CHEMWATCH

Bulletin Board

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OCT. 02, 2020

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ASIA PACIFIC

Free webinar hosted by Safe Work Australia and Comcare as a part of the National Safe Work Month

2020-09-25

You are invited to join a free webinar hosted by Safe Work Australia and Comcare as part of National Safe Work Month.

The COVID-19 pandemic has transformed our workplaces. This year's National Safe Work Month theme, **Work Health and Safety through COVID-19**, acknowledges and reflects the wide-reaching impacts of COVID-19 on Australian businesses, employers and workers.

Workplaces have faced new work health and safety (WHS) risks associated with isolated work, mental health, working from home, managing staff and workloads remotely, and the ongoing risk management of exposure to COVID-19.

The webinar will explore the rapid and large-scale changes that workplaces of different sizes and across various industries have undertaken to address the WHS risks and challenges presented by COVID-19 at work.

Presenters from Safe Work Australia and Comcare will discuss how the changes in WHS have contributed to this accelerated shift including:

- WHS risks and hazards
- leadership and culture
- working arrangements, and
- WHS policy and systems.

Webinar details

Date: Thursday 8 October 2020

Time: 10.30 am – 11.30 am AEDT

Via: Microsoft Teams

Who should attend:

- employers
- work health and safety practitioners

You are invited to join a free webinar hosted by Safe Work Australia and Comcare as part of National Safe Work Month.

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- health and safety representatives
- human resources managers
- mid-level managers
- workers.

For more information and to register, visit the **Comcare website**

Safe Work Australia, 25 September 2020

https://www.safeworkaustralia.gov.au/

China outlines restrictions on single-use plastics

2020-09-16

Ministry of Commerce announces increased oversight on use of disposable plastic items by businesses; sets ban on range of single-use plastic items including plastic shopping bags, tableware, hospitality products.

In a notification published on August 28, 2020, the *Chinese Ministry of Commerce* outlined a set of upcoming restrictions on the use of plastics within the country. An overview article by law firm *Keller and Heckman LLP* clarifies that local authorities are expected to establish a central purchasing system for shopping bags used in grocery markets and encourage the catering industry to use alternative plastic products (such as biodegradable bags and straw boxes). Supervision of food delivery businesses should also be increased, and they should be encouraged to reduce consumption of single-use plastic products and promote alternatives that are reusable, degradable, and recyclable.

Full Article

Food Packaging Forum, 16 September 2020

https://www.foodpackagingforum.org/news/china-outlines-restrictions-on-single-use-plastics

Supervision of food delivery businesses should also be increased, and they should be encouraged to reduce consumption of single-use plastic products and promote alternatives that are reusable, degradable, and recyclable.

AMERICA

California gets even more aggressive on PFAS

2020-09-23

The cost of regulatory compliance is compounded by the risk of litigation that has spread across the nation like asbestos, lead paint and tobacco litigation, says Alston & Bird's Jeffrey Dintzer and Gregory Berlin

California is notorious for having the most stringent body of environmental law in the nation. For better or worse, the state is consistently on the forefront of passing environmental regulations long before the rest of the country, including the federal government. Thus, it is unsurprising that the state has taken an aggressive approach on regulating per- and polyfluoroalkyl substances (PFAS)—the "forever chemicals" that have become the subject of hundreds of lawsuits throughout the nation.

Full Article

Law.com, 23 September 2020

https://www.law.com/therecorder/2020/09/23/california-gets-even-more-aggressive-on-pfas/

Why dangerous 'forever' chemicals are allowed in US drinking water

2020-09-24

The federal government has still not set limits for PFAS compounds, and some allege that could be because it is a polluter of them itself

In 2014, residents of Horsham Township, near Philadelphia, learned that their water had been contaminated with potentially toxic chemicals linked to an array of health problems, including learning delays in children and cancer. Those residents include Frank and Lisa Penna, who allege in a lawsuit that their water was among the contaminated supplies.

