CHEMWATCH

Bulletin Board

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ASIA PACIFIC

EPA calls for information on glyphosate

2021-04-28

The Environmental Protection Authority (EPA) is calling for information on the use of the herbicide glyphosate in New Zealand.

This weed killer has been used by home gardeners, farmers, and councils in New Zealand since the 1970s. Although it is commonly known as the active ingredient in Roundup, there are 89 mixtures containing glyphosate that are approved for use in this country.

We are seeking information from New Zealanders – including industry and the general public – about the manufacture, importation, and patterns of use of glyphosate in this country, as well as information on the availability of alternatives, and any impacts on Māori.

Dr Chris Hill, General Manager, Hazardous Substances and New Organisms, says "Glyphosate is currently approved for use in the European Union until 15 December 2022, and can be used there until that date.

"The European Chemicals Agency (ECHA) and the European Food Safety Authority (EFSA) are in the process of reviewing the classification and approval of glyphosate, with their conclusions set to be released in mid-2022.

"Issuing a call for information now will enable us to have a greater understanding of the New Zealand context by the time the EU findings are published, and ensure we're better prepared to assess those findings.

"There has been ongoing public debate about the effects of glyphosate on environmental and human health.

"Our position at this time remains that products containing glyphosate are safe to use when all the rules (controls) around their use are followed. This is in line with the current regulatory opinion in Australia, Canada, the European Union and the United States.

"The EPA monitors international developments and continually reviews global research on hazardous substances, including glyphosate, and we have no evidence that risks associated with using glyphosate, or its hazardous nature, have changed. However, we feel the time is right for us to take another look at this substance. This is something we have been considering for some time, and is in line with our stance as a proactive

Although it is commonly known as the active ingredient in Roundup, there are 89 mixtures containing glyphosate that are approved for use in this country.

regulator - putting the environment and the health of people front and centre.

"The call for information will provide us with information on how glyphosate is currently being used in New Zealand. It is possible this has changed since we approved its use.

"We want to understand whether products containing glyphosate may be damaging the environment or human health, despite the clear rules in place. We also want to know about the economic benefits of glyphosate's use, and any potential alternatives. The information gathered will be used to help inform our next steps."

The call for information will remain open until 5.00 pm on 27 August 2021.

Read about the call for information and how to participate

Read more about glyphosate

Read More

EPA New Zealand, 28 April 2021

https://www.epa.govt.nz/news-and-alerts/latest-news/epa-calls-for-information-on-glyphosate/

New era in chemical management

2021-04-30

The new regime for classifying hazardous substances is now in effect, in the interests of making it safer for New Zealanders using chemicals.

New Zealand is now using the Globally Harmonised System (GHS 7), an internationally agreed way of classifying chemicals. It captures physical hazards such as flammability, human health hazards such as skin irritation, and environmental hazards such as how toxic a chemical is in water.

The changes primarily require importers and manufacturers to update their hazard classification, labelling, and safety data sheets. Consumers should start to see the GHS pictograms appearing on product labels, as New Zealand's chemical labelling aligns with the rest of the world.

The Environmental Protection Authority (EPA) has led the three-year project, engaging with the European Chemicals Agency, the Organisation for Economic Co-operation and Development (OECD), domestic regulators and stakeholders including industry and the public.

The project received $820,000 of funding in Budget 2019, to bring New Zealand's 20-year-old hazard classification system up to date.

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"Chemicals touch every area of our lives. The world of chemical management is dynamic and fast-moving, so it's important we stay on top of best practice," says the EPA's General Manager of Compliance, Monitoring, and Enforcement, Gayle Holmes.

The project received $820,000 of funding in Budget 2019, to bring New Zealand's 20-year-old hazard classification system up to date.

"The changes align our chemical management with the rest of the world, support international trade, and facilitate improved regulatory compliance," says Gayle Holmes.

Although there is a transition period through to 2025 for many requirements, the EPA is strongly encouraging industry to comply with the various changes sooner rather than later.

A large and diverse number of chemicals classed as hazardous substances are in use in New Zealand. The EPA is responsible for approvals covering more than 150,000 hazardous substances regulated under the HSNO Act.

The next phase of the project is to complete a move to the International Uniform Chemical Information Database, later in 2021.

"Once all the chemical data is migrated, the database will provide a solid foundation for our chemical management regime into the future," says Gayle Holmes.

Read more about the changes

EPA New Zealand, 30 April 2021

https://www.epa.govt.nz/news-and-alerts/latest-news/new-era-in-chemical-management/

AMERICA

CLEAR Act returns, sighting PFAS

2021-04-26

As the state gradually lifts its finger off the pandemic pause button, the 105th cadre of the Wisconsin State Legislature begins rolling out its compendium of proposed bills, aiming to flourish the wellbeing of everyone in the dairyland and taking the state—as its motto proclaims —"forward."

But with Gov. Tony Evers' announcement at a press conference in La Crosse Wednesday, the fate of PFAS regulation once again falls to Wisconsin legislators.

That relaxing of the pause button also means digging back into some difficult issues that, to some extent, straggled legislatively underfoot when COVID-19 stepped onto the stage in the middle of the 2019-21 biennium session.

Locally, Per- and polyfluoroalkyl substances, aka PFAS, contamination represents one of those issues that received a temporary reprieve from legislative action over the last year. But with Gov. Tony Evers' announcement at a press conference in La Crosse Wednesday, the fate of PFAS regulation once again falls to Wisconsin legislators.

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EH Extra, 26 April 2021

https://www.ehextra.com/news/clear-act-returns-sighting-pfas/article_98bb48af-afa5-506c-bb30-e64159f450d1.html

Board approves phase out of hydrofluorocarbons in Virginia

2021-04-26

The Virginia State Air Pollution Control Board unanimously approved a final regulation prohibiting the use of certain hydrofluorocarbons in specific end uses.

HFCs are used in the manufacture of some foam products, aerosols, refrigerants, aerosols and fire extinguishers, and can have a significant impact on global warming in part due to their long presence in the atmosphere before breaking down.

The regulation, approved by the Board following Virginia Department of Environmental Quality (DEQ) staff recommendations, public comment and discussion, will become effective June 1, 2021. The regulation was developed with participation and support of a stakeholder workgroup pursuant to legislation passed by the Virginia General Assembly in 2020 in advance of federal requirements to phase out these compounds.

The production and use of HFCs in the Commonwealth of Virginia, in most applications, must be discontinued by Jan. 1, 2022.

"We are pleased to become the tenth state, and the first southern state, to phase out HFCs, which is necessary to limit the Commonwealth's contributions to climate change," said DEQ Director David Paylor. "This regulation continues the significant progress Virginia has already made –

The regulation, approved by the Board following Virginia Department of Environmental Quality (DEQ) staff recommendations, public comment and discussion, will become effective June 1, 2021.

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and continues to make – to become a more environmentally protective, climate-friendly state."

Over the last quarter, there were no new high priority violations and one consent order. An additional nine consent orders are in development. The Mountain Valley Pipeline Lambert Compressor Station air permit is expected to be considered by the Board at its next meeting this summer.

The Board also heard updates from Director Paylor and staff. Director Paylor reported that the agency will receive approximately $12 million that was approved by the 2020 General Assembly, which will help restore funds the agency has lost in recent decades. The funds will enable the agency to hire approximately 65 positions in Air, Water and Land programs, as well as outreach staff in each of DEQ's six regional offices, who will support the agency's Office of Communications – and as just announced by the agency this week – the new Office of Environmental Justice.

Air and Renewable Energy Division Director Mike Dowd discussed the development of upcoming regulations to limit methane leaks from natural gas infrastructure, greenhouse gas inventory and the Advanced Clean Cars bill (**HB 1965**), as well as efforts to conform DEQ regulations to federal requirements.

Dowd also shared that the Commonwealth received $43 million in proceeds from its first auction as a participant of the Regional Greenhouse Gas Initiative (RGGI), which will fund low-income energy efficiency programs and resiliency efforts. The next RGGI auction will be held in June.

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Augusta Free Press, 26 April 2021

https://augustafreepress.com/board-approves-phase-out-of-hydrofluorocarbons-in-virginia/

EPA seeks comment on ITC's revisions to TSCA Section 4€ Priority Testing List

2021-04-28

The U.S. Environmental Protection Agency (EPA) published a *Federal Register* notice on April 28, 2021, announcing a 30-day comment period on the Toxic Substances Control Act (TSCA) Interagency Testing Committee's (ITC) revisions to the Priority Testing List. **86 Fed. Reg. 22414**. In the 74th ITC Report, ITC revised the TSCA Section 4(e) Priority Testing List by adding

Environmental Protection Agency (EPA) published a Federal Register notice on April 28, 2021, announcing a 30-day comment period on the Toxic Substances Control Act (TSCA) Interagency Testing Committee's (ITC) revisions to the Priority Testing List.

the following 15 high-priority substances designated pursuant to TSCA Section 6(b) and 24 organohalogen flame retardants:

Chemical Substance	Chemical Abstracts Service Registry Number
High-Priority Substances	
1,3-Butadiene	106-99-0
Butyl benzyl phthalate (BBP) - 1,2-Benzene- dicarboxylic acid, 1-butyl 2(phenylmethyl) ester	85-68-7
Dibutyl phthalate (DBP) (1,2-Benzene-dicarboxylic acid, 1,2- dibutyl ester)	84-74-2
o-Dichlorobenzene	95-50-1
p-Dichlorobenzene	106-46-7
trans-1,2- Dichloroethylene	156-60-5
1,2-Dichloropropane	78-87-5
Dicyclohexyl phthalate	84-61-7
Di-ethylhexyl phthalate (DEHP) - (1,2-Benzene- dicarboxylic acid, 1,2-bis(2- ethylhexyl) ester)	117-81-7
Di-isobutyl phthalate (DIBP) - (1,2-Benzene- dicarboxylic acid, 1,2-bis-(2methylpropyl) ester)	84-69-5
Formaldehyde	50-00-0
1,3,4,6,7,8-Hexahydro-4,6,6,7,8,8-hexamethylcyclopenta [g]-2-benzopyran (HHCB)	1222-05-5
Phthalic anhydride	85-44-9
4,4′-(1-Methylethylidene)bis[2, 6-dibromophenol] (TBBPA)	79-94-7
1,1,2-Trichloroethane	79-00-5
Organohalogen Flame Retardants	
Bis(hexachlorocyclopentadieno) cyclooctane	13560-89-9

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Chemical Substance	Chemical Abstracts Service Registry Number
1,2-Bis(2,4,6-tribromophenoxy)ethane	37853-59-1
1,1′-Ethane-1,2-diylbis(pentabromobenzene)	84852-53-9
2-(2-Hydroxyethoxy) ethyl 2-hydroxypropyl 3,4,5,6-tetrabromophthalate	20566-35-2
2,2′-[(1-Methylethylidene)bis[(2,6-dibromo-4,1-phenylene)oxymethylene]]bis[oxirane]	3072-84-2
Mixture of chlorinated linear alkanes C14-17 with 45-52 % chlorine	85535-85-9
N,N-Ethylene-bis(tetrabromophthalimide)	32588-76-4
Pentabromochlorocyclohexane	87-84-3
(Pentabromophenyl)methyl acrylate	59447-55-1
Pentabromotoluene	87-83-2
Perbromo-1,4-diphenoxybenzene	58965-66-5
Phosphonic acid, (2-chloroethyl)-, bis(2-chloroethyl) ester	6294-34-4
Propanoic acid, 2-bromo-, methyl ester	5445-17-0
Tetrabromobisphenol A-bis(2,3-dibromopropyl ether)	21850-44-2
Tetrabromobisphenol A bis(2-hydroxyethyl) ether	4162-45-2
Tetrabromobisphenol A diallyl ether	25327-89-3
Tetrabromobisphenol A dimethyl ether	37853-61-5
2,4,6-Tribromoaniline	147-82-0
1,3,5-Tribromo-2-(prop-2-en-1-yloxy) benzene	3278-89-5
Tris(2-chloroethyl) phosphite	140-08-9
Tris(2,3-dibromopropyl) phosphate	126-72-7

Chemical Substance	Chemical Abstracts Service Registry Number
1,3,5-Tris(2,3-dibromopropyl)-1,3,5-triazine-2,4,6(1H,3H,5H)-trione	52434-90-9
Tris(tribromoneopentyl)phosphate	19186-97-1
2,4,6-Tris-(2,4,6-tribromophenoxy)-1,3,5-triazine	25713-60-4

ITC requests that EPA add these chemical substances and the other five high-priority substances and six organohalogen flame retardants currently on the Priority Testing List to 40 C.F.R. Section 716.120(a), the list of substances subject to the TSCA Section 8(d) Health and Safety Data Reporting rule (40 C.F.R. Part 716). The rule requires manufacturers (including importers) of chemical substances and mixtures added to the Health and Safety Data Reporting rule to submit lists and copies of unpublished health and safety studies to EPA. Comments are due **May 28, 2021**.

EPA notes that in addition to the chemical substances being added to the Priority Testing List in the 74th ITC Report, the Priority Testing List includes two alkylphenols, 45 High Production Volume (HPV) Challenge Program orphan chemicals, cadmium, a category of cadmium compounds, six non-phthalate plasticizers, 25 phosphate ester flame retardants, two other flame retardants, nine chemicals to which children living near hazardous waste sites may be exposed, and 19 diisocyanates and related compounds.

Read More

TSCAblog, 28 April 2021

http://www.tscablog.com/entry/epa-seeks-comment-on-itcs-revisions-to-tsca-section-4e-priority-testing-lis

EUROPE

EU chemicals strategy roundtable prepares for inaugural meeting

2021-04-23

The European Commission has selected the members of its much anticipated high-level roundtable that will support actions under its new chemicals strategy. But conflicting interests may mean common ground is hard to come by for implementing ambitious controls on substances of concern.

But conflicting interests may mean common ground is hard to come by for implementing ambitious controls on substances of concern.

The 32 members will meet virtually on 5 May for three hours with the Commission presenting its expectations of the roundtable's role and the implementation of the strategy.

The main discussion will be on the social and economic dimensions of industry transition to safe and sustainable chemicals. This follows an inaugural workshop on the subject held on 19 March.

The roundtable comprises representatives from five trade bodies: Cefic, SMEunited, Cosmetics Europe, Eurometaux, and the soaps and detergents association Aise. It includes top executives from chemical industry titans Henkel, Covestro and Solvay, food ingredients producer Corbion and retailer Coop Denmark. The remaining positions were allotted to civil society, scientific and international organisations.

In total 116 entities applied for membership. The Commission said it has a "well-balanced" composition of different groups of stakeholders, but there was criticism of limited downstream industrial perspective.

Member Joel Tickner, a professor at the University of Massachusetts Lowell, said there could have been stronger participation from the "hidden middle" of the supply chain, such as converters and formulators.

The group is expected to meet twice a year and will be chaired by environment commissioner Virginijus Sinkevičius and internal market commissioner Thierry Breton. Portugal, which currently holds the presidency of the Council of the EU, is the only member state participant, though its seat will rotate every six months in tandem with the presidency.

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Chemical Watch, 23 April 2021

https://chemicalwatch.com/252896/eu-chemicals-strategy-roundtable-prepares-for-inaugural-meeting

The compounds are all on a Commission priority list of 28 potential endocrine disrupting chemicals in cosmetic products.

Four potential EDCs are safe in cosmetics, says Commission consumer safety body

2021-04-22

The European Commission's Scientific Committee on Consumer Safety has adopted final Opinions on four potential endocrine disrupting chemicals (EDCs): resorcinol; propylparaben; and UV filters benzophenone-3 and octocrylene. All four are safe in cosmetics in limited concentrations, according to the committee.

The compounds are all on a Commission priority list of 28 potential endocrine disrupting chemicals in cosmetic products.

The SCCS found that resorcinol is safe in limited concentrations in hair dyes and shampoos, despite evidence for endocrine-disrupting properties. *In vitro* and animal studies have shown that it has thyroid effects, inhibiting the enzyme thyroid peroxidase. In its final Opinion, the committee acknowledges the anti-thyroid effects, but says that available human studies point to a "relatively much higher level of exposure than is the case from cosmetics".

Propylparaben is safe when used as a preservative in cosmetic products up to a maximum concentration of 0.14%, the SCCS found. Available data provide "some indications" for potential endocrine effects but not enough evidence to regard the substance as an EDC, it concludes.

UV filters

The committee decided that benzophenone-3 (BP-3) is safe when used as a UV filter in cosmetics, at maximum concentrations of 2.2% in body creams and sprays, provided that there is no additional BP-3 in the products to protect the cosmetic formulation.

It agrees that there are "indications" from some studies that the substance may have endocrine-disrupting effects and that further investigations are warranted. However, it considers that currently available evidence for its endocrine-disrupting properties is "inconclusive, and at best equivocal".

The SCCS also considers that octocrylene is safe as a UV filter at concentrations up to 10% in cosmetic products. Although some *in vivo* studies suggest that it may have endocrine effects, the evidence is not yet conclusive enough to derive a specific endocrine-related toxicological point of departure for use in safety assessment, it concludes.

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Chemical Watch, 22 April 2021

https://chemicalwatch.com/252966/four-potential-edcs-are-safe-in-cosmetics-says-commission-consumer-safety-body

Review of the existing maximum residue levels for 8-hydroxyquinoline according to Article 12 of Regulation (EC) No 396/2005

2021-04-26

According to Article 12 of Regulation (EC) No 396/2005, EFSA has reviewed the maximum residue levels (MRLs) currently established at European level for the pesticide active substance 8-hydroxyquinoline. To assess the occurrence of 8-hydroxyquinoline residues in plants, processed commodities, rotational crops and livestock, EFSA considered the conclusions derived in the framework of Commission Regulation (EC) No 33/2008, as well as the European authorisations reported by Member States (including the supporting residues data). Based on the assessment of the available data, MRL proposals were derived and a consumer risk assessment was carried out. Although no apparent risk to consumers was identified, some information required by the regulatory framework was missing. Hence, the consumer risk assessment is considered indicative only and all MRL proposals derived by EFSA still require further consideration by risk managers.

Based on the assessment of the available data, MRL proposals were derived and a consumer risk assessment was carried out.

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EFA, 26 April 2021

https://www.efsa.europa.eu/en/efsajournal/pub/6566

Chemical compliance requirements for EU MDR and IVDR

2021-04-26

Chemical Compliance Requirements for EU MDR and IVDR

Did you know that both the new Medical Device Regulation (MDR) and the In Vitro Diagnostic Regulation (IVDR) for the European Union (EU) include chemical compliance requirements in one of their subsections? In other words, to have your medical device CE marked for use in Europe, you may not only need to be aware of all the chemicals in your device, but you may need to also ensure they don't include certain chemicals. If this is news to you, keep on reading—this is important! A note before we begin: I'll mostly be discussing this in context of MDR to keep it simple, but IVDR is different, though similar—the differences are discussed lower down.

The chemical compliance portion of MDR is section 10.4. That section first details scope, so we'll start there, too. The only medical devices that are in scope are devices that "are invasive and come into direct contact with the human body, (re)administer medicines, body liquids or other substances, including gases, to/from the body, or transport or store such medicines, body fluids or substances, including gases, to be (re)administered to the body." Invasive is defined as "any device which, in whole or in part, penetrates inside the body, either through a body orifice or through the surface of the body." Generally speaking, that means only devices that are considered external communicating or implanted by 10993-1 fall within this scope.

Read More

MDDI, 26 April 2021

https://www.mddionline.com/regulations/chemical-compliance-requirements-eu-mdr-and-ivdr

Updated IT tools for poison centre notifications

2021-04-28

IUCLID has been updated with new features for companies preparing notifications to poison centres. The new features include free text information to complement the picklist options available in IUCLID, and a new 'dossier viewer' that helps users compile notification information into an easy-to-view, web-based report before submitting. More improvements

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to the tool are foreseen in May for users preparing their notifications online.

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ECHA, 28 April 2021

https://poisoncentres.echa.europa.eu/

Invasive is defined as "any device which, in whole or in part, penetrates inside the body, either through a body orifice or through the surface of the body."

Janet's Corner

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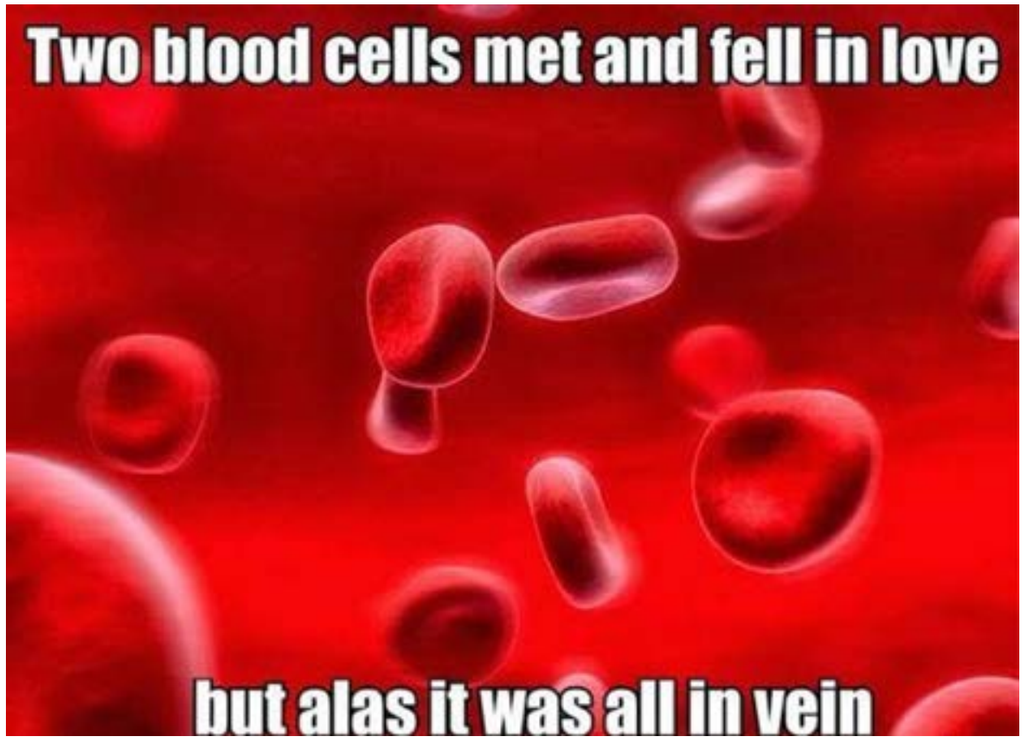
In Vein

2021-05-07



https://www.ranker.com/list/funny-science-puns/nathandavidson

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Methanol

2021-05-07

Methanol, also known as methyl alcohol, wood alcohol, wood naphtha or wood spirits, is a chemical with the formula CH_3OH (often abbreviated MeOH). It is the simplest alcohol, and is a light, volatile, colourless, flammable liquid with a distinctive odour very similar to, but slightly sweeter than, ethanol (drinking alcohol). At room temperature, it is a polar liquid, and is used as an antifreeze, solvent, fuel, and as a denaturant for ethanol. Because of its toxic properties, methanol is frequently used as a denaturant additive for ethanol manufactured for industrial uses — this addition of methanol exempts industrial ethanol from liquor excise taxation. Methanol is often called wood alcohol because it was once produced chiefly as a by-product of the destructive distillation of wood. Methanol is produced naturally in the anaerobic metabolism of many varieties of bacteria, and is ubiquitous in the environment. As a result, there is a small fraction of methanol vapour in the atmosphere. Over the course of several days, atmospheric methanol is oxidised with the help of sunlight to carbon dioxide and water. [1]

Methanol, also known as methyl alcohol, wood alcohol, wood naphtha or wood spirits, is a chemical with the formula CH3OH (often abbreviated MeOH).

USES [2]

Methanol is used in many ways. On its own, applications include:

- Transportation Fuel - Methanol is the most basic alcohol. It is easy to transport, readily available, and has a high octane rating that allows for superior vehicle performance compared to gasoline.
- Wastewater Denitrification - Methanol is also used by municipal and private wastewater treatment facilities to aid in the removal of nitrogen from effluent streams. As wastewater is collected in a treatment facility, it contains high levels of ammonia. Through a bacterial degradation process this ammonia is converted into nitrate. If discharged into the environment, the nutrient rich nitrate in sewage effluent can have a devastating effect on water ecosystems. Methanol, which quickly biodegrades, is a cost-effective way to help revitalise waterways tainted by the effects of nitrates.
- Fuel Cell Hydrogen Carrier - Methanol is used as a key component in the development of different types of fuel cells. From large-scale fuel cells to power vehicles or provide back-up power to remote equipment, to portable fuel cells for electronics and personal use, methanol is an ideal hydrogen carrier.

- Biodiesel Transesterification - In the process of making biodiesel fuel, methanol is used as a key component in a process called transesterification. Methanol is used to convert the triglycerides in different types of oils into usable biodiesel fuel. The transesterification process reacts methanol with the triglyceride oils contained in vegetable oils, animal fats, or recycled greases, forming fatty acid alkyl esters (biodiesel) and the by-product glycerin.
- Electricity Generation - Different companies are also exploring the use of methanol to drive turbines to create electricity.

Methanol is also used as a key component of hundreds of chemicals including formaldehyde, acetic acid and olefins –which are all basic chemical building blocks for a number of common products. An example of some types of materials that are made from methanol include:

- Plastics
- Synthetic fibres
- Paints
- Resins
- Magnetic film
- Safety glass laminate
- Adhesives
- Solvents
- Carpeting
- Insulation
- Refrigerants
- Windshield washer fluid
- Particle board
- Pigments and dyes

SOURCES & ROUTES OF EXPOSURE [3]

Exposure to methanol can occur in many ways. Occupational exposure to methanol can commonly occur through inhalation and dermal contact. Individuals may be exposed to methanol in the ambient air from its evaporation during solvent uses or from automobile exhaust, through the consumption of various foods, and through dermal contact with various consumer products such as paint thinners and strippers, adhesives, cleaners, and inks. Natural emission sources of methanol include volcanic

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gases, vegetation, microbes, and insects; methanol is also formed during biological decomposition of biological wastes, sewage, and sludge.

HEALTH EFFECTS

Acute Effects [4]

Methanol may be acutely toxic following inhalation, oral or percutaneous exposure. Acute toxicity from methanol manifests as CNS depression, followed by a latent period of varying duration from 8-36 hours and occasionally up to 48 hours. Subsequently, metabolic acidosis develops, superimposed with headache, nausea and features of ocular toxicity. Ocular toxicity may range from photophobia and misty or blurred vision to markedly reduced visual acuity and complete blindness; ingestion of as little as 4-10 mL methanol in adults may cause permanent damage. Coma and death may occur after substantial exposures. The minimal lethal dose following ingestion is considered to be in the range of 300-1000 mg kg-1. Severe intoxication, if survived, may cause permanent damage to the CNS, manifest as a Parkinsonian-like condition and permanent blindness.

Chronic Effects [3]

Chronic inhalation or oral exposure to methanol may result in headache, dizziness, giddiness, insomnia, nausea, gastric disturbances, conjunctivitis, visual disturbances (blurred vision), and blindness in humans. EPA has not established a Reference Concentration (RfC) for methanol. The Reference Dose (RfD) for methanol is 0.5 milligrams per kilogram body weight per day (mg/kg/d) based on increased liver enzymes (SAP and SGPT) and decreased brain weight in rats.

Reproductive/Developmental Effects

No information is available on the reproductive or developmental effects of methanol in humans. Developmental effects have been observed in the offspring of rats and mice exposed to methanol by inhalation. These included skeletal, cardiovascular, urinary system, and central nervous system (CNS) malformations in rats and increased resorptions and skeletal and CNS malformations in mice. No information is available on the carcinogenic effects of methanol in humans or animals. EPA has not classified methanol with respect to carcinogenicity.

SAFETY [5]

First Aid Measures

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

Fire & Explosion

- Fire Hazards: Highly flammable in presence of open flames and sparks, of heat. Non-flammable in presence of shocks. When Methanol is heated to decomposition, it emits acrid smoke and irritating fumes.
- Explosion Hazards: Explosive in presence of open flames and sparks, of heat. Methanol is explosive in the form of vapour when exposed to heat or flame and may travel considerable distance to source of ignition and flash back. In addition, explosive mixtures are formed with air due to its low flash point. It is also explosive when mixed with choroform + sodium methoxide and diethyl zinc. It boils violently and explodes.

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- Fire Fighting Media and Instructions: Flammable liquid, soluble or dispersed in water. SMALL FIRE: Use DRY chemical powder. LARGE FIRE: Use alcohol foam, water spray or fog.

Engineering Controls & Personal Protection

- Engineering Controls: Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapours below their respective threshold limit value. Ensure that eyewash stations and safety showers are proximal to the work-station location.
- Personal Protection to be used when handling methanol include: Splash goggles, lab coat, vapour respirator (be sure to use an approved/certified respirator or equivalent) and gloves.
- Personal Protection in Case of a Large Spill: Splash goggles, full suit, vapour respirator, boots and gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

REGULATION [5,6,7]

Exposure Limits

United States:

TWA: 200 from OSHA (PEL) [United States]

TWA: 200 STEL: 250 (ppm) from ACGIH (TLV) [United States] [1999] STEL: 250 from NIOSH [United States]

TWA: 200 STEL: 250 (ppm) from NIOSH SKIN

Australia:

TWA: 262 milligrams of methanol per cubic metre of air.

STEL: 328 milligrams of methanol per cubic metre of air.

Canada:

TWA: 200

STEL: 250 (ppm) [Canada]

European Union:

TWA: 200 PPM 8 hour(s).

TWA: 260 MG/M3 8 hour(s).

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'Crazy worms' have invaded the forests of 15 states, and scientists are worried

2021-04-27

Some call them crazy worms. Pick one up, and you'll see why, as the creepy-crawly jerks, writhes and springs out of your hand. (It may even leave its tail behind, as a grim souvenir.) And now, scientists are finding the wrigglers have spread to at least 15 states across the U.S.

The worms of the genus Amynthas — also known as snake worms, Asian jumping worms and Alabama jumpers, according to Smithsonian Magazine — are a highly invasive lot that first made their way to North America in the 19th century, stowed away on ships carrying plants and dirt. Since then, they've spread, well, like crazy, and have now been sighted in more than a dozen states, including Minnesota, Wisconsin, Missouri, Illinois, Iowa, Nebraska, Ohio, Texas, Louisiana, Indiana, Kansas, Indiana, Kentucky, Tennessee and Oklahoma, Newsweek.com reported.

They resemble common earthworms, only smaller and brownish in color. However, their reputation is far more sinister. Adult crazy worms reproduce quickly and without mates, laying clutches of eggs the same color as the soil, according to Smithsonian. Once they hatch, the worms swiftly devour the nutrients in the topsoil around them, leaving behind a loose, grainy mess that resembles coffee grounds.

However, their reputation is far more sinister.

This nutrient-depleted soil erodes quickly, leaving little sustenance for native plants, or competing species of worms and fungi, Brad Herrick, an ecologist at the University of Wisconsin-Madison, told PBS Wisconsin.

"One thing that we've noticed … is that these earthworms, not only do they change the soil structure and the nutrient dynamics in the soil, but they also somehow or another displace other species of earthworms that are already there," Herrick said.

It's unclear how, exactly, the worms continue to spread across the country. According to a January 2020 article in The Atlantic, scientists think the worms could be hitchhiking from across state borders in imported plants, on the treads of truck tires, by clinging to landscaping equipment or even sailing down waterways (their cocoons can travel surprisingly far in water).

Researchers are still investigating the long-term effects of these highly invasive worms on North America's forests — but, in the short-term, it's clear they're bad news for soil and the native worms that live there.

For now, there's no good way to control their spread in forests that they have already infested, according to Newsweek, but there is some guidance on what to do if you spot one in your garden. Simply place any adult worms you find in a bag, leave them in the sun for 10 minutes, then throw them away. If, that is, they don't jump out of your hands first.PLAY SOUND

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livescience.com, 27 April 2021

https://www.livescience.com

Marine microplastics are now invading the atmosphere, study finds

2021-04-27

Take a deep breath. The air that fills your chest and lungs is a vital mix of oxygen and nitrogen. Other things might be mingled in the air, too. For instance, small amounts of carbon monoxide, nitrogen dioxide, lead, or particulate matter such as dust and pollen commonly pollute the air. But there is something else lurking in the air we depend upon: tiny pieces of plastic.

A new study in the Proceedings of the National Academy of Sciences (PNAS) looks at how microplastics — plastic fragments smaller than 5 millimeters (about a fifth of an inch) but bigger than 1 micron — are emitted into the atmosphere, and end up spiraling around the globe in a process akin to the biogeochemical cycles of water or nitrogen. Right now, the environmental and health consequences of atmospheric plastic are largely unknown, and experts are calling for further research on the issue.

"What we wanted to do [was] try to understand how plastic is getting into the atmosphere," lead author Janice Brahney, assistant professor of natural resources at Utah State University, told Mongabay in an interview. "This is something that we don't know very well."

The authors hypothesize that plastic particles are "entrained into the atmosphere through mechanical processes." For example, sea spray is known to launch tiny plastic pieces into the air when bubbles break at the surface. Vehicles traveling along roads can also push plastic upwards. Farmers tilling their land and applying fertilizers made from biosolids, which have been shown to contain microplastics, as well as plastic mulch, are other potential sources.

But there is something else lurking in the air we depend upon: tiny pieces of plastic.

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By combining microplastic deposition data from 11 different sites in the western United States with an atmospheric transport model, the study found that roads emitted 84% of atmospheric microplastics, while the ocean emitted 11% and agricultural soil dust accounted for 4%. Cities didn't seem to contribute that much, which may run counter to what a lot of people may think, according to Brahney.

"If you've asked most people where they thought atmospheric microplastics were coming from, they would probably say a city," she said. "And we found that not to really be the case." This is probably because cities have large, tall buildings that disrupt airflow, she said, which would disable the wind's ability to lift microplastics into the air.

The study also found that annual plastic production on land wasn't the key source of atmospheric microplastics — that would be the marine environment. This highlights the role of "legacy pollution in atmospheric plastics," Brahney said.

"It's the plastics we've produced over decades and decades and decades that ends up in the marine environment, getting turned up and broken down and then emitted into the atmosphere," she said. "That was a really interesting finding because that again is opposite of what people might expect."

dThe mass production of synthetic plastic took off after WWII, when plastic packaging and disposable kitchenware gained in popularity. Since then, it's estimated that about 10 billion metric tons of plastic have been globally produced, and that 12-18% of this plastic has ended up in the natural world.

The study estimates that about 10 teragrams (10 million metric tons) of microplastics are emitted into the atmosphere each year, equivalent to the annual amount of anthropogenic black carbon emissions.

Study co-author Natalie Mahowald, an Earth and atmospheric scientist at Cornell University, said the paper may have raised more questions than it answered.

"We're just pointing out that there [are] atmospheric microplastics," Mahowald told Mongabay in an interview. "And we need to figure out what the sources are, what the impacts are, and how we can solve this problem."

To Mahowald, one of the most important things to investigate is how this influx of microplastics is impacting atmospheric processes.

"They're likely to … be interacting with clouds, especially ice clouds, but also could be changing the chemistry of the atmosphere," she said. "So not only are we worried about human health [and] ecosystem impacts, but there could be impacts on the earth system, on the climate system as well."

Steve Allen, a microplastics expert and co-author of another study on atmospheric microplastics, said the PNAS paper confirms assumptions that large amounts of microplastics are circulating in and out of the world's oceans.

"We had assumed that was the case but the modeling shows it quite clearly," he told Mongabay in an email.

He said that while the study's modeling was very sophisticated and detailed, the quantities it used were actually quite conservative.

"By giving it conservative inputs it may be underestimating quantities blowing offshore and blowing onshore," Allen said. "It is hard to quantify as yet because we have so few studies to base anything on. This study is a great first step towards it and shows how much more data we need.

"We can safely say that atmospheric microplastics are a real thing and [they are] clearly being transport[ed across] long distances," he added. "The studies on the effects of microplastics suggests that we need to do something about it. Now."

Both Brahney and Mahowald also say the issue needs to be urgently addressed, and that a lot more research needs to be conducted to understand the potential impacts of atmospheric microplastics.

"I think everyone on the planet should be concerned because if it [microplastic] is moving through the atmosphere, there's no surface of the Earth that's untouched by microplastic deposition or atmospheric microplastics," Brahney said.

"If we don't change our behavior, we can expect 10 times as much or more [microplastics in the atmosphere] in the next few decades because of the accumulation of the mismanaged plastics in the environment," Mahowald said. "So to me, that's the big thing [and] we're right at the beginning of seeing this problem."

news.mongabay.com, 27 April 2021

https://www.news.mongabay.com

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The fight to clean up the EPA

2021-04-27

THE ENVIRONMENTAL PROTECTION AGENCY recently acknowledged what was plain to most outside observers throughout the Trump era. "Over the past few years, I am aware that political interference sometimes compromised the integrity of our science," Michal Freedhoff, acting assistant administrator for EPA's Office of Chemical Safety and Pollution Prevention, wrote it in a March 10 internal memo. Freedhoff pointed to a 2020 risk evaluation of the chemical trichlorethylene, which she said was altered at the direction of White House staff; the 2018 decision to re-register the carcinogenic pesticide dicamba, for which senior leadership directed career staff to discount scientific information on negative impacts; and an assessment of the toxic compound PFBS, which the EPA released on Trump's last day in office and Freedhoff described as containing conclusions that were "the product of biased political interference."

"That interference undermined the agency's scientific integrity policy and eroded the trust that the American public has in EPA, the quality of our science, and our ability to protect their health and the environment," Freedhoff wrote.

The internal reckoning within the EPA is part of the Biden administration's effort to recommit to scientific integrity throughout the federal government. On his first day in office, the new president issued an executive order in which he pledged "to listen to the science; to improve public health and protect our environment; to ensure access to clean air and water; to limit exposure to dangerous chemicals and pesticides." A week later, the White House issued a memorandum that laid out a plan for how federal agencies should go about restoring trust in scientific integrity.

The internal reckoning within the EPA is part of the Biden administration's effort to recommit to scientific integrity throughout the federal government.

The pledges might come across as banal platitudes if they didn't directly follow four years in which political and corporate interests routinely prevailed over law and expert knowledge. Science took a hit throughout the federal government: at the Fish and Wildlife Service, the Department of Energy, and the Forest Service, and of course in the Oval Office, where Trump altered hurricane forecasts with a Sharpie and hyped ineffective coronavirus drugs. But the EPA weathered the last administration particularly badly, as industry insiders oversaw the disappearance of information about climate change from the agency's website; the reversal of the proposed ban on the neurotoxic pesticide chlorpyrifos; the altering of scientific documents to downplay cancer risks; the invitation of

companies by the agency to remove evidence of carcinogenic pollution from the public record; and a wide range of devastating rollbacks hugely consequential to the environment and human health.

