CHEMWATCH

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apvma.gov.au, 18 May 2021

https://apvma.gov.au/node/85896

RTA renews compliance with occupational health and safety standards in Dubai

2021-05-19

The Roads and Transport Authority (RTA) has reiterated its commitment to full implementation of occupational health and safety standards at all RTA-affiliated buildings, facilities and projects as well as in all public transport.

The RTA made the statement on the sidelines of its participation during a remote World Day for Safety and Health at Work event held recently by the International Labour Organisation (ILO).

The event attracted more than 1,400 representatives of Health, Safety and Environment (HSE) from all over the world. The RTA also held a remote workshop for its employees to raise awareness on the implementation of a safe working environment.

Read More~sGulf News, 19 May 2021

https://gulfnews.com/uae/transport/rta-renews-compliance-with-occupational-health-and-safety-standards-in-dubai-1.79309367

Why a highly toxic herbicide should be banned in Australia

2021-05-19

There's a weedkiller used in Australia that's so toxic, one sip could kill you. It's called paraquat and debate is brewing over whether it should be banned.

Paraquat is already outlawed in many places around the world. The Australian Pesticides and Veterinary Medicines Authority has been reviewing paraquat's use here for more than two decades, and its final decision is due later this year.

We are medical and environmental scientists, and have researched the harmful effects of paraquat, even when it's used within the recommended safety range. We strongly believe the highly toxic chemical should be banned in Australia.

The potentially lethal effects on humans are well known. In Australia in 2012, for example, a farmer died after a herbicide containing paraquat accidentally sprayed into his mouth. And our research has found paraquat also causes serious environmental damage.

Read More:

Mirage, 19 May 2021

https://www.miragenews.com/why-a-highly-toxic-herbicide-should-be-banned-562253/

AMERICA

100% of breast milk samples tested positive for toxic "forever chemicals"

2021-05-13

New study finds that newer PFAS chemicals build up in people, despite opposite claims made by the chemical industry

Toxic PFAS is used in food packaging, clothing, and other products, but national regulation lags behind state and corporate actions.

SEATTLE, WA—Today a new study finding toxic chemicals in 100% of breast milk samples tested was published in Environmental Science & Technology. Scientists from Toxic-Free Future, Indiana University, the University of Washington, and Seattle Children's Research Institute led the research, which shows that toxic PFAS (per- and polyfluorinated substances)—including new generation compounds currently in use—build up in people. Despite chemical industry assurances that current-use PFAS do not build up in people, the study finds detections of these chemicals in breast milk to be on the rise globally and doubling every four years.

Despite chemical industry assurances that current-use PFAS do not build up in people, the study finds detections of these chemicals in breast milk to be on the rise globally and doubling every four years.

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Previous reports have confirmed that companies put PFAS chemicals in a wide range of everyday products, from food packaging and clothing to carpet and upholstery. States and retailers are starting to take action to restrict these chemicals in products, but federal regulations are needed to prevent the use of PFAS or other chemicals that can build up in breast milk in consumer products.

This study, the first since 2005 to analyze PFAS in breast milk from mothers in the United States, found that 50 out of 50 women tested positive for PFAS, with levels ranging from 52 parts per trillion (ppt) to more than 500 ppt. Breast milk samples were tested for 39 different PFAS, including 9 current-use compounds. Results found that both current-use and phased-out PFAS contaminate breast milk, exposing nursing infants to the effects of toxic chemicals. A total of 16 PFAS were detected with 12 found in more than 50% of the samples. The levels of PFAS that are currently in use in a wide range of products are rising in breast milk.

"We now know that babies, along with nature's perfect food, are getting toxic PFAS that can affect their immune systems and metabolism," explains Toxic-Free Future science director and study co-author Erika Schreder. "We shouldn't be finding any PFAS in breast milk and our findings make it clear that broader phaseouts are needed to protect babies and young children during the most vulnerable stages of life. Moms work hard to protect their babies, but big corporations are putting these, and other toxic chemicals that can contaminate breast milk, in products when safer options are available."

Read More

Safer Chemicals, Healthy Families, 13 May 2021

https://saferchemicals.org/2021/05/13/100-of-breast-milk-samples-tested-positive-for-toxic-forever-chemicals/

"[The findings] are alarming in terms of the effects on the long-term health and safety of these residents," the lawmakers wrote.

What do politicians have to say about 'Fractured?'

2021-05-13

Here are the responses we've gotten so far from politicians about our study that found Pennsylvania families living near fracking wells are being exposed to high levels of harmful industrial

EHN conducted a two-year study that found Pennsylvania families living near fracking wells are being exposed to high levels of harmful industrial chemicals. Our findings are documented in the four-part series *Fractured: The body burden of living near fracking*.

A few weeks after the series was published, a group of 34 lawmakers from the state House and Senate issued a public letter to Governor Tom Wolf, Acting Secretary of the Department of Health Alison Beam, and Secretary of the Department of Environmental Protection Patrick McDonnell calling on them to take action in response to our findings.

"[The findings] are alarming in terms of the effects on the long-term health and safety of these residents," the lawmakers wrote. "Does this administration believe it has adequately protected Pennsylvanians from the harms of fracking? Does this administration honestly believe that fracking is safe for our families? The people of Pennsylvania deserve answers to these questions."

The full letter is available here. This is a complete list of the politicians who signed it:

Read More

The Daily Climate, 13 May 2021

https://www.dailyclimate.org/fractured-fracking-study-politician-response-2652962721/fractured-responses-from-politicians

Chemical giants hid dangers of 'forever chemicals' in food packaging

2021-05-12

Chemical giants DuPont and Daikin knew the dangers of a PFAS compound widely used in food packaging since 2010, but hid them from the public and the Food and Drug Administration (FDA), company studies obtained by the Guardian reveal.

The chemicals, called 6:2 FTOH, are now linked to a range of serious health issues, and Americans are still being exposed to them in greaseproof pizza boxes, carryout containers, fast-food wrappers, and paperboard packaging.

The companies initially told the FDA that the compounds were safer and less likely to accumulate in humans than older types of PFAS, also known as "forever chemicals" and submitted internal studies to support that claim.

But Daikin withheld a 2009 study that indicated toxicity to lab rats' livers and kidneys, while DuPont in 2012 did not alert the FDA or public to new internal data that indicated that the chemical stays in animals' bodies for much longer than initially thought.

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Had the FDA seen the data, it is unlikely that it would have approved 6:2 FTOH, said Maricel Maffini, an independent researcher who studies PFAS in food packaging.

Science from industry, the FDA and independent researchers now links 6:2 FTOH to kidney disease, liver damage, cancer, neurological damage, developmental problems and autoimmune disorders, while researchers also found higher mortality rates among young animals and mothers exposed to the chemicals.

Had the FDA seen the data, it is unlikely that it would have approved 6:2 FTOH, said Maricel Maffini, an independent researcher who studies PFAS in food packaging. And though Daikin may have broken the law, it and DuPont, which has previously been caught hiding studies that suggest toxicity in PFAS, are not facing any repercussions.

"Those things shouldn't happen, and if they do then there should be consequences, but oversight is lax," Maffini said.

In 2020, the FDA reached agreements with some major PFAS manufacturers to voluntarily stop using 6:2 FTOH compounds in food packaging within five years. But documents show that the FDA first became aware of DuPont's hidden study in 2015, and public health advocates say a 10-year timeline to reassess and remove the chemical is unacceptable.

Moreover, the FDA phase-out only applies to 6:2 FTOH compounds, and does not include other similar "short chain" PFAS, raising questions about whether the agency is fully protecting the public from the class of potentially toxic chemicals.

"I think people need to be able to rely on the FDA to turn science at the agency into real action, and right now that doesn't seem to be the case," said Tom Neltner, chemicals policy director with the Environmental Defense Fund. He and Maffini obtained the companies' studies and related documents from Daikin's website and the FDA through Freedom of Information Act requests.

The 6:2 FTOH compound is part of a newer generation of "short chain" PFAS that were designed to replace older and supposedly more harmful "long chain" PFAS. The industry claims that short chain compounds are uniformly safe and "practically non-toxic". However, independent researchers like Erika Schreder, science director for Toxic Free Future, have found that PFAS, regardless of chain length, accumulate in the environment and humans, and are toxic.

"The fact that we continue to uncover evidence that the current-use PFAS have similar toxicity to the [long chain] compounds that have been phased

out makes a strong argument for regulating harmful chemicals like PFAS as a class," Schreder said.

In a statement to the Guardian, an FDA spokesperson defended the agency's handling of 6:2 FTOH, noting that the studies "do not demonstrate an imminent health hazard" and more studies were needed to draw concrete conclusions about its safety, and that of other short chain PFAS.

Daikin and Chemours, a company that in 2015 was spun off from DuPont's PFAS division, did not respond to requests for comment.

DuPont hides alarming new data

Industry reports and communications among the FDA and PFAS producers between 2008 and 2020 show how a sequence of inadequate chemical safety analyses, hidden studies and lax oversight created a scenario in which Americans continue to be exposed to the dangerous compound in food packaging.

The 2008 6:2 FTOH studies that DuPont submitted to the FDA monitored the impact of high exposure levels to the chemical on two generations of lab rats. The animals suffered kidney failure, liver damage, mammary gland problems, mottled teeth and other issues. However, DuPont and the FDA felt that humans' exposure would be much lower and, with little supporting evidence, believed that the short chain PFAS would not accumulate in human bodies, Maffini said.

She called such studies on PFAS "inaccurate and inappropriate" because the chemicals are toxic at "extremely low levels" and are known to accumulate in animals' bodies.

Indeed, the longer-term DuPont study completed in 2012 found that 6:2 FTOH stayed in lab animals' bodies for longer than previously thought. Still, DuPont did not alert the FDA or publish the study.

Though the law does not require companies to make such information public, the results strongly suggested a health threat, and DuPont "had an ethical obligation to not just publish it, but flag it for the FDA", Neltner said.

Three years later, DuPont partially summarized its 2012 findings in a peer-reviewed 6:2 FTOH study that Maffini said used "cherry-picked" data to support its claim that the compound was safe. Though it omitted the 2012 study's details, communications show it caught the attention of the FDA,

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which wrote that the study alerted the agency "to potential biopersistence of [6:2 FTOH] and raised potential safety concerns".

That triggered a safety review, but the process would drag out for about five years as Americans continued to be exposed.

Even when DuPont in its 2008 study reported some health problems in lab animals at high exposure levels, it did so in a way that appears designed to confuse, Maffini noted. One passage that revealed that high doses of the chemical lead to blood in rats' urine read that the doses "resulted in a significant reduction in the number of female rats with blood absent in the urine".

Daikin omits damning science

The FDA in 2009 approved the Daikin-developed 6:2 FTOH compound for use in food packaging, partly basing the decision on the company's studies that suggested that the chemical was non-toxic.

But about 10 years later, Maffini and Neltner discovered that Daikin had withheld two studies from the FDA that suggested toxicity to lab animals' livers and kidneys at low exposure levels – one completed before the FDA approved the chemical, and one after.

They caught the omission by cross-checking studies for the chemical posted to Daikin's website with those submitted to the FDA, and found the data on health effects was never given to the agency. Neltner noted that the law required the first study to be submitted to the FDA. Maffini said they asked Daikin about the omission and the company responded by removing the report from its website, but it can still be found using the Wayback machine site.

As part of its safety review of the chemical, the FDA convened a 2018 meeting with Chemours, Daikin and others in the industry at which the agency requested studies related to 6:2 FTOH. Communications confirm that the FDA did not previously have DuPont's 2012 study or Daikin's 2007 study.

Between 2018 and 2020, three FDA analyses that included Daikin's and DuPont's studies broadly concluded that 6:2 FTOH may stick in the human body for years and could be more toxic than the companies had previously suggested.

A 2019 communication between the FDA and the PFAS manufacturer Asahi showed urgency on the part of the agency to get the chemical

removed from the market, but in July 2020 it announced that four major producers of the compound had agreed to have all food packaging with 6:2 FTOH off the shelves by 2025.

In its announcement, the FDA wrote that the extended timeline "balances uncertainty about the potential for public health risks with minimizing potential market disruptions to food packaging supply chains during the Covid-19 public health emergency".

Maffini questioned whether the public's health was being put first.

"The agency's own scientists were in a rush to get it out of the marketplace so it's really hard to understand why the FDA agreed to a five-year phase-out," she said.

Neltner also underscored what he and Maffini view as other deficiencies in the FDA's chemical approval process that contributed to the 6:2 FTOH problem: the agency does not demand sufficient safety data up front and there is no systematic reassessment to determine whether chemicals are safe after they are sent to the market.

The FDA again defended its process, stating that the agency "updates our safety assessments as appropriate" and said industry "must provide sufficient information demonstrating that" chemicals are safe.

But Neltner said the problems with 6:2 FTOH suggest otherwise.

"They're making grossly inaccurate assumptions that are not defensible," Neltner said.

The Guardian, 12 May 2021

https://www.theguardian.com/environment/2021/may/12/chemical-giants-hid-dangers-pfas-forever-chemicals-food-packaging-dupont

EUROPE

Nature food study finds gaps in food system plastics research

2021-05-12

Systematic scoping review assesses the research literature covering plastic's effects on human health, the environment, and food security/economics through the entire food system from 2000 through 2018; includes over 3,300 studies; found majority of previous research focused on food security/economics; identified gaps related to studies on the effect of plastics on human health, meta-analyses, and research within low-income nations

The review assessed the number of research papers published from 2000 through 2018 as-sessing the impacts of plastic on human health, food security and economics, or the environment, at any point in the food life cycle from agri-cultural production to waste disposal.

On February 18, 2021, peer-reviewed journal Nature Food published a systematic scoping review by Joe Yates et al. from the London School of Hygiene and Tropical Medicine on the effects of plastics in the food system. The review assessed the number of research papers published from 2000 through 2018 assessing the impacts of plastic on human health, food security and economics, or the environment, at any point in the food life cycle from agricultural production to waste disposal. Over 3,300 studies were included. The authors found the majority of work during that time period "had at least one outcome related to food security and economics" (75%), followed by human health (which includes food nutrient content, food contamination, and medical effects, 48%), and the environment (8%). Few studies in the reviewed literature (2–4%) directly investigated the effects of food system plastics on human health such as chemical presence in urine samples or long-term health effects. According to the interactive evidence map published with the paper, 117 studies (3.5%) looked at some aspect of the relationship between plastic food packaging and human health.

Read More

Food Packaging Forum, 12 May 2021

https://www.foodpackagingforum.org/news/nature-food-study-finds-gaps-in-food-system-plastics-research

Mercosur trade deal will fuel 'poison pesticides' back into EU

2021-05-07

The EU-Mercosur trade agreement, as it currently stands, will exacerbate the 'boomerang effect' of pesticides banned in the EU whose residues re-enter the bloc as food imports, a study on Tuesday (11 May) has found.

The EU exported 7,000 tonnes of pesticides, prohibited inside Europe due to environmental and health concerns, to the Mercosur bloc of South American countries (Brazil, Argentina, Paraguay and Uruguay) countries in 2018 and 2019.

But residues of these dangerous substances have been found in agricultural products the EU imports from the Mercosur, such as fruits or vegetables.

But residues of these dangerous substances have been found in agricultural products the EU imports from the Mercosur, such as fruits or vegetables.

EU law does not prohibit the export of pesticides banned in the EU to third countries, allowing companies to make profits by selling these chemicals to non-EU countries - what has previously triggered calls to ban the export of toxic pesticides to third countries.

Food coming from outside the EU, on average, has more than twice the amount of pesticide residues than products produced within the bloc.

In 2018, the EU exported a total of more than half a billion euros' worth of pesticides to Mercosur, mostly to Brazil (€446m worth).

Conversely, Mercosur exported dozens of agricultural products to the EU, worth over €21bn, during the same year - including soybeans, grains, fruits, and coffee.

Read More

EU Observer, 7 May 2021

https://euobserver.com/climate/151818

INTERNATIONAL

There's no need to control PFAS as a class, industry scientists say

2021-05-19

The number of commercial per- and polyfluoroalkyl substances (PFAS) that need screening for possible regulation number in the hundreds, not thousands, industrial chemists say (*Integr. Environ. Assess. Manage.* 2021, DOI: 10.1002/ieam.4450).

Their analysis counters a policy proposal in the European Union that would restrict production and use of most PFAS—persistent synthetic chemicals designed to resist degradation—as a single class. Exposure to PFAS that are metabolically active is linked to cancer, immune system problems, developmental problems, and other health effects.