Known as PFAS, for per- and polyfluoroalkyl substances, the chemicals in this class of approximately 5,000 substances have become notorious as much for their potential danger as for their perseverance. Because the chemical bonds that hold the compounds together don't break down easily, they last a very long time – a reality that has led to a commonly used name for the group: "Forever chemicals."

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PFAS compounds are also ubiquitous, used in a range of products, from food-delivery boxes to nonstick cookware to stain-resistant clothing. But one of the most troubling routes to PFAS exposure is drinking water that has been contaminated by discharges from factories and other facilities.

Full Article

The Guardian, 24 September 2020

https://www.theguardian.com/us-news/2020/sep/24/pfas-dangerous-forever-chemicals-drinking-water

Amazon's 'Climate Pledge Friendly' to make it easier for customers to discover, shop for sustainable products

2020-09-24

Label launches with 25K+ products endorsed by team of third-party sustainability certifiers. And Amazon's new 'Compact by Design' certification aims to reduce carbon emissions through increased efficiency and better packaging.

PFAS compounds are also ubiquitous, used in a range of products, from food-delivery boxes to nonstick cookware to stain-resistant clothing.

Today, Amazon launched Climate Pledge Friendly — a program to help make it easy for customers to discover and shop for more sustainable products. Customers will now see the Climate Pledge Friendly label on more than 25,000 products; to signify that they have one or more of 19 different sustainability certifications that help preserve the natural world, and the people who make and use them.

Customers will now see the Climate Pledge Friendly label on more than 25,000 products…

Climate Pledge Friendly selection includes grocery, household, fashion, beauty and personal electronics products, as well as items from a range of other categories — from some usual-suspect brands such as Seventh Generation, Burt's Bees Baby, The Honest Company, Mrs. Meyers and HP Inc; as well as Georgia-Pacific, Office Depot, Rubbermaid, 3M, Ecolab, Diversey, Staples, Kittrich, Branch Creek, Tork, Simoniz, Neenah, Betco and PortionPac, to name a few. Climate Pledge Friendly products are clearly labeled in shopping results, have additional sustainability information on the product page, and are featured in a dedicated section of the site.

Amazon has partnered with 19 trusted third-party certifications — all of which assess products to ensure that they meet sustainability standards that help preserve the natural world, and the people who make and use them. For example, Amazon has partnered with the Cradle to Cradle Products Innovation Institute — a global non-profit dedicated to transforming the safety, health and sustainability of products. The Cradle

to Cradle certification encourages innovation to maximize the positive impacts of products and materials; and all Cradle to Cradle Certified products are safe, sustainable products made to support a circular economy.

"Cradle to Cradle certification provides a framework for product optimization based on the principles of designing with safe and healthy materials, using clean renewable energy and water, celebrating diversity, and eliminating the concept of waste," said William McDonough, co-founder of the Cradle to Cradle Products Innovation Institute, who worked with Amazon on the development of the Climate Friendly Badge program. "We love that Amazon is making it simple for customers to find sustainable products. Amazon's new program will expand our reach and enable us to empower more brands to deliver safer and more sustainable products for the circular economy."

Cradle to Cradle Certified products included in the program include those from Redkin, Wolford, G-Star and Frosch.

Amazon evaluated hundreds of external sustainability certifications and chose organizations that certify products that have demonstrated tangible sustainability benefits. For example, Bluesign Technologies works with product design teams to eliminate harmful substances right from the beginning of the manufacturing process, and sets and controls standards for environmentally conscious and safe textile production.

"We are thrilled to partner with Amazon as a verifying entity for Climate Pledge Friendly, ultimately making it easier for customers to discover and shop more sustainable products," said Bluesign CEO Jill Dumain. "Amazon's new program will encourage brands and manufacturers to manufacture and source more sustainably, become verified, and grow their product selection. When consumers shop for more sustainable products on Amazon, they can now benefit from the bluesign® PRODUCT verification, which focuses on chemical safety for consumers and workers, as well as on environmental impact reduction."