Michael Regan, the recently appointed administrator, has already made it clear that he is intent on righting the ship. "Scientific integrity is one of EPA's foundational values," Regan declared in March, as he dismissed more than 40 advisers to the agency's Science Advisory Board and Clean Air Scientific Advisory Committee, which Trump had stacked with industry operatives.

Francesca Grifo, a scientist who has served as the EPA's top scientific integrity officer since 2013, is heading up the delicate work of rooting out the political interference in the agency. "We are on a reset," Grifo told The Intercept, going on to describe a process of informing staff members about the agency's science integrity policy, encouraging them to speak out about violations of it, and identifying gaps that left the agency vulnerable to an administration that didn't agree with it. "We will be seeking to close the loopholes," said Grifo. "Everything's on the table."

But even as the EPA begins this sweeping effort, some staff and environmental experts are already worrying that the agency's overhaul won't go far enough to successfully quash the powerful industries that have corrupted the agency during and well before the Trump administration.

Naming Names

The EPA has already begun to correct the scientific record marred under Trump. Earlier this month, it issued an updated toxicity assessment for PFBS, the PFAS compound that was the subject of the Trump administration's flawed assessment earlier this year and had been awaiting assessment for two years before that. But agency officials have not named or held accountable the people responsible for interference with that assessment or any of the other breaches of scientific integrity it has already identified. Nor does the agency intend to punish the employees and former employees who undermined the agency's operations, according to Grifo.

"We're not playing a blame game," Grifo told The Intercept. "The way our scientific integrity policy is written is that specific disciplinary accountability is not in our lane. So our work is to figure out what happened and safeguard the science."

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But the choice not to hold wrongdoers accountable leaves the agency vulnerable to ongoing corruption, according to several science and good government experts interviewed for this article. "The science integrity policy itself is pretty good," said Erik Olson, an attorney who began his career at the EPA and now directs the Natural Resources Defense Council's advocacy initiatives on health, food, and agriculture. "But if you have routine violations of the policy with no known consequences, it means that it's a paper tiger that isn't worth the paper it's written on."

Without consequences, the scientific integrity policy is essentially greenwashing.

Bill Hirzy, a chemist who worked at EPA from 1981 to 2008, agreed on the importance of accountability. "There should be disciplinary action of some meaningful sort — employment consequences, demotions, suspensions," said Hirzy, who helped author one of the agency's first science integrity policies. Without consequences, the scientific integrity policy is essentially greenwashing, said Hirzy. "It looks really good on paper. And when they go to congressional hearings, they can trot it out. But when bad stuff is happening in the agency, there is no way for them to remedy it."

Hirzy pointed to a provision within the policy that specifies that "it does not create any obligation, right or benefit for any member of the public, substantive or procedural, enforceable by law or in equity by any party against the United States, its departments, agencies, or entities, its officers, employees or agents, or any other person."

"That means you can't grieve it. And you can't bring any action against management for violations of it," he said. "That's the poison pill." Hirzy, who served as an officer of EPA Headquarters Professionals' union for 20 years, noted that none of the five unions that represent EPA employees were consulted in drafting the current policy or have a role in addressing complaints lodged through it.

Grifo said that the EPA's inspector general undertakes some investigations. But that office focuses on criminal cases of waste, fraud, and abuse and has only undertaken a very limited number of employee integrity cases in recent years.

An EPA scientist who filed a scientific integrity complaint with Grifo's office said they, too, feel it is imperative to hold corrupt actors responsible. "There have been multiple recent meeting about scientific integrity recently, and over and over they say that they are not here to punish," they said. "The word 'punish' always comes up here as, 'We are not here to

punish.' We hear that they want to create a new culture moving forward. But if there are absolutely no consequences when breaches of scientific integrity happen, then the policy doesn't have any effect."

The scientist, who spoke with The Intercept on the condition that their name, division, and subject of research were not mentioned, is one of hundreds of EPA staff members who reached out to Grifo's office during the Trump administration. According to slides Grifo presented to EPA staff on March 31, 73 people sought help from her office in 2020 alone: triple the number that queried the office in 2016. The biggest proportion of those, 64 percent, complained of interference. Others alleged suppression, manipulation of scientific evidence, and alteration of scientific products. The number of complaints that involved the office of the administrator also shot up under President Donald Trump. According to the presentation, the office was processing 25 active complaints as of March 31.

I Can't Sleep At Night

While the office works through that backlog, the people who have filed the outstanding complaints can be under extraordinary pressures.

"I can't sleep at night," said the EPA staffer who filed the scientific integrity allegation now pending with Grifo's office. "I am under so much mental strain, I couldn't get out of bed for a while." The scientist, who works on an issue of significance to public health, described witnessing their superior altering their work in a way that they believe could result in widespread health consequences. "I lie awake at night thinking about the impact this is going to have on the American public."

"I lie awake at night thinking about the impact this is going to have on the American public."

That unnamed scientist isn't suffering alone, according to Kyla Bennett, director of science policy at PEER, an organization that supports environmental whistleblowers. "Some of my clients who are involved in the scientific integrity process regularly call me sobbing on the phone because they're so afraid that their inability to stop the agency from doing what it's doing will harm the American public," she said.

While those who committed the violations aren't punished, the scientist said that some of the people they know who have called out improprieties at the agency have faced unofficial punishment. "Everyone I know or talk

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to who has filed a complaint has been retaliated against," they said, "and, so far, no one who has done the retaliation has been held accountable."

It's unclear how many EPA employees have faced retribution, but a 2020 survey of 181 staff members of the agency's Office of Pollution Prevention and Toxics suggests that the problem is rampant. Only 41 percent surveyed agreed with the statement that "I can disclose a suspected violation of any law, rule or regulation without fear of reprisal." And a mere 18 percent of respondents agreed with the statement that "My organization's senior leaders maintain high standards of honesty and integrity."

Big Money

Even though the agency is now in the hands of an administrator and president who have pledged to protect science, decisions about how to handle allegations may fall to staff who aren't as committed to that value. Since its inception, the agency has struggled against the influence of the wealthy and powerful industries it regulates, which can reward former employees while they're at the EPA and provide them with lucrative contracts and jobs after they leave the agency. And the problem extends beyond the political appointees, who have been the focus of most of the media attention of corruption within EPA in recent years.

"It's extremely difficult to weed out the influence of the regulated industries," said Hirzy, who described how the resources of energy and chemical companies have influenced employees at all levels within the agency. "The staff person wants to become a branch chief, the branch chief wants to become a division director, and the division directors want to be office directors and then assistant administrators. From there, they go to industry," he said.

And yet the current policy deputizes office directors and deputy directors to handle scientific integrity complaints. "There is a conflict there," said Amer Al-Mudallal, an EPA chemist and president of Chapter 280 of the National Treasury Employees Union. "It's not in the interest of the senior managers to bring these violations to the committee."

The scientist who filed an integrity complaint also worried about assigning managers any role in addressing scientific integrity issues. "Managers are not just complicit in integrity violations, but in some cases they are the agents of the integrity violations," they said.

Asked about involving division heads in the scientific integrity process, Grifo said that if they're worried about speaking with their own managers, staff members can reach out to her directly or to managers who work in other divisions of the agency.

The Cleanup

In the face of these pressures, EPA scientists left the agency in droves during the Trump administration. The unnamed scientist said they thought about quitting too: "We were at a point as a group where we would either leave our colleagues in the dust to be abused and ground down or to try to do something about it."

Ultimately, they decided to stay and file the science integrity complaint. While the pressures at work have remained in the months since, they still hope to stay at the EPA. "I feel a sense of responsibility that as long as I am able to put up with it, I don't want to abandon my colleagues and the American people."

Grifo, too, considered — and reconsidered — leaving during the Trump years, when EPA management sidelined and silenced her office. The muzzling was so severe that, in 2019, when House members invited her to speak at a hearing on a bill that would have given scientific integrity protections the force of law, Grifo wasn't even allowed to testify. (Instead the EPA sent a former Trump campaign worker who has ties to a Las Vegas casino and no science background.)

"Do I stay being partially effective? Or do I go and do something else? Or do I go and end up on the front page of the Times?" Grifo said of her thought process during those years. It was the hope of helping the agency recover that led her and the EPA's science adviser, with whom she works closely, to stay. "We wanted to be around for the cleanup," she said.

Now, as that cleanup process gets underway, many within the agency's ranks are desperately hoping it will strengthen protections to the point that EPA can withstand industry pressures not just during the Biden administration but under any administration that comes into the White House.

"My fear is that it's going to be back to square one as soon as we get another bad president in office," said the unnamed scientist, who is still

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awaiting a response to their complaint. "Unless we get some real change, we'll go right back to the dark ages."

theintercept.com, 27 April 2021

https://www.theintercept.com

Plastics and toxic chemicals are killing fish—and poisoning us

2021-04-27

Plastic, pesticides and other toxic substances are devastating the world's fish and marine animals, according to a report released Tuesday.

The study, which was not peer-reviewed, was published by the International Pollutants Elimination Network (IPEN), a global coalition of environmental organizations. It reviewed academic research conducted worldwide on the impacts of plastic and toxic chemicals, and is the first systematic review of these dispersed studies designed to paint a global picture of the problem.

The findings were dire: Pollution is compromising the world's oceans, fisheries and coastal communities while exacerbating the impacts of climate change and overfishing.

"Many people think that fish declines are just the result of overfishing," said Matt Landos, a researcher, aquatic veterinarian and co-author on the report.

"In fact, the entire aquatic food web has been seriously compromised with fewer fish at the top, losses of invertebrates in the sediments and water column, less healthy marine algae, coral and other habitats, (and) a proliferation of bacteria and toxic algae blooms. Chemical pollution (and) climate change … are the chief reason for these losses."

About three billion people worldwide rely on fish for protein, particularly in less wealthy countries, the report noted. In Canada, oceans, lakes and rivers are culturally and nutritionally vital to many Indigenous communities and support fisheries worth roughly $3.7 billion, according to Statistics Canada.

Yet fish and aquatic animal populations are falling worldwide, despite reduced pressure on wild fish populations. That includes aquatic animals in rivers and lakes — about 83 per cent of freshwater fish populations are in decline — to the world's oceans. And the proliferation of plastics and

About three billion people worldwide rely on fish for protein, particularly in less wealthy countries, the report noted.

chemicals, alongside overfishing, climate change and other stressors, is to blame.

Between 100,000 and 350,000 chemicals are sold today, and only about one per cent have been tested to assess their health and environmental impact, the report notes. Plastics are equally widespread, and about 8.3 billion tonnes have been produced since the 1950s, according to the UN.

Pesticides, pollutants like phthalates and per- and polyfluoroalkyls (PFAS), pharmaceuticals and plastics are particularly concerning, the report noted.

"Much of the action is taking place in animals' life stages that are largely hidden from the naked eye. (For instance), the impacts we're seeing are quite serious on embryonic life," Landos said.

The chemicals poison aquatic animals' immune, endocrine and other key biological systems, he explained. They can also bioaccumulate throughout the food chain, poisoning top predators like seals, whales — and people.

Plastics have an even broader impact as they're often eaten by fish and other animals, stuffing their stomachs and leaving them to starve. Microplastics also leach toxic chemicals into organisms and aquatic environment, Landos noted.

The study's findings come as no surprise to the principal investigator of the University of British Columbia's ocean pollution research unit, Juan Jose Alava Santos, who did not work on the report.

"Anthropogenic pollution is probably one of the main anthropogenic stressors in the Anthropocene — an era of global change where humans have basically reshaped and changed many ecological processes," he said. "The ocean is basically receiving a cocktail of chemicals that end up in the water and also in the sediment."

This pollution compounds with overfishing and climate change to upend the ecological balance of oceans, rivers and lakes, he said. That's because warmer and more acidic waters can pose health threats or habitat risks to vulnerable species, while overfishing transforms the predator-prey relationships between different aquatic animals.

"We see that it is kind of a conspiracy between climate change and overfishing (that can) exacerbate pollution in the environment," he said. Those impacts can be particularly felt in the world's pollution hot spots — places like the Arctic, the English Channel and the Salish Sea.

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In the Pacific Northwest and the English Channel, years of pesticide use and industrial pollution have left persistent organic pollutants in oceanic and riparian sediments. Meanwhile, global atmospheric currents carry pollution from temperate and tropical latitudes to the poles, where colder temperatures make them fall from the clouds and contaminate remote polar ecosystems, he explained.

Ending the crisis will take a wholesale transformation in how we use and regulate chemicals and plastics, Landos and Alava Santos agreed. Pollution can originate almost anywhere — from farm fields to landfills to factories — and pollution laws have so far failed to end the problem. Ending it will take a systemic transformation.

"So many of these issues come back to the way in which we've designed our economies as linear economies, with the primary driver in that linear economy being fossil fuels," explained Landos.

For instance, the oil and gas industry is banking on plastics to make up between 45 and 95 percent of its future growth, according to a 2020 report by the Carbon Tracker Initiative. Nor can other pollutants, from pesticides to PCBs, continue to be produced and released into the environment without exacerbating the crisis, Alava Santos echoed.

"We have to shift from thinking about maintaining a linear economy to moving to a circular economy that doesn't continuously add more pollution into the biosphere and hope that it's not going to have an ever-worsening effect," said Landos. "What the data says is that there is already a very, very serious effect (on biodiversity) from the pollution we've already generated."

nationalobserver.com, 27 April 2021

https://www.nationalobserver.com

People used to drink a very specific kind of urine to treat motion sickness

2021-04-28

Humans have been trying to understand and combat motion sickness for millennia. In 2017, a trio of neurobiologists from Munich looked at classic texts like the The Odyssey and Siku Quanshu and found different descriptions of nausea and dizziness relating to ship, cart, and even camel travel. Entire battles were lost because warriors got too sick on the open seas. But no matter what, each culture connected the ailment to different

Entire battles were lost because warriors got too sick on the open seas.

body parts: The Greeks and Romans blamed their stomachs, while the Chinese blamed their livers and their brains. These are all technically correct, though the true root of motion sickness is in your cerebrum. When fixed on a target like an enemy fort or a TikTok sea shanty, your eyes think that you're at rest while your vestibular system, located in your inner ear, tells your body that it's moving. This mismatch grows even stronger if you hit choppy waves or stop-and-go traffic.

Because ancient people didn't understand the cause of motion sickness, they used some pretty out-there remedies to try and cure it. Some would rub wormwood, wine vinegar, olive oil, and mint on their noses, or drink raindrops off the end of bamboo shoots. Others used poisonous plants like hellebore to clear out the stomach, and even drank pee from young children.

Today we know that the best way to fight the churn is to just get used to the turbulence, whether it be in hyper-realistic video games or on a birding boat trip. Modern medicine has also given us histamine-fighting solutions like dramamine and scopoline, but you can also try vetted prophylactics like soup crackers and apple slices. Just don't chug a can of ginger ale—your stomach will have a tough time breaking down the sugars, and you'll probably end up blowing chunks anyway.

Popsci.com, 28 April 2021

https://www.popsci.com

Climate change has been altering Earth's axis for at least 30 years

2021-04-29

Climate change has been altering Earth's poles since at least the 1990s, new research finds.

The planet's spin on its axis is determined, in part, by the distribution of weight around the globe, in the same way the spin of a top is determined by its shape. Satellite data from 2002 and later had already shown that climate change is altering this weight distribution, largely because melting glaciers and ice sheets have caused the North and South poles to drift.

Scientists had also observed polar drift in the 1990s, but uncovering the cause of that drift was tricky, because there were no direct satellite observations of water distribution around the globe from that era. Now, researchers have compared possible scenarios of total water distribution

Now, researchers have compared possible scenarios of total water distribution around the world and found that the best explanation for the changes to the poles in the 1990s is human-caused climate change.

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around the world and found that the best explanation for the changes to the poles in the 1990s is human-caused climate change. Melting ice sheets, combined with groundwater pumping for agriculture, altered the water distribution on the planet enough to make the planet's axis shift.

"The findings offer a clue for studying past climate-driven polar motion," said study co-author Suxia Liu, a hydrologist at the Chinese Academy of Sciences.

A changing axis

Earth's axis shifts for a lot of reasons, ranging from long-term changes in the heat-driven process of convection within the mantle to annual changes in ocean currents and winds. In 2002, NASA and the German Aerospace Center launched the Gravity Recovery and Climate Experiment (GRACE) satellites, which used measurements of Earth's gravity field to monitor changes in ice, liquid water and Earth's crust. GRACE's precise measurements allowed geoscientists to break down the various causes of polar shifts in the post-2002 era. It was clear that ice melt, driven by climate change, was having an influence. In 2013, for example, researchers reported in the journal Geophysical Research Letters that rapid melt of the ice in Greenland had caused an eastward shift of the North Pole around 2005.

Figuring out what caused polar shifts before 2002, though, required creativity. Researchers knew that polar drift shifted eastward in 1995 and that it sped up by 17 times between 1995 and 2020 compared with 1981 to 1995. But they didn't know why.

Liu and her colleagues used the real-world observations of how the poles shifted in the 1990s and created two possible global water-distribution scenarios to see which best explained the changes. In the first scenario, the changes in water distribution around the world between 1981 and 2020 were similar to what was recorded by GRACE between 2002 and 2020. In the second, the researchers took into account observations of ice melt during the earlier period.

The second scenario, which accounted for ice melt, better matched what really happened with polar drift, Liu and her colleagues found. Ice melt from the polar regions explained most of the polar drift, the researchers reported March 22 in the journal Geophysical Research Letters; the rest was explained by water loss from nonpolar regions.

Human activity

Like climate change, these shifts in water distribution were human-caused.

"[W]atching distribution of the hotpots of the change of the TWS [terrestrial water storage], they related to popular groundwater pumping regions," Liu wrote in an email to Live Science.

Humans pump an incredible amount of groundwater for agriculture. For example, in India alone in 2010, people moved 92 trillion gallons (351 trillion liters) of water from underground reservoirs onto agricultural fields, the researchers wrote in their paper. California and northern Texas also showed large mass changes due to groundwater pumping. Because of the physics of rotation, the movement of groundwater at the midlatitudes has a stronger effect on polar drift for the same amount of water at higher latitudes, they added, so these changes add up quickly.

Overall, the changes in polar drift aren't noticeable in daily life. They might alter the length of the day by a millisecond or so over time, Vincent Humphrey, a climate scientist at the University of Zurich who was not involved in this research, said in a statement. However, there are 176 years of data on polar drift — years in which scientists have no direct measurements of water distribution around the globe. Using polar drift, scientists can work backward to figure out where the water was.

"Our next step is to extend the relationship into operational forecasting with longer reconstructed data," Liu said.

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EPA rule to phase out gases used in refrigerators, coolants

2021-05-03

WASHINGTON — In the first Biden administration rule aimed at combating climate change, the Environmental Protection Agency is proposing to phase down production and use of hydrofluorocarbons, highly potent greenhouse gases commonly used in refrigerators and air conditioners.

The proposed rule follows through on a law Congress passed in December authorizing a 15-year phaseout of HFCs. The new rule is intended to decrease U.S. production and use of the gases by 85% over the next 15 years, part of a global phaseout intended to slow climate change.

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HFCs are considered a major driver of global warming and are being targeted worldwide. President Joe Biden has pledged to embrace a 2016 global agreement to reduce HFCs.

"With this proposal, EPA is taking another significant step under President Biden's ambitious agenda to address the climate crisis," EPA Administrator Michael Regan said in a statement Monday. "By phasing down HFCs, which can be hundreds to thousands of times more powerful than carbon dioxide at warming the planet, EPA is taking a major action to help keep global temperature rise in check."

The phasedown of HFCs is widely supported by the business community, Regan said, and "will help promote American leadership in innovation and manufacturing of new climate-safe products. Put simply, this action is good for our planet and our economy."

A huge pandemic relief and spending bill passed by Congress in December, and signed by former President Donald Trump, directs EPA to sharply reduce production and use of HFCs. The measure won wide support in both parties and was hailed as the most significant climate change law in at least a decade.

Besides targeting HFCs, the so-called American Innovation and Manufacturing, or AIM Act also promotes technologies to capture and store carbon dioxide produced by power and manufacturing plants and calls for reductions in diesel emissions by buses and other vehicles.

Delaware Sen. Tom Carper, a Democrat who chairs the Senate Environment and Public Works Committee, praised the EPA rule and said the United States was joining the rest of the world in reducing use of HFCs, helping to avoid the worst effects of global warming.

"Passing the AIM Act was a momentous climate achievement that will help save our planet, and today we are one step closer to its benefits being a reality," Carper said in a statement.

Carper and Sen. John Kennedy, R-La., pushed for the HFC proposal, which they said would give U.S. companies the regulatory certainty needed to produce "next-generation" coolants as an alternative to HFCs. Both men represent states that are home to chemical companies that produce the alternative refrigerants.

The HFC provision was supported by an unusual coalition that included major environmental and business groups, including the National Association of Manufacturers and the Air-Conditioning, Heating and

Refrigeration Institute, which represents companies that make residential and commercial air conditioners, water heaters and commercial refrigeration equipment.

The industry has long been moving to use of alternative refrigerants and was pushing for a federal standard to avoid a patchwork of state laws and regulations.

"EPA's action will help create the certainty necessary for U.S. companies to maintain their natural technological advantage in the global HFC marketplace," said Stephen Yurek, president and CEO of the heating and refrigeration group.

David Doniger, a senior climate and clean-energy official with the Natural Resources Defense Council, said the EPA rule will deliver "enormous public health and climate benefits to all Americans."

Replacing HFCs with safer, commercially available alternatives "is a critical and totally doable first step to head off the worst of the climate crisis ... that will save industry money in the bargain," Doniger said.

EPA estimates the proposed rule would save nearly $284 billion over the next three decades and prevent the equivalent of 187 million metric tons of carbon dioxide emissions, roughly equal to annual greenhouse gas emissions from one out of every seven vehicles registered in the United States.

Biden issued an executive order in January that embraces the 2016 Kigali Amendment to the 1987 Montreal Protocol on ozone pollution. The amendment calls for the U.S. and other large industrialized countries to reduce HFCs by 85% by 2036. Biden's order directs the State Department to prepare documents for submission of the amendment to the Senate for formal ratification.

chicago.suntimes.com, 3 May 2021

https://www.chicago.suntimes.com

First-known pregnant mummy discovered

2021-05-01

Researchers have discovered the world's first-known pregnant mummy, dating from the first century in Egypt. The find was unexpected, as inscriptions on the mummy's coffin suggested the remains inside belonged to a male priest, according to a new study.

"It's the first such preserved case," Ejsmond told Live Science in an email.

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The mummy was donated to the University of Warsaw in Poland in 1826; only recently did archaeologists with the Warsaw Mummy Project conduct a detailed analysis of the mummy while studying the National Museum in Warsaw's collection of animal and human mummies.

X-ray and CT scans of the mummy revealed that the remains inside belonged to a female and did not match the coffin and cartonnage case that was made for a male. The mummy was obviously not the remains of a priest named Hor-Djehuty from ancient Thebes, whose name was inscribed onto the coffin, the researchers said. PLAY SOUND

"It was complete surprise because we were looking for ancient diseases or causes of deaths," lead author Wojciech Ejsmond, co-director of the Warsaw Mummy Project said. "Also, we thought that this is a body [of] a priest."

The mummy turned out to be the remains of a female who died when she was between 20 and 30 years of age and was about 6.5 to 7.5 months pregnant, based on the circumference of the fetus's head.

"It's the first such preserved case," Ejsmond told Live Science in an email. There have previously been skeletons of pregnant women found, but no mummies with preserved soft tissue, he said.

The scans showed four mummified bundles — likely her lungs, liver, stomach with intestines, and heart — inside the female mummy. Those were extracted, embalmed and then placed back inside the mummy's abdominal cavity, which was a customary practice in ancient Egypt. But the fetus had not been similarly removed from the uterus.

The researchers haven't determined the sex of the fetus or why it was left in the womb.

The researchers hypothesize that the fetus may have been thought of as "still an integral part of the body of its mother, since it was not yet born," according to the study. A baby that didn't yet have a name may not have been thought of as a distinctive individual, as ancient Egyptian beliefs held that naming was an important part of being human.

"Thus, its afterlife could only have happened if it had gone to the netherworld as part of its mother," the authors wrote. Another hypothesis is that a fetus of that age would have been difficult to extract due to the thickness and hardness of the uterus, and so the people mummifying the mother may not have been able to extract the fetus without damaging her body or that of the fetus, they wrote.

The archaeologists are also not sure why this mummy was inside a male's coffin; however, it's thought that up to 10% of mummies are found in the "wrong" coffins, due to illegal excavations and looting, according to the study. What's more, there was damage to the wrappings on the mummy's neck, likely caused by robbers who may have stolen some amulets, according to the study.

The authors have called her the "Mysterious Lady of the National Museum in Warsaw" because there's still much that's unknown about her. "Her mummy represents a fine example of ancient Egyptian embalming skills, thus suggesting her high social standing," the authors wrote. She was also buried with a "rich set" of amulets, according to the study.

It's also not clear why she died. "High mortality during pregnancy and childbirth in those times is not a secret," Ejsmond told Science in Poland. "Therefore, we believe that pregnancy could somehow contribute to the death of the young woman."

The team now hopes to analyze small samples of blood that were preserved in the mummy's soft tissues to try to figure out the cause of death.

This find "allows us to gather first hand evidence" of prenatal health in ancient times, Ejsmond told Live Science. "We can make comparative studies with contemporary cases, look for traces of ancient medical procedures to study the history of medicine."

The findings were published April 28 in the Journal of Archaeological Science.

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A tiny gecko with a big personality and even bigger problem

2021-04-29

At just five centimeters from nose to tail, the Florida reef gecko is so frail that handling it with bare hands is enough to tear its skin. That makes catching it a tricky task: to do so safely, biologists wiggle their fingers in the leaf litter and look beneath cover—such as sabal palm fronds or debris, like wood—to spook any geckos-in-residence. Once they spot movement,

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they block off the area with their forearms and clear as much litter as possible, creating a trap. Then, they gently guide the gecko into a vial not much bigger than itself—all touch-free.

"These geckos are really, really fast," said Emily Powell, a gecko expert and evolutionary biology doctoral candidate at the University of Miami in Florida. "Your eyes have to be trained to [catch] that movement."

It's difficult, taxing, sometimes frustrating work, but it may just save the species from extinction, because while the reef gecko may be able to dash away from curious scientists, chances are it's not outrunning climate change.

"If we hadn't been interested in [this species] we would have just continued going about having absolutely no idea that they were potentially declining," said Stephanie Clements, the lead author of a recent study in Biodiversity and Conservation and a doctoral student at the University of Miami studying conservation biology.

Clements and Powell's paper is the first to assess the status of the Florida reef gecko (Sphaerodactylus notatus notatus) in Florida. The animal is a subspecies of the brown-speckled sphaero (S. notatus), a member of the dwarf gecko family that occurs in the Bahamas, Cuba, and the southernmost part of Florida, including Miami and the Florida Keys.

By comparing its vulnerability with that of other at-risk reptiles and amphibians in the United States, the authors concluded it's the most vulnerable reptile in the nation to sea level rise due to its dependence on low-lying coastal habitats.

…the authors concluded it's the most vulnerable reptile in the nation to sea level rise due to its dependence on low-lying coastal habitats.

Clements and her team surveyed 58 sites from Miami to the Florida Keys, including sites where the geckos were documented in the past and those with suitable habitat. They found geckos at just 41 percent of the sites in total, and discovered the geckos are absent from nine historical sites, indicating a population decline over the past century.

The authors estimate that a sea level rise of 2.2 meters, based on a 2015 forecast study looking at carbon emissions and energy infrastructure, would put 85 percent of the gecko's suitable habitat underwater. The finding may help inform the International Union for Conservation of Nature Red List database's regional population information, where the conservation status of the species across its entire range is ranked as least concern.

The Florida reef gecko may be a master at surviving periodic flooding, according to researchers. It displays habitat versatility and its eggs are more salt-tolerant than adults. The geckos have also been found taking refuge in trees and urban structures, such as parking lots and buildings.

"But sea level rise is a whole different ball game because that would be a permanent habitat change," Powell said.

Life as a Gecko

The Florida reef gecko is an underdog: small, vulnerable, unpopular, but surprisingly robust.

"They're teeny tiny, but big personalities," said Stuart Nielsen, a herpetologist at the Florida Museum of Natural History.

Dwarf geckos have binocular vision, meaning their eyes work independently, sort of like a chameleon's, to spot prey while keeping one eye (literally) on predators. Round, sticky toepads give the lizards their grip, and these charismatic toes also give the genus its name, roughly translating from Latin to mean "ball-fingered."

"[The genus is] mega-diverse, they have this really cool biology, they're charismatic," said Tony Gamble, a herpetologist and assistant professor of biology at Marquette University in Wisconsin. "And from a scientific standpoint, they're really good models to study evolution."

Powell, who jokingly refers to herself as "Lady of the Geckos," has spent hours in the field searching for, catching, and collecting data on brown-speckled sphaeros across southeastern Florida and the Bahamas. She said there are several differences between the Bahamian populations and those in Florida, including their size and coloration. For example, both male and female geckos in Florida can have three stripes on their heads, making it difficult to visually tease the sexes apart. Subspecies in the Bahamas, however, exhibit stronger sexual dimorphism, or differing characteristics between sexes. Bahamian populations also tend to be more colorful.

The brown-speckled sphaero lays one massive egg that can weigh up to a third of its body weight. While this implies a slow reproductive process, the geckos also occur in high densities, making for a complicated assessment of how well populations may be capable of rebounding after catastrophic events like a hurricane.

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For the tiny gecko, it's a big world out there. Survival in a rapidly changing coastal environment, imperiled by rising seas due to climate change is no easy feat.

Small Gecko, Big World

Sea level rise is the most obvious threat to the Florida reef gecko, a coastal specialist that desiccates easily and thrives on humidity. But the combined effects of other factors could make for an even more uncertain future.

The gecko's small size makes it an attractive snack for virtually any animal that can fit it in their mouth, Powell said. Other lizards, birds, snakes, even centipedes are all potential predators—many of which happen to be invasive in Florida. Invasive brown anoles, for example, are known to eat Florida reef geckos.

Other invasive species pose threats beyond predation. The Australian pine (Casuarina equisetifolia), a tall species of she-oak, smothers native plants and shrubs in shade and needles, killing the plants that reef geckos depend on. Another invasive species, the ashy gecko (Sphaerodactylus elegans), may be outcompeting its Florida reef gecko cousins for habitat and resources in Key West.

Lots of species living in coastal habitats are also vulnerable, Powell said, because those areas are often heavily impacted by human activity, such as development for desirable real estate. Every three in four Florida residents live on the coast, according to data from the National Oceanic and Atmospheric Administration, with nearly 1,000 people moving to the Sunshine State every day.

The geckos do have one advantage, according to Nielsen, who was not involved with the study: "They can live in lots of different types of habitats, both natural and disturbed."

Still, without more research, many factors remain unknown. For example, scientists know little about the geckos' salinity tolerance, how far they can travel, their resilience to storm surges and flooding, or even their full genetic profile.

Although their study focuses on Florida, Clements said the population decline and threats could imply that conservation efforts are also required throughout the rest of the species' Caribbean range. Island nations at high risk of climate change impacts, she said, often lack the funds and resources to conduct research on an obscure dwarf gecko species.

"There are these compounding effects of us just not knowing anything, and then also having all of these extra risks," Clements said.

And the reef gecko continues to keep scientists on their toes. Biologists have documented surprising fluctuations in population densities, especially before and after hurricanes. Nielsen said the geckos' reliance on microhabitat might play a role, such as their affinity for seagrape (Coccoloba uvifera), a native coastal plant with broad leaves that block sunlight, creating a damp understory with plenty of leaf litter to shelter in.

Nielsen said he didn't spot a single gecko in a park on Key Biscayne, off the coast of Miami, for a couple of years after Hurricane Irma in 2017. But once seagrapes returned to the park, so did the geckos.

"As long as seagrape survives, I think it stands a chance," Nielsen said. "I think they're far more resilient than we probably give them credit for."

Saving a Species at Risk

If the Florida reef gecko is indeed as threatened as the authors' data imply, that means we may need to act fast to protect what's left of them. But how do you save a species hardly anyone knows about?

"If you don't know what it is, you won't want to protect it," said Rangel Diaz, a recreation specialist in the Conservation and Learning Department at the Deering Estate in Miami.

Diaz said visitors to the 180-hectare Deering Estate protected area rarely know what Florida reef geckos are. "Most people don't ever see them," he said, though the geckos have been known to make their way into the bathrooms and staff offices. Preserved areas like Deering Estate, a tropical hardwood hammock ecosystem, still foster thriving populations. The preserve is elevated above sea level, making it less at risk to storm surges during hurricanes than other nearby coastal areas.

The reef gecko population at Deering Estate supports the idea that a micro reserve conservation approach may help protect local populations. Micro reserves are small patches of protected area, which seem well-suited to the geckos, the authors say.

However, Clements said it's still uncertain whether the approach would be successful. Small habitat patches have greater "edge area," which could invite unintended consequences like higher rates of predation. Indeed, maps of the gecko's existing habitat show severe fragmentation, which

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can increase these "edge effects," isolate populations, and limit genetic diversity by restricting breeding opportunities.

Longing to Belong

The researchers submitted a listing petition making the case that state officials include the Florida reef gecko as an endangered or threatened species. Based on International Union for Conservation of Nature criteria, the gecko's Florida populations could be endangered, Clements said. But while state and federal criteria include variables such as population size, range size, and distribution, she said they do not include variables accounting for climate change or sea level rise.

"It's easy for a population that is potentially genetically important to just go extinct without anyone noticing, if the whole species is considered to be not at risk," Powell said.

Others in the scientific community are unsure the state will grant conservation status to the species, because the question of its origins—and whether it is in fact native—remains up in the air.

Historical accounts of the species in Florida date back to the 1850s, not long after Key West officially became a US territory in 1822, supporting one theory that humans accidentally introduced the geckos from Cuba via cargo ships. Another hypothesis is that it was a "wave species," Nielsen said, blown to the Florida mainland from the Caribbean islands via hurricanes.

However, Powell's genetic data tell a different story.

"The genetics suggest that they are native … that originally they colonized Key Largo, not Key West," said Powell, who studies speciation.

While the data still require DNA samples from Cuban populations, her findings could refute the existing hypothesis that the species was introduced to Florida.

"Sphaerodactylus geckos are great colonizers, they're really good at getting across bodies of water, and they've done it all over the Caribbean," Gamble said. "Depending on how unique they are, that will determine what level of effort is necessary to keep them a part of the fauna of South Florida."

For now, gecko enthusiasts can only hope the nimble S. notatus will stick around long enough for people to learn its name.

"We should probably start doing things now to protect it," Diaz said, "because [if not] we're going to lose it."

hakaimagazine.com, 29 April 2021

https://www.hakaimagazine.com

How scientists caught footage of 'the kraken' after centuries of searching

2021-05-01

Architeuthis dux — the world's largest known squid — is surprisingly camera shy.

The elusive giant squid has wriggled its way into folklore for thousands of years, inspiring tales of fearsome krakens with bodies as large as islands. In reality, A. dux is a tad smaller than that, capable of growing to about 46 feet (14 meters) long — about the length of a semi-trailer.

But despite their size, these cephalopods are almost never seen in the water; most observations of the behemoths come from dead or dying squids that wash up on shores or become ensnared in deep-sea trawling nets. That finally changed in 2012, when a team of marine scientists filmed a young A. dux in its natural habitat, about 2,000 feet (630 m) below the sea south of Japan.

Now, a study published online in the journal Deep Sea Research Part 1: Oceanographic Research Papers delves into why these giants of the deep are so elusive, and explains how a team of researchers was able to capture the first footage of A. dux in its natural habitat in 2012, and again in 2019 in the Gulf of Mexico.

According to the study authors (many of whom were present for the 2019 giant squid sighting), the creature's evasiveness is due, in part, to its enormous eyes.

Giant squids can live thousands of feet below the ocean's surface. Very little sunlight can penetrate this deep so to adapt, the giant squid evolved the largest eyes in the animal kingdom. Each of these cephalopods' peepers are about as large as a basketball — roughly three times the diameter of any other animal, Live Science previously reported.

These huge eyes not only help giant squids make their way around the deep, dark ocean, but probably also make them extra sensitive to the bright lights that marine researchers mount to their submersibles and

In reality, A. dux is a tad smaller than that, capable of growing to about 46 feet (14 meters) long — about the length of a semi-trailer.

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underwater cameras, according to the study authors. That sensitivity could explain why giant squids are so hard to find in their natural habitats; by the time a research vehicle reaches a squid's swimming grounds, the squid has long since fled the craft's lights and vibrations.

To correct this over-illumination, the researchers involved in the 2012 and 2019 A. dux sightings turned down the lights on their submersible (named the Medusa). After reaching the desired depths, the Medusa turned off its lights and stopped moving, allowing creatures of the deep to come to it rather than actively navigating across the bottom of the sea. The team also illuminated its camera with a dim red light instead of the bright white lights typically used on expeditions like these, capitalizing on a natural deep-sea color-blindness.

"Many deep-sea species, including squid, have monochromatic visual systems that are adapted to blue [light] and blue bioluminescence rather than long wavelength red-light," the researchers wrote in the study. "Using red light may thus be a less obtrusive method for illuminating deep-sea species for videography."

The researchers also used the squids' attraction to blue light to their advantage, outfitting the Medusa with a custom lure that they called the E-Jelly. This small, spinning ring of neon blue lights sat on the end of an outstretched arm, mimicking the movement and glow of a bioluminescent jellyfish.

The lure worked, drawing A. dux out of the darkness in both 2012 and 2019. In fact, the giant squid spotted in the Gulf of Mexico was a little too convinced by the E-Jelly's display; as footage of the encounter shows, the giant squid tried to attack the Medusa's camera arm with its tentacles in the hope of taking home a nice jellyfish meal. (This assault enabled the team to measure the squid's tentacles, which appeared nearly 6 feet, or 1.8 m, long).

This strategy of combining low-light equipment with bioluminescent bait seems to be the most effective known method of tricking the giant squid out of hiding, the researchers concluded. That's a handy trick, as there is much to learn about the kraken's behavior that can only come to light in the darkness of its natural habitat.

