around the time of the Good Friday Agreement (the political accord signed in April 1998 that helped bring an end to the Troubles), Boyce and colleagues took part in an initiative to study the geology of Curraghinalt and assess its commercial potential.

"It was really a fresh hope for the people of Northern Ireland and that's the impact that I saw for it," he recalls. "At a time when, you know, not a lot of people were investing in Northern Ireland."

He mentions the Omagh bombing, in which a group calling itself the Real IRA detonated a car bomb on a Saturday afternoon in August 1998, killing 29 people, including a woman who was pregnant with twins. Omagh is a

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20-minute drive from Curraghinalt. In the minds of some, the economic opportunities of a brand new gold mine offered Northern Ireland a chance to escape the horrors of the past – and still offers the local area economic hope for the future.

Back in the 1990s, it was the price of gold that ultimately stymied the mine's prospects, says Boyce. But that is no barrier now. And, he says, the size of the mine – Dalradian estimates it could produce 130,000 ounces (4 tonnes) annually for 20 years or more – makes it unique in the UK.

"For gold, Curraghinalt is far and away the biggest gold mine that's ever been found in the UK," says Boyce. "It dwarfs everything else."

Yet the story of Curraghinalt speaks to the challenges of industrial gold mining in 2020, especially when operating near existing communities in an area of natural beauty. The mine is situated in a fairly remote part of Northern Ireland surrounded by farms and wilderness. Omagh, for instance, has a population of fewer than 20,000 people.

Since 2009, Dalradian has been excavating samples from below ground at its site in Curraghinalt while promoting plans for the mine to locals. The proposals include building an underground mine, rather than an open pit-style project, and extracting ore that would be processed partly in Tyrone, partly overseas.

Following fierce opposition, in 2019 Dalradian dropped its plan to use cyanide at the site. In some gold mining operations, solutions containing cyanide are used to dissolve gold from ore mined out of the ground so that the metal can be extracted and collected. Dalradian also says it has reduced water usage by 30% and gas emissions by 25% as part of its aim to become Europe's first carbon neutral mine.

But campaigners continue to express concerns that chemicals could be washed into nearby rivers and harm local wildlife. Pollution from the mine could also negatively affect people's health, they claim. And they also fear that a large heap of "tailings" – waste material extracted from the mine and left aboveground – would blight the area's scenery.

BBC Future had arranged to tour Dalradian's site in Tyrone but the company cancelled the visit two days before it was due to take place without explanation.

In a statement, a spokesman for Dalradian said: "This is a safe and environmentally responsible project which will emulate the successes of other modern mines in Europe."

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The company says it has listened to the community, offering tours and changing its mining processes when concerns were raised.

"People can also be assured that the project is being scrutinised by an independent, robust planning process and that it has been designed to meet exacting standards. We've held around 100 meetings with regulators so far and the local Public Health Agency has made no objection to the project on public health grounds."

And regarding the tailings: "The dry stack will have an average thickness of 17m (56 feet), will be replanted during operations, is located in a natural hollow and will be blended into the local landscape."

In a recent application for permission to discharge materials including heavy metals into a nearby stream, Dalradian also mentioned corrosive substances such as sulphuric acid and sodium hydroxide. On this point, the spokesman said, "Although it's not expected that they will be used routinely, as they will be stored on-site they must be listed in the discharge consent."

A treatment plant would be used for water management, he added, and noted that the mine offered a "massive opportunity" at a time when Northern Ireland's economy faced uncertainty over Brexit.

While campaigners like O'Kane say they will not accept the mine under any circumstances, there are certainly some who would. It is difficult to get a sense of exactly how many in Tyrone are for or against. The Northern Ireland Department for Infrastructure planning portal contains more than 41,000 public comments about Dalradian's proposals, more than 90% of which are objections. When asked by BBC Future why many of these responses appeared to be duplicates, the department said it believed the figures were an "accurate summary" of representations received.

Duplicates can arise for a number of reasons, a spokesman said: "They can relate to individuals making a representation on more than one occasion given there has been various amendments to the proposal."

With a public inquiry now looming over the plans, it's up to the authorities to investigate and represent the interests of local people before coming to a decision about whether the works ought to go ahead, suggests Boyce. "Let the politicians do what politicians are paid to do," he adds.

In recent years, across the Irish Sea in Scotland, local objections were raised over plans for a different mine, at Cononish, in Loch Lomond National Park. Boyce notes that environmental concerns were voiced

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there, too, but ultimately the project gained support and was granted planning permission. The first gold from the mine could be produced as early as November.

A mine at Curraghinalt that proved to be productive would certainly attract interest from investors, argues Chris Mancini, a research analyst at Gabelli Gold Fund, which invests in gold. And he argues that it would be safe, environmentally speaking.

But it won't do for some. For Fidelma O'Kane and her fellow campaigners, the mine has become anathema – a threat to the very character of the place where they live.

"The area is a beautiful area, it's designated an Area of Outstanding Natural Beauty," insists O'Kane. "We don't want it industrialised with heavy industry.

"The clean, green image of our country would be gone forever."

Whatever happens next at Curraghinalt, there's no doubt that Dalradian's efforts have sparked many discussions locally about what people would be willing to accept. It's the sort of debate that could well become more common if the price of gold remains high and companies seek out small but nonetheless lucrative gold deposits in places that may have little or no tradition of gold mining.

Then again, if we really have reached peak gold, the rush might not last very long.

bbc.com, 28 October 2020

<https://www.bbc.com>

How to be happy, according to science

2020-10-26

In 2014, two psychologists at the University of California, Berkeley, launched an online course with a lofty goal: teaching students how to be happy, through both science and practice, in just eight weeks. No big deal, right?

The amazing thing: It seemed to work. Thousands of students took the Science of Happiness course (which is still free to audit on edX, a provider of open online courses) and learned about the science of connection, compassion, gratitude and mindfulness. Perhaps more importantly, they

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also completed a series of simple activities that research suggests increase happiness.

Those who fully participated saw their positive feelings increase each week. They reported feeling less sadness, stress, loneliness, anger and fear, while at the same time experiencing more amusement, enthusiasm and affection, as well as a greater sense of community. During the course, students' happiness and life satisfaction increased by about 5%. And that boost remained even four months after the course ended (though it's difficult to fully untangle that result; it could've been from doing the activities, the students' new understanding of the psychology of happiness, or something totally different).

How does this work? Can you really change how happy you are that easily?

According to the research, yes. Even during challenging times, like the coronavirus pandemic.

The malleability of happiness

"There's a misconception that happiness is built-in and that we can't change it," says Laurie Santos, a professor of psychology at Yale University who teaches a free Coursera class called The Science of Well-Being.

One popular theory that suggests we can affect our feelings is the happiness pie chart, proposed in a 2005 paper (PDF) published in the Review of General Psychology. At the time, researchers suggested that while 50% of your happiness is determined by your genes and 10% by your life circumstances, 40% is determined by your daily activities. Though this breakdown has faced criticism (that it's too simple, and doesn't take into account how your genes and environment interact), it taps into an idea that's fairly widely accepted: At least some of your happiness is within your control.

"The science shows that our circumstances -- how rich we are, what job we have, what material possessions we own -- these things matter less for happiness than we think," Santos says. (Research does show that wealthier people are happier than poorer people -- but not by a ton.)

Another big misconception? That happiness is the same as a consistently positive emotional state, says Emiliania Simon-Thomas, who co-teaches Berkeley's The Science of Happiness course and is also the science director of Berkeley's Greater Good Science Center. Being happy doesn't mean you feel pure joy and cheerfulness every hour of every day. Humans aren't designed that way (and think of how annoying you'd be if you were). You

During the course, students' happiness and life satisfaction increased by about 5%.

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experience setbacks, problems, the loss of loved ones. And those negative feelings are an essential part of your emotional life, too.

Happiness, experts say, means accepting negative experiences, and having the skills to manage and cope with them, and to use them to make better decisions later.

“We think happiness is like a Facebook reel of vacations and achievements and checkboxes for life goals,” Simon-Thomas says. “But people who pursue happiness in that sort of belief system end up being less happy than people who define happiness in a more overarching, quality-of-life way.”

How to make yourself happier, according to science

The appealing thing about being able to control at least part of your own happiness is you can do it from home, or anywhere, for free. Here are five exercises that clinical studies have shown improve your feelings of happiness and well-being.

(An important caveat: For people with clinical anxiety, depression or other mental health issues, these exercises aren't a replacement for therapy, medication or other professional interventions. However, some research suggests they can be beneficial as a supplement to those services.)

1. Enhance your social connections

Social connection is the biggest factor affecting happiness, multiple studies have found. One of the most convincing is the Harvard Study of Adult Development which, for more than 80 years has followed the lives of hundreds of participants and, now, their children.

Close relationships (with spouses, family, friends, community members) are the biggest factor keeping people happy throughout their lives, researchers discovered. People with strong relationships are happier, and physically and mentally healthier, than those who are less well-connected. (The researchers are still studying the connection between relationships and physical health -- there's evidence that good relationships result in lower levels of stress hormones, and less chronic inflammation.) Quality relationships (not quantity) are better predictors of a long and happy life than social class, IQ or genetics, according to the study.

Just how important relationships are came as a surprise, says Robert Waldinger, the current director of the study, whose 2015 TED Talk on the subject has been viewed more than 34 million times. “We figured that if

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you have good relationships, you're likely to be happier, but we did not believe at first the data showing us that good relationships actually keep our bodies healthier and help us live longer. And then other studies began to find the same thing.”

These relationships require work, Waldinger says. You have to keep up with people, which means giving them your time and attention -- especially during the pandemic. Call them, video chat with them, take a socially distanced walk if you can. Deliberately choose to spend time together.

Other ingredients for a long and happy life include not smoking or abusing alcohol, exercising regularly and finding work-life balance, the Harvard study found. “Rather than just being your grandmother's good advice, there's real science behind this,” Waldinger says. “You can quantify the number of years you'll live longer, if you do these things.”

2. Engage in random acts of kindness

Find ways to perform small, random acts of kindness during your day. These acts can be incredibly simple, from complimenting a stranger at the grocery store on his or her shirt to making your spouse coffee before work to engaging a co-worker you don't usually talk with in a friendly Zoom chat.

Deliberately performing random acts of kindness can make you feel happier and less depressed and anxious, according to a series of studies (PDF) from Sonja Lyubomirsky at UC Riverside. Varying those acts you do for others has a longer-term effect on your own happiness.

This works because these acts tap into your natural prosocial behavior, or the basic human impulse to help others, Simon-Thomas says. When you invest your own resources in the welfare of others, it activates your brain's reward system -- you feel good that you made the other person feel good.

3. Express gratitude

Writing down three things you're grateful for at the end of each day, and why they happened, leads to long-term increases in happiness and decreases in depressive symptoms, according to a 2005 study from Martin Seligman, director of the Positive Psychology Center at the University of Pennsylvania. It doesn't matter how large or small each thing is -- just write them down, in a notebook or your Notes app or wherever. For example, you might write down “Finished a paper, because I worked hard on it. Had a good talk with my friend because she called me. Went for a walk and saw some cute dogs, because it was a nice day.”

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The point is to train your mind to orient itself to the parts of your life that are good, instead of directing your attention to things that are stressful or irritating, Simon-Thomas says.

The pandemic might make it harder to feel grateful, but taking time to count your blessings even now is still a powerful way to improve well-being, Santos adds.

4. Practice mindfulness

You may have already tried all those mindfulness apps. But exercises like meditation that teach your brain to focus on the present instead of the past or future can increase feelings of self-acceptance, according to a 2011 study (PDF) from the International Journal of Wellbeing.

“The idea is to be present -- don’t judge your emotions, but recognize them,” says Elizabeth Dunn, a psychology professor at the University of British Columbia. If you need a hand, Dunn helped launch a free set of wellness exercises called Peace, by the fintech company Happy Money. These exercises use research on positive psychology and cognitive behavioral therapy to increase happiness and reduce feelings of stress.

(Another caveat: If you have PTSD, proceed with caution or check with your doctor first, as mindfulness exercises may be triggering, experts say, because they can unearth trauma.)

5. Practice self-compassion

This might be the most challenging item on the list, Simon-Thomas says. Particularly in the West, people have adopted a propensity for self-criticism as a cultural value, and tend to self-punish when dealing with setbacks and failures, she says. But excessive self-criticism gets in the way of achieving your goals.

There are three parts to practicing self-compassion, and they draw on some of the other exercises on this list: Be present in the moment rather than dwelling on the past or looking anxiously to the future. Understand that setbacks are part of being human, and all people experience them. Cultivate a warm, supportive inner voice rather than a hostile, self-critical one.

You can work to hone your supportive inner voice by writing a letter to yourself, using the tone you’d use if you were writing to a relative or friend who’d asked for support, Simon-Thomas says. For example, if you lost your job, you might be beating yourself up over it. But if a friend lost his job,

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you’d be more likely to say: “Hey, this just wasn’t meant to be. You have so much to offer and will find the right opportunity.”

“It’s a way to tap into a different way of speaking to ourselves that’s important for being able to manage difficulties and setbacks, and grow from life’s challenges,” Simon-Thomas says.

One more big caveat: Race

Virtually every major study on happiness and well-being has one thing in common: The vast majority of researchers and participants are white. Lack of diversity is a big problem across most areas of psychological research: Of more than 26,000 empirical articles published between 1974 and 2018 in top-tier cognitive, developmental and social psychology journals, only 5% highlighted race, according to a study from Stanford University published in June. The majority of psychology journal editors and authors published were white, the study found.

“There’s a theoretical importance and social importance in just making sure that all humans are represented in our science,” says Steven O. Roberts, lead author of the study and an assistant professor of psychology at Stanford. “From a purely statistical point of view, you can’t take findings from a subset from middle class white Protestant US citizens and use that to make inferences about happiness, period. Because happiness extends obviously beyond that.”

Many of the basics of happiness research, and the efficacy of the exercises above, would likely hold true across racial groups, because underlying human biology is more powerful than the differences between groups, Waldinger says. This is especially true for social connections. However, the daily microaggressions and fears that people of color face could change the conditions of happiness for those groups, he adds.

One of the basic tenets of biological science is that race doesn’t play a role in how the brain responds to certain stimuli. However, researchers are also only beginning to learn more about epigenetics -- an emerging field of science that studies how trauma may activate certain genes, and how people potentially pass those genes down to their children.

“The social experiences associated with racial identity can give rise to differences in our psychological experiences,” Roberts says. “Biologically, we’re all the same. There’s no biological basis to race. But there’s definitely a social basis to race.”

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Diversifying research populations gives us a more accurate understanding of humanity as a whole, which could help us learn more about the foundations of happiness for everyone. After all, “people of color can be happy,” Roberts says. “Everyone can be happy.”

cnet.com, 26 October 2020

<https://www.cnet.com>

Radical diagnostic could save millions of people at risk of dying from blood loss

2020-10-29

Engineers at Monash University in Australia have developed a fast, portable and cheap diagnostic that can help deliver urgent treatment to people at risk of dying from rapid blood loss.

In a world-first outcome that could save more than two million lives globally each year, researchers have developed a diagnostic using a glass slide, Teflon film and a piece of paper that can test for levels of fibrinogen concentration in blood in less than four minutes.

Fibrinogen is a protein found in blood that is needed for clotting. When a patient experiences traumatic injury, such as a serious car accident, or major surgery and childbirth complications, fibrinogen is required in their blood to prevent major hemorrhaging and death from blood loss.

Typically, heavily bleeding patients must be transported to a hospital or emergency center where they undergo diagnostic tests before being treated. These tests are time consuming and costly as they require expensive equipment, specialized/trained personnel and can take up to half an hour.

This new development by researchers at Monash University’s Department of Chemical Engineering and BioPRIA (Bioresource Processing Institute of Australia), in collaboration with Haemokinesis, removes the need for centralized hospital equipment to detect, monitor and treat fibrinogen levels—something never achieved until now.

Additionally, this diagnostic can be upscaled into a point-of-care tool and placed in ambulances and other first responder vehicles, in regional and remote locations, and in GP clinics. It takes just four minutes to complete.

Findings were published in the prestigious journal, ACS Sensors.

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Professor Gil Garnier, Director of BioPRIA, said this diagnostic will allow emergency doctors and paramedics to quickly and accurately diagnose low levels of fibrinogen in patients, giving them faster access to life-saving treatment to stop critical bleeding.

“When a patient is bleeding heavily and has received several blood transfusions, their levels of fibrinogen drop. Even after dozens of transfusions, patients keep bleeding. What they need is an injection of fibrinogen. However, if patients receive too much fibrinogen, they can also die,” Professor Garnier said.

“There are more than 60 tests that can measure fibrinogen concentration. However, these tests require importable machinery on hospital table tops to use. This means that critical time has to be spent transporting heavily bleeding patients to a hospital—before they even undergo a 30 minute diagnosis.”

Ph.D. candidate in the Department of Chemical Engineering and research co-author, Marek Bialkower, said the implications for this diagnostic are significant.

“Our diagnostic can eliminate the preparation time, labor and transportation difficulties of traditional techniques used in the hospital, Mr Bialkower said.

“It can diagnose hypofibrinogenemia in critically bleeding patients anywhere in the world, and can drastically reduce the time to treatment needed for fibrinogen replacement therapy. The test can take less than four minutes, about five times faster than the current gold standard methods.”

The test works by placing a pre-mixed droplet of a blood sample and an enzyme solution onto a solid surface, allowing it to clot, and then dropping a paper strip on top. The further that blood moves down the strip of paper, the lower the fibrinogen concentration.

The diagnostic can work with a variety of blood conditions. Furthermore, diluting blood samples not only increases the test’s sensitivity, but also eliminates the effect of interfering substances in the blood.

Hypofibrinogenemia (insufficient fibrinogen to enable effective clotting) in critical bleeding is common. More than 20 per cent of major trauma patients have hyperfibrinogenemia.

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Dr. Clare Manderson, Research Fellow in the Monash Department of Chemical Engineering and co-author of the study, said the early diagnosis of hypofibrinogenemia could stop bleeding in these patients and save their lives.

“The development of the world’s first handheld fibrinogen diagnostic is a game changer for the millions of people who die each year from critical blood loss. It will also ease pressure on emergency departments knowing that this life-saving treatment can be delivered on site and in quick time,” Dr. Manderson said.

“Our capacity to develop this diagnostic using cheap and readily available materials means it can be easily commercialized for use across the world.”

phys.org, 29 October 2020

<https://www.phys.org>

Microscopic sponge turns dirty cooking oil into biodiesel on the cheap

2020-10-25

Scientists at Australia’s RMIT have developed a tiny sponge with big potential, and say the micron-sized material can be used to convert discarded cooking oil into biodiesel in a very cost-effective manner. And the catalyst is no one-trick pony, with the ability to also turn other waste products into valuable building blocks for a range of materials.

The sponge-like material is a new type of ultra-efficient catalyst for turning complex molecules into raw materials. The RMIT team behind it actually describes it as the first of its kind, in that the ability to carry out a series of different chemical reactions within the one material while offering a high degree of control over the output is unprecedented.

“Catalysts have previously been developed that can perform multiple simultaneous reactions, but these approaches offer little control over the chemistry and tend to be inefficient and unpredictable,” says co-lead investigator Professor Karen Wilson. “Our bio-inspired approach looks to nature’s catalysts – enzymes – to develop a powerful and precise way of performing multiple reactions in a set sequence. It’s like having a nanoscale production line for chemical reactions – all housed in one, tiny and super-efficient catalyst particle.”

The sponge-like catalyst is micron sized and highly porous. When molecules are fed into the sponge, they undergo a chemical reaction in

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the large pores and then make their way into the smaller pores, where a second chemical reaction takes place. The process is not only cheap, but can make use of low-grade ingredients that would otherwise be destined for the scrapheap.

Among those is cooking oil, which currently needs to be cleaned thoroughly in an energy-intensive process to rid it of its contaminants before it can be turned into biodiesel. The approaches in use today can only handle feedstocks with 1-2 percent contaminants, whereas the durable new process developed by the RMIT team can handle feedstocks containing up to 50 percent contaminants.

The researchers say that in its current form, the catalyst can turn these types of low-grade feedstocks into low-carbon biodiesel using basically just a large container, along with some gentle heating and stirring. With further work, the technology could be adapted to produce jet fuel from agricultural waste, rubber tires or algae.

Additionally, the efficiency of the technology could double the productivity of processes currently used to produce chemical precursors for a wide variety of products, such as medicines and packaging, from food waste, tires and microplastics.

From here, the researchers are working to scale up the process for larger output, with an eye on commercialization.

“Our new catalysts can help us get the full value of resources that would ordinarily go to waste – from rancid used cooking oil to rice husks and vegetable peelings – to advance the circular economy,” says co-lead investigator Professor Adam Lee. “And by radically boosting efficiency, they could help us significantly reduce environmental pollution from chemical manufacturing and bring us closer to the green chemistry revolution.”

The research was published in the journal Nature Catalysis.

newsatlas.com, 25 October 2020

<https://www.newsatlas.com>

Is it possible for anything to be ‘germ-free’?

2020-10-25

Everyone has probably done it hundreds of times, especially lately — rubbed hands with sanitizer, scrubbed kitchen counters with antibacterial wipes, patted down a toilet-seat cover in a public restroom and used feet,

Is it even possible to keep germs away?

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elbows or shoulders to try to open the bathroom door — all in the name of keeping those nasty, scary, invisible germs away.

But what if all of this careful cleaning is an exercise in futility? Is it even possible to keep germs away?

Not really, said Emily Sickbert-Bennett, director of the University of North Carolina (UNC) Medical Center's Infection Prevention program and associate professor of epidemiology and infectious diseases at the UNC School of Medicine. **PLAY SOUND**

"There are more bacteria in and on our bodies than cells," Sickbert-Bennett told Live Science. There are lots of bacteria that naturally occur all over, in water and soil and on other animals, she added.

But these microbes aren't all bad, she said. In fact, most of them are innocuous unless they wind up in the wrong place — like the staphylococcus bacteria that live harmlessly in a person's nose but can be deadly in the bloodstream.

Other microbes are constantly pathogenic, meaning they are always a disease risk. The virus that causes COVID-19 is one of these, Sickbert-Bennett said. These more problematic microbes are likely what most people are worried about when they're trying to get rid of "germs."

So, is there any hope for keeping our environments clear of these microscopic bad guys?

Sickbert-Bennett said the better question to ask is not how to keep surfaces germ-free, but how to stop the germs found in our environments from causing infections.

"Surfaces can be disinfected with everyday household wipes or sprays, and that certainly eliminates the microbes that are found on those surfaces," she said, but those surfaces tend to become continuously recontaminated. Any time two surfaces interact, like a door knob and a finger, microbes are swapped. Plus, microbes in the air can quickly resettle on surfaces that were just disinfected.

"The most important thing is really thinking about the 'chain of infection,'" Sickbert-Bennett said — the small steps that have to happen for a microbe like a virus to infect someone. "Where are the points along that chain where you can interrupt it?" she asked.

In other words, though some harmful microbes might get into your home or onto your skin, the point is to make sure they don't get to a place where

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they can cause an infection. The COVID-19 bugs, for example, need to be transferred while intact into a person's respiratory system or eyes, so by washing hands before touching the nose, mouth or eyes — the chain of transmission for COVID-19 is broken.

So think about keeping E. Coli out of the gut by cooking food appropriately, and try to keep adenovirus — a common pink eye culprit — out of the eye by washing your hands and not touching your eyes. But otherwise don't stress too much about the world of microbes humans live in. The majority of these germs have their purpose and don't pose a risk to human health. And in fact, many microbes actually help animals thrive and survive, according to studies examining germ-free mice, Helen Vuong, a postdoctoral scholar of Integrative Biology and Physiology at the University of California, Los Angeles wrote in *The Conversation*.

"Even within our bodies there are a lot of good bacteria that are helping to outcompete the more pathogenic ones and keep us healthy," Sickbert-Bennett said.

Originally published on Live Science.

[livescience.com](https://www.livescience.com), 25 October 2020

<https://www.livescience.com>

New catalyst turns greenhouse gases into hydrogen gas 2020-10-26

A new nanocatalyst that recycles major greenhouse gasses, such as carbon dioxide (CO₂) and methane (CH₄), into highly value-added hydrogen (H₂) gas has been developed. This catalyst is expected to greatly contribute to the development of various waste-to-energy conversion technologies, as it has more than twice the conversion efficiency from CH₄ to H₂, compared to the conventional electrode catalysts.

A research team, led by Professor Gun-Tae Kim in the School of Energy and Chemical Engineering at UNIST has developed a novel method to enhance the performance and stability of catalysts, used in the reaction (i.e., dry reforming of methane, DRM) that produces H₂ and carbon monoxide (CO) from well-known greenhouse gasses, such as CO₂ and CH₄.

The conventional catalysts used for the dry reforming of methane (DRM) are nickel (Ni)-based metal complexes. Over time, however, the performance of catalysts degrade, so does the catalyst lifetime. This is because carbon accumulates on the surface of the catalysts, as

...as it has more than twice the conversion efficiency from CH₄ to H₂, compared to the conventional electrode catalysts.

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the catalysts clump together or their reaction is repeated at a higher temperature.

“The uniform and quantitatively controlled layer of iron (Fe) via atomic layer deposition (ALD) facilitates the topotactic exsolution, increasing finely dispersed nanoparticles,” says Sangwook Joo (Combined MS/Ph.D. in the School of Energy and Chemical Engineering, UNIST), the first author of the study.

The research team also confirmed that exsolution is promoted even with a very small amount of ALD-deposited Fe oxide (Fe₂O₃). “Notably, at 20 cycles of Fe oxide deposition via ALD, the particle population reaches over 400 particles (Ni-Fe alloys),” says Arim Seong of the School of Energy and Chemical Engineering, UNIST, the first co-author of the study. “As these particles are composed of Ni and Fe, they also exhibited high catalytic activity.”

The new catalyst exhibited high catalytic activity for the DRM process with no observable degradation in performance for more than 410 hours of continuous operation. Their results also showed a high methane conversion (over 70%) at 700 degrees C. “This is more than twice the power conversion efficiency that of the conventional electrode catalysts,” noted Professor Kim. “Overall, the abundant alloy nanocatalysts via ALD mark an important step forward in the evolution of exsolution and its application to the field of energy utilization.”

phys.org, 26 October 2020

<https://www.phys.org>

Chile mandates real-time environmental monitoring at salmon farms

2020-10-21

Ocean-based fish farms in Chile have been ordered by Chilean officials to start monitoring environmental conditions in and around their pens in real time and immediately transmit the data to government environmental agencies.

According to the August regulation from the Superintendencia de Medioambiente (SMA), ocean-based aquaculture sites will need to monitor water conditions for dissolved oxygen, salinity and temperature “since the variation in these parameters can significantly affect the quality of the

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immediate aquaculture environment and can also create a detriment to the general aquatic environmental quality.”

The regulation will be rolled out in two stages. SMA has identified 27 farms to be part of the first stage, and they will have to meet the new requirement by December 11. Other farms have until next June to comply.

“Government officials have set aggressive deadlines for this regulation, so farm operators are going to have to act quickly in order to comply with the new requirements,” said Juan Pablo Barrales, managing director of Innovasea’s new Chile office in Puerto Varas.

A New Era in Aquaculture

Chile is believed to be the first country to require its fish farms to conduct real-time reporting of environmental data.

While many of the 300+ fish farms in Chile already monitor certain environmental parameters in order to protect their fish stocks, not all of them do it in real time. Some still rely on handheld monitors and record the data manually in logbooks or spreadsheets.

And few, if any, farms measure parameters at more than one location.

The new regulations require that farms install monitors at depths of 5 and 10 meters at two locations: a spot that’s outside the fish pen area and another inside the pen containing the largest biomass.

One challenge for fish farmers will be their ability to regularly relocate monitors to comply with that second provision since the pen with the largest biomass tends to change over time due to harvesting and other operational activities.

Innovasea’s wireless aquaMeasure sensors are ideal for such deployments as they can easily be transferred to a new location by any farm employee in just a matter of minutes.

“Moving wired sensors, receivers and their cables from one place to another can be a serious issue for fish farmers,” said Barrales. “Innovasea’s wireless technology is a game-changer that enables farm operators to do that much easier.”

agriculture-expt.com, 21 October 2020

<https://www.agriculture-xprt.com>

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What is an antigen?

2020-10-27

An antigen is a molecule that stimulates an immune response by activating lymphocytes, which are white blood cells that fight disease. Antigens may be present on invaders such as cancer cells, bacteria, viruses, parasites, fungi, and transplanted organs and tissues. Learn more about antigens and how the immune system interacts with them to protect you.

The Immune System

The human body relies on certain defenses to help keep sickness at bay. The defense system, known as the immune system, works in conjunction with many other processes to stomp out bodily threats on a cellular level. It does this by triggering a response that leads to the production of cells that will fight off infections.

There are two types of immunity at work within the body—innate and acquired.

Innate immunity is a type of protection against pathogens that's nonspecific. It's generally the first part of the immune system to respond to the appearance of an antigen, but it doesn't have the ability to memorize certain threats and mount a specific defense if they show up again.

Acquired immunity is a little different in the way that it responds to the appearance of antigens. It is the part of immunity that works to identify the difference between threatening cells, targeting only outside pathogens.¹ Acquired immunity is typically the process that gets activated when an antigen is present.

How It Works

The body needs to be able to recognize what belongs and what doesn't, and antigens are recognizable by the immune system.¹ This helps the body determine whether or not an immune response is needed by identifying the specific antigen.

Antigens bind to receptors on lymphocytes (a type of white blood cell). This then causes the multiplication of lymphocytes and triggers the immune response. The immune response can include producing specific antibodies against the antigen.

Types

There are two types of immunity at work within the body—innate and acquired.

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Antigens can be divided into two main groups, both of which work differently to fight off infection in the body. These groups are known as foreign antigens and autoantigens.

Foreign Antigens

Otherwise known as heteroantigens, this type comes from outside of the body and are present on bacteria, viruses, snake venom, certain food proteins, and cells from other people. When it comes to lymphocyte response to foreign antigens, it's likely that for them to do so the innate immune system must first be activated.¹

Autoantigens

Self-antigens are already present within the body with the immune system being able to clearly recognize them against other cells. These antigens don't trigger an immune response in healthy individuals because the body knows they're not harmful.

The Role of Antigens

As mentioned above, the antigen is the immune response initiator. It can either be bound by a specific antibody present in secretions or the blood, or by a B cell antigen receptor. The B cell antigen receptor is a transmembrane protein that is also a form of antibody.

Vaccines

A vaccination is a medical injection that contains a weakened or dead version of the specific pathogen it is meant to prevent, or only part of the germ or toxin that would cause a disease. Vaccines are used to encourage an immune response within the body to create the specific antibodies needed to bind to that particular antigen.

When the immune system creates a specific antibody, such as an influenza antibody, when you do come into further contact with the virus your body is well-equipped to fight it off by using the previously created antibodies.

Once vaccinated, these specific antibodies are created for years following the initial entrance into the body. This can produce immunity to that particular strain due to the body's ability to recognize the specific antigen if it happens to show up again.²

In Viral Infection

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In a viral infection such as the seasonal flu, the immune system develops a response by creating antibodies that can bind to the specific antigen. The process works in a similar way as it would with a vaccine, although the viral germs are much stronger in a live version.

The antigens that enter the body signal the immune response, thus causing the body to create antibodies for the specific strain of viral infection. These antibodies then utilize what is known as immunological memory.

The immunological memory is your immune system's ability to ward off further illness from the same strain of disease using the antibodies it previously created in response to antigens.²

The Role of Antibodies

Antibodies are created by cells within the immune system. They are produced to respond to specific antigens when they appear, to bind and eliminate the threatening pathogens from the body. They do this by neutralizing the threat it possesses or by alerting the proper part of the immune system to take over.

Significance

Antigens are important to the overall healthy function of the body because, without them, it's unlikely people would make it through any foreign substance infection. Antigens are an important part of the immune response, and an immune response is required to keep the body free of any harmful substances.

If antigens aren't present, the proper immune response wouldn't be initiated and the bacteria or virus would be free to damage cells.

Antigens are also present on the surface of the cells of your body. These can play a significant role in the case of a transplant or transfusion, since the cells of another person may be recognized as foreign and trigger an immune reaction.

Testing Relevance

Tests for antigens and antibodies are the staple of clinical laboratories where your doctor sends your blood samples. These tests can help diagnose illnesses, prevent immune reactions, or check to see whether you have responded to a vaccine.

Antigen Test

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Antigen tests are used to diagnose illnesses that are currently present in the body. Unlike antibodies which can tell whether a person has ever had a virus or other pathogen, antigen tests can only determine an ongoing infection. This is because the antigen disappears along with the pathogen it was bound to.

For example, in terms of COVID-19, antigen tests are likely the first line of discovery because they can determine whether or not a person is ill with the virus at the current time.³ This is important to help ward off the spread of the infection to other people.

Antibody Test

An antibody test works differently than the antigen test in the sense that it can be done long after the antigens have left the body. This specific test is used to determine whether or not an infection had ever occurred by singling out the antibodies that were created when the immune response took place.

As opposed to COVID-19 antigen testing, antibody testing can be done any time following the infection. It can be utilized to help isolate the viral information, seeing who has been previously exposed and developed an immune response. In developing a vaccine, researchers will look to see whether a vaccinated person developed antibodies.⁴

Blood and Tissue Antigen Testing

Testing for different blood or tissue antigens is a very important aspect of blood transfusion or tissue or organ transplant.

In the case of blood transfusion, blood types must match A, B, and O antigens between donor and recipient. If not matched, the body has preformed antibodies that can immediately attack the unmatched red blood cells. The resulting transfusion reaction can be fatal.⁵

Similarly, tissue typing such as for human leukocyte antigen (HLA) is commonly done before organ or tissue transplant. Matching these can help prevent organ or tissue rejection.

A Word From Verywell

Antigens can often be confused with antibodies, but the two hold very distinct positions when it comes to warding off pathogens that could lead to detrimental infection within the body. The antigen acts as more of an eliminator and antibody generator when it binds with certain immune cells.

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Antigens may not be the main attraction when it comes to immunity, but they play a crucial role in the prevention and elimination of diseases.

verywellhealth.com, 27 October 2020

<https://www.verywellhealth.com>

Rare, 2-headed snake discovered by Florida house cat

2020-10-27

What has two brains, no legs and the best profile pic on Facebook? That would be this rare, two-headed racer snake recently discovered by a house cat in Palm Harbor, Florida.

The cat's family was rudely introduced to the supernatural serpent about a month ago when their cat, Olive, dropped the critter on their living room floor, according to a Facebook post. The family was bewildered to see that a small, speckled snake with two heads attached to the same body, each one able to move its eyes, neck and tongue independently. The family named the snake "Dos" — Spanish for "two."

PLAY SOUND

"His biggest problem is eating," Kay Rogers, the cat's owner, said of the two-headed snake on Facebook. "We are trying lots of things, but he has trouble coordinating his two heads."

This condition — known as bicephaly — is an uncommon abnormality that occurs during embryonic development, when identical twins fail to fully separate, Live Science previously reported. The condition appears in all sorts of animals, including deer and porpoises; humans seem to encounter living bicephalic snakes about once a year. In 2019, a bicephalic baby rattlesnake named "Double-Dave" turned up in New Jersey, while a two-headed viper slithered onto a family's property in Virginia in 2018. Dos just helped 2020 meet its quota.

Bicephalic animals tend to have a rough go of it in the wild, where their competing brains make it harder to do things like catch prey or flee predators. As such, they often end up in the custody of wildlife experts. For now, Dos is being cared for by the Florida Fish and Wildlife Conservation Commission (FWC), which recently took some spiffy head shots (heads shots?) of the snake for Facebook. FWC experts identified Dos as a juvenile southern black racer (*Coluber constrictor Priapus*), a small, nonvenomous snake common in the southeastern United States.

The family named the snake "Dos" — Spanish for "two."

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Dos certainly has a better shot of survival under the care of FWC herpetologists than in the wild (for starters, no need to worry about curious cats anymore), but life will be far from easy. In nature, two heads aren't always better than one. Just ask this worm that grew a second face on its butt.

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livescience.com, 27 October 2020

<https://www.livescience.com>

News in Brie! Scientists discover cheese is so smelly because it helps microbes 'talk' to the bacteria that makes it ripe

2020-10-25

Many of us can be put off a Stinking Bishop or a gooey Gorgonzola by its strong whiff.

Scientists, however, have found why that smell is so vital – it helps microbes 'talk' to the bacteria that ripen cheese.

Researchers at Tufts University in the US discovered the bacteria respond to volatile organic compounds (VOCs) produced by fungi in the rind and released into the air, giving the delicious flavours found on cheese boards.

The combination of bacteria, yeast and fungi is critical to its flavour so the experts say discovering how to control the microbial ecosystem is a breakthrough in the art of cheese-making.

'Humans have appreciated the diverse aromas of cheeses for hundreds of years, but how these aromas impact the biology of the cheese microbiome had not been studied,' said Benjamin Wolfe, professor of biology and one of the authors of the study – published in *Environmental Microbiology*.

'Our latest findings show that cheese microbes can use these aromas to dramatically change their biology and the findings' importance extends beyond cheese-making to other fields as well.'

As bacteria and fungi grow on ripening cheeses, they secrete enzymes that break down amino acids to produce compounds that contribute to the flavour and aroma of cheese.

They are the reason why camembert, stilton and limburger have their signature smells.

'The bacteria are able to actually eat what we perceive as smells,' said Casey Cosetta, who co-authored the study.

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The researchers found VOCs don't just contribute to the taste and texture of cheese, but also provide a way for fungi to communicate with and 'feed' bacteria in the cheese microbiome.

'The bacteria are able to actually eat what we perceive as smells,' said Casey Cosetta, who co-authored the study. 'With VOCs, the fungi are really providing a useful assist to the bacteria to help them thrive.'

Cheese expert Steve Parker, author of *British Cheese On Toast*, warned not everything can be perfected in a lab, saying cheesemakers believe the environment in the dairy and the maturing room and the moulds and yeasts in there is what gives a cheese 'unique characteristics'.

[dailymail.co.uk](https://www.dailymail.co.uk), 25 October 2020

<https://www.dailymail.co.uk>

Aliens on 1,000 nearby stars could see us, new study suggests

2020-10-23

There are about 1,000 star systems where aliens, if they existed, could be watching us from afar, new research suggests.

Those 1,004 star systems are in a direct line of sight to our planet, and close enough to us that they could not only detect planet Earth, but also chemical traces of Earthly life.

Over the course of the last decade, astronomers have found exoplanets orbiting distant stars using a simple formula: Keep an eye on a star and wait for it to suddenly dim. That dimming is a sign of a planet passing between the star and the telescope. Analyzing how the light changes as the star dims can reveal the chemical contents of the planet's atmosphere.

But this method works only for planets whose orbits happen to take them between their host stars and Earth. In a new paper, researchers flipped that formula on its head, asking: Which nearby stars are lined up properly for their inhabitants to see Earth transit in front of the sun? Would any life-forms in those star systems be able to detect signs of us, the living things on Earth's surface? The answer is yes, it turns out, for a great number of nearby stars.

"If observers were out there searching, they would be able to see signs of a biosphere in the atmosphere of our Pale Blue Dot," Lisa Kaltenegger,

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a Cornell University astronomer and lead author of the paper, said in a statement.

Planets, it turns out, are common in space. Since researchers first confirmed finding one transiting in front of its star in 1992, astronomers have found 4,292 confirmed planets beyond our solar system, orbiting 3,185 stars, thanks largely to the planet hunting Transiting Exoplanet Survey Satellite (TESS). The James Webb Space Telescope (JWST), slated to launch at some point this decade, should have the precision to study many of those planets in more detail — possibly detecting gases like methane or oxygen in their atmospheres, which would be likely signs of life.

PLAY SOUND

What if aliens had their own JWST? Within 326 light-years, the researchers found, there are 1,004 with vantage points to spot Earth. Of those, 508 have viewing angles that would give them at least 10 hours of observational data every time Earth passed between that location and the sun — ideal conditions for spotting this little rocky planet and the signs of life in its atmosphere.

"Only a very small fraction of exoplanets will just happen to be randomly aligned with our line of sight so we can see them transit," said Lehigh University astrophysicist Joshua Pepper, co-author of the paper, in the statement. "But all of the thousand stars we identified in our paper in the solar neighborhood could see our Earth transit the sun, calling their attention."

About 5% of the 1,004 stars are likely too young for intelligent life to have evolved, the researchers surmise, even if a planet with habitable conditions orbited them. But the remaining 95% belong to star categories that can sustain life for billions of years, which Earth's experience suggests is long enough for intelligent life to evolve, assuming conditions are right.

Most of the stars on the list are toward the farther end of the 326 light-year range, because the zone where Earth's transit is visible gets smaller as you get closer to our solar system. But the closest star on the list is only 28 light-years away. And there are several more nearby stars that are on track to enter the zone where they might spot Earth within centuries. Some are bright enough in the sky to see from Earth.

Two stars on the list have known exoplanets. And a red dwarf just 12 light-years from Earth with known exoplanets — known as Teegarden's star — does not currently have the right viewing angle to spot Earth but at

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its current rate of movement will enter the Earth-spotting zone as soon as 2044.

The next step, the researchers wrote, is to focus intelligent life-hunting operations on the 1,004 stars identified in their paper. They specifically mentioned SETI's Breakthrough Listen program, designed to detect communications from advanced alien civilizations.

This research was published Oct. 20 in the journal *Monthly Notices of the Royal Astronomical Society*.

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livescience.com, 23 October 2020

<https://website>

You may have a new organ lurking in the middle of your head

2020-10-20

You may think we've learned everything there is to know about human spit, but it turns out the well has not gone dry. Scientists may have identified a previously undiscovered pair of salivary glands near the center of our heads, *The New York Times* reports. According to standard anatomy textbooks, the body has just three major sets of salivary glands: one under the tongue, another below the jaw, and the third near the ears. This potential fourth pair sits near where the nasal cavity meets the throat. Researchers noticed these unfamiliar structures while looking through the computerized tomography scans of 100 patients diagnosed with prostate or urethral gland cancer. They then examined tissues from two cadavers, and found that the structures were similar to salivary glands located underneath the tongue, they reported last month in *Radiotherapy and Oncology*. More research is needed to conclude whether these mysterious structures are newly discovered organs, or one of the hundreds of minor salivary glands in the mouth and throat. If the finding is confirmed, it would be the first discovery of salivary glands in about 300 years.

[sciencemag.org](https://www.sciencemag.org), 20 October 2020

<https://www.sciencemag.org>

This potential fourth pair sits near where the nasal cavity meets the throat.

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These oceanographers want to turn marine slime into drugs

2020-10-27

ON WEDNESDAY, A crew of technicians will hoist a remotely operated vehicle dubbed Hercules from its berth on an oceanographic research vessel down into a patch of ocean about 150 miles off the Southern California coast. After being released from the crane, the tethered craft will slowly sink to the seafloor between 2,000 and 5,000 feet below, and begin a treasure hunt for new kinds of compounds that could one day become medicines.

The VW Beetle-sized Hercules and 211-foot Nautilus will spend the next 10 days in a region called the Southern California Borderlands, which includes underwater seamounts, canyons, and ridges that are covered in layers of mineral-laden sediments and rocks. The expedition is led by Scripps and the Ocean Exploration Trust (which operates the Nautilus), and sponsored by the National Oceanic and Atmospheric Administration.

The geological features contain crusts of phosphorite and ferromanganese—minerals that have commercial value as sources of fertilizer and are mined from the seafloor off the coasts of Namibia and Mexico. But it's the living creatures that populate this unexplored habitat that could hide a biological goldmine. That's because the compounds produced by these seafloor animals may also have anti-cancer, antibacterial, or antiviral properties.

As of this month, 15 drugs derived from marine organisms have been approved by federal regulators, according to a database compiled by the Midwestern University Department of Marine Pharmacology, including treatments for various cancers and a cholesterol-lowering drug. Another 23 compounds derived from everything from marine sponges and worms to pufferfish are currently in Phase I, II, or III Food and Drug Administration clinical trials.

As just a few examples, in June, the FDA approved a new treatment for lung cancer called lurbinectedin that was originally synthesized from a toxin found in the sea squirt, or tunicate, a marine invertebrate that uses the poison to ward off enemies. A protein called griffithsin that was synthesized from a species of red algae from New Zealand a decade ago might also have use as an antiviral. In 2016, a group of US and French researchers published a study showing the chemical blocked infection of the virus that causes Middle East respiratory syndrome, or MERS. In

That's because the compounds produced by these seafloor animals may also have anti-cancer, antibacterial, or antiviral properties.

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December 2019, researchers at the University of Pittsburgh began a Phase I clinical trial with griffithsin to test its ability to block HIV infections as well. Now some researchers are investigating whether this same compound might help in the fight against the novel coronavirus.

To find new drug-producing animals, algae, and microbes, the oceanographers aboard the Nautilus first have to learn more about the animals that live there. The expedition's chief scientist, Lisa Levin, a professor of integrative oceanography at the Scripps Institution of Oceanography, says the goal of the cruise is to understand the habitat and how animals interact with the mineral-laden rocks. "Most of the places we are going, nobody has been to," Levin says. "But we do know the whole region has corals and sponges, anemones, and other invertebrates."

Levin is studying the interaction between the animals and the rocky bottom they call home. "We don't know very much about whether there are animals that prefer to be on those substrates, or avoid them," Levin says.

Levin will help specially trained ROV pilots aboard the Nautilus hover the Hercules over the bottom habitats to observe the sea creatures using multiple cameras, including a high-definition video camera that sends images through a fiber-optic cable to the ship and then via satellite to scientists, students, and the public through a round-the-clock livestreaming system. The pilots operate the vehicle's powerful robot arms to grab samples of rocks as well as to insert a coring device into seafloor sediments, where Levin hopes to find even smaller animals. "The rocks are full of animals, but most people aren't looking for these little tiny things," she says. "In the sediment, we take a core and slice it up into vertical fractions."

Once the samples are collected and brought back to the surface, Paul Jensen will begin the task of identifying animals and microbes that might be good candidates for novel biopharmaceutical compounds. To do that, Jensen, a professor at the Center for Marine Biotechnology and Biomedicine, which is operated by the Scripps Institution of Oceanography at UC San Diego, will scrape bacterial slime from rocks, take razor-thin slices from sponges, and check for algae living on corals. He's hoping to find chemical toxins that protect these animals from getting eaten by predators, but might also be harnessed to help humans fight cancer or infectious diseases.

"There are lots of sponges and soft corals that often have microbes with symbiotic associations with them," says Jensen. "That often includes a

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chemical component they may produce that defends it from predation. Now we have deep sea communities that nobody has looked at."

Jensen has been hunting for ocean treasures since he was a graduate student. In fact, a compound he and colleagues at Scripps found in sediments off the Bahamas back in 1990 is now undergoing Phase III clinical trials as a treatment for a type of brain cancer called glioblastoma. Back then, Jensen had to culture and grow the compound in a lab and see if it had any useful properties. Now researchers can skip the culturing step, collect DNA from the animal or microbe, and assess its potential to produce desirable molecules—looking for genetic sequences in the new creatures that they already know give rise to compounds that work against diseases. "If the compound is in the DNA from a sponge and looks promising," Jensen says, "we don't have to go out and collect kilos of the sponge to try to find the molecule. We can take the DNA and, using molecular approaches, we can clone that DNA in a microbe we can grow in the lab and make the molecule that way."

These molecules are then tested against bacterial or cancer cell lines to see if they either kill them or stop them from growing. Additionally, by understanding the genes of the new organisms, researchers can decipher how the proteins are structured and then produce them synthetically.

"We now know a lot about the genes involved in making them," Jensen says. "This is pretty fun and changed the face of how people do drug discovery."

Jensen isn't making any promises that the upcoming expedition will find any new blockbuster drugs. It takes years of basic science, lab testing, and then millions of dollars to run clinical trials to see if they are both safe and effective in fighting human disease.

The pipeline of drugs from the sea, or so-called "marine biopharmaceuticals," has been growing, says Barry O'Keefe, a senior scientist at the National Cancer Institute who leads up drug development from natural products. O'Keefe says that so far 15 marine-related drugs have been approved for human use globally, while another 23 are being tested in FDA clinical trials. "Sometimes things take a while to mature," O'Keefe says about the long time between discovery of a compound and development of a drug treatment. "There's such a long time-frame to understand how things work."

O'Keefe authored the research paper in 2009 about the properties that red algae from New Zealand has in blocking MERS infections. Jensen's initial

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research found that griffithsin binds to the MERS virus's spike glycoprotein and stops it from entering human cells, effectively stopping the infection. He says colleagues have been contacting him to see if it might work against the novel coronavirus, which is related to MERS.

He is excited that his paper is receiving new interest in the face of a novel health threat. "I've been getting a lot of calls about it," O'Keefe says. "It's not so usual that a 10 year-old paper gets that popular."

For Jensen and the other scientists on board the Nautilus, they hope their search for nature's medicines proves just as fruitful. "If we can find new classes of molecules, that's a pretty big deal," Jensen says. "Maybe they will be antiviral or antibacterial or anti-cancer. But finding them is the first part."

wired.com, 27 October 2020

<https://www.wired.com>

Climate change hits rock and roll as prized guitar wood shortage looms

2020-10-28

Every winter and spring, rains across the central U.S. combine with snowmelt along the northern reaches of the Mississippi River to inundate the hardwood-dominated bottomlands of the lower Mississippi. When the floodwaters recede and soils dry up in summer, logging crews harvest species of trees that include green ash. Being partly submerged for months encourages these trees to produce thin-walled cells with large gaps between them, creating a low-density wood prized by musical instrument makers. Since the 1950s, American guitar giant Fender Musical Instruments has used this kind of ash to create its iconic electric guitars. Countless music legends, from bluesman Muddy Waters to rockers Keith Richards of the Rolling Stones and Chrissie Hynde of the Pretenders, have loved their Fenders, and many say this wood gives the instruments a warm but crystal-clear twang. This niche has earned it colloquial labels such as "swamp ash," "music ash" or "punk ash" in the lumber and music industries (although the names are used for a couple of others species of ash as well).

Once cheap and readily available, swamp ash became an integral part of Fender's DNA over the decades, says Mike Born, former director of wood technology at the company. But earlier this year an acute shortage forced Fender to announce it would move away from using swamp ash in its famous line of Stratocasters and Telecasters—reserving the wood

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for vintage models only. Fender blamed the dwindling supply on longer periods of climate-fueled flooding along the lower Mississippi—which is endangering saplings and making it harder for lumber companies to reach standing trees—as well as the looming threat of an invasive tree-boring beetle. Another renowned U.S. manufacturer called Music Man raised similar sourcing concerns in 2019, which the company described as having "one of the worst harvests in recent history."

The ominous situation shows how climate change consequences can reverberate through all aspects of society—even rock and roll. And the swamp ash supply could soon become still more tenuous because experts expect global warming to continue making floods worse. "The average player just won't be able to afford it," Born says.

INUNDATION AND INVASION

In the lower Mississippi River, these trees are capable of enduring seasonal flooding. As soon as the bottomlands are dry enough, logging crews set out to harvest the timber. "Once the river goes back within its banks, the ground is just as safe to cross with heavy logging equipment as a Walmart parking lot," says Norman Davis, former president and a current adviser for Anderson-Tully Lumber in Vicksburg, Miss. The company was once Fender's biggest supplier of swamp ash, but increasingly intense flooding events have made things difficult. "The bottomlands have been pretty much inaccessible the last two and a half years," he says.

Between June 2018 and July 2019, the U.S. experienced its 12 wettest months on record, according to the National Oceanic and Atmospheric Administration. The agency found the 2019 spring floods along the Mississippi were among the most damaging in modern history. And a 2018 study in *Nature* showed the area's flooding has become more frequent and severe over the past 150 years. "We've got intense rainfall from climate change that's increasing the amount of water going into the river," says Gerald Galloway, an expert on Mississippi River hydrology and a civil and environmental engineering professor at the University of Maryland. And an expanding system of dams, walls and levees—originally intended to prevent floods—may instead be making the situation even worse.

Green ash is a fast-growing species, and it has adapted to seasonal flooding. But lengthening periods of high water can still mean trouble, especially for seedlings. "If you're talking about an early-growing-season flood that flushes out in a couple of weeks, it's not really a problem for ash," says Brady Self, a forestry specialist in bottomland hardwoods at the Mississippi State University Extension Service. But they are not geared to

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withstand year after year of long-duration floods. "If the water stays on for months and at a time when the seedlings just don't have their heads above the water, they might have trouble surviving," Self says. Lee Jones of J. M. Jones Lumber Company in Natchez, Miss., says he has witnessed some damage. "The river has been up for so long, and for so much, that it's killed a lot of the trees," he says.

Another threat is also lurking around the corner: the emerald ash borer. The larvae of this invasive beetle, native to Asia, tunnel through wood and disrupt trees' ability to transport water and nutrients. Since it was first spotted in this country (in Michigan in 2002), the pest has spread to 35 U.S. states and five Canadian provinces and killed millions of native ash trees. "I think it's the most rapid-spreading insect we've seen attacking trees in the U.S.," says Jennifer Koch, a Forest Service biologist.

The emerald ash borer has not reached the lower Mississippi floodplains, but Koch says "it's only a matter of time" until the beetle does so. Aware of this threat, several lumber companies started harvesting any adult swamp ash trees they could find in areas selected for annual logging in 2015. Previously, they would limit the take to about 30 percent of adult ash trees in those designated spots. Koch says the decision makes sense under the current circumstances, though it leaves fewer trees for the future.

FINDING AN ALTERNATIVE

Meanwhile Fender's announcement about moving away from ash has triggered some dismay in the guitar world. For Richie Kotzen, who rose to fame decades ago with the heavy metal bands Poison and Mr. Big, the ramifications are personal: he recently learned that his signature Fender guitar models, crafted with swamp ash bodies since the 1990s, will now need to be made with a different type of wood. "Many years ago, I had decided what my favorite woods were on a guitar. I learned that I liked a swamp ash body with a maple neck, and I stuck with it," he says. "Now I'm going to have to figure out a replacement wood for ash."

There are a handful of options, including red alder, which is native to North America's West Coast. Since the late 1950s, Fender has used alderwood to make less expensive versions of many of its swamp ash guitar models. But many aficionados think ash wood's blond finish and open grain make for a prettier-looking instrument—and for nuanced differences in sound tonality that sets it apart from alderwood. "Ash has a very fast attack. Think of a bright clap," says Brian Swerdfeger, vice president of Fender's guitar-research-and-development wing. "Alder has a warmer, softer attack. Still a clap, but it's rounder."

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Koch and other researchers are also trying to breed green ash (and other ash species) that might resist the emerald ash borer and replace decimated tree stands. The project will take decades, but with climate change continuing largely unabated, future flooding problems in the bottomlands are unlikely to wane. "I can adapt to a new wood," Kotzen says. "But I'm much more bothered by the environmental issue."

The area of the Mississippi River near where Jones's and Davis's companies log receded this past summer, and logging crews have returned to the bottomlands. The region's ash will remain a precarious commodity in the foreseeable future, however. "There's great demand, but I don't think we're going to have much punky ash to sell," Jones says. "There just aren't as many trees left."

Because it may get harder for future generations to lay their hands on swamp ash Fender guitars, music fans may have to content themselves with the legacy of the wood—perhaps by cranking up the "Stairway to Heaven" solo Led Zeppelin's Jimmy Page shredded on his swamp ash Dragon Telecaster.

scientificamerican.com, 28 October 2020

<https://www.scientificamerican.com>

Can lab-grown brains become conscious?

2020-10-27

In Alysson Muotri's laboratory, hundreds of miniature human brains, the size of sesame seeds, float in Petri dishes, sparking with electrical activity.

These tiny structures, known as brain organoids, are grown from human stem cells and have become a familiar fixture in many labs that study the properties of the brain. Muotri, a neuroscientist at the University of California, San Diego (UCSD), has found some unusual ways to deploy his. He has connected organoids to walking robots, modified their genomes with Neanderthal genes, launched them into orbit aboard the International Space Station, and used them as models to develop more human-like artificial-intelligence systems. Like many scientists, Muotri has temporarily pivoted to studying COVID-19, using brain organoids to test how drugs perform against the SARS-CoV-2 coronavirus.

But one experiment has drawn more scrutiny than the others. In August 2019, Muotri's group published a paper in *Cell Stem Cell* reporting the creation of human brain organoids that produced coordinated waves

The idea of bodiless, self-aware brains was already on the minds of many neuroscientists and bioethicists.

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of activity, resembling those seen in premature babies¹. The waves continued for months before the team shut the experiment down.

This type of brain-wide, coordinated electrical activity is one of the properties of a conscious brain. The team's finding led ethicists and scientists to raise a host of moral and philosophical questions about whether organoids should be allowed to reach this level of advanced development, whether 'conscious' organoids might be entitled to special treatment and rights not afforded to other clumps of cells and the possibility that consciousness could be created from scratch.

The idea of bodiless, self-aware brains was already on the minds of many neuroscientists and bioethicists. Just a few months earlier, a team at Yale University in New Haven, Connecticut, announced that it had at least partially restored life to the brains of pigs that had been killed hours earlier. By removing the brains from the pigs' skulls and infusing them with a chemical cocktail, the researchers revived the neurons' cellular functions and their ability to transmit electrical signals².

Other experiments, such as efforts to add human neurons to mouse brains, are raising questions, with some scientists and ethicists arguing that these experiments should not be allowed.

The studies have set the stage for a debate between those who want to avoid the creation of consciousness and those who see complex organoids as a means to study devastating human diseases. Muotri and many other neuroscientists think that human brain organoids could be the key to understanding uniquely human conditions such as autism and schizophrenia, which are impossible to study in detail in mouse models. To achieve this goal, Muotri says, he and others might need to deliberately create consciousness.

Researchers are now calling for a set of guidelines, similar to those used in animal research, to guide the humane use of brain organoids and other experiments that could achieve consciousness. In June, the US National Academies of Sciences, Engineering, and Medicine began a study with the aim of outlining the potential legal and ethical issues associated with brain organoids and human-animal chimaeras.

The concerns over lab-grown brains have also highlighted a blind spot: neuroscientists have no agreed way to define and measure consciousness. Without a working definition, ethicists worry that it will be impossible to stop an experiment before it crosses a line.

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The current crop of experiments could force the issue. If scientists become convinced that an organoid has gained consciousness, they might need to hurry up and agree on a theory of how that happened, says Anil Seth, a cognitive neuroscientist at the University of Sussex near Brighton, UK. But, he says, if one person's favoured theory deems the organoid conscious whereas another's doesn't, any confidence that consciousness has been attained vanishes. "Confidence largely depends on what theory we believe in. It's a circularity."

Sentient states

Creating a conscious system might be a whole lot easier than defining it. Researchers and clinicians define consciousness in many different ways for various purposes, but it is hard to synthesize them into one neat operational definition that could be used to decide on the status of a lab-grown brain.

Physicians generally assess the level of consciousness in patients in a vegetative state on the basis of whether the person blinks or flinches in response to pain or other stimuli. Using electroencephalogram (EEG) readings, for instance, researchers can also measure how the brain responds when it is zapped with an electrical pulse. A conscious brain will display much more complex, unpredictable electrical activity than one that is unconscious, which responds with simple, regular patterns.

But such tests might not adequately probe whether a person lacks consciousness. In brain-imaging studies of people who are in a coma or vegetative state, scientists have shown that unresponsive individuals can display some brain activity reminiscent of consciousness — such as activity in motor areas when asked to think about walking³.

In any case, standard medical tests for consciousness are difficult to apply to brain cells grown in dishes, or disembodied animal brains. When Muotri suggested that his organoids' firing patterns were just as complex as those seen in preterm infants, people were unsure what to make of that. Some researchers don't consider the brain activity in a preterm infant to be complex enough to be classed as conscious. And organoids can't blink or recoil from a painful stimulus, so they wouldn't pass the clinical test for consciousness.

By contrast, it's much more likely that an intact brain from a recently killed pig has the necessary structures for consciousness, as well as wiring created by memories and experiences the animal had while it was alive. "Thinking about a brain that has been filled with all this, it is hard to

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imagine that brain would be empty," says Jeantine Lunshof, a philosopher and neuroethicist at Harvard University in Cambridge, Massachusetts. "What they can do in terms of thinking I don't know, but it's for sure not zero," says Lunshof. Bringing a dead brain back to a semblance of life, as the Yale team did, might have the potential to restore a degree of consciousness, although the scientists took pains to avoid this by using chemical blocking agents that prevented brain-wide activity.

Researchers agree that they need to take the possibilities raised by these studies seriously. In October 2019, UCSD held a conference of about a dozen neuroscientists and philosophers, together with students and members of the public, with the intention of establishing and publishing an ethical framework for future experiments. But the paper has been delayed for months, partly because several of the authors could not agree on the basic requirements for consciousness.

Increasingly complex

Almost all scientists and ethicists agree that so far, nobody has created consciousness in the lab. But they are asking themselves what to watch out for, and which theories of consciousness might be most relevant. According to an idea called integrated information theory, for example, consciousness is a product of how densely neuronal networks are connected across the brain. The more neurons that interact with one another, the higher the degree of consciousness — a quantity known as phi. If phi is greater than zero, the organism is considered conscious.

Most animals reach this bar, according to the theory. Christof Koch, president of the Allen Institute for Brain Science in Seattle, Washington, doubts that any existing organoid could achieve this threshold, but concedes that a more advanced one might.

Other competing theories of consciousness require sensory input or coordinated electrical patterns across multiple brain regions. An idea known as global workspace theory, for instance, posits that the brain's prefrontal cortex functions as a computer, processing sensory inputs and interpreting them to form a sense of being. Because organoids don't have a prefrontal cortex and can't receive input, they cannot become conscious. "Without input and output, the neurons may be talking with each other, but that doesn't necessarily mean anything like human thought," says Madeline Lancaster, a developmental biologist at the University of Cambridge, UK.

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Connecting organoids to organs, however, could be a fairly simple task. In 2019, Lancaster's team grew human brain organoids next to a mouse spinal column and back muscle. When nerves from the human organoid connected with the spinal column, the muscles began to spontaneously contract⁴.

Most organoids are built to reproduce only one portion of the brain — the cortex. But if they develop long enough and with the right kinds of growth factor, human stem cells spontaneously recreate many different parts of the brain, which then begin coordinating their electrical activity. In a study published in 2017, molecular biologist Paola Arlotta at Harvard University coaxed stem cells to develop into brain organoids composed of many different cell types, including light-sensitive cells like those found in the retina⁵. When exposed to light, neurons in the organoids began firing. But the fact that these cells were active doesn't mean the organoids could see and process visual information, Arlotta says. It simply means that they could form the necessary circuits.

Arlotta and Lancaster think their organoids are too primitive to be conscious, because they lack the anatomical structures necessary to create complex EEG patterns. Still, Lancaster admits that for advanced organoids, it depends on the definition. "If you thought a fly was conscious, it's conceivable that an organoid could be," she says.

However, Lancaster and most other researchers think that something like a revitalized pig brain would be much more likely to achieve consciousness than an organoid. The team that did the work on the pig brains, led by neuroscientist Nenad Sestan, was trying to find new ways to revitalize organs, not to create consciousness. The researchers were able to get individual neurons or groups to fire and were careful to try and avoid the creation of widespread brain waves. Still, when Sestan's team saw what looked like coordinated EEG activity in one of the brains, they immediately halted the project. Even after a neurology specialist confirmed that the pattern was not consistent with consciousness, the group anaesthetized the brains as a precautionary measure.

Sestan also contacted the US National Institutes of Health (NIH) for guidance on how to proceed. The agency's neuroethics panel, including Lunshof and Insoo Hyun, a bioethicist at Case Western University in Cleveland, Ohio, assessed the work and agreed that Sestan should continue to anaesthetize the brains. But the panel hasn't settled on more general regulations, and doesn't routinely require a bioethics assessment for organoid proposals because its members think that consciousness is

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unlikely to arise. The NIH hasn't arrived at a definition of consciousness, either. "It's so flexible, everyone claims their own meaning," Hyun says. "If it's not clear we're talking about the same thing, it's a big problem for discourse."

Fuzzy definitions

Some think it is futile to even try to identify consciousness in any sort of lab-maintained brain. "It's just impossible to say meaningful things about what these bunches of brain cells could think or perceive, given we don't understand consciousness," says Steven Laureys, a neurologist at the University of Liège in Belgium, who pioneered some of the imaging-based measures of consciousness in people in a vegetative state. "We shouldn't be too arrogant." Further research should proceed very carefully, he says.

Laureys and others point out that the experience of an organoid is likely to be very different from that of a preterm infant, an adult human or a pig, and not directly comparable. Furthermore, the structures in an organoid might be too small to have their activity measured accurately, and similarities between the EEG patterns in organoids and preterm baby brains could be coincidental. Other scientists who work on brain organoids agree with Laureys that the question of whether a system is conscious could be unanswerable. Many avoid the idea entirely. "I don't know why we would try to ask that question, because this system is not the human brain," says Sergiu Pasca, a neuroscientist at Stanford University in California. "They're made out of neurons, neurons have electrical activity, but we have to think carefully about how to compare them."

Muotri wants his organoid systems to be comparable, in at least some ways, with human brains, so that he can study human disorders and find treatments. His motivation is personal: his 14-year-old son has epilepsy and autism. "He struggles hard in life," Muotri says. Brain organoids are a promising avenue, because they recapitulate the earliest stages of brain wiring, which are impossible to study as a human embryo develops. But studying human brain disorders without a fully functioning brain, he says, is like studying a pancreas that doesn't produce insulin. "To get there, I need a brain organoid model that really resembles a human brain. I might need an organoid that becomes conscious."

Muotri says he is agnostic about which definition to use to decide whether an organoid reaches consciousness. At some point, he says, organoids might even be able to help researchers answer questions about how brains produce conscious states. For instance, mathematician Gabriel Silva at UCSD is studying neural activity in Muotri's organoids to develop an

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algorithm that describes how the brain generates consciousness⁶. The goal of his project, which is partially funded by Microsoft, is to create an artificial system that works like human consciousness.

At the moment, there are no regulations in the United States or in Europe that would stop a researcher from creating consciousness. The National academies panel plans to release a report early next year, outlining the latest research and making a judgement on whether regulations are needed. Members plan to weigh in on questions such as whether to obtain people's consent to develop their cells into brain organoids, and how to study and dispose of organoids humanely. The International Society for Stem Cell Research is also working on organoid guidelines, but is not addressing consciousness because it doesn't think the science is there yet.

Hyun says that the NIH neuroethics panel has not yet seen any proposals to create complex, conscious organoids that would necessitate new guidelines. And Muotri says he doesn't know of anyone else deliberately trying to create conscious organoids either, although a sufficiently complex organoid could, by some definitions, reach that status accidentally.

Still, Muotri and others say they would welcome some guidelines. These could include requiring scientists to justify the number of human brain organoids they use, to use them only for research that cannot be done in any other way, to restrict the amount of pain that can be inflicted on them, and to dispose of them humanely.

Having such advice in place ahead of time would help researchers weigh up the costs and benefits of creating conscious entities. And many researchers stress that such experiments have the potential to yield important insights. "There are truly conscious people out there with neurological disorders with no treatments," Lancaster says. "If we did stop all of this research because of the philosophical thought experiment," she adds, "that would be very detrimental to actual human beings who do need some new treatment."

Treatments could still, however, be tested in brain organoids made using mouse stem cells, or in regular animal models. Such experiments could also inform discussions about the ethical use of human organoids. For instance, Hyun would like to see researchers compare the EEG patterns of mouse brain organoids with those of living mice, which might indicate how well human organoids recapitulate the human brain.

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For his part, Muotri sees little difference between working on a human organoid or a lab mouse. “We work with animal models that are conscious and there are no problems,” he says. “We need to move forward and if it turns out they become conscious, to be honest I don’t see it as a big deal.”

nature.com, 27 October 2020

<https://www.nature.com>

Why bat scientists are socially distancing from their subjects

2020-10-23

There’s nothing Winifred Frick likes better than crawling through guano-filled caves and coming face-to-face with bats. As chief scientist of Bat Conservation International, she is on a mission to promote understanding of bats and protect imperiled species from extinction.

For months, though, Frick has avoided research that would put her within spitting distance of bats. Her only projects to persist through the pandemic have been conducted from afar, like using acoustic monitors to eavesdrop on the animals’ squeaks and swooshes. In an era of COVID-19, that “hands-off” approach and other precautions are crucial to protect both bats and people, Frick, a biologist at the University of California, Santa Cruz, and over two dozen other scientists argue online September 3 in PLOS Pathogens.

Why the call to action? SARS-CoV-2, the virus that causes COVID-19, likely originated in bats in China (SN: 3/26/20). But neither it nor other coronaviruses belonging to the same genus — Betacoronavirus — have been detected in the more than 40 bat species in North America, although the animals do harbor other types of coronaviruses. Scientists are not worried about catching SARS-CoV-2 from these bats. They’re afraid of giving it to the bats — not an impossibility, the authors argue, given that the United States leads the world in infections, with nearly 8 million as of October 16.

“We can’t tell bats to socially distance,” Frick says. “We want to reduce the chance that there’s any pathogen transfer across animals, full stop.” The goal is to prevent viral “spillover.”

Human-to-bat transmission isn’t an unheard-of scenario. People are likely to blame for introducing *Pseudogymnoascus destructans*, the fungus that causes white nose syndrome, to North American bats. The disease has

“We can’t tell bats to socially distance,” Frick says.

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killed millions of bats throughout the United States and Canada since it was first detected in 2006 (SN: 3/31/16).

It’s unknown if bats are susceptible to SARS-CoV-2 infection, or if the virus would make them sick — bats rarely become ill from the viruses they carry (SN: 2/12/20). But infected bats might spread the virus back to humans, the authors say.

Worse, introducing SARS-CoV-2 to other coronaviruses carried by North American bats could provide the ingredients for creating a new virus (SN: 11/30/17). Either scenario could stoke pre-existing fears about bats spreading disease, presenting a major hurdle for bat conservationists trying to bolster support for the animals.

The International Union for the Conservation of Nature’s bat specialist group, which includes Frick, initially advocated for the hands-off approach in April. Because so little was known in the early days of the pandemic about how SARS-CoV-2 spreads, that group recommended that researchers shut down any projects that involved interacting with bats. In August, the group updated its guidelines to also address spelunking and other activities that might bring humans into bat habitat.

The guidelines still recommend replacing fieldwork with distanced alternatives whenever possible. Picking through guano can identify bat species and reveal the viruses they carry, and cameras positioned outside bat caves and roosts can give a sense of abundance. Scientists can even resurrect evidence of pathogens held in the preserved tissues of bat specimens in museums.

But not all bat research can be socially distanced, and that means taking pandemic precautions, like ensuring field crews aren’t sick with COVID-19 and are wearing personal protective gear. White nose syndrome research already requires disposable Tyvek suits and gloves to reduce spreading the fungus. Now, masks will be a regular part of the ensemble.

For Frick, speaking up for bats has always been a part of being a bat biologist. Besides having a passion for the animals, conservation and human health are inseparable, she says. And bats provide ecosystem services that benefit humans, like pest control that saves North American farmers more than an estimated \$3.7 billion per year, according to a study published in 2011 in *Science*. As human populations expand into shrinking bat habitat, bats and humans increasingly cross paths, making viral spillover events and other harmful interactions more likely. The pandemic

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has intensified those risks, and for Frick, put the need to speak up “on steroids now.”

sciencenews.org, 23 October 2020

<https://www.sciencenews.org>

Do camels really have water in their humps?

2020-10-26

To survive in the desert, camels store water in their humps, right? Not quite. Although camels do have tricks to make the most of water they find, their humps aren't one of them. So why do camels have humps on their backs?

The answer: fat storage.

“They deal with dry seasons when food and water is scarce,” said Rick Schwartz, an animal care supervisor and national spokesperson at the San Diego Zoo. When food is available, camels eat enough calories to build up their humps so they can survive long periods of time when food is scarce. With a “full” hump, a camel can go up to four or even five months without food, Schwartz said. When camels use up their fat, their empty humps flop over like a deflated balloon until they eat enough to “inflate” them again, Schwartz said. **PLAY SOUND**

Camel calves aren't born with these fat deposits and don't grow them while they are nursing. “All the energy they're getting from mom is going to the growth of the body,” Schwartz told Live Science. Young camels begin to wean when they are 4 to 6 months old, although their humps don't start to form until they are 10 months to a year old. “But as the wild camels are dealing with the cycles of the seasons, they need to have some sort of hump within that first year,” Schwartz said. “They have to make it through that first dry season.”

There are two species of camels. Bactrian camels (*Camelus bactrianus*) live in parts of western China and Central Asia, and they have two humps. Arabian camels (*Camelus dromedarius*) are more common and have only one. But as far as Schwartz is aware, the extra hump does not allow Bactrian camels to go longer without food.

Although many animals store fat around their stomachs and sides, camels pack on the pounds vertically. One theory is that camels have a stomach callus which they lay directly in the sand, and belly fat could make it harder to lay this way, Schwartz said. Another theory is that being tall and narrow,

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with fat stored in humps instead of around the sides, means camels are exposed to less sunlight and less heat.

Because camel humps store food, the dromedaries need other ways to cope with water scarcity. For example, camels can can drink up to 30 gallons (114 liters) of water in one sitting, they excrete dry feces to retain water, and their kidneys efficiently remove toxins from water in the body so they can retain as much as possible, Schwartz explained. Camels have several other ways to make each drink of water go far, such as by catching moisture from every breath they exhale through their nose.

This incredible ability to make do with less water is “probably why the myth came about that if they go so long without water, they must be storing water in the humps,” Schwartz said.

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<https://www.livescience.com>

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