Other third-party certifiers participating in the program include OEKO-TEX and Textile Exchange — which evaluate the safety and sustainability of textiles; Fairtrade, which helps farmers and workers secure better incomes and farm more sustainably to tackle climate change challenges; the Forest Stewardship Council, the only certification system focusing exclusively on forest products that Amazon has selected to feature in the program; and Green Seal, which certifies products for health and safety — prohibiting carcinogens, mutagens, and reproductive toxins in certified products.

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As part of the Climate Pledge Friendly initiative, Amazon is also announcing Compact by Design — a new, externally validated certification that identifies products which, while they may not always look very different, have a more efficient design. With the removal of excess air and water, products require less packaging and become more efficient to ship. At scale, these small differences in product size and weight lead to significant carbon emission reductions.

Seventh Generation, for example, offers a Compact by Design-certified super-concentrated laundry detergent that uses 60 percent less plastic and 50 percent less water than the standard 100-ounce laundry bottle, enabling significant energy and material savings. If every US household were to buy one bottle of Easy Dose ultra-concentrated laundry detergent instead of Seventh Generation's conventional 100-ounce laundry detergent, this would save 220,000 tons of CO2e every year, equivalent to not driving 540 million miles.

Full Artilcle

Sustainbable Brands, 23 September 2020

https://sustainablebrands.com/read/product-service-design-innovation/amazon-s-climate-pledge-friendly-to-make-it-easier-for-customers-to-discover-shop-for-sustainable-products

EPA publishes final SNUR for carbon nanotubes (Generic) (PMN P-15-54)

2020-09-17

On September 17, 2020, the U.S. Environmental Protection Agency (EPA) published final significant new use rules (SNUR) under the Toxic Substances Control Act (TSCA) for chemical substances that were the subject of premanufacture notices (PMN) and are subject to Orders issued by EPA pursuant to TSCA. 85 Fed. Reg. 57968. The SNURs require persons who intend to manufacture (defined by statute to include import) or process any of these chemical substances for an activity that is proposed as a significant new use to notify EPA at least 90 days before commencing that activity. The final SNURs include one for carbon nanotubes (generic) (PMN P-15-54). The SNUR requirements do not apply to quantities of the PMN substance that have been embedded or incorporated into a polymer matrix that itself has been reacted (cured) or embedded in a permanent solid polymer form that is not intended to undergo further processing, except mechanical processing. The significant new uses are:

The final SNURs include one for carbon nanotubes (generic) (PMN P-15-54).

- **Workplace protection**. Requirements as specified in Section 721.63(a)(1), (2)(i) and (ii), and (3) through (6), and (c). When determining which persons are reasonably likely to be exposed as required for Section 721.63(a)(1) and (4), engineering control measures (*g*., enclosure or confinement of the operation, general and local ventilation) or administrative control measures (*e.g*., workplace policies and procedures) shall be considered and implemented to prevent exposure, where feasible. For purposes of Section 721.63(a)(5), respirators must provide a National Institute for Occupational Safety and Health (NIOSH) assigned protection factor (APF) of at least 50. For purposes of Section 721.63(a)(6), particulate (including solids or liquid droplets).

Full Article

Nano and other emerging chemical technologies blog, 17 September 2020

https://nanotech.lawbc.com/2020/09/epa-publishes-final-snur-for-carbon-nanotubes-generic-pmn-p-15-54

Oil and gas companies must monitor fracking emissions as Colorado adopts first-in-the-nation rules to reduce air pollution

2020-09-24

Oil and gas companies will have to control and monitor emissions from fracking and meet tighter emission-performance standards on the electric motors used at drill sites, under some first-in-the-nation rules passed Wednesday night by Colorado air quality regulators.

The new rules for the so-called pre-production phase of drilling are in addition to regulations the state's Air Quality Control Commission (AQCC) last year issued to reduce emissions from oil and gas storage tanks, pipelines and low-producing wells.

Developed after extensive negotiations between the state Air Pollution Control Division and stakeholders, including industry and environmental groups, the regulations are part of an ongoing effort by the commission to tighten controls on oil and gas operations, a major source for ozone and greenhouse gas emissions.

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Full Article

Colorado Sun, 24 September 2020

https://coloradosun.com/2020/09/24/colorado-adopts-fracking-emission-rules/

EUROPE

Into the crucible: Will the European chemicals industry rise to the circularity challenge?

2020-09-24

The stakes are big. According to the UN "Global Chemicals Outlook" (2019), chemicals sales more than doubled between 2004 and 2014, and are geared towards doubling again by 2030 and potentially quadrupling by 2060. As for Europe, its 28,000 chemical companies with 1.2 million employees added a record €565 billion of value to the European economy in 2018 alone, making it the fourth largest industry in the EU.

With 90% of GDP growth taking place outside Europe in the coming decades, the challenge for the chemicals industry will be to find its place in this growing global market. Can it achieve this better by continuing its transformation into a sustainable industry that supplies other sustainable industries, or should it rather focus on price competitiveness and pushing for more lax regulation?

Europe has recognized that its future competitive edge will be based on resource efficiency and high-quality durable products, so increasing the production of more sustainable chemicals seems the obvious way to go.

The COVID-19 crisis has only highlighted Europe's need to reinforce strategic autonomy, public health, and environmental standards. But the European market is also seen by many leading companies as the testing ground for what will happen in other global regions in future decades.

The trouble with hazardous substances

21,515 chemical substances were registered with the European Chemicals Agency (ECHA) by 2018, and more and more of these substances are classified as being "hazardous" under the EU's Classification, Labelling and Packaging (CLP) regulation system.

As for Europe, its 28,000 chemical companies with 1.2 million employees added a record €565 billion of value to the European economy in 2018 alone, making it the fourth largest industry in the EU.

That means that some 60% of the chemicals circulating on the European market (by weight) have been identified as hazardous for human health and the environment, including basic chemicals like oxygen or hydrogen, that are needed to produce other chemicals, and household products, from detergents and disinfectants to vinegar.

Full Article

Packaging Europe, 24 September 2020

https://packagingeurope.com/will-the-european-chemicals-industry-rise-to-the-circularity-challenge/

EEA briefing on biodegradable and compostable plastics

2020-09-10

European Environment Agency (EEA) publishes report providing on overview of challenges and opportunities; includes introduction to relevant terminology, implications of use, and comparison of existing certifications; calls for clearer labeling and increased campaigns to inform consumers

On September 7, 2020, the *European Environment Agency (EEA)* published a briefing that discusses the challenges and opportunities of biodegradable and compostable plastics. The article introduces the definitions and implications of using plastics that are bio-based, biodegradable, oxo-degradable, and compostable. It also provides an overview of the current certifications and reference standards for compostability and biodegradability depending on various environmental conditions. Referenced studies in the briefing have shown that the multitude of labels that exist are difficult for consumers to understand, who are often surprised to learn that a bio-based plastic is not necessarily compostable or biodegradable. Different requirements for industrial versus home composting were also found to be confusing. While these plastics are seen to have potential environmental benefits in specific applications, the *EEA* identified that "biodegradable, compostable and bio-based plastics need clearer labelling and repeated awareness-raising campaigns targeting users to ensure their correct disposal and treatment."

The article introduces the definitions and implications of using plastics that are bio-based, biodegradable, oxo-degradable, and compostable.

ECHA's committees back restricting over 1,000 skin sensitising chemicals used in clothing and other articles

2020-09-22

ECHA/NR/20/29

The Committee for Socio-economic Analysis (SEAC) supports France and Sweden's proposal to restrict the use of skin sensitising substances in clothing, footwear and other articles with similar skin contact. If adopted, the restriction will prevent many people from developing new skin allergies while also relieving the symptoms of many of those who already have them. This is expected to result in health benefits equivalent to at least €708 million per year.

SEAC adopted its final opinion on France and Sweden's proposal to restrict skin sensitising substances in textile, leather, synthetic leather, hide and fur articles, that are placed on the market for the first time. This follows an earlier opinion by the Committee for Risk Assessment (RAC) in March 2020. Both committees concluded that an EU-wide restriction is the most appropriate means to address the risks to EU citizens. In addition, SEAC concluded that the expected benefits and costs to society of the proposal mean that it is likely to be proportionate.

Skin sensitisation is a health effect that leads to a lifelong sensitivity to a specific allergen. Currently, there is a growing concern about skin sensitisation from exposure to chemicals in textile and leather products: it is estimated that up to 5 million people in the European Economic Area are already sensitised and up to 180 000 new cases occur each year.

The proposed restriction covers substances that have a harmonised classification as skin sensitisers under the Classification, Labelling and Packaging (CLP) Regulation such as chromium VI, nickel and cobalt compounds. It also proposes to restrict some dyes that are considered to have skin sensitising properties, but which do not have a harmonised classification. The proposal introduces a link with the CLP Regulation meaning that any substance that is classified as a skin sensitiser in the future under CLP would automatically be covered by the restriction. When substances are automatically added to the restriction, SEAC recommends a transitional period of three years between classification and the conditions of the restriction taking effect to allow manufacturers to adapt.

If adopted by the European Commission, the restriction will prevent many new skin allergies while also relieving the symptoms of many people who already have them. This is expected to save European society at least €708

This is expected to result in health benefits equivalent to at least €708 million per year.

million a year in reduced healthcare costs, productivity losses (e.g. due to sick leaves) and welfare losses (in terms of reduced quality of life due to the allergy). The raw material costs for industry to replace the chemicals are estimated to be up to €23.8 million per year. There will also be costs related to reformulation, testing and enforcement.

Following SEAC's adoption, the opinions of both RAC and SEAC as well as the proposal of France and Sweden will be sent to the European Commission, which will take the decision together with the EU Member States.

Full Article

~ECHA, 22 September 2020

https://echa.europa.eu/-/echa-s-committees-back-restricting-over-1-000-skin-sensitising-chemicals-used-in-clothing-and-other-articles

The ultimate guide to cheat regulation and sell toxic chemicals in the EU

2020-09-24

Did you ever wonder how companies can get away with having harmful chemicals on the EU market? Wonder no more.

ChemSec presents to you the ultimate guide to cheat EU chemicals regulation and get away with it. We will show you how to dodge regulation in the first place, and how to delay controls and ensure that your toxic chemical stays on the EU market for a long time once your company has been targeted by the authorities. The steps presented in this guide are all well-tested and proven to work – laggard companies have been following them with great success for years.

Step 1: Don't reveal your chemical's true identity

If there's one thing you should know, it's that scientific uncertainty stalls the regulatory process. With this in mind, you don't want anyone to be able to pinpoint your toxic chemical's composition and identify it. What you want instead is a vague and unclear substance that no one can really put their finger on. So, that's what you tell them: "Yeah, it's kind of like this other chemical but at the same time it isn't, you know, there's a lot of 'ifs' and 'buts' to it".

The European Chemicals Agency (ECHA) will then label it a *UVCB substance,* which basically means that they don't know what it is.

The steps presented in this guide are all well-tested and proven to work – laggard companies have been following them with great success for years.

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Alternatively, make sure that your chemical contains contaminants that could – *potentially* – influence its hazard profile. The important thing is that they can't know for sure.

Why do you want to do all this? Well, to ensure that regulatory action will be delayed since more information is needed to define and evaluate your chemical properly. Don't worry, you can always update your registration at a later stage and claim that the substance now is purer, doesn't have contaminants, or that you now know how to specify its identity.

Step 2: Be smart about the CAS number

Don't choose a CAS number (chemical identification number) that someone else has already registered and where lots of data is available. That would only increase the risk of ECHA targeting you sooner rather than later. Remember, you want to delay all regulatory action for as long as possible!

Instead, you should use a CAS number that is somewhat descriptive of your chemical but not used by other registrants. If you're willing to spend 1,000 euros, you could also choose to register a completely new CAS number. This would give you the possibility to tailor it to your every need. How about that for creative freedom?

Full Article

ChemSec, 24 September 2020

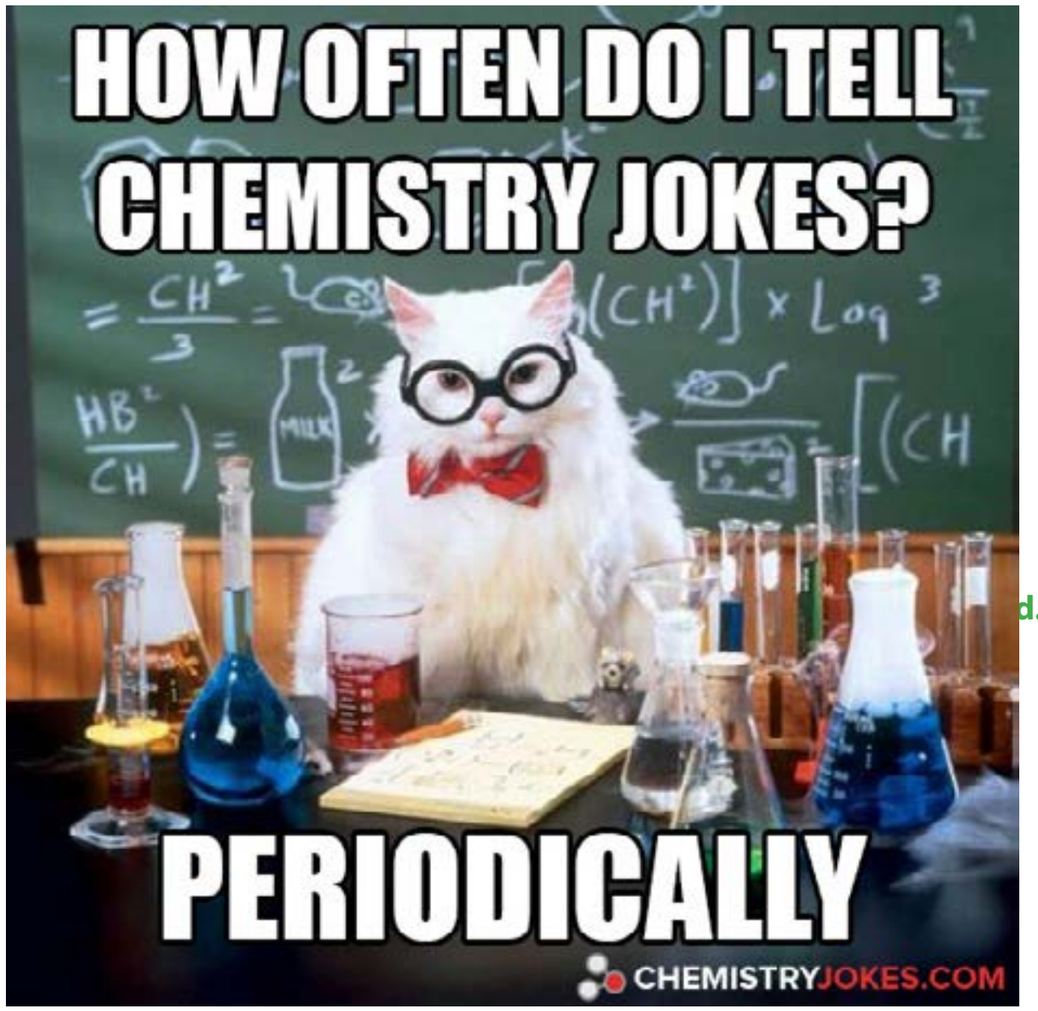
https://chemsec.org/the-ultimate-guide-to-cheat-regulation-and-sell-toxic-chemicals-in-the-eu/

Janet's Corner

OCT. 02, 2020

How Often Do I Tell Chemistry Jokes?

2020-10-02



https://www.chemistryjokes.com/jokes/how-often-do-i-tell-chemistry-jokes/

Hazard Alert

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Sodium bicarbonate

2020-10-02

Sodium bicarbonate, aka baking soda or bicarbonate of soda, is a soluble odourless white crystalline powder. It is a salt that breaks down to form bicarbonate and sodium in water. [1,2,4]

USES [2,3]

Sodium bicarbonate is used across a range of applications in various industries. It is an alkaline solution, meaning it neutralises acids. In this capacity it is used as an antacid—for conditions such as heartburn and indigestion. It can also be used to help contrast-induced nephropathy, stomach ulcers, dental plaque, and tooth discolouration. Besides its use as an antacid, bicarbonate of soda is used in baking as a leavening agent.

ROUTES OF EXPOSURE [5]

- Sodium bicarbonate can be taken intravenously and orally.

Sodium bicarbonate, aka baking soda or bicarbonate of soda, is a soluble odourless white crystalline powder.

HEALTH EFFECTS

Sodium bicarbonate poisoning affects a range of systems, including the integumentary and respiratory systems.

Acute Effects [6]

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

If a high concentration of chemical dust is inhaled, it can result in coughing, sneezing, or a sore throat. If large amounts of the chemical compound are ingested, it can cause gastrointestinal problems or abdominal pain. Eye contact with the chemical can result in mild irritation, including temporary redness and temporary impairment of vision.

Chronic Effects [6]

Chronic exposure to sodium bicarbonate is toxic to multiple body systems. Long term skin exposure to the chemical may cause dermatitis, characterised by skin redness and swelling, which may cause blistering and scaling and thickening of the epidermis. Although this chemical is not thought to cause other long term effects, exposure should be minimised as a matter of course.

SAFETY

First Aid Measures [6]

- Ingestion: If swallowed, immediately give the victim water to drink. First aid is usually not required; if in doubt, contact the poisons hotline.
- Skin contact: Remove all contaminated clothing, footwear and accessories. Do not re-wear clothing until it has been thoroughly decontaminated. Immediately rinse affected areas with plenty of soap and water. Contact a doctor in the event of continued irritation.
- Eye contact: Flush eyes (including under the eyelids), with water for at least 15 minutes. Removal of contact lenses should only be done by skilled personnel. Contact a medical professional immediately.
- Inhalation: If the person inhales fumes, combustion products or aerosols, remove them from the contaminated site. Other measures are usually unnecessary. If in doubt, contact the poisons information centre.
- General: Never administer anything by mouth to an unconscious, exposed person.

Exposure Controls/Personal Protection [6]

- Engineering controls: Emergency eyewash fountains and quick-drench areas should be accessible in the immediate area of the potential exposure. Ensure there is adequate ventilation. Use a local exhaust ventilation or process enclosure, to limit the amount of chemical dust in the air.
- Personal protection: Safety glasses, protective and dustproof clothing, gloves, a P.V.C apron and an appropriate mask or dusk respirator. Wear impervious shoes. Other protection could include barrier cream and skin cleansing cream. For specifications regarding other PPE, follow the guidelines set in your jurisdiction.

REGULATION [8]

United States:

The Time Weighted Average (TWA) for sodium bicarbonate has been set at 10mg/m^3.

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Australia [7]

No TWA has been set specifically for this chemical. Instead, there is a blanket limit of 10mg/m^3 for dusts when no other limits have been specified.

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Plastic pollution: Washed clothing's synthetic mountain of 'fluff'

2020-009-16

When you add it up, the total amount of synthetic microfibres going into the wider environment as we wash our clothes is an astonishing number.

US scientists estimate it to be 5.6 million tonnes since we first started wearing those polyester and nylon garments in a big way in the 1950s.

Just over half this mass - 2.9 million tonnes - has likely ended up in our rivers and seas.

That's the equivalent of seven billion fleece jackets, the researchers say.

But while we fret about water pollution, and rightly so, increasingly this synthetic "fluff" issue is one that affects the land.

The University of California, Santa Barbara, team which did the calculations found that emission to the terrestrial environment has now overtaken that to water bodies - some 176,500 tonnes a year versus 167,000 tonnes.

The reason? Wastewater treatