CHEMWATCH

Bulletin Board

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AUG. 05, 2022

(click on page numbers for links)

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ASIA PACIFIC

Decision to approve EDN

2022-07-27

EDN is a gas used to kill common pests found in wood. The active ingredient of EDN, ethanedinitrile, has not been previously assessed by the EPA.

The decision-making committee:

- approved EDN on the basis that its benefits are significant, and adverse effects are negligible with the appropriate control measures
- accepted the evidence that EDN is the most viable replacement for methyl bromide for treating timber and logs
- also acknowledged the concerns of Māori and the wider public regarding the health and environmental effects of EDN.

Controls for EDN

Controls are set to manage the risks of EDN under the HSNO Act and the Health and Safety at Work Act 2015.

There is a maximum application rate

The maximum application rate is 120 g of EDN/m^3.

Use is restricted

EDN is restricted to fumigating export logs or timber under a sheet or in a shipping container. Using EDN in a ship's hold is not allowed.

Wind speed

Average wind speed must be at least two metres per second (2 m/s) in the 10 minutes before ventilation takes place.

Tolerable exposure limit

The tolerable exposure limit for ethanedinitrile has been set at 0.034 ppm (as a 24-hour average).

Notification and reporting

Controls under the HSNO Act require that:

- relevant local authorities are notified of intended fumigations

An EPA decision-making committee has approved an application to import or manufacture EDN, a fumigant for timber and logs.

- relevant local authorities are notified as soon as practicable and within 24 hours if the tolerable exposure limit is exceeded
- a copy of the annual report of fumigation activities (required by WorkSafe) is provided to the EPA.

Other controls

Controls under the Health and Safety at Work Act are covered by WorkSafe Safe Work Instruments:

- Health and Safety at Work (Hazardous Substances—Requirements for Specified Fumigants) Amendment Safe Work Instrument 2022 – WorkSafe website
- Health and Safety at Work (General Risk and Workplace Management—Exposure and Health Monitoring Requirements for Ethanedinitrile) Safe Work Instrument 2022 – WorkSafe website.

Read More

New Zealand EPA, 27-07-22

https://www.epa.govt.nz/public-consultations/decided/decision-to-approve-edn/

Chemical added to the Inventory following issue of assessment certificate (early listing) – 22 July 2022

2022-07-22

The following industrial chemical has been added to the Australian Inventory of Industrial Chemicals under section 83 of the Industrial Chemicals Act 2019.

AICIS approved chemical name (AACN)	2,5-Furandione, polymer with 1-alkene, .alpha.-methyl-.omega.-(2-propen-1-yloxy)poly(oxy-1,2-ethanediyl) and 1-alkene, alkyl amide
Defined scope of assessment	The chemical has been assessed as: meeting the PLC criteria (Schedule 2 of the Rules) and not meeting the definition of lung overloading potential [within the meaning given in the Industrial Chemicals Categorisation Guidelines (the Guidelines)]
Listing date	11 July 2022

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Chemical added to the Inventory following the issue of an assessment certificate

Published date

22 July 2022

Read More

AICIS, 22-07-22

https://www.industrialchemicals.gov.au/news-and-notices/chemical-added-inventory-following-issue-assessment-certificate-early-listing-22-july-2022

Chemicals added to the Inventory 5 years after issue of assessment certificate – 27 July 2022

2022-07-27

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.

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

CAS Number	1043888-25-0
Chemical Name	Hexanedioic acid, mixed 4-methyl-2-propylhexyl and 5-methyl-2-propylhexyl and 2-propylheptyl esters
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	4 July 2022

CAS Number	1803166-30-4
Chemical Name	2-Propenoic acid, 2-methyl-, 2-dodecylhexadecyl ester, polymer with methyl 2-methyl-2-propenoate and 2-tetradecyloctadecyl 2-methyl-2-propenoate

CAS Number	1803166-30-4
Molecular Formula	$(C_{36}H_{70}O_2.C_{32}H_{62}O_2.C_5H_8O_2)_x$
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	11 July 2022

CAS Number	1616796-88-3
Chemical Name	1,3-Benzenedicarboxylic acid, polymer with 1,4-benzenedicarboxylic acid, 2,2-dimethyl-1,3-propanediol, 1,2-ethanediol and O,O,O-tris(4-isocyanatophenyl) phosphorothioate
Molecular Formula	$(C_{21}H_{12}N_3O_6PS.C_8H_6O_4.C_8H_6O_4.C_5H_{12}O_2.C_2H_6O_2)_x$
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	12 July 2022

CAS Number	1847401-64-2
Chemical Name	Decanedioic acid, polymers with glycerol, polyethylene glycol and succinic anhydride monopolyisobutylene derivs.
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	12 July 2022

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CAS Number	1793072-86-2
Chemical Name	2-Propenoic acid, 2-methyl-, 2-hydroxyethyl ester, polymer with hexadecyl 2-propenoate, octadecyl 2-propenoate and 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl 2-methyl-2-propenoate
Molecular Formula	$(C_{21}H_{40}O_2.C_{19}H_{36}O_2.C_{12}H_9F_{13}O_2.C_6H_{10}O_3)_x$
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	14 July 2022

CAS Number	121436-73-5
Chemical Name	Ethanaminium, N,N,N-trimethyl-2-[(1-oxo-2-propen-1-yl)oxy]-, chloride (1:1), polymer with ethenylbenzene
Molecular Formula	$(C_8H_{16}NO_2.C_8H_8.Cl)_x$
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	15 July 2022

CAS Number	145899-78-1
Chemical Name	3-Oxazolidineethanol, 2-(1-methylethyl)-, 3,3'-carbonate
Molecular Formula	$C_{17}H_{32}N_2O_5$
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	18 July 2022

CAS Number	152049-37-1
Chemical Name	Hexanedioic acid, polymer with butanedioic acid, 1,4-butanediol and 2-hydroxybutanedioic acid

CAS Number	152049-37-1
Molecular Formula	$(C_6H_{10}O_4.C_4H_{10}O_2.C_4H_6O_5.C_4H_6O_4)_x$
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	20 July 2022

CAS Number	246867-88-9
Chemical Name	Poly(oxy-1,2-ethanediyl), .alpha.-(2-hydroxy-3-sulfopropyl)-.omega.-hydroxy-, mono-C_{12-14}-alkyl ethers, 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	25 July 2022

Published date: 27 July 2022

Read More

AICIS, 27-07-22

https://www.industrialchemicals.gov.au/news-and-notices/chemicals-added-inventory-5-years-after-issue-assessment-certificate-27-july-2022

AMERICA

Mexico Publishes NOM-037, Draft Health and Safety Conditions for Teleworking

2022-07-28

On July 15, 2022, Mexico's Federal Official Gazette published the Ministry of Labor and Social Welfare's (STPS) draft of NOM (Official Mexican Standard)-037 STPS, which, if adopted, would implement protective measures for teleworkers (remote workers) and their workspaces.

What Is the Goal of NOM-037?

The draft standard aims to establish basic conditions and specific measures to prevent teleworkers' occupational diseases and accidents.

The draft standard aims to establish basic conditions and specific measures to prevent teleworkers' occupational diseases and accidents that could endanger their physical integrity, life, and health.

Employer Obligations

With this potential amendment to the Federal Labor Law, employers would be required to comply with certain obligations, such as agreeing with the employee on a place of work and ensuring the site has connectivity so that information and communication technologies could be properly used and managed. Additionally, the site would have to have reliable electricity, lighting, ventilation, and ergonomic conditions, and the employer would have to verify the presence of these conditions and ensure a safe workplace that allows for an employee's development and continuity.

Employers would be required to create a written Telework Policy that outlines risk prevention methods, provides mechanisms for employees to avoid isolation, and states any other rules that ensure teleworkers are being supervised without violating their privacy.

The Policy also would have to state the length of the work schedule and list the guaranteed labor rights and conditions. Employers also would be required to provide a mechanism that allows employees to inform employers of domicile changes or temporary transfers and other relevant requests.

Further, employers would be required to inform employees of any health and safety risks they might face and maintain a checklist of teleworking safety and health conditions. Employers would be permitted to visit remote workspaces, with the employee's prior authorization, to ensure there are no evident risks and to follow up on accident notices that occur outside the workplace, with cause or in the exercise of their teleworking activities. Social Security protocols would have to be followed at all times.

Read More

The National Law Review, 28-07-22

https://www.natlawreview.com/article/mexico-publishes-nom-037-draft-health-and-safety-conditions-teleworking

Rhode Island PFAS Regulations Become Law

2022-07-28

On June 27, 2022, Rhode Island passed two new laws into effect that regulate six types of PFAS in food packaging, drinking water, ground water, surface waters, and landfills. These laws place stringent requirements on companies doing business in Rhode Island and open the door to regulatory agency enforcement action in the state of Rhode Island. In addition, the Rhode Island PFAS regulations mean that companies that have not already done so absolutely must assess both past and current PFAS uses and risks that the new laws present. Failing to do so could result in costly remediation efforts, lawsuits, and the need to quickly change manufacturing or other industrial processes to minimize risk.

Rhode Island PFAS Regulations

The first law passed into effect was (H7223/S2298), known as the "PFAS In Drinking Water, Groundwater and Surface Waters" law. Of note, the law sets an interim drinking water standard for the state of 20 parts per trillion (ppt) for six specific PFAS – PFOA, PFOS, PFHxS, PFNA, PFHpA, and PFDA. Under the law, water suppliers must, by July 1, 2023, test water supplies for the regulated PFAS. If any of the six PFAS, or any combination thereof, are detected in excess of 20 ppt, the water company must begin quarterly testing and provide potable water to all users of the water system until testing shows quantities of the regulated PFAS below 20 ppt.

In addition, the new law requires the Rhode Island Department of Health to set permanent standards for PFAS in drinking water by 2024. The permanent standards can be set for PFAS as an entire class or any subclass. It also requires the Rhode Island Department of Environmental Management to set standards for PFAS in ground water and surface water by December 31, 2023, as well as landfill standards by December 31, 2022. Finally, by November 1, 2023, the Department of Environmental Management must submit a plan for a statewide plan into potential sources of PFAS pollution.

Read More

The National Law Review, 28-07-22

https://www.natlawreview.com/article/rhode-island-pfas-regulations-become-law

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Report recommends blood tests, medical monitoring for people exposed to toxic PFAS chemicals

2022-07-28

A new report from the National Academies recommends blood tests and medical monitoring for people likely to have high exposure to the toxic chemicals known as PFAS.

The report offers the first comprehensive summary detailing links between PFAS levels in the blood and specific health concerns. It concludes there is now "sufficient evidence" of association between PFAS exposure and kidney cancer in adults, decreased infant and fetal growth, decreased immune response, and high cholesterol in adults and children.

Ned Calogne, who chaired the study committee for the report, said he was surprised by the strength of the evidence linking PFAS to disease, and also by the "ubiquitousness" of PFAS exposure in the United States.

"We find contamination in all 50 states and at least two territories, and in over 2,800 communities across the country," said Calogne, a physician and incoming associate dean for public health practice at the Colorado School of Public Health.

PFAS chemicals have been used in many commercial items, like food packaging, stain-proof rugs, and nonstick cookware, and are also common in firefighting foams. The compounds are often called "forever chemicals" because they don't degrade easily and are very stable in water. To learn more about PFAS and if they've been found in your environment, read this.

Read More

Wbur, 28-07-22

https://www.wbur.org/news/2022/07/28/report-confirms-pfas-chemicals-linked-to-health-issues

EUROPE

Reminder – upcoming GB active substance renewal submission deadlines

2022-07-29

Apply for active substance renewal by the deadlines to keep products on the GB market

Under the GB BPR, active substance approvals will expire unless a renewal application is submitted at least 550 days before their expiry date.

Under the GB BPR, active substance approvals will expire unless a renewal application is submitted at least 550 days before their expiry date.

The 550-day deadlines are coming up for the following active substance/ product type combinations under GB BPR:

- Hydrochloric acid (CAS n/a EC 231-595-7) in product type 2

28 October 2022

- Margosa extract from the kernels of Azadirachata Indica extracted with water and further processed with organic solvents (CAS 84696-25-3 EC 283-644-7) in product type 18

28 October 2022

- Undecan-2-one (methyl nonyl ketone) (CAS 112-12-9 EC 203-937-5) in product type 19

28 October 2022

- 1-(4-chlorophenyl)-3-(2,6- difluorobenzoyl)urea (Diflubenzuron) (CAS 35367-38-5 EC 252-529-3) in product type 18

31 July 2023

- 4-phenoxyphenyl (RS)-2-(2- pyridyloxy)propyl ether (Pyriproxyfen) (CAS 95737-68-1 EC 429-800-1) in product type 18

31 July 2023

- Alkyl (C12-16) dimethylbenzyl ammonium chloride (ADBAC/BKC (C12-16)) (CAS 68424-85-1 EC 270-325-2) in product type 8

31 July 2023

- Didecyldimethylammonium chloride (DDAC) (CAS 7173-51-5 EC 230-525-2) in product type 8

31 July 2023

- Formaldehyde (CAS 50-00-0 EC 200-001-8) in product types 2 and 3

31 July 2023

- Powdered corn cob (CAS n/a EC n/a) in product type 14

31 July 2023

- Thiamethoxam (CAS 153719-23-4 EC 428-650-4) in product type 18

31 July 2023

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Any person, company or taskforce/consortium can support an active substance/product type combination for renewal – it doesn't have to be the original supporter.

Check the GB Article 95 List to see who the original supporters were

If a renewal application is not submitted for the above active substance/ product type combinations under GB BPR, the approvals will expire. This means the active substances can no longer be used in biocidal products of the relevant product types in Great Britain.

Read More

HSE, 29-07-22

https://www.hse.gov.uk/

GB Article 95 List – take action by 31 December 2022

2022-07-29

Biocidal active substance and product suppliers included on the EU Article 95 List at the end of the EU exit transition period on 31 December 2020 were automatically added to the GB Article 95 List.

If you wish to remain on the GB Article 95 List after 31 December 2022, you must:

- resubmit your data or letter of access to HSE; and
- confirm to HSE that you (or your representative) are established in the UK(Great Britain or Northern Ireland).

If you have already provided your data or letter of access to comply with earlier GB resubmission deadlines, you do not need to submit this again.

Suppliers that fail to complete both actions by 31 December 2022 will be removed from the GB Article 95 List.

IMPORTANT: Biocidal products containing active substances sourced from suppliers that are removed from the list cannot be supplied in GB – product suppliers are advised to check with their active supplier that the necessary actions are being taken

Read More

HSE, 29-07-22

https://www.hse.gov.uk/

Resubmit data and confirm you are based in the UK by 31 December 2022

Chemical safety – better access to chemicals data for safety assessments

2022-07-22

Summary

This initiative aims to improve access to chemicals data by removing technical and administrative obstacles. This is based on the principle that data should be easy to find, share and reuse, as well as be interoperable and secure.

The initiative will make it easier to access and use all available data and will increase transparency. It will also enable EU and national authorities, where necessary, to commission testing and monitoring of chemical substances as part of the regulatory framework.

Topic

Environment

Type of act

Proposal for a regulation

Call for evidence

FEEDBACK: OPEN

Feedback period

19 July 2022 - 16 August 2022 (midnight Brussels time)

Read More

European Commission, 29-07-22

https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13459-Chemical-safety-better-access-to-chemicals-data-for-safety-assessments_en

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INTERNATIONAL

How to group PFAS? Expert panel finds no single answer

2022-07-26

A panel of expert on the chemistry and toxicology of per- and polyfluoroalkyl substances (PFAS) as well as on mixtures risk assessment and toxicokinetics in general came together "to provide insight and guidance on [PFAS] grouping for the purposes of protecting human health from drinking water exposures, and how risks to PFAS mixtures should be assessed." The results from the series of "blind, independent responses to charge questions, and review and comments on co-panelists responses" were published in Regulatory Toxicology and Pharmacology on July 8, 2022. The panelists "represent various stakeholder groups including academia, regulators, and consultants" from four countries. They came to no unanimous conclusions but did have some general majority agreements.

The panelists agreed that "human health risk assessment must be based on the principles of hazard and exposure" and that "compound-specific mode of action or adverse outcome pathway (AOP) information is 'the gold standard'" for grouping PFAS. However, when comparing ratings of feasibility versus scientific merit of all the methods for grouping chemicals, mode of action had the highest scientific merit score but the lowest feasibility score. Using carbon chain length and chemical structure as the grouping methodology had the highest feasibility score and was in the middle of the range for merit. But "some panelists believed that categorizing PFAS with similar structures was inadequate without consideration of the toxic mode of actions dose-response relationships, and potencies." The experts note that the current lack of available information for the majority of PFAS also creates a significant challenge for risk assessment.

Read More

Food Packaging Forum, 26-07-22

https://www.foodpackagingforum.org/news/how-to-group-pfas-expert-panel-finds-no-single-answer

Studies detect microplastics in bottled and outdoor drinking water

2022-07-25

On July 21, 2022, the French association Agir pour l'Environnement published a report of their study in which they analyzed microplastics in bottled waters sold in France. The association contracted the Labocéa laboratory to perform the analysis. They found microplastics in seven out of the nine waters tested, including in waters from Badoit, Carrefour, Cristaline, Evian, Perrier, Vittel, and Volvic. Concentrations ranged between 1 and 121 particles < 5 mm per liter. Importantly, the highest quantity of particles was present in the "Vittel Kids," meaning water intended for children. Assuming an average consumption of 131 liters of bottled water, sums up to a consumption of 16,000 microplastics per year alone with drinking water.

Agir pour l'Environnement commented that "it is unacceptable to let the bottled water industry sell water polluted with microplastics, but presented as supposedly 'pure' and moreover 300-times more expensive than tap water! The government must protect our health and the environment, in priority that of the children, by making sure that the food chain is not polluted with microplastics. We must get out of disposable plastic as soon as possible, starting with the banning of plastic bottles."

A study published in 2018, tested 259 bottles (all but one were made of plastics) of eleven brands and detected microplastics in 93% of the bottled waters with an average of 10 particles > 100 µm and 325 particles between 6.5 and 100 µm (FPF reported). Microplastics have also been detected in mineral waters packed in glass bottles and beverage cartons (FPF reported) as well as in drinking water (FPF reported).

In an article published on July 18, 2022, in the journal Environmental Pollution, V.C. Shruti from Universidad Nacional Autónoma de México (UNAM), Mexico, analyzed free drinking water from Mexican outdoor refill kiosks for the presence of microplastics.

The researchers sampled drinking water from 22 refill kiosks located in neighborhood parks in nine municipalities of Mexico city and identified plastic particles using epifluorescence microscopy and polymer composition using attenuated total reflection-fourier-transform infrared spectroscopy (ATR-FTIR). All samples contained microplastics but quantities differed between 23 and 202 microplastics per liter between sample sites. Most of the plastics were fibers (88%) while 9% were

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fragments, and 3% were films. 56% of the fibers had a length shorter 200 µm and the majority were transparent. Shruti et al. further reported that microplastics were made of nine polymer types with polyvinyl alcohol (PVA) being the most predominant type.

Read More

Food Packaging Forum, 25-07-22

https://www.foodpackagingforum.org/news/studies-detect-microplastics-in-bottled-and-outdoor-drinking-water

REACH Update

AUG. 05, 2022

HSENI launches new initiative on 'REACH'

2022-07-27

The Health and Safety Executive Northern Ireland (HSENI) has launched a campaign to promote compliance with the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) in Northern Ireland (NI).

The REACH Regulation came into force on 1 June 2007 to replace a number of other pieces of legislation with a single system.

REACH is aimed at understanding potential chemical hazards and managing their risks to protect humans, animals, and the environment. Thus, no chemicals without health and safety data should be placed on the market.

Read More

Farming Life, 27-07-22

https://www.farminglife.com/country-and-farming/hseni-launches-new-initiative-on-reach-3783190

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Janet's Corner

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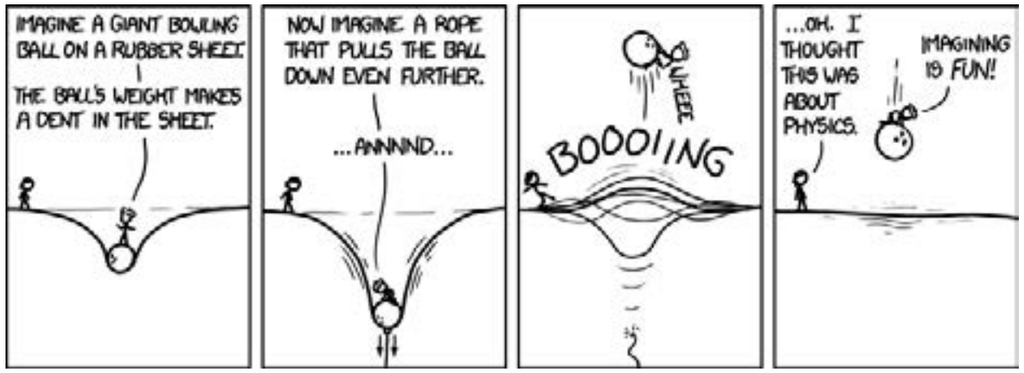
Rubber Sheet

2022-08-05



https://xkcd.com/1158/

Lindane (γ-Hexachlorocyclohexane)

2022-08-05

Lindane, also known as gamma-hexachlorocyclohexane, (γ-HCH), is an organochlorine chemical variant of hexachlorocyclohexane that has been used both as an agricultural insecticide and as a pharmaceutical treatment for lice and scabies.[1] It is a white solid that may evaporate into the air as a colourless vapour with a slightly musty odour. It is also available as a prescription (lotion, cream, or shampoo) to treat head and body lice, and scabies. Lindane has not been produced in the United States since 1976, but is imported for insecticide use. [2]

USES [3]

Lindane is used as an insecticide on fruit and vegetable crops, for seed treatment, in forestry, and for livestock and pet treatment. Whilst it is no longer manufactured in the United States, it is still formulated there. Aerial application of the chemical is prohibited. Lindane is also used topically for the treatment of head and body lice and scabies; it is available in 1 percent preparations as a lotion, cream, or shampoo.

SOURCES AND ROUTES OF EXPOSURE [2,3,4]

The most probable route of lindane exposure in humans is oral ingestion of food containing the insecticide. Lindane may also be inhaled, when released to the air during its formulation or use as an insecticide, from wind erosion of contaminated soil, or from release from hazardous waste sites. Lindane has been detected in groundwater and surface water samples collected near hazardous waste sites; however, the chemical has only very rarely been detected in drinking water supplies. Furthermore, lindane exposure can occur dermally, when applied as a lotion or shampoo to treat lice or scabies. Workers involved in the formulation or application of products containing γ-HCH may be exposed to higher concentrations. Once in the body, lindane is stored for a short time in body fat. It tends to leave the body very quickly through urine. Small amounts leave the body in faeces and when you exhale.

HEALTH EFFECTS [3]

Acute Effects

Acute inhalation exposure to lindane in humans has resulted in irritation of the nose and throat, effects on the blood (anaemia), and skin effects

Lindane, also known as gamma-hexachlorocyclohexane, (γ-HCH), is an organochlorine chemical variant of hexachlorocyclohexane that has been used both as an agricultural insecticide and as a pharmaceutical treatment for lice and scabies.[1] It is a white solid that may evaporate into the air as a colourless vapour with a slightly musty odour.

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(elevated itchy patches of skin). The major effects noted from oral exposure to lindane in humans are effects on the nervous system, such as seizures and convulsions. Vomiting and nausea and effects on the cardiovascular and musculoskeletal systems have also been reported. Oral studies in animals have reported effects on the liver, kidney, immune, and nervous systems from acute lindane exposure.

Chronic Effects

Chronic exposure to lindane by inhalation in humans has been associated with effects on the liver, blood, and nervous, cardiovascular, and immune systems. Effects noted in animal studies from chronic oral exposure to lindane include effects on the blood (decrease in numbers of red and white blood cells), immune, and nervous systems, and the liver and kidney.

Reproductive/Developmental Effects

Limited information is available regarding the reproductive or developmental effects of lindane in humans. The one available study reported increased levels (not statistically significant) of follicle stimulating hormone and decreased levels of testosterone in men occupationally exposed to lindane. It is not known whether these hormonal changes could result in diminished reproductive capability. Animal studies have reported reproductive effects, such as decreased sperm count, increased testicular weight, and disruption of spermatogenesis from oral exposure to lindane. Disrupted ovarian cycling and reduced ovulation rate were reported in female animals exposed to lindane by gavage (experimentally placing the chemical in the stomach). Lindane has not been reported to cause developmental effects, such as birth defects, in animals via oral exposure.

Cancer Risk

No studies are available concerning carcinogenic effects in humans or animals following inhalation exposure to lindane. Lindane has been demonstrated to be a liver carcinogen in mice via oral exposure. EPA considers lindane to be a possible human carcinogen and has ranked it in EPA's Group B2/C.

SAFETY [5]

First Aid Measures

- Eye Contact: Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least

15 minutes. WARM water MUST be used. Get medical attention immediately.

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

Exposure Controls and Personal Protection

Engineering Controls

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

Personal Protection

The following personal protective equipment should be used when handling lindane:

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

For large spills, the following should be used:

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

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

REGULATION [5,6,7]

Exposure Limits

United States

American Conference of Governmental Industrial Hygienists (ACGIH) Threshold limit value – time-weighted average (TLV-TWA) = 0.5 mg/m3 for lindane.

National Institute for Occupational Safety and Health (NIOSH) Recommended exposure limit (REL) = 0.5 mg/m3 for lindane. Immediately dangerous to life and health (IDLH) limit = 50 mg/m3 for lindane.

Occupational Safety and Health Administration (OSHA) Permissible exposure limit (PEL) = 0.5 mg/m3 for lindane.

Environmental Protection Agency (EPA) Safe Drinking Water Act Maximum contaminant level (MCL) = 0.0002 mg/L for lindane.

Food and Drug Administration (FDA) Maximum permissible level in bottled water = 0.0002 mg/L for lindane. Action levels for lindane in food and in animal feed range from 0.1 to 0.5 ppm. Lindane is a prescription drug subject to labelling and other requirements.

Australia

Safe Work Australia TWA: 0.008 ppm and 0.1mg/m3

United Kingdom

NIOSH SKIN TWA: 0.5 (mg/m3)

Inhalation TWA: 0.1 (mg/m3)

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Supercharged biotech rice yields 40% more grain

2022-07-22

By giving a Chinese rice variety a second copy of one of its own genes, researchers have boosted its yield by up to 40%. The change helps the plant absorb more fertilizer, boosts photosynthesis, and accelerates flowering, all of which could contribute to larger harvests, the group reports today in Science.

The yield gain from a single gene coordinating these multiple effects is "really impressive," says Matthew Paul, a plant geneticist at Rothamsted Research who was not involved in the work. "I don't think I've ever seen anything quite like that before." The approach could be tried in other crops, too, he adds; the new study reports preliminary findings in wheat.

A crop's yield is fiendishly complex because many genes interact to influence plant productivity. For years, biotechnologists have searched for single genes that augment yield, without much luck. In recent years they've shifted their interest to genes that control other genes, and therefore multiple aspects of physiology, such as taking up nutrients from the soil, setting the pace of photosynthesis, and directing resources from leaves to seeds. Modifying one such regulatory gene in maize gives a 10% higher yield—a major gain compared with the 1% increase per year achieved by traditional plant breeding.

To find other candidate yield boosters, a team led by plant biologist Wenbin Zhou of the Chinese Academy of Agricultural Sciences (CAAS) combed through 118 rice and maize regulatory genes, which encode proteins called transcription factors, that other researchers had previously identified as likely important in photosynthesis. Zhou's team sought to find out whether any of the genes were activated in rice grown in low-nitrogen soil, because such genes might boost uptake of the nutrient. Increasing their activity in rice grown in regular soil could nudge the plant to draw in even more nitrogen—and make more grain.

The team found 13 genes that turned on when rice plants were grown in nitrogen-poor soil; five led to a fourfold or greater boost in nitrogen uptake. They inserted an extra copy of one of the genes, known as OsDREB1C, into a rice variety called Nipponbare that's used for research. They also knocked out the gene in other individual rice plants. Greenhouse experiments by Shaobo Wei and Xia Li of CAAS showed plants without the gene grew less well than control plants, whereas those with extra copies of OsDREB1C grew faster as seedlings and had longer roots.

Genetic tweak may boost photosynthesis and fertilizer absorption in wheat, other crops, too

Good nutrition was one reason: Isotopic tracers revealed the plants with extra copies of OsDREB1C took up extra nitrogen through their roots and moved more of it to the shoots. The modified plants were also better equipped for photosynthesis; they had about one-third more chloroplasts, the photosynthetic organelles within plant cells, in their leaves and roughly 38% more RuBisCO, a key enzyme in photosynthesis. Planted in the field over 2 to 3 years, the enhanced rice gave higher yields at three sites in China with climates ranging from temperate to tropical.

Importantly, the researchers also transformed a high-yielding rice variety often planted by farmers by adding an extra copy of the gene. These modified modern rice plants produced up to 40% more grain per plot than did controls, the researchers report. "That's a big number," says Pam Ronald, a rice geneticist at the University of California, Davis. "Amazing."

As in the greenhouse experiments, the modified plants in the field boasted both bigger grains and more of them. "What they've done is to take a very good [rice variety] and shown they can make it better," says Steve Long, a plant physiologist at the University of Illinois, Urbana-Champaign, who adds that the result is a "lot more convincing" than improving a research variety.

The modified plants also flowered sooner, which gave them more time to devote to making grain. Faster flowering can offer other advantages, depending on the environment, for example allowing farmers to grow more crops per season or to harvest crops before damaging summer heat sets in. However, although the modified Nipponbare flowered up to 19 days earlier, the widely farmed variety of rice bloomed just 2 days earlier.

To demonstrate broader potential, the team added the rice OsDREB1C gene to a research variety of wheat and found the same types of effects. OsDREB1C and similar genes are present not just in rice, wheat, and other grasses, but also in broad-leaved plants. The researchers discovered comparable outcomes from adding an extra copy to the well-studied mustard plant called Arabidopsis. That's consistent with a common role across the plant kingdom, suggesting other kinds of crops might be amenable to yield boosts from this modification.

Transgenic crops such as the rice Zhou's team made are unacceptable to some consumers. But Zhou and colleagues say the same yield boost could be accomplished by editing the plant's own genes, which in some countries is now more lightly regulated than transgenic engineering. Another benefit is that increasing nitrogen efficiency of crops could lessen pollution of streams and lakes from excess fertilizer that runs off fields,

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Ronald says. And improved photosynthesis will be vital for adding to global food supplies, notes Steven Kelly of the University of Oxford in a commentary. "You can get huge jumps if you've got the right transcription factor," Long says. "I'm sure there'll be more."

Science, 22 July 2022

https://science.org

Natural clean-up: Bacteria can remove plastic pollution from lakes

2022-07-26

A study of 29 European lakes has found that some naturally-occurring lake bacteria grow faster and more efficiently on the remains of plastic bags than on natural matter like leaves and twigs.

The bacteria break down the carbon compounds in plastic to use as food for their growth.

The scientists say that enriching waters with particular species of bacteria could be a natural way to remove plastic pollution from the environment.

The effect is pronounced: the rate of bacterial growth more than doubled when plastic pollution raised the overall carbon level in lake water by just 4%.

The results suggest that the plastic pollution in lakes is 'priming' the bacteria for rapid growth— the bacteria are not only breaking down the plastic but are then more able to break down other natural carbon compounds in the lake.

Lake bacteria were found to favor plastic-derived carbon compounds over natural ones. The researchers think this is because the carbon compounds from plastics are easier for the bacteria to break down and use as food.

The scientists caution that this does not condone ongoing plastic pollution. Some of the compounds within plastics can have toxic effects on the environment, particularly at high concentrations.

The findings are published today in the journal Nature Communications.

"It's almost like the plastic pollution is getting the bacteria's appetite going. The bacteria use the plastic as food first, because it's easy to break down, and then they're more able to break down some of the more difficult food—the natural organic matter in the lake," said Dr. Andrew

Some of the compounds within plastics can have toxic effects on the environment, particularly at high concentrations.

Tanentzap in the University of Cambridge's Department of Plant Sciences, senior author of the paper.

He added: "This suggests that plastic pollution is stimulating the whole food web in lakes, because more bacteria means more food for the bigger organisms like ducks and fish."

The effect varied depending on the diversity of bacterial species present in the lake water—lakes with more different species were better at breaking down plastic pollution.

A study published by the authors last year found that European lakes are potential hotspots of microplastic pollution.

When plastics break down they release simple carbon compounds. The researchers found that these are chemically distinct to the carbon compounds released as organic matter like leaves and twigs break down.

The carbon compounds from plastics were shown to be derived from additives unique to plastic products, including adhesives and softeners.

The new study also found that bacteria removed more plastic pollution in lakes that had fewer unique natural carbon compounds. This is because the bacteria in the lake water had fewer other food sources.

The results will help to prioritize lakes where pollution control is most urgent. If a lake has a lot of plastic pollution, but low bacterial diversity and a lot of different natural organic compounds, then its ecosystem will be more vulnerable to damage.

"Unfortunately, plastics will pollute our environment for decades. On the positive side, our study helps to identify microbes that could be harnessed to help break down plastic waste and better manage environmental pollution," said Professor David Aldridge in the University of Cambridge's Department of Zoology, who was involved in the study.

The study involved sampling 29 lakes across Scandinavia between August and September 2019. To assess a range of conditions, these lakes differed in latitude, depth, area, average surface temperature and diversity of dissolved carbon-based molecules.

The scientists cut up plastic bags from four major UK shopping chains, and shook these in water until their carbon compounds were released.

At each lake, glass bottles were filled with lake water. A small amount of the 'plastic water' was added to half of these, to represent the amount of

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carbon leached from plastics into the environment, and the same amount of distilled water was added to the others. After 72 hours in the dark, bacterial activity was measured in each of the bottles.

The study measured bacterial growth—by increase in mass, and the efficiency of bacterial growth—by the amount of carbon-dioxide released in the process of growing.

In the water with plastic-derived carbon compounds, the bacteria had doubled in mass very efficiently. Around 50% of this carbon was incorporated into the bacteria in 72 hours.

"Our study shows that when carrier bags enter lakes and rivers they can have dramatic and unexpected impacts on the entire ecosystem. Hopefully our results will encourage people to be even more careful about how they dispose of plastic waste," said Eleanor Sheridan in the University of Cambridge's Department of Plant Sciences, first author of the study who undertook the work as part of a final-year undergraduate project.

Phys Org, 26 July 2022

https://phys.org

Gas getting too expensive? These people are making their own in their backyard

2022-07-23

Making your own gas can provide free fuel for cooking and cut down on waste.

The world wastes around a third of all food produced every year.

In Australia, that equals more than 7 million tonnes of edible food, and is estimated to cost the economy more than $36 billion annually, according to a report commissioned by the federal government.

At the same time, many of us cook on gas, which is getting more expensive and contributing to greenhouse gas pollution.

But there's a growing movement of people and businesses looking to kill two birds with one stone.

Creating biogas at home from food waste, which can then be used for cooking, is getting simpler.

Some companies now offer larger-scale systems for restaurants and even refugee camps, as well as basic home set-ups.

Around six years ago, Annett and Paul ditched city life in Sydney and moved to northern New South Wales, where they built an off-the-grid tiny house.

As part of that set-up, they installed a biogas food digester that they feed food scraps and toilet waste.

From that organic material, the system produces methane, which is fed by a line to a gas stove-top in their house.

Annett says there are some days in summer when the system is most productive, and they struggle to keep up with the amount of gas it creates, which they use to subsidise their solar-powered electric cooker.

"It's good. We're basically using it in the mornings or at night when the sun's not out," Annett says.

"We actually have to try to use it all up before [the system] fills up."

Making gas pays for itself

Emissions from food waste make up about 3 per cent of Australia's total greenhouse gas emissions every year, according to data from the former federal government.

Around the world, it's closer to 8 per cent of emissions.

Although creating biogas at home is not a "panacea" for our food-based emissions, it is one potentially valuable piece of the puzzle, according to the authors of a 2019 Australian study.

In the case study the authors looked at, it turned out to be a financially viable option too.

That study found that enough gas was produced from a single household to cook for an average of nearly 38 minutes each day.

However, that included some days where no gas was used, and others where up to two hours of gas supply was used.

According to their data, a system would pay for itself in just over four years based on savings from purchasing gas alone.

And that was based on the lower gas prices of the time.

If savings from fertiliser, which is a by-product of creating methane from food waste, were also factored in, that payoff time would be shorter again.

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Like Annett and Paul, Ned lives on an off-grid property near the Hawkesbury River in New South Wales and creates his own biogas.

"It's probably been about six months now [since we got the system].

"The bladder where the gas is stored lasts about two and a half hours' run time."

He says he realised the real utility of making his own biogas when his family was recently flooded in.

"[The delivery driver] couldn't get in to deliver a gas bottle," he says.

"This whole idea that you can always go to the shop and get things … that's not always the way."

He says their system doesn't produce enough gas to supply all their cooking needs, but it's excellent as a backup and for diverting waste from landfill.

"We probably don't have as much food waste as [the average family].

"We're a family of five — three little kids — the amount of gas cooking we do is probably more than we'd be able to generate on purely residential food waste consumption.

"[But] if it's got a few days between usage it's a fantastic backup, because it is reliable and it is stored."

Annett says it's a similar case with her family's system.

In the beginning, they went to the farmers markets to get extra food waste to feed it, but now they're only using the gas as a backup.

"We're not feeding it as much as we could — you could feed it up to six litres [of food waste], per day but we're only adding about one to two.

"If you only use it for making coffee or tea you can use it every day but if you cook meals on it ... we have to watch it a little bit."

What if I live in an apartment?

There are other requirements for creating biogas at home too that mean it's not a viable option for everyone.

While there are a number of different systems, and some people even make their own bespoke versions, they all take up quite a bit of space and are probably not conducive to apartment living.

That's because unlike liquefied natural gas that we get in gas bottles, for instance, methane produced from food scraps remains in its expanded, gaseous form.

Ned's pretty handy and is looking into ways to compress his homemade methane, but for others that wouldn't be an option.

Another issue is temperature.

Anaerobic digestion stops below about 20 degrees Celsius, and has an optimum digestion temperature of around 35C.

Although an electric heating device is one option to keep production going in cold climates, Annett says their system slows significantly at this time of year.

"It's winter at the moment and it's not as warm as it needs to be. It's not as productive as it is in summer."

So are there solutions for people without space or in colder climates?

Western Australia's City of Cockburn Council is collecting food waste from partners including fish and chips stores and bakeries.

They're then delivering that waste to a fertiliser plant where the methane is captured and used to power generators to produce electricity.

At their peak, they estimate the generators are supplying electricity from biogas to around 3,000 homes.

What began as a trial became a permanent service in 2021.

And Byron Shire is looking to implement a similar program permanently, which will also include waste from households.

Byron already has a three-bin system, with one dedicated to food waste that the eco-conscious community has got behind, according to bioenergy project manager John Hart.

"There's been really strong participation from the residential base up here."

With that waste collection system already in place, he says he's hoping to see their biogas generator up and running soon.

"We'd like to break ground in around February 2023 after the summer holidays and have the facility running a year later," he says.

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As well as being a cheaper alternative than landfill for businesses, Mr Hart thinks with the rising costs of fuels and waste disposal, savings could filter back to ratepayers.

"The business case for this facility is that we're keeping it local. We'll be reducing truck movements and powering the council's largest sewerage treatment plant with green electricity.

"It stands to reason that residential rates will drop, which will be a huge success story for the local residential ratepayer."

A waste treatment solution for refugee camps

Internationally, a company called HomeBiogas is making a system it says can work in apartment buildings, and will be plumbed into the garbage disposal chute in the sink.

It's also launching a system aimed at restaurants and army bases, and has been supplying refugee camps with systems to help manage food and toilet waste.

"HomeBiogas is supplying biogas systems for the treatment of organic waste at refugee camps in Africa, after winning two UN tenders," chief executive officer Oshik Efrati says.

Founded by a trio of marine biologists, that company says it's distributed over 15,000 systems so far, which offset more than 76,000 tonnes of CO2 emissions globally in 2021.

Mr Efrati expects those figures to ramp up significantly in the coming years as bigger products come online.

"Each commercial system can reduce greenhouse gas emissions by up to 1,000 tonnes of CO2-equivalent a year, compared to six tonnes a year for the household systems."

He says producing biogas at the source is part of a global movement to reframe "waste" as a resource.

"Countries across the world are starting to understand this and have implemented regulations forbidding sending waste to landfills," he says.

"We do not have any other options as landfills are filling up and their methane emissions are particularly damaging to the environment."

The UN and the International Energy Agency agree.

They've estimated biogas could supply up to 20 per cent of our gas demand as we transition away from fossil fuels.

Ned says it's a no-brainer.

"The fact that it can take all food waste and process it on site … on a community level as well as global, if people were not putting food waste into landfill, that would be huge."

ABC News, 23 July 2022

https://abc.net.au

PFAS linked to infertility, diabetes and billions in economic costs

2022-07-27

Researchers at the NYU Grossman School of Medicine have found strong evidence exposure to a common group of household chemicals can be associated with 13 different health conditions. The related economic costs have been estimated at between US$5 billion and $60 billion annually in the United States alone.

First developed in the 1940s, per- and polyfluoroalkyl substances (PFAS) encompass more than 4,700 different chemical molecules. For decades these chemicals were used in a variety of manufacturing contexts, from non-stick cookware and waterproof clothing to carpets and firefighting foams.

Because PFAS chemicals tend to persist in he environment for long periods of time they have anecdotally been dubbed "forever chemicals." And the sheer pervasiveness of PFAS in 20th century manufacturing led to studies finding traces of the chemicals in the blood of nearly every American.

Leveraging a very large body of pre-existing research, this new study looked to quantify the disease burden of PFAS exposure and estimate the economic cost of this in regards to medical bills and lost worker productivity. The goal of the economic estimate was to offer regulators a way to evaluate the cost-benefit of eliminating PFAS from our environment.

Some of the conditions linked to PFAS in the new study have been previously associated with exposure to the chemicals. These include kidney cancer, hypothyroidism and low birth weight. But the broader systematic analysis conducted in the new study also pointed to more

A new study suggests the high cost of trying to remove PFAS from our natural environment and water supplies may be less than the current annual economic impact of the chemicals on health care

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novel PFAS health conditions, such as infertility, endometriosis, bronchitis and type 2 diabetes.

Calculating the associated economic costs of PFAS-related disease and disability in the United States, the most conservative estimate was $5.52 billion annually. At the other end of the spectrum the study found those costs could be as much as $62.6 billion every year.

Senior author Leonardo Trasande said these findings should help lawmakers understand that engaging in decontamination programs to remove PFAS from water supplies would likely be a cheaper option considering these broader economic costs.

"Our results strongly support the recent decision by the Environmental Protection Agency to lower the safe allowable level of these substances in water," said Trasande. "Based on our estimates, the cost of eradicating contamination and replacing this class of chemical with safer alternatives is ultimately justified when considering the tremendous economic and medical risks of allowing them to persist in the environment."

Despite the striking findings, the researchers point out in the study how conservative they were in calculating these estimates. Only data from studies with strong evidence was included in evaluations of disease burden.

"We did not include outcomes reported by the C8 Science Panel that were not confirmed in general population studies, as those associations were identified in a highly exposed population and our focus was on estimating the disease burden and economic costs due to routine exposure," the study noted. "We also did not include endpoints for which not enough consistent evidence has accumulated, such as prematurity, attention-deficit hyperactivity disorder, and lowered IQ in children resulting from prenatal exposure, and prostate cancer in adult men."

Ultimately, the researchers suggest these findings are merely the tip-of-the-iceberg in regards to the impacts of PFAS exposure. Further study is set to better investigate the long-term effects of PFAS exposure, and expand to estimate economic impacts from other known toxic chemicals such as bisphenols.

The study was published in the journal Exposure and Health.

New Atlas, 27 July 2022

https://newatlas.com

Bees may feel pain

2022-07-26

We swat bees to avoid painful stings, but do they feel the pain we inflict? A new study suggests they do, a possible clue that they and other insects have sentience—the ability to be aware of their feelings.

"It's an impressive piece of work" with important implications, says Jonathan Birch, a philosopher and expert on animal sentience at the London School of Economics who was not involved with the paper. If the study holds up, he says, "the world contains far more sentient beings than we ever realized."

Previous research has shown honey bees and bumble bees are intelligent, innovative, creatures. They understand the concept of zero, can do simple math, and distinguish among human faces (and probably bee faces, too). They're usually optimistic when successfully foraging, but can become depressed if momentarily trapped by a predatory spider. Even when a bee escapes a spider, "her demeanor changes; for days after, she's scared of every flower," says Lars Chittka, a cognitive scientist at Queen Mary University of London whose lab carried out that study as well as the new research. "They were experiencing an emotional state."

To find out whether these emotions include pain, Chittka and colleagues looked at one of the criteria commonly used for defining pain in animals: "motivational trade-offs." People will endure the pain of a dentist's drill for the longer term benefits of healthy teeth, for example. Similarly, hermit crabs will leave preferred shells to escape an electric shock only when given a particularly high jolt—an experiment that demonstrated crabs can tell the difference between weak and strong painful stimuli, and decide how much pain is worth enduring. That suggests crabs do feel pain and don't simply respond reflexively to an unpleasant stimulus. Partly as a result of that study, crabs (and other crustaceans, including lobsters and crayfish) are recognized as sentient under U.K. law.

Chittka's team gave 41 bumble bees (Bombus terrestris) a choice between two high-quality feeders containing a 40% sugar solution and two feeders with lower percentages of sucrose. The researchers placed the feeders in a testing arena on top of individual heating pads colored pink or yellow. Initially, all the heating pads were turned off; the bees entered the arena one at a time and sampled the feeders. They had to sip from each one to detect the amount of sugar. All preferred the feeders with the most sugar.

Study suggests all insects may be sentient

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The scientists then warmed up the yellow pads beneath two of the high sucrose feeders to 55°C (a temperature high enough to cause the bees to consider leaving, but not so high as to cause injuries); feeders on the pink pads stayed cool. For a bee, landing on a hot yellow pad would be like us "touching a hot plate," says lead author Matilda Rose Gibbons, a behavioral neuroscientist and Ph.D. student in Chittka's lab. But bees that could withstand the pain would also get more sugar.

When given a choice between hot, sugar-rich feeders and cool, low-sugar feeders, the bees chose the former, the scientists report today in the Proceedings of the National Academy of Sciences. "If the sugar was superconcentrated, the bees would put up with more pain," Gibbons says. "They could walk away whenever they wanted, but they didn't. Getting that sugar was a huge motivator." When both the hot and cool feeders held high-sugar solutions, the bees avoided those on the yellow pads—demonstrating they used associative memories when choosing where to feed, the scientists report.

Besides crustaceans, "This is the first direct demonstration that arthropods"—a group that also includes insects and spiders—"can also do trade-offs," Birch says. He calls the study "intellectually fascinating" and "ethically important," given growing interest in farming insects for human consumption—and the complete lack of "research into the welfare needs of insects."

Still, it remains unclear whether bees really feel what we call pain; the scientists point out that their study does not provide "formal proof" of this ability. Given its subjective nature, "proving that insects feel pain is probably impossible," says Greg Neely, a behavioral geneticist at the University of Sydney. He has shown fruit flies' nervous systems can experience chronic pain, but he doubts that insects have the neurological systems to allow pain to register as a complex emotion.

Definitively proving insects mentally feel pain probably isn't possible, agrees Jennifer Mather, a zoologist and cephalopod expert at the University of Lethbridge whose studies helped prove those animals are sentient. Nevertheless, given that insects represent at least 60% of all animals, she says, "We can't ignore them. There is still anthropocentrism in Western science that rejects the idea of caring about 'dumb invertebrates.' Papers like this one will gradually chip away at this self-centered attitude."

Science, 26 July 2022

https://science.org

Carbon dating hampered by rising fossil-fuel emissions

2022-07-27

The researchers who track the ever-rising levels of atmospheric carbon dioxide have charted a landmark moment. As of 2021, the burning of fossil fuels has officially shifted the composition of carbon isotopes in the air of the Northern Hemisphere enough to cancel out a useful signal from nuclear-weapons testing1.

This could cause problems for valuable carbon-dating techniques. Modern items now look like objects from the early twentieth century in terms of radiocarbon dating, says Heather Graven, a chemical physicist at Imperial College London who has been charting this effect for years. The trend "could soon make it difficult to tell if something is 1,000 years old or modern", says Paula Reimer, a radiocarbon-dating specialist at Queen's University Belfast, UK. Although there are usually other clues to an object's provenance, "there are often stray finds without that information", says Reimer, such as unidentified human remains that might come from a historic burial site or from a person who died recently.

The development also means that forensic scientists will no longer be able to use radiocarbon fingerprints to pinpoint the ages of materials such as ivory, antiques and wine. "If you're working in forensics or detecting fakes, this is a really sad moment," says Tom Higham, an archaeologist at the University of Vienna.

Time machine

Carbon-dating techniques rely on the fact that there are several isotopes of carbon in the air. Stable carbon-12 is the most common. But there is also a small amount of radioactive carbon-14, which is generated mainly when cosmic rays interact with the atmosphere. The proportion of carbon-14 varies naturally over time.

Living things absorb both types of carbon. After they die, the relative amounts of the two isotopes start to change as the radioactive carbon-14 decays with a half-life of 5,700 years. By measuring how much carbon-14 is left in an object, researchers can date organic materials, such as wood, fabric or bone, that are up to about 55,000 years old. Typically, the smaller the ratio of carbon-14, the older the material.

Between 1952 and 1962, the testing of nuclear weapons released a spike of 'bomb carbon' that quickly doubled the amount of carbon-14 in the air. Since then, that carbon-14 has been slowly absorbed by living things and the ocean. At the same time, the burning of fossil fuels has been rapidly releasing CO2 that does not contain carbon-14.

Archaeologists will increasingly have to rely on other techniques as emissions continue to alter the composition of carbon isotopes in air.

As of 2021, these two effects have officially cancelled each other out in the Northern Hemisphere (see 'Altered carbon'). This means that the carbon-14 ratio in modern materials is now the same as in those from pre-industrial times. And because fossil fuels are still being burnt, the proportion of carbon-14 in the air will lessen further, mimicking conditions even further in the past. By 2050, Graven predicts1, the carbon-14 ratio will be similar to what it was in the Middle Ages (between the fifth and fifteenth centuries).

When there are wiggles and spikes in the proportion of carbon-14 in the air over time, radiocarbon dating can't always distinguish one date from another. This is true for the period of 800 BC to 400 BC, for example: "You literally can't date anything [precisely] within that 400 years," says Higham. The phenomenon of fossil fuels cancelling out bomb carbon provides yet another opportunity for radiocarbon confusion.

Bye-bye bomb curve

For modern objects that are just decades old, the decay of carbon-14 is negligible. But the rapid spike in carbon-14 released by nuclear weapons has created a diagnostic 'bomb curve' of carbon-14 levels. "It's the silver lining of bomb testing," says Higham. This means that the amount of carbon-14 in an object can provide a precise time stamp for organic materials formed between around 1960 and 2020. Higham has used it to detect forged whisky and date Chinese tea, among other things; the technique has been used on everything from groundwater to human cells2.

Researchers have long known that the end of this technique was coming, but increasing CO2 emissions have accelerated the process. In the coming decades, as fossil-fuel use wanes and the bomb curve flattens, the carbon-14 value will no longer be diagnostic of a date. "It's such a shame," says Higham.

"This wildlife forensics tool; the window is closing on its effectiveness," says palaeoecologist Kevin Uno at Columbia University in New York City, who has used the bomb curve to date ivory samples and study elephant poaching3. "It's kind of depressing."

The demise of the bomb curve means that researchers will increasingly have to rely on other techniques or isotopes to do their dating, including

a third type of carbon, carbon-13. "There may be some other radionuclide we can use," says Uno.

Nature, 27 July 2022

https://nature.com

Harm From Blue Light Exposure Increases With Age

2022-07-28

The damaging effects of daily, lifelong exposure to the blue light emanating from phones, computers and household fixtures worsen as a person ages, new research by Oregon State University suggests.

The study, published today in Nature Partner Journals Aging, involved Drosophila melanogaster, the common fruit fly, an important model organism because of the cellular and developmental mechanisms it shares with other animals and humans.

Jaga Giebultowicz, a researcher in the OSU College of Science who studies biological clocks, led a collaboration that examined the survival rate of flies kept in darkness and then moved at progressively older ages to an environment of constant blue light from light-emitting diodes, or LEDs.

The darkness-to-light transitions occurred at the ages of two, 20, 40 and 60 days, and the study involved blue light's effect on the mitochondria of the flies' cells.

Mitochondria act as a cell's power plant, generating adenosine triphosphate, or ATP, a source of chemical energy.

In earlier research, Giebultowicz showed that prolonged exposure to blue light affected flies' longevity, regardless of whether it shined in their eyes.

"The novel aspect of this new study is showing that chronic exposure to blue light can impair energy-producing pathways even in cells that are not specialized in sensing light," Giebultowicz said. "We determined that specific reactions in mitochondria were dramatically reduced by blue light, while other reactions were decreased by age independent of blue light. You can think of it as blue light exposure adding insult to injury in aging flies."

Collaborating with Giebultowicz on the work, partially funded by the National Institutes of Health, were Yujuan Song, Jun Yang and David Hendrix of the OSU College of Science, Matthew Robinson of the College

"Our previous work demonstrated that daily lifelong exposure to blue light, but not other visible wavelengths, has damaging effects on the brain, motor abilities and lifespan of the model organism."

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of Public Health and Human Sciences, and Alexander Law and Doris Kretzschmar of Oregon Health & Science University.

The scientists note that natural light is crucial for a person's circadian rhythm – the 24-hour cycle of physiological processes such as brain wave activity, hormone production and cell regeneration that are important factors in eating and sleeping patterns.

But there is evidence suggesting that increased exposure to artificial light is a risk factor for sleep and circadian disorders, Giebultowicz said. And with the prevalent use of LED lighting and device displays, humans are subjected to increasing amounts of light in the blue spectrum since commonly used LEDs emit a high fraction of blue light.

"This technology, LED lighting, even in most developed countries, has not been used long enough to know its effects across the human lifespan," she said. "There are increasing concerns that extended exposure to artificial light, especially blue-enriched LED light, may be detrimental to human health. While the full effects of blue light exposure across the lifespan are not yet known in humans, accelerated aging observed in short-lived model organism should alert us to the potential of cellular damage by this stressor."

In the meantime, there are a few things people can do to help themselves that don't involve sitting for hours in darkness, the researchers say. Eyeglasses with amber lenses will filter out the blue light and protect your retinas. And phones, laptops and other devices can be set to block blue emissions.

"Our previous work demonstrated that daily lifelong exposure to blue light, but not other visible wavelengths, has damaging effects on the brain, motor abilities and lifespan of the model organism," Giebultowicz said. "Now we're reporting that the damaging effects of blue light on the flies are strongly age dependent – the same length of exposure to the same intensity of light decreases lifespan and increases neurodegeneration more significantly in old flies than in young ones."

In the earlier research, flies subjected to daily cycles of 12 hours in light and 12 hours in darkness had shorter lives compared to flies kept in total darkness or those kept in light with the blue wavelengths filtered out.

The flies exposed to blue light showed damage to their retinal cells and brain neurons and had impaired locomotion – the flies' ability to climb the walls of their enclosures, a common behavior, was diminished.

Some of the flies in the experiment were mutants that didn't develop eyes, and even those eyeless flies displayed impairment, suggesting flies didn't have to see the light to be harmed by it.

Technology Networks, 28 July 2022

https://www.technologynetworks.com

Diabetes breakthrough restores insulin production using existing drug

2022-07-24

Australian scientists have demonstrated a new way to restore insulin production in pancreatic cells, using a drug that's already approved for use in humans. The study could mark a major breakthrough towards new treatments for diabetes.

Blood glucose levels are managed by the hormone insulin, which is produced in beta cells in the pancreas. However, these cells begin to die off in patients with type 1 diabetes, resulting in little or no insulin production and a lifelong requirement for supplementary insulin shots to manage the disease.

In a new study, researchers from Monash University have identified a new way to restore insulin production in the pancreas. In lab experiments on pancreatic stem cells from donors with type 1 diabetes, the team was able to activate them to begin expressing insulin by exposing them to a drug compound known as GSK126.

Intriguingly, these progenitor cells don't normally produce insulin, but the drug let them functionally step into the shoes of the beta cells that had stopped working. In principle, a single course of this kind of drug over a few days could replace the need for regular insulin shots in diabetics.

The team says that the new potential treatment has a few advantages over other techniques currently in use or under development. Pancreas transplants are effective, but subject to organ donor shortages and other complications like rejection. Other teams have converted skin cells into stem cells and used those to produce new beta cells, and although results have been promising in mice, immune-suppressing drugs need to be given to prevent rejection.

The new treatment would work much faster, within a matter of days, and without the need for surgery. But perhaps the biggest advantage is that GSK126 is already approved by the US FDA and elsewhere in the world

A new study could help restore insulin production to the pancreas of patients with type 1 diabetes.

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as a treatment for cancer. Its safety profile is already being assessed in clinical trials, which could reduce hurdles down the road for its use against diabetes.

That said, the scientists caution that it is still very early days. These experiments were conducted on cells in culture – not even in animals yet – so there's still plenty of work to do. Nevertheless, it remains an intriguing new possible tool.

"Before you get to patients, there are many issues to be resolved," said Dr Keith Al-Hasani, co-lead author of the study. "More work is required to define the properties of these cells and establish protocols to isolate and expand them. I would think therapy is pretty far away. However, this represents an important step along the way to devising a lasting treatment that might be applicable for all types of diabetes."

The research was published in the journal Signal Transduction and Targeted Therapy.

New Atlas, 24 July 2022

https://newatlas.com

Two Weeks In, the Webb Space Telescope Is Reshaping Astronomy

2022-07-25

As soon as President Biden unveiled the first image from the James Webb Space Telescope (JWST) on July 11, Massimo Pascale and his team sprang into action.

Coordinating over Slack, Pascale, an astrophysicist at the University of California, Berkeley, and 14 collaborators divvied up tasks. The image showed thousands of galaxies in a pinprick-size portion of the sky, some magnified as their light bent around a central cluster of galaxies. The team set to work scrutinizing the image, hoping to publish the very first JWST science paper. "We worked nonstop," said Pascale. "It was like an escape room."

Three days later, just minutes before the daily deadline on arxiv.org, the server where scientists can upload early versions of papers, the team submitted their research. They missed out on being first by 13 seconds, "which was pretty funny," said Pascale.

In the days after the mega-telescope started delivering data, astronomers reported exciting new discoveries about galaxies, stars, exoplanets and even Jupiter.

The victors, Guillaume Mahler at Durham University in the United Kingdom and colleagues, analyzed that same first JWST image. "There was just a sheer pleasure of being able to take this amazing data and publish it," Mahler said. "If we can do it fast, why should we wait?"

The "healthy competition," as Mahler calls it, highlights the enormous volume of science that is already coming from JWST, days after scientists started receiving data from the long-awaited, infrared-sensing mega-telescope.

The Dawn of Time

One of JWST's much-touted abilities is the power to look back in time to the early universe and see some of the first galaxies and stars. Already, the telescope — which launched on Christmas Day 2021 and now sits 1.5 million kilometers from Earth — has spotted the most distant, earliest galaxy known.

Two teams found the galaxy when they separately analyzed JWST observations for the GLASS survey, one of more than 200 science programs scheduled for the telescope's first year in space. Both teams, one led by Rohan Naidu at the Harvard-Smithsonian Center for Astrophysics in Massachusetts and the other by Marco Castellano at the Astronomical Observatory of Rome, identified two especially remote galaxies in the data: one so far away that JWST detects the light it emitted 400 million years after the Big Bang (a tie with the oldest galaxy ever seen by the Hubble Space Telescope), and the other, dubbed GLASS-z13, seen as it appeared 300 million years after the Big Bang. "It would be the most distant galaxy ever found," said Castellano.