"It's not scientifically accurate or appropriate to base regulation on a false premise, which is what some authorities are proposing to do by saying that the number of PFAS is so high that it's impossible to distinguish

Exposure to PFAS that are metabolically active is linked to cancer, immune system problems, developmental problems, and other health effects.

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among them," says lead author Robert Buck, a technical fellow at Chemours.

In the study, Buck's team examined the 4,730 PFAS listed in a 2018 report from the Organisation for Economic Co-operation and Development (OECD). The researchers say that the OECD report included PFAS that were phased out of production, never commercialized, or made in small quantities, such as less than 1 kg, for research purposes. Such chemicals aren't candidates for regulation, they say.

The American Chemistry Council (ACC), the largest association of US chemical manufacturers, assisted the study. The ACC hired a consulting firm to collect data from PFAS makers AGC Chemicals Americas, Chemours, and Daikin; aggregate the information; and protect trade secrets.

The authors, one from each of the three companies along with an independent fluorochemicals consultant, then analyzed the data. They determined that 256 of the PFAS in the OECD report are "commercially relevant," meaning they are present in products offered for sale, used to make those products, or contain impurities or degradation products such as metabolites.

If PFAS from other manufacturers were analyzed similarly, the total number of commercially relevant substances would likely rise above 256 but fall far below the OECD's number, Buck tells C&EN.

And several hundred PFAS, "in our opinion, would not present an unmanageable situation for regulatory authorities," says Jay West, executive director of ACC's Performance Fluoropolymer Partnership. The three participating companies are members of the partnership.

Read More

Chemical & Engineering News, 19 May 2021

https://cen.acs.org/environment/persistent-pollutants/no-need-control-PFAS-as-class-industry-scientists-say/99/i19

Netherlands and OECD make the case for more swift adoption of longer term emissions regulations

2021-05-19

The International Maritime Organization-convened Marine Environment Protection Committee (MEPC) meets virtually next month for what promises to be a more packed schedule than normal. The primary goal

The primary goal is to thrash out once and for all the short-term emission-cutting goals for shipping.

is to thrash out once and for all the short-term emission-cutting goals for shipping. Looking further ahead, however, The Netherlands and the Organisation for Economic Co-operation and Development (OECD) have sent in a joint submission highlighting the importance of starting work on mid-term measures such as carbon pricing and fuel standards.

"The lack of commercial viability is the most important market failure related to zero-carbon shipping," the submission states, something the authors believe is caused by the fact that negative side-effects of conventional fuels, such as GHG emissions and air pollution, are not taken into account in the price of maritime transport.

"Significantly stringent carbon pricing and/or a fuel standard will resolve this market failure and make zero-carbon shipping commercially viable. Hence there is a need to commence the consideration of mid-term measures, with a priority on measures that could create a market for zero-carbon shipping, namely carbon pricing and/or fuel standards – at a significant stringency and with revenue use to support deployment," the submission urges, pointing out that due to the long lifetime of ships, the transition away from fossil fuels needs to have started by 2030, hence the need to start discussions on mid-term measures as soon as possible.

The initial IMO strategy contains a non-exhaustive list of candidate short-, mid- and long-term measures. The mid-term measures included are: implementation programmes for the effective uptake of alternative low-carbon and zero-carbon fuels; operational efficiency measures for both new and existing ships; new/innovative emission reduction mechanisms, possibly including market-based measures (MBMs); technical cooperation and capacity-building activities; and exchange of best practices.

This raises the question which of these measures, or which combination of measures, would be most effective at reducing GHG emissions from ships and in which sequence should they be implemented?

The authors of the submission suggest a market for low-carbon shipping could be created by internalising the negative externalities of high-carbon shipping, either via carbon pricing or regulation such as fuel standards. There are various ways in which carbon could be priced, including via a carbon tax or levy and emissions trading schemes. An alternative approach could be to regulate fuels and their carbon content via fuel standards. Fuel standards and carbon pricing could also be integrated with each other, via a proposed trading scheme that covers ships that over-comply and under-comply with the fuel standards. In the case of a low carbon price, the authors suggest a complementary measures – like

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a fuel standard – are necessary in order to achieve an effective transition towards zero-carbon shipping. Both measures would require application of lifecycle assessment of emissions.

Read More

247.com, 19 May 2021

https://splash247.com/netherlands-and-oecd-make-the-case-for-more-swift-adoption-of-longer-term-emissions-regulations/

ECHA updating guidance concerning REACH information requirements for nanoforms

2021-05-19

The European Chemicals Agency (ECHA) is in the process of updating its guidance on the information requirements and chemical safety assessment (IR&CSA) for nanoforms under the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) regulation. ECHA has developed three appendices concerning information requirements (appendices to IR&CSA Guidance Chapters R.7a, R.7b, and R.7c) to provide advice to registrants for use when preparing REACH registration dossiers that cover nanoforms. ECHA is updating two of the appendices, Appendix R7-1 to Chapter R.7a and Appendix R7-2 to Chapter R.7c. The draft update states that the advice provided focuses on specific recommendations for testing materials that are nanoforms of substances. Annex VI defines the terms "nanoform" and "set of similar nanoforms" and establishes the requirements for characterization of the identified nanoforms/sets of similar nanoforms of the substance. According to the draft update, part of the advice provided is not strictly nanoform specific and may also be applicable to other particulate forms of substances (*e.g.*, relevance of dissolution rate). The draft update notes that when such advice has been included, "it is because it is considered especially relevant for nanoforms and should be part of the nanoform specific guidance." In the absence of any suitable specific provision (either because the endpoint is not relevant for nanoforms, because the guidance already provided is considered to be equally applicable to nanoforms as to non-nanoforms, or because more research or adaptation is needed before developing advice), no additional guidance for the information requirement has been included.

The appendix intends to provide advice specific to nanoforms and does not preclude the applicability of the general principles given in Chapter R.7a (*i.e.*, the parent guidance). When no advice has been given for a specific endpoint, the advice provided in the parent guidance should be followed. ECHA notes that the appendix and its parent guidance provide specific guidance on meeting the information requirements set out in REACH Annexes VI to XI. General information for meeting the information requirements, such as collection and evaluation of available information and adaptation of information requirements, is available in Chapters R.2 to R.5 of the Guidance on IR&CSA.

ECHA states that when considering the use of data already available, the Guidance on information requirements and chemical safety assessment — Appendix R.6-1 for nanoforms applicable to the Guidance on QSARs and Grouping of Chemicals "may be useful as it provides an approach on how to read-across the hazard data between nanoforms (and the non-nanoform) of the same substance."

The draft update states that the advice provided focuses on specific recommendations for testing materials that are nanoforms of substances.

Read More

The National Law Review, 19 May 2021

https://www.natlawreview.com/article/echa-updating-guidance-concerning-reach-information-requirements-nanoforms

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Janet's Corner

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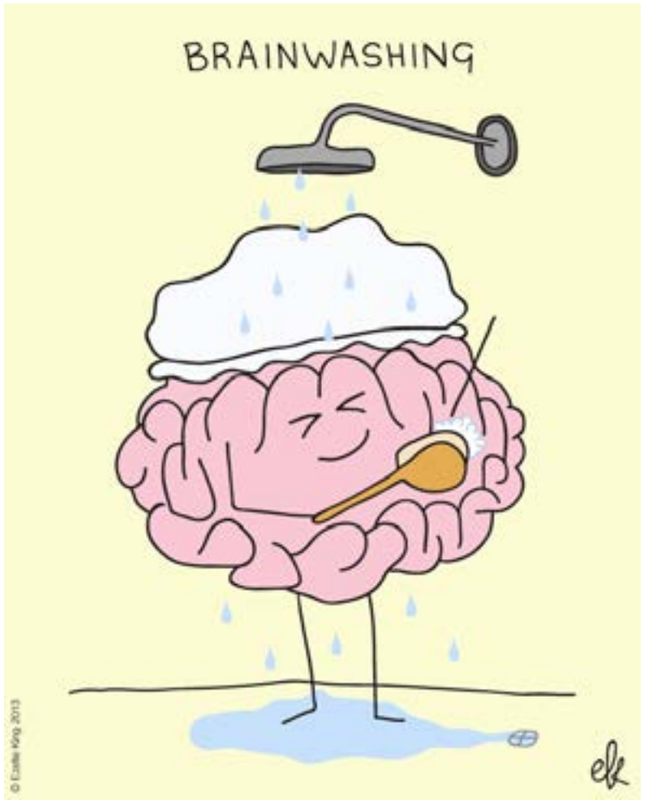
Brainwashing

2021-05-28



https://rhymeswithspaghetti.tumblr.com/image/62412477067

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Hazard Alert

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Chloroprene

2021-05-28

Chloroprene is the common name for the organic compound 2-chlorobuta-1,3-diene, which has the chemical formula C_4H_5Cl. [1] It is a halogenated alkene that exists at room temperature as a clear colourless liquid with a pungent ether-like odour. Chloroprene is practically insoluble in water, soluble in alcohol, and miscible with acetone, benzene, and ethyl ether. It is highly flammable and polymerises on standing, making it unstable in the environment. [2]

USES [2]

The only commercial use identified for chloroprene is as a monomer in the production of the elastomer polychloroprene (neoprene), a synthetic rubber used in the production of automotive and mechanical rubber goods, adhesives, caulks, flame-resistant cushioning, construction materials, fabric coatings, fibre binding, and footwear. Other uses of this polymer include applications requiring chemical, oil, or weather resistance or high gum strength. The United States Food and Drug Administration permits the use of chloroprene as a component of adhesives used in food packaging and also permits the use of polychloroprene in products intended for use with food.

SOURCES & ROUTES OF EXPOSURE

Sources of Exposure [3]

- Workers may be occupationally exposed to chloroprene by inhalation or dermal exposure.
- The release of chloroprene to the environment may occur during its manufacture, transport, and storage and during the manufacture of polychloroprene elastomers and polychloroprene-containing products.

Routes of Exposure [2]

The routes of human exposure to chloroprene are:

- Inhalation
- Ingestion
- Dermal contact

Chloroprene is the common name for the organic compound 2-chlorobuta-1,3-diene, which has the chemical formula C4H5Cl.

HEALTH EFFECTS [3]

Acute Effects

- Symptoms reported from acute human exposure to high concentrations of chloroprene include giddiness, headache, irritability, dizziness, insomnia, fatigue, respiratory irritation, cardiac palpitations, chest pains, nausea, gastrointestinal disorders, dermatitis, temporary hair loss, conjunctivitis, and corneal necrosis.
- Acute exposure may damage the liver, kidneys, and lungs; affect the circulatory system and immune system; depress the central nervous system (CNS); irritate the skin and mucous membranes; and cause dermatitis and respiratory difficulties in humans.
- High level exposures have affected the liver, lungs, kidneys and CNS in animals exposed by inhalation, gavage, or injection.
- Acute oral exposure of rats caused inflammation of the mucous membranes; damage to the lungs, liver, spleen, and kidneys; and irritation of the gastrointestinal tract.
- Acute animal tests in rats and mice, have demonstrated chloroprene to have moderate acute toxicity by inhalation and high acute toxicity from ingestion. (5)

Chronic Effects

- Symptoms of chronic exposure in workers were fatigue, chest pains, giddiness, irritability, dermatitis, and hair loss.
- One study has suggested that chronic exposure of humans to chloroprene vapour associated with neoprene production may contribute to liver function abnormalities. Disorders of the cardiovascular system and depression of the immune system have also been observed in workers chronically exposed to chloroprene.
- Eye irritation, nasal discharge, olfactory epithelial degeneration, restlessness, lethargy, hair loss, growth retardation, and effects to the liver, kidney, thyroid, blood, and lungs have been observed in rodents following chronic inhalation exposure.
- EPA has calculated a provisional Reference Concentration (RfC) of 0.007 milligrams per cubic metre (mg/m3) for chloroprene based on respiratory effects in rats.
- EPA has calculated a provisional Reference Dose (RfD) of 0.02 milligrams per kilogram body weight per day (mg/kg/d) for chloroprene.

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Reproductive/Developmental Effects

- A study reported functional disturbances in spermatogenesis in workers exposed to chloroprene and increased spontaneous abortions in the wives of exposed workers. However, insufficient details are available in the reports to adequately evaluate the results.
- Reproductive effects including a decreased number of spermatogonia, a decline in sperm motility, an increased number of dead sperm, and degeneration of the testes have been observed in male rats exposed by inhalation or dermal contact.
- Increased embryonal mortality and decreased foetal weight were reported in rats exposed by inhalation; contamination may have occurred during this study. No effects on embryonic or foetal survival nor incidence of soft tissue or skeletal defects were observed in other studies of rats exposed by inhalation.

Cancer Risk

- Epidemiological studies of rubber workers in the Soviet Union have indicated a possible association between exposure to chloroprene and skin and lung cancer. However, levels of exposure causing symptoms have not been well defined and these studies have major methodological deficiencies. An increased incidence of lung cancer was not reported in another study of American workers occupationally exposed to chloroprene during the manufacture of neoprene.
- An inhalation bioassay by the NTP showed clear evidence of carcinogenic activity in both rats and mice, based on increased incidences of neoplasms of the oral cavity, thyroid gland, lung, kidney, liver, skin, mammary glands, and other organs.
- EPA has classified chloroprene as a Group D, not classifiable as to human carcinogenicity, because of the absence of adequate data.
- The International Agency for Research on Cancer (IARC) has classified chloroprene as a Group 2B, possibly carcinogenic to humans.

SAFETY [4]

First Aid Measures

- Eye: Non corrosive to eyes. In the case of entering into eyes, please wash them with copious amounts of water.
- Skin: The compound is not likely to be hazardous by skin contact but cleansing the skin with soap and water after use is advisable. If molten

material gets on skin, cool rapidly with cold water. Do not attempt to remove material from skin. Obtain medical treatment for thermal burn.

- Inhalation: Irritating fumes occurred only in the heating process. If too many fumes inhaled, please move patient to fresh air or administer oxygen and assist ventilation as required.
- Ingestion: Ingestion is not a probable route of exposure. Chloroprene rubber is not considered a serious threat for human health, for which is low toxicity.

Exposure Controls & Personal Protection

Engineering Controls

- Local exhaust ventilation may be necessary to control air contaminants from hot processing. The use of local ventilation is recommended to control emissions near the source.
- Provide mechanical ventilation for confined spaces.
- Facilities storing or utilising this material should be equipped with an eyewash facility and a safety shower.

Personal Protective Equipment (PPE)

The following personal protective equipment is recommended when handling chloroprene:

- Eye/Face Protection: In the heating process, wear safety glasses when possibility exists for eye and face contact due to splashing or spraying of molten material. Have eye-wash stations available where eye contact can occur.
- Skin Protection: Wear gloves impervious to the heating conditions of use. Additional protection may be necessary to prevent skin contact including use of face shield, boots or full body protection. A safety shower should be located in the work area.
- Respirators: In the heating process, air purifying respirator with an organic vapour cartridge with a dust/mist filter may be permissible under certain circumstances where airborne concentrations are expected to exceed exposure limits.
- Protective Clothing: If there is potential contact with hot/molten material, wear heat resistant clothing and footwear.

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REGULATION

UNITED STATES [5]

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

- General Industry**:**29 CFR 1910.1000 Z-1 Table-- 25 ppm, 90 mg/m^3 TWA; Skin
- Construction Industry**:**29 CFR 1926.55 Appendix A -- 25 ppm, 90 mg/m^3 TWA; Skin
- Maritime: 29 CFR 1915.1000 Table Z-Shipyards -- 25 ppm, 90 mg/m^3 TWA; Skin

ACGIH: The American Conference of Governmental Industrial Hygienists has established a Threshold Limit Value (TLV) for chloroprene of 10 ppm, 36 mg/m^3 TWA; Skin

NIOSH: The National Institute for Occupational Safety and Health has set a Recommended Exposure Limit (REL) for chloroprene of 1 ppm, 3.6 mg/m^3 Ceiling (15 minutes); Appendix A - NIOSH Potential Occupational Carcinogens

Australia [6]

Safe Work Australia: Safe Work Australia has set a Time Weighted Average (TWA) concentration for chloroprene of 10ppm or 36mg/m^3 for a 40 hour work week.

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New types of imager could help spot smuggled nuclear materials

2021-05-19

Much as a smoke detector gives only a vague idea of where a fire is, current methods to detect smuggled nuclear materials are slow and imprecise. But a new technique that images nuclear materials based on the neutrons and gamma rays they shed can locate these dangers in record time, scientists report.