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Persuading the body to regenerate its limbs

2021-03-03

Each year, researchers from around the world gather at Neural Information Processing Systems, an artificial-intelligence conference, to discuss automated translation software, self-driving cars, and abstract mathematical questions. It was odd, therefore, when Michael Levin, a developmental biologist at Tufts University, gave a presentation at the 2018 conference, which was held in Montreal. Fifty-one, with light-green eyes and a dark beard that lend him a mischievous air, Levin studies how bodies grow, heal, and, in some cases, regenerate. He waited onstage while one of Facebook's A.I. researchers introduced him, to a packed exhibition hall, as a specialist in "computation in the medium of living systems."

Levin began his talk, and a drawing of a worm appeared on the screen behind him. Some of the most important discoveries of his career hinge on the planarian—a type of flatworm about two centimetres long that, under a microscope, resembles a cartoon of a cross-eyed phallus. Levin is interested in the planarian because, if you cut off its head, it grows a new one; simultaneously, its severed head grows a new tail. Researchers have discovered that no matter how many pieces you cut a planarian into—the record is two hundred and seventy-nine—you will get as many new worms. Somehow, each part knows what's missing and builds it anew. What Levin showed his audience was something even more striking: a video of a two-headed planarian. He had cut off the worm's tail, then persuaded the organism to grow a second head in its place. No matter how many times the extra head was cut off, it grew back.

The most astonishing part was that Levin hadn't touched the planarian's genome. Instead, he'd changed the electrical signals among the worm's cells. Levin explained that, by altering this electric patterning, he'd revised the organism's "memory" of what it was supposed to look like. In essence, he'd reprogrammed the worm's body—and, if he wanted to, he could switch it back.

Levin had been invited to present at an A.I. conference because his work is part of a broader convergence between biology and computer science. In the past half century, scientists have come to see the brain, with its trillions of neural interconnections, as a kind of computer. Levin extends this thinking to the body; he believes that mastering the code of electrical charges in its tissues will give scientists unprecedented control over how

No matter how many times the extra head was cut off, it grew back.

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and where they grow. In his lab, he has coaxed frogs to regenerate severed legs, and tadpoles to grow new eyeballs on their stomach.

"Regeneration is not just for so-called lower animals," Levin said, as an image of Prometheus appeared on the screen behind him. Deer can regenerate antlers; humans can regrow their liver. "You may or may not know that human children below the age of approximately seven to eleven are able to regenerate their fingertips," he told the audience. Why couldn't human-growth programs be activated for other body parts—severed limbs, failed organs, even brain tissue damaged by stroke?

Levin's work involves a conceptual shift. The computers in our heads are often contrasted with the rest of the body; most of us don't think of muscles and bones as making calculations. But how do our wounds "know" how to heal? How do the tissues of our unborn bodies differentiate and take shape without direction from a brain? When a caterpillar becomes a moth, most of its brain liquefies and is rebuilt—and yet researchers have discovered that memories can be preserved across the metamorphosis. "What is that telling us?" Levin asked. Among other things, it suggests that limbs and tissues besides the brain might be able, at some primitive level, to remember, think, and act. Other researchers have discussed brainless intelligence in plants and bacterial communities, or studied bioelectricity as a mechanism in development. But Levin has spearheaded the notion that the two ideas can be unified: he argues that the cells in our bodies use bioelectricity to communicate and to make decisions among themselves about what they will become.

Levin's work has appeared both in textbooks and in Japanese manga. He publishes between thirty and forty papers a year, and his collaborators include biologists, computer scientists, and philosophers. He is convincing a growing number of biologists that it is possible to decipher, and even speak, the bioelectric code. Tom Skalak, a bioengineer and the vice-president for research emeritus at the University of Virginia, told me that Levin plays a subversive role in a field that has tended to focus on how genes direct growth. "He goes well beyond the dogma of 'a gene makes a protein, and the protein makes a cell phenotype, and if you just understand genes and proteins you'll understand everything,' " Skalak said.

Grasping the bioelectric code, Levin believes, will give us a new way of interacting with our bodies. "In an important way, control over three-dimensional shape is the pressing problem of biomedicine," he told me. "If you think about it, everything other than infection could be handled if we controlled shape. So birth defects, traumatic injury, aging, degenerative

disease, cancer." He continued, "If we could understand what three-dimensional shape really was, we could do almost anything."

Levin was born in Moscow in 1969. As a child, he spent hours looking at bugs and electrical parts. One day, to distract him when he was having an asthma attack, his father turned the family's TV set around and opened up the back. Levin stared, marvelling, he told me, that "somebody knew exactly how to put all the parts in the exact correct order to make the cartoons come out the other end." He started collecting bugs in earnest at the age of seven, around the same time that he took up books on physics and astronomy. "As amazing as the TV set is, this is even more so," he recalled thinking, of how an egg transforms into a caterpillar, then a chrysalis, then a butterfly. "It becomes this amazing little robot that will run around and do things and have a life of its own." With the bugs on his mind, he learned to build a radio by taking one apart.

At eight or nine, with the help of his father, Levin started reading books about cybernetics—the study of "control systems," created in the late nineteen-forties by the computing pioneer Norbert Wiener. A cybernetic system, such as a thermostat, controls itself using feedback: a thermometer detects a change in room temperature, and then turns on the heat or cooling system until the desired temperature has been reached. Cybernetic systems work through a kind of internal conversation, and can accomplish surprisingly complex tasks, such as maintaining a car's speed while on cruise control or regulating an animal's metabolism. It seemed reasonable to think that the developing body itself was cybernetic: its many parts used inner feedback mechanisms to align around shared goals.

Levin's parents faced anti-Semitism in the Soviet Union. In 1978, when he was nine, they took advantage of a visa program for Soviet Jews and moved the family to Lynn, Massachusetts, spending three months on the way as refugees in Italy. Levin's father, who had programmed computers for the Soviet weather service, landed a job at Compugraphic, a typesetting company. He brought home old equipment, including a computer with a black-and-white monitor that ran only Fortran, an early programming language. When Levin told his parents that he wanted to play Pac-Man, his father said that he could do it only if he programmed his own version.

By the time Levin succeeded, he'd moved past playing to programming. He'd also set up a rudimentary biology lab in his bedroom, ordering dangerous chemicals shipped to the made-up "St. Augustine School

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of Science" at his home address. He tested whether bean plants could navigate mazes as they grew, and investigated their responses to magnetic fields.

In 1986, when Levin was seventeen, he and his father attended the World's Fair, in Vancouver. There, at a used-book store, he discovered "The Body Electric: Electromagnetism and the Foundation of Life," a scientific memoir in which Robert O. Becker, an orthopedic surgeon, described the experiments he had carried out on salamanders and other animals, exploring the role that electricity played in their development and in their ability to regenerate limbs. (Salamanders can regenerate their severed limbs and tails; if you remove a leg and graft on a tail, the tail morphs into a leg.) "It looked like everything I was thinking about," Levin said. Reading his way through Becker's bibliography, he learned that medical interest in electricity was thousands of years old. Anteros, a former slave of the Roman emperor Tiberius, had stepped on an electric fish at the beach and found relief for his gout; in seventeenth-century Europe, "medical electricity" was used to treat impotence and other ailments. In the nineteenth century, the Italian physician Luigi Galvani had argued for the existence of an inherent "animal electricity," showing that touching the end of a frog's severed nerve to the outside of one of its muscles completed a circuit, making the muscle twitch. This phenomenon, called galvanism, became a plot device in Mary Shelley's "Frankenstein."

In the twentieth century, the reality of bioelectricity began to come into focus. In 1909, it was discovered that larval salamanders regenerate faster when electricity courses through their aquarium water; in the following decades, researchers measured distinct bioelectrical patterns associated with development and wound healing. Eventually, biologists came to understand that electricity is integral to cellular life. Cell membranes are studded with tiny valves known as ion channels, which maintain the cell's negatively charged interior and positively charged exterior by allowing charged atoms called ions to flow in and out. Some ion channels open or close in response to the voltage outside, leading the cell to change its behavior in response to electrical signals and thereby creating a feedback loop. Cells employ the bioelectric system as a kind of intercellular internet; they use it to build intricate and expansive communication networks that control the transcription of genes, the contraction of muscles, and the release of hormones. Many drugs target ion channels, using them to treat arrhythmia, epilepsy, and chronic pain.

When Levin arrived for college at Tufts, in 1988, he decided to major in computer science, so that he could work on artificial intelligence. But he

also found himself contemplating all the creatures—the "little robots"—that seemed to contain the secret of computing. "There are amoebas that are storing memories," he recalled thinking at the time. "There are eggs that develop into amazingly patterned creatures." He added a biology major.

Levin had been calling researchers and reading everything he could on the topic of bioelectricity. He showed his reading list to Susan Ernst, a biologist at Tufts; she was impressed, but told him that she had no room in her lab for more undergraduates. The next day, she changed her mind. "I said out loud to myself, 'How can I consider myself a teacher and turn him away?' " she told me. She called Levin, and they decided that he would apply electromagnetic fields to sea-urchin embryos. "We found that, sure enough, it screwed up development pretty good," he said.

Levin struck Ernst as "irrepressible." He began borrowing not just equipment but personnel from other labs: Ernst, who is now retired, grew used to seeing students she didn't know at her microscopes, working on Levin's experiments. As an undergraduate, even as he ran a small backup-software company with his father, Levin was the primary author of two papers published with Ernst. When he earned a Ph.D. at Harvard Medical School, in 1996, for groundbreaking work on how bodies learn to distinguish left from right, his dissertation adviser, the geneticist Clifford Tabin, gave him a congratulatory toast. "You are the most likely to crash and burn and never be heard from again," Tabin recalls saying. "You're also the most likely to do something really fundamentally important, that no one else on earth would have done, that will really change the field."

Levin ran a developmental-biology lab at Harvard's Forsyth Institute until he returned to Tufts as a professor, in 2008. In 2016, the Microsoft co-founder Paul Allen awarded him a four-year, ten-million-dollar grant, with which he established the Allen Discovery Center; its stated mission is to crack the morphogenetic code—the system that "orchestrates how cells communicate to create and repair complex anatomical shapes."

When I visited Levin's lab at Tufts, a few months before the pandemic, he steered me down a hall lined with enlarged journal covers featuring his work. We passed an administrative area—"This is the human space," he said—then visited a microscopy suite, a chemical room, and a large lab; finally, we made our way to "worm world"—a room where industrial-sized incubators hummed. Levin pointed through an incubator's glass doors to racks of Tupperware containers, each holding thousands of planaria

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swimming in Poland Spring water and eating organic beef liver: "The good life," he said.

The containers were casserole dishes filled with floating specks. Some contained worms with strange heads—spiky, tubular, hat-shaped—while one held the famous two-headed worms. "We got one worm from Japan in 2000, and we chopped it up into pieces," Levin explained. Most of the inhabitants of worm world were descendants of the same parent.

When animals develop, they don't follow a script. Instead, responding to their environment, the cells negotiate and feel their way toward a final form. A fertilized egg divides, and divides again, creating a hollow ball of cells called a blastula; genes instruct these cells to release chemicals, and other cells, reacting to those chemical concentrations, decide to migrate elsewhere or to develop into specific types of tissue. Other influences—oxygen, nutrients, hormones, sometimes toxins—further shape gestation.

It's tempting to think that genes contain blueprints for the body and its parts. But there is no map or instruction set for an organ inside a cell. "The first decisions you make are not behavior decisions, they're growth decisions," Levin told me, and the most crucial choices—"where your eyes go, where your brain goes, which part's going to be a leg, which part's going to be an arm"—emerge without a central directive. Kelly McLaughlin, a molecular biologist at the Allen Center, explained that it was simple "to take stem cells and cause them to make heart cells beating in a dish." And yet, she went on, "those heart cells are a sheet of cells, beating in a dish, flat." Cells turn into three-dimensional organs by interacting with one another, like water molecules forming an eddy.

Mathematicians and computer scientists, versed in the language of self-organizing systems—crystals, traffic, storms—have turned out to possess useful conceptual tools for understanding development. "One is modularity," Levin said: elements of a system can be connected in a module, and then triggered "anywhere, at any time, in new contexts." Another is the "test-operate-exit" loop: "Keep moving, until the error of anatomy is small enough, and then stop." Cell groups, he said, are capable of following lots of different plans; they shift their goals depending on what their neighbors are doing.

Down the hall from worm world, Levin showed me the lab's microinjection room. Thousands of frog embryos are transferred there twice a week, so that researchers can analyze their developmental decisions. The scientists' first task is to eavesdrop on bioelectric patterning. In 2011, Dany Spencer Adams, a postdoc in Levin's lab, bathed a frog embryo in a voltage-

sensitive dye; in the area of tissue where the face would later form, she saw an electrical pattern, which Levin described as resembling "a paint-by-numbers puzzle." It was a glowing image of a face.

The researchers suspected that, if they could re-create this "electric face" elsewhere in the body, they would be able to grow a face there, too. They induced the cells in what would become the embryos' stomach to build extra ion channels, encouraging an electric image of an eye. In the spots where they placed this paint-by-numbers pattern, some of the embryos developed extra eyes. In time, their nervous systems began building optic nerves to connect the new eyes to the brain by way of the spinal cord.

It was as though the team had spoken the keyword "eye." The cells started talking about building one, and everything else followed. Not all patterns are as simple to interpret or create as the electric face; prompting the regeneration of a missing ear or hand, Levin said, may require detecting and mastering bioelectric patterns that are abstract and hard to decipher. Still, it may be possible to find keywords for them—smaller pieces of the pattern that can get cells coöperating along the right lines.

Patterns aren't the only way to inspire coöperation. In 2018, Levin's team attached a plastic cuff containing progesterone, a hormone that alters the behavior of ion channels, to the stump where a frog had once had a leg. They left the cuff on for twenty-four hours, then observed for about a year. Ordinarily, a frog that's lost a leg will regrow a cartilaginous spike in its place. But the frogs in the experiment grew paddle-like limbs. About nine months later, little toes started to emerge. Levin thinks that, eventually, the same kind of cuff could be used on humans; you might wear one for a few months, long enough to persuade your body to restart its growth. (Ideally, researchers would find a way to speed development, too; otherwise, you'd be stuck with a tiny arm for years.)

Levin was wary of showing me any mouse experiments. He has grown tired of hearing his work compared to the sinister alchemy described in "Frankenstein." "That story is about scientific irresponsibility," he said. Although his research is in many ways unusual, it is ordinary in its treatment of animals—by some estimates, American researchers experiment on more than twenty-five million a year. "I get two types of e-mails and phone calls," Levin told me. "Some of the people call and say, 'How dare you do these things?' for various reasons—animal rights, playing God, whatever. And then most call and they say, 'What the fuck is taking you so long?' " From time to time, Levin receives a call from a would-

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be volunteer. "I'm going to come down to your lab," he recalled one of them saying, "and I'll be your guinea pig. I want my foot back."

None of the developmental biologists I spoke with expressed any doubt that we would someday be able to regrow human limbs. They disagreed only about how long it would take us to get there, and about how, exactly, regrowth would work. Other projects explore growing body parts in labs for transplantation; 3-D-printing them whole, using tissue cells; flipping genetic switches ("master regulators"); or injecting stem cells into residual limbs. The solution may eventually involve a medley of techniques.

Levin's vision isn't confined to limb regrowth; he's interested in many other forms of morphogenesis, or tissue formation, and in how they can be modelled using computers. He led me down the hall to a room where an elaborate, waist-high machine glowed. The device consisted of twelve petri dishes suspended above an array of lights and cameras, which were hooked up to a cluster of high-powered computers. He explained that the system was designed to measure tadpole and planarian I.Q.

In a study published in 2018, Levin's team bathed frog embryos in nicotine. As they expected, the frogs exhibited a range of neural deformities, including missing forebrains. The researchers then used a piece of software called BETSE—the BioElectric Tissue Simulation Engine—that a member of the Allen Center, Alexis Pietak, had built. In this virtual world, they applied various drugs and observed their effects on both bioelectric signalling and brain development, hoping to find an intervention that would reverse the nicotine's damage. The software "made a prediction that one specific type of ion channel can be exploited for just such an effect," Levin said. The team tried the drug on real embryos that had been damaged by nicotine, and found that their brains rearranged themselves into the proper shape. The software, the researchers wrote, had allowed for "a complete rescue of brain morphology."

The I.Q. machine gave them another way to measure the extent of the rescue. Inside it, colored L.E.D.s illuminate petri dishes from below, dividing them into zones of red and blue; when a grown tadpole ventures into the red, it receives a brief shock. Levin found that normal tadpoles uniformly learned to avoid the red zones, while those that had been exposed to nicotine learned to do so only twelve per cent of the time. But those treated with the bioelectricity-recalibrating drug learned eighty-five per cent of the time. Their I.Q.s recovered.

Researchers disagree about the role that bioelectricity plays in morphogenesis. Laura Borodinsky, a biologist who studies development

and regeneration at the University of California, Davis, told me that "there are many things that we still need to discover" about how the process works, including "how the genetic program and the bioelectrical signals are intermingled." Tom Kornberg, a biochemist at the University of California, San Francisco, studies another intercellular system that is similar to bioelectricity; it consists of morphogens, special proteins that cells release in order to communicate with one another. Kornberg's lab investigates how morphogens move among cells and tell them what to do. "What is the vocabulary? What's the language?" Kornberg said, in reference to morphogenesis. There is probably more than one.

Tabin, Levin's former adviser and the chair of genetics at Harvard Medical School, told me that he is "agnostic" about how bioelectricity should be understood. Levin describes bioelectricity as a "code." But, Tabin said, "there's a difference between being a trigger to initiate morphogenesis versus storing information in the form of a code." He offered an analogy. "Electricity is required to run my vacuum cleaner," he said. "It doesn't mean there's necessarily an electric code for vacuuming." The current flowing through the outlet isn't telling the vacuum what to do. It's just turning it on.

Levin thinks that bioelectricity is more complex than that. The right bioelectrical signal can transform a Dustbuster into a Dyson—or a tail into a head. Tweaking the signal produces highly specific outcomes—a head that's spiky, tubular, or hat-shaped—without the need to adjust individual genes, ion channels, or cells. "You can hack the system to make the changes," Levin said. "Currently, there's no competing technology that can do these things."

Levin's work has philosophical dimensions. Recently, he watched "Ex Machina"—a sci-fi film, directed by Alex Garland, in which a young programmer is introduced to Ava, a robot created by his tech-mogul boss. Unnerved by how beguilingly realistic Ava is, the hero slices his own arm open in search of wires. Since childhood, Levin, too, has wondered what we are made of; having become a father himself, he enjoys talking about such questions with his sons, who are now teen-agers. Once, when his older son was six or seven, Levin asked him how a person could be sure that he hadn't been created mere seconds ago, and provided with a set of implanted memories. "I didn't really think about what the consequences for a kid might be," Levin said, laughing and a little embarrassed. "He was upset for about a week."

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Our intuitions tell us that it would be bad to be a machine, or a group of machines, but Levin's work suggests precisely this reality. In his world, we're robots all the way down. A bioelectrical signal may be able to conjure an eye out of a stomach, but eye-making instructions are contained neither in the cells' genome nor in the signal. Instead, both collectively and individually, the cells exercise a degree of independence during the construction process.

The philosopher Daniel Dennett, who is Levin's colleague at Tufts, has long argued that we shouldn't distinguish too sharply between the sovereign, self-determining mind and the brute body. When we spoke, Dennett, who has become one of Levin's collaborators, was in bed at a Maine hospital, where he was recovering from hip surgery. "I find it very comforting to reflect on the fact that billions of little agents are working 24/7 to restore my muscles, heal my wounds, strengthen my legs," he said.

In our discussion of Levin's work, Dennett asked me to imagine playing chess against a computer. He told me that there were a few ways I could look at my opponent. I could regard it as a metal box filled with circuits; I could see it as a piece of software, and inspect its code; and I could relate to it as a player, analyzing its moves. In reality, of course, a chess computer offers more than three levels of explanation. The body allows more still: genetics, biophysics, biochemistry, bioelectricity, biomechanics, anatomy, psychology, and finer gradations in between, all these levels acting together, each playing an integral role. Levin doesn't claim to understand the entire system, nor does he maintain that bioelectricity is the only important level. It's just one where he's found some leverage. He likens revising an organism's body through bioelectric stimulation to launching software applications. "When you want to switch from Photoshop to Microsoft Word, you don't get out your soldering iron," he said.

In modifying the body, Levin is more whisperer than micromanager; he makes suggestions, then lets the cells talk among themselves. "Michael has these brilliant examples of how individual cells communicate with each other," Dennett said. But the reverse is also true: when communication breaks down, cells can go haywire. Consider cancer, Levin said. It can be created by genetic damage, but also by disruptions in bioelectric voltage. In an experiment reported in 2016, Levin's team injected cancer-causing mRNA into frog embryos, and found that injected areas first lost their electrical polarity, then developed tumor-like growths. When the researchers counteracted the depolarization, some of the tumors disappeared. In Levin's terms, the cancer cells had lost the thread of the wider conversation, and begun to reproduce aimlessly, without

coöperating with their neighbors. Once communications had been restored, they were able to make good decisions again.

Having built radios as a kid, Levin now hopes to assemble bodies from first principles. His ultimate goal is to build what he calls an "anatomical compiler"—a biological-design program in which users can draw the limbs or organs they want; the software would tell them where and how to modify an organism's bioelectric gradients. "You would say, 'Well, basically like a frog, but I'd like six legs—and I'd like a propeller over here,' " he explained. Such a system could fix birth defects, or allow the creation of new biological shapes that haven't evolved in nature. With funding from DARPA—a federal research agency contained within the Department of Defense—he is exploring a related possibility: building machines made from animal cells. Recently, Josh Bongard, a computer scientist at the University of Vermont, designed a computer model in which small robotic cubes connect, creating microrobots that might someday clean up toxic waste or perform microsurgery. Levin took stem and cardiac cells from frogs and sculpted them into blobs that approximated the robot designs; they began working together, matching the simulations. Bongard likened Levin to a magician pulling rabbits out of a hat. "After a while, you start asking not just what's in the hat," he said, "but how deep does the inside of that hat go?"

On a warm afternoon, Levin and I drove out to Middlesex Fells Reservation—a twenty-six-hundred-acre state park with more than a hundred miles of trails. We set out through the woods along Spot Pond, a large reservoir where people sail and kayak in the summer. As we walked, our bodies worked up a light sweat. Occasionally, Levin stopped to wonder at fungi clinging to a tree trunk, or to look under a rock for creepy crawlies. Spotting an ant, he recalled trying to feed ants as a child and being surprised at their stubbornness. He noted that planaria can have different personalities—even clones of the same worm. He interrupted his comments on neural decoding to study a plant. "Look at the colors on these berries," he said. "What the hell? I've never seen that before. It looks almost like candy. Let me get a picture of this."

I jokingly asked Levin if, when looking at nature, he saw computer code raining down, as in "The Matrix." "That's a funny question," he said. "I do not see the Matrix code, but I'm often taking pictures or kayaking or something, and thinking about this stuff." I asked him if he saw squirrels and trees differently from the way others do. Not a squirrel, he said, because everyone recognizes it as a cognitive agent—a system with beliefs and desires. But a cell or a plant, for sure.

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"I look everywhere, and I ask the question What's the cognitive nature of this system? What's it like to be a—" He paused. "What's your sensory world like, what decisions are you making, what memories do you have, if any? What predictions do you make? Do you anticipate future events? Slime molds can anticipate regular stimuli. I look for cognition everywhere. In some places you don't find it, and that's fine, but I think I see it broader than many people."

We stopped to look at a log and found a red splotch that appeared to be a slime mold.

"I don't know what it actually is," Levin said. "I'm not much of a zoologist."

Bending down, he peeled off some bark: a second splotch. Researchers have found that, if a slime mold learns something and then crawls over and touches another mold, it can pass on its memory; in 2016, a pair of French scientists showed how one mold could teach another to find some hard-to-reach food through a gooey mind meld.

"That, I think about all the time," Levin said. "What does it mean to encode information in a way that, almost like a brain transplant, you can literally give it to another creature?"

We left the log and continued on. Lichen spotted the rocks, and chipmunks chattered in the trees. There was electricity all around us. "

newyorker.com, 3 March 2021

https://www.newyorker.com

Sponges can crawl, but it costs them bits of their bodies

2021-04-26

Sea sponges don't move, or so many scientists believed. But researchers report today in Current Biology that deep in the Arctic Sea sponges do creep, and they sacrifice pieces of their own bodies to do so.

During an Arctic expedition, scientists aboard the icebreaker Polarstern surveyed an underwater mountain ridge, using a boat-towed camera and a remote-controlled aquatic vehicle. At depths between 1000 and 580 meters, beyond the reach of sunlight, the researchers observed a thriving community of sponges. They also found snaking trails of spicules—fragments of the sponge skeleton—connected to many of the creatures.

The researchers ruled out gravity and currents as likely sponge-moving forces because many of the animals were plopped on the uphill ends of

Instead, the sponges are moving on their own, the team concludes.

these trails, and because the site lacked evidence of strong flows. Instead, the sponges are moving on their own, the team concludes.

The scientists believe the sponges sink their spicules into the ground and pull on them to haul their bodies forward. As the animals move ahead, the embedded spicules rip off their bodies, and a trail of skeletal fragments and fleshy bits forms behind. (You can see a zig-zagging spicule trail in the image above.) Laboratory experiments had shown some sponges were capable of this behavior, but no one had found evidence in the wild.

As for why the animals are crawling around in the first place, the researchers think it's a way to scavenge for food in the nutrient-scarce polar depths. Another possibility is that the sponges move to disperse their offspring, or that they build spicule trails to provide sponge larvae with surfaces to settle on.

sciencemag.org, 26 April 2021

https://www.sciencemag.org

COVID-19 can affect the brain. New clues hint at how

2021-04-27

For more than a year now, scientists have been racing to understand how the mysterious new virus that causes COVID-19 damages not only our bodies, but also our brains.

Early in the pandemic, some infected people noticed a curious symptom: the loss of smell. Reports of other brain-related symptoms followed: headaches, confusion, hallucinations and delirium. Some infections were accompanied by depression, anxiety and sleep problems.

Recent studies suggest that leaky blood vessels and inflammation are somehow involved in these symptoms. But many basic questions remain unanswered about the virus, which has infected more than 145 million people worldwide. Researchers are still trying to figure out how many people experience these psychiatric or neurological problems, who is most at risk, and how long such symptoms might last. And details remain unclear about how the pandemic-causing virus, called SARS-CoV-2, exerts its effects.

"We still haven't established what this virus does in the brain," says Elyse Singer, a neurologist at the University of California, Los Angeles. There are probably many answers, she says. "It's going to take us years to tease this apart."

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"We still haven't established what this virus does in the brain," says Elyse Singer, a neurologist at the University of California, Los Angeles.

Getting the numbers

For now, some scientists are focusing on the basics, including how many people experience these sorts of brain-related problems after COVID-19.

A recent study of electronic health records reported an alarming answer: In the six months after an infection, one in three people had experienced a psychiatric or neurological diagnosis. That result, published April 6 in Lancet Psychiatry, came from the health records of more than 236,000 COVID-19 survivors. Researchers counted diagnoses of 14 disorders, ranging from mental illnesses such as anxiety or depression to neurological events such as strokes or brain bleeds, in the six months after COVID-19 infection.

"We didn't expect it to be such a high number," says study coauthor Maxime Taquet of the University of Oxford in England. One in three "might sound scary," he says. But it's not clear whether the virus itself causes these disorders directly.

The vast majority of those diagnoses were depression and anxiety, "disorders that are extremely common in the general population already," points out Jonathan Rogers, a psychiatrist at University College London. What's more, depression and anxiety are on the rise among everyone during the pandemic, not just people infected with the virus.

Mental health disorders are "extremely important things to address," says Allison Navis, a neurologist at the post-COVID clinic at Icahn School of Medicine at Mount Sinai in New York City. "But they're very different than a stroke or dementia," she says.

About 1 in 50 people with COVID-19 had a stroke, Taquet and colleagues found. Among people with severe infections that came with delirium or other altered mental states, though, the incidence was much higher — 1 in 11 had strokes.

Taquet's study comes with caveats. It was a look back at diagnosis codes, often entered by hurried clinicians. Those aren't always reliable. And the study finds a relationship, but can't conclude that COVID-19 caused any of the diagnoses. Still, the results hint at how COVID-19 affects the brain.

Blood vessels scrutinized

Early on in the pandemic, the loss of smell suggested that the virus might be able to attack nerve cells directly. Perhaps SARS-CoV-2 could breach the

skull by climbing along the olfactory nerve, which carries smells from the nose directly to the brain, some researchers thought.

That frightening scenario doesn't seem to happen much. Most studies so far have failed to turn up much virus in the brain, if any, says Avindra Nath, a neurologist who studies central nervous system infections at the National Institutes of Health in Bethesda, Md. Nath and his colleagues expected to see signs of the virus in brains of people with COVID-19 but didn't find it. "I kept telling our folks, 'Let's go look again,'" Nath says.

That absence suggests that the virus is affecting the brain in other ways, possibly involving blood vessels. So Nath and his team scanned blood vessels in post-mortem brains of people who had been infected with the virus with an MRI machine so powerful that it's not approved for clinical use in living people. "We were able to look at the blood vessels in a way that nobody could," he says.

Damage abounded, the team reported February 4 in the New England Journal of Medicine. Small clots sat in blood vessels. The walls of some vessels were unusually thick and inflamed. And blood was leaking out of the vessels into the surrounding brain tissue. "You can see all three things happening at the same time," Nath says.

Those results suggest that clots, inflamed linings and leaks in the barriers that normally keep blood and other harmful substances out of the brain may all contribute to COVID-related brain damage.

But several unknowns prevent any definite conclusions about how these damaged blood vessels relate to people's symptoms or outcomes. There's not much clinical information available about the people in Nath's study. Some likely died from causes other than COVID-19, and no one knows how the virus would have affected them had they not died.

Inflamed body and brain

Inflammation in the body can cause trouble in the brain, too, says Maura Boldrini, a psychiatrist at Columbia University in New York. Inflammatory signals released after injury can change the way the brain makes and uses chemical signaling molecules, called neurotransmitters, that help nerve cells communicate. Key communication molecules such as serotonin, norepinephrine and dopamine can get scrambled when there's lots of inflammation.

Neural messages can get interrupted in people who suffer traumatic brain injuries, for example; researchers have found a relationship between

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inflammation and mental illness in football players and others who experienced hits to the head.

Similar evidence comes from people with depression, says Emily Troyer, a psychiatrist at the University of California, San Diego. Some people with depression have high levels of inflammation, studies have found. "We don't actually know that that's going on in COVID," she cautions. "We just know that COVID causes inflammation, and inflammation has the potential to disrupt neurotransmission, particularly in the case of depression."

Among the cells that release inflammatory proteins in the brain are microglia, the brain's version of the body's disease-fighting immune system. Microglia may also be involved in the brain's response to COVID-19. Microglia primed for action were found in about 43 percent of 184 COVID-19 patients, Singer and others reported in a review published February 4 in Free Neuropathology. Similar results come from a series of autopsies of COVID-19 patients' brains; 34 of 41 brains contained activated microglia, researchers from Columbia University Irving Medical Center and New York Presbyterian Hospital reported April 15 in Brain.

With these findings, it's not clear that SARS-CoV-2 affects people's brains differently from other viruses, says Navis. In her post–COVID-19 clinic at Mount Sinai, she sees patients with fatigue, headaches, numbness and dizziness — symptoms that are known to follow other viral infections, too. "I'm hesitant to say this is unique to COVID," Navis says. "We're just not used to seeing so many people getting one specific infection, or knowing what the viral infection is."

Teasing apart all the ways the brain can suffer amid this pandemic, and how that affects any given person, is impossible. Depression and anxiety are on the rise, surveys suggest. That rise might be especially sharp in people who endured stressful diagnoses, illnesses and isolation.

Just being in an intensive care unit can lead to confusion. Delirium affected 606 of 821 people — 74 percent — while patients were in intensive care units for respiratory failure and other serious emergencies, a 2013 study found. Post-traumatic stress disorder afflicted about a third of people who had been seriously sick with COVID-19 (SN: 3/12/21).

More specific aspects of treatment matter too. COVID-19 patients who spent long periods of time on their stomachs might have lingering nerve pain, not because the virus attacked the nerve, but because the prone position compressed the nerves. And people might feel mentally fuzzy, not because of the virus itself, but because a shortage of the anesthetic

drug, propofol, meant they received an alternative sedative that can bring more aftereffects, says Rogers, the psychiatrist at University College London.

Lingering questions — what the virus actually does to the brain, who will suffer the most, and for how long — are still unanswered, and probably won't be for a long time. The varied and damaging effects of lockdowns, the imprecision doctors and patients use for describing symptoms (such as the nonmedical term "brain fog") and the indirect effects the virus can have on the brain all merge, creating a devilishly complex puzzle.

For now, doctors are busy focusing on ways in which they can help, even amid these mysteries, and designing larger, longer studies to better understand the effects of the virus on the brain. That information will be key to helping people move forward. "This isn't going to be over soon, unfortunately," Troyer says.

sciencenews.org, 27 April 2021

https://www.sciencenews.org

Is the U.S. doing enough to address the meat industry's role in antibiotic resistance?

2021-04-27

In December, as COVID-19 cases were spiking again, the U.S. Food and Drug Administration (FDA) released its annual report on the volume of "medically important" antibiotics sold for use in animal agriculture. Despite the distraction of a pandemic, experts and advocates who track a different public health threat—antibiotic resistance—took note. Although ag sales of antibiotics had been steadily dropping since a peak in 2015, the report showed that for the second year in a row, the trend had reversed. Overall sales were ticking up, driven by the pork and beef industries.

"I wasn't surprised, but I was disappointed," said Lena Brook, the director of food campaigns at the Natural Resources Defense Council (NRDC). "The beef and pork sectors have been the highest users since the FDA started releasing species-level data . . . and we haven't seen any new commitments [to reducing use] from producers in either of those sectors."

In response, in January, a coalition of organizations including the NRDC issued a call for "urgent action" from the incoming Biden administration, "to act on the antibiotic resistance crisis as swiftly as it will surely act

The danger is obvious: If antibiotic-resistant bacteria infects humans more often, once-minor health issues could become life-threatening.

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on the COVID-19 crisis" by setting a national target to reduce medically important antibiotic use in livestock and establishing a system to track it.

The call turns up the flame on an issue that's been simmering for years, with health experts and agencies warning that the overuse of antibiotics in agriculture is a leading cause of resistant bacteria. (For the purposes of this story, all references to "antibiotics" are to "medically important antibiotics" only.)

The danger is obvious: If antibiotic-resistant bacteria infects humans more often, once-minor health issues could become life-threatening. The World Health Organization (WHO) identifies antibiotic resistance as "one of the biggest threats to global health" today, and a 2019 Centers for Disease Control (CDC) report found antibiotic-resistant bacteria cause 2.8 million infections and 35,000 deaths annually in the U.S. The CDC's numbers did show an 18 percent decrease in deaths over the six years since its initial 2013 report, as a result of actions that have been taken to curb overuse in both healthcare and agriculture. But other estimates of deaths attributable to antibiotic-resistant bacteria are much higher.

A 2015 National Action Plan to combat antibiotic resistance produced by the Obama White House identified curbing "misuse and overuse" of antibiotics in food production as a primary goal, and policies since have strengthened veterinary oversight and outlawed the use of antibiotics strictly for growth promotion. But agencies have not banned their use for disease prevention, so the majority of pork and beef producers continue to administer them to all of their animals regularly in food and water. "It just so happened that many of the medically important antibiotics that were approved for growth promotion are still approved for prevention in very much the same way, on a routine basis," said Matthew Wellington, public health campaigns director for U.S. PIRG, a public interest advocacy group. "It's basically like plugging one leak in a very leaky tub."

To be clear, the FDA's data shows sales of medically important antibiotics for use in animal agriculture have dropped 25 percent overall since 2010. But NRDC calculates that 65 percent of the antibiotics sold in the U.S. are still for use in animal agriculture. And while tracking has been vastly improved in healthcare, data on how livestock producers are using antibiotics is spotty and incomplete.

Industry representatives say meat producers only use antibiotics strategically for animal health and that overuse is a problem manufactured by anti-meat advocates. But the slight uptick in the last two years mirrors trends seen in European countries that banned growth promotion earlier,

and other data clearly shows routine use in feed and water is still the norm in pork and beef production. According to public health experts, any widespread, routine antibiotic use presents a public health threat, and current levels are not sustainable. "The pace of change is too slow given how scary the antibiotic resistance health threat is," Brook said. "It's another global health pandemic that we're living through . . . it's just unfolding at a much slower pace than the tsunami that hit us with COVID."

Antibiotic Use in Pork and Beef Production

Accurate, consistent data on medically important antibiotic use in animal agriculture does not exist, so the only option is to piece together numbers that add up to a partial picture. The FDA tracks sales data, and what we know is that overall sales rose between 2010 and 2015 and then dropped considerably in 2016 and 2017. Experts attribute that change to a confluence of two factors: a massive reduction in antibiotic use in poultry and the FDA's prohibition of antibiotics used solely for growth promotion overall, which was in the works in collaboration with industry throughout 2016. While numbers did tick up in 2018 and 2019—3 percent compared to 2018 and 11 percent compared to 2017—they are still significantly below 2010 levels.

The sales increases were primarily caused by a 9 percent increase in pork production and a 1 percent increase in beef production. During that time, sales to the poultry industry continued to fall drastically, as companies responded to consumer demand for antibiotic-free chicken. In 2019, industry data showed nearly 60 percent of chickens raised for meat were raised without antibiotics.

And since the FDA started collecting species-specific data in 2016, antibiotic sales for cattle and pigs have dropped by 30 and 18 percent, respectively. In an email response to Civil Eats, Anne Norris, a representative from the FDA's Center for Veterinary Medicine, said the more recent increase is "not necessarily noteworthy on its own," in the context of the larger downward trends, and that it's the third lowest number on record, after 2017 and 2018. "FDA's actions over the last several years . . . have fundamentally changed the way animal producers obtain and use medically important antimicrobials in food-producing animals," Norris said.

Lance Price, a professor at George Washington University, has been studying antibiotic resistance since 2003 and co-founded the Antibiotic Resistance Action Center. He said that, over the last several decades, the FDA has "made steady, incremental progress in terms of limiting which

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drugs can be used in animal production in an attempt to control resistant infections in people," such as drastically limiting the use of cephalosporins, drugs critical to treating pneumonia, strep throat, and other common infections, in 2012.

On the industry side, Liz Wagstrom, chief veterinarian for the National Pork Producers Council (NPPC) also pointed to the longer-term decreases in pork since the "high point of 2015" and attributed the recent uptick to overall industry growth. "From 2018 to 2019, the number of hogs marketed in the United States grew by 4.5 percent and weights also increased," Wagstrom said.

Neither the North American Meat Institute nor the National Cattlemen's Beef Association agreed to comment for this article.

Wagstrom pointed to the fact that the FDA data only shows sales estimates, but producers are not required to track actual use. The FDA has worked with the U.S. Department of Agriculture (USDA) on limited studies using voluntary data. The USDA chose a sampling of cattle feedlots and hog farms and conducted surveys on those operations' antibiotic use during 2016, and results from these two different projects provide some insights, although they were completed before the rules prohibiting use for growth promotion went into effect.

Overall, the reports show widespread routine antibiotic use in feed and and/or water. In its report on cattle, the agency found 56 percent of feedlots administered medically important antibiotics in feed; among large feedlots, 78 percent did. Drugs were used primarily for growth promotion, respiratory disease, and liver abscesses (which form because cattle are not meant to eat grain). The most commonly used drugs were tetracyclines, characterized as highly important for human medicine by WHO, and tylosin, which is in a class deemed critically important. The USDA also found that 41 percent of the feedlots that reported using antibiotics in feed never recorded the use. In its survey of pork production, the USDA found 94 percent of farms gave their pigs medically important antibiotics in their feed and/or water. Tetracyclines, penicillin, and other drugs were most often administered for growth promotion, respiratory disease, and/or diarrhea. In the pork industry, the agency found record-keeping was much better.

Separate FDA studies, published last year as a package of research looking at antibiotic use in agriculture, looked at 2016 and 2017 records from feedlots and large hog operations and found similar trends. Nearly

all of the drugs were given in food and water, suggesting that treating individual sick animals accounts for a tiny fraction of use.

The NPPC disputes that characterization. "Medically important antibiotics are used when animals are sick or known to be at risk of disease outbreaks. This is done under the direction of veterinarians after careful consideration of the clinical history of farms and results of diagnostic workups," Wagstrom said. "This is not a routine use but rather, when needed, antibiotics are utilized strategically to protect animal health and welfare to allow us to send healthy animals to market."

Advocates say data like this—together with examples from other countries that have effectively ended routine preventative use in similar industrial systems—shows that producers are using antibiotics to address flaws in the system rather than fixing the system, which would cost more up front. They say that if cattle feed is causing widespread liver abscesses, for example, the feed should be changed rather than adding antibiotics to it. If pigs get infections because of exposure to waste in barns, the management style should be changed (to give animals more space or to add bedding to the barns, for example) rather than putting antibiotics in their water.

Finally, they point to the fact that the numbers show that the ban on antibiotics for growth promotion has not led to more responsible, targeted use of important drugs because of the prevention loophole.

"If your business model is to add low doses of antibiotics to animal feed to increase feed efficiency—and maybe also to fight off infections, but mostly to increase feed efficiency—and the prescriptions on the bag for preventing disease and for promoting growth are exactly the same for a third of the drugs, then you just change what you call it," Price said.

Why Does Antibiotic Use in Barns and Feedlots Matter?

Like viruses, bacteria have the ability to mutate. As more antibiotics are used, especially for long periods of time in high volumes in animals, they can mutate to resist those antibiotics. That new bacteria, now resistant to the antibiotic, can then be passed to humans—in the meat itself, through workers on farms, or through the environment, when manure is spread on fields or scattered along highways as animals are trucked to slaughter.

Between 2005 and 2008, Bob Martin, the food system policy director at Johns Hopkins Center for a Livable Future, directed the Pew Commission on Industrial Farm Animal Production, a comprehensive, independent

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assessment of the meat industry's impacts on the environment, public health, and more. In addition to zoonotic viruses, the top veterinary experts and physicians involved in the commission identified antibiotic resistance as one of the biggest public health threats posed by industrial agriculture.

The commission was not concerned with targeted antibiotics given to sick animals, a practice most experts agree is responsible, just as it is in humans. They were concerned with "subtherapeutic" doses that are given to animals on a regular basis to prevent illness and promote growth. "The logical conclusion we reached was that this low-level daily use [of antibiotics] in farm animal production in these large operations was the main driver of antibiotic resistance in the country, and that there was evidence of it . . . causing resistant infections in people," Martin said.

Methicillin-resistant staphylococcus aureus (MRSA), for example, can cause staph infections that are difficult to treat and is classified as a "serious threat" to human health by the CDC. In 2017, it caused an estimated 323,700 hospitalizations and 10,600 deaths. Many studies have found that pigs and pig farmers in industrial systems carry MRSA, but the prevalence varies considerably from study to study, and workers often carry the bacteria without falling ill. A 2016 analysis found multidrug-resistant staph bacteria in surface water near fields sprayed with waste from industrial hog farms in North Carolina; a March 2021 study that examined the same region found evidence of multidrug-resistant strains spreading between pigs, farmworkers, and residents there. Another study published in JAMA in 2013 looked at patients in a Pennsylvania health care system and found "proximity to swine manure application to crop fields and livestock operations each was associated with MRSA and skin and soft-tissue infection."

The bacteria associated with urinary tract infections (UTIs) have also become increasingly resistant to antibiotics, and one 2018 study published by the American Society of Microbiology found that strains of E. coli that were causing UTIs in people matched those found in commercial poultry flocks. Based on the results, the lead researcher said "we can more confidently say that the E. coli went from poultry to people and not vice versa," as a result of individuals eating contaminated meat.

Regulation and Policy Fixes

The 2017 rule change that ended the routine use of medically important antibiotics exclusively for growth promotion and moved other uses under veterinary oversight was the most significant action the FDA has taken to

address animal agriculture's contribution to antibiotic resistance to date. The issue, Price and others said, is that the rule did not go as far as banning the routine use for prevention (as opposed to treatment) and many of the drugs used in the two cases are the same.

Price pointed to one particular chart in the December FDA report to support the assertion that many producers likely continued using the same antibiotics but began characterizing the use as disease prevention only. In 2017, when the sales of drugs for growth promotion officially disappeared, the sales of drugs for "therapeutic indications only" doubled.

"There is an [overall] decrease, so we'll give them credit for that," he said. "But that jump in that purple line is, I think, just a business decision to continue doing what they were doing." (NPPC interprets the graph as showing the portion of producers that were solely administering for growth promotion ended, but those that were also using antibiotics for both purposes—growth promotion and disease prevention—continued using them for prevention.)

Lena Brook and her NRDC colleague David Wallinga, the author of a 2020 NRDC report on antibiotic use in beef production, said it was telling that countries that had followed an earlier policy arc followed a similar path in terms of sales trends. When the Netherlands banned the use of medically important antibiotics for growth promotion, sales dipped but then slightly increased in subsequent years. But when the government then also banned routine use for disease prevention, sales were cut in half over the next four years.

Because the Netherlands and Denmark both have large industrial pork industries and are now operating with medically important antibiotics approved only for treatment, Wallinga said they provide illustrative examples for what is possible in the U.S.

"There is no reason to think that a lot of the best practices that they have come up with couldn't be replicated here. The FDA and the U.S. industries like to say differently, but I just don't think they have a leg to stand on from a scientific standpoint," said Wallinga. But, he adds, "these enormously powerful companies would have to [stop] raising animals in ways that were designed for maximum economic output and not designed to optimize the health of the animals or to avoid antibiotic use."

Wallinga and several others said that while there are still many European countries using medically important antibiotics in animal agriculture at high rates, the E.U. has made more progress in reducing use overall.

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(According to NRDC numbers, for example, beef producers in the Netherlands use an estimated 50 mg of antibiotics per kg of livestock, compared to 162 mg in the U.S. Pork producers in the U.K. use 183 mg per kg of pig vs. 338 kg in the U.S.) And next year, a new E.U. law completely prohibiting the routine use of medically important antibiotics for prevention will go into effect.

Price says a similar ban on preventative use should be top priority in the U.S. too. But that's unlikely to happen anytime soon. Instead, the Antibiotics Off the Menu Coalition is calling for more modest—but still lofty—goals: the establishment of a true tracking system that accounts for all use at the farm level and a quantitative federal goal to reduce medically important antibiotic use in animal agriculture by 50 percent by the end of 2023.

In the meantime, U.S. PIRG and other groups are also working to push the FDA toward requiring drug companies to reduce the legal window when antibiotics can used in livestock.

"We know that typically, less is better," Wellington said. Currently, there are 89 approved drugs that can be given to animals continuously, without time limitation. The FDA has started the process of establishing duration limits and is accepting comments on a draft of a potential framework for doing so until June 11. But many of the proposed changes give companies broad discretion and would not go into effect for six years or more. "The concept paper is incredibly disappointing," he said. "We're asking for a much quicker timeline and to have it be focused on real duration limits that we know will help curb antibiotic resistance."

States are also moving forward with enforcing stricter laws within their borders. California's law that eliminated low-dose use of medically important antibiotics for prevention and required veterinary oversight for all therapeutic uses went into effect in 2017. Maryland passed a similar law in 2017, and it was updated in 2019 to ensure that routine preventative use would be eliminated. Its Department of Agriculture is now collecting and reporting real data on farm-level antibiotic use in an unprecedented way.

In addition to the Netherlands and Denmark, these states could serve as proving grounds for what the next level of reduction would mean for producers and the meat industry. "People are doing it all around the world. The models exist. It's just that our current model of production is not

conducive to it," Price said. "But if by design your system makes the animals sick, you should probably change the system."

civileats.com, 27 April 2021

https://www.civileats.com

Why 99% of ocean plastic is "missing"

2021-04-27

Starting in the 1990s, the world's attention began turning to the specter of ocean garbage patches — heaps of plastic and other debris that accumulate in distinct areas of the ocean, thanks to currents known as gyres. These patches came to symbolize our global addiction to plastic production and consumption.

A lot of the plastic we consume ends up in the ocean due to man-made causes, such as poor waste management practices. Some of it ends up there because of natural disasters. There's a lot of Japanese plastic floating in the Great Pacific Garbage Patch, for example, due to the 2011 tsunami. Japan is a country that otherwise has above-average waste management policies.

All of this plastic consumption — and the world's inadequacy at containing it — means an estimated 8 million metric tons of plastic end up in the ocean every year. It is remarkably difficult to track all of this plastic, but in 2019, a group of researchers affiliated with the Ocean Cleanup published a study about plastic debris in the Great Pacific Garbage Patch. They excavated plastic from it and, using what they found, made a model showing what is likely floating in each of the five (at least) ocean garbage patches around the world. They also estimated that what's floating on the surface of the water accounts for only 1 percent of what we put into the ocean.

That left scientists to undertake a massive plastic modeling project to piece together where a majority of it ends up. It turns out most of it might be closer than we think.

vox.com, 27 April 2021

https://www.vox.com

A lot of the plastic we consume ends up in the ocean due to man-made causes, such as poor waste management practices.

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Ashwagandha has a host of benefits—and some sneaky side effects

2021-04-29

Adaptogens are everywhere these days. These powerful herbs are said to help our bodies manage and adapt to stress. And, well, anything that can help us get a handle on stress definitely has our attention. We wouldn't be surprised to hear that many of you feel the same way.

One of the most popular adaptogens is an herb called ashwagandha—also known as Withania somnifera or Indian ginseng. The root of ashwagandha is widely used in Ayurvedic medicine. It can be taken in various forms, including as a capsule, powder, tea, or tincture (check out our roundup of some of the best ashwagandha supplements here).

While ashwagandha has been used in Ayurvedic medicine for hundreds of years, it has also become popular outside Ayurveda for its many supposed health benefits. Ashwagandha is said to be able to help us in many different ways, from increasing energy levels to regulating our nervous system, improving sleep and rest, preventing or stopping stress-related hair loss, and even boosting libido.

"One of the hallmarks of ashwagandha is its adaptogen and nervine properties," says Ellie Heintze, a licensed acupuncturist and naturopathic doctor at Starting Point Acupuncture and Wellness. "It can help with balancing stress levels, boosting mood, and helping with mental clarity and focus. There are also studies that show ashwagandha can help with inflammation and reduce pain."

Read on for some benefits and side effects of ashwagandha.

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It May Help Balance Stress in Your Body

Adaptogens can help increase the body's resistance to many different forms of stress, including physical, chemical, biological, and psychological stress.

"Adaptogens are intended to bring the body into balance and help cultivate and maintain resilience," says Jaclyn Tolentino, DO, who is a physician at Parsley Health.

There are also studies that show ashwagandha can help with inflammation and reduce pain."

Ashwagandha in particular can help with balancing stress levels. "One of the hallmarks of ashwagandha is its adaptogen and nervine properties," Heintze says.

One reason ashwagandha may help to reduce and balance stress is by reducing cortisol levels in the body. Cortisol is a the body's primary stress hormone and plays a huge role in the body's "fight or flight" response. When cortisol levels are elevated, you may experience symptoms like increased heart rate and blood pressure.

Many studies on adaptogens are small and limited in scope, so there isn't a ton of clinical data to support the various potential benefits of adaptogens on the body. But Tolentino points out that adaptogens like ashwagandha have been used in forms of traditional medicine for hundreds of years.

"I personally recommend adaptogens in my practice when appropriate—if it's something I think the patient would benefit from incorporating into their wellness routine, and it's not contraindicated in any way," she says.

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It May Have Cognitive Benefits

Having trouble focusing lately? Ashwagandha may help with memory, mental clarity, focus, and other related areas of cognition.

"Ashwagandha...has been used traditionally to improve memory and cognitive function, and it may also improve mood," Tolentino says. "While we have limited clinical data on these benefits, ashwagandha may still be incorporated safely into your wellness routine if ashwagandha is determined to be clinically appropriate for you."

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It May Reduce Inflammation and Pain

Studies show that ashwagandha may decrease inflammation in the body. This is important because inflammation in the body plays a significant role in overall health, especially when the inflammation is chronic (read all about how inflammation can affect your health here).

While these benefits may urge you to give ashwagandha a try, it's important to be aware of some potential side effects, too. Here are some that are important to know about.

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You May Experience Digestive Issues

Nausea, stomach irritation, diarrhea, and other digestive issues are possible when taking ashwagandha. One positive here is that if you stick to the recommended dose, this may not be as much of a problem.

"Ashwagandha is a safe herb when used as directed," Heintze says. "When taking doses exceeding recommendations or larger doses, it may cause digestive upset or nausea."

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You Might Experience Headaches

Headaches and drowsiness are both potential side effects of ashwagandha. But these headaches—along with the digestive side effects—aren't always long-lasting. "Some of these side effects can be short-lived," Tolentino explains.

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Not Recommended for Pregnancy

The experts we spoke with for this piece agree that taking ashwagandha during pregnancy is not recommended. If you have any questions about this, it's important to consult with a medical professional.

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Consult With Your Doctor

"Ashwagandha may be contraindicated if you take certain medications or are currently being treated for certain medical conditions, including autoimmune disorders or certain thyroid conditions," Tolentino explains. For that reason, it's a great idea to check with your doctor before taking ashwagandha. This is an important step that can help you make sure that ashwagandha won't interfere with any medications you are taking, or present problems or heightened risks in relation to any other conditions you have.

"Herbal medicines and supplements can be powerful," Tolentino says. "While ashwagandha is safe and well tolerated for most individuals, I do recommend discussing the usage of these treatments with your healthcare provider prior to incorporating them into your routine."

Ashwagandha may have some benefits for your health, from stress reduction to improved cognition. But as with many types of herbal

supplements and pharmaceutical medications, it carries potential side effects as well, ranging from headaches to digestive issues. Remember that before taking ashwagandha, it's important to check in with your doctor to make sure this supplement is the right choice for you.

byrdie.com, 29 April 2021

https://www.byrdie.com

Profits soar for algae farmers amid chlorophyll boom, but experts cast doubt on health benefits

2021-04-30

The only farm in Australia that grows chlorella is scrambling to meet demand amid a TikTok and Instagram frenzy, but doctors and dieticians say you should probably just eat your veggies.

Key points:

- A North Queensland algae farm is looking to ramp up production as demand soars
- Experts say there is little evidence that chlorophyll delivers the benefits it's celebrated for
- The farm aims to partner with the fossil fuel industry so it can use carbon dioxide to grow algae

BioGenesis farm manager Frank Mason said production had blossomed in the three years since the company set up outside Bowen in North Queensland.

Now the farm is looking to expand its operation as demand for the nutrient-rich algae – which contains chlorophyll – soars in popularity online.

"At the moment we're producing about 300 square metres – about 30 kilos per day – but the reality is that we have enough capacity to produce 800 kilos per week," Mr Mason said.

"We've certainly got demand.

"What it is is we need more processing machinery."

Hyped or healthy?

"We've certainly got demand. What it is we need [is] more processing machinery."

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Algal supplements have been around for many years but social media marketing for chlorophyll dietary supplements seems to be driving a spike in demand.

Chlorella is marketed as having the highest source of natural chlorophyll on the planet and there is no shortage of recommendations coming from prominent influencers.

The hashtag "chlorophyll" has trended on TikTok, Instagram and other social media sites, with searches bringing up hundreds of thousands of posts.

But the health benefits of chlorophyll – the pigment that makes the leaves of plants green – are questionable, according to Nutrition Australia dietitian Leanne Elliston.

"It's important chlorophyll does get researched thoroughly — it's still fairly early days for me to recommend using this on a regular basis," she said.

"There needs to be vigorous studies — we need to look into more studies to find whether chlorophyll is in fact an important component in our health.

"I think what's most important is the other nutrients in green leafy vegetables — your folate, vitamins, iron and antioxidants."

'Extremely limited studies'

Dermatologist Leona Yip said chlorophyll has taken off as a treatment for skin problems, but more research was needed into its potential benefits.

"We know theoretically chlorophyll has some antioxidant and anti-inflammatory properties, but there are extremely limited human studies," she said.

"We don't know whether this translates to benefits to treat problems like acne, rosacea, or whether it even gets to your skin at all."

Ms Elliston said in most cases the extraction of nutrients for supplements came in second to simply eating the raw products that contain the vitamins and minerals.

"When we consume those nutrients in isolation they never work quite as well as nature has intended," she said.

"It's always a good idea to get nutrition from foods."

Dr Yip and Ms Elliston said people who took health advice from online sources were unlikely to seek medical advice from specialists.

"When I see patients I talk about scientific, evidence-based skincare like retinoids, antioxidants — things we know have more credible evidence," Dr Yip said.

"Maybe people on social media buying into that hype are not into seeing medical doctors, maybe they prefer to go with what's being marketed."

'Win-win outcome'

The Bowen farm is described as a "pilot scale", but the business is attempting to find a commercial partner to expand further in order to increase production.

"Ultimately we need to be attached to a large consumer of, basically, fossil fuels, such as a coal or gas-fired power station or a sugar mill where we can coexist and turn their carbon dioxide into algae," Mr Mason said.

"Basically we'll then use that as a nutraceutical and animal food — it'll provide a win-win outcome.

"We've certainly got demand.

"The issue's not demand, the issue is our capacity to supply it."

abc.net.au, 30 April 2021

https://www.abc.net.au

These 'creativity genes' allowed humans to take over the world

2021-04-29

Creativity could be one of the main reasons Homo sapiens survived and dominated over related species such as Neanderthals and chimpanzees, according to a new study.

The idea that creativity may have given Homo sapiens a survival edge over Neanderthals has been around a long time, said senior author Dr. Claude Robert Cloninger, a professor emeritus in the psychiatry and genetics departments at Washington University in St. Louis. But that's a tricky case to prove, as we still don't know how creative Neanderthals actually were, he said.

Self-awareness is "what enables us to have divergent, original creative thinking [and to] be very flexible," Cloninger said.

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"The problem with evaluating creativity in extinct species is, of course, you can't talk to them," Cloninger told Live Science. So an international team of researchers, led by a group at the University of Granada in Spain and the Washington University School of Medicine in St. Louis, looked at genes to examine what distinguished humans, including their creative ability, from their distant relatives.

The researchers had previously identified 972 modern genes that regulate three distinct systems of learning and memory in Homo sapiens: emotional reactivity, self-control and self-awareness. The emotional reactivity network involves the ability to form social attachments and learn behaviors while the self-control network involves the ability to set goals, cooperate with others and make tools.

The self-awareness network, on the other hand, involves "episodic learning" or remembering and improving upon past behaviors and autobiographical memory of a person's life as a narrative with a past, present and a future "within which the person can explore alternative perspectives with intuitive insight and creative imagination," according to the study.

Self-awareness is "what enables us to have divergent, original creative thinking [and to] be very flexible," Cloninger said.

In the new study, the researchers analyzed DNA previously taken from Neanderthal (Homo neanderthalensis) fossils, modern humans (Homo sapiens), and chimpanzees (Pan troglodytes). They found that the genes related to the oldest network — emotional reactivity — were identical among Homo sapiens, Neanderthals and chimpanzees. But the chimpanzees completely lacked the genes that led to self-awareness and self-control in humans.

Some, but not all, of those genes were present in Neanderthals. "The Neanderthals were about halfway between the chimps and modern humans" in the number of these genes they carried, Cloninger told Live Science.

What's more, 267 of those 972 genes were unique to Homo sapiens, and they were all so-called regulatory genes. In other words, they dial the activity of other genes up or down. These genes — which were absent in chimpanzees and Neanderthals — regulate the brain networks involved in self-awareness and creativity.

Unique to Homo sapiens PLAY SOUND

The emotional reactivity network evolved in monkeys and apes about 40 million years ago, the self-control network evolved a little less than 2 million years ago, and the self-awareness and creativity network emerged just 100,000 years ago, when humans were under pressure from a changing climate that reduced the supply of food and other resources necessary for survival, Cloninger said.

Then, some 40,000 years ago, Homo sapiens with "unprecedented cultural and technological sophistication" began rapidly replacing Neanderthals around the world, according to the study. This sophistication was likely driven by our Homo sapiens ancestors' creativity and self-awareness, which enabled them to live longer, healthier lives, the authors said.

Such longevity would have allowed a longer learning period for kids and adolescents and thus more time to accumulate knowledge. Living longer, healthier lives would have also encouraged cooperation among individuals and extended communities to promote the success of their children, grandchildren and others in the community. That, in turn, would enable "the technological innovativeness, behavioral flexibility, and exploratory disposition needed to allow Homo sapiens to spread throughout the world more successfully than other human lineages," the authors wrote.

Still, the study comes with several limitations, including that traits such as creativity and self-awareness are complex and that Neanderthals are no longer around, making it difficult to assess them solely based on their genes. (For example, a person's environment can also influence their personality and behavior.) Indeed, some researchers are not convinced that comparing the modern human genome to that of an extinct species can lead to robust conclusions.

"We do not know the causal link between genetics and these higher traits, even if the authors identified networks of genes that are associated with some measures of self-awareness, creativity or prosocial behavior," said Thomas Suddendorf, a professor in the School of Psychology at the University of Queensland in Australia who was not part of the study.

So, although the findings are interesting, "I would caution against drawing any firm conclusions from such data about extant, let alone about extinct, species," Suddendorf told Live Science in an email. It is "undoubtedly" the case that humans are more creative than other animals currently living, including chimpanzees, he said.

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The authors noted in the study that they "cannot exclude the possibility that Neanderthals had genes that were not present in [Homo] sapiens and influenced their personality and learning abilities." In other words, Neanderthals may not have had the same genes for creativity and self-awareness, but rather their own set of genes that we don't understand.

The findings were published April 21 in the journal Molecular Psychiatry.

Originally published on Live Science.

livescience.com, 29 April 2021

https://www.livescience.com

Scientists have identified four distinct types of Alzheimer's and what they do to us

2021-05-02

The more we understand about Alzheimer's, the faster we can work towards better treatments and ultimately a cure, which makes discovering four distinct subtypes of the brain disease an important one.

Using machine learning algorithms trained at brain scans of 1,143 people either with healthy brains or brains affected by Alzheimer's, scientists have identified four distinct ways tau proteins get tangled up among neurons.

Misshapen tau proteins are closely linked to the development and progression of Alzheimer's, but it was thought that the pattern of tau entanglement in the brain was more or less the same in everyone with the disease.

"We identified four clear patterns of tau pathology that became distinct over time," says neurologist Oskar Hansson from Lund University in Sweden.

"The prevalence of the subgroups varied between 18 and 30 percent, which means that all these variants of Alzheimer's are actually quite common and no single one dominates as we previously thought."

The first variant, discovered in 33 percent of cases, sees tau spreading mainly within the temporal lobe and affecting patient memory. The second, found 18 percent of the time, spreads across the other parts of the cerebral cortex – memory problems are less common, but difficulties in planning and performing actions are more common.

"We identified four clear patterns of tau pathology that became distinct over time," says neurologist Oskar Hansson from Lund University in Sweden.

The third variant, found in 30 percent of all cases, is where tau spreads in the visual cortex (used for processing sight) – patients have trouble orienting themselves, judging distance, and identifying shapes. The fourth and final variant, seen in 19 percent of cases, spreads asymmetrically in the brain's left hemisphere and affects language processing.

The discoveries were made possible by detailed, 3D Positron Emission Tomography (PET) scans. Follow-up analysis over two years confirmed the presence of these four distinct patterns in people with Alzheimer's, and it could help explain why different people show different symptoms as the disease progresses.

"This would suggest that Alzheimer's is an even more heterogeneous disease than previously thought," says neuroscientist Jacob Vogel from McGill University in Canada.

"We now have reason to reevaluate the concept of typical Alzheimer's, and in the long run also the methods we use to assess the progression of the disease."

Alzheimer's is already the leading form of dementia worldwide, and the number of affected people continues to rise sharply as populations age. We know that it causes a steady loss of neurons, but it's still not clear exactly why that happens – and as yet, there's no known cure.

Progress is being made, though. Previous studies have also looked at splitting Alzheimer's up until subtypes to give us a better understanding of the disease, while we're also learning more about neurons vulnerable to Alzheimer's, and how its effects might be reversed.

The next step is to extend the analysis across a longer time period – up to 10 years, suggest the researchers. Knowing which subtype is present in a patient could, for example, give them a better idea of which symptoms to expect and when, as well as opening up options for new treatments.

"This knowledge is important for doctors who assess patients with Alzheimer's, and it also makes us wonder whether the four subtypes might respond differently to different treatments," says Hansson.

The research has been published in Nature Medicine.

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Scientists scour the Amazon for pathogens that could spark the next pandemic

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When Marcelo Gordo opens the picnic cooler, the stench is suffocating. Three dead pied tamarin monkeys, their cream-and-caramel-colored coats visible through plastic wrap, are curled up inside. Gordo, a biologist at the Federal University of Amazonas, Manaus, explains that a student accidentally unplugged the freezer where he'd stored the monkeys, which had been killed on the road and given to him by city officials. Despite the decay, they are worth investigating.

Inside the spartan necropsy room at a veterinary school here, veterinarian Alessandra Nava and two graduate students pull on goggles, N95 masks, and blue nitrile gloves and begin to cut bits of tissue and collect bodily fluids from the monkeys. They pack the samples into vials to be transported to the Fiocruz Amazônia Biobank, a pathogen research collection that Nava helps oversee at the Amazonian regional office of the Oswaldo Cruz Foundation, a branch of Brazil's Ministry of Health more commonly known as Fiocruz. There, she and others will test the samples for parasitic worms, viruses, and other infectious agents.

Nava and her colleagues are on the front lines of the search for animal diseases that could spill over and infect humans—and perhaps cause the next pandemic. New diseases can come from anywhere: Severe acute respiratory syndrome and COVID-19 both originated in China, for instance. Another recent coronavirus disease, Middle East respiratory syndrome, was first found in Saudi Arabia. But many researchers suspect tropical rainforests, with their staggering biodiversity, are the most likely cradle of dangerous new pathogens.

But many researchers suspect tropical rainforests, with their staggering biodiversity, are the most likely cradle of dangerous new pathogens.

When human populations encroach on rainforests, the risk of spillover skyrockets. Manaus, Brazil, a city of 2.2 million people in the Amazon rainforest, is just such a place. The jungle that stretches for hundreds of kilometers in every direction has long threatened inhabitants with infections circulating in wildlife. Some 12% of the word's 1400 bat species—known to host a bewildering range of viruses—flit through the Amazon forest. Its monkeys and rodents carry plenty of potential threats as well.

Urban growth, highway expansion, hydroelectric dam construction, mining for gold, and deforestation for cattle ranches and small farms

erode the jungle and bring humans and wildlife into ever closer contact. In Brazil, the pro-business policies of President Jair Bolsonaro have only boosted that risk. By monitoring local animal populations and human patients, researchers at Fiocruz hope to head off zoonoses—diseases that leap from animals to humans—before they spiral out of control. Their work highlights the importance of curbing human activities that boost the risk of spillover. It could also guide surveillance for new and rare diseases in hospitals, which would enable health workers to respond fast if a rainforest pathogen became a wider threat.

Ironically, Fiocruz's work has been stymied by one such disease. Manaus has experienced two brutal waves of COVID-19, a disease thought to have originated in bats. The city's cumulative death toll, roughly 9000, is among the world's highest per capita. Nava's team has not captured animals at field sites in a year, partly out of concern that the researchers themselves might infect wild animals with the coronavirus. And the labs at Fiocruz Amazônia that process her samples have been commandeered for coronavirus research.

For Felipe Naveca, the lab's vice director of research and innovation, the upheaval has been personal as well as professional. COVID-19 killed his father and may have contributed to the death of his grandmother. In the lab, Naveca led one of the first genetic studies of the new P.1 coronavirus variant that has emerged from Manaus and appears to be especially dangerous because it is more transmissible and evades immunity. He is proud that his team has processed 18,000 COVID-19 tests for local health authorities. "Helping to save someone's life was much more rewarding than publishing a scientific article," he says. But like his colleagues, Naveca is anxious to get back to the lab's core mission. "We must keep searching for those emergent threats."

THE OFFICE of Fiocruz Amazônia occupies a former military hotel in downtown Manaus, nestled between a small church and a luxury condominium high-rise. Several rooms with softly humming freezers and refrigerators house the biobank: a collection of feces, blood, and other tissues and fluids from more than 100 rainforest animals. Forty species are represented; the majority are monkeys, bats, and rodents, the mammals thought most likely to transmit disease to people. Other collections in the building include insects that torment these animals and could serve as vectors for ferrying pathogens to humans.

The Fiocruz Amazônia Biobank was partly modeled on the $200 million PREDICT early warning program. Launched in 2009 by the U.S. Agency for

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International Development, PREDICT identified nearly 1000 previously unknown animal viruses with zoonotic potential before the Trump administration canceled it in 2020. Whereas PREDICT was global, Nava and her colleagues do the same kind of work at a regional level. They're searching for animal reservoirs of known viral and parasitic diseases, including obscure viral fevers and filariasis, a parasitic worm infection that can cause the horribly disfiguring syndrome elephantiasis. They're also using DNA sequencers to scour samples from animals for pathogens that have yet to emerge.

"What they are doing is brilliant and important," says Andrew Dobson, a biologist at Princeton University who studies the ecology of wildlife diseases. "It shows that even in countries with limited resources and a very negative governmental attitude towards science, it is possible to set up a monitoring scheme for novel viruses."

Veteran disease hunter Dennis Carroll, who founded and ran PREDICT, agrees. "Amazonia is one of the richest, most ecologically diverse regions of the world," he adds. "So getting any insight into that region is really important."

A black-and-white photograph in a second-floor foyer of Fiocruz Amazônia depicts one inspiration for this work: Brazil's legendary doctor and disease sleuth, Carlos Chagas. Attired for an expedition in a white suit and knee-high boots, Chagas stands in a canoe surrounded by his oarsmen. In 1909, Chagas discovered the cause of the disease that now bears his name. Using a simple microscope, he identified the culprit as a protozoan (now called Trypanosoma cruzi) and showed that it is transmitted by the bite of triatomine bugs, often called kissing bugs. Chagas disease, whose symptoms range from fever to heart failure decades later, still kills hundreds of thousands of people a year in Latin America.

Naveca is doing similar detective work with the more sophisticated tools of modern genetics. One pathogen that concerns him is the little-studied Oropouche virus, which is spread primarily by a species of midge, Culicoides paraensis. Oropouche, which causes fever, headache, and joint pain, has sparked at least 30 outbreaks and sickened more than 500,000 people since it was first identified in 1955. Its range has gradually expanded to include Panama, six South American countries, and Trinidad and Tobago, where it first appeared. The midge itself, however, lives as far away as the northern United States, where it and related insects are called no-see-ums, suggesting the virus could spread beyond South America. The southern house mosquito (Culex quinquefasciatus), a carrier of West

Nile and Saint Louis encephalitis viruses, can also transmit Oropouche, though not very efficiently, and its range throughout the tropics raises the possibility of Oropouche outbreaks in Africa, southeast Asia, and Australia.›

Naveca and his colleagues hope to find out which animal or animals are the primary natural reservoirs for this virus. There are plenty of candidates: Oropouche has been identified in sloths, marmosets, finches, and several other birds and mammals. The team recently reported using the polymerase chain reaction to identify the virus' genetic material in urine and saliva—as opposed to blood—which could make the hunt for its animal reservoir easier and aid diagnosis in patients.

Naveca is also worried about another little-studied virus that is rapidly expanding in South America: the Mayaro virus, which causes flulike symptoms, making it hard to distinguish from more common tropical diseases such as chikungunya and dengue fever. As with Oropouche, he's hoping to pinpoint the virus' natural reservoirs and investigate whether cases of it are going undiagnosed.

Mayaro is a likely candidate for the next large-scale outbreak of an animal virus in Brazil or beyond, Naveca and other scientists warn. Its primary vector, the mosquito Haemagogus janthinomys, is a forest dweller restricted to Central America and northern South America, but laboratory experiments show the yellow fever mosquito (Aedes aegypti) and the Asian tiger mosquito (A. albopictus)—two species widely distributed in tropical and subtropical areas—can also transmit the disease. A. aegypti is especially well adapted to breeding in cities.

To Naveca, the Zika virus is a case study in the value of tracking obscure pathogens. First identified in Africa in 1947, where it spilled over from monkeys, it circulated largely unnoticed and with few casualties for decades. Then, it caused an outbreak in Oceania in 2013 and, 18 months later, a massive epidemic in Latin America. Researchers suddenly discovered a disturbing consequence of the disease—microcephaly and other birth defects in infants born to infected mothers. "Zika was a virus that nobody was paying attention to until 10 years ago," Naveca says. "We can fight better the enemies we know better."

Naveca now hopes to carry on Chagas's disease-hunting tradition with a deal he's negotiating to procure a 25-meter, flat-bottomed boat that has been outfitted to be a floating laboratory. Preserving perishable human and animal samples at remote field sites has been a critical obstacle, and the vessel would bring the lab to the biological materials, rather than the other way around. Naveca hopes to join its maiden research

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voyage, possibly later this year, to remote Amazon villages, where he and colleagues plan to trap bats, rodents, primates, and insects, and bring a trove of specimens back to Fiocruz Amazônia.

EVEN WITHIN MANAUS, there are lots of opportunities for fieldwork. When Science visited last year, Gordo had set up an improvised lab inside a classroom at Sumaúma State Park, a tiny patch of uncut rainforest in the middle of the city, wedged between a busy highway and an upscale mall. Using cages baited with ripe bananas, he and his assistants trapped nine pied tamarins and injected them with a sedative, then swabbed their oral and anal cavities, clipped locks of hair, and drew blood. Then they set the animals free.

It's peculiar and sometimes dangerous work. Monkeys have bitten and sneezed on Gordo, and on this trip a syringe broke as he squeezed the plunger, spraying monkey blood on his face shield. He says his wife complains when he stashes monkey carcasses in their home fridge.

Manaus's Yoda-faced pied tamarins live all over the city. Like North American squirrels and raccoons, they don't respect property lines and make urban gardens their pantries and playgrounds. There's no evidence so far that Manaus's urban monkeys are a human health threat, and Gordo, worried about "unreasonable killings or deforestation," is reluctant to discuss that possibility. But he and others are investigating whether monkeys carry parasites, such as the nematodes that cause filariasis, or viruses such as Zika and chikungunya.

For Gordo, an equal concern is spillback—infections passed from humans to wildlife. Zika, for example, appears to have traveled from humans back to wild monkeys during Brazil's epidemic. Fears that the virus might harm wildlife rose when researchers showed that a pregnant monkey native to Brazil had a spontaneous abortion after it was exposed to Zika. The fetus had birth defects similar to those seen in humans.

So far, Gordo has not found the virus in Manaus's monkeys, but they may be at risk: A study he co-authored last year found mosquitoes from two species thought to carry Zika, Haemagogus janthinomys and Sabethes chloropterus, in both monkey and human habitats in a forest reserve on the edge of the city. The pied tamarins are already critically endangered, found nowhere else but in and around Manaus. Their population is expected to decline by 80% within the next 16 years. A virus outbreak could push them over the edge.

Humans are at risk from spillback as well. In Europe and the United States, scientists worry about COVID-19 outbreaks on mink farms, for example, because such events give the virus more opportunities to evolve and jump back into people. Likewise, primate populations infected with Zika could reignite human outbreaks. This happened with yellow fever: Brought to South America centuries ago with the slave trade, the virus has been impossible to eliminate from Brazil because it established itself in wild monkey populations, which occasionally pass it back to people.

After trapping monkeys for a day in the Sumaúma park, Gordo went home and bottle-fed an infant pale-throated sloth only slightly larger than his cupped hands. A friend had found it untended on the ground in a forest fragment not far from his university office. Despite everything he's learned about zoonotic diseases, Gordo said he was "not too worried." The sloth pup looked healthy. But several weeks later it got sick and died, possibly from pneumonia.

NAVA BELIEVES the Fiocruz center's work is only becoming more urgent with changing land use patterns in the Amazon. Deforestation has soared since Bolsonaro came to power in 2019—transforming habitat in ways that could make viral hosts and vectors more dangerous and increasing the likelihood of spillover.

In 2016, she and colleagues reported that 9% of bats in small clearings around settlements in Brazil's coastal Atlantic Forest had active infections of one or more of 16 viruses, including coronaviruses and hantavirus. In less-disturbed forests nearby, fewer than half as many bats were infected, and with only six different viruses. The findings fit a widely debated hypothesis known as the dilution effect, which holds that in forests with greater biodiversity, mosquitoes and other vectors have more targets and end up biting animals not capable of incubating a given virus, thereby slowing its spread. Reducing biodiversity by clearing land can do the opposite, and it also pushes humans into closer proximity to wildlife. Bats are a particular concern, Nava says, because they often roost in buildings.

It all underscores the need to stop destroying rainforest, she says—although she acknowledges that Brazil's policies are unlikely to change under Bolsonaro, who has nearly 2 years left in his term. In the meantime, Nava says, disease fighters must keep monitoring the jungle for dangerous

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diseases. "We have no power to reduce deforestation," she says. But, she adds, "We have the power to search for new viruses."

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