Both galaxies look extremely small, perhaps 100 times smaller than the Milky Way, yet they show surprising rates of star formation and already contain 1 billion times the mass of our sun — more than expected for galaxies this young. One of the young galaxies even shows evidence of a disklike structure. More studies will be done to break apart their light to glean their characteristics.

Another early-universe program has also turned up "incredibly distant galaxies," said Rebecca Larson, an astronomer at the University of Texas, Austin and a member of the Cosmic Evolution Early Release Science (CEERS) survey. Just weeks into the survey, the team has bagged a handful of galaxies from the universe's first 500 million years, although Larson and her colleagues haven't released their exact findings yet. "It's better than I imagined and it's only the beginning," she said.

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More early galaxies hide in the image of the galaxy cluster presented by President Biden and studied by Pascale and Mahler. Called SMACS 0723, the cluster is so heavy that it bends the light of more distant objects, bringing them into view. Pascale and Mahler found up to 16 remote galaxies that have been magnified in the image; their exact ages aren't yet known.

The telescope took a closer look at one distant galaxy in the image, a smudge of light that dates to 700 million years after the Big Bang. With its spectrograph, JWST detected heavy elements, particularly oxygen, in the galaxy. Now scientists are hoping the telescope will find an absence of heavy elements in even earlier galaxies — evidence that these galaxies contain only Population III stars, the hypothesized first stars in the universe, thought to have been monstrously huge and made entirely from hydrogen and helium. (Only as those stars exploded did they forge heavier elements such as oxygen and spew them into the cosmos.)

"We're looking for galaxies where we see no heavy elements," said Andy Bunker, an astrophysicist at the University of Oxford. "That might be a smoking gun for the first generation of stars formed from primordial hydrogen and helium. Theoretically they should exist. It depends whether they're bright enough."

Galactic Structure

For scientists seeking to understand the structure of galaxies and how stars form within them, JWST has already provided impactful data.

One observing program, led by Janice Lee at the National Science Foundation's NOIRLab in Arizona, looks for young sites of star formation in galaxies. On behalf of Lee's team, JWST observed a galaxy 24 million light-years away called NGC 7496, whose young star-forming regions have until now been shrouded in darkness; Hubble's instruments were unable to penetrate the thick dust and gas that surrounds these regions. JWST, though, can see infrared light that bounces off the dust, allowing the telescope to probe close to the moments when the stars switched on and nuclear fusion ignited in their cores. "The dust is actually lighting up," said Lee.

What's most remarkable, she said, is that NGC 7496 is a normal galaxy, "not a poster-child galaxy." Yet under the watchful eye of JWST, it suddenly comes to life and reveals channels where stars are forming. "It's just phenomenal," she said.

John Barentine, an astronomer at the dark-sky conservation firm Dark Sky Consulting in Arizona, meanwhile, made a more serendipitous discovery in one of JWST's first images. The telescope's picture of the Southern Ring Nebula, 2,500 light-years from Earth, showed remarkable clarity. Off to the side, an intriguing galaxy viewed edge-on (a unique vantage point for studying the galaxy's central bulge), previously misidentified as part of the nebula itself, poked into view.

"We have this exquisitely sensitive machine that is going to serendipitously reveal things we didn't even know we were looking for," Barentine said. "In almost every image Webb takes, it's worth poking around in the background."

An Eye on Stars and Planets

Smaller targets are in JWST's crosshairs, too, including the planets of our own solar system. Jupiter appeared in magnificent fashion as part of the first batch of images, captured in an exposure lasting just 75 seconds.

Astronomers know that Jupiter's upper atmosphere is hundreds of degrees hotter than the lower atmosphere, but they aren't sure why. By detecting infrared light, JWST could see the heated upper atmosphere shining; it appears as a red ring around the planet. "We have this layer a few hundred kilometers above the cloud decks, and it's glowing because it's hot," said Henrik Melin, a planetary scientist at the University of Leicester. "We've never seen it like this before on a global scale. That's an extraordinary thing to see."

Melin's program plans to use JWST in the coming weeks to study the driving force behind this atmospheric heating.

Hiding in JWST's image of Jupiter is the volcanic moon Io interacting with Jupiter's aurora — creating a small bump in the aurora. The image reveals "material coming from Io streaming down the magnetic field lines," said Melin. The effect has been seen before, but it was easily picked out by JWST with barely a glance at the planet.

JWST is probing planets in other star systems too. Already, the telescope has taken a peek at the famous TRAPPIST-1 system, a red dwarf star with seven Earth-size worlds (some potentially habitable), though the data is still being analyzed. Early observations have been released of a less hospitable planet, a "hot Jupiter" called WASP-96 b, in a tight 3.4-day orbit around its star.

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JWST found water vapor in the planet's atmosphere, confirming evidence of water reported days earlier by Chima McGruder of the Harvard-Smithsonian Center and colleagues, who used a ground-based telescope. But JWST can go further; by observing WASP-96 b's ratio of carbon to oxygen, it may be able to solve a confounding mystery about hot Jupiters: how they attain such close orbits around their stars. More oxygen would suggest that the gas giant initially formed near the star, while a higher carbon ratio would suggest that it formed in more carbon-rich regions further away.

Meanwhile, JWST may have spotted a temporary light in the sky — a short-lived event known as a transient — which it was not initially designed to do. The astronomer Mike Engesser and colleagues at the Space Telescope Science Institute in Baltimore, Maryland (the operations center for JWST), noticed a bright object not apparent in Hubble images of the same region. They think it's a supernova, or exploding star, some 3 billion light-years away — proof that the telescope can find these events.

JWST should be capable of finding far more distant supernovas too, which will give it another way to serve as a probe of the early universe. It may also find stars being torn apart by the supermassive black holes that reside at galaxies' centers, something no previous telescope has seen. "For the first time we're going to be able to peer into these very deep, dark regions," said Ori Fox, an astronomer at the Space Telescope Science Institute who leads the team studying transients.

Transients, like other astronomical phenomena, are set to be redefined. After decades of planning and construction, JWST has hit the sky running. The issue now is keeping pace with the constant barrage of science coming down from a machine so complex yet faultless it almost defies belief that it was built by human brains. "It's working, and it's insane," said Larson.

Quanta Magazine, 25 July 2022

https://quantamagazine.org

New evidence hints at the role of gut microbiota in autistic spectrum disorder

2022-07-29

Autism spectrum disorder (ASD) is a neurological and developmental condition that affects how humans communicate, learn new things and behave. Symptoms of ASD can include difficulties in interacting with

others and adapting to changes in routine, repetitive behaviors, irritability and restricted or fixated interests for specific things.

While symptoms of autism can emerge at any age, the first signs generally start to show within the first two years of a child's life. People with ASD can encounter numerous challenges, which can be addressed through support services, talk therapy and sometimes medication.

To this day, neuroscientists and medical researchers have not identified the primary causes of ASD. Nonetheless, past findings suggest that it could be caused by the interaction of specific genes with environmental factors.

Interestingly, recent neuroscience studies have found that the biological makeup of the gut could contribute to some of the most characteristic symptoms of ASD. More specifically, experiments on mice suggest that the pathway between gut bacteria and the central nervous system can affect social behaviors.

Building on previous findings, researchers at University of Rome 'Tor Vergata' and University of Calabria have recently carried out a new study on mice, investigating the effects of transplanting fecal microbiota gathered from autistic donors to mice. Their results, published in Neuroscience, provide further evidence that links gut microbiota with social behaviors typical of ASD.

"Fecal microbiota transplant (FMT) via gavage from autistic children donors to mice, led to the colonization of ASD-like microbiota and autistic behaviors compared to the offspring of pregnant females exposed to valproic acid (VPA)," Ennio Avolio and his colleagues wrote in their paper. "Such variations seemed to be tightly associated with increased populations of Tenericutes plus a notable reduction ($p < 0.001$) of Actinobacteria and Candidatus S. in the gastrointestinal region of FMT mice as compared to controls."

Essentially, Avolio and his colleagues examined two different groups of mice. Mice in the first group (i.e., the experimental group) received transplanted microbiota originating from the gut of children with ASD, while mice in the other (i.e., the control group) were exposed to VPA, a synthetic compound with anticonvulsant properties, while in their mothers' wombs.

"Contextually, FMT accounted for elevated expression levels of the pro-inflammatory factors IL-1β, IL-6, COX-1 and TNF-α in both brain and small intestine," the researchers wrote in their paper. "Villous atrophy

To this day, neuroscientists and medical researchers have not identified the primary causes of ASD.

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and inflammatory infiltration (Caspase 3 and Ki67) were increased in the small intestine of FMT and VPA mice compared to controls. Moreover, the observed FMT-dependent alterations were linked to a decrease in the methylation status."

Interestingly, Avolio and his colleagues observed that the mice who received the ASD microbiota exhibited unusual behaviors while completing different maze tests that are widely used in neuroscience studies. Their behaviors could be linked to those observed in children and adults with ASD.

The recent findings gathered by this team of researchers seem to confirm previous results in the field, suggesting that gut microbiota can indeed play a role in social behaviors. In the future, they could inspire new research in this area and contribute to the testing and gradual introduction of treatments for autism that also consider diet and gut health.

"Overall, findings of the present study corroborate a key role of gut microbiota in ASD," Avolio and his colleagues wrote in their paper. "However, further investigations are required before any possible manipulation of gut bacteria with appropriate diets or probiotics can be conducted in ASD individuals."

Medical Xpress, 29 July 2022

https://medicalxpress.com

Researchers identify how cells move faster through mucus than blood

2022-07-25

Researchers at the University of Toronto, Johns Hopkins University and Vanderbilt University have discovered that certain cells move surprisingly faster in thicker fluid—think honey as opposed to water, or mucus as opposed to blood—because their ruffled edges sense the viscosity of their environment and adapt to increase their speed.

Their combined results in cancer and fibroblast cells—the type that often creates scars in tissues—suggest that the viscosity of a cell's surrounding environment is an important contributor to disease, and may help explain tumor progression, scarring in mucus-filled lungs affected by cystic fibrosis, and the wound-healing process.

The study, "Membrane ruffling is a mechanosensor of extracellular fluid viscosity," published today in Nature Physics, sheds new light on cell environments, an under-explored area of research.

"This link between cell viscosity and attachment has never been demonstrated before," says Sergey Plotnikov, assistant professor in the Department of Cell and Systems Biology in the Faculty of Arts & Science at the University of Toronto and a co-corresponding author of the study. "We found that the thicker the surrounding environment, the stronger the cells adhere to the substrate and the faster they move—much like walking on an icy surface with shoes that have spikes, versus shoes with no grip at all."

Understanding why cells behave in this surprising way is important because cancer tumors create a viscous environment, which means spreading cells can move into tumors faster than non-cancerous tissues. Since the researchers observed that cancer cells speed up in a thickened environment, they concluded that the development of ruffled edges in cancer cells may contribute to cancer spreading to other areas of the body.

Targeting the spreading response in fibroblasts, on the other hand, may reduce tissue damage in the mucus-filled lungs affected by cystic fibrosis. Because ruffled fibroblasts move quickly, they are the first type of cells to move through the mucus to the wound, contributing to scarring rather than healing. These results also may imply that by changing the viscosity of the lung's mucus, one can control the cell movement.

"By showing how cells respond to what's around them, and by describing the physical properties of this area, we can learn what affects their

"Perhaps if you put a liquid as thick as honey into a wound, the cells will move deeper and faster into it, thereby healing it more effectively."

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behavior and eventually how to influence it," says Ernest Iu, Ph.D. student in the Department of Cell and Systems Biology in the Faculty of Arts & Science at the University of Toronto and study co-author.

Plotnikov adds, "For example, perhaps if you put a liquid as thick as honey into a wound, the cells will move deeper and faster into it, thereby healing it more effectively."

Plotnikov and Iu used advanced microscopy techniques to measure the traction that cells exert to move, and changes in structural molecules inside the cells. They compared cancer and fibroblast cells, which have ruffled edges, to cells with smooth edges. They determined that ruffled cell edges sense the thickened environment, triggering a response that allows the cell to pull through the resistance—the ruffles flatten down, spread out and latch on to the surrounding surface.

The experiment originated at Johns Hopkins, where Yun Chen, assistant professor in the Department of Mechanical Engineering and lead author of the study, and Matthew Pittman, Ph.D. student and first author, were first examining the movement of cancer cells. Pittman created a viscous, mucus-like polymer solution, deposited it on different cell types, and saw that cancer cells moved faster than non-cancerous cells when migrating through the thick liquid. To further probe this behavior, Chen collaborated with U of T's Plotnikov, who specializes in the push and pull of cell movement.

Plotnikov was amazed at the change in speed going into thick, mucus-like liquid. "Normally, we're looking at slow, subtle changes under the microscope, but we could see the cells moving twice as fast in real time, and spreading to double their original size," he says.

Typically, cell movement depends on myosin proteins, which help muscles contract. Plotnikov and Iu reasoned that stopping myosin would prevent cells from spreading, however were surprised when evidence showed the cells still sped up despite this action. They instead found that columns of the actin protein inside the cell, which contributes to muscle contraction, became more stable in response to the thick liquid, further pushing out the edge of the cell.

The teams are now investigating how to slow the movement of ruffled cells through thickened environments, which may open the door to new treatments for people affected by cancer and cystic fibrosis.

Phys Org, 25 July 2022

https://phys.org

Flooding could expose toxic soil in city neighborhoods

2022-07-22

For decades in Houston, where resident Bryan "Lucas" Parras grew up near the city's shipping channel, neighborhoods have faced the cumulative impacts of toxic emissions. The area is crammed with industrial facilities, chemical plants and oil refineries. Pollution has become such an ingrained part of life, Parras said, that residents on the city's East End automatically adjust to the health threats: limiting time outdoors, filtering their water and making sure to carry their inhalers in case of asthma attacks.

"A lot of the pollution in Houston has just become normalized because there's so much and because so little has been done," said Parras, 45, and a co-founder of Texas Environmental Justice Advocacy Services. The group, known as t.e.j.a.s., for years has advocated on behalf of impacted neighborhoods by providing residents with tools to protect themselves and the environment.

Some of Houston's pollution is hidden in its soil. Failing to account for toxic contaminants that have settled in the ground in Houston and cities across the United States is likely to have serious consequences as weather becomes more extreme due to climate change. A recent study by researchers from New York University, Rice University and Brown University found that urban communities with a higher likelihood of flood risks face additional potential dangers from soil contaminated by decades of past industrial activities.

It's a new type of climate injustice, the researchers warn: floods spreading toxic industrial contaminants in racially marginalized neighborhoods.

"We're very concerned about the remobilization of toxics which may have wide ranging negative health outcomes," said the study's lead author, Thomas Marlow, a postdoctoral fellow in the Center for Interacting Urban Networks at New York University Abu Dhabi.

The study builds on 2018 research that the study's co-authors, sociologists James R. Elliott and Scott Frickel, outlined in their 2018 book Sites Unseen:

Climate change is surfacing industries' toxic legacy in marginalized communities.

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Uncovering Hidden Hazards in American Cities. They found that the failure to map so-called "relic" industrial sites leaves communities in the dark about potential contamination hot spots created by long-closed businesses outlived by their hazardous byproducts.

They looked at historical industrial directories for four American cities — New Orleans, Minneapolis, Portland and Philadelphia — and discovered that more than 90% of sites where hazardous industry has operated over the past half-century have become "lost, hidden from view" and ignored by government agencies.

Their latest study, published last month in the journal Environmental Research Letters, examined those cities and two additional ones, Houston and Providence. They compared the data from the manufacturing facilities with estimates of future flood risks.

In those six cities, the researchers found that more than 6,000 former industrial sites have an elevated flood risk over the next 30 years where legacy pollution is likely to exist in the soil. They also found entire zones of flood-prone relic industrial sites that could potentially expose thousands to hundreds of thousands of residents to toxic chemicals.

Floods risk spreading hazardous pollutants

Harris County, Texas, home to Houston, has nearly 2,000 flood-prone sites where chemical manufacturing, petroleum refining, metal fabrication and other polluting industries once operated from 1950 to 2010. A study by researchers from New York University, Rice University and Brown University, which focused on this area and five others across the country, found risks of floods spreading contaminants buried in the soil.

A disproportionate number of the people in the affected zones are low-income, those living in lower-quality housing and people of color.

The study cannot speak to the extent of soil contamination in these zones. But soil studies conducted by scientists across the country over the last several decades have found extensive soil contamination in the urban core of cities such as New Orleans, Indianapolis and Detroit, with toxic metals such as lead often the most common.

"I don't think it was a good idea to have industry next to residences, especially given that the industries weren't very well regulated at first," said Howard Mielke, an urban geochemistry and health expert at Tulane University School of Medicine who has spent four decades investigating the dangers of lead in soil across the country.

Almost every major city had a lead smelter or some form of lead industry, including paint or battery manufacturing, he noted. Cities are still experiencing the consequences today.

"There are a lot of other substances that have accumulated in these soils — lead is a very strong indicator of multiple [types] of pollution," Mielke said. The U.S. Government Accountability Office has examined the risks of major contaminated sites across the country and found that about 60% of these Superfund sites are at risk of being disturbed by climate change-driven flooding and wildfires.

"Everyone's beginning to agree that this is a huge issue," Elliott said. He and his co-authors are sharing their data for the six cities to help urban planners and other city officials create strategic plans to address the risks.

In Houston, the study's data shows the relic sites are located not just along the ship channel, but also one to two miles inland. Ancillary industries operated in that area and working-class residents settled there; today it is largely Latino.

Elliott has also researched industrial development in the area during more recent decades. He found that companies are increasingly building infrastructure, such as above-ground storage tanks, in floodplains. "So the contemporary issues and concerns are growing alongside the relics that are largely hidden," Elliott said.

Marlow, Frickel and Elliott hope their findings will trigger a broader discussion about how cities remediate urban lands. Instead of thinking in terms of site-by-site cleanups, officials need neighborhood-level or watershed-level approaches that recognize the widespread effects of industrial pollution.

And government agencies should engage historically marginalized communities in the strategic planning process, they said.

In Houston's shipping channel corridor, with industrial warehouses abutting homes, schools and even childcare centers, Parras said there's no escaping the environmental hazards. He wants to see a public health reckoning: one that acknowledges, documents and prevents environmental threats from current emissions and the legacy pollution that's accumulated in the water and soil.

Once pollution settles on the soil or contaminates the water, it becomes invisible to the naked eye, which makes it difficult for people to connect the harm with the exposure, Parras said. "That's what makes it easy for

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politicians to dismiss because there's no evidence — because we haven't looked for that evidence," he said.

For Parras, addressing the legacy of industrial pollution means not only remediating the soil, but also preventing the use of chemicals until they are studied and proven safe. That's known as the precautionary principle.

"You can't operate under a precautionary principle without acknowledging the legacy of harm that exists," said Parras. "[The legacy] is still hurting people. That's the real problem."

The Center for Public Integrity, 22 July 2022

https://publicintegrity.org

How long is COVID infectious? What scientists know so far

2022-07-26

When the US Centers for Disease Control and Prevention (CDC) halved its recommended isolation time for people with COVID-19 to five days back in December, it said that the change was motivated by science. Specifically, the CDC said that most SARS-CoV-2 transmission occurs early in the course of the illness, in the one to two days before the onset of symptoms and for two to three days after.

Many scientists disputed that decision then and they continue to do so. Such dissent is bolstered by a series of studies confirming that many people with COVID-19 remain infectious well into the second week after they first experience symptoms. Reductions in the length of the recommended isolation period — now common around the world — are driven by politics, they say, rather than any reassuring new data.

"The facts of how long people are infectious for have not really changed," says Amy Barczak, an infectious-disease specialist at Massachusetts General Hospital in Boston. "There is not data to support five days or anything shorter than ten days [of isolation]." Barczak's own research, published on the medRxiv preprint server, suggests that one-quarter of people who have caught the Omicron variant of SARS-CoV-2 could still be infectious after eight days1.

A numbers game

Although the question is simple — for how long is someone with COVID-19 contagious? — experts caution that the answer is complicated.

Those with SARS-CoV-2 are often advised to isolate for only a few days. But evidence is mounting that some people can continue to pass on the virus for much longer.

"We always think of it as a black and white thing … if somebody's infectious or not infectious — but in reality, it's a numbers game and a probability," says Benjamin Meyer, a virologist at the University of Geneva in Switzerland.

And that numbers game has shifting rules and baselines. Emerging variants, vaccination and varying levels of natural immunity provoked by previous infection can all influence how quickly someone can clear the virus from their system, Meyer says, and this ultimately dictates when they stop being infectious. Behavioural factors matter as well. People who feel unwell tend to mix less with others, he adds, so the severity of someone's symptoms can influence how likely they are to infect others.

Something most scientists are confident about is that PCR tests can return a positive result even after someone is no longer infectious. This probably occurs when the tests, which detect viral RNA, pick up non-infectious remnants left behind after most of the live virus has been eliminated.

By contrast, lateral flow (or 'rapid antigen') tests offer a better guide to infectiousness, because they detect proteins produced by actively replicating virus.

"There's still all of these things that we're not exactly sure about, but if I had to sum it up in one very concise message, it would be that if you're antigen positive, you shouldn't go out and interact closely with people who you don't want to be infected," says Emily Bruce, a microbiologist and molecular geneticist at the University of Vermont in Burlington.

What about somebody who has tested negative on a lateral flow test for a few days but still has a fever and a hacking cough? Bruce says it's important to remember that although lingering symptoms might look and sound serious, they do not indicate continued infectiousness.

"You can definitely have symptoms for longer than you test positive on lateral flow," she says. "And I think that's because many of the symptoms are caused by the immune system and not directly by the virus itself."

Transmission tests

In countries such as the United Kingdom, the relaxation of the isolation guidelines coincided with the withdrawal of free lateral flow tests. So, assuming that many of the people who follow the new recommendations are going to stop isolating after five days without testing, scientists have been investigating in particular how many people with COVID-19 are likely to remain infectious after this point.

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It's not practical to track direct onward transmission of the virus from large numbers of people and to measure how it reduces over time, so researchers instead rely on proxy measurements to determine the point at which they would expect people to stop being contagious.

Researchers with access to a high-security biosafety level 3 laboratory — as Barczak has — can do this by running experiments to test whether live SARS-CoV-2 can be cultured from samples taken from patients over several consecutive days.

"If you're still shedding virus that we can culture out of your nose, there's at least a good chance you're still infectious to other people," she says. As different variants have emerged and various research groups have done these experiments, Barczak says, a consensus has emerged that it's very unusual for people to shed culturable virus after ten days. "So, it's very unusual for people to stay infectious after ten days," she says.

Other studies take a step further away from the real world, and use levels of viral RNA measured by PCR tests to infer whether someone is infectious. This makes it easier to work with large sample sizes. For example, a project run by the Crick Institute and University College Hospital, both in London, can draw on PCR tests carried out on more than 700 participants, obtained from when symptoms developed.

A study based on this group suggests that significant numbers of people retain viral loads high enough to trigger onward infection at days seven to ten, irrespective of the variant type or how many vaccine doses people had received. The study was published on the medRxiv preprint server on 10 July2.

"We're not measuring live virus, but there is now a huge amount of work in the literature that provides a pretty good mapping of what constitutes a viral load likely to yield infectious virus," says David LV Bauer, a virologist at the Crick Institute who is co-investigator on that study. "So while it's not a perfect picture, it's a reasonable one."

'Rebound phenomenon'

Yonatan Grad, an infectious-disease specialist at the Harvard T.H. Chan School of Public Health in Boston, Massachusetts, who has worked on similar PCR-based studies of infectiousness, agrees that ten days is a useful rule of thumb for when people should no longer be contagious. But he cautions that a small number of people could still be infectious beyond that point.

Some such cases in the United States have been linked to the common antiviral drug Paxlovid (nirmatrelvir–ritonavir), he says. "There's a rebound phenomenon where people will see that their symptoms seem to resolve and they may even test negative on a rapid test, but then a few days later symptoms and the virus come back."

Barczak says this is one of the key questions that researchers are now studying. "Antivirals change the dynamics of symptoms, change the dynamics of the immune response and change the dynamics of how you shed," she says. "I think this is really important, because people are out in the world thinking they're not infectious after ten days. But if they have Paxlovid rebound they might be."

Nature, 26 July 2022

https://nature.com

Ancient Microbial "Dark Matter" – Thousands of Unknown Bacterial Species Discovered in Hawaiian Lava Caves

2022-07-21

Higher bacterial diversity than scientists expected has been uncovered in the lava caves, lava tubes, and geothermal vents on the big island of Hawaii. The findings have been reported in a new study published today (July 21, 2022) in the journal Frontiers in Microbiology.

This research investigates the variety and interactions within these microbial ecosystems, which illustrate how life may have existed on Mars and the early Earth in the past. Surprisingly, the findings showed that a class of bacteria known as Chloroflexi are often "hub" species, meaning that they are connected with many other species and typically play crucial ecological roles in the community. Many Chloroflexi species are little understood, and further research will reveal previously undiscovered species, as well as insights into the role these species play in these extreme environments.

"This study points to the possibility that more ancient lineages of bacteria, like the phylum Chloroflexi, may have important ecological 'jobs,' or roles," said first author Dr. Rebecca D Prescott of NASA Johnson Space Center and University of Hawaii at Manoa, in the US. "The Chloroflexi are an extremely diverse group of bacteria, with lots of different roles found in lots of different environments, but they are not well studied and so we don't know what they do in these communities. Some scientists call such groups

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Centuries-Old Lava Caves of Hawaii Island Contain Thousands of Unknown Bacterial Species

'microbial dark matter' — the unseen or un-studied microorganisms in nature."

Unseen volcanic life

Prescott and her colleagues gathered 70 samples from a variety of locations, including active geothermal vents (fumaroles), as well as "younger" and "older" lava tubes and caves, which were under 400 years old and between 500 and 800 years old, respectively, to get a sense of how the bacterial communities might change over time. They were able to determine the diversity and abundance of the bacterial classes in each sample by sequencing the ribosomal RNA present in the samples. Co-occurring bacterial networks also provided hints regarding possible interactions between these microorganisms.

The harshest conditions—the geothermal sites—were expected to have lower diversity than the more established and habitable lava tubes. While the diversity was indeed found to be lower, the team of researchers was surprised to discover that the interactions within these communities were more complex than in locations with higher diversity.

"This leads to the question, do extreme environments help create more interactive microbial communities, with microorganisms more dependent on each other?" said Prescott. "And if so, what is it about extreme environments that helps to create this?"

Since Chloroflexi, and another class called Acidobacteria, were present at nearly all of the locations, they may play essential roles in these communities. However, these were not the most abundant bacteria, and the individual communities from the different sites showed large variations in the diversity and complexity of the microbial interactions. Counterintuitively, the most abundant groups, Oxyphotobacteria and Actinobacteria, were not often 'hub' species, suggesting that their roles may be less important to the overall structure of the community.

More questions than answers

Since the current study was based on the partial sequencing of one gene, it cannot accurately determine the species of microbes or their 'jobs' in the community. Therefore, further research is needed to help reveal the individual species that are present, as well as to better understand these bacteria's roles in the environment.

"Overall, this study helps to illustrate how important it is to study microbes in co-culture, rather than growing them alone (as isolates)," said Prescott.

"In the natural world, microbes do not grow in isolation. Instead, they grow, live, and interact with many other microorganisms in a sea of chemical signals from those other microbes. This then can alter their gene expression, affecting what their jobs are in the community."

Beyond the insights about past, or even future, life on Mars, bacteria from volcanic environments can also be useful in understanding how microbes turn volcanic rock (basalt) into soils, as well as bioremediation, biotechnology, and sustainable resource management.

SciTech Daily, 21 July 2022

https://scitechdaily.com

Trees and fungi are the ultimate friends with benefits

2022-08-03

Take a walk in the bush, and you'll find yourself immersed in a soundscape of chatter.

You might hear birds bantering to one another as they forage for food, or swarms of insects serenading potential partners.

But the quietest life forms are having some of the liveliest conversations.

Trees might seem like the type who prefer to keep to themselves, but beneath your feet they are busy forming secret relationships with vast networks of underground fungi.

Big, old trees rely on this "wood-wide web" to shuttle nutrients to their younger neighbours, while others use it to send chemical signals that warn nearby trees of looming threats, such as diseases and pests.

"The symbiosis is important for all aspects of plant growth, but also the diversity we see in our landscape," says Ian Anderson, a fungal ecologist at Western Sydney University.

It's a friends-with-benefits arrangement that's been around for millions of years, but researchers are only just beginning to unravel the secrets of how trees and fungi interact, particularly in Australian ecosystems, says Tom May, a mycologist at the Royal Botanic Gardens Victoria.

"It's just as challenging a frontier as deep space — it's deep in the soil."

Roots that wear socks

Trees and fungi rely on each other to thrive, but we still have a lot to learn about their complex partnership.

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If you could shrink yourself down and dive beneath the forest floor, you would encounter a wonderland of miniature life forms working hard to keep the ecosystem running.

Among the busy mites and microbes, you'd be surrounded by dozens of tree roots wearing ghostly white "socks".

These sock-like coverings are known as ectomycorrhizal fungi, the most common type of symbiotic fungi in forests.

The friendly fungi reach into the soil with their hyphae — long, cobwebby filaments that are thinner than a strand of human hair.

In the northern hemisphere, these fungi "fingers" make up an estimated 30 per cent of the biomass in forests.

"There's kilometres of hyphae in just handfuls of soil," Dr May says.

These bundles of hyphae — or mycelium — are tasked with doing the food shopping for their tree hosts.

As they branch out into the soil, the hyphae release special enzymes that turn hard-to-access nutrients like nitrogen and phosphorous into forms that the tree can readily consume, Dr May says.

"They slobber over their food."

In exchange for their nutrient-scavenging efforts, host trees send their fungal partners a pay cheque of sugar and carbon, which they produce from sunlight via photosynthesis.

This gives the fungi the energy they need to grow and scour every crevice of soil for tree nutrients.

"There's almost like an economy," says Jonathan Plett, a molecular mycologist at Western Sydney University.

Trees are generous hosts, providing a home for dozens of species of mycorrhizal fungi that each have a role to play.

"Some of those fungi are connecting up to different trees of the same species, sometimes they're connecting up to different trees of different species," Dr May says.

"It's very complex."

Australia's invisible friendships

Over the past two decades, most of the research exploring the relationship between fungi and trees has focused on northern hemisphere ecosystems, such as pine forests.

Studies from this side of the world have revealed that trees don't just rely on their mycorrhizal fungi to look after themselves.

One 2015 study found that drought-ravaged Douglas fir trees (Pseudotsuga menziesii) — which are native to North America — offload their carbon and send chemical stress signals to nearby ponderosa pine (Pinus ponderosae) trees.

But the conversations between Australian native trees and their mycorrhizal fungi are still largely shrouded in mystery.

Over the past few years, Dr Plett and his team have been digging into the nitty-gritty of how mycorrhizal fungi help eucalyptus trees thrive and communicate.

While Aussie tree-fungi relationships share some similarities with their northern hemisphere counterparts, Dr Plett has noticed some striking differences.

For one, his experiments have shown that Australian mycorrhizal fungi have evolved to take some heat.

Dr Plett has found that mycorrhizal fungi from the northern hemisphere don't cope well when they are exposed to temperatures above 25 degrees, leaving their tree partners vulnerable as a result.

"They either die or they go dormant and just kind of sit there ... they don't help the plant anymore," he says.

It's a different story for Australian fungi, which continue thriving at temperatures as high as 37 degrees.

"They love it," Dr Plett says.

"If you think of the Australian environment ... they've had that temperature extreme long enough that they've somehow adapted to that."

Dr Plett and his team have also found eucalyptus trees aren't quite as loyal to their fungi partners as northern hemisphere tree species, which tend to stick with the same type of mycorrhizal fungi for life.

As seedlings, eucalypts pair up with arbuscular mycorrhizal fungi — a group that usually favours crops and grasses over trees.

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But like teenagers who drift away from childhood friends, eucalypts switch over to ectomycorrhizal fungi as they grow into adults.

"Eucalypts are one of only a very few hosts that do that," Professor Anderson says.

Because arbuscular mycorrhizal fungi typically sustain plants in nutrient-poor soils — a key feature of the Australian landscape — Professor Anderson suspects they give young eucalypts a good start in life until they're ready to meet their long-term partners.

"It is another peculiarity of the Australian native ecosystem."

Proteins as passwords

But not all underground fungi are interested in making friends with trees.

For instance, the Australian honey fungus (Armillaria luteobubalina) is the main culprit behind root rot in eucalyptus trees, and can spread from tree to tree like an underground wildfire.

So, how can trees tell the difference between friend and foe?

The answer lies in tiny molecular differences. Dr Plett has found that when mycorrhizal fungi encounter a tree's roots, they secrete special proteins that can unlock the tree's root cells without setting off its alarm bells.

If trading nutrients is like a conversation between trees and fungi, then proteins are the language mycorrhizal fungi use to "talk" to the tree's immune system, Dr Plett says.

"That's what allows that fungus to actually push into the root without the plant killing it off."

Some species of fungi will go even further to maintain a loving bond with their chosen trees.

Earlier this year, Dr Plett and his colleagues reported evidence that a fungus called Pisolithus microcarpus manipulates gene activity in the roots of flooded gum trees (Eucalyptus grandis).

As this fungus colonises the gum tree roots, it releases microRNA — small chunks of genetic material that control the production of certain proteins — a strategy that's more common among pathogenic fungi.

In the lab, Dr Plett and his team found that the fungus donated some of these genetic scraps to its host tree's roots, helping it form a lasting bond with its woody partner.

But it wasn't a one-sided relationship. The researchers also found that seedlings with the fungal microRNA in their roots pulled more nutrients from the soil than those without it.

The study showed that the fungus gave the trees some genetic tweaks that boosted their immune response and nutrient-processing capabilities.

The perfect match for regeneration

While eucalyptus seedlings are often inoculated with mycorrhizal fungi before they are planted in the wild, the results are hit and miss.

Some seedlings will grow up strong and robust, while others struggle to establish themselves, even if their roots are wrapped with the same type of mycorrhizal fungi.

Part of the problem is that not all fungi — even those within the same species — are willing to share the fruits of their labour, with some hoarding the nutrients they collect.

This could be due to subtle genetic and metabolic differences among individuals, Dr Plett says.

"Different types of fungi colonise different types of trees, much like we gravitate to certain people and not others."

By cracking the riddle of how trees rely on fungi to thrive and communicate, Dr Plett hopes to identify the most compatible tree-fungi partnerships — a boon for the nursery industry and bush regeneration efforts.

And while trying to play matchmaker is painstaking work, the pay-off could be huge.

Dr Plett estimates that inoculating eucalyptus and pine seedlings with the right mycorrhizal partners could cut fertiliser use by up to 40 per cent, and even help store more carbon underground.

Getting this delicate balance right is also important for restoring landscapes that are out of whack to begin with, such as cleared farmland.

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For instance, in soil with abnormally high nitrogen and phosphorous levels, some trees dump their mycorrhizal partners as they get their nutrient needs met elsewhere, Dr May says.

But independent living has its downsides.

"[The trees] don't get all the other benefits, like disease protection," he says.

Given that roughly 50 species of Australian fungi are now on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species, cataloguing our native fungi and understanding their role in Australia's forests is more important than ever, Dr May says.

This means turning our attention to the underworld, instead of the heavens.

"It's interesting how people are really captured by cataloguing the stars … there's nothing going on out in space that we need to worry about," Dr May says.

ABC News, 3 August 2022

https://abc.net.au

The end of everything: 5 ways the universe could be destroyed

2022-07-22

Everything has to end eventually – but does that include the universe itself? And if so, how? And when?

Everything has to end eventually – but does that include the universe itself? And if so, how? And when? It might be hard to imagine a catastrophe big enough to affect the entirety of existence, but physicists do expect it all to end at some point – and it may come sooner than we think. Here are some of the leading hypotheses about how the universe could end, and when.

To figure out how the cosmos could come to a close, physicists look back to the beginning. About 13.8 billion years ago, space and time burst forth from an incredibly dense singularity, an event that's come to be known as the Big Bang. The universe rapidly expanded from that point, with matter cooling and condensing into galaxies and all the stars and planets they contain.

But the universe is still expanding, and doing so at an accelerating pace, thanks to a mysterious force that scientists call "dark energy." As that

name suggests, we know very little about how this force works or why it's pushing everything away from everything else, but it has some pretty major implications for the ultimate fate of the universe. How it plays out depends on how you tweak the numbers in the models.

The Big Freeze

According to our best models of the evolution of the universe, the most likely scenario is what's called the Big Freeze. If dark energy keeps accelerating the expansion of the universe forever – and calculations suggest that it will – then the cosmos is in for a slow death that's drawn out for a googol years. That unfathomable number is a one followed by 100 zeroes.

If you could watch a patch of sky in fast-forward over billions of years, the stars would start to turn red, then fade out completely. That's because the expanding universe would stretch the wavelength of their light farther and farther towards the red end of the spectrum, before rendering them completely invisible to the eye.

Of course, even if you couldn't see them, the distant stars and galaxies would still exist – at least for a few trillion years. But after a while, the expansion would dilute the dust and gas floating around in space, until there isn't enough concentrated in any one region to fuel the birth of new stars. With no more being born, stars eventually become an endangered and then extinct species, as the last of them die off.

So begins the universe's "Degenerate Era," about 100 trillion years from now. By this point, only white dwarfs, neutron stars and black holes exist, but these too will fade – white dwarfs and some neutron stars will slowly cool into invisible, inert black dwarfs, while other neutron stars will collapse into black holes.

By the year 10 tredecillion (a one followed by 43 zeroes), there won't be anything but black holes left. And even these aren't eternal – as Stephen Hawking predicted, black holes slowly give off radiation until they eventually evaporate.

After about 1 googol years, once all the black holes are gone too, the universe settles into its final age – the Dark Era. Light and matter are distant memories, and the remaining loose particles will live the loneliest possible existence, rarely having the chance to whizz within a light-year of each other, let alone interact. And nothing else will ever happen, for eternity.

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The Big Rip

A similar scenario leads to a far more dramatic death, much sooner. In this model, dark energy doesn't just accelerate the expansion of the universe at a steady pace, it accelerates exponentially, eventually tearing the very fabric of reality apart – an ending called the Big Rip.

There's a physical limit to the distance into space that we could ever see, even if you had the most powerful telescope possible. That limit is dictated by the speed of light – at a certain point, objects are too far away for their light to have had enough time to reach Earth. This region is called the observable universe.

In the Big Rip model, the exponentially accelerating expansion pushes more and more objects beyond that boundary, meaning that the observable universe is constantly shrinking. Any two objects that are farther apart than this boundary allows can no longer influence each other through the fundamental forces, like gravity or electromagnetism.

As that distance shrinks, large scale structures of the universe will begin to crumble – as gravity's influence shrinks, it won't be able to hold galaxy clusters together, and they'll start dissolving. Eventually the same will happen to the galaxies themselves, sending stars drifting off on their own. Later, the cosmic event horizon will shrink beyond the scale of an individual star system, meaning planets will no longer be bound to their orbits around stars.

In the final few minutes of existence, that event horizon would shrink smaller than the scale of molecules, disrupting the forces that hold matter together, shredding stars, planets and everything on them. And finally, those loose atoms themselves would be ripped apart particle by particle. The last victim is the fabric of spacetime itself.

The scientists who propose this model predict that, if it were to happen, the universe has about 22 billion years left to live. Thankfully though, other scientists believe that this scenario involves parameters that aren't realistic, so is less likely to occur than some of the other ideas on this list.

The Big Crunch

Perhaps the universe will end in the exact opposite way – instead of expanding forever into nothingness, it changes course and collapses in on itself in a so-called Big Crunch.

In the cosmic tug of war between gravity trying to pull everything together and dark energy trying to push it apart, scientists usually stack their chips in favor of dark energy, which would ultimately lead to a Big Freeze or Big Rip ending. But we can't completely count gravity out of the running.

If the density of matter in the universe is high enough, its gravity could overcome the expansion and trigger a contraction phase instead. Everything will begin to move towards everything else as the universe shrinks once again. Much like our current expansion phase, anyone alive at the time wouldn't be directly affected – at least until near the end.

Galaxy clusters would start to merge, then galaxies themselves, and eventually individual stars would collide more regularly. But the real trouble begins with the cosmic microwave background – the background radiation of the universe left over from the Big Bang. As its photons are shifted towards the blue end of the spectrum, this radiation heats up, until eventually it becomes hotter than stars. That means the stars can no longer radiate their heat outwards, and will continue to get hotter and hotter until they evaporate.

In the last few minutes, the temperature of the universe would be so extremely hot that atoms themselves fall apart. Not that they'll have long to worry about that, since they'll be sucked into the black holes that are taking up an increasing percentage of the shrinking universe.

Eventually, the entire contents of the universe will be crushed together into an impossibly tiny space – a singularity, like a reverse Big Bang.

Different scientists give different estimates of when this contraction phase might begin. It could be billions of years away yet. Or, according to a recent study, it could be quite soon, cosmically speaking, as the universe reverses course about 100 million years from now. In that model, the contraction phase would take about a billion years before we return to that singularity.

The Big Bounce

But that might not be the end. A variation on the above hypothesis suggests that moments before the universe collapses into an infinitely dense singularity, it's saved by quantum processes and reverses course once again, beginning a new period of expansion that's effectively another Big Bang for a brand new universe. This model is known as the Big Bounce.

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While it might sound a little too convenient, proponents of the idea say that there is some precedent in the world of quantum physics – after all, as the universe shrinks towards a singularity, it becomes so small that quantum rules take over from the large-scale classical physics we're familiar with.

At that point, quantum tunneling can occur, where particles can overcome barriers that by all accounts they shouldn't have enough energy to pass through. This drives processes like radioactive decay and, according to a recent study, could also allow a contracting universe to "escape" the fate of total collapse and begin expanding again.

Intriguingly, support for the Big Bounce arises out of another theory called loop quantum gravity, which was created as a way to explain gravity in terms of quantum mechanics.

The fun implication of the Big Bounce hypothesis is that we might be in the middle of a never-ending chain of universes being created and destroyed.

The Big Slurp

The final doomsday scenario on this list is perhaps the most unsettling, because it could already be barreling down on us and we wouldn't know until it hit. It's called a false vacuum decay, or more colloquially the Big Slurp.

It's a law of physics that a system will naturally try to become stable. To do so it moves from a state of high energy to one with lower energy, until it stabilizes into its lowest possible energy state. For quantum fields, this is known as its vacuum state.

It's thought that all known quantum fields are in their stable vacuum states – except for one: the Higgs field. It seems to be in a false vacuum state, which means that it currently appears stable but is predicted to not be in its lowest energy state.

But that could change without warning. Literally any second, the Higgs field could suddenly slip into a lower energy state, taking out a huge chunk (if not all) of the universe in the process.

All it would take is for one tiny point in space to collapse into this lower energy state, which would send a bubble of vacuum decay expanding outwards at the speed of light. Moving that fast, we couldn't even see it coming until the wall of that bubble slammed into Earth.

What happens once we're inside this bubble? No one's really sure, but it will probably rewrite the laws of nature. There's a chance that life might be possible under these new physics – but the universe could be so completely different that we can't even imagine it. Worst case scenario, all matter is destroyed.

If there's good news to be found, it's that there's a lot of uncertainty to the idea. Some models predict that false vacuum decay isn't likely to occur for many billions of years yet, or that it's impossible altogether. Others suggest that it should have happened by now, indicating our current universe might actually be the strange new physics inside the bubble.

The Higgs field could also be more stable than we give it credit for. It was, after all, only confirmed relatively recently with the discovery of the Higgs boson, so there's still plenty left to learn through further study.

Or maybe the false vacuum bubble has just swallowed the Sun and will be here in eight minutes.

New Atlas, 22 July 2022

https://newatlas.com

Just add water to activate a disposable paper battery

2022-07-28

A water-activated disposable paper battery is presented in a proof-of-principle study in Scientific Reports. The authors suggest that it could be used to power a wide range of low-power, single-use disposable electronics—such as smart labels for tracking objects, environmental sensors and medical diagnostic devices—and minimize their environmental impact.

The battery, devised by Gustav Nyström and colleagues, is made of at least one cell measuring one centimeter squared and consisting of three inks printed onto a rectangular strip of paper. Sodium chloride salt is dispersed throughout the strip of paper and one of its shorter ends has been dipped in wax. An ink containing graphite flakes, which acts as the positive end of the battery (cathode), is printed onto one of the flat sides of the paper while an ink containing zinc powder, which acts as the negative end of the battery (anode), is printed onto the reverse side of the paper. Additionally, an ink containing graphite flakes and carbon black is printed on both sides of the paper, on top of the other two inks. This ink connects the positive and negative ends of the battery to two wires, which are located at the wax-dipped end of the paper.

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When a small amount of water is added, the salts within the paper dissolve and charged ions are released. These ions activate the battery by dispersing through the paper, resulting in zinc in the ink at the negative end of the battery releasing electrons. Attaching the wires to an electrical device closes the circuit so that electrons can be transferred from the negative end—via the graphite and carbon black-containing ink, wires and device—to the positive end (the graphite-containing ink) where they are transferred to oxygen in the surrounding air. These reactions generate an electrical current that can be used to power the device.

To demonstrate the ability of their battery to run low-power electronics, the authors combined two cells into one battery and used it to power an alarm clock with a liquid crystal display. Analysis of the performance of a one-cell battery revealed that after two drops of water were added, the battery activated within 20 seconds and, when not connected to an energy-consuming device, reached a stable voltage of 1.2 volts. The voltage of a standard AA alkaline battery is 1.5 volts. After one hour, the one-cell battery's performance decreased significantly due to the paper drying. However, after two more drops of water were added, it maintained a stable operating voltage of 0.5 volts for more than one additional hour.

The authors propose that the biodegradability of paper and zinc could enable their battery to minimize the environmental impact of disposable, low-power electronics. They suggest that the sustainability of the battery can be further increased by minimizing the amount of zinc used within the ink, which also allows the amount of electricity the battery generates to be precisely controlled.

Tech Xplore, 28 July 2022

https://techxplore.com

The biodegradability of paper and zinc could enable their battery to minimize the environmental impact of disposable, low-power electronics.

Scientists discover new 'origins of life' chemical reactions

2022-07-28

Four billion years ago, the Earth looked very different than it does today, devoid of life and covered by a vast ocean. Over the course of millions of years, in that primordial soup, life emerged. Researchers have long theorized how molecules came together to spark this transition. Now, scientists at Scripps Research have discovered a new set of chemical reactions that use cyanide, ammonia and carbon dioxide—all thought

"We've come up with a new paradigm to explain this shift from prebiotic to biotic chemistry," says Ramanarayanan Krishnamurthy, Ph.D.

to be common on the early earth—to generate amino acids and nucleic acids, the building blocks of proteins and DNA.

"We've come up with a new paradigm to explain this shift from prebiotic to biotic chemistry," says Ramanarayanan Krishnamurthy, Ph.D., an associate professor of chemistry at Scripps Research, and lead author of the new paper, published July 28, 2022 in the journal Nature Chemistry. "We think the kind of reactions we've described are probably what could have happened on early earth."

In addition to giving researchers insight into the chemistry of the early earth, the newly discovered chemical reactions are also useful in certain manufacturing processes, such as the generation of custom labeled biomolecules from inexpensive starting materials.

Earlier this year, Krishnamurthy's group showed how cyanide can enable the chemical reactions that turn prebiotic molecules and water into basic organic compounds required for life. Unlike previously proposed reactions, this one worked at room temperature and in a wide pH range. The researchers wondered whether, under the same conditions, there was a way to generate amino acids, more complex molecules that compose proteins in all known living cells.

In cells today, amino acids are generated from precursors called α-keto acids using both nitrogen and specialized proteins called enzymes. Researchers have found evidence that α-keto acids likely existed early in Earth's history. However, many have hypothesized that before the advent of cellular life, amino acids must have been generated from completely different precursors, aldehydes, rather than α-keto acids, since enzymes to carry out the conversion did not yet exist. But that idea has led to debate about how and when the switch occurred from aldehydes to α-keto acids as the key ingredient for making amino acids.

After their success using cyanide to drive other chemical reactions, Krishnamurthy and his colleagues suspected that cyanide, even without enzymes, might also help turn α-keto acids into amino acids. Because they knew nitrogen would be required in some form, they added ammonia—a form of nitrogen that would have been present on the early earth. Then, through trial and error, they discovered a third key ingredient: carbon dioxide. With this mixture, they quickly started seeing amino acids form.

"We were expecting it to be quite difficult to figure this out, and it turned out to be even simpler than we had imagined," says Krishnamurthy. "If you

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mix only the keto acid, cyanide and ammonia, it just sits there. As soon as you add carbon dioxide, even trace amounts, the reaction picks up speed."

Because the new reaction is relatively similar to what occurs today inside cells—except for being driven by cyanide instead of a protein—it seems more likely to be the source of early life, rather than drastically different reactions, the researchers say. The research also helps bring together two sides of a long-standing debate about the importance of carbon dioxide to early life, concluding that carbon dioxide was key, but only in combination with other molecules.

In the process of studying their chemical soup, Krishnamurthy's group discovered that a byproduct of the same reaction is orotate, a precursor to nucleotides that make up DNA and RNA. This suggests that the same primordial soup, under the right conditions, could have given rise to a large number of the molecules that are required for the key elements of life.

"What we want to do next is continue probing what kind of chemistry can emerge from this mixture," says Krishnamurthy. "Can amino acids start forming small proteins? Could one of those proteins come back and begin to act as an enzyme to make more of these amino acids?"

In addition to Krishnamurthy, authors of the study, "Prebiotic Synthesis of α-Amino Acids and Orotate from α-Ketoacids Potentiates Transition to Extant Metabolic Pathways," are Sunil Pulletikurti, Mahipal Yadav and Greg Springsteen.

Phys Org, 28 July 2022

https://phys.org

Hidden Chaos Found to Lurk in Ecosystems

2022-07-27

Physical scientists seem to find the phenomenon of chaos everywhere: in the orbits of planets, in weather systems, in a river's swirling eddies. For nearly three decades, ecologists considered chaos in the living world to be surprisingly rare by comparison. A new analysis, however, reveals that chaos is far more prevalent in ecosystems than researchers thought.

Tanya Rogers was looking back through the scientific literature for recent studies on chaos in ecosystems when she discovered something unexpected: No one had published a quantitative analysis of it in over 25 years. "It was kind of surprising," said Rogers, a research ecologist at the

New research finds that chaos plays a bigger role in population dynamics than decades of ecological data seemed to suggest.

University of California, Santa Cruz and the new study's first author. "Like, 'I can't believe no one's done this.'"

So she decided to do it herself. Analyzing more than 170 sets of time-dependent ecosystem data, Rogers and her colleagues found that chaos was present in a third of them — nearly three times more than the estimates in previous studies. What's more, they discovered that certain groups of organisms, like plankton, insects and algae, were far more prone to chaos than larger organisms like wolves and birds.

"That really wasn't in the literature at all," said Stephan Munch, an evolutionary ecologist at Santa Cruz and a co-author of the study. Their results suggest that to protect vulnerable species, it is both possible and necessary to build more complex population models as guides for conservation policies.

When ecology was first recognized as a formal science in the 19th century, the prevailing assumption was that nature follows simple, easily understood rules, like a mechanical clock driven by interlocking gears. If scientists could measure the right variables, they could predict the outcome: More rain, for example, would mean a better apple harvest.

In reality, because of chaos, "the world is a lot more whack-a-mole," said George Sugihara, a quantitative ecologist at the Scripps Institution of Oceanography in San Diego who was not involved in the new research. Chaos reflects predictability over time. A system is said to be stable if it changes very little over a long timescale, and random if its fluctuations are unpredictable. But a chaotic system — one ruled by nonlinear responses to events — may be predictable over short periods but is subject to increasingly dramatic shifts the further out you go.

"We often give the weather as an example of a chaotic system," said Rogers. A summer breeze over the open ocean probably won't impact tomorrow's forecast, but under just the right conditions, it could theoretically send a hurricane plowing into the Caribbean in a few weeks.

Ecologists began flirting with the concept of chaos in the 1970s, when the mathematical biologist Robert May developed a revolutionary tool called the logistic map. This branching diagram (sometimes known as a cobweb plot because of its appearance) shows how chaos creeps into simple models of population growth and other systems over time. Since the survival of organisms is affected so much by chaotic forces like the weather, ecologists assumed that species populations in nature would also often rise and fall chaotically. Logistic maps quickly became ubiquitous

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in the field as theoretical ecologists sought to explain population fluctuations in organisms like salmon and the algae that cause red tides.

By the early '90s, ecologists had amassed enough time-series data sets on species populations and enough computing power to test these ideas. There was just one problem: The chaos didn't seem to be there. Only about 10% of the examined populations seemed to change chaotically; the rest either cycled stably or fluctuated randomly. Theories of ecosystem chaos fell out of scientific fashion by the mid-1990s.

The new results from Rogers, Munch and their Santa Cruz mathematician colleague Bethany Johnson, however, suggest that the older work missed where the chaos was hiding. To detect chaos, the earlier studies used models with a single dimension — the population size of one species over time. They didn't consider corresponding changes in messy real-world factors like temperature, sunlight, rainfall and interactions with other species that might affect populations. Their one-dimensional models captured how the populations changed, but not why they changed.

But Rogers and Munch "went looking for [chaos] in a more sensible way," said Aaron King, a professor of ecology and evolutionary biology at the University of Michigan who was not involved in the study. Using three different complex algorithms, they analyzed 172 time series of different organisms' populations as models with as many as six dimensions rather than just one, leaving room for the potential influence of unspecified environmental factors. In this way, they could check whether unnoticed chaotic patterns might be embedded within the one-dimensional representation of the population shifts. For example, more rainfall might be chaotically linked to population increases or decreases, but only after a delay of several years.

In the population data for about 34% of the species, Rogers, Johnson and Munch discovered, the signatures of nonlinear interactions were indeed present, which was significantly more chaos than was previously detected. In most of those data sets, the population changes for the species did not appear chaotic at first, but the relationship of the numbers to underlying factors was. They could not say precisely which environmental factors were responsible for the chaos, but whatever they were, their fingerprints were on the data.

The researchers also uncovered an inverse relationship between an organism's body size and how chaotic its population dynamics tend to be. This may be due to differences in generation time, with small organisms that breed more often also being more affected by outside variables more

often. For example, populations of diatoms with generations of around 15 hours show much more chaos than packs of wolves with generations almost five years long.

However, that doesn't necessarily mean that wolf populations are inherently stable. "One possibility is that we're not seeing chaos there because we just don't have enough data to go back over a long enough period of time to see it," said Munch. In fact, he and Rogers suspect that because of the constraints of their data, their models might be underestimating how much underlying chaos is present in ecosystems.

Sugihara thinks that the new results might be important for conservation. Improved models with the right element of chaos could do a better job of forecasting toxic algal blooms, for example, or tracking fishery populations to prevent overfishing. Considering chaos could also help researchers and conservation managers to understand how far out it's possible to meaningfully predict population size. "I do think that it's useful for the issue to be in people's minds," he said.

However, he and King both caution against placing too much faith in these chaos-conscious models. "The classical concept of chaos is fundamentally a stationary concept," King said: It is built on the assumption that chaotic fluctuations represent a departure from some predictable, stable norm. But as climate change progresses, most real-world ecosystems are becoming increasingly unstable even in the short term. Even taking many dimensions into account, scientists will have to be conscious of this ever-shifting baseline.

Still, taking chaos into consideration is an important step toward more accurate modeling. "I think this is really exciting," said Munch. "It just runs counter to the way we currently think about ecological dynamics."

Quanta Magazine, 27 July 2022

https://quantamagazine.org

Jurassic marine world unearthed in a farmer's field

2022-07-29

The discovery of an exceptional prehistoric site containing the remains of animals that lived in a tropical sea has been made in a farmer's field in Gloucestershire.

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Discovered beneath a field grazed by an ancient breed of English Longhorn cattle, the roughly 183-million-year-old fossils are stunningly well preserved like they were frozen in time.

Contained within three-dimensionally preserved limestone concretions, the remains of fish, ancient marine reptiles, squids, rare insects and more have been revealed for the first time by a team of paleontologists. The fossils come from an inland rock layer that was last exposed in the U.K. more than 100 years ago and represented a unique opportunity to collect fossils from a time when this part of the country was deep underwater.

The newly found site is at Court Farm, Kings Stanley near Stroud, Gloucestershire and was discovered by Sally and Neville Hollingworth, avid fossil collectors who recently uncovered the remains of mammoths in the nearby Cotswold Water Park which was featured in the BBC One documentary "Attenborough and the Mammoth Graveyard" in 2021.

Sally and Neville explained: "These fossils come from the Early Jurassic, specifically a time called the Toarcian. The clay layers exposed at this site near Stroud have yielded a significant number of well-preserved marine vertebrate fossils that are comparable to the famous and exquisitely preserved similar fauna of the Strawberry Bank Lagerstätte from Ilminster, Somerset—a prehistoric site of exceptional fossil preservation. Excavations at Kings Stanley over the last week have revealed a rich source of fossil material, particularly from a rare layer of rock that has not been exposed since the late 19th Century."

Dr. Dean Lomax, a paleontologist and a Visiting Scientist at The University of Manchester, who recently led the excavation of the Rutland ichthyosaur that also dates to the Toarcian geological age, was part of the team and said: "The site is quite remarkable, with numerous beautifully preserved fossils of ancient animals that once lived in a Jurassic sea that covered this part of the U.K. during the Jurassic. Inland locations with fossils like this are rare in the U.K. The fossils we have collected will surely form the basis of research projects for years to come."

Many of the specimens collected will be donated to the local Museum in the Park, Stroud, where they will form a significant part of the museum's paleontology collections. One of the team members, Alexia Clark, who is the museum's Documentation and Collections Officer said: "We're excited to expand our knowledge of the geology of the Stroud District and we are looking forward to a time when we can share these amazing finds with our members and visitors. Being part of the excavation team has been a real

Contained within three-dimensionally preserved limestone concretions, the remains of fish, ancient marine reptiles, squids, rare insects and more have been revealed.

privilege and I can't wait to share details of that experience through our members' newsletter."

Among the best finds were several fossil fish with excellent details of their scales, fins and even their eyeballs. One of the most impressive discoveries was a three-dimensionally preserved fish head, belonging to a type of Jurassic fish called Pachycormus. The fish looks as if it is "leaping off the rock" that it was contained inside. A digital 3D model of this fossil has been created by Steven Dey of ThinkSee3D.

Field observations and preparation of the fauna found so far indicate that the Court Farm fossils were rapidly buried, as suggested by the absence of any encrusting animals or burrows in the sediment. The layered concretions around the skeletons formed relatively early before the sediments were compacted, as the original sediment layering is preserved. These concretions prevented further compaction and compression from the overlying sediments during burial and thus preserved the fossils in three-dimensional time capsules.

Neville added, "Using the latest fossil preparation and imaging techniques to understand this unique fauna in more detail will create a rich repository. Also, we will leave a permanent reference section after excavations have concluded. Given the location and enthusiasm from the landowner and local community to be involved it is hoped to plan and develop a local STEM enrichment program as there will be opportunities for community groups and local schools to be involved in the research, particularly from the Stroud area with a focus of targeting audiences in areas of low STEM capital."

The landowner, Adam Knight, said: "I'm delighted that after the initial work that Sally and Nev did over three years ago we now have a full-scale dig on the farm involving a range of fossil experts from The Natural History Museum, The University of Manchester, University of Reading and The Open University. On Friday we were also joined by Emily Baldry (16) on a day's work experience before she goes to University to study paleontology—it's wonderful to see her enthusiasm for her chosen profession. It has been a real pleasure to host the dig and I'm excited to see the results of what has been found."

Going forward, the team will continue to analyze the specimens and publish their research with the fossils planned for display at Museum in

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the Park, Stroud, and at the Boho Bakery Café at Court Farm, Kings Stanley, Gloucestershire.

Phys Org, 29 July 2022

https://phys.org

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