"It's an elegant method," says Alexander Glaser, a physicist at Princeton University who works on nuclear weapons verification and was not involved with the new study. If it proves itself in real-world scenarios, he says, the new approach could strengthen border security and help map radioactive contamination at disaster sites like Chernobyl and Fukushima.

Nuclear power plants and weapons centers have long kept a close eye on fissile materials—the stuff of atomic bombs—using radiation portal monitors (RPMs) to screen people or vehicles leaving a site. Resembling airport metal detectors, RPMs detect neutrons and gamma rays emitted by radioactive substances. They can distinguish the low-level radiation from everyday materials such as bananas or cat litter from the stronger signals from materials that actually pose a danger like plutonium or highly enriched uranium.

Security experts became more concerned about the proliferation of nuclear materials after the collapse of the Soviet Union in 1991 and the 9/11 attacks in 2001. RPMs installed worldwide between 1993 and 2019 flagged 290 confirmed or likely incidents of nuclear trafficking. But if inspectors are rushing to find and defuse a bomb in a shipping container, it would help to know precisely where the device is located. That's where the new approach comes in.

Bo Cederwall, a nuclear physicist at the KTH Royal Institute of Technology, had the idea while working at France's National Large Accelerator for Heavy Ions. Those experiments involve blasting atomic nuclei with a particle beam that knocks off neutrons, leaving energetically excited nuclei that radiate gamma rays. The scientists measure the timing and energies of the gamma rays and neutrons, which serve as fingerprints to distinguish one nucleus from another, enabling researchers to sift out the rarest nuclei for further study.

A few years ago, Cederwall realized that such an approach, coupled with machine learning methods, might come in handy for zeroing in

If it proves itself in real-world scenarios, he says, the new approach could strengthen border security and help map radioactive contamination at disaster sites like Chernobyl and Fukushima.

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on plutonium and other radioisotopes that, when they decay, also emit gamma rays and neutrons. "I saw a chance to bring new ideas and fresh blood into the game," he says.

Since 2017, Cederwall has worked with Swedish authorities on nuclear safeguards and security technologies. Now, they are assessing spent fuel at a former research reactor site with thousands of drums filled with radioactive waste. "I wanted to help them figure out what the heck is inside those drums" without cracking open the lids, Cederwall says.

The new technique relies on detectors that emit light when struck by either a neutron or a gamma ray and measure the time of arrival with nanosecond precision. Suppose two detectors sit face to face, separated by 1 meter or so, and that a nucleus decays and emits a neutron that hits one detector and a gamma ray that hits the other. The difference in the arrival times, when accounting for the detailed physics of the nuclear decay process, defines a fuzzy, somewhat spherical shell in space in which the nucleus could have been. Timing many neutron–gamma ray pairs with several detectors produces a set of probability shells that should intersect at a point—the location of the source.

As a proof of principle, Cederwall and colleagues focused on detection of californium-252, a readily available radioisotope widely used as a proxy for weapons-grade plutonium. Their prototype neutron-gamma emission tomography (NGET) detector looks a little like two sets of four magnum wine bottles installed on either side of an aluminum RPM-like frame. Analyzing scores of collisions in a matter of seconds, the researchers found they could quickly pinpoint the source to within 4 centimeters of its actual location, as they report today in Science Advances. Some modest tweaks should shave that to about 1 centimeter, Cederwall says.

The ability to pinpoint a source may offer a "paradigm shift" in nuclear safeguards, Cederwall asserts. NGET detectors might also be shrunk to fit on a drone. That offers "a really fascinating possibility" of quickly mapping radiological contamination at disaster sites or environmental surveying, he says.

"I don't think that's a far-fetched claim," says Brian Quiter, a nuclear physicist at Lawrence Berkeley National Laboratory (LBNL), whose team is also working on a drone-based nuclear materials detector. But NGET must still prove itself in real-world scenarios, he says.

One big challenge is that the real world is messy: Smuggled nuclear materials could be cocooned in materials that deflect neutrons streaming

from the source. The californium in the Swedish team's experiments was "not sitting in a container full of stuff," notes Kai Vetter, a nuclear physicist at LBNL.

Tuning out scattered neutrons is a challenge, Cederwall acknowledges. But NGET's probabilistic machine learning approach, he argues, should make it "less sensitive to scattering than other techniques."

sciencemag.org, 19 May 2021

https://www.sciencemag.org

Greta Thunberg aims to change how food is produced

2021-05-23

Swedish climate activist Greta Thunberg has set her sights on changing how the world produces and consumes food in order to counteract a trio of threats: carbon emissions, disease outbreaks and animal suffering.

In a video posted on Twitter on Saturday, Thunberg said the environmental impact of farming as well as disease outbreaks such as COVID-19, which is believed to have originated from animals, would be reduced by changing how food was produced.

"Our relationship with nature is broken. But relationships can change," Thunberg said in the video marking the International Day of Biological Diversity.

A focus on agriculture and linking the climate crisis to health pandemics is a new angle for Thunberg who has typically focused her ire on policy-makers and carbon emissions from fossil fuels.

"The climate crisis, ecological crisis and health crisis, they are all interlinked," she said.

Thunberg said the spillover of diseases from animals to humans was caused by farming methods, adding that a move to a plant-based diet could save up to 8 billion tonnes of CO2 each year.

The World Health Organization has said the coronavirus was probably transmitted from bats to humans through another animal, while scientists say 60% of the infectious human diseases that emerged from 1990 to 2004 came from animals.

Meanwhile, demand for alternatives to regular meat is surging worldwide due to concerns about health, animal welfare and the environment.

"Our relationship with nature is broken. But relationships can change," Thunberg said in the video marking the International Day of Biological Diversity.

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More than two dozen firms are testing lab-grown fish, beef and chicken, hoping to break into an unproven segment of the alternative meat market, which Barclays estimates could be worth $140 billion by 2029.

The Global Center on Adaptation, which works to accelerate climate resilience, said in January climate change could depress global food production by up to 30%, while rising seas and more intense storms could force hundreds of millions of people in coastal cities out of their homes. read more

reuters.com, 23 May 2021

https://www.reuters.com

Urchin mobs team up to butcher sea stars that prey on them

2021-05-21

Sea urchins are underwater lawnmowers, their unabating, vegetarian appetites capable of altering whole nearshore ecosystems. But the spiny invertebrates will also sink their teeth into something a bit more challenging — and dangerous — new research suggests.

In a first, researchers recently discovered urchins attacking and eating predatory sea stars. The observations flip a classic predator-prey script, researchers report in the June Ethology.

In 2018, marine behavioral ecologist Jeff Clements and his colleagues were at the Kristineberg Marine Research Station in Fiskebäckskil, Sweden, studying common sun stars (Crossaster papposus). At one point, Clements wanted to separate one of the sun stars for a short while and needed aquarium space. He placed the starfish in a tank containing about 80 green sea urchins (Strongylocentrotus droebachiensis).

"I thought, 'Okay, there's a bunch of sea urchins in there, these guys are predators of urchins, nothing's gonna happen,'" recalls Clements, of Fisheries and Oceans Canada in Moncton. The urchins, he says, hadn't eaten anything in two weeks.

The next day, when Clements came into the lab, he couldn't find the sun star. There was a pile of urchins on the side of the tank, with something red barely visible underneath. Clements pried the urchins off, revealing the victim.

"The sea star was absolutely decimated," he says. "The urchins had just ripped it apart."

"The sea star was absolutely decimated," he says. "The urchins had just ripped it apart."

Clements and his colleagues soon realized this behavior hadn't been documented before, So, the team ran two trials, each with a single sun star in the urchin tank, recording how this "predator-prey role reversal" plays out.

One urchin would approach the sun star, feeling around, eventually attaching to one of the sun star's many arms. Other urchins would follow suit, covering the sun star's arms. When the team removed the urchins after about an hour, they found the arm tips were chewed off, along with the eyes and other sensory organs positioned there.

This aspect of the sun star's anatomy may put it at a disadvantage.

"[The tips] are the first part of the sun star that the urchin is going to encounter as it approaches," says Clements. "So if the urchin consumes those first, the sun star is going to be less effective at escaping the attacks."

The team has named this incapacitation "urchin pinning."

It's possible the urchins are acting in self-defense, preemptively destroying a predator in their midst. Though, it could be the urchins' relative hunger that's behind the attacks instead, says Julie Schram, an animal physiologist at the University of Alaska Southeast in Juneau not involved with the research. In crowded lab conditions with limited food — similar to this study — urchins can switch up their diet in surprising ways, she notes. Some species have been documented cannibalizing each other, for instance.

"This would suggest to me that when starved, adult urchins will seek out alternate food sources," she says.

Urchins' capacity to feed on predatory sea stars had been hinted at before, with sea stars turning up in urchin stomach contents, says Jason Hodin, a marine biologist at the University of Washington in Friday Harbor. But this was often interpreted as scavenging.

"Active predation was the more interesting possibility, and it's satisfying to see that possibility confirmed, at least in the lab," says Hodin, who was not involved with the research.

If these urchin attacks are something that also happens in the wild, Clements thinks there could be some interesting ramifications for kelp forest ecosystems. When overabundant, urchins can graze kelp forests

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down to nothing (SN: 3/29/21), leaving behind urchin "barrens." If urchins are feeding on whatever animals are left behind, it'd be easier for their numbers to remain high.

"If [the urchins] are using animals to persist in these urchin barrens when kelp is low or nonexistent, it could actually delay the recovery of these kelp forests back to their original state," says Clements.

Such discussions of ecosystem influences are premature, says marine ecologist Megan Dethier, and are making way too much out of a "peculiar lab situation." Such attacks haven't been documented even in urchin barrens, where food is scarce, notes Dethier, of the University of Washington Friday Harbor Laboratories.

And the urchin attacks can't be intentional since the animals don't have a brain or central nervous system, she says. "Urchins doing a coordinated predatory attack is not biologically feasible."

The synchronized attacks may be based on chemical consequences of the ongoing feeding releasing smells into the water, Clements says. Once the first urchin starts chewing on the sun star, the other urchins may start recognizing the sun star as food. In the future, Clements wants to run experiments manipulating the hunger and density of urchins to see what factors influence their appetite for sun stars.

The findings are a reminder that even with simple nervous systems, invertebrates like urchins can execute surprisingly complex behaviors, Clements says. "These animals aren't just kicking around doing nothing on the [sea] bottom."

sciencenews.org, 21 May 2021

https://website

Two more coronaviruses can infect people, studies suggest

2021-05-21

Eight children hospitalized with pneumonia in Malaysia several years ago had evidence of infections with a novel coronavirus similar to one found in dogs, a research team reports today. Only seven coronaviruses were previously known to infect people, the latest being SARS-CoV-2, the spark of the COVID-19 pandemic. The discovery of this likely new human pathogen, along with the report of an instance of a coronavirus that appears to have jumped from pigs to people many years ago, could

"I think the more we look, the more we will find that these coro-naviruses are crossing species everywhere," says Stanley Perlman, a virologist at the University of Iowa who was not involved in the new work.

significantly expand which members of the viral family pose another global threat.

"I think the more we look, the more we will find that these coronaviruses are crossing species everywhere," says Stanley Perlman, a virologist at the University of Iowa who was not involved in the new work.

The researchers have not definitely linked either new virus to human disease. And there's no evidence that the two new coronaviruses can transmit between people—each infection may have been a dead-end jump into a person from a nonhuman host. But many researchers worry the viruses may evolve that ability within a person or the animals they normally infect. A complete genome sequence of the virus found in one Malaysian patient, reported today in Clinical Infectious Diseases, reveals a chimera of genes from four coronaviruses: two previously identified canine coronaviruses, one known to infect cats, and what looks like a pig virus.

This is the first report suggesting a caninelike coronavirus can replicate in people, and further studies will need to confirm the ability. The researchers have grown the virus in dog tumor cells but not yet in human cells.

Unlike with SARS-CoV-2 and other known human coronaviruses, "We don't have any clear evidence that this particular [coronavirus] strain is better adapted to humans because of its spike structure," says veterinary virologist Anastasia Vlasova of Ohio State University (OSU), Wooster, lead author of the study. Human infections from dog coronaviruses may occur "at a much higher frequency than we previously thought," she adds. This particular virus might not transmit between people, but we don't know that for sure, Vlasova cautions.

The eight children whose tissue samples Vlasova and her colleagues studied were mainly living in traditional longhouses or villages in rural or suburban Sarawak on Borneo, where they likely had frequent exposure to domestic animals and jungle wildlife. They were among 301 hospitalized pneumonia patients during 2017–18 and the researchers screened their nasopharyngeal samples—tissue from the upper part of the throat—for a large variety of human and nonhuman coronaviruses.

Standard hospital diagnostics for pneumonia or other respiratory illness would not have detected dog and cat coronaviruses. No one has been looking for these viruses in patients with such illnesses until recently. "These canine and feline coronaviruses are everywhere in the world," Perlman says.

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The entire novel virus sequence from the children's samples most resembles a canine coronavirus. However, the sequence for its spike protein, which attaches to host cell receptors to initiate an infection, is closely related to the spike sequence of canine coronavirus type I and the one for a porcine coronavirus known as transmissible gastroenteritis virus (TGEV). And one part of the spike protein bears a 97% similarity to the spike of a feline coronavirus.

This chimera is unlikely to have arisen at once, but instead involved repeat genetic reshuffles between different coronaviruses over time. "This is a mosaic of several different recombinations, happening over and over, when nobody's watching. And then boom, you get this monstrosity," says virologist Benjamin Neuman at Texas A&M University, College Station.

The animal that actually transmitted the novel virus to the people could have been a cat, pig, dog, "or some wild carnivores," says Vito Martella, a veterinary virologist at the University of Bari in Italy. He plans to screen stored fecal samples from Italian children with acute gastroenteritis to see whether he can find something similar.

Researchers already knew three canine coronavirus subtypes mix readily with feline and porcine coronaviruses. "What is more surprising is that these [animal] viruses can actually cause disease in a person," Perlman says, because one would expect them to lack some of the genes important for adapting well to people.

Seven of the eight children whose tissues harbored sequences of the virus were younger than 5 years old, and four of them were infants, mostly from Indigenous ethnic groups. Each was hospitalized for 4 to 7 days and recovered.

Scientists divide coronaviruses into four genera—alpha, beta, gamma, and delta—and the new one is an alpha. It is the third such alpha coronavirus to infect people; the other two cause common colds, and most people are exposed to them early in life. That pattern may explain why only children were perhaps sickened by this new one. Ralph Baric, a virologist at the University of North Carolina, Chapel Hill, suggests adults may have some immunity to the newly discovered alpha coronavirus because of repeated exposure to the other two.

So far, the most dangerous human coronaviruses—SARS-CoV-1, SARS-CoV-2, and MERS-CoV—are the betas. Researchers haven't seen alphas trigger an outbreak of serious disease in humans, Neuman says, "but that doesn't feel like much comfort in the wild world of viruses."

In March, researchers at the University of Florida reported in a medRxiv preprint the first evidence of a porcine delta coronavirus that infects people, in serum from three Haitian children who had fevers in 2014—15. The researchers transferred serum samples into monkey cells and were able to grow viruses that they matched, genetically, to known porcine coronaviruses. (The work has been submitted to a peer-reviewed journal.)

Delta coronaviruses were once thought to infect only birds. Then, in 2012, a delta coronavirus infected swine in Hong Kong. It "appears to have jumped over from songbirds," says OSU coronavirologist Linda Saif, who went on to isolate the virus in swine cell cultures.

The same virus caused a major fatal diarrheal disease outbreak in baby pigs in the United States in 2014. It has since been shown to infect cell lines from humans, pigs, and chickens; lab studies have shown the virus causes persistent infection and diarrheal disease when put into poultry. "It's out on its own, a left field–type virus that infects both avian and mammalian species," Baric says. "There aren't any other coronaviruses that I know can do this."

Some virologists have labeled the Hong Kong delta coronvirus a pandemic threat. The Haitian virus differs considerably and virologists want to test local children and adults for antibodies to it. If its ability to infect people is confirmed, it may also be viewed as a pandemic threat, Saif says.

Together, the two reports point to the importance of animal diseases in public health, and the need for coronavirus vaccines for domesticated animals. "This research clearly shows that more studies are desperately needed to evaluate critical questions regarding the frequency of cross-species [coronavirus] transmission and potential for human-to-human spread," Baric says.

Gregory Gray at Duke University, senior author on the Malaysian chimeric coronavirus study, also advocates for surveillance among pneumonia patients in areas known to be hot spots for novel viruses or places where large populations of animals and humans mix, such as live animal markets and large farms. "These spillovers take years," Gray says. "It's not like in the movies. They go through different steps to infect humans." So far indications are that the chimeric virus has not evolved to transmit efficiently between people.

sciencemag.org, 20 May 2021

https://www.sciencemag.org

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Mammal brains may use the same circuits to control tongues and limbs

2021-05-19

Precise control of the tongue is often vital in life, from the way frogs capture flies to human speech (SN: 1/31/17). But much remains unknown about how the brain controls the tongue, given how its quick motions are difficult to track. Now, experiments show that the brain circuits in mice that help the tongue lick water may be the same ones that help primates reach out to grasp objects, scientists report online May 19 in Nature.

Using high-speed video, neuroscientist Tejapratap Bollu and colleagues recorded the sides and bottoms of mouse tongues as the rodents drank from a waterspout. With the help of artificial intelligence to develop 3-D simulations of the appendages, the researchers discovered that successful licks required previously unknown corrective movements, too fast to be seen in standard video. These adjustments came after the tongue missed unseen or distant droplets, or when the spout was unexpectedly retracted a millimeter or more. Inhibiting a brain region that controls the body's voluntary motions impaired these corrections, suggesting this brain area was behind these movements.

These newfound corrective motions are similar to ones that primates use when reaching out with their limbs for uncertain targets, the researchers say. Those primate adjustments are also controlled by similar brain circuits as those used by the mice. "This to me shows that mammalian brains use similar principles to control the tongue and the limb," says Bollu, now at the Salk Institute for Biological Studies in La Jolla, Calif. "Everything we know about reaching in the primates can also be used to understand how the brain controls [tongue] movements."

"Everything we know about reaching in the primates can also be used to understand how the brain controls [tongue] movements."

Future research with X-ray and MRI scans could show how the brain controls tongue movements associated with chewing and swallowing, which could have clinical applications, Bollu says. The methods used in this work, he notes, could also help yield insights on other muscly appendages, such as elephant trunks and octopus arms.

sciencenews.org, 19 May 2021

https://www.sciencenews.org

Paralyzed person types at record speed—by imagining handwriting

2021-05-13

A new approach to brain-computer interface has allowed a paralyzed person to type with unprecedented speed, The Scientist reported yesterday. As Science first reported in 2019, researchers used electrodes implanted in a motor region of the brain to read out letters as a person paralyzed from the neck down imagined writing by hand. Previous systems, where users select on-screen letters by moving a cursor with their minds, have reached speeds up to about 40 characters per minute, but the new approach allowed speeds of up to 90 characters per minute with 94% accuracy, the researchers reported this week in Nature. Future improvements to the setup—such as making it smaller, wireless, and easier to calibrate—could ready it for wider clinical use.

sciencemag.org, 13 May 2021

https://www.sciencemag.org

UNCW researcher finds sponge that 'eats' toxic compounds

2021-05-19

Beneath the clear, turquoise waters off the shores of Carrie Bow Cay, Belize, sponges and seaweed have taken up residence where coral once flourished.

The sponges that cover reef there — part of the Meso-American Barrier Reef — pump massive amounts of seawater, are a food source for various reef fish, and, as one doctorate student at the University of North Carolina Wilmington has discovered, certain species of sponge absorb toxic chemical compounds.

Lauren Olinger has spent more than two years researching several species of the most common sponges in the Caribbean that now thrive on the reef.

What she has discovered is that sponges with an abundance of microbes, or tiny living things too small to be seen by the unaided eye, "take up" significant amounts of compounds versus sponges that have a low abundance of microbes.

Future improvements to the setup—such as making it smaller, wireless, and easier to calibrate—could ready it for wider clinical use.

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"From the compounds that these species were taking up, a lot of them were organohalides, so that means that they had halogen in them," Olinger said in a recent telephone interview. "It's interesting that an animal could use something that's halogenated. These compounds can be really toxic. They can also include contaminants so there's some interesting consequences there and it might tell us something about what these compounds are being used for."

Organohalides include the elements chlorine and bromine, which are toxic in humans. They include many toxic pollutants, such as polychlorinated biphenyls, or PCBs, insecticides, and industrial byproducts.

UNCW professor Joseph Pawlik said Olinger's research demonstrates, for the first time, that sponges can eat organic compounds that have halogens in them.

"These are classes of compounds that include many toxic pesticides and industrial solvents," he said. "We're not saying that it's taking those up. We're just saying that we know they're taking up organohalides. We can identify the molecules well enough. We don't necessarily have absolute identification of the compounds and that's a matter of the technique that's being used to identify compounds that are found in very, very small concentrations. The next stage of Lauren's work is to actually identify some of those compounds."

Sponges are actually known for consuming dissolved organic carbon, an unusual food source for animals. But dissolved organic carbon, or DOC, can be up to 90% of what a sponge eats, Olinger said.

Olinger and her colleagues dived and collected seawater going into and coming out of sponges along a reef system off the small island on which the Smithsonian Institute's Carrie Bow Cay Field Station is located, about 15 miles offshore.

Those samples were taken to the field office and prepared for analysis back at UNCW, where dissolved organic matter, or DOM, included in those samples were analyzed.

Olinger's research is being published in Frontiers in Marine Science.

A hypothesis referred to as the "sponge loop" suggests that sponges benefit coral reefs by taking up DOM and converting it into their own bodies.

"If sponges are converting this carbon into something that other animals could use then this could be simulating the reef because, on coral reefs, they're really desert-like," Olinger said. "There's not a lot of nutrients there."

Yet, the ever-growing presence of sponges on reefs, including the coral reefs of the Florida Keys, are not necessarily a good sign.

"What we've seen over the course of the last several decades is that reefs are being taken over more and more by sponges in addition to seaweeds and the one species that seems to be doing particularly well that grows very large is the giant barrel sponge, which gets to the size of small car," Pawlik said. "The positive thing about sponges, unlike seaweeds, they do provide critical habitat for fish, lobster and all the other things that human beings like to eat. But, they don't build calcium carbonate reefs. So, over long periods of time reefs are going to disappear. Sponges cannot persist in storms, in hurricanes the way coral reefs can. It's just not as strong. That's why sponges are a poor substitute in the end."

If sponges are allowed to thrive in these environments, Olinger said, that will make it harder for corals to recover or come back in and grow.

Sponges simply cannot replace coral, but their importance to the sea is undeniable.

"If we find that a certain species of sponge does something important to seawater or has a change in the seawater or eats something out of the seawater, that's really important," Olinger said. "If there's a contaminate there could be applications for using that sponge as a bioremediation. That's super out-there, but it's an idea. Otherwise, there's a whole level of things that eat sponges and that if we know if sponges are doing something good for the environment like recycling carbon, then we could make a stronger case for protecting the fish that eat them so that we can maintain a more healthy environment."

costalreview.org, 19 May 2021

https://www.coastalreview.org

European Parliament amps up pressure on EU-US data flows and GDPR enforcement

2021-05-22

European Union lawmakers are facing further pressure to step in and do something about lackadaisical enforcement of the bloc's flagship data protection regime after the European Parliament voted yesterday to back

But it's now nearly three years since the regulation begun being applied and criticism over weak enforcement is getting harder for the EU's executive to ignore.

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a call urging the Commission to start an infringement proceeding against Ireland's Data Protection Commission (DPC) for not "properly enforcing" the regulation.

The Commission and the DPC have been contacted for comment on the parliament's call.

Last summer the Commission's own two-year review of the General Data Protection Regulation (GDPR) highlighted a lack of uniformly vigorous enforcement — but commissioners were keener to point out the positives, lauding the regulation as a "global reference point".

But it's now nearly three years since the regulation begun being applied and criticism over weak enforcement is getting harder for the EU's executive to ignore.

The parliament's resolution — which, while non-legally binding, fires a strong political message across the Commission's bow — singles out the DPC for specific criticism given its outsized role in enforcement of the General Data Protection Regulation (GDPR). It's the lead supervisory authority for complaints brought against the many big tech companies which choose to site their regional headquarters in the country (on account of its corporate-friendly tax system).

The text of the resolution expresses "deep concern" over the DPC's failure to reach a decision on a number of complaints against breaches of the GDPR filed the day it came into application, on May 25, 2018 — including against Facebook and Google — and criticises the Irish data watchdog for interpreting "without delay" in Article 60(3) of the GDPR "contrary to the legislators' intention – as longer than a matter of months", as they put it.

To date the DPC has only reached a final decision on one cross-border GDPR case — against Twitter.

The parliament also says it's "concerned about the lack of tech specialists working for the DPC and their use of outdated systems" (which Brave also flagged last year) — as well as criticizing the watchdog's handling of a complaint originally brought by privacy campaigner Max Schrems years before the GDPR came into application, which relates to the clash between EU privacy rights and U.S. surveillance laws, and which still hasn't resulted in a decision.

The DPC's approach to handling Schrems' 2013 complaint led to a 2018 referral to the CJEU — which in turn led to the landmark Schrems II

judgement last summer invalidating the flagship EU-U.S. data transfer arrangement, Privacy Shield.

That ruling did not outlaw alternative data transfer mechanisms but made it clear that EU DPAs have an obligation to step in and suspend data transfers if Europeans' information is being taken to a third country that does not have essentially equivalent protections to those they have under EU law — thereby putting the ball back in the DPC's court on the Schrems complaint.

The Irish regulator then sent a preliminary order to Facebook to suspend its data transfers and the tech giant responded by filing for a judicial review of the DPC's processes. However, the Irish High Court rejected Facebook's petition last week. And a stay on the DPC's investigation was lifted yesterday — so the DPC's process of reaching a decision on the Facebook data flows complaint has started moving again.

A final decision could still take several months more, though — as we've reported before — as the DPC's draft decision will also need to be put to the other EU DPAs for review and the chance to object.

Update: The DPC said today that it's now written to Facebook following the lifting of the stay — giving the company six weeks to provide submissions on the preliminary order.

The parliament's resolution states that it "is worried that supervisory authorities have not taken proactive steps under Article 61 and 66 of the GDPR to force the DPC to comply with its obligations under the GDPR", and — in more general remarks on the enforcement of GDPR around international data transfers — it states that it:

Is concerned about the insufficient level of enforcement of the GDPR, particularly in the area of international transfers; expresses concerns at the lack of prioritisation and overall scrutiny by national supervisory authorities with regard to personal data transfers to third countries, despite the significant CJEU case law developments over the past five years; deplores the absence of meaningful decisions and corrective measures in this regard, and urges the EDPB [European Data Protection Board] and national supervisory authorities to include personal data transfers as part of their audit, compliance and enforcement strategies; points out that harmonised binding administrative procedures on the representation of data subjects and admissibility are needed to provide legal certainty and deal with crossborder complaints;

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The knotty, multi-year saga of Schrems' Facebook data-flows complaint, as played out via the procedural twists of the DPC and Facebook's lawyers' delaying tactics, illustrates the multi-layered legal, political and commercial complexities bound up with data flows out of the EU (post-Snowden's 2013 revelations of U.S. mass surveillance programs) — not to mention the staggering challenge for EU data subjects to actually exercise the rights they have on paper. But these intersecting issues around international data flows do seem to be finally coming to a head, in the wake of the Schrems II CJEU ruling.

The clock is now ticking for the issuing of major data suspension orders by EU data protection agencies, with Facebook's business first in the firing line.

Other U.S.-based services that are — similarly — subject to the U.S.' FISA regime (and also move EU users data over the pond for processing; and whose businesses are such they cannot shield user data via "zero access" encryption architecture) are equally at risk of receiving an order to shut down their EU-U.S. data-pipes. Or else having to shift data processing for these users inside the EU.

U.S.-based services aren't the only ones facing increasing legal uncertainty, either.

The U.K., post-Brexit, is also classed as a third country (in EU law terms). And in a separate resolution today the parliament adopted a text on the U.K. adequacy agreement, granted earlier this year by the Commission, which raises objections to the arrangement — including by flagging a lack of GDPR enforcement in the U.K. as problematic.

On that front the parliament highlights how adtech complaints filed with the ICO have failed to yield a decision. (It writes that it's concerned "non-enforcement is a structural problem" in the U.K. — which it suggests has left "a large number of data protection law breaches… [un]remedied".)

It also calls out the U.K.'s surveillance regime, questioning its compatibility with the CJEU's requirements for essential equivalence — while also raising concerns about the risk that the U.K. could undermine protections on EU citizens data via onward transfers to jurisdictions the EU does not have an adequacy agreement with, among other objections.

The Commission put a four-year lifespan on the U.K.'s adequacy deal — meaning there will be another major review ahead of any continuation of the arrangement in 2025.

It's a far cry from the "hands-off" 15 years the EU-U.S. "Safe Harbor" agreement stood for, before a Schrems challenge finally led to the CJEU striking it down back in 2015. So the takeaway here is that data deals that allow for people's information to leave Europe aren't going to be allowed to stand unchecked for years; close scrutiny and legal accountability are now firmly up front — and will remain in the frame going forward.

The global nature of the internet and the ease with which data can digitally flow across borders of course brings huge benefits for businesses — but the resulting interplay between different legal regimes is leading to increasing levels of legal uncertainty for companies seeking to take people's data across borders.

In the EU's case, the issue is that data protection is regulated within the bloc and these laws require that protection stays with people's information, no matter where it goes. So if the data flows to countries that do not offer the same safeguards — be that the U.S. or indeed China or India (or even the U.K.) — then that risk is that it can't, legally, be taken there.

How to resolve this clash, between data protection laws based on individual privacy rights and data access mandates driven by national security priorities, has no easy answers.

For the U.S., and for the transatlantic data flows between the EU and the U.S., the Commission has warned there will be no quick fix this time — as happened when it slapped a sticking plaster atop the invalidated Safe Harbor, hailing a new "Privacy Shield" regime; only for the CJEU to blast that out of the water for much the same reasons a few years later. (The parliament resolution is particularly withering in its assessment of the Commission's historic missteps there.)

For a fix to stick, major reform of U.S. surveillance law is going to be needed. And the Commission appears to have accepted that's not going to come overnight, so it seems to be trying to brace businesses for turbulence…

The parliament's resolution on Schrems II also makes it clear that it expects DPAs to step in and cut off risky data flows — with MEPs writing that "if no arrangement with the U.S. is swiftly found which guarantees an essentially equivalent and therefore adequate level of protection to that provided by the GDPR and the Charter, that these transfers will be suspended until the situation is resolved".

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So if DPAs fail to do this — and if Ireland keeps dragging its feet on closing out the Schrems complaint — they should expect more resolutions to be blasted at them from the parliament.

MEPs emphasize the need for any future EU-U.S. data transfer agreement "to address the problems identified by the Court ruling in a sustainable manner" — pointing out that "no contract between companies can provide protection from indiscriminate access by intelligence authorities to the content of electronic communications, nor can any contract between companies provide sufficient legal remedies against mass surveillance".

"This requires a reform of US surveillance laws and practices with a view to ensuring that access of US security authorities to data transferred from the EU is limited to what is necessary and proportionate, and that European data subjects have access to effective judicial redress before US courts," the parliament adds.

It's still true that businesses may be able to legally move EU personal data out of the bloc. Even, potentially, to the U.S. — depending on the type of business; the data itself; and additional safeguards that could be applied.

However, for data-mining companies like Facebook — which are subject to FISA and whose businesses rely on accessing people's data — then achieving essential equivalence with EU privacy protections looks, well, essentially impossible.

And while the parliament hasn't made an explicit call in the resolution for Facebook's EU data flows to be cut off that is the clear implication of it urging infringement proceedings against the DPC (and deploring "the absence of meaningful decisions and corrective measures" in the area of international transfers).

The parliament also states in the resolution that it wants to see "solid mechanisms compliant with the CJEU judgement" set out — for the benefit of businesses with the chance to legally move data out of the EU — saying, for example, that the Commission's proposal for a template for Standard Contractual Clauses (SCCs) should "duly take into account all the relevant recommendations of the EDPB".

It also says it supports the creation of a tool box of supplementary measures for such businesses to choose from — in areas like security and data protection certification; encryption safeguards; and

pseudonymisation — so long as the measures included are accepted by regulators.

It also wants to see publicly available resources on the relevant legislation of the EU's main trading partners to help businesses that have the possibility of being able to legally move data out of the bloc get guidance to help them do so with compliance.

The overarching message here is that businesses should buckle up for disruption of cross-border data flows — and tool up for compliance, where possible.

In another segment of the resolution, for example, the parliament calls on the Commission to "analyse the situation of cloud providers falling under section 702 of the FISA who transfers data using SCCs" — going on to suggest that support for European alternatives to U.S. cloud providers may be needed to plug "gaps in the protection of data of European citizens transferred to the United States" and — in a more blatant push for digital sovereignty — "reduce the dependence of the Union in storage capacities vis-à-vis third countries and to strengthen the Union's strategic autonomy in terms of data management and protection".

techcrunch.com, 22 May 2021

https://www.techcrunch.com

The red meat issue Biden won't touch

2021-05-23

President Joe Biden is not going to ban red meat. In fact, his administration isn't doing much to confront the flow of harmful greenhouse gases from the very big business of animal agriculture.

The Agriculture Department's newly published "climate-smart agriculture and forestry" outline says almost nothing about how Biden aims to curb methane emissions from livestock operations. But environmentalists argue that any effort to shrink the farm industry's climate footprint is half-baked if it relies on voluntary efforts and doesn't address America's system of meat production.

"USDA is setting itself up to fail on its climate and environmental justice goals," says Chloe Waterman, senior program manager at Friends of the Earth U.S., a nonprofit environmental advocacy group.

USDA didn't respond to several requests for comment on this article.

The problem is that meat has become an intense culture war issue.

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The problem is that meat has become an intense culture war issue. Look no further than the manufactured outrage over the recent right-wing media attack falsely claiming that Biden wants to control each individual's beef intake. Or look at the steady stream of press releases by farm-state lawmakers blasting any hint that federal or local governments are somehow helping "meatless Monday" campaigns.

But by the numbers, agriculture is a significant part of the climate problem: it accounts for 10 percent of all U.S. greenhouse gases. Livestock production — everything from raising pigs for bacon to dairy herds — is the largest source of potent methane emissions, according to the Environmental Protection Agency. That means addressing how we produce and consume meat is critical to Biden's pledge to put the U.S. on track to reach net-zero agricultural emissions before any other nation.

The powerful farm lobby in Washington and state capitals opposes regulation of large-scale livestock operations and the promotion of alternatives to meat and dairy. Instead, Biden administration officials are talking up unproven technologies and feel-good sustainability goals when they discuss methods of how to tackle climate change with the agriculture industry.

Agriculture Secretary Tom Vilsack is largely focused on offering new financial incentives for farmers and ranchers to adopt more climate-friendly practices. In terms of livestock emissions, Vilsack touts innovations like feed additives that reduce the potency of an animal's gas and feces, or digester systems that capture methane fumes from manure pits and convert them into a source of energy.

Stephanie Feldstein, population and sustainability director at the Center for Biological Diversity, a nonprofit environmental group, argues that such methods only have marginal benefits for the environment.

"There's simply too much meat and dairy being produced right now for any of those small tweaks to get the emissions reductions that we need," she said. "There are so many policies, from dietary guidelines to what school meals are reimbursed, to agricultural loans and government purchases, that are currently promoting overproduction of meat — and all of that needs to change."

It's not just Biden's farm chief who is treading carefully on livestock emissions: John Kerry, the president's special climate envoy, rejected the idea that the government will eventually have to tell Americans to eat less meat.

"Not necessarily, because there's a lot of research being done now that will change both the way meat is produced, cattle are herded and fed," Kerry said in a recent BBC interview. But he also acknowledged that Biden's aggressive goals for slashing greenhouse gas emissions rely heavily on technology that hasn't been developed yet.

That's why environmental advocates are pressing for more immediate action. More than two dozen groups petitioned the EPA last month to restrict greenhouse gases from large dairy and hog farms under the Clean Air Act, specifically operations with at least 500 cows or 1,000 hogs.

Many such large operations are propped up by USDA's guaranteed loans and other farm support programs, Ben Lillliston, director of rural strategies and climate change at the left-leaning Institute for Agriculture and Trade Policy, noted recently.

He's urging USDA to "stop public funding for high emitting factory farms," referring to what the industry prefers to call concentrated animal feeding operations, or CAFOs.

Since the Biden administration took over, agribusinesses and the prominent agricultural trade groups have accelerated efforts to head off federal regulators by setting their own climate goals and trumpeting steps that producers are taking to lower their environmental footprint.

"Many meat producers, packers and processors have already committed to further strengthen their contributions to healthy land, air and water," said Eric Mittenthal, a spokesperson for the North American Meat Institute, which represents meatpackers and processors.

Other groups are throwing their weight behind the sort of voluntary efforts that Vilsack is promoting. The National Pork Producers Council has been touting the potential climate benefits of methane capture and genetically engineered pigs that better digest nutrients and effectively give off less gas. But it warned that more aggressive measures, such as curbing the growth of hog operations, would backfire.

The National Cattlemen's Beef Association also supports voluntary initiatives along the lines of existing USDA conservation programs. Practices like rotational grazing and planting cover crops "have lately become buzzwords for policymakers in Washington," but they've long been employed by farmers and ranchers, Ethan Lane, the group's vice president of government affairs, said.

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"It's important to note that a sustainable future for the cattle industry does not necessitate a total overhaul of the way producers do business," Lane said. "The U.S. cattle and beef industry has had the lowest greenhouse gas emissions intensity in the world for 25 years. Direct emissions from cattle account for only 2 percent of the nation's overall emissions."

There's also not much appetite in Congress for stricter regulations. Sens. John Thune (R-S.D.) and Kyrsten Sinema (D-Ariz.) recently filed legislation that would prohibit the government from requiring livestock emission permits.

"Livestock producers are working to improve efficiency and reduce emissions from their operations," Thune, the second-ranked Senate Republican, said in a statement. "They should not be subject to onerous regulations and costly permit fees for their animals' emissions, which could ultimately lead to higher food costs for consumers."

MOST READ

On the other side, more progressive lawmakers are pushing for USDA to take a tougher stance on large-scale livestock production.

"For too long we've relied on an extractive, exploitative form of corporate agriculture, with lots of negative consequences," House Appropriations Chair Rosa DeLauro said at a recent hearing on USDA research programs.

The Connecticut Democrat cited a new study in the Proceedings of the National Academy of Sciences that found that nearly 16,000 Americans die each year from air pollution caused by food production — primarily meat, dairy and crops used for animal feed. The findings, which industry groups dispute, suggest that shifting America's diet more toward plant-based foods could reduce such deaths by as much as 83 percent.

Notably, DeLauro says it's time for taxpayers to subsidize research into alternative proteins at the same rate as traditional livestock production, calling such products a "compelling option for addressing agricultural emissions." It's a key statement coming from the top lawmaker in charge of allocating more than a trillion dollars of annual spending.

Plant-based meats are quickly gaining in popularity, but they still account for less than 1 percent of all refrigerated meat sales.

A policy paper from the nonprofit Climate Advisers and the Good Food Institute, which advocates for alternative meats, says a "global protein transition" is needed to reach the goals in the Paris climate agreement.

Speeding up the adoption of alternative meats while making the existing system more efficient could make a bigger dent in cutting global emissions than switching to electric vehicles, according to the report.

Some beef producers are seeking a middle ground.

Mike Salguero, the founder of ButcherBox, which delivers grass-fed beef and other meats directly to consumers, said the beef industry for decades has focused primarily on food safety and efficiency, rather than sustainability. But the growing focus on climate change and the wave of slaughterhouse shutdowns during the coronavirus pandemic are forcing more people to rethink the way meat is produced.

Salguero wrote a letter to Vilsack last week asking USDA to formally study ways to encourage raising cattle on pastures — a system widely seen as better for the environment — instead of sending them to massive feedlots.

There are currently too many hurdles and inefficiencies for grass-fed beef production to gain a large market share, he said. Salguero cited the lack of access to large slaughterhouses and the structure of farm financing that often forces producers to sell their cattle to a feedlot when their loans are due.

"I don't think meat is going away," he said. "I do think meat can be done a lot better. We're proving there's a market for it, and proving there's a third way."

politico.com, 23 May 2021

https://www.politico.com

Team links popular weed killer chemical to preterm births

2021-05-24

The researchers found that the presence of the chemical in women's urine in late pregnancy was linked to an increased risk for premature birth, while the association was inconsistent or null earlier in the pregnancy.

"Since most people are exposed to some level of glyphosate and may not even know it, if our results reflect true associations, then the public health implications could be enormous," says senior author John Meeker, professor of environmental health sciences and senior associate dean for research at the University of Michigan School of Public Health.

"Ours is the first study to measure AMPA, and only the second to measure glyphosate in relation to birth outcomes."

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"It is well understood that infants who are born preterm have an increased risk for adverse long-term health effects, and the results of this study indicate the need for further investigation," says first author Monica Silver, who conducted the study while a postdoctoral fellow at the School of Public Health..

Meeker says a couple of years ago he and his collaborators were driving near the northern coast of Puerto Rico, visiting local clinics and research collaborators when he noticed a sign advertising a commonly used herbicide on a corner, the lush greenery of the tropical island as a backdrop.

"I'm like, I'm wondering if we can measure its main chemical, glyphosate, in our participants. Maybe that's high here," Meeker says.

Twelve years ago, Meeker and collaborators established the PROTECT pregnancy and birth cohort to look into what environmental factors predicted preterm birth in Puerto Rico, which had been rising in the island for the last couple of decades.

Over time, the team—including dozens of collaborators in five clinics and two hospitals throughout the island—have studied a broad range of environmental factors, including maternal stress, chemicals, metals, etc.

After seeing the road sign, Meeker and his team searched the scientific literature and realized that while glyphosate is the most heavily used herbicide in the world and that there's mounting evidence of its negative effects on human health, very few studies focused on prenatal exposure and its impact on human reproductive and developmental outcomes.

The researchers decided to measure glyphosate and aminomethylphosphonic acid (AMPA)—one of the primary degradation products of the herbicide—by testing urine, since the chemicals are not metabolized by mammals. They tested the urine of 247 pregnant women at the first and third study visit of their pregnancy, at 16-20 weeks and 24-28 weeks.

Looking at preterm births (babies born at less than 37 weeks of pregnancy) and comparing them to controls, the research team found that the odds of preterm birth were significantly elevated among women with higher urinary concentrations of glyphosate and AMPA at the third visit, while associations with levels at the first visit were largely null or inconsistent.

The researchers say that AMPA is formed not only from the degradation of glyphosate, but from other common industrial chemicals as well. AMPA is also highly persistent and can take months to break down in the environment.

"Despite the potential for widespread exposure to glyphosate and AMPA, there is very little information regarding the health effects of exposure during pregnancy," Silver says. "Ours is the first study to measure AMPA, and only the second to measure glyphosate in relation to birth outcomes."

Meeker says that another small study from Indiana recently reported that higher exposures to glyphosate were correlated with reduced gestation age at birth.

"Our results are consistent with those findings when explored in a different study population and using a different study design, which lends some additional confidence to what we're observing, but more work is needed," he says.

The researchers say they hope to expand the research by looking at other cohorts around the United States. One such opportunity may lie within the NIH-funded Environmental Influences on Child Health Outcomes study, where information from dozens of birth cohorts, including PROTECT, are being combined to investigate predictors of children's health and disease among tens of thousands participants from across the country.

The new research appears in Environmental Health Perspectives. Additional authors are from the University of Michigan; NSF International; the University of Puerto Rico Graduate School of Public Health, UPR Medical Sciences Campus, San Juan; Northeastern University in Boston; and the University of Georgia.

Funding for the research came from the National Institute of Environmental Health Sciences, the National Institutes of Health, and the Environmental Influences on Child Health Outcomes program.

futurity.org, 24 May 2021

https://www.futurity.org

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Move over, Death Valley: These are the two hottest spots on Earth

2021-05-19

Death Valley holds the record for the highest air temperature on the planet: On 10 July 1913, temperatures at the aptly named Furnace Creek area in the California desert reached a blistering 56.7°C (134.1°F). Average summer temperatures, meanwhile, often rise above 45°C (113°F).

But when it comes to surface temperature, two spots have Death Valley beat. A new analysis of high-resolution satellite data finds the Lut Desert in Iran and the Sonoran Desert along the Mexican-U.S. border have recently reached a sizzling 80.8°C (177.4°F).

More than 11,000 World Meteorological Organization manned and automated weather stations measure air temperatures in the shade, in ventilated hutches about 1.5 meters above ground level. But vast swaths of Earth's surface, especially in remote regions, lack these instruments, leaving them out of the record books.

For the past 2 decades, a pair of Earth-observing satellites equipped with NASA's Moderate Resolution Imaging Spectroradiometer (MODIS)—an instrument that measures everything from ozone levels to phytoplankton abundance—have scanned the entire globe, day in and day out. In areas without cloud cover, MODIS measures the infrared heat emitted by surfaces to take their temperature—essentially, how the soil, dirt, or ice would feel if touched.

Average summer temperatures, meanwhile, often rise above 45°C (113°F).

Surface temperatures tend to run hotter than the air above, especially on sunny days when surfaces are heated both by air and the Sun's radiant energy. "Think of your car sitting in a parking lot on a summer day and how the handle burns your fingers. Or the sand burning your feet at the beach," says ecologist David Mildrexler of the conservation organization Eastern Oregon Legacy Lands.

In 2011, Mildrexler and his colleagues gleaned from MODIS data that summer temperatures routinely soared above 60°C (140°F) in arid regions, with a high of 70.7°C (159.3°F) in Lut in 2005. Since that study, software improvements have sharpened MODIS's resolution from 5-kilometer pixels to 1-kilometer pixels, bringing even hotter spots into focus. Lut hit its all-time high in 2018, a record the Sonoran, in a weird coincidence, matched the next summer, Yunxia Zhao of the University of California, Irvine, and colleagues report this month in the Bulletin of the American Meteorological Society.

But with its "consistently hot footprint over a large area," says Mildrexler, who was not involved in the present study, "the Lut Desert has really emerged as the hottest place on Earth."

Zhao and her colleagues uncovered other superlatives. The maximum temperature swing in a single day was 81.8°C (147.3°F), from –23.7°C (–10.7°F) to 58.1°C (136.6°F) on 20 July 2006 in China's Qaidam Basin, a crescent-shaped depression hemmed in by mountains on the Tibetan Plateau. And the coldest spot on our planet? No big surprise: Antarctica. But a satellite reading of –110.9°C (–167.6°F) in 2016 is more than 20° chillier than the coldest air temperature recorded in 1983.

It's unclear whether climate change is driving up surface temperatures, Zhao says. But she notes that the Sonoran's highs coincided with La Niña, a climate oscillation featuring cooler surface temperatures in the central Pacific Ocean and drier desert conditions.

Higher temperatures are bad news for desert creatures being pushed to the edge of their heat tolerances. "These extremes are really laying it on the ecosystems," Mildrexler says. On the flip side, he says, the data reveal an impressive cooling effect of forests. Trees tap water with their deep roots and dissipate heat through transpiration, he notes, which cools their canopies and the surrounding air. "That keeps maximum temperatures down and protects biodiversity."

And that offers a lesson for urban planners, Mildrexler says: Greener really is cooler.

*Correction, 20 May, 12:50 p.m.: This story has been updated to correct the Fahrenheit reading for the maximum temperature swing in a single day in the Qaidam Basin.

sciencemag.org, 19 May 2021

https://www.sciencemag.org

'Tree farts' contribute about a fifth of greenhouse gases from ghost forests

2021-05-20

If a tree farts in the forest, does it make a sound? No, but it does add a smidge of greenhouse gas to the atmosphere.

Gases released by dead trees — dubbed "tree farts" — account for roughly one-fifth of the greenhouse gases emitted by skeletal, marshy forests

But in the short term, dead trees decay and stop taking up carbon dioxide through photosynthesis, "so that's going to be a major greenhouse gas source."

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along the coast of North Carolina, researchers report online May 10 in Biogeochemistry. While these emissions pale in comparison with other sources, an accurate accounting is necessary to get a full picture of where climate-warming gases come from.

A team of ecologists went sniffing for tree farts in ghost forests, which form when saltwater from rising sea levels poisons a woodland, leaving behind a marsh full of standing dead trees. These phantom ecosystems are expected to expand with climate change, but it's unclear exactly how they contribute to the world's carbon budget.

"The emergence of ghost forests is one of the biggest changes happening in response to sea level rise," says Keryn Gedan, a coastal ecologist at George Washington University in Washington, D.C., who was not involved in the work. "As forests convert to wetlands, we expect over long timescales that's going to represent a substantial carbon sink," she says, since wetlands store more carbon than forests. But in the short term, dead trees decay and stop taking up carbon dioxide through photosynthesis, "so that's going to be a major greenhouse gas source."

To better understand how ghost forests pass gas into the atmosphere, the researchers measured greenhouse gases wafting off dead trees and soil in five ghost forests on the Albemarle-Pamlico Peninsula in North Carolina. "It's kind of eerie" out there, says Melinda Martinez, a wetland ecologist at North Carolina State University in Raleigh.

But Martinez ain't afraid of no ghost forest. In 2018 and 2019, she measured CO2, methane and nitrous oxide emissions from dead trees using a portable gas analyzer she toted on her back. "I definitely looked like a ghostbuster," she says.

Soils gave off most of the greenhouse gases from the ghost forests. Each square meter of ground emitted an average 416 milligrams of CO2, 5.9 milligrams of methane and 0.1 milligrams of nitrous oxide per hour. On average, dead trees released about 116 milligrams of CO2, 0.3 milligrams of methane and 0.04 milligrams of nitrous oxide per square meter per hour — totaling about one-fourth the soil's emissions.

Measuring greenhouse gases from the trees is "kind of measuring the last breath of these forests," says Marcelo Ardón, an ecosystems ecologist and biogeochemist at North Carolina State University. The dead trees "don't emit a ton, but they are important" to a ghost forest's overall emissions.

Ardón coined the term "tree farts" to describe the dead trees' greenhouse gas emissions. "I have an 8-year-old and an 11-year-old, and fart jokes are what we talk about," he explains. But the analogy has a biological basis, too. Actual farts are caused by microbes in the body; the greenhouse gases emitted by ghost forests are created by microbes in the soil and trees.

In the grand scheme of carbon emissions, ghost forests' role may be minor. Tree farts, for instance, have nothing on cow burps (SN: 11/18/15). A single dairy cow can emit up to 27 grams of methane — a far more potent greenhouse gas than CO2 — per hour. But accounting for even minor sources of carbon is important for fine-tuning our understanding of the global carbon budget, says Martinez (SN: 10/1/19). So it would behoove scientists not to turn up their noses at ghost tree farts.

sciencenews.org, 20 May 2021

https://www.sciencenews.org

Stop worrying and love the F-150 Lightning

2021-05-20

1. Start with the price—how could you not? The Ford F-150 Lightning, the new electric version of the ur–American pickup truck, will go on sale next spring for $39,974. Because Ford vehicles still qualify for the federal EV tax credit, most Americans will pay a little less than $32,500 for this truck.

Thirty-two grand after subsidies—an astonishing price. For years, climate-concerned transportation experts have sought to make electric vehicles cost the same or less than their internal-combustion cousins. The F-150 Lightning is nearly there. In January, the average new car purchase in the United States crossed the $40,000 mark; the Lightning is well below that bar, and inhabits the same neighborhood as Toyota's RAV4 Hybrid, Jeep's Gladiator pickup, and the Honda Odyssey. After subsidies, the electric F-150 is only about $4,000 more than its gas-burning twin. The entry-level electric model claims 563 horsepower and a respectable 230 miles of range, and it immediately sits among the least expensive electric vehicles on the market: Tesla's Model 3, with 260 miles of range, sells for $39,490 (but does not qualify for federal subsidies).

2. But it isn't any electric car. It's a Ford F-150, the country's best-selling vehicle in every year since Donkey Kong debuted and Ronald Reagan entered the White House. One in every 16 vehicles on American roads is an F-150, and it is the most used vehicle in 39 states, according to a

For years, climate-concerned transportation experts have sought to make electric vehicles cost the same or less than their internal-combustion cousins.

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Boston Consulting Group study commissioned by Ford. "There's lots of different kinds of sodas; there's only one Coke. There's lots of different electric pickup trucks, but there's only one F-150," Jim Farley, Ford's chief executive, told me, which may sound immodest but actually borders on understatement: Receipts from F-Series trucks alone exceed Coca-Cola's annual corporate revenue; that of every major U.S. sports league, combined; or Disney's global theme-park business. According to the same BCG study, 8 percent of the U.S. labor force uses an F-Series truck in their daily job.

Or more relevant, for our purposes: Ford sells about 900,000 F-150s every year; all automakers collectively sold 250,000 new EVs total last year. "This may be one of the important products in decarbonization," Tim Latimer, an energy-industry veteran, tweeted last week. (He is now the chief executive of the geothermal company Fervo.) An electric F-150 opens up an enormous new market for EVs and signals that climate-friendly technology has reached the soybean fields and construction sites of middle America.

It is, as such, almost miraculously simpatico with President Joe Biden's climate strategy. Biden has pitched climate action as a kind of infrastructure upgrade, and soaked the urgent scientific language of climate change in a rugged American savor. Ford has essentially done the same. (Biden and Ford aren't so different as brands: old-school American standards with union roots that must address an older, working-class audience and a younger, more professional class at the same time.) So it made sense that Biden essentially debuted the car yesterday during a speech at a Michigan plant where UAW members will assemble the truck, accidentally disclosing the truck's zero-to-60 acceleration time (4.4 seconds). The two need each other: Biden needs mainstream EVs such as the F-150, and Ford needs Democrats to build thousands of charging stations nationwide, so that consumers feel like buying an EV is actually an option.

3. But forget about the price or the aesthetics: We need a truck like this. Not so long ago, America's coal-heavy electricity sector posed the greatest threat to the long-term health and stability of the planet's climate. Representative Thomas Massie, a Republican from Kentucky, could put a FRIEND OF COAL license plate on his Tesla and mean it. Then the whirlwind of the 2010s swept through—today, 40 percent of U.S. electricity comes from renewables or zero-power sources—and now the transportation sector is the country's dirtiest. America's gasoline-powered cars and light trucks are the main reason. Cars and light trucks now contribute about 20 percent of U.S. emissions, more than any other economic activity.

Mass transit accounts for about 1 percent of passenger miles traveled by land in the United States. Even if Americans quadrupled their use of public transportation, most travel would happen by car or truck, whether electric or gas-powered. And even if the country saw a revolution in urban and suburban land use to discourage driving—I am praying for it as much as anyone—private vehicles would remain essential to rural living. We need electric vehicles.

4. An electric vehicle is, at a mechanical level, a giant battery on wheels. Ford is pitching this not only as a technical necessity but as a feature: They want you to plug stuff into the car. "Let's say you're at a tailgate or at work. You can set up a cement mixer, a band, or lights and draw only half the power the truck is capable of producing at a time," Linda Zhang, the chief engineer on the Lightning, told me. Like all electric vehicles, the F-150 replaces the hefty internal-combustion engine with a much smaller electric motor, and like many EVs therefore has a storage compartment under its front hood: a "frunk." Except the F-150 has a "power frunk"—the most marvelous three-syllable phrase American marketing has produced since "half-priced apps"—meaning that it both opens to the touch of a button and has multiple plugs for appliances.

The Lightning can store so much power that, in a blackout, it can supply a house's normal power usage for three days, according to Ford. If the house conserves power, it can keep the lights on for more than a week, Zhang said. Talking about this feature, Ford employees and Farley himself have referenced the Texas blackouts. The Lightning is a technology of resilience, of climate adaptation.

5. Chemically speaking, decarbonization—the move away from carbon-based fossil fuels—is a shift to less dense forms of energy. Gasoline, for its many flaws, contains an enormous amount of potential energy in a very small amount of mass. Transitioning away from it means, in practical terms, that electric vehicles will be much heavier than gasoline-powered vehicles. The F-150 Lightning weighs 6,500 pounds, about the same as the gargantuan Hummer H2 of the mid-2000s. The battery alone is 1,800 pounds.

These are hefty, dangerous vehicles. Ford has said that it will send software updates to its EVs over the air, and that it will soon transmit its new autonomous-driving feature, BlueCruise, to its EV fleet. But the tonnage of the Lightning, specifically, means that it must especially prioritize advanced safety features, sensors, and auto-braking. Otherwise pedestrians, cyclists, and drivers of smaller and lighter vehicles will die.

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6. Perhaps the most intriguing aspect of the F-150 Lightning is that its target audience is not necessarily consumers. For the first time ever, Ford is selling a version of the F-150 aimed at corporate fleet managers: Think landscaping companies, HVAC-repair companies, electricians, any company that operates multiple trucks at once. Corporate fleets are, in many ways, even better suited for electrification than consumer vehicles. They are driven every day but rarely travel long distances, they benefit from the lower upkeep costs of an EV, and they are usually stored in the same place overnight—which means they can be charged overnight. Ford says that for the first time, fleet managers will be able to see the location of all their trucks on a map, and they will be able to monitor their charge levels remotely. This combination of lower fuel costs and greater workplace surveillance strikes me as all but guaranteeing the electrification of many corporate fleets.

7. And it signals a change for Ford, that most American of automakers. For the past few years, companies that specialize in one or another sector of the economy—food delivery or taxi service, for instance—have chased higher valuations by claiming to be technology companies. But the onset of electrification means that car companies will actually be technology companies, and almost content companies: Ford's customers will spend a good part of their day looking at a screen, and Ford will constantly have to improve the experience of looking at that screen.

This is the transition, at least, that worries Farley the most. "We came from a paradigm where we sell something, a vehicle, we finance it maybe with our credit company, and then we'd see the customer four or five years later," he said. With EVs, "suddenly we have a daily relationship with the customer."

This mode will also free Ford from the tyranny of gas prices. But it will move it into the world of silicon and software. Earlier today, Ford's F-150 production lines rolled to a halt because of the global semiconductor shortage. The age of fuel scarcity might be over. The material world of the new economy has just begun.

theatlantic.com, 20 May 2021

https://www.theatlantic.com

About 87% of Australia's mammals, 93% of its reptiles and 45% of its bird species can be found only in Australia, according to the Australian Wildlife Conservancy.

Egg-laying mammals and peacock spiders: Meet some of Australia's weirdest creatures

2021-05-19

Australia is famed for its weird and wonderful animals. From the alien blue-ringed octopus, which carries enough venom to kill 26 adult humans within minutes, to the duck-billed platypus with it's patchwork anatomy, Australia is packed with species that, to the rest of the world, don't make a lot of sense.

This is because these strange species often aren't found anywhere else on Earth. About 87% of Australia's mammals, 93% of its reptiles and 45% of its bird species can be found only in Australia, according to the Australian Wildlife Conservancy.

During Earth's geographical evolution, the smallest of the seven continents, modern-day Australia, broke away from a supercontinent called Gondwana that dominated the world's landscape hundreds of millions of years ago. This meant that the species living in Australia didn't evolve in quite the same way as animals elsewhere on Earth, with the exception of migrating species that could fly or swim beyond the shores of Australia. This has resulted in some of the most fascinating, frightening and downright odd animals to ever walk the planet.

Ocean sunfish (Mola mola)

Although not endemic to Australia, these strange creatures can be seen swimming around the southern shores of the continent. Sunfish are the heaviest-known bony fish on Earth, with one species, Mola alexandrini, reaching a whopping 5,000 pounds (2,300 kilograms).

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What's most notable about these fish are their incredibly large dorsal and anal fins, making them over 13 feet (4 meters) tall. These ocean giants deep-dive into very cold waters to feed on zooplankton and avoid predators. To warm themselves back up, they move close to the surface to bask in the sun's heat, according to the Smithsonian magazine.

Giant centipede (Ethmostigmus rubripes)

Over 6 inches (16 centimeters) long and made up of 27 body segments supporting up to 23 pairs of legs, Australia's giant centipede is one of the biggest in the world. To sustain their body size, these arthropods feed on insects, snails and worms.

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To capture and kill their prey, the centipedes have modified legs called forcipules that curve around the head and can deliver a potent venom, according to Australian Geographic. The venom is strong enough to kill a large animal quickly, and can cause severe pain to humans if the insect is disturbed or handled, according to the Australian Museum.

Net-casting spider (Deinopis ravidus)

Australia is famous for its many scary spiders, but net-casting spiders are among the most innovative. Rather than building a silken web and passively waiting for prey to become entangled, these spiders take a proactive approach, using a net of silk to trap their food.

These spiders typically use their nets to capture ants, beetles and even other spiders during the night, according to the Australian Museum. To help them see in the dark, the unusual arachnids have two large eyes, Live Science previously reported, earning them the nickname "ogre-faced spider." Before the sun rises, net-casters will consume their nightly catch, including the net to recycle the silk.

Peacock spider (Maratus volans)

Peacock spiders are found in the south of Australia and are well known for their elaborate courtship dance, Live Science reported. Males wave around their third pair of legs and reveal their vibrant abdomen to attract a female. The spiders are tiny, measuring around an eighth of an inch (a few millimeters) long.

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Giant fishkiller (Lethocerus insulanus)

As the name suggests, these aggressive-looking water bugs have a taste for small fish, along with tadpoles, frogs and snails. To catch their prey, they sit on a plant stem that's submerged underwater , grabbing passing fish using their long, needle-tipped front legs, according to the Australian Museum. They then inject digestive enzymes into the prey's body to liquefy tissues, making it ready for consumption.

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Short-beaked echidna (Tachyglossus aculeatus)

Echidnas are not only one of the strangest animals in Australia, but possibly the entire world. These hedgehog-like creatures are one of only two kinds of mammals on Earth that lay eggs, according to San Diego Zoo Wildlife Alliance — the other is the duck-billed platypus.

Adding to their oddities, echidnas have toothless jaws, so they crush their insect prey — of which they eat around 40,000 per day — between their tongue and the roof of their mouth. Echidnas feed during the night to avoid the high daytime temperatures and to maintain their low body temperature of 90 degrees Fahrenheit (32 degrees Celsius).

Giant panda snail (Hedleyella falconeri)

Named for their long pair of black stalks, giant panda snails are Goliaths in the mollusk world, with shells reaching up to 4 inches (10 cm) long, making them the largest land snails in Australia, according to the Atlas of Living Australia. Giant panda snails spend their time in subtropical rainforests in eastern Australia, feeding on fungi on the forest floor after or during rainfall.

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Spiny leaf insect (Extatosoma tiaratum)

Masters of camouflage, these insects have evolved an exoskeleton that mimics the foliage of their forest habitat. Males can fly away when they feel threatened, but females are flightless so are completely reliant on their ability to blend into their environment, according to the Australian Museum.

They have been found to sway in the wind to mimic the movement of vegetation in order to stay hidden from predators. Spiny leaf insects also curl up their abdomen to look like a scorpion.

Arafura file snake (Acrochordus arafurae)

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These stealthy serpents can grow up to 8 feet (2.5 m) long and spend their time swimming through the waters of lagoons, pools and flooded grasslands. Arafura file snakes feed almost exclusively on fish and can spend hours at a time hunting underwater.

To immobilize their prey, they wrap around and constrict fish weighing up to 2.2 pounds (1 kg) before ingesting them. They are helped in this by their rough skin — which is where file snakes got their name, Kakadu National Park said on its website.

Marsupial mole (Notoryctes typhlops)

Meet Australia's unusual mole. Unlike its cousins from around the world, this small mammal has a life cycle that is closer to that of a kangaroo than a common mole. As a marsupial, fetuses are partly developed in the womb, before emerging into the mother's pouch to suckle milk until they have grown up enough to leave. However, there have been no recorded sightings of any marsupial mole pups in the wild, so it remains unclear how long they stay in their mother's pouch.

Little is known about marsupial moles, according to Animal Diversity Web. It is not known whether they create residential networks of tunnels or a permanent burrow, or whether they are solitary nomads. They are believed to continually burrow through sand, simultaneously filling in the tunnel behind them, Australia's Northern Territory government said in a fact sheet. They have evolved in such a way that enables them to survive on the small percentage of oxygen between the grains of sand.

Blue-tongued skink (Tiliqua scincoides)

Found roaming through tussock grass and forest leaf litter, at around 24 inches (60 cm) long, this lengthy lizard is famous for sticking out its blue tongue. Skinks use their brightly colored tongues to ward off predators, flattening their tongues and puffing out their bodies to appear larger and more threatening, the Australian Museum said.

The front of the tongue reflects ultraviolet (UV) light, according to San Diego Wildlife Alliance. This suggests that common predators of the skink, such as bird species that can see UV rays, will be dazed by a flash of UV and think twice about attacking them.

Dugong (Dugong dugon)

Often referred to as sea cows, these marine mammals spend most of their time hoovering up seagrass from shallow coastal waters. Unlike their

manatee cousins, dugongs sport a dolphin-like tail and do not live in freshwater.

They can be found mostly in northern and western Australian waters. Dugongs can weigh up to about 800 pounds (360 kg), consuming up to 90 pounds (40 kg) of seagrass every day. These mammals are equipped with a rounded muscular lip, called a cleft, that rips up the seagrass from the seabed, according to Oceana.

livescience.com, 19 May 2021

https://www.livescience.com

Why do we get shots in the arm? It's all about the muscle

2021-05-21

Millions have rolled up their sleeves for the COVID-19 vaccine, but why haven't they rolled up their pants legs instead? Why do we get most shots in our arms?

As an associate professor of nursing with a background in public health, and as a mother of two curious kids, I field this question fairly often. So here's the science behind why we get most vaccines in our arm.

It's worth noting that most, but not all, vaccines are given in the muscle – this is known as an intramuscular injection. Some vaccines, like the rotavirus vaccine, are given orally. Others are given just beneath the skin, or subcutaneously – think of the measles, mumps and rubella vaccine. However, many others are given in the muscle.

But why is the muscle so important, and does location matter? And why the arm muscle – called the deltoid – in the top of the shoulder?

Muscles have immune cells

Muscles make an excellent vaccine administration site because muscle tissue contains important immune cells. These immune cells recognize the antigen, a tiny piece of a virus or bacteria introduced by the vaccine that stimulates an immune response. In the case of the COVID-19 vaccine, it is not introducing an antigen but rather administering the blueprint for producing antigens. The immune cells in the muscle tissue pick up these antigens and present them to the lymph nodes. Injecting the vaccine into muscle tissue keeps the vaccine localized, allowing immune cells to sound the alarm to other immune cells and get to work.

Muscles make an excellent vaccine administration site because muscle tissue contains important immune cells.

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Once a vaccine is recognized by the immune cells in the muscle, these cells carry the antigen to lymph vessels, which transport the antigen-carrying immune cells into the lymph nodes. Lymph nodes, key components of our immune system, contain more immune cells that recognize the antigens in vaccines and start the immune process of creating antibodies.

Clusters of lymph nodes are located in areas close to vaccine administration sites. For instance, many vaccines are injected in the deltoid because it is close to lymph nodes located just under the armpit. When vaccines are given in the thigh, the lymph vessels don't have far to travel to reach the cluster of lymph nodes in the groin.

Muscles keep the action localized

Muscle tissue also tends to keep vaccine reactions localized. Injecting a vaccine into the deltoid muscle may result in local inflammation or soreness at the injection site. If certain vaccines are injected into fat tissue, the chance of irritation and inflammation reaction increases because fat tissue has poor blood supply, leading to poor absorption of some vaccine components.

Vaccines that include the use of adjuvants – or components that enhance the immune response to the antigen – must be given in a muscle to avoid widespread irritation and inflammation. Adjuvants act in a variety of ways to stimulate a stronger immune response.

Yet another deciding factor in vaccine administration location is the size of the muscle. Adults and children ages three and older tend to receive vaccines in their upper arm in the deltoid. Younger children receive their vaccines mid-thigh because their arm muscles are smaller and less developed.

Another consideration during vaccine administration is convenience and patient acceptability. Can you imagine taking down your pants at a mass vaccination clinic? Rolling up your sleeve is way easier and more preferred. Infectious disease outbreaks, as in flu season or amid epidemics like COVID-19, require our public health system to vaccinate as many people as possible in a short time. For these reasons, a shot in the arm is preferred simply because the upper arm is easily accessible.

All things considered, when it comes to the flu shot and the COVID-19 vaccine, for most adults and kids, the arm is the preferred vaccination route.

theconversation.com, 21 May 2021

https://www.theconversation.com

How does time work?

2021-05-20

When considering time, it's easy to quickly get lost in the complexity of the topic. Time is all around us — it's ever-present and is the basis of how we record life on Earth. It's the constant that keeps the world, the solar system and even the universe ticking.

Civilizations have risen and fallen, stars have been born and extinguished, and our one method of keeping track of every event in the universe and on Earth has been comparing them to the present day with the regular passing of time. But is it really a constant?

Some 13.8 billion years ago, the universe was born, and since then time has flown by to the present day, overseeing the creation of galaxies and the expansion of space. But when it comes to comparing time, it's daunting to realize just how little of it we have actually experienced.

Earth might be 4.5 billion years old, but modern humans have inhabited the planet for around 300,000 years — that's just 0.002% the age of the universe. Feeling small and insignificant yet? It gets worse. We have experienced so little time on Earth that in astronomical terms we're entirely negligible.

In the 17th century, physicist Isaac Newton saw time as an arrow fired from a bow, traveling in a direct, straight line and never deviating from its path. To Newton, one second on Earth was the same length of time as that same second on Mars, Jupiter or in deep space. He believed that absolute motion could not be detected, which meant that nothing in the universe had a constant speed, even light. By applying this theory, he was able to assume that if the speed of light could vary, then time must be constant. Time must tick from one second to the next, with no difference between the length of any two seconds. This is something that it's easy to think is true. Every day has roughly 24 hours; you don't have one day with 26 and one with 23 hours.

Is time really as simple as a movement from one second to the next?

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However, in 1905, Albert Einstein asserted that the speed of light doesn't vary, but rather it is a constant, traveling at roughly 186,282 miles per second (299,792 kilometers per second). He postulated that time was more like a river, ebbing and flowing depending on the effects of gravity and space-time. Time would speed up and slow down around cosmological bodies with differing masses and velocities, and therefore one second on Earth was not the same length of time everywhere in the universe.

This posed a problem. If the speed of light was really a constant, then there had to be some variable that altered over large distances across the universe. With the universe expanding and planets and galaxies moving on a humongous scale, something had to give to allow for these small fluctuations. And this variable had to be time.

It was ultimately Einstein's theory that was not only believed to be the truth, but also proven to be entirely accurate. In October 1971, two physicists named J.C. Hafele and Richard Keating set out to prove its validity. To do this, they flew four cesium atomic clocks on planes around the world, eastward and then westward.

Can You Time-Travel?

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According to Einstein's theory, when compared with ground-based atomic clocks — in this instance at the U.S. Naval Observatory in Washington, D.C. — Hafele and Keating's airborne clocks would be about 40 nanoseconds slower after their eastward trip, and about 275 nanoseconds faster after traveling west, due to the gravitational effects of the Earth on the velocity of the planes, according to their 1972 study in the journal Science. Incredibly, the clocks did indeed register a difference when traveling east and west around the world — about 59 nanoseconds slower and 273 nanoseconds faster, respectively, when compared with the U.S. Naval Observatory. This proved that Einstein was correct, specifically with his theory of time dilation, and that time did indeed fluctuate throughout the universe.

What happens during time dilation?

What does the theory of special relativity mean in terms of time? Check out our explanation of special relativity first to truly get a grasp of time dilation.

Newton and Einstein did agree on one thing, though — that time moves forward. So far, there is no evidence of anything in the universe that is

able to dodge time and move forwards and backward at will. Everything ultimately moves forward in time, be it at a regular pace or slightly warped if approaching the speed of light. But why does time tick forward? Scientists aren't certain, but they have several theories to explain time's one-track "mind." One of these brings in the laws of thermodynamics, specifically the second law. This states that everything in the universe wants to move from low to high entropy, or from uniformity to disorder, beginning with simplicity at the Big Bang and moving to the almost random arrangement of galaxies and their inhabitants in the present day. This is known as the "arrow of time," or sometimes "time's arrow," likely coined by British astronomer Arthur Eddington in 1928, analytic philosopher Huw Price said at Séminaire Poincaré in 2006.

Eddington suggested that time was not symmetrical: "If as we follow the arrow, we find more and more of the random element in the state of the world, then the arrow is pointing towards the future; if the random element decreases, the arrow points towards the past," he wrote in "The Nature of the Physical World" in 1928. For example, if you were to observe a star in almost uniformity, but later saw it explode as a supernova and become a scattered nebula, you would know that time had moved forward from equality to chaos.

Another theory suggests that the passage of time is due to the expansion of the universe. As the universe expands, it pulls time with it, as space and time are linked as one; but this would mean that if the universe were to reach a theoretical limit of expansion and begin to contract, then time would reverse — a slight paradox for scientists and astronomers. Would time really move backward, with everything coming back to an era of simplicity and ending with a Big Crunch? It's unlikely we will be around to find out, but scientists can postulate on what might happen.

It's incredible to think of the progress humanity has made in our understanding of time over the past century. From ancient time-telling sundials to modern atomic clocks, we can even track the passing of a second more closely than ever before. Time remains a complex topic, but thanks to scientific visionaries, we are getting closer to unlocking the secrets of this not-so-constant universal constant.

The importance of Einstein's theory of special relativity

Einstein's theory of special relativity relies on one key fact: The speed of light is the same no matter how you look at it. To put this into practice, imagine you are traveling in a car at 20 mph (32 km/h), and you drive past

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a friend who is standing still. As you pass them, you throw a ball out in front of the car at 10 mph (16 km/h).

To your friend, the ball's speed combines with that of the car, and so appears to be traveling at 30 mph (48 km/h). Relative to you, however, the ball travels at only 10 mph, as you are already traveling at 20 mph.

Now imagine the same scenario, but this time you pass your stationary friend while traveling at half the speed of light. Through some imaginary contraption, your friend can observe you as you travel past. This time you shine a beam of light out of the car windscreen.

In our previous calculation we added together the speed of the ball and the car to find out what your friend saw, so in this instance, does your friend see the beam of light traveling at one-and-a-half times the speed of light?

According to Einstein, the answer is no. The speed of light always remains constant, and nothing can travel faster than it. On this occasion, both you and your friend observe the speed of light traveling at its universally agreed value at roughly 186,282 miles per second. This is the theory of special relativity, and it's very important when talking about time.

Time: The fourth dimension of the universe

It was once thought that space and time were separate, and that the universe was merely an assortment of cosmic bodies arranged in three dimensions. Einstein, however, introduced the concept of a fourth dimension — time — that meant that space and time were inextricably linked. The general theory of relativity suggests that space-time expands and contracts depending on the momentum and mass of nearby matter. The theory was sound, but all that was needed was proof.

That proof came courtesy of NASA's Gravity Probe B, which demonstrated that space and time were indeed linked. Four gyroscopes were pointed in the direction of a distant star, and if gravity did not have an effect on space and time, they would remain locked in the same position. However, scientists clearly observed a "frame-dragging" effect due to the gravity of Earth, which meant the gyroscopes were pulled very slightly out of position. This seems to prove that the fabric of space itself can be altered, and if space and time are linked, then time itself can be stretched and contracted by gravity.

How long is a second?

There are two main ways of measuring time: dynamic and atomic time. The former relies on the motion of celestial bodies, including Earth, to keep track of time, whether it's the rotation time of a distant spinning star such as a pulsar, the motion of a star across our night sky or the rotation of Earth. However, a spinning star not withstanding, which can be hard to observe, these methods are not always entirely accurate.

The old definition of a second was based on the rotation of Earth. As it takes the sun one day to rise in the east, set in the west and rise again, a day was almost arbitrarily divided into 24 hours, an hour into 60 minutes and a minute into 60 seconds. However, Earth doesn't rotate uniformly. Its rotation decreases at a rate of about 30 seconds every 10,000 years due to factors such as tidal friction. Scientists have devised ways to account for the changing speed of Earth's rotation, introducing leap seconds," but for the most accurate time you have to go even smaller.

Atomic time relies on the energy transition within an atom of a certain element, commonly caesium. By defining a second using the number of these transitions, time can be measured with an accuracy of losing a tiny portion of a second in a million years. The definition of a second is now defined as 9,192,631,770 transitions within a caesium atom, Scientific American reported.

Atomic clocks: The most accurate track of time

The most accurate clock in the universe would probably be a rotating star like a pulsar, but on Earth atomic clocks provide the most accurate track of time. The entire GPS system in orbit around Earth uses atomic clocks to accurately track positions and relay data to the planet, while entire scientific centers are set up to calculate the most accurate measure of time — usually by measuring transitions within a caesium atom.

While most atomic clocks rely on magnetic fields, modern clocks are using lasers to track and detect energy transitions within caesium atoms and keep a more definite measure of time. Although caesium clocks are currently used to keep time around the world, strontium clocks promise twice as much accuracy, while an experimental design based on charged mercury atoms could reduce discrepancies even further to less than 1 second lost or gained in 400 million years.

livescience.com, 20 May 2021

https://www.livescience.com

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Hardy water bears survive bullet impacts—up to a point

2021-05-18

They can survive temperatures close to absolute zero. They can withstand heat beyond the boiling point of water. They can shrug off the vacuum of space and doses of radiation that would be lethal to humans. Now, researchers have subjected tardigrades, microscopic creatures affectionately known as water bears, to impacts as fast as a flying bullet. And the animals survive them, too—but only up to a point. The test places new limits on their ability to survive impacts in space—and potentially seed life on other planets.

The research was inspired by a 2019 Israeli mission called Beresheet, which attempted to land on the Moon. The probe infamously included tardigrades on board that mission managers had not disclosed to the public, and the lander crashed with its passengers in tow, raising concerns about contamination. "I was very curious," says Alejandra Traspas, a Ph.D. student at Queen Mary University of London who led the study. "I wanted to know if they were alive."

The test places new limits on their ability to survive impacts in space—and potentially seed life on other planets.

Traspas and her supervisor, Mark Burchell, a planetary scientist at the University of Kent, wanted to find out whether tardigrades could survive such an impact—and they wanted to conduct their experiment ethically. So after feeding about 20 tardigrades moss and mineral water, they put them into hibernation, a so-called "tun" state in which their metabolism decreases to 0.1% of their normal activity, by freezing them for 48 hours.

They then placed two to four at a time in a hollow nylon bullet and fired them at increasing speeds using a two-stage light gas gun, a tool in physics experiments that can achieve muzzle velocities far higher than any conventional gun. When shooting the bullets into a sand target several meters away, the researchers found the creatures could survive impacts up to about 900 meters per second (or about 3000 kilometers per hour), and momentary shock pressures up to a limit of 1.14 gigapascals (GPa), they report this month in Astrobiology. "Above [those speeds], they just mush," Traspas says.

The results suggest the tardigrades on Beresheet were unlikely to survive. Although the lander is thought to have crashed at a few hundred meters per second, the shock pressure its metal frame generated hitting the surface would have been "well above" 1.14 GPa, Traspas says. "We can confirm they didn't survive."

The research also places new limits on a theory known as panspermia, which suggests some forms of life could move between worlds, as stowaways on meteorites kicked up after an asteroid strikes a planet or moon. Eventually, the meteorite could impact another planet—along with its living cargo.

Charles Cockell, an astrobiologist at the University of Edinburgh who was not involved in the study, says the research shows how unlikely panspermia is. "What this paper is showing is that complex multicellular animals cannot be easily transferred," he says. "In other words, Earth is a biogeographical island with respect to animals. They're trapped, like a flightless bird on an island."

Traspas, however, says it shows panspermia "is hard," but not impossible. Meteorite impacts on Earth typically arrive at speeds of more than 11 kilometers per second. On Mars, they collide at least at 8 kilometers per second. These speeds are well above the threshold for tardigrades to survive. However, some parts of a meteorite impacting Earth or Mars would experience lower shock pressures that a tardigrade could live through, Traspas says.

Objects strike the Moon at still lower speeds. When impacts on Earth send bits of rock and debris hurtling toward the Moon, about 40% of that material could travel at speeds low enough for any tardigrades to survive, Traspas and Burchell say, theoretically allowing them to jump from our planet to the Moon. A similar passage, they add, could take place from Mars to its moon, Phobos. And other life might have an even better chance of surviving; compared with water bears, some microbes can survive even faster impacts of up to 5000 meters per second, according to previous research.

The new experiment also has implications for our ability to detect life on icy moons in the outer Solar System. Saturn's moon Enceladus, for example, ejects plumes of water into space from a subsurface ocean that could support life, as might Jupiter's moon Europa. If the findings of the new study apply to potential life trapped in the plumes, a spacecraft orbiting Enceladus—at relatively low speeds of hundreds of meters per second—might sample and detect existing life without killing it.

No such orbiting mission is currently planned for Enceladus or Europa—upcoming NASA and European flyby missions will swoosh by the latter at high speeds of several kilometers per second. But perhaps one day far in the future an orbiter might be in the cards, with an ability to detect life at gentler speeds. "If you collect it and it died on impact, how do you know

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whether it's been dead for millions of years?" asks Anna Butterworth, a planetary scientist at the University of California, Berkeley, who has studied plume impacts on spacecraft. "If you collect microscopic life and it's moving around, you can say it's alive."

sciencemag.org, 18 May 2021

https://www.sciencemag.org

European fire ant chemicals may send spiders scurrying away

2021-05-18

To make a spider flee, bring on the fire ants. Or rather, just their chemical signals.

Some spiders common in North American homes avoid building their webs in chambers that recently housed European fire ants, researchers report May 19 in Royal Society Open Science. The ants probably left behind chemical traces, the researchers say. That could signal danger to the arachnids because ants sometimes feast on spiders. The reaction hints that the insects might be a source of natural spider-repelling chemicals.

The reaction hints that the insects might be a source of natural spider-repelling chemicals.

"A lot of people are afraid of spiders, and there's nothing on the market that is reliable that keeps the spiders away," says Andreas Fischer, an arachnologist at Simon Fraser University in Burnaby, Canada.

Fischer and his colleagues housed false black widow spiders (Steatoda grossa) in a glass container with three connected chambers. The arachnids were less likely to settle down in empty compartments that had once contained European fire ants (Myrmica rubra), an invasive species in North America. Other spider species — black widow (Latrodectus hesperus), cross (Araneus diadematus) and hobo (Eratigena agrestis) — also had an aversion to the former fire ant chambers.

The finding is exciting but not ready for real-world use, Fischer says. "I really hope that people don't go out there and get European fire ants into their garden to get rid of spiders." The ants are aggressive, "horrendous pests" with stinging bites and are tough to get rid of. Another type of fire ant (Solenopsis invicta) native to South America is among the costliest invasive species in the world (SN: 3/31/21).

The team plans to pinpoint what chemical spooks the spiders and figure out if it can be made in the lab. Then the researchers will make sure the potential spider repellent is not toxic or a homing beacon for ants.

"That's the last thing we want, that we get rid of spiders but attract ants," Fischer says.

sciencenews.org, 18 May 2021

https://www.sciencenews.org

How a weird theory of gravity could break cause-and-effect

2021-05-21

Astronomers have known that galaxies across the universe are behaving badly. Some are spinning too fast, while others are just way too hot and still others glommed into super structures too quickly.

But they don't know why. Perhaps some new hidden particle, like dark matter, could explain the weirdness. Or perhaps gravity is acting on these coalescing clusters of stars in a way scientists hadn't expected.

For decades, astronomers have debated the possibilities. While most astronomers believe that dark matter exists, some still think that we need to modify our theory of gravity. However, new research has found a critical flaw in modified gravity theories: They allow for effects to occur without causes and for information to travel faster than the speed of light. This is bad … for modified gravity.

"It may change this … research area considerably, forcing it in rather new directions," lead researcher and Tufts University astrophysicist Mark Hertzberg told Live Science.PLAY SOUND

Cold, but not too cold

Something funny is going on in the universe. For instance, based on what scientists would predict based on the masses of galaxies, stars orbit around the centers of them far too quickly; the temperature of the gas inside of galaxy clusters is far too hot; and large structures appeared in our universe far too soon.

At galactic and cosmological scales, either astronomers' understanding of the force of gravity is totally off, or there's a new ingredient in our universe that exerts gravity but is otherwise invisible. The latter idea is known as cold dark matter (CDM), which is the name given to a hypothetical form of matter that is as yet unknown to physics. The "cold" is there to note that whatever exotic particle might be responsible for the dark matter, it moves

However, new research has found a critical flaw in modified gravity theories: They allow for effects to occur without causes and for information to travel faster than the speed of light.

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relatively slowly, in contrast to other potential dark matter candidates like the neutrino — an example of a candidate for hot dark matter particles.

By filling galaxies with a form of matter that is invisible to light, the CDM hypothesis is wildly successful at explaining the majority of observations of galaxies and the larger universe. It is by far the most commonly accepted explanation for why the universe behaves as it does.

But the CDM hypothesis isn't perfect. Whatever it is, it sits outside the Standard Model of particle physics, meaning we have no idea what it is. Also, it has difficulty explaining something called the Baryonic Tully-Fisher Relation. The observed relationship shows that the total mass of normal matter, called baryonic matter, of a galaxy is proportional to the fourth power of the rotation speed. But CDM models predict that the relationship should be to the third power, predicting that galaxies spin slower for a certain amount of mass than they actually do.

What else could be going on?

Tout le MOND

An alternative to the whole CDM idea is a modified understanding of gravity. The simplest models fall under a class called MOND, for Modified Newtonian Dynamics. These models replace Newtonian physics (think Force = mass x acceleration) with other relationships that match the observed rotation rate of stars inside galaxies. While these models were popular when dark matter was first discovered in the 1970s and 1980s, they have failed to account for observations of galaxy clusters and the larger universe; as such, most scientists have all but rejected these models.

But the inadequacies of CDM to explain internal galactic dynamics provide an opening for MOND to survive. If a "MONDian" theory wants to compete on the galactic stage, however, it must be compatible with our other theories of physics, such as the special theory of relativity and quantum mechanics. So that's exactly what Hertzberg and his team set out to do. The results of their study were published in May to the preprint database arXiv, so the study hasn't been peer-reviewed.

"The only possibility to obtain something new [within the framework of relativity and quantum mechanics] is to add new degrees of freedom," Hertzberg told Live Science. In other words, in order to get MONDian theories to work with known physics, you have to add a whole bunch of funky stuff to theories. In examining that funky stuff, Hertzerg and collaborators found "some theoretical problems lurking in these attempts."

Local and causal

For instance, Hertzberg and his collaborators examined whether MONDian theories protect two principles: locality and causality. Locality is the concept that objects are directly influenced only by their surroundings — in order for one object to influence another, it must transmit that influence via something like a force that travels at a finite speed. Causality is the simple notion that all events have a cause.

If a theory violates locality and/or causality, it is unlikely to fit in with our theories of physics, which do protect both principles

"If one gives up the principles of causality and locality, then it means we are essentially unable to explain the structure of the Standard Model of Particle Physics and General Relativity, as they are some of the central principles that go into constructing these theories in the first place," Hertzberg said. "In other words, if causality were badly broken in nature, we likely would have seen it already in various corrections to particle physics in the lab or tests of gravity in space."

In other words, we should've noticed by now.

Since all available evidence indicates that locality and causality are preserved (at least at macroscopic scales), then they should be obeyed by any new theory of physics. The team of physicists put MONDian theories to the test and found that they contain features that allow for non-locality and acausality. In other words, if MONDian theories are correct, then it's possible for events to happen without a cause and for effects to travel instantaneously, which violates the speed-of-light limit in the universe.

"Since we found that the existing proposals for radically new dark matter and MOND-like theories have some form of acausality, then it suggests they may not be embedded into fundamental physics, at least in their present form," Hertzberg said.

The end of MOND?

It might indeed be possible for locality and causality to be violated on galactic scales, but this would be extremely difficult to reconcile with everything else we know about physics.

As to the future of MONDian theories, Hertzberg speculated, "it motivates attempts to try to construct some classes of similar models that somehow maintain causality, but this looks difficult to achieve. In our paper, we show that a generalized form of these models fails the above tests for consistency."

Still, the "cold dark matter" paradigm has difficulty explaining the details of galactic physics. But there could be far more mundane reasons for this rather than upending all known physics. Modeling how galaxies form and evolve, even just accounting for all the messy processes where normal matter plays a role, is very difficult. Perhaps, a more sophisticated understanding of galaxies will provide an explanation for the observed Baryonic Tully-Fisher Relation.

And CDM is by far the best explanation we have.

"What is great about CDM is that it is theoretically on firm ground, and passes all the above theoretical consistency tests, even though it is not part of the Standard Model of Particle Physics," Hertzberg said. "The reason I say it is on firm ground is that there is no known theoretical reason why there shouldn't be some stable, neutral particles out there in the universe that don't couple to us very much. So CDM is reinforced, for now, as the leading idea."

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https://www.livescience.com

Millions of electric cars are coming. What happens to all the dead batteries?

2021-05-20

The battery pack of a Tesla Model S is a feat of intricate engineering. Thousands of cylindrical cells with components sourced from around the world transform lithium and electrons into enough energy to propel the car hundreds of kilometers, again and again, without tailpipe emissions. But when the battery comes to the end of its life, its green benefits fade. If it ends up in a landfill, its cells can release problematic toxins, including heavy metals. And recycling the battery can be a hazardous business, warns materials scientist Dana Thompson of the University of Leicester. Cut too deep into a Tesla cell, or in the wrong place, and it can short-circuit, combust, and release toxic fumes.

That's just one of the many problems confronting researchers, including Thompson, who are trying to tackle an emerging problem: how to recycle the millions of electric vehicle (EV) batteries that manufacturers expect

But when the battery comes to the end of its life, its green benefits fade.

to produce over the next few decades. Current EV batteries "are really not designed to be recycled," says Thompson, a research fellow at the Faraday Institution, a research center focused on battery issues in the United Kingdom.

That wasn't much of a problem when EVs were rare. But now the technology is taking off. Several carmakers have said they plan to phase out combustion engines within a few decades, and industry analysts predict at least 145 million EVs will be on the road by 2030, up from just 11 million last year. "People are starting to realize this is an issue," Thompson says.

Governments are inching toward requiring some level of recycling. In 2018, China imposed new rules aimed at promoting the reuse of EV battery components. The European Union is expected to finalize its first requirements this year. In the United States, the federal government has yet to advance recycling mandates, but several states, including California—the nation's largest car market—are exploring setting their own rules.

Complying won't be easy. Batteries differ widely in chemistry and construction, which makes it difficult to create efficient recycling systems. And the cells are often held together with tough glues that make them difficult to take apart. That has contributed to an economic obstacle: It's often cheaper for batterymakers to buy freshly mined metals than to use recycled materials.

Better recycling methods would not only prevent pollution, researchers note, but also help governments boost their economic and national security by increasing supplies of key battery metals that are controlled by one or a few nations. "On the one side, [disposing of EV batteries] is a waste management problem. And on the other side, it's an opportunity for producing a sustainable secondary stream of critical materials," says Gavin Harper, a University of Birmingham researcher who studies EV policy issues.

To jump-start recycling, governments and industry are putting money into an array of research initiatives. The U.S. Department of Energy (DOE) has pumped some $15 million into a ReCell Center to coordinate studies by scientists in academia, industry, and at government laboratories. The United Kingdom has backed the ReLiB project, a multi-institution effort. As the EV industry ramps up, the need for progress is becoming urgent, says Linda Gaines, who works on battery recycling at DOE's Argonne National

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Laboratory. "The sooner we can get everything moving," she says, "the better."

EV BATTERIES are constructed a bit like nested dolls. Typically, a main pack holds several modules, each of which is constructed from numerous smaller cells (see graphic, below). Inside each cell, lithium atoms move through an electrolyte between a graphite anode and a cathode sheet composed of a metal oxide. Batteries are usually defined by the metals in the cathode. There are three main types: nickel-cobalt-aluminum, iron-phosphate, and nickel-manganese-cobalt.

Now, recyclers primarily target metals in the cathode, such as cobalt and nickel, that fetch high prices. (Lithium and graphite are too cheap for recycling to be economical.) But because of the small quantities, the metals are like needles in a haystack: hard to find and recover.

To extract those needles, recyclers rely on two techniques, known as pyrometallurgy and hydrometallurgy. The more common is pyrometallurgy, in which recyclers first mechanically shred the cell and then burn it, leaving a charred mass of plastic, metals, and glues. At that point, they can use several methods to extract the metals, including further burning. "Pyromet is essentially treating the battery as if it were an ore" straight from a mine, Gaines says. Hydrometallurgy, in contrast, involves dunking battery materials in pools of acid, producing a metal-laden soup. Sometimes the two methods are combined.

Each has advantages and downsides. Pyrometallurgy, for example, doesn't require the recycler to know the battery's design or composition, or even whether it is completely discharged, in order to move ahead safely. But it is energy intensive. Hydrometallurgy can extract materials not easily obtained through burning, but it can involve chemicals that pose health risks. And recovering the desired elements from the chemical soup can be difficult, although researchers are experimenting with compounds that promise to dissolve certain battery metals but leave others in a solid form, making them easier to recover. For example, Thompson has identified one candidate, a mixture of acids and bases called a deep eutectic solvent, that dissolves everything but nickel.

Both processes produce extensive waste and emit greenhouse gases, studies have found. And the business model can be shaky: Most operations depend on selling recovered cobalt to stay in business, but batterymakers are trying to shift away from that relatively expensive metal. If that happens, recyclers could be left trying to sell piles of "dirt," says materials scientist Rebecca Ciez of Purdue University.

THE IDEAL is direct recycling, which would keep the cathode mixture intact. That's attractive to batterymakers because recycled cathodes wouldn't require heavy processing, Gaines notes (although manufacturers might still have to revitalize cathodes by adding small amounts of lithium). "So if you're thinking circular economy, [direct recycling] is a smaller circle than pyromet or hydromet."

In direct recycling, workers would first vacuum away the electrolyte and shred battery cells. Then, they would remove binders with heat or solvents, and use a flotation technique to separate anode and cathode materials. At this point, the cathode material resembles baby powder.

So far, direct recycling experiments have only focused on single cells and yielded just tens of grams of cathode powders. But researchers at the U.S. National Renewable Energy Laboratory have built economic models showing the technique could, if scaled up under the right conditions, be viable in the future.

To realize direct recycling, however, batterymakers, recyclers, and researchers need to sort out a host of issues. One is making sure manufacturers label their batteries, so recyclers know what kind of cell they are dealing with—and whether the cathode metals have any value. Given the rapidly changing battery market, Gaines notes, cathodes manufactured today might not be able to find a future buyer. Recyclers would be "recovering a dinosaur. No one will want the product."

Another challenge is efficiently cracking open EV batteries. Nissan's rectangular Leaf battery module can take 2 hours to dismantle. Tesla's cells are unique not only for their cylindrical shape, but also for the almost indestructible polyurethane cement that holds them together.

Engineers might be able to build robots that could speed battery disassembly, but sticky issues remain even after you get inside the cell, researchers note. That's because more glues are used to hold the anodes, cathodes, and other components in place. One solvent that recyclers use to dissolve cathode binders is so toxic that the European Union has introduced restrictions on its use, and the U.S. Environmental Protection Agency determined last year that it poses an "unreasonable risk" to workers.

"In terms of economics, you've got to disassemble … [and] if you want to disassemble, then you've got to get rid of glues," says Andrew Abbott, a chemist at the University of Leicester and Thompson's adviser.

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TO EASE THE PROCESS, Thompson and other researchers are urging EV- and batterymakers to start designing their products with recycling in mind. The ideal battery, Abbott says, would be like a Christmas cracker, a U.K. holiday gift that pops open when the recipient pulls at each end, revealing candy or a message. As an example, he points to the Blade Battery, a lithium ferrophosphate battery released last year by BYD, a Chinese EV-maker. Its pack does away with the module component, instead storing flat cells directly inside. The cells can be removed easily by hand, without fighting with wires and glues.

The Blade Battery emerged after China in 2018 began to make EV manufacturers responsible for ensuring batteries are recycled. The country now recycles more lithium-ion batteries than the rest of the world combined, using mostly pyro- and hydrometallurgical methods.

Nations moving to adopt similar policies face some thorny questions. One, Thompson says, is who should bear primary responsibility for making recycling happen. "Is it my responsibility because I bought [an EV] or is it the manufacturer's responsibility because they made it and they're selling it?"

In the European Union, one answer could come later this year, when officials release the continent's first rule. And next year a panel of experts created by the state of California is expected to weigh in with recommendations that could have a big influence over any U.S. policy.

Recycling researchers, meanwhile, say effective battery recycling will require more than just technological advances. The high cost of transporting combustible items long distances or across borders can discourage recycling. As a result, placing recycling centers in the right places could have a "massive impact," Harper says. "But there's going to be a real challenge in systems integration and bringing all these different bits of research together."

There's little time to waste, Abbott says. "What you don't want is 10 years' worth of production of a cell that is absolutely impossible to pull apart," he says. "It's not happening yet—but people are shouting and worried it will happen."

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https://www.sciencemag.org

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