CHEMWATCH

Bulletin Board

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ASIA PACIFIC

Guidance for importers and manufacturers

2021-10-29

There is specific guidance for importing, manufacturing and using every type of hazardous substance in New Zealand–from cosmetics to pesticides or explosives.

Hazardous substances are regulated under the Hazardous Substances and New Organisms Act 1996, and we set the rules for anyone who wants to import or manufacture a hazardous substance.

Many common products imported and manufactured in New Zealand are regulated as hazardous substances. Paints, glues, garden sprays, pool chemicals and cleaning products can all have hazardous properties and, if they do, are regulated as hazardous substances.

If you import or manufacture a hazardous substance (product), you are responsible for knowing its hazardous properties. You're also responsible for making sure that you follow the rules. We have listed some important things you need to do to help you with that.

Read More

EPA New Zealand, 29 October 2021

https://www.epa.govt.nz/industry-areas/hazardous-substances/guidance-for-importers-and-manufacturers/

EPA to consider EDN, a methyl bromide alternative

2021-10-29

Draslovka, a Czech-based firm, has applied for approval to import ethanedinitrile (EDN) into New Zealand as an alternative to the fumigant methyl bromide which is used for export logs and timber at New Zealand ports.

The application

EDN has been identified as a possible substitute following an international review of alternative treatments.

In 2018, 22 percent of all exported logs were treated with methyl bromide. According to the Ministry for Primary Industries, fumigation of logs and

Many common products imported and manufactured in New Zealand are regulated as hazardous substances.

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timber exports accounts for 92 percent of methyl bromide use in New Zealand.

An EPA Decision-making Committee is considering the EDN application.

Application timeline

The timeline for this application process has been extended to enable additional information to be considered. You can see what's happened so far, and related documents for this application, on the timeline.

Read More

EPA New Zealand, 29 October 2021

https://www.epa.govt.nz/public-consultations/in-progress/new-fumigant-for-logs-and-timber/

Upcoming Chinese footwear mandatory standards

2021-10-27

The China government will issue two mandatory footwear standards in the near future. One is safety technical specifications for infants' and children's footwear, and the other is general safety requirements for adults' footwear.

There will be an expected grace period of 24 months after the release date of the standards. Although both the old and new mandatory standards will be effective at the same time during this transition period, it is recommended that manufacturers carry out quality control according to the new standards. Once the grace period ends, all footwear in the market including inventories shall meet the requirements of the new standards.

1. Safety technical specifications for infants' and children's footwear, which is intended for footwear for infants and children of age 14 and under, will replace some existing mandatory standards and become the main mandatory standard of children's footwear in China market. The standard covers requirements for both physical safety performance and chemical substances restriction. The physical safety performance requirements include no broken needle, sharp edge and sharp point, effective heel height restriction and small part hazards of infant shoes. The restriction of chemical substances include chromium VI, banned azo dyes,

There will be an expected grace period of 24 months after the release date of the standards.

formaldehyde, heavy metals, dimethyl fumarate, chlorinated phenols, N-nitrosamine, phthalate and short chain chlorinated paraffin.

2. General safety requirements for adults' footwear will replace some existing mandatory standards and become the main mandatory standard of adults' footwear in China market. The standard covers requirements for chemical substances restriction, including chromium VI, banned azo dyes, formaldehyde, heavy metals, dimethyl fumarate, chlorinated phenols, phthalate and short chain chlorinated paraffin.

Stay tuned to our technical bulletins once these mandatory standards are formally released if you have footwear being sold in China market.

Read More

Bureau Veritas, 27 October 2021

https://www.cps.bureauveritas.com/newsroom/upcoming-chinese-footwear-mandatory-standards

Explosives

2021-10-29

Explosives must be approved for use before they can be imported or manufactured in New Zealand.

Most explosives, including fireworks, need an Import Certificate before you can bring them into the country.

All explosives are hazardous substances, and their use in New Zealand is regulated jointly by us and WorkSafe New Zealand.

We manage the approvals for importing and manufacturing explosives, and set and enforce the rules for labelling, packaging and safety datasheets. You can find information below that outlines how to legally import explosives, including fireworks.

WorkSafe New Zealand look after the rules for handling and storing explosives, and also regulate outdoor firework displays.

Most explosives, including fireworks, need an Import Certificate before you can bring them into the country.

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Find out more about the rules for handling and storing explosives - WorkSafe NZ

See our guidance for importers and manufacturers of explosives (PDF, 474KB)

Read More

EPA New Zealand, 29 October 2021

https://www.epa.govt.nz/industry-areas/hazardous-substances/guidance-for-importers-and-manufacturers/explosives/

AMERICA

DENR tightens regulation on 'highly toxic' cadmium

2021-11-02

The Department of Environment and Natural Resources (DENR) will be enforcing a policy regulating the use of cadmium, a highly toxic chemical and a known human carcinogen.

DENR Administrative Order 2021-08 or the Chemical Control Order (CCO) for Cadmium and Cadmium Compounds aims to protect human health and the environment from the cancer-causing chemical.

While the DAO imposing the chemical control on cadmium and cadmium compounds was signed on May 6, 2021, by Environment Secretary Roy A. Cimatu, it was only last October 22, 2021, that the order was published in a newspaper of nationwide circulation finally putting the policy legally in effect.

The CCO, which will take effect this November, requires any person or entity engaged in the importation, manufacture, distribution, and industrial use of cadmium and cadmium compounds to register with and obtain importation clearance from the Environmental Management Bureau (EMB).

Applicants are further required to meet the specified requirements pertaining to the importation, manufacturing, chemical management plan, emergency, and contingency plan, labeling, workers' training, handling, transport, treatment, storage, and disposal.

DENR Administrative Order 2021-08 or the Chemical Control Order (CCO) for Cadmium and Cadmium Compounds aims to protect human health and the environment from the cancer-causing chemical.

The CCO further requires any person or entity involved in the transport, recycling, treatment, storage, and disposal of cadmium-containing wastes to register and comply with all the applicable provisions of the rules and regulations on hazardous waste management under Republic Act 6969, or the Toxic Substances and Hazardous and Nuclear Wastes Control Act of 1990.

Read More

Business Mirror, 2 November 2021

https://businessmirror.com.ph/2021/11/02/denr-tightens-regulation-on-highly-toxic-cadmium/

CA Proposition 65 – 60 day notice summary for Q3 2021

2021-11-04

This Bureau Veritas report provides a summary of the California Proposition 65 60-Day Notices in Q3 2021. This report includes the enforcement trends and the most targeted products and chemicals.

This report includes the enforcement trends and the most targeted products and chemicals.

Enforcement Trends:

• The highest amount of notices by product category was for food and herbal supplements, which accounted for 41% of all 60 Day Notices. Of those notices: 179 were for lead, 89 for acrylamide, 14 for arsenic, 13 for cadmium, 3 for furan, 2 for mercury, 1 for carbaryl, and 45 for two or more chemicals.

• Bags, cases, etc. accounted for 19% of all notices this quarter. Of those, the majority were for one or more phthalates, however, 9 were for Bisphenol A (BPA), and 2 were for lead.

• A new category for BPA Notices issued this quarter was Bisphenol A (BPA) in socks. See BV Bulletin 21B-100 for details.

• 41% of notices were for phthalates: 244 were for DEHP, 45 for DINP, 24 for DIDP, 13 for DBP and 14 for two or more phthalates. The notices covered a wide range of products.

• 36% of notices were for metals: 224 for lead, 13 for cadmium, 8 for arsenic, 2 for mercury and 50 for two or more metals

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Bureau Veritas, 4 November 2021

https://www.cps.bureauveritas.com/newsroom/ca-proposition-65-60-day-notice-summary-q3-2021

US FDA restores ban on lead in hair dyes

2021-10-17

The US Food and Drug Administration plans to enforce a ban on lead acetate in hair dyes beginning in January 2023, the agency announced Oct. 7. The FDA finalized the ban in October 2018 in response to a 2017 petition from environmental and public health groups. But the agency put the ban on hold after receiving objections from Combe, the manufacturer of Grecian Formula, which formerly contained lead acetate. The FDA now says that the objections do not justify changing the rule. The ban will go into effect Jan. 6, 2022, and the FDA will start enforcing it a year later to give companies time to deplete their stocks and reformulate their products. The agency approved the use of lead acetate in hair dyes in 1980. The chemical was once commonly used in men's hair dyes to gradually darken gray hair, but most manufacturers have replaced it with less toxic ingredients like bismuth citrate. The FDA states that "new data available since lead acetate was permanently listed demonstrate that there is no longer a reasonable certainty of no harm from the approved use of this color additive."

But the agency put the ban on hold after receiving objections from Combe, the manufacturer of Grecian Formula, which formerly contained lead acetate.

Read More

CEN, 17 October 2021

https://cen.acs.org/safety/consumer-safety/US-FDA-restores-ban-lead/99/i38

Radioactive material and pesticides among new contaminants found in US tap water

2021-11-03

Analysis identifies 56 new chemicals in water supplies – including some linked to critical diseases

Water utilities and regulators in the US have identified 56 new contaminants in drinking water over the past two years, a list that includes dangerous substances linked to a range of health problems such as cancer, reproductive disruption, liver disease and much more.

The revelation is part of an analysis of the nation's water utilities' contamination records by the Environmental Working Group, a clean water advocate that has now updated its database for the first time since 2019.

It found that the jump is partly driven by newly identified PFAS, a toxic class of "forever chemicals" that are widely used across dozens of industries and are thought to be contaminating drinking water for more than 100 million people. Pesticides, water disinfectant byproducts and radioactive materials are among other substances identified by regulators.

Though the new contaminant list is disturbing, it would be much longer if regulators and utilities were properly monitoring the nation's water supply, said the EWG senior scientist Tasha Stoiber.

"It speaks to the fact that we don't have nearly strong enough regulations in place to protect drinking water, and the regulation process is much too slow," she said. "We're testing for things that are already in our drinking water after the fact … and we're not keeping pace with these chemicals."

The list includes some substances that have been in production and used for years, but are only now being monitored by regulators as their links to health problems become clear. Other contaminants include those that industry is only beginning to use in larger quantities.

Many of the substances were identified as part of the Environmental Protection Agency's unregulated contaminant monitoring rule (UMCR), which is one of the first steps in the regulation process. It tracks chemicals' presence in some water systems and its aim is to provide the EPA with a picture of how widespread a chemical's contamination is before new limits are established.

Among other substances detected is HAA-9, a byproduct of the drinking water disinfection process. Regulators previously set limits for HAA-5, a contaminant in the same family that was found to cause health problems. Industry claimed HAA-9 was safe, but recent studies linked it to low birthrate, so the EPA is beginning to track it.

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However, setting limits can be a lengthy process, and the EPA has failed to set a new limit under the UMCR in the 20 years since the rule was implemented. The agency found what Stoiber characterized as "eye-opening" levels of PFAS compounds in 2013 yet is aiming to set water limits for just two kinds by next year.

Read More

The Guardian, 3 November 2021

https://www.theguardian.com/environment/2021/nov/03/us-tap-water-contaminants-discovery-radioactive-material-pesticides

EUROPE

3M PFAS production shut down in Belgium by environmental regulators

2021-11-01

The Belgian regulators' edict to stop PFAS production came after recent blood samples of 800 people near the plant.

3M has temporarily shut down some operations at a factory in Belgium after environmental regulators there banned emissions of PFAS.

3M has temporarily shut down some operations at a factory in Belgium after environmental regulators there banned emissions of PFAS.

It appears to be the first time any regulator globally has moved to stop production of PFAS, a controversial class of chemicals that 3M pioneered decades ago.

Amid a dispute over water and soil pollution, the Flemish environmental agency issued a new safety measure on Oct. 29 that prohibits emissions of all forms of PFAS from 3M's factory in Zwijndrecht, a city in the northern part of the country in the province of Antwerp.

In response, 3M Belgium launched an appeal seeking an "urgent" suspension of the PFAS ban until the appeal is resolved, the company said in a U.S. securities filing. 3M acknowledged "uncertainties" over how long the ban will last.

The Belgian regulators' edict to stop PFAS production came after recent blood samples were taken from 800 people near the plant.

PFAS, short for per- and polyfluoroalkyl substances, are known for their nonstick and water-resistant properties and have long been used in products ranging from fabric protectors to firefighting foam.

But the so-called "forever chemicals" don't break down in the environment and can accumulate in blood. PFAS have polluted groundwater — including in Washington County — and have been linked to significant health risks, including certain types of cancer.

3M stopped making PFAS chemicals at the heart of the controversy — PFOA and PFOS — about 20 years ago.

But the company is facing a tidal wave of U.S. litigation over pollution related to those two compounds. And the U.S. Environmental Protection is discussing designating PFOA and PFOS as hazardous substances.

In Belgium, recent public health tests established increased blood levels of certain PFAS chemicals — including PFOA and PFOS. But those blood tests did not contain PFAS compounds that are currently made at the plant and have no negative health effects, 3M said in its appeal to Belgian regulators.

The Belgian plant is one of five PFAS manufacturing sites Maplewood-based 3M has around the world: the others are in Cottage Grove; Decatur, Ala.; Cordova, Ill.; and Gendorf, Germany.

Read More

Star Tribune, 1 November 2021

https://www.startribune.com/belgian-environmental-regulators-shut-down-3m-pfas-production/600112110/

EU safety evaluation of food enzyme D-psicose 3-epimerase from Genetically Modified Corynebacterium glutamicum

2021-10-20

On October 18th, 2021, the European Food Safety Authority published an assessment "Safety evaluation of the food enzyme d-psicose 3-epimerase from the genetically modified Corynebacterium glutamicum strain FIS002".

The scope of the data assessment highlights the following:

Genotoxicity tests did not raise a safety concern

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- The food enzyme is used in processing fructose to produce a specialty carbohydrate d-allulose;
- Genotoxicity tests did not raise a safety concern;
- Under the intended conditions of use, the risk of allergic sensitization and elicitation reactions by dietary exposure is low;
- The food enzyme preparation contains multiple copies of an antimicrobial resistance gene, which is considered a hazard;
- The available results concluded that the identified hazard associated with the food enzyme d-psicose 3-epimerase produced with the genetically modified C. glutamicum strain FIS002 will not result in a risk.

Read More

Selerant, 20 October 2021

https://resources.selerant.com/food-regulatory-news/eu-safety-evaluation-of-food-enzyme-d-psicose-3-epimerase-from-genetically-modified-corynebacterium-glutamicum

INTERNATIONAL

International industry warns of trade barriers from EU cosmetics Regulation review

2021-11-04

International industry warns of trade barriers from EU cosmetics Regulation review

Changing the way cosmetic ingredients are assessed for safety in the EU will have a "remarkable impact" on trade with third countries, non-EU representatives of the cosmetics industry have warned.

The European Commission is considering making extensive revisions to the cosmetic products Regulation, intended to ensure the goals of the EU's chemicals strategy for sustainability are achieved.

In comments to the Commission's consultation on the inception impact assessment (IIA) for the review, international trade groups have expressed alarm at the proposal to extend the generic approach to risk assessment

Changing the way cosmetic ingredients are assessed for safety in the EU will have a "remarkable impact" on trade with third countries, non-EU representatives of the cosmetics industry have warned.

(GRA) – currently implemented on carcinogenic, mutagenic and reprotoxic (CMR) chemicals – to other hazard classes, which they said would disconnect EU rules from those in other markets.

Fearing bans on chemicals that are currently widely used in the industry, the US Personal Care Products Council (PCPC) said the policy could result in "longstanding and intractable" technical barriers to trade.

"We offer lavender and alcohol, which are likely to be subject to bans," the PCPC gave as an example. "This would result in fragmented supply chains and disproportionately affect US SMEs that may not be able to maintain separate supply chains for the EU market."

The UK Cosmetic, Toiletry and Perfumery Association (CTPA) warned that UK companies will withdraw products from the EU market, and vice versa, if they are forced to create separate formulations for the two jurisdictions.

Companies "may not be able to sustain the development of duplicate products as well as duplicate supply chains", it said.

And the Cosmetic, Toiletry and Fragrance Association (CTFA), which represents more than 80% of cosmetic companies in South Africa, said GRA-related bans on chemicals "will add the burden of reformulating products destined for the EU market, which will likely be sourced from the international market, thus adding delays in the manufacture and product supply and additional costs".

Read More

Chemical Watch, 4 November 2021

https://chemicalwatch.com/364967/international-industry-warns-of-trade-barriers-from-eu-cosmetics-regulation-review

CLP: One regulation to rule them all

2021-11-04

You've probably seen or heard the term "CLP" before, but may not know exactly what it is. CLP is an EU chemical regulation, short for Classification, Labelling and Packaging of Substances and Mixtures, with an important, albeit somewhat hidden role in the EU policy

But CLP's time trapped is the shadows is about to end. The regulation is going to be revised into a more omnipotent framework – and you can help forge it.

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discussions. But CLP's time trapped is the shadows is about to end. The regulation is going to be revised into a more omnipotent framework – and you can help forge it.

A key aspect of the Chemicals Strategy for Sustainability is the principle "one substance – one assessment". The idea going forward is that the discussions and decisions on hazardous properties of substances – currently being held and made in different fora depending on whether the substance falls under REACH, food packaging, pesticides, biocides, or another category – are all going to take place under the umbrella of CLP. Once a substance is classified under CLP, regulatory action will be triggered automatically.

Key improvement: Additional hazard classes and criteria

An important part of the CLP revision is that new hazard classes, with their own criteria, will be included in the regulation. Currently, there are only classification criteria for carcinogenicity, mutagenicity and toxicity to reproduction, along with aquatic toxicity, skin and respiratory sensitization, and a few other hazard classes.

Companies are obliged to test their chemicals for these hazardous properties and provide the information on packages and labels. One way to do this is through so called pictograms – symbols of dead trees or fish, sculls, exclamation marks, and other images meant to illustrate the hazard.

Hazardous properties that trigger regulation, but are not yet identified under CLP, include Endocrine Disrupting Chemicals (EDCs), Persistent, Bioaccumulative and Toxic / very Persistent and very Bioaccumulative (PBT/vPvB), and Persistent, Mobile and Toxic / very Persistent and very Mobile (PMT/vPvM).

The European Commission and related committees are currently working to establish legal criteria for identifying such properties. We at ChemSec are active in those discussions, having experience from identifying these hazardous properties for our SIN List.

Read More

Chemsec, 4 November 2021

https://chemsec.org/clp-one-regulation-to-rule-them-all/

UNESCO invites Lagos into membership of megacities alliance for water, climate

2021-11-01

The United Nations Educational Scientific and Cultural Organization (UNESCO) has invited Lagos state into membership of the Megacities Alliance for Water and Climate (MAWAC), a convergence of 33 mega-cities of the world with a focus on addressing climate change challenges.

The alliance is scheduled to be formally inaugurated in January 2022 in Paris, France.

The executive secretary of Lagos State Water Regulatory Commission (LASWARCO), Mrs. Funke Adepoju disclosed this on Wednesday at the opening ceremony of the 9th West African Clean Energy and Environment Trade Fair Conference 2021 organized by the Delegation of German Industry and Commerce in Ghana.

The delegation is represented in 140 locations in 92 countries abroad to foster bilateral trade relations between Germany and other regions worldwide.

Adepoju said the invitation of Lagos state as a member of MAWAC will "greatly provide an opportunity for the state to access technical and financial support for programs and projects to overcome the challenges of climate change."

She said in the last 20 months, the state government through LASWARCO had developed frameworks and guidelines for stakeholders and service providers in the water sector in line with the regulatory mandate of the commission.

These guidelines, according to Adepoju, include Packaged Water Service Guidelines, Regulation for Drinking Water Quality, Practice Order for Water Tankers and Groundwater Quality Control, and Drilling License Regulation.

The alliance is scheduled to be formally inaugurated in January 2022 in Paris, France.

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Leadership, 1 November 2021

https://leadership.ng/unesco-invites-lagos-into-membership-of-megacities-alliance-for-water-climate/

2nd stakeholder consultation on a restriction for Bisphenol A and Bisphenols of similar concern (BPAF, BPB, BPF, BPS)

2021-10-28

Reasons and aims of this analysis

Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BAuA), the competent authority for REACH of Germany, and Umweltbundesamt (UBA), hereafter referred to as 'the authorities', are currently preparing a REACH Annex XV Restriction Dossier for bisphenol A (BPA) + bisphenols of similar concern (as defined under Section II.) since all these substances are considered to have endocrine disrupting properties in the environment.

Endocrine disrupting substances (EDs) in the environment interfere with the hormone system of wildlife animals and can thereby cause adverse and population relevant effects. Thus, exposure to EDs endanger the survival of populations or subpopulations in the affected ecosystems. Due to the still limited knowledge on e.g. the endocrine system of invertebrates and hence their sensitivities to EDs exposure, the decoupling of exposure and adverse effects (even transient exposure during sensitive juvenile life stages can result in adverse effects in adult animals or in subsequent generations) and missing test systems to address specific endocrine mediated modes of action (e.g. thyroid active chemicals in fish) it is not possible to predict and derive a safe threshold for EDs in the environment that is sufficiently protective.

BPA, BPB and the other bisphenols of similar concern (BosC) act via several endocrine pathways that are conserved among a broad range of species and taxa. Hence, environmental exposure to these chemicals not only affects single species and populations but directly whole ecosystems.

Based on these considerations any exposure of the environment with BPA and BosC is subject to the minimization requirement.

Read More

Endocrine disrupting substances (EDs) in the environment interfere with the hormone system of wildlife animals and can thereby cause adverse and population relevant effects.

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BAUA, 28 October 2021

https://link.webropolsurveys.com/Participation/Public/285b96ad-500b-4629-b6a7-908043b3e9e2?displayId=Ger2377521

Morel Support

2021-11-12

https://www.pinterest.com.au/pin/215891375878303463/

Disulfoton

2021-11-12

Disulfoton is a manufactured substance used as a pesticide to control a variety of harmful pests that attack many field and vegetable crops. Disulfoton does not occur naturally. Pure disulfoton is a colourless oil with no identifiable odour and taste. The technical product is dark yellowish, and has an aromatic odour. It does not easily dissolve in water or evaporate to air. It is most likely to be present in hazardous waste sites with other wastes, either in drums or mixed with soil. [1] The molecular formula for disulfoton is $C_8H_{19}O_2PS_3$. [2]

USES [1]

Disulfoton is used to protect small grains, sorghum, corn, and other field crops; some vegetables, fruit, and nut crops; and ornamental and potted plants against certain insects. Although it is used primarily in agriculture, small quantities are used on home and garden plants. Small quantities also are used for other purposes, such as mosquito control in swamps. The use of disulfoton has decreased in recent years.

IN THE ENVIRONMENT [1]

Disulfoton enters the environment principally when it is applied as a spray or as granules on field crops, vegetables, potted plants, and home gardens. Disulfoton also can enter the environment when it accidentally spills or leaks during storage and transport. Disulfoton may also enter the environment from hazardous waste sites. Environmental contamination by disulfoton mainly affects soil and water. Natural chemical reactions and bacterial attack remove disulfoton from soil and water. Such reactions form some by-products that are more toxic than disulfoton. Fish accumulate disulfoton in their bodies. The levels of disulfoton in fish can be hundreds of times higher than the level in water. Disulfoton binds moderately well to soil and typically does not travel deep into soil with rainwater.

SOURCES & ROUTES OF EXPOSURE [1]

Sources of Exposure

- Breathing contaminated air;
- drinking contaminated water; and
- eating contaminated food.

Disulfoton is a manufactured substance used as a pesticide to control a variety of harmful pests that attack many field and vegetable crops.

- Disulfoton is rarely detected in air.
- Workers in industries that manufacture and formulate disulfoton are at a higher risk of exposure.
- Workers who spray the pesticide in fields and some farm workers who enter the fields following spraying also are at a higher risk of exposure than the general population.
- Among the general population, people who frequently use the pesticide in their homes and gardens are potentially at higher risk.
- People who live near hazardous waste sites that contain disulfoton also are potentially at a higher risk of exposure.
- Children playing at or near these hazardous waste sites may be exposed by touching and eating soil that contains disulfoton.

Routes of Exposure

The major routes of exposure to disulfoton are:

- inhalation;
- ingestion;
- contact with skin/eyes

HEALTH EFFECTS [3]

Acute Toxicity

Disulfoton is very highly toxic to all mammals by all routes of exposure. It is labelled with a DANGER signal word. Whether absorbed through the skin, ingested, or inhaled, early symptoms in humans may include blurred vision, fatigue, headache, dizziness, sweating, tearing, and salivation. Symptoms occurring at high doses include defecation, urination, fluid accumulation in the lungs, convulsions, or coma. Death can occur if high enough doses lead to stoppage of respiratory muscles and/or constriction of the windpipes. Ingestion of high doses can lead to rapid onset of effects on the stomach while symptoms resulting from skin exposure may be delayed for up to 12 hours. Complete recovery from acute poisoning takes at least one week, but complete restoration of the blood to normal enzyme (cholinestrase) levels may take up to three months.

Chronic Toxicity

Disulfoton is rapidly absorbed through the skin. This chemical inhibits cholinesterase, and, as a result, may affect the eyes, respiratory system, and central nervous system. Continual daily absorption may cause flu-like

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symptoms, loss of appetite, weakness, and uneasiness. While repeated exposure to disulfoton may inhibit the cholinesterase enzyme and thus interfere with the nervous system, 30-day human exposures have not resulted in significant enzyme inhibition. Workers chronically exposed to organophosphates, of which disulfoton is a member, have developed irritability, delayed reaction times, anxiety, slowness of thinking, and memory defects. Chronic exposure of workers may also lead to cataracts.

Reproductive Effects

In a long-term reproduction study, 98.5% pure disulfoton was fed at doses ranging from 0.05 to 0.5 mg/kg/day to both male and female albino rats. At the high dose, the number of animals per litter was reduced by 21% in the first and third generations and a 10 to 25% lower pregnancy rate was noted. Some third-generation litters whose parents were exposed to this dose, developed fatty deposits and swelling in their livers. Exposed adults and litters had a 60% to 70% inhibition of red blood cell cholinesterase. This suggests that long-term exposures to high doses of disulfoton may cause reproductive effects in humans.

Teratogenic Effects

In one study, pregnant rats were given disulfoton (98.2% pure) at doses ranging from 0.1 to 1.0 mg/kg/day through a stomach tube during the sensitive period of gestation. Cholinesterase activity was decreased. In the foetuses, no developmental defects were seen except at high doses, where incomplete bone development was noted (4, 10). In another study, rabbits were given disulfoton (97.3% pure) during the sensitive period. At the higher doses (1.5 and 2.0 mg/kg/day), the mothers experienced tremors, incoordination, and death, while foetal growth was not affected. These studies indicate that disulfoton is very unlikely to cause birth defects in humans.

Mutagenic Effects

Studies have demonstrated that disulfoton is mutagenic to bacteria.

Carcinogenic Effects

Studies of rats and mice fed high doses for two years did not show significant tumour growth. The EPA has determined that there is no evidence that disulfoton is carcinogenic.

SAFETY [4]

First Aid Measures

- General advice: Consult a physician. Show this safety data sheet to the doctor in attendance.
- If inhaled: If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.
- In case of skin contact: Wash off with soap and plenty of water. Take victim immediately to hospital. Consult a physician.
- In case of eye contact: Flush eyes with water as a precaution.
- If swallowed: Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

Exposure Controls & Personal Protection

Exposure Controls

- Appropriate engineering controls should be used when handling disulfoton.
- Avoid contact with skin, eyes and clothing.
- Wash hands before breaks and immediately after handling the product.

Personal Protective Equipment

The following personal protective equipment is recommended when handling disulfoton:

- Eye/face protection: Face shield and safety glasses Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).
- Skin protection: Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands. The selected protective gloves have to satisfy the specifications of EU Directive 89/686/EEC and the standard EN 374 derived from it.
- Body Protection: Complete suit protecting against chemicals, the type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

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- Respiratory protection: Where risk assessment shows air-purifying respirators are appropriate use a full-face respirator with multi-purpose combination (US) or type ABEK (EN 14387) respirator cartridges as a backup to engineering controls. If the respirator is the sole means of protection, use a full-face supplied air respirator. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

REGULATION [1,5,6]

United States

NIOSH: The National Institute for Occupational Safety and Health (NIOSH) recommends an exposure limit of 0.1 mg disulfoton/m^3 of air for a 10-hour workday within a 40-hour workweek.

EPA: The Environmental Protection Agency recommends that no more than 10 parts of disulfoton per billion parts (ppb) of water be present in drinking water that children drink for periods of up to 10 days. Disulfoton in drinking water should not exceed 3 ppb for children or 9 ppb for adults if they drink the water for longer periods, and should not exceed 0.3 ppb for adults who will drink the water during an average lifetime. EPA has designated disulfoton as a hazardous substance, but it does not intend to cancel or restrict registration of pesticide products containing disulfoton. Federal regulations limit the amount of disulfoton that factories can release into wastewater. EPA requires industries to report releases or spills of 1 pound or more.

OSHA: The Occupational Safety & Health Administration has not established any regulation.

Australia

Safe Work Australia: Safe Work Australia has established a Time Weighted Average (TWA) concentration of 0.1mg/m^3 for disulfoton over a 40-hour workweek.

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'Tsunami' of gravitational waves sets record for most ever space-time ripples detected

2021-11-10

A record "tsunami" of gravitational waves — ripples in the fabric of space-time — could help to unlock the mysteries of how the universe and its stars evolved and put Einstein's theory of general relativity to the test.

Scientists working at the Laser Interferometer Gravitational-Wave Observatory (LIGO) in the U.S. and the Virgo interferometer in Italy detected a staggering 35 separate gravitational wave events between November 2019 and March 2020, more than a third of the total discovered to date. The researchers published their findings Nov. 5 to the preprint database arXiv, which means they have yet to be peer-reviewed.

Gravitational waves are the ripples created in the fabric of space-time when two extremely dense objects — such as neutron stars or black holes — get locked into a binary orbit around each other and eventually collide. These space-time ripples were first detected in 2015, but since then, scientists have been getting better at spotting the waves as they lap at our cosmic shores.

"These discoveries represent a tenfold increase in the number of gravitational waves detected by LIGO and Virgo since they started observing," co-author Susan Scott, an astrophysicist at the Australian National University and a member of the international Advanced LIGO team, said in a statement. "This really is a new era for gravitational wave detections, and the growing population of discoveries is revealing so much information about the life and death of stars throughout the universe."

The LIGO and Virgo detectors spot gravitational waves by picking up the tiny distortions in the fabric of space they make as they pass through the detectors. The L-shaped detectors have two arms with two identical laser beams inside — each of the two LIGO detectors has 2.48-mile-long (4 kilometers) arms, and Virgo's arms measure 1.86 miles (3 km). If a gravitational wave passes through Earth, the laser in one arm of the detector is compressed and the other expands, alerting scientists to the wave's presence. But the tiny scale of these distortions — often the size of a few thousandths of a proton or neutron — means that the detectors have to be incredibly sensitive.

According to the scientists, 32 of the 35 new detections are from the merging of distant black holes. As the infinitely dense cores of the

These space-time ripples were first detected in 2015, but since then, scientists have been getting better at spotting the waves as they lap at our cosmic shores.

cosmic behemoths spiral into each other in ever faster and tighter loops, they eventually combine to form an even more massive black hole. The gravitational waves kicked up in the wake of these events, like the ripples formed in a pond after a stone is thrown in, can reveal a great deal about the black holes that made them.

"Looking at the masses and spins of the black holes in these binary systems indicates how these systems got together in the first place," Scott said. "It also raises some really fascinating questions. For example, did the system originally form with two stars that went through their life cycles together and eventually became black holes? Or were the two black holes thrust together in a very dense dynamical environment, such as at the centre of a galaxy?"

The observations reveal a surprising diversity in black hole sizes throughout the universe. For instance, one black-hole pair was 145 times the mass of the sun, while another was only 18 times the sun's mass.

The other three wave detections are slightly more mysterious, possibly coming from the merger of the infinitely dense black holes with other, less dense, cosmic objects. It's likely that these second objects were neutron stars — the ultradense remnants of massive stars formed after enormous stellar explosions called supernovas, the astronomers said.

And these weirder signals may just be the first of many such signals to be detected. Improvements in the sensitivity of the detectors will allow scientists to pick up fainter signals from more unexpected sources. This could not only give them some unprecedented glimpses into the nature and evolution of gravitational wave making stars and stellar remnants in the universe but also allow researchers to devise new tests for the laws of gravity — set out by Albert Einstein's theory of general relativity — which describe the behavior of all massive objects.

"Our latest results prove that they [black holes] come in many sizes and combinations — we have solved some long-standing mysteries, but uncovered some new puzzles too," co-author Christopher Berry, an astronomer at the University of Glasgow in Scotland, said in a statement. "Using these observations, we are closer to unlocking the mysteries of how stars, the building blocks of our universe, evolve."

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Earth's lower atmosphere is rising due to climate change

2021-11-05

Global temperatures are rising and so, it seems, is part of the sky.

Atmosphere readings collected by weather balloons in the Northern Hemisphere over the last 40 years reveal that climate change is pushing the upper boundary of the troposphere — the slice of sky closest to the ground — steadily upward at a rate of 50 to 60 meters per decade, researchers report November 5 in Science Advances.

Temperature is the driving force behind this change, says Jane Liu, an environmental scientist at the University of Toronto. The troposphere varies in height around the world, reaching as high as 20 kilometers in the tropics and as low as seven kilometers near the poles. During the year, the upper boundary of the troposphere — called the tropopause — naturally rises and falls with the seasons as air expands in the heat and contracts in the cold. But as greenhouse gases trap more and more heat in the atmosphere, the troposphere is expanding higher into the atmosphere (SN: 10/26/21).

Temperature is the driving force behind this change, says Jane Liu, an environmental scientist at the University of Toronto.

Liu and her colleagues found that the tropopause rose an average of about 200 meters in height from 1980 to 2020. Nearly all weather occurs in the troposphere, but it's unlikely that this shift will have on a big effect on weather, the researchers say. Still, this research is an important reminder of the impact of climate change on our world, Liu says.

"We see signs of global warming around us, in retreating glaciers and rising sea levels," she says. "Now, we see it in the height of the troposphere."

sciencenews.org, 5 November 2021

https://www.sciencenews.org

Cause of mysterious brain-invading-fungus outbreak finally discovered

2021-11-04

Scientists have finally found the cause of a mysterious brain-invading tropical fungus outbreak that killed more than 40 dolphins and porpoises in the Pacific Northwest: humans.

Between 1997 and 2016, scientists found 42 dead dolphins in the Salish Sea around British Columbia and Washington. All had died of an infection

from a tropical fungus, Cryptococcus gattii, which had entered their lungs and eventually spread to their brains.

A similar outbreak occurred in humans from 1999 to 2007, when 218 people in British Columbia were infected by the fungus and 19 died from complications of the ensuing disease.

But it remained a mystery how the fungus, which usually lives inside soil and trees in tropical and subtropical climates and doesn't spread between animals, reached a northern climate and infected dolphins out at sea.

A new study published October 22 in the journal Diseases of Aquatic Organisms has finally solved the mystery: Climate change pushed the habitable zone of the fungus farther north, and then human activity from construction and deforestation displaced the fungus from the soil and trees and moved it into the air, where its deadly spores wafted out to sea.

From there, the brain-invading fungal miasma likely settled over the sea's surface, where it was inhaled by porpoises and dolphins when they came up to breathe. Indeed, the Dall's porpoise (Phocoenoides dalli), which is particularly prone to engaging in playful surface activities — such as riding in the wakes produced by boats — was identified by the team to have had a 100 times greater risk of catching the disease than the more common harbor porpoise (Phocoena phocoena).

The first probable case of C. gattii infection in the Salish sea outbreak may have occurred in a porpoise in 1997, a full two years before the epidemic's first confirmed human case in 1999, according to the researchers. In the future, identification of such infections in animals could provide better advanced warning of disease outbreaks that have the potential to infect humans, especially as climate change enables those diseases to spread in unprecedented ways.

This is just one example of how the warming climate has caused a fungus to expand its range. Cases of valley fever — a disease caused by the Coccidioides fungus, which commonly resides in the Southwest — tripled in California between 2014 and 2018. And a 2019 modeling study predicts that by 2100 the fungus will have expanded its range as far east as Kansas and as far north as North Dakota.

Another 2019 study, published in the journal mBio, hypothesized that the drug-resistant fungus Candida auris — of which there have been numerous outbreaks in Asia, Europe and the Americas since the first reported case of the fungus infecting a woman in Tokyo in 2009 — was

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getting more successful at invading warm human bodies because it had adapted to higher temperatures in the wild.

"As we change the environment in unprecedented ways, we could see more diseases that affect people and wildlife," lead author Sarah Teman, a research assistant at the University of California, Davis School of Veterinary Medicine, said in a statement.

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Flame retardants cause brain changes in mice offspring

2021-11-05

Summary: Female mice exposed to PBDEs, a type of flame-retardant found on everyday household items, pass on the chemicals to their developing offspring. In female offspring, this can cause alterations in social memories and behaviors which are reminiscent of human compulsive behaviors associated with autism.

Source: UCR

Polybrominated diphenyl ethers, or PBDEs, are a class of fire-retardant chemicals that are ubiquitous. They are found on upholstery, carpets, curtains, electronics, and even infant products. Flame retardants migrate out of products into dust that humans contact and can ingest. Considered to be global environmental pollutants, they have been detected in water, soil, air, food products, animals, and human tissues. They are found, too, in breast milk of women all over the world.

A research team led by scientists at the University of California, Riverside, has found that when female mice exposed to PBDEs pass on these neuroendocrine-disrupting chemicals to their developing offspring, the female offspring show traits relevant to autism spectrum disorders, or ASD. Their short-term social-recognition ability and long-term social memory is reduced significantly and the offspring show exaggerated "marble burying" behavior—repetitive behavior reminiscent of human compulsive behavior, a core symptom of ASD.

"Our data support a link between maternal toxicant exposures and abnormal social and repetitive behavior in mice offspring that is relevant

The research team also found that the female offspring's olfactory—or smell—discrimination of social odors is significantly compromised.

to ASD," said Margarita Curras-Collazo, a professor of neuroscience, who led the study published in the journal Archives of Toxicology.

The research team also found that the female offspring's olfactory—or smell—discrimination of social odors is significantly compromised.

"Humans mostly rely on faces to recognize people and most autistics show deficits in face-identity processing," Curras-Collazo explained. "Mice, on the other hand, rely on smell for social recognition. The female offspring of mother mice exposed to PBDEs showed olfactory deficits that dampened their ability to recognize other mice. In effect, these offspring do not distinguish new mice from familiar ones. Humans with ASD also show abnormal olfactory ability."

In their experiments, the researchers exposed the mother mice orally to flame retardants; their offspring acquired PBDEs in their brains through blood during gestation and mother's milk during lactation. They then measured social and repetitive behavior and olfactory discrimination in female offspring in adulthood.

Next, the researchers examined the brains of the offspring, specifically, gene expression for oxytocin, a neuropeptide involved in social recognition memory. They found that oxytocin and other pro-social genes had undergone changes, suggesting that PBDEs target distinct brain systems to promote neurodevelopmental abnormalities.

"This shows that developmental PBDE exposure produces ASD-relevant neurochemical, olfactory, and social behavioral traits in adult female offspring that may result from early neurodevelopmental reprogramming within central social and memory neural networks," said Elena Kozlova, a student in the UCR Neuroscience Graduate Program working in Curras-Collazo's lab and the first author of the research paper.

To the authors' knowledge, their study is the first to show autistic-relevant behavior and brain changes in female offspring from maternal transfer of environmental pollutants. The behaviors were also tested in exposed mothers, but they were largely unaffected.

"This indicates that PBDEs are particularly detrimental if exposure occurs during development and effects are long-lasting, which is concerning given that children are disproportionately exposed to PBDEs," Kozlova said.

While most biomedical research is done using rodents, these studies have implications for humans. Like humans, mice live in social groups and communicate dominance and subordinate behavior while competing for

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access to resources. A mouse's ability to recognize others is a key behavior with translational relevance to human social cognition.

"Consumers need to be aware they are being exposed to chemicals like PBDEs," Curras-Collazo said. "You cannot avoid these chemicals since they are added to many indoor products in the home, school, car and airplane. To avoid them you can buy PBDE-free furniture or cover the foam in your furniture, choose less contaminated foods, and vacuum and mop frequently to remove PBDE-contaminated dust. It's crucial that we understand that these chemicals are present in our bodies and what they are doing."

Curras-Collazo believes legislators need to be aware that safe alternatives to toxic chemicals in production are possible, such as non-synthetic materials that serve as flame retardants.

"Further, funding agencies need to support basic science toxicology studies so that flame retardant chemicals like PBDEs can be examined in further detail before they are released for commercialization," she said. "Funding is needed, too, for longitudinal human studies to allow the developmental effects of these chemicals to be studied over a lifetime."

Curras-Collazo and Kozlova were joined in the study by colleagues at UC Riverside, Duke University in North Carolina, Loma Linda University in California, Pontifical Catholic University in Puerto Rico, German National Research Center for Environmental Health, Technical University of Munich in Germany, and U.S. Environmental Protection Agency in North Carolina.

neurosceincenews.com, 5 November 2021

https://www.neurosciencenews.org

28,000 tons of COVID-19 waste now swirling around in our oceans

2021-11-10

During the COVID-19 pandemic, more than 28,000 tons (25,000 metric tons) of pandemic-related plastic waste, such as masks and gloves, have ended up in the ocean, according to a new study.

That's more than 2,000 double-decker buses worth of waste, The Guardian reported. And within a few years, a portion of those plastic gloves and packaging materials from pandemic purchases could be swirling around the North Pole.

That's more than 2,000 double-decker buses worth of waste, The Guardian reported.

The analysis found that 193 countries produced about 9.2 million tons (8.4 million metric tons) of pandemic-associated plastic waste from the start of the pandemic to mid-August 2021, according to The Guardian.

The majority of the plastic — about 87.4% — was used by hospitals, while 7.6% was used by individuals. Packaging and test kits accounted for about 4.7% and 0.3% of the waste, respectively, the authors reported in a recent study, published online on Nov. 8 in the journal Proceedings of the National Academy of Sciences.

The team developed a model to predict how much of this plastic waste wound up in the ocean after being discarded. They predicted that, as of Aug. 23, about 28,550 tons (25,900 metric tons) of the plastic debris had already found its way into the oceans, transported there by 369 major rivers, according to The Guardian.

In three years' time, the majority of the debris will shift from the surface ocean to beaches and the seafloor, with more than 70% washing onto beaches by year's end, the authors wrote.

While in the short-term, the trash will mostly impact coastal environments near its original sources, in the long-term, garbage patches may form in the open ocean, the model predicts. For instance, patches may accumulate in the northeast Pacific and the southeast Indian oceans. And plastic that gets swept toward the Arctic Circle will hit a dead-end, and much of it will then swiftly sink to the seabed, the model predicts. The researchers also predict that a so-called circumpolar plastic accumulation zone will form by 2025.

And "at the end of this century, the model suggests that almost all the pandemic-associated plastics end up in either the seabed (28.8%) or beaches (70.5%), potentially hurting the benthic ecosystems," meaning the deepest regions of the ocean, the authors wrote.

"The recent COVID-19 pandemic has led to an increased demand for single-use plastic, intensifying pressure on this already out-of-control problem," the study authors wrote. "These findings highlight the hotspot rivers and watersheds that require special attention in plastic waste management."

In particular, the study highlights a need for better systems for collecting, treatmenting and disposing of medical plastic waste in developing countries, to keep it out of rivers, and an overall need to limit the use of

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single-use plastics and increase the use of sustainable alternatives, where possible, the authors wrote.

Read more about the new study in The Guardian.

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Killer whales' low genetic diversity offers a warning for the future

2021-11-04

Killer whales are one of the most widely distributed mammals on Earth. These cosmopolitan cetaceans arose millions of years ago and have persisted through myriad threats—from the dramatic climate shifts of the last ice age, to the hunters who aggressively pursued them until the 1980s. But behind their resilience lurks a danger that threatens their hard-fought existence: many killer whale populations have low genetic diversity.

But behind their resilience lurks a danger that threatens their hard-fought existence: many killer whale populations have low genetic diversity.

"The reason for this actually goes way, way back into their past," says Andrew Foote, an evolutionary biologist at the Norwegian University of Science and Technology and the leader of a new project that pieced together the genetic history of killer whales from across the globe.

During the tail end of the last global glaciation, pods of killer whales spread out from ice-free areas near the equator, setting up shop in once uninhabitable waters. Ever since, some of these populations have evolved largely in isolation. In a pair of recent papers, Foote and his colleagues show how these cetacean trailblazers established what eventually became islands of stagnating genetic diversity. "Essentially," says Foote, within some of these populations, modern killer whales "all have the same DNA as those colonizers," even after thousands of years.

To come to this result, Foote and his team worked with researchers around the world to assemble a data set of 26 genomes from different killer whale populations—from North Atlantic pods to those living off Antarctica. They used genomic sequencing to map out entire sets of genes from individual killer whales, then extrapolated the results to the population level. In particular, the team looked for long strings of genes that had identical copies from the mother and father, an indication of inbreeding within a population. The killer whales that live near the Earth's poles, it turns out, are particularly inbred.

Today, some killer whale populations are faring better than others. The new research suggests that—when factoring in differing pressures from hunting, habitat loss, pollution, and other forces—some of that modern success hinges on the makeup of their initial populations thousands of years ago. A slightly larger group of colonizers meant a larger gene pool to work from. It also helped if the original founders' genes were as diverse as possible. More importantly, those early colonizers had to have begun reproducing prolifically to maintain a large population size. When it comes to maintaining genetic diversity, every little bit of reproductive success in each generation counts.

For isolated groups that are dwindling in size and with few apparent opportunities for the infusion of fresh genetic material over many generations, successive inbreeding spells trouble for future progeny, says Chloe Robinson, an ecologist at the Canadian NGO Ocean Wise, who didn't participate in the examination. Harmful genetic mutations are building up in the modern descendants of these populations faster than natural selection can purge them from the bloodline. "It's a bit of a ticking time bomb," says Robinson.

Axel Janke, a geneticist at Goethe University in Germany who also wasn't involved in the recent studies, explains that low genetic diversity can weaken a population's ability to adapt to environmental shocks. Having a homogeneous gene pool is like having fewer plays on hand to survive any curveballs the environment throws at them. If all members have nearly identical genetics, "a single infection can kill that population," he says.

Looking at two modern killer whale populations shows how these differences can play out over time.

In Norway, for instance, an ancestral pod successfully monopolized the bountiful herring and multiplied quickly, maintaining high numbers over generations. This allowed their population to weather their genetic bottleneck by diluting out dangerous mutations. "Having a big population size has been key to their survival," says Foote. "Herring was their savior."

In comparison, the killer whales that settled in the Scottish seas are spiraling toward extinction. The early colonizers didn't breed as quickly as their Norwegian peers. "They've been inbreeding probably for a long, long time," says Foote. Stuck with a tiny start-up gene pool, the population is floundering—they have produced no new calves in 20 years.

As killer whale numbers off Scotland and elsewhere dwindle further because of pollution, habitat loss, and the decimation of their food

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sources, the situation is only going to get worse, says Magnus Wolf, an evolutionary geneticist at the Senckenberg Research Institute in Germany who was not involved in the new research. The fallout from a shrinking population is a reduced gene pool, which may accelerate the species' decline.

"Everybody talks about species loss, but nobody talks about genetic loss," says Wolfe. We may not see the result of the damage that has already been done until it is too late.

Killer whales, as a species, have been hanging on—some populations, barely—since Earth thawed out from its last glaciation. But in their survival is a warning. With the world warming because of anthropogenic climate change, many species are already beginning their own poleward migrations. History cautions that even if a few particularly itinerant animals can outrun warming waters, it may not be without consequences—even thousands of years down the line.

hakaimagazine.com, 4 November 2021

https://www.hakaimagazine.com

South Africa $8.5bn finance package offers a model for ending reliance on coal

2021-11-04

A financial package to speed South Africa's transition away from coal is creating a buzz at Cop26 climate talks, where campaigners hope it could provide a model for other emerging economies.

The nation is at the heart of a string of announcements in Glasgow, UK to support developing countries in ditching the most polluting fossil fuel.

After months of high-level political negotiations, France, Germany, the UK, the US and the EU announced an $8.5 billion package of grants and concessional finance over 3-5 years to accelerate the retirement of coal plants and the deployment of renewable energy.

Crucially, it also targets economic regeneration in coal mining regions, with electric vehicle manufacturing and green hydrogen among the potential alternative job opportunities.

South African president Cyril Ramaphosa described it as "a watershed moment".

The nation is at the heart of a string of announcements in Glasgow, UK to support developing countries in ditching the most polluting fossil fuel.

"South Africa has consistently argued that developed economies must support a just transition in developing economies. [This] represents a first-of-its kind partnership to turn these commitments into reality, and a model for similar forms of collaboration globally," he said.

"We're witnessing the end of coal power in real-time," Leo Roberts, research manager for think tank E3G's coal transition team told Climate Home News. These announcements "point to a shift towards a world in which finance is available to help developing countries move away from coal".

The partnership could be emulated by others amid a raft of commitments to ditch coal.

Indonesia, Vietnam and Chile are among 18 new countries that committed not to build or invest in new coal power and phase out coal plants in the 2040s .

Earlier this week, Indonesia's finance minister Sri Mulyani Indrawati said the country could phase out coal power by 2040, with financial support from the international community. That is a major shift from its national climate submission to the UN earlier this year, which sees coal meeting 38% of electricity demand in 2050.

Like South Africa, Indonesia has communities dependent on coal mining, who could suffer from a transition to clean energy in the absence of economic regeneration.

For the first time, financial instruments are being put together to address the issue.

Part of the South African package includes $500 million from a $2bn Accelerating Coal Transition (ACT) initiative launched by the Climate Investment Funds (CIFs) in Glasgow on Wednesday.

It is the first dedicated international fund to help developing countries exit coal, with funding from the US, the UK, Germany, Canada, and Denmark.

Indonesia, India, the Philippines and South Africa are the first beneficiaries of the scheme that aims to leverage private investments to support the transition from coal to clean energy. Together, they represent more than 15% of global coal-related emissions.

Mafalda Duarte CEO of the Climate Investment Funds, told Climate Home News the fund aims to catalyse at least 10 times its core funding by bringing in private financiers and multilateral development banks.

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Duarte told Climate Home the fund aimed to address a gap in the financial architecture by providing support to reskill coal workers and social protection measures such as temporary income support to those losing their jobs.

"If we don't provide this support, this coal phase out is probably not going to happen in time to meet our climate objectives," she said.

The $8.5bn package is "groundbreaking" because it was "co-created" by South Africa and donor countries, rather than imposed by wealthy nations, Maesela Kekana, South Africa's climate change chief negotiator, told Climate Home News.

Kekana said environment minister Barbara Creecy had been lobbying the CIFs for a coal transition programme to be established.

"We were right at the forefront. We fought for that. That's how important the ACT programme is for us," he said.

"There's nothing like this out there. It's never been done before. And now we're going to roll it out," he said. "We are determined to make this work because we believe that this is a good model."

South Africa pitched for the funds after debt-burdened state utility Eskom said it was seeking $10bn in international finance to help it shut most of its coal-fired power plants by 2050.

The country uses coal for 87% of its electricity generation and 20% of its liquid fuels, drawing on significant domestic resources.

UK climate envoy John Murton and a delegation from the US in September helped to seal the deal ahead of Cop26.

"That was a turning point in our view because we started to realise how serious these countries were. Everyone was working non-stop at the technical and political level to make it happen," Kekana said.

With Eskom accounting for around 41% of the country's emissions, decarbonising the electricity grid is a priority for South Africa to meet its climate goal. But the deal goes beyond cutting coal emissions to creating alternative, cleaner jobs and livelihoods.

Jesse Burton, an energy policy researcher focusing on the South African coal sector, said the package could help address some of the technical challenges of the transition, which have been impeded by Eskom's huge debt.

"But how the pot of money is going to be carved out need to be ironed out. It's can't just be about rolling out renewables, it has to be about the just transition," she said.

climatechangenews.com, 4 November 2021

https://www.climatechangenews.com

Antiviral pill cuts COVID-19 hospitalizations and deaths by 98%, Pfizer says

2021-11-06

A new COVID-19 pill cuts the risk of hospitalization or death by 89% when taken within three days of symptom onset, Pfizer recently announced.

The antiviral pill, PAXLOVID, was given in a placebo-controlled clinical trial to people with COVID-19 who were at high risk of developing severe disease. The pill works by inhibiting an enzyme called a protease, which the virus SARS-CoV-2 needs to keep replicating.

The drug was so clearly effective that an independent data monitoring committee recommended the trial be stopped so that people in the placebo-arm of the trial could receive the drug. Pfizer plans to submit the data to the Food and Drug Administration (FDA) for emergency use authorization "as soon as possible," according to a statement from the company.

More than 1,200 adults in the U.S. and abroad who tested positive for SARS-CoV-2 and had mild to moderate symptoms were enrolled in the clinical trial. Participants had at least one underlying condition or characteristic that made them at high risk of developing severe disease. None of the participants were vaccinated, according to The New York Times. Each participant took either PAXLOVID, in combination with ritonavir (an HIV drug that Pfizer says helps slow the breakdown of the antiviral drug, allowing it to stay in the body for longer), or a placebo pill every 12 hours for five days.

Out of 389 participants who took PAXLOVID within three days of symptom onset, only three were hospitalized and none died, while out of 385 people who took the placebo within three days, 37 were hospitalized and seven died.

What's more, out of 607 participants who took PAXLOVID within five days of symptom onset (including the people who took the drug within three days), six were hospitalized and none died. Out of 612 who took

The pill works by inhibiting an enzyme called a protease, which the virus SARS-CoV-2 needs to keep replicating.

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the placebo within five days of symptom onset, 41 were hospitalized and 10 died. Adverse events were similar between the placebo and the experimental drug groups and most were mild, according to the statement.

This isn't the first COVID-19 pill to be developed; The FDA is currently reviewing Merck's COVID-19 pill, known as molnupiravir, which the company said cut COVID-19 hospitalizations and deaths by 50% if taken within five days, and which was just approved in the United Kingdom, according to The Associated Press.

PAXLOVID is a modified version of a decades-old drug that was first developed as an intravenous therapeutic during the SARS epidemic, but that now specifically targets SARS-CoV-2 and can be taken as a pill, according to the Times.

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The tentacled butterfly ray comes back from the dead

2021-11-10

On a sultry autumn afternoon in 2019, as fishermen hauled in a net of Persian Gulf shrimp, Mohsen Rezaie-Atagholipour stood by waiting to sort through the scraps. A marine biologist at Iran's Qeshm Environmental Conservation Institute, Rezaie-Atagholipour was scouting for the sharks and rays that the fishermen accidentally snagged in their nets. But as he weighed and measured several familiar creatures—collecting data for Iran's first shark and ray conservation program—something unexpected caught his eye: a small olive green ray with two tiny tentacles just below its eyes. The biologist looked at the creature in disbelief: "I found the tentacled butterfly ray."

In 2017, the International Union for Conservation of Nature listed the tentacled butterfly ray as critically endangered, and possibly extinct. The last time anyone had recorded seeing one was in 1986, off Pakistan. The species was thought to have been wiped out across its range, from the Red Sea to the western Bay of Bengal. Unfortunately, the animal Rezaie-Atagholipour found was dead.

"All of the researchers we've spoken to who work in India, Pakistan, and the region, have never seen it, and they've been working there for quite

The biologist looked at the creature in disbelief: "I found the tentacled butterfly ray."

a long time," says Rima Jabado, a marine scientist and founder of the United Arab Emirates–based Elasmo Project, who worked with Rezaie-Atagholipour and others to document the discovery in a new paper. "We're excited it is still in Iran."

But from that initial, surprising discovery, the tentacled butterfly rays just kept turning up. Between October 2019 and November 2020, Rezaie-Atagholipour surveyed 96 hauls from shrimp trawlers operating in the Gulf of Oman and the eastern Persian Gulf and found a total of 367 tentacled butterfly rays in 39 catches. The species made up nearly 15 percent of all the rays in the by-catch.

"That was very surprising," Rezaie-Atagholipour says. The scientists suspect that the area off southern Iran may be the tentacled butterfly ray's last stronghold.

For Hamid Reza Esmaeili, a fish biologist at Iran's Shiraz University who wasn't involved in the research, this "lost and found" discovery provides an opportunity for scientists to study the ecology and behavior of this poorly understood species.

Yet the very fishing activities that helped scientists find the imperiled ray also threaten its existence. In a separate study, Jabado and her colleagues found that overfishing disproportionately affects species of sharks, rays, and chimeras found in tropical and subtropical coastal waters, including in the northern Indian Ocean. "We have extreme fishing pressure from the number of countries operating here," she says. "There's kind of nowhere to hide."

Although Iranian trawlers aren't targeting rays, they often pick them up as by-catch. Due to lengthy haul hours, the rays typically die before the nets are even pulled out of the water. Most shrimpers sell their by-catch at a low price to fish-meal manufacturers.

Rezaie-Atagholipour plans to work with fishing communities to reduce by-catch rates. One approach could be to use turtle excluder devices. Made of metal and mesh, and placed at the neck of a trawl net, these tools have been shown to reduce ray by-catch by 18 to 59 percent.

Abdulnoor Malahi, a fisherman working on a shrimp trawler in Iran, welcomes the use of such devices, provided they don't restrict his shrimp catch. But he believes the real solution is to ban trawling. Without that,

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many marine animals stand to be wiped out, he says. And the tentacled butterfly ray may go extinct for real.

hakaimagazine.com, 10 November 2021

https://www.hakaimagazine.com

This frog mysteriously re-evolved a full set of teeth

2021-11-11

Long-limbed and sporting dramatic horns above its eyes, Guenther's marsupial frog is a bizarre-looking amphibian from the misty cloud forests of the Andean slopes. Like other marsupial frogs this species, known as Gastrotheca guentheri, doesn't produce free-swimming tadpoles, but rather rears its young under a flap of skin on its back.

But it has one even more puzzling trait: It possesses a full set of teeth.

Wait. Frogs have teeth? Actually, yes: Most frogs have a small number of them on their upper jaws. But virtually all 7,000 species of living frogs lack teeth along their lower jaws—except for G. guentheri.

But virtually all 7,000 species of living frogs lack teeth along their lower jaws—except for G. guentheri.

Unfortunately, this species hasn't been sighted since 1996—and even before then, was seldomly found or studied. There are precious few samples of the animals in museum collections—less than 30 specimens may exist in the entire world. As a result, no real images of the teeth themselves existed.

This lack of study has left many questions outstanding, including a very simple one: What does this weirdo frog's jaw look like?

Daniel Paluh, a herpetologist pursuing a PhD at the University of Florida, wanted to fill in this gap in knowledge. Along with colleagues at the Florida Museum of Natural History, he used a micro-CT scanner to peer into the skulls of six G. guentheri specimens preserved for decades in alcohol.

The images and analysis, published November 10 in the journal Evolution, provide the first in-depth glimpse of the species' jaws and teeth.

Teeth lost, teeth regained

The study also helps resolve other questions. Around 230 million years ago, the ancestors of modern frogs lost the teeth along their bottom jaws for good. So why does Guenther's marsupial frog have teeth, and how did they arise?

To begin with, Paluh and colleagues have shown that these teeth are indeed genuine, and formed by bony tissue called dentin and encased in enamel, refuting suggestions that these structures were possibly "pseudo-teeth." The researchers also found that these teeth, sourced from the University of Kansas Museum of Natural History, closely resemble teeth those along the upper jaws of other marsupial frogs—making them more likely to be the real deal.

These findings provide tantalizing evidence disproving a century-old evolutionary theory known as Dollo's Law of Irreversibility. Coined by the paleontologist Louis Dollo, the theory posits that once a trait is lost in a group of organisms, it is gone for good. An organism cannot re-evolve something its ancestor lost, like how humans have not re-evolved tails, the thinking goes.

While the theory's logic seems sound, evolutionary biologists have poked holes in Dollo's Law with examples ranging from lizards redeveloping egg-laying to stick insects losing and then regaining wings.

But the re-evolution of teeth in G. guentheri may be the most unlikely case yet. In 2011, evolutionary biologist John Wiens reconstructed the evolutionary relationships between 170 different species of frogs to create a timeline between when frogs lost their lower teeth 230 million years ago and when G. guentheri regained its teeth. He found that the teeth were not regained until around 20 million years ago, an "unprecedented" length of time between the loss of a trait and its re-evolution.

Wiens, who currently works at the University of Arizona and was not involved with the recent study, believes that G. guentheri had one advantage when it came to re-evolving teeth—it still had a functional network of genes to create teeth along its upper jaw.

"It's not like they had to re-evolve teeth from scratch," Wiens says. "It's just a question of putting them in a place that they haven't been in 200 million years."

That process would have probably been impossible in other hopping amphibians, such as toads, which are completely toothless. John Abramyan, a biologist at the University of Michigan-Dearborn who was also not involved in the study, recently investigated the genes coding for enamel in toads, which completely lost their teeth around 60 million years ago. He found the genes had essentially degenerated into pseudogenes over millions of years.

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"These genes are essentially jobless," and nonfunctional, Abramyan says. "[But] since most frogs still produce teeth in their upper jaws, they theoretically have all the tools to make a functional tooth, so it's less of an evolutionary leap."

An evolutionary puzzle

Nevertheless, this doesn't tell us why or how this species regained their lower teeth, though diet certainly plays a role, Paluh says. As the primary tool animals use to bite and chew their food, teeth are often molded by what is on the menu. Paluh believes that most frogs' penchant for small insects, and the use of sticky tongues to snag prey, made teeth less important to some species. However, G. guentheri possesses a healthy appetite that includes prey as large as lizards and other frogs. When going after big game, it may help to have lower teeth to secure squirming prey.

But if the teeth re-evolved to help Guenther's marsupial frog engulf larger prey, why haven't teeth re-evolved in other carnivorous frogs? Some frogs, like South America's bulky "Pacman" frogs, sport jagged fangs along their lower jaws to secure prey. But these fangs are pseudo-teeth—bony extensions of the mandible, lacking both dentin and enamel.

Some answers may be hiding in the treefrog's embryos, according to Alexa Sadier, an evolutionary biologist at the University of California-Los Angeles. While she primarily explores the evolution of bat teeth, she recently reviewed several cases where lost traits remained in the early stages of a creature's development. She believes that comparing the development of G. guentheri with the embryos of other frog species may help yield insights into how and when genes turn tooth formation on or off.

She expects that if researchers do scan embryos, they'll find more evidence of teeth that disappear during development—as well as the accompanying genetic wiring.

Paluh also hopes to do some developmental genetic work on the frog, but fresh embryos are not an option—a living G. guentheri specimen has not been spotted in the wild since 1996, not even in the damp, volcanic foothills of Ecuador's Cotacachi Cayapas Ecological Reserve where they once thrived. While little is known about them, their numbers have dwindled as agriculture and logging devastate the cloud forests of Ecuador and Colombia. Some fear the species is already extinct.

However, the sudden rediscovery of a presumed extinct frog is not unprecedented. In 2018, for example, researchers found the horned marsupial frog (Gastrotheca cornuta) after failing to spot one for 13 years in the same Ecuadorian cloud forests where G. guentheri were once observed.

Paluh hopes that Guenther's marsupial frog likewise reappears—not least because living samples of this amphibian will be crucial for learning more about their teeth, and solving this evolutionary enigma.

nationalgeographic.com, 11 November 2021

https://www.nationalgeographic.com

Deepest earthquake ever detected should have been impossible

2021-11-09

Scientists have detected the deepest earthquake ever, a staggering 467 miles (751 kilometers) below the Earth's surface.

That depth puts the quake in the lower mantle, where seismologists expected earthquakes to be impossible. That's because under extreme pressures, rocks are more likely to bend and deform than they are to break with a sudden release of energy. But minerals don't always behave precisely as expected, said Pamela Burnley, a professor of geomaterials at the University of Nevada, Las Vegas, who was not involved in the research. Even at pressures where they should transform into different, less quake-prone states, they may linger in old configurations.

"Just because they ought to change doesn't mean they will," Burnley told Live Science. What the earthquake may reveal, then, is that the boundaries within Earth are fuzzier than they're often given credit for.

Crossing the boundary

The quake, first reported in June in the journal Geophysical Research Letters, was a minor aftershock to a 7.9-magnitude quake that shook the Bonin Islands off mainland Japan in 2015. Researchers led by University of Arizona seismologist Eric Kiser detected the quake using Japan's Hi-net array of seismic stations. The array is the most powerful system for detecting earthquakes in current use, said John Vidale, a seismologist at the University of Southern California who was not involved in the study. The quake was small and couldn't be felt at the surface, so sensitive instruments were needed to find it.

The depth of the earthquake still needs to be confirmed by other researchers, Vidale told Live Science, but the finding looks reliable. "They did a good job, so I tend to think it's probably right," Vidale said.

This makes the quake something of a head-scratcher. The vast majority of earthquakes are shallow, originating within the Earth's crust and upper mantle within the first 62 miles (100 km) under the surface. In the crust, which extends down only about 12 miles (20 km) on average, the rocks are cold and brittle. When these rocks undergo stress, Burnley said, they can only bend a little before breaking, releasing energy like a coiled spring. Deeper in the crust and lower mantle, the rocks are hotter and under higher pressures, which makes them less prone to break. But at this depth,

What the earthquake may reveal, then, is that the boundaries within Earth are fuzzier than they're often given credit for.

earthquakes can happen when high pressures push on fluid-filled pores in the rocks, forcing the fluids out. Under these conditions, rocks are also prone to brittle breakage, Burnley said.

These kinds of dynamics can explain quakes as far down as 249 miles (400 km), which is still in the upper mantle. But even before the 2015 Bonin aftershock, quakes have been observed in the lower mantle, down to about 420 miles (670 km). Those quakes have long been mysterious, Burnley said. The pores in the rocks that hold water have been squeezed shut, so fluids are no longer a trigger.

"At that depth, we think all of the water should be driven off, and we're definitely far, far away from where we would see classic brittle behavior," she said. "This has always been a dilemma."

Changing minerals

The problem with earthquakes deeper than around 249 miles has to do with the ways the minerals behave under pressure. Much of the planet's mantle is made up of a mineral called olivine, which is shiny and green. Around 249 miles down, the pressures caused olivine's atoms to rearrange into a different structure, a blue-ish mineral called wadsleyite. Another 62 miles (100 km) deeper, wadsleyite rearranges again into ringwoodite. Finally, around 423 miles (680 km) deep into the mantle, ringwoodite breaks down into two minerals, bridgmanite and periclase. Geoscientists can't probe that far into the Earth directly, of course, but they can use lab equipment to recreate extreme pressures and create these changes at the surface. And because seismic waves move differently through different mineral phases, geophysicists can see signs of these changes by looking at vibrations caused by large earthquakes.

That last transition marks the end of the upper mantle and the beginning of the lower mantle. What's important about these mineral phases is not their names, but that each behaves differently. It's similar to graphite and diamonds, said Burnley. Both are made of carbon, but in different arrangements. Graphite is the form that's stable at Earth's surface, while diamonds are the form that's stable deep in the mantle. And both behave very differently: Graphite is soft, gray and slippery, while diamonds are extremely hard and clear. As olivine transforms into its higher-pressure phrases, it becomes more likely to bend and less likely to break in a way that triggers earthquakes.

Geologists were puzzled by earthquakes in the upper mantle until the 1980s, and still don't all agree on why they occur there. Burnley and her

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doctoral advisor, mineralogist Harry Green, were the ones to come up with a potential explanation. In experiments in the 1980s, the pair found that olivine mineral phases were not so neat and clean. In some conditions, for example, olivine can skip the wadsleyite phase and head straight to ringwoodite. And right at the transition from olivine to ringwoodite, under enough pressure, the mineral could actually break instead of bending.

"If there was no transformation happening in my sample, it wouldn't break," Burnley said. "But the minute I had transformation happening and I was squishing it at the same time, it would break."

Burnley and Green reported their finding in 1989 in the journal Nature, suggesting that this pressure in the transition zone could explain earthquakes below 249 miles.

Going deeper

The new Bonin earthquake is deeper than this transition zone, however. At 467 miles down, it originated in a spot that should be squarely in the lower mantle.

One possibility is that the boundary between the upper and lower mantle is just not exactly where seismologists expect it to be in the Bonin region, said Heidi Houston, a geophysicist at the University of Southern California who was not involved in the work. The area off the Bonin island is a subduction zone where a slab of oceanic crust is diving beneath a slab of continental crust. This sort of thing tends to have a warping effect.

"It's a complicated place, we don't know exactly where this boundary between the upper and lower mantle is," Houston told Live Science.

The paper's authors argue that the subducting slab of crust may have essentially settled onto the lower mantle firmly enough to put the rocks there under a tremendous amount of stress, generating enough heat and pressure to cause a very unusual break. Burnley, however, suspects the most likely explanation has to do with minerals behaving badly — or at least oddly. The continental crust that plunges toward the center of the Earth is much cooler than the surrounding materials, she said, and that means that the minerals in the area might not be warm enough to complete the phase changes they are supposed to at a given pressure.

Again, diamonds and graphite are a good example, Burnley said. Diamonds aren't stable at Earth's surface, meaning they wouldn't form spontaneously, but they don't degrade into graphite when you stick them into engagement rings. That's because there's a certain amount of energy

the carbon atoms need to rearrange, and at Earth's surface temperatures, that energy isn't available. (Unless someone zaps the diamond with an X-ray laser.)

Something similar may happen at depth with olivine, Burnley said. The mineral might be under enough pressure to transform into a non-brittle phase, but if it's too cold — say, because of a giant slab of chilly continental crust all around it — it might stay olivine. This could explain why an earthquake could originate in the lower crust: It's just not as hot down there as scientists expect it to be.

"My general thinking is that if the material is cold enough to build up enough stress to release it suddenly in an earthquake, it's also cold enough for the olivine to have been stuck in its olivine structure," Burnley said.

Whatever the cause of the quake, it's not likely to be repeated often, Houston said. Only about half of subduction zones around the world even experience deep earthquakes, and the kind of large quake that preceded this ultra-deep one only occurs every two to five years, on average.

"This is a pretty darn rare occurrence," she said.

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https://www.livescience.com

Carbon capture and storage: does it work, and does it mean we can keep burning fossil fuels?

2021-11-09

Does Australia have a bad reputation on climate change?

Among the worst in the world, according to at least one survey of international media and social media content by intelligence and social analytics company Meltwater Australia.

But heading into Glasgow, the federal government did commit Australia to a net zero target by 2050.

Though light on detail, the government's net zero plan predicts that investing in "priority low emissions technologies" will achieve 40 per cent of our emissions reduction needed to get us there.

But heading into Glasgow, the federal government did commit Australia to a net zero target by 2050.

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One of those "priority" technologies singled out for focus by the government is carbon capture and storage, or CCS.

Proponents of CCS, including Minister for Energy and Emissions Reduction Angus Taylor, argue the technology allows us to continue profiting from fossil fuels while also getting our emissions down.

But critics say CCS is a failed technology that the government is using to delay the inevitable shutdown of our fossil fuel industries.

What is carbon capture and storage?

As the name implies, CCS involves capturing carbon dioxide at the site of production, such as a gas liquefaction plant or coal-fired power station.

The gas is then pumped deep underground where it can migrate into porous substrate, such as sandstone, and be trapped.

There is also carbon capture use/utilisation and storage (CCUS), which usually involves a process known as enhanced oil/gas recovery, where captured carbon dioxide is pumped into depleted oil or gas reservoirs in order to force out any remaining fuel from the reservoir.

Once the hard-to-recover fossil fuel is removed, the captured carbon dioxide then remains trapped inside the underground reservoir.

Does carbon capture and storage work?

Yes, to an extent, but it's complicated.

CCUS has been in use since the 1970s, when it was known as enhanced oil recovery and its purpose was to increase oil yield rather than sequester emissions.

But fossil fuel industries claim it has also proven effective since then in reducing a proportion of the emissions from some polluting industries.

The first CCS/CCUS projects started out small but have become much more ambitious in recent years, according to Kathryn Amos, head of the University of Adelaide's Australian School of Petroleum and Energy Resources (ASPER).

Chevron has provided funding for ASPER's carbon capture and storage research.

"There are a number of CCS projects that work really well around the world," Dr Amos said.

According to the US Department of Energy's Carbon Capture and Storage Database, there are 43 active sites where carbon capture and storage is taking place worldwide, including enhanced oil recovery projects.

That includes 10 in the US, five in China and four in Australia.

However, only one of those Australian projects (Gorgon) is on a commercial scale. The other three are small-scale research studies not intended to make an impact on emissions reduction.

Gas giant Santos has a $220 million CCS project in development at Moomba in South Australia, where it plans to store more than 1 million tonnes of CO2 each year, starting in 2024.

That project has been made eligible for receiving carbon credits.

Santos chief executive officer Kevin Gallagher says the project is a "critical step in decarbonising natural gas".

Matthias Raab, executive director of CO2CRC, an Australian carbon capture utilisation and storage research company, says CCS can help make quick gains in getting our emissions down.

"We need to be genuinely open to what we can do to have the big wins as quickly as we can," Dr Raab told the ABC's Science Friction.

"In my eyes, carbon sequestration is a big, big winner."

But critics, including Mark Ogge from the Australia Institute, say carbon capture and storage is a government fossil fuel handout, which is putting our transition to proven clean technology in peril.

"[Carbon capture and storage in Australia has] been around for about 20 years and it's led to a huge delay in us doing anything serious about winding back fossil fuel emissions," Mr Ogge says.

"The amount of CO2 that's actually captured and put underground is minuscule.

"For every billion dollars of taxpayers' money that goes into this … every one of those dollars is a dollar not spent on things that are proven to reliably work and can be rolled out now and have huge abatement potential."

The Gorgon gas facility in Western Australia is the world's largest "dedicated" CCS project, meaning the captured CO2 isn't used to extract more fossil fuels.

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Despite having the financial backing of Chevron, Exxon Mobil and Shell, and $60 million from the WA government, the project has been racked by technical issues.

Originally supposed to capture 80 per cent of its emissions over a five-year period, it's never reached full capacity and has only achieved storage of about 30 per cent of emissions with the remaining emissions — estimated to be in the vicinity of 10 million tonnes of CO2 — being released to the atmosphere.

For scale, it was estimated at one point by Climate Analytics that the Gorgon plant was releasing roughly the same amount of CO2 into the atmosphere each year as was being collectively saved by every rooftop solar panel in Australia.

The company had talks in July with the WA government, which could result in Chevron needing to purchase around $100 million in carbon credits.

Majority of CCS projects fail

Encountering problems is far from rare for carbon capture and storage projects.

A study published in Environmental Research Letters last year found more than 80 per cent had either failed to launch, or failed after launch.

The majority of carbon capture storage projects have failed.(ABC News: William Rollo)

Lead author of that study, Ahmed Abdullah from Carleton University in Canada, says there are some key reasons why they fail.

"The global record of deploying carbon capture is overwhelmingly one of failure when you consider the huge number of projects that have been proposed over the previous two decades," Assistant Professor Abdullah said.

"The question was, as engineers, can we learn from that failure?"

Paradoxically, they found that it was usually the smaller, less ambitious projects that succeeded.

Of the 14 most expensive US-based projects they looked at, 13 were abandoned.

"It turns out that when government endeavours to fund these projects that are large, shiny and therefore cost a lot of money, but also employ the next generation of advanced technologies, well-advanced technologies often fail," Dr Abdullah said.

But when they work, what percentage of emissions are captured?

Exact figures are difficult to come by, but Dr Raab estimates it's in the vicinity of 90 per cent for coal and higher for gas.

"Let's say 95 per cent plus is being captured and is then being stored geologically," he said.

But senior scientist with Climate Analytics and lead author of the Intergovernmental Panel on Climate Change's 4th Assessment Report Bill Hare, says it's lower than that.

"For projects in Canada, it's about 60 to 70 per cent," Dr Hare says.

"The capture [rate in] CO2 reservoirs also turns out to be not complete either. It's optimistically claimed to be 80 to 90 per cent, but I don't think there are any examples.

"For enhanced oil recovery, a significant portion of the CO2 comes back to the atmosphere, but it turns out there haven't been many studies published."

Where it was once thought that carbon capture and storage would play an important role in getting global emissions down, Dr Hare says green technologies have advanced to the point where that's no longer the case.

"There are a few sectors where if you'd asked me five or so years ago, I'd have said I can't see many options [other than CCS], like in cement, steel, fertilisers … but right now in 2021, that looks quite unfeasible," he said.

"Green steel is now quite famous [using hydrogen], fertiliser is also quite carbon intensive, but it's looking like you can make fertiliser with green hydrogen, you can make a green ammonia, and away you go."

Once the CO2 is stored, can it leak?

The possibility of a leakage, and who is responsible for those emissions. is a major problem for carbon capture and storage, according to Dr Hare.

A 3-kilometre-long crack was found near Statoil's Sleipner carbon capture and storage site in the North Sea in 2011, and the fracture was found to be leaking gases.

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While none of the sequestered CO2 was determined to be leaking, the discovery was a wake-up call that more rigorous screening of storage sites was needed.

"The storage of carbon underground is not as straightforward as it sounds," Dr Hare says.

"One of the most famous ones is the Sleipner field in the North Sea; that's been well studied and it turns out to have a lot of cracks in it — that's been a shock and a surprise.

"If anyone says it's easy and safe and the CO2 will stay underground for a long time, that needs to be treated very sceptically."

But Dr Amos says the technology is safe, and CO2 can be stored in the same wells where gas has been held for millions of years.

"Some of the targets of CO2 storage are depleted oil and gas reservoirs. We know they're pretty safe options for storage because those are the locations that were naturally storing gas."

Dr Raab agrees.

"We're looking at existing oil and gas reservoirs and the knowledge that we have about how they originated, how they were holding oil and gas and liquids for millions of years," he says.

He says it's "no secret" there have been problems in the past, but that the industry has improved its practices.

"I think we need to make an assumption really here that the industry [has come] a long way," he says.

"There are certain measures that need to be in place to simply ensure the best practices."

Dr Hare says if there's a leak down the track, it's taxpayers that will foot the bill.

"If you look at the new, much-touted methodology for CCS, it's very weak for monitoring of storage and long-term security, and these issues are essentially put back onto the government," he says.

"The major proponents of CCS in Australia don't want that liability. It tells you they're not stupid, and it makes you wonder about the wisdom of the government accepting liability."

Dr Raab says liability won't be an issue.

"This is an extremely well-understood undertaking."

But Mr Ogge says focusing on the technology is a distraction from the bigger picture.

"It's a 50-year-old oil and gas industry practice of pumping CO2 into the ground to force out more oil from depleted fields, which increases emissions," he said.

"It's been re-branded as carbon capture and storage to basically greenwash it and allow the oil and gas industry to get taxpayer subsidies by presenting it as a climate abatement measure.

"It really is just a complete scam."

abc.net.au, 9 November 2021

https://www.abc.net.au

Why is the flu shot less effective than other vaccines?

2021-11-08

The effectiveness of the seasonal flu shot pales in comparison to knockout shots like the MMR vaccine, which is about 97% effective at preventing measles, 88% effective at preventing mumps and 97% effective against rubella. By contrast, flu shots typically range from 40% to 60% effective, and sometimes their effectiveness dips as low as 10%.

But why are flu shots less effective than other commonly used vaccines? A lot of it comes down to the rapid mutation of influenza viruses and the uncertainty around which strains might be circulating when flu season rolls around, experts told Live Science. And some of the vaccine's flaws may stem from how the shot is manufactured and the specific parts of the influenza virus it targets.

But although the flu shot isn't perfect, it still offers enough protection that the shot is worth getting, Live Science previously reported. PLAY SOUND

PICKING THE RIGHT STRAINS

The seasonal flu shot typically trains the body to fight four types of influenza virus, according to the Centers for Disease Control and Prevention (CDC): two influenza A viruses of the subtypes H1N1 and H3N2, and two influenza B viruses from the so-called Victoria and Yamagata lineages, which refer to branches of the influenza family tree. These

By contrast, flu shots typically range from 40% to 60% effective, and sometimes their effectiveness dips as low as 10%.

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influenza viruses mutate rapidly from year to year, meaning their genetic code changes and the proteins that appear on their outer surfaces change rapidly, too.

The flu shot works by training the immune system to recognize one of these surface proteins, called hemagglutinin (HA), which juts off the virus "like a lollipop on a stick," said Dr. William Schaffner, an infectious disease specialist at Vanderbilt University in Tennessee. Similar to the novel coronavirus's infamous spike protein, the HA protein enables influenza viruses to bind to and infiltrate cells to infect them. And the HA protein mutates rapidly, essentially doing a costume change every year and thus making it hard for the immune system to recognize it.

Another challenge is that flu shots must be manufactured and ready to go before flu season, so scientists use various strategies to predict which flu strains will be circulating in the coming months.

"You try to anticipate which strains are going to be active during your winter, early," Schaffner said. "But we have to project, because it takes time to make the vaccine." And even as the vaccine is being prepped, the circulating viruses can keep on mutating, sometimes to the point that they no longer match the shots well. And by the time flu season begins, the influenza strains scientists thought would be most prevalent can sometimes be overtaken by other versions of the viruses.

To predict which flu strains will dominate in the upcoming season, more than 140 national influenza centers in 113 countries collect swab samples from people who get flu-like sicknesses throughout the year, identifying those who actually caught influenza, according to Scientific American. Five World Health Organization-affiliated centers then do gene sequencing of the samples, characterize the proteins that lie on the viral surface, and run laboratory tests to see how well past vaccines neutralize the circulating flu strains, according to the CDC. They also determine which strains appear to be making the most people sick, and how fast the strains are spreading.

In February, consultants from each center come up with a recommendation for which strains to include for the Northern Hemisphere's flu vaccine for the upcoming winter. In September, they do the same for the Southern Hemisphere.

"Sometimes, the choice is right on target," Schaffner said. And then "there are other times that the flu manages to evade our predictions."

That said, even when there's a "good match" between the vaccine strains and circulating strains, the shots only tend to be about 40% to 60% effective. This modest effectiveness may be related to the fact that the shots target only the HA protein, rather than multiple spots on the influenza virus, and that the human immune system can sometimes be undermined by its previous exposures to the flu, Science magazine reported.

The natural immune response to an influenza infection involves generating antibodies against multiple proteins on the viral surface, not just HA, according to a 2013 report in Clinical Microbiology Reviews. The vaccines, by comparison, primarily generate antibodies against the HA protein, and it's unclear if targeting additional surface proteins could boost the shots' effectiveness, Science magazine reported.

Our first exposures to the flu in childhood may also bias how the immune system responds to vaccination, sometimes to our detriment, according to Science. After its first flu exposure, the body generates long-lived memory B cells, immune cells that remember the virus and can reactivate to produce more antibodies in the future. Some evidence suggests that later, if one is vaccinated against a similar — but not identical — flu virus to the first one they encountered, the body may reactivate these memory B cells, which crank out antibodies that miss their intended target.

Many flu vaccines are tested in ferrets that have never been exposed to flu before, so it's difficult to know whether the shot will work similarly in humans who've likely encountered flu viruses several times before.

PROBLEMS WITH MANUFACTURING?

The way most flu shots are produced may also undermine their success.

Most flu vaccines contain viruses that have been grown in chicken eggs, as part of the manufacturing process. "You have to modify the virus a little bit so it grows abundantly in eggs," Schaffner explained. And there's some evidence that, as the egg-borne virus replicates, it may pick up mutations that cause its genetics to diverge from the circulating flu strains. So when the egg-borne viruses are then killed or weakened for use in flu vaccines, they no longer match flu viruses in the wild.

In general, influenza A(H3N2) viruses mutate the fastest out of the flu subtypes included in the vaccines, so influenza A(H3N2) viruses are the most likely to produce "escape mutants" that can evade vaccines. A(H3N2) also appears most prone to so-called egg-adapted changes, the CDC

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states. These factors may explain why flu shots are typically less protective against H3N2.

Although most flu vaccines start out in eggs, not all do, according to the CDC. Some of the viruses used in inactivated flu shots — which contain "dead" flu viruses — are grown in mammalian cells, and so-called recombinant flu vaccines don't require live virus samples at all.

For the recombinant vaccines, scientists build a synthetic gene that codes for the HA protein and then produce the protein inside baculoviruses, which naturally infect insects. Some studies hint that genetically engineered HA may provide better protection against influenza than egg-grown viruses, Science magazine reported, but Schaffner said this still needs to be confirmed with further research.

HOW TO IMPROVE THE FLU SHOT

Many groups are currently working on new-and-improved flu vaccines that aim to provide more protection, and some may not need to be updated every year.

For example, researchers at Stanford University are working to develop a flu vaccine that targets the HA "stem" — the stick portion of the "lollipop" — rather than going after the HA protein itself, according to a statement. (A similar vaccine, called Flu-v, showed promise in an early-stage clinical trial, Live Science previously reported.)

Although the HA protein mutates relentlessly, a portion of its stem looks the same in many different influenza strains and doesn't change from year to year. So by targeting the stem rather than the HA protein, flu vaccines could offer protection against multiple strains without needing to be updated, Science magazine reported.

Such a vaccine would "cover virtually all influenza strains," Schaffner said. In pursuit of a broad-spectrum flu vaccine, some groups are targeting a different protein on the influenza virus surface, called neuraminidase, according to Science magazine. And still other groups have identified specific bits of the HA "lollipop" that appear consistent among flu subtypes, Nature reported.

Adding specific adjuvants, or ingredients that rev up the immune system, to universal flu vaccines could also help them call both trained memory B cells and naive B cells into action, broadening the body's antibody response, according to a 2020 report in the journal Proceedings of the National Academy of Sciences.

In addition to the groups pursuing "universal" flu vaccines, several vaccine-makers, including COVID-19 vaccine developers Moderna and Pfizer, are currently testing flu vaccines that use a genetic molecule called mRNA as their base. Once inside the body, the mRNA gives cells instructions to build influenza antigens, and thus teaches the immune system how to recognize the viruses.

Compared to egg-grown vaccines, which take months to produce, mRNA vaccines can be turned out incredibly quickly and don't require live virus samples. That means that, in theory, strains for the vaccines could be selected closer to the start of flu season, ensuring a closer match to the circulating strains.

But for now, despite their flaws, the currently available flu shots are the best option for protecting yourself against the flu. A flu shot in the arm will offer at least partial protection, Schaffner said, but "vaccines in the refrigerator never prevented any disease."

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https://www.livescience.com

How to choose a COVID-19 vaccine booster shot

2021-11-08

It's been a little over six months since I got my second dose of the COVID-19 vaccine from Pfizer and its German partner BioNTech, and a phone call from my state health department over the weekend reminded me that I am eligible for a booster. But do I really need to get a third COVID-19 shot? If so, which of the three authorized or approved vaccines available in the United States should I get? To make my decision, I looked at the evidence and talked to some experts. What I found out could be useful to anyone deciding on a booster.

Let's start with Johnson & Johnson. Everyone who got that shot as their initial vaccine is recommended to get a booster, U.S. health officials and experts say (SN: 10/19/21). That's because the antibody response from that one-dose vaccine isn't as high as for the two-dose mRNA vaccines from Pfizer and Moderna, and it is waning. "It doesn't go away entirely," says Sachin Nagrani, medical director of Heal, a company that provides primary health care in people's homes via telehealth visits and house calls. But a few months after the J&J shot, "it seems like your immune response is less protective."

What I found out could be useful to anyone deciding on a booster.

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There are few studies on J&J boosters, but the AstraZeneca vaccine, which is built on similar technology but not available in the United States, could provide some clues (SN: 11/23/20; SN: 2/27/21). Both vaccines use adenoviruses to deliver DNA instructions for building the coronavirus's spike protein to cells. Studies show combining AstraZeneca's COVID-19 vaccine with a boost from the Pfizer shot (or sometimes Moderna) was more effective than getting another dose of AstraZeneca.

For instance, in Sweden, a double dose of AstraZeneca was about 50 percent effective at preventing symptomatic illness. But AstraZeneca followed by Pfizer was 67 percent effective and AstraZeneca boosted with Moderna was 79 effective, researchers reported October 18 in the Lancet Regional Health – Europe.

A preliminary study that mixed and matched vaccines in the United States found that people who got J&J as their first dose developed much higher levels of antibodies if their second dose was an mRNA vaccine than if it was another jab of J&J. Those data suggest that people who got vaxxed with J&J should consider getting an mRNA booster.

For people like me who got an mRNA vaccine in the first go-around, choosing a booster is a bit more complicated. Boosters are recommended for people 65 and older, but I'm younger than that. People who have a high chance of getting exposed to COVID-19 through their jobs or living situations can also get a booster. But right now I work from home, where just my husband and I live. People with underlying health conditions that put them at greater risk of severe disease are also eligible. I do have a couple of health conditions that make me more vulnerable. But how much more benefit would I get from a booster shot than from the two doses I already received?

Much of what we know about mRNA booster shots comes from data collected in Israel, where everyone 12 and older has been eligible for a third dose of the Pfizer vaccine since the end of August. People who were fully vaccinated with two doses of the vaccine and had no underlying health risks, had a very low chance of developing severe COVID-19 or needing to be admitted to a hospital: Just 3.1 of every 100,000 healthy people who had gotten two doses of vaccine got severe disease, researchers reported October 29 in the Lancet.

But with underlying health risks, that number started to climb. Of every 100,000 fully vaccinated people with one or two health risks, 82 developed severe disease. And with three or more health risks, the rate was 113 of every 100,000 people. Getting a booster dropped the severe disease rate

for those with one or two health conditions to 3.2 per 100,000 and cut the rate by a bit more than half — to 51.6 per 100,000 — for those with three or more health conditions. That evidence leads me to think a booster is in order for me.

For young, healthy people the risk equation may be different. Nagrani says it's OK for people in that situation to wait a while for more data on the vaccine's longevity before getting a booster. But people 65 and older and those with health conditions or who live in assisted-living facilities should probably get a booster now.

The next question is which shot should I get? It's now fine to mix and match vaccine doses for booster shots. I could stick with Pfizer, or switch to Moderna or J&J. The first thing I'm considering is: What's my goal? While I would like to not get infected with COVID-19 at all, that's maybe not so realistic. None of the COVID-19 vaccines produce "sterilizing immunity," which protects you from getting infected. But they all provide protection against illness.

At first glance, it looks as if the mRNA vaccines are the way to go, but I've been intrigued by discussions in the recent advisory board meetings for the U.S. Food and Drug Administration and Centers for Disease Control and Prevention about different types of immunity produced by the vaccines. The mRNA vaccines give gangbuster levels of neutralizing antibodies, which help keep the coronavirus from infecting cells. But adenovirus-based vaccines like J&J's and AstraZeneca's seem to be better at revving up long-lasting protection from immune cells called T cells. And some evidence suggests that a combo of an mRNA vaccine with an adenovirus-based vaccine like J&J's could have some advantages.

In a study in France, participants got either two doses of the Pfizer vaccine or a dose of AstraZeneca with a Pfizer chaser. People who got Pfizer for both doses were twice as likely to get infected with the coronavirus as those who got the mixed doses, researchers reported October 21 in Nature. That was 10 infections among the 2,512 (0.39 percent) who got the mixed doses, compared with 81 infections among the 10,609 people (0.76 percent) who got Pfizer alone.

I asked one of that study's coauthors, Jacqueline Marvel, an immunologist at the International Center for Infectious Disease Research (CIRI) in Lyon, France, about whether I should switch to J&J for my booster shot to give my T cells a lift or stick with an mRNA vaccine. "I'm not sure you want to change the vaccine just for increasing the T cell response," she said. That answer surprised me a little because Marvel studies T cells for a living.

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"I'm pro T cell," she said. But "neutralizing antibodies are what you want to have first. The antibodies stop the virus from getting into the cells and protect you much earlier than the T cells would," Marvel explained. "If people don't want to be ill and have symptoms, you want the antibodies." And to maximize antibodies, the mRNA vaccines are the way to go.

Side effects from the booster doses are similar to those experienced from earlier doses, though some data suggest the effects after a booster may be milder than after the second dose. Some people are worried about rare side effects such as myocarditis, an inflammation of the heart muscle, that has sometimes happened after an mRNA dose, particularly for young males after the second dose. But that side effect is uncommon: Just 17 out of 2.5 million people who got a Pfizer booster shot in Israel developed myocarditis or pericarditis, Israeli health officials reported (SN: 10/19/21). I'm not a young man and my first two doses produced only a sore arm, so side effects aren't a big concern for me.

All of this convinced me to get an mRNA shot. But which one? That decision came down to convenience. I got online and searched for places where I could get my booster. It turns out that few of the grocery stores, pharmacies or other vaccine providers in my area offer the Moderna vaccine (even fewer have the J&J shot), but Pfizer doses are plentiful. So I got a Pfizer booster in my right arm and a flu vaccine in the left. (It's safe to take both at the same time.) According to the CDC, I'm not alone. Almost 99 percent of people fully vaccinated with Pfizer also chose Pfizer for their booster.

My arms might ache for a little while, but that's a price I'm more than willing to pay to avoid severe illness for myself and to help protect those around me from getting infected.

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https://www.sciencenews.org

Ferocious 'penis worms' were the hermit crabs of the ancient seas

2021-11-08

The Cambrian period (543 million to 490 million years ago) brought the first great explosion of biodiversity to Earth, with the ancestors of practically all modern animals first appearing. One of the most feared among them was the penis worm.

One of the most feared among them was the penis worm.

Technically known as priapulids — named for Priapus, the well-endowed Greek god of male genitals — penis worms, as they're commonly known, are a division of marine worms that have survived in the world's oceans for 500 million years. Their modern descendants live largely unseen in muddy burrows deep underwater, occasionally freaking out fishermen with their floppy, phallus-shaped bodies. But fossils dating back to the early Cambrian show that penis worms were once a scourge of the ancient seas, widely distributed around the world and in possession of extendible, fang-lined mouths that could make a snack out of the poor marine creature that crossed them.

But, fearsome as they were, penis worms themselves were not without fear. In a new study published Nov. 7 in the journal Current Biology, researchers discovered four priapulid fossils that were nestled into the cone-shaped shells of hyoliths, a long-extinct group of marine animals.

Because all of the worms were found in the same type of shell, and in roughly the same position, it's likely that the worms had appropriated the shells as their homes, just as modern hermit crabs do, the researchers said.

If that's the case, then it would seem that penis worms invented the "hermit" lifestyle hundreds of millions of years before the crustaceans that made it famous.

"The only explanation that made sense was that these shells were their homes — something that came as a real surprise," study co-author Martin Smith, an associate professor of paleontology at Durham University in England, said in a statement via email.

The team discovered the four hermit penis fossils in the collections of the Guanshan fossil deposits, from southern China. These fossil deposits, dating to the early Cambrian (about 525 million years ago) are famous for preserving not just hard structures such as teeth and shells, but also soft tissue — like the bodies of priapulids — which are much rarer to find in the fossil record.

In each shell, the worm's bottom sits squished into the bottom of the cone, while the worm's head and mouth dangle out over the side — sort of like a melting swirl of soft-serve ice cream. According to the researchers, the fossil region contained dozens of other empty shells, but no other free-living priapulids, suggesting the connection between the two was no mere accident. Furthermore, each worm fit snugly in its sheath, suggesting the creatures chose their shells for permanent protection from Cambrian predators, rather than as temporary refuge.

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This type of "hermiting" behavior has never been seen in priapulids before, nor in any species before the Mesozoic era (250 million to 65 million years ago), the researchers wrote. For Smith, it's "mind-boggling" that this complex behavior could have emerged so soon after the great burst of biodiversity known as the Cambrian explosion, more than 500 million years ago. In the harsh world of the early ocean, it seems even fearsome penis worms had to get creative.

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More eyes on polluters: The growth of citizen monitoring

2021-11-03

On the grounds of a western Pennsylvania convent, two small white cylinders fixed under the eave of a garage are helping to monitor air in a region that has long suffered from poor air quality and that soon will face a major additional source of emissions from a vast new petrochemical plant.

The cylinders, each not much bigger than a soda can, collect data on particulates and volatile organic compounds (VOCs) — both potentially harmful pollutants ¬— in the air surrounding the Sisters of St. Joseph of Baden, about 25 miles north of Pittsburgh.

The monitors are part of a network in the vicinity installed by Mark Dixon, an independent air-quality advocate and filmmaker who has been monitoring air pollution in the Pittsburgh area since 2016. He's now focusing on an ethane cracker plant being built by the oil giant Shell at Monaca on the south bank of the Ohio River, about five miles northwest of the convent. Dixon has so far installed 14 monitors within about five miles of the plant; he aims to add six more before the Shell plant opens.

The plant will convert ethane from the region's many natural gas wells into tiny pellets, or "nurdles," to be made by customers into plastic products. It is expected to open in 2022.

Dixon and other air-quality activists fear the complex will worsen air quality in an area that has lived with air pollution from the coal and steel industries for decades. Despite the closing of many steel plants, Pittsburgh's air quality is still rated ninth-worst in the United States for year-round particulate pollution by the American Lung Association.

The plant will convert ethane from the region's many natural gas wells into tiny pellets, or "nurdles," to be made by customers into plastic products.

Dixon said the monitoring is designed to make sure that Shell is polluting within permitted levels and to let the company know "that there are [other] eyes on Shell that go beyond just noses and eyeballs."

The devices being used by Dixon, which cost $200 to $300 each, automatically upload the information to two websites — Purple Air and Airviz — that contain maps showing air quality at specific locations in near real-time. The monitors are now collecting baseline information that will be used to show any changes when the cracker plant begins operating.

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Dixon acknowledged that the data gathered by his monitors isn't "regulatory grade," but argued that they give citizens a basis on which to make their case to regulators to set higher standards or just enforce current rules. He is funded by the Mountain Watershed Associations's Direct Support Fund, a local group that provides small grants to grassroots organizations and advocates working on environmental justice, fracking, and pollution created by petrochemical plants.

In the Ohio River valley, residents are collecting fragments of plastic to compare with any leakage of nurdles from the new plant when it opens. The Mountain Watershed Association has been using fine nets to trap plastic debris in the river near the Shell plant.

"You don't want people fishing in these waters, and you don't want people eating fish that have ingested nurdles," said James Cato, the association's community organizer. "These plastic pellets don't biodegrade; they just break down into slightly smaller chunks of plastic that end up in the ecosystem."

Another community group, Protect PT, monitors for noise around the natural gas fracking wells that will supply the Shell plant and is taking baseline readings around the plant site ahead of its opening. The group trains volunteers to gather noise data and then compares that with federal regulations to see if there's a violation, said Gillian Graber, Project PT's executive director. She said municipalities may have noise ordinances but may not have the capacity to enforce them. "The municipality is not going to have someone to do that in most cases; they don't have the technology," she said.

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The practice of citizens using their own time and technical know-how to monitor the pollution of air, water, and land has been underway for decades, providing an additional layer of information on contaminants that threaten public health but may be overlooked by regulators or undercounted by companies. But improvements in low-cost technologies and a growing distrust of companies and regulators have recently swelled the ranks of citizen scientists.

"The availability of low-cost monitors has enabled a greater degree of participation," said Matt Mehalik, executive director of the Breathe Project, a nonprofit that advocates for air quality in southwestern Pennsylvania. "The barriers to participation are much lower. It's a recognition that unless people speak up on issues related to their health, things may not get addressed."

Communities for a Better Environment, a California nonprofit, was a leader in this field starting in the 1990s when it helped local residents sample air in the San Francisco Bay area. Much of the sampling took place in low-income communities of color, with residents monitoring air near local refineries and sending samples for analysis by laboratories.

"The primary use was to demand your voice be heard, and it helped people organize to make things better for their health and their community," said Greg Karras, a former researcher for the nonprofit.

In the Santa Cruz Mountains near California's Silicon Valley, Ryan Poling uses a sensor from Purple Air to monitor air pollution from wildfires in the region. Poling, 42, a software engineer, said the sensor alerted him to very high levels of microscopic particles called PM2.5 around his house as a result of this summer's fires. The smoke forced him to stay indoors for about two weeks. He also installed two sensors inside that alerted him to unhealthy indoor air quality during the worst part of this summer's fire season.

Poling and his family moved to California from Pittsburgh in 2018 partly to escape the Pennsylvania city's air problems; he now finds he's enveloped by unhealthy air for part of each year. His sensor, which cost him $249, automatically posts near real-time data about the fine-particle content of air at his house to the Purple Air website. The company says that about 30,000 of its sensors are installed worldwide, enabling people in many places to see what air quality is like in surrounding towns and regions.

A fracking-driven industrial boom renews pollution concerns in Pittsburgh. Read more.

"I mainly just use it as a real-time way to look and see if it's OK to go for a run outside, or if I should stay inside that day," he said. "Do I have the windows open? Do I need to close everything up?"

In Pennsylvania, the Catholic community of the Sisters of St. Joseph has been hosting Mark Dixon's air monitors since December 2020. Their presence is consistent with the sisters' belief that they have a responsibility to God to care for the environment, and their concerns are heightened with the imminent opening of the Shell plant.

"The protection of our environment is certainly related to our faith," said Sister Kari Pohl, the congregational coordinator of justice and peace and one of about 70 nuns who live at the religious community. She said the women are inspired by Pope Francis's 2015 encyclical, Laudato Si, in which he calls for a higher standard of care for the natural environment.

Sister Pohl said she wore a medical-standard face mask one day in July when she went to pick blackberries in the convent's community garden because the air quality was so poor. While she's worried about the effects of the whole petrochemical industry on the environment, she's focused on the new Shell complex.

"The Shell plant is probably the most visible footprint of the petrochemical industry's expansion in our area," she said.

Curtis Smith, a spokesperson for Shell, said the plant has been designed to minimize air emissions and is complying with all state and federal environmental regulations. "Regulations require that Shell demonstrate that the project will not impact air quality," he said.

The Pennsylvania Department of Environmental Protection has permitted the plant to emit 522 tons a year of VOCs such as benzene and toluene, both of which are potential carcinogens. That's more than twice as much as the 222 tons of VOCs emitted in 2018 by the Clairton Coke Works, a leading source of the Pittsburgh area's pollution.

The Shell plant will also be allowed to discharge up to 159 tons a year of PM2.5 fine particles, which are typically emitted from smokestacks or automobiles and can impair lung function and lead to health problems, including an irregular heartbeat and aggravated asthma, according to the U.S. Environmental Protection Agency.

John Stolz, a Duquesne University professor of environmental microbiology and a longtime critic of the natural gas industry, has estimated that the cracker will need fracked gas from more than 1,000

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new wells every 5 to 10 years. Smith did not respond to requests for comment on Stolz's projection, but he did say that natural gas will fuel a cogeneration plant on site, producing electricity, and that any excess power from the plant will be sold to the grid, which would potentially reduce carbon emissions from other fossil fuel use.

In 2017, the company agreed to set up air quality monitoring on the perimeter of its plant, in response to a lawsuit by the Clean Air Council and the Environmental Integrity Group, two nonprofits.

But even with the company's own monitoring, there's a need for data collected by citizens who are often more aware of changing air conditions than corporations or regulators, argued Mehalik of the Breathe Project.

Citizen science can begin simply by residents smelling bad air, as happened in recent weeks when Shell was coating some of its new infrastructure and the odors drifted off site, Mehalik said. The emission was detected on some VOC monitors, but they did not identify the chemical. Dozens of people posted their concerns on a Facebook page and reported the incident to county officials, who then alerted the state Department of Environmental Protection, he said. Shell eventually identified the chemical, but not until four days after the release.

"This is why citizen science monitoring is critical, in that the feedback loop between smelling something and being able to raise the alarm and diagnose what the issue is requires citizens to pay close attention to what's happening so that they can get information and resolution as quickly as possible," Mehalik said. "It's usually the citizens who figure out what's going on before the company discloses it."

A similar hands-on approach is being taken in Charleston, South Carolina, where a water-quality nonprofit found that the same kind of tiny plastic pellets that will be produced by the Pennsylvania Shell plant had leaked onto beaches and into waterways from a local shipping facility.

Charleston Waterkeeper, with a full-time staff of three, investigated a report that the pellets were fouling a local beach. The group then discovered that the material was widespread, especially near the plant, operated by Frontier Logistics, which was receiving the material by train from a cracker plant in Texas. That led to a sampling protocol that estimated the density of nurdles by individuals picking up as many as possible within 10 minutes. In some places, there were so many that sampling areas rarely exceeded 1 square meter, said Andrew Wunderley, executive director of Charleston Waterkeeper.

Last March, the Charleston Waterkeeper won a lawsuit against Frontier on the grounds that the company had violated two federal environmental laws by allowing the pellets to leak from its plant and its trains. The company agreed to pay $1 million to create a water-quality fund.

"What I really hope is that it sends a message to these other facilities — if you don't operate in a way that respects this community and respects our natural resources, we're going to find out about it, using citizen science, and we're going to hold you accountable," Wunderley said.

In the western Pennsylvania town of New Brighton, about nine miles north of the Shell plant, Randy Shannon has two of Dixon's monitors fixed to the corner of the house where he has lived for the last 30 years. Shannon, 74, is a long-time opponent of the local natural gas industry, which since the mid-2000s has been exploiting the rich reserves beneath southwestern Pennsylvania using the controversial technique of hydraulic fracturing, or fracking.

The plastics pipeline: A surge of new production is on the way. Read more.

Now he's worried about what the Shell plant might do to local air quality, and he has gone so far as to take out a reverse mortgage on his home — meaning that the bank now owns it, but he's allowed to live in it for the rest of his life — so that he can walk away if the air gets too bad.

"There's a real possibility that the atmosphere can become unhealthy," he said. "I'm worried that the air quality might get so bad that it would affect the value of the house."

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https://www.e360.yale.edu

Mysterious glass in the Atacama Desert may be from an ancient exploding comet

2021-11-04

Mysterious bits of twisted glass strewn across Chile's Atacama Desert may have originated from a large comet that exploded in Earth's atmosphere around 12,000 years ago, according to a new study.

The ancient explosion — which may have been multiple back-to-back explosions — would have produced intense winds as strong as tornadoes and scorching heat that burned the desert sand, transforming it into

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silicate glass, or a solid that contains silicon and oxygen in a particular structure.

Though researchers first discovered these glass deposits around a decade ago, their origins had remained a mystery. The silicon glasses, some dark green and some black, are found in concentrated patches across a 47-mile-long (75 kilometers) corridor in the Atacama Desert, according to a statement from Brown University. The individual glasses are "twisted and folded " and have been found to stretch up to 20 inches (50 centimeters) across — slightly larger than a pizza box.

The researchers who first discovered the glasses hypothesized that they came from a bolide, or fireballs that explode in the atmosphere; but another group later concluded that the glasses were the result of intense grass fires, according to the new study. At the time, the area wasn't a desert, it had sandy soil, but also trees and grass, according to the statement.

Though researchers first discovered these glass deposits around a decade ago, their origins had remained a mystery.

To figure out the culprit, researchers from the U.S. and Chile conducted a chemical analysis of dozens of glass samples found in that desert. Inside the glass, the researchers found minerals called zircons, some of which had decomposed into baddeleyite, a rare zirconium oxide mineral, according to the statement. That transition from zircon to baddeleyite typically occurs at temperatures higher than 3,040 degrees Fahrenheit (1,670 degrees Celsius), much hotter than the temperature that grass fires would have reached, according to the statement.

The researchers also discovered minerals in the glasses that have previously been found only in meteorites and other rocks originating in space; some of the minerals, such as cubanite and troilite, were similar to the minerals discovered in samples from a comet called Wild 2 collected by NASA's Stardust mission. What's more, the odd, twisted shapes of the glasses also point to the intense heat and winds that would be produced by such a comet explosion. The researchers concluded that these glasses are likely the result of a comet similar to Wild 2.

"This is the first time we have clear evidence of glasses on Earth that were created by the thermal radiation and winds from a fireball exploding just above the surface," lead author Pete Schultz, a professor emeritus at Brown University's Department of Earth, Environmental and Planetary Sciences, said in the statement. "To have such a dramatic effect on such a large area, this was a truly massive explosion. Lots of us have seen bolide fireballs streaking across the sky, but those are tiny blips compared to this."

The researchers estimated that the explosion occurred around 12,000 years ago, but they hope that further studies will help to pinpoint the date and size of the comet with more precision.

"It's too soon to say if there was a causal connection or not, but what we can say is that this event did happen around the same time as when we think the megafauna disappeared, which is intriguing," Schultz said. "There's also a chance that this was actually witnessed by early inhabitants, who had just arrived in the region. It would have been quite a show."

The study was published Nov. 2 in the journal Geology.

The findings were Originally published on Live Science.

livescience.com, 4 November 2021

https://www.livescience.com

Ten reasons for optimism on climate change

2021-11-03

The 26th U.N. Climate Change Conference got underway in Glasgow this week, and it already looks like a slow-motion train wreck. The leaders of three of the biggest polluting nations – Russia, Brazil, and China – aren't there. The national pledges that have already been made to cut emissions won't be met – and even if they were, they aren't enough to avoid catastrophic warming. Rich nations of the world are woefully behind in their commitment to pay $100 billion a year into the Green Climate Fund to help poor nations adapt to climate impacts and transition to clean energy. The conference runs through Nov. 12 and new deals and commitments will emerge. But right now, given the scale of the crisis we face, signs of urgency, ambition, and leadership are hard to find.

As Rob Larter, a scientist with the British Antarctic Survey, put it in a tweet: "I think that in the main what's going on is a lot of politicians from many countries are trying to work out how they can come out of it looking good without really committing themselves to doing much."

But the climate fight is a big and complex war that's being carried out on many fronts. Even for experienced climate warriors, it's hard to keep the whole picture in your head at once. The apathy and self-dealing in Glasgow are obvious. What's less obvious are signs of real progress.

Here are ten reasons for optimism:

But right now, given the scale of the crisis we face, signs of urgency, ambition, and leadership are hard to find.

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1. The worst-case scenarios for climate warming have so far been averted. It's often argued that the nearly 30 years of climate talks since the Rio Earth Summit in 1992 have led to nothing. But that's not true. A decade ago, we were heading for a world 4°C (or more) warmer by 2100, which would have been catastrophic for life as we know it. But now, with the policies that are already in place, we're heading for just under 3°C, perhaps a little lower. With the official pledges updated last month — if successfully translated into effective policies — we would limit warming to around 2.5°C. And since then, another 25 countries have updated their pledges. 2.5 C of warming is still horrific, but it's far less horrific than 4 C.

2. The price of clean energy is falling fast. A decade ago, the virtue of coal was that it was cheap and plentiful. No more. Utility-scale solar power declined in cost by 90 percent between 2009 and 2021. The cost of onshore wind power declined by 70 percent over the same period. Even in Big Coal states like Ohio, electricity from solar power will overtake coal by the end of the decade.

3. The Age of Accountability for Big Oil has begun. Last week, the U.S. House Committee on Oversight and Reform grilled Big Oil CEOs for knowingly spreading lies about the risks of climate change. Republicans on the committee, led by James Comer of Kentucky, trotted out 30 year-old myths about energy independence and how fossil fuels are the elixir of working families. But Democrats were merciless. Kati Porter of California used M&Ms and bags of rice to make a point about how much land the oil companies have tied up in land leases. New York's Alexandria Ocasio-Cortez was typically sharp about the dangers of life in a rapidly warming world: "Some of us have to actually live the future that you all are setting on fire for us." The CEOs squirmed, fidgeted, and blustered. Maybe it was all theater. Or maybe it was a foreshadowing of climate accountability to come.

4. President Biden's climate agenda is big, smart, and serious. It's been downsized and cut up. It's been ransacked and shanghaied by West Virginia Senator Joe Manchin. But Biden's Build Back Better Act, which includes $500 billion for climate funding, would still be the biggest investment in clean energy and climate adaptation the U.S. has ever made. It includes investments for virtually every aspect of the economy, from clean energy transmission and storage to tax credits for electric vehicles and the production of low-carbon steel. Can Biden get it through congress? That remains to be seen, especially after the drubbing Democrats took in this week's elections. The good news is that the U.S. is pressing forward on other fronts, including new rules to limit methane

emissions, a potent greenhouse gas. Thanks in part to a big push from the U.S., more than 100 nations signed a Global Methane Pledge in Glasgow, vowing to cut methane emissions by 30% by 2030.

5. Scientists are getting their game on. Michael Mann, Katharine Hayhoe, Gavin Schmidt, Andrea Dutton and Andrew Dessler are all top climate scientists who have a knack for calling out bullshit when they see it. And they're calling it out more and more. Mann has been particularly aggressive. "Look no further than Australia, a country that deserves better than the feckless coalition government that currently reigns," he wrote in The Los Angeles Times last week. As Mann points out, Australia's commitment to reduce carbon emissions by 26% to 28% by 2030 is half what other industrialized nations such as the U.S. and the European Union have committed to. Mann also roasted Saudi Arabia and Russia for making a mockery of the Glasgow negotiations by agreeing to "a laughably delinquent" date of 2060 for reaching net zero emissions.

6. The fossil fuel divestment movement is snowballing. As activist and writer Bill McKibben noted in The New York Times last week, $40 trillion in endowments and portfolios has vowed to abstain from investing in coal and gas and oil. "That's bigger than the GDP of China and the U.S. combined," McKibben wrote. There is still a lot of money sloshing around out there for fossil fuel development, but slowing the flow from the spigot sends a powerful signal. Here's one sign of how well divestment campaigns are working: the West Virginia Coal Association called divestment "the dumbest movement in history."

7. Increased focus on the link between the climate crisis and public health. A rapidly warming world, researchers wrote in The Lancet, a prestigious British medical journal, is exposing humans to searing heat and extreme weather events; increasing the transmission of infectious diseases; exacerbating food, water and financial insecurity; endangering sustainable development; and worsening global inequality. "Health is the vector for climate action," Johan Rockstrom, the director of the Potsdam Institute for Climate Impact Research, said in Glasgow. "It is what people care about, and what motivates them to take action."

8. The war on coal is getting serious. China has vowed to stop funding new coal plants abroad. Billionaire Michael Bloomberg just launched a new crusade to shut down coal plants in 25 countries. Bloomberg has already waged war against coal in the US, helping to shut down 280 plants. Coal's demise can't happen fast enough, but it is happening.

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9. Climate justice takes center stage. What do the rich polluters owe the poor who are suffering the worst climate impacts? This has always been an issue at previous climate talks. In Glasgow, it's the issue. And climate justice leaders, who see their very existence at stake in these negotiations, are in no mood to play footsie with the leaders of rich nations. As Fiji's Prime Minister, Voreqe Bainimarama put it: "We Pacific nations have not travelled to the other end of the world to watch our future to be sacrificed at the altar of appeasement of the world's worst emitters."

10. Writers and artists are finding their voices. "Nothing will be saved without you." That's the first line of a poem by Yrsa Daley-Ward, a writer of mixed Nigeria-Jamaican heritage, which she read in the opening ceremony in Glasgow. If there's a better one-sentence call to action for the climate movement, I haven't heard it.

rollingstone.com, 3 November 2021

https://www.rollingstone.com

How did birds survive the dinosaur-killing asteroid?

2021-11-04

But, mysteriously, some dinosaurs survived: the birds.

When the dinosaur-killing asteroid collided with Earth about 66 million years ago, it triggered a slew of horrific events — shockwaves, wildfires, acid rain, tsunamis, volcanic eruptions and nuclear winter-like conditions — that killed about 80% of all animal species. But, mysteriously, some dinosaurs survived: the birds.

But why did some lineages of birds endure, while others perished? New research on a well-preserved ancient bird skull suggests that the bird species that survived the cataclysm had bigger cerebrums, or forebrains — the front region of the brain.

Although it's not clear exactly how larger forebrains helped birds survive, as the forebrain is responsible for many processes, "it likely had to do with behavioral plasticity — the birds with bigger forebrains could probably modify their own behavior quickly enough to keep up with how quickly their environment was changing," study lead researcher Chris Torres, a National Science Foundation postdoctoral research fellow in the Heritage College of Osteopathic Medicine at Ohio University, told Live Science in an email.

The study was published online July 30 in the journal Science Advances and was presented online Nov. 2 at the Society of Vertebrate

Paleontology's annual conference, which is virtual this year due to the COVID-19 pandemic.

Bird brain

Bird bones are delicate and rarely fossilize well or in three dimensions, meaning that scientists hardly ever get a good look at ancient bird braincases, the interior part of the skull where the brain sat. But a few years ago, researchers found a well-preserved, partially 3D fossil of Ichthyornis, an ancient toothy bird that lived during the Cretaceous period, in a rock formation dating to 87 million to 82 million years ago in Kansas.

"It has a nearly complete skull, which is incredibly rare both for this particular species (Ichthyornis) as well as fossil birds in general," said Torres, who did the research as doctoral student in the Department of Integrative Biology at the University of Texas at Austin. "This new fossil preserves most of the bones that make up the skull, providing us with our first complete looks at many of those bones."

So Torres and his colleagues used X-ray computed tomography (CT) scanning to digitally reconstruct Ichthyornis' facial skeleton and brain structure. An analysis of the brain shape revealed that ancient birds like Ichthyornis had a "old fashioned" brain; its brain was more like the brains of dinosaurs than the brains of living birds.

Living birds have "enormous forebrains relative to the rest of their brains," Torres said. The forebrains of today's birds are large compared with the forebrains of ancient birds and dinosaurs that lived just before the end-Cretaceous mass extinction. Given that Ichthyornis, a very close relative of living birds, still didn't have a big forebrain like living birds do, "we can infer that those big brains evolved in the ancestor of living birds," Torres wrote in the email.

Perhaps this big forebrain gave the ancestor of living birds an evolutionary advantage that helped them survive the "catastrophic global climate change that likely occurred during that mass extinction, which helps explain why only extant [living] birds, and not any other kinds of dinosaurs, managed to survive," Torres said.

However, Ichthyornis's brain did have a surprising feature: a wulst. This structure, previously known only from birds that lived after the mass extinction, is thought to be a visual and sensory processing center that plays a role in flight. The discovery of a wulst in a Mesozoic, or dinosaur-

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age, bird reveals that ancient bird brains were more complex than previously thought.

The brain structure analysis shows that bird brains didn't evolve in a neat progression over time, but developed as a complex mosaic of brain structures. "It's not a clear linear progression of everything becoming more complex or better adapted," said Jack Tseng, an assistant professor of vertebrate paleontology at the University of California, Berkeley and an assistant curator at its Museum of Paleontology, who was not involved in the study. "There are actually bits and pieces that were added on over time, [in] different combinations."

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Hellish Venus poses many mysteries. New spacecraft aim to solve them.

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If we couldn't see Venus, we'd hardly dare to imagine such a deceptive world.

Named for the Roman goddess of love and fertility, the planet is one of the nighttime sky's most beautiful sights. But up close, Venus smells like rotting eggs. Its raindrops would dissolve flesh, and at its surface, temperatures are hot enough that wood and gasoline would spontaneously burst into flame, while the pressure is so high that submarines would crumple.

Though today's Venus is grotesque, scientists suspect it was once quite different—temperate, perhaps awash in oceans, maybe even inhabited. For billions of years, our solar system may have been home to two blue marbles orbiting the sun, side by side. Yet while life on Earth flourished and thrived, a catastrophic amount of carbon accumulated in Venus's atmosphere, triggering a runaway greenhouse effect that laid waste to our once-verdant sibling. Now Venus is a deadly marble—a world gone wrong.

Now Venus is a deadly marble—a world gone wrong.

Or is it?

"I don't know that Venus went wrong," says Lori Glaze, NASA's planetary science division director. "I prefer to say that Earth went right."

Maybe, instead of a planetary accident, Venus is an ominous portent: the natural end-state of terrestrial planets in similar orbits. Or maybe Venus never was the watery, life-friendly world that some scientists envision.

Three planetary missions, launching over the next decade, will reveal whether Venus ever had liquid oceans, and if so, how expansive they were and how long they lasted. The robotic trio will precisely map the planet's surface, look for signs of active volcanism, and peer into the world's interior. By helping us better understand our sister world, these spacecraft will also help us learn whether the millions of rocky planets in Venus-like orbits around other stars could be habitable.

"I really think that Venus is the key to unlocking planetary habitability," says Stephen Kane of the University of California, Riverside. "We always obsess about habitability, and we forget to ask the question: What makes a planet uninhabitable? That's what Venus is."

But some Venusian mysteries can't be answered by this new fleet of missions. Key questions such as the amount of ongoing seismic activity will require scrutiny by long-lived landers or rovers, machines that must survive the crushing conditions at the planet's surface. Scientists are already developing the technologies needed to make such ambitious journeys possible, testing electronics and other hardware in chambers that simulate the alien planet's unforgiving temperatures and pressures.

"I can't believe I'm even saying there's going to be a trio of missions sent to Venus," says Jennifer Whitten of Tulane University, deputy principal investigator for NASA's VERITAS Venus mission. "We're going to get so much information, and I think the next step forward is landing on the surface."

Siblings on different paths

The confoundingly beautiful planet that gleams in our skies has entranced astronomers since they first fixed it in their telescopic sights in the 1600s. And up until the 1960s, scientists had some pretty wild ideas about what might live on the planet next door.

"Textbooks in those days showed Venus as a tropical jungle," recalls my dad, Frank Drake, a radio astronomer. "It was reasonable. Venus was closer to the sun and it had clouds, and it was thought to be a lot like Earth."

But after pointing a radio telescope at the planet in 1961 (the same telescope at the Green Bank Observatory he used to conduct humanity's first scientific search for intelligent aliens the year before), Dad deduced

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that the Venusian surface was nowhere near tropical—it was roasting at more than 700 degrees Fahrenheit.

Soon after, he found that the planet's temperature was always set to "broil," even on the night-side. That was odd, since Venus itself spins staggeringly slowly. One seemingly interminable day on its wretched surface lasts for 243 days on Earth, which is longer than Venus's 225-day year. The night-side should have been much cooler after roughly four months without sunlight.

"That was a real surprise," Dad says. "It told us that the atmosphere of Venus must be very heavy. It was so massive you could turn the sun off and it would not change its temperature for 100 days."

Follow-up observations confirmed Dad's calculations as well as an independent prediction made by Carl Sagan, and soon it was evident that all was not exactly well on the planet sometimes referred to as Earth's twin.

Scientists now know that Earth and Venus are round, similar in size, and probably similar in bulk composition, but that's where the likenesses end.

While Earth is temperate and watery, Venus is searing and parched. Its surface temperature averages 860 degrees Fahrenheit. Its desiccated landscapes are imprinted with the signatures of flowing lava, not watery rivers—and its surface pressure is 90 times that of Earth's, similar to the crushing force you'd feel some 3,000 feet underwater.

Overhead, Earth's clouds billow and vanish, but Venus's sky is perpetually overcast. Forty-five miles of suffocating clouds block all but a smidgen of sunlight. Strong winds blow in the upper layers, and the entire atmospheric shroud whips around the planet.

Whether Venus has always been an infernal world is among the primary questions scientists are hoping to answer in the next decade. If Venus did have oceans—if it was another blue marble for billions of years—then perhaps the planets like Venus orbiting faraway stars could also be temperate worlds. But if Venus was born this way, a lethal product of its composition and proximity to the sun, then all those "exo-Venuses" may be similarly barren.

"Until you understand why and how and when Venus got to be the way it is, we aren't really all that well equipped to make sense of what we see in other planetary systems," says planetary scientist Paul Byrne of Washington University in St. Louis.

"My heart wants it to be this tragic story of a world gone wrong. And I want to think that there were not just oceans there, but there were things swimming around in those oceans. Either way, whatever answer we find is going to be profound."

The Venus revolution

But since the mid-1960s, Mars has gobbled up the majority of funding for U.S. planetary missions. The last time NASA sent a probe to explore Venus was in 1989, when the Magellan spacecraft set out to make a rough radar map of the planet's surface. Since then, 14 NASA spacecraft have launched toward Mars.

"When I first joined the Venus community, and invited myself to the meetings and whatnot about 10 years ago, they were a very data-starved community," says Kane, who had previously focused primarily on exoplanets. "They looked with great envy at their Martian colleagues, who just seemed to get all the missions in the world thrown at them, while our maps of Venus are extremely lacking—they're very, very poor resolution."

For decades, the Soviets were the planet's primary explorers. Starting in the 1960s, they hurled dozens of spacecraft at the shrouded world, some destined for a relatively peaceful orbit while others quickly turned to goop on the planet's punishing surface. In 1975, one of those doomed landers, Venera 9, beamed a few images of the Venusian landscape back to Earth—the first photos taken from the surface of another planet.

"It was just such a completely alien landscape," Kane says. "I became obsessed with Venus as a child." In total, four Soviet spacecraft transmitted images during their short-lived perches on the planet, inspiring artists to imagine what a lander must look like on a broiling landscape beneath sickly orange clouds.

Most recently, Japanese and European orbiters have been surveying the planet, and India is developing a new Venus mission, but for the last couple of years Venus has been orbited by just one lonely spacecraft: Japan's Akatsuki. For many scientists, it has felt like Venus was forgotten, a world that was always eclipsed by the continual search for water—and signs of life—elsewhere.

Not anymore. In June, NASA associate administrator Thomas Zurbuchen stunned the planetary science community when he announced not one, but two new Venus missions as part of the space agency's Discovery program. The next week, the European Space Agency announced that it,

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too, would launch a spacecraft to Venus. NASA's two missions are known by the acronyms DAVINCI and VERITAS, and ESA calls its mission EnVision.

When asked, "Why Venus, and why now?" Zurbuchen said the NASA selection came down to a handful of key factors: new and intriguing science results about Venus's climate history, a wealth of planets orbiting other stars that are probably exo-Venuses, and mission designs that could accomplish great science within the Discovery program's limited budget of a few hundred million dollars—the smallest of NASA's three interplanetary mission categories.

"I like to say that Venus is the new hot planet," Zurbuchen says, fully aware of the pun. Although a team of astronomers recently announced tantalizing but controversial evidence of phosphine gas on Venus, a possible sign of life, Zurbuchen says the finding didn't play a role in NASA's mission selections. None of the new missions are designed to search for phosphine directly, but they will transform what we know about Venus's past and future.

"We have an opportunity to study Venus and get more than the sum of the parts of those three individual missions," says Glaze, who began her career as a volcanologist before being bitten by the Venus bug, and who recused herself from the NASA selection process. Together, the spacecraft will create "a fantastic, complete picture of Venus."

A whole new world

The trio will set sail for Venus later this decade. DAVINCI will likely launch in 2029 and fly by Venus twice before pulling into orbit. The spacecraft will image the planet's clouds and surface in multiple wavelengths, but the star of the mission is a probe that, over the course of an hour in 2031, will gently descend through the Venusian clouds, taking the first detailed images of the surface from above before crash-landing.

"It's a spherical probe, kind of the size of a large beach ball, or some would say a small bean bag chair," says DAVINCI deputy principal investigator Giada Arney of NASA's Goddard Space Flight Center. If the probe survives its descent, it could operate for up to 17 minutes on the surface—but that's not required, Arney says, "that's just a bonus."

As it sinks, the titanium probe will sample the planet's atmosphere. In particular, it'll sniff around for noble gases—elements such as helium, xenon, krypton, and argon—that linger in the Venusian air like molecular fossils, or direct tracers of the planet's history.

Those noble gases will reveal the planet's formation pathway, history of volcanism and giant impacts, and the origin of its water. The probe will also pay close attention to the relative amounts of normal and heavy hydrogen atoms, which will tell scientists how much water made its way into the atmosphere—key to understanding whether Venus ever had oceans.

"Even though we can explain the data we have right now with oceans, we can also explain them with other models that don't have oceans," Arney says. "If we do find strong evidence for oceans in the past … that might suggest that habitability might be more tenacious, that it can exist and endure on planets that we would otherwise have considered uninhabitable."

The probe's landing site, called Alpha Regio, is one of the planet's wrinkled, deformed surface regions known as tesserae. Scientists suspect these terrains could be the remains of ancient continents.

One of the big questions about the tesserae—so named by Russian scientists in the 1980s because they resemble parquet flooring—is whether they are made of granitic or basaltic rocks. On Earth, granite requires water to form and makes up our continental crusts, while basaltic rocks are forged by volcanoes. VERITAS, the other NASA mission, will attempt to solve this mystery by studying Venus's surface composition.

From orbit, VERITAS will also make maps of the planet's gravity field, which will help scientists study the planet's interior structure, and it will watch for signs of active Venusian volcanoes—one of the main ways scientists suspect the planet releases heat, given the absence of tectonic plates like those on Earth.

"There's been these tantalizing hints of volcanic activity, but nobody's really observed it, or taken a picture of volcanic activity," Whitten says. "We can see on the surface just this cornucopia of volcanic landforms, really. It's just awesome.

Piecing together the planet's geologic history—and current levels of activity—requires much better maps than scientists currently have. VERITAS will gather extremely detailed radar and topographic measurements of the planet's landscapes—which cover more than three times as much area as Earth's continents—to generate far superior maps to the grainy data from Magellan. EnVision will also make exquisitely detailed maps of about 25 percent of the planet's surface—maps that Byrne says will absolutely revolutionize what we know about the alien terrain.

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"It's going to feel like Christmas, to get all this stuff," Byrne says. "We are going to be introduced to a whole new world."

Braving the blasted surface

For decades, NASA has followed a set strategy in planetary exploration: First, fly past another world, as the agency did with the Mariner probes that zoomed by Venus in the 1960s. Then send orbiters, followed by landers, and finally, rovers.

Although the Perseverance rover and its kin are currently trundling around the landscapes of Mars, Venus exploration is still largely stuck at the orbiter stage. None of the Soviet landers lasted for long before losing their battle with Venus's environment—the record is 127 minutes, held by Venera 13.

"Looking down the line, there's important science questions that we will need to be on the planet for, and that's really what we're all about," says Tibor Kremic, who is spearheading some of the lander technology development at NASA's Glenn Research Center outside Cleveland.

Answering questions about the planet's weather, how its atmosphere interacts with the surface, the precise composition of that surface, and its seismic activity requires long-lived surface missions. At NASA and elsewhere, teams are already developing electronics and other hardware that can function in the extreme Venusian environment. Two additional challenges are figuring out how to power a lander, given that solar energy is scarce beneath all those clouds, and designing communications systems that can relay observations back to Earth.

"We're still a little ways away," says Alan Mantooth, a distinguished professor of electrical engineering at the University of Arkansas who is developing Venus lander technologies. "But we are getting much closer."

Mantooth, Kremic, and their colleagues are borrowing from some of the lessons learned while designing electronics for extreme aeronautical applications and natural gas turbines. They've developed silicon carbide circuits and transistors that should work perfectly well on Venus. They've also made sensors from gallium nitride, another heat-resistant semiconducting material, and they've figured out how to package those electronics in casings that will resist crumpling like a tin can under extreme pressures.

Teams test their hardware in chambers that simulate the harshness at Venus's surface. The biggest of these is called the Glenn Extreme Environment Rig (GEER). There, in the 800-liter pressure cooker, Kremic and

his team can pump in a mix of gases that mimics Venus's reactive, corrosive atmosphere. Already, they've graduated from testing small components like circuits, sensors, and shielding to placing entire subsystems in the chamber—for months at a time.

The next big step, Kremic says, would be testing a small prototype Venus lander. A mission concept called LLISSE, or Long-Lived In-Situ Solar System Explorer, would send a roughly 22-pound robot with a suite of sensors to the Venusian surface, where it would attempt to survive for at least 60 days. The team is working toward putting a LLISSE prototype in GEER, which Kremic says will likely happen around the end of 2025.

"I think the ability to survive on the surface of Venus for even a few weeks is going to be an absolute game-changer," Glaze says.

Seeing Venus's landscapes from its surface will radically change how we view our next-door neighbor, much as the albums of images from the Martian surface transformed that planet from a ruddy dot into a sweeping world of mountains, craters, and canyons. Even the grainy Venera images, transmitted a half-century ago by melting Soviet landers, had a powerful effect—Kane keeps a painting of the Venera probe on his office wall.

Soon sharper technologies will bring our alien sister into clearer focus, provoking questions we never thought to ask and revealing vistas that are more beautiful and more terrifying than we ever dared to imagine.

nationalgeographic.com, 7 October 2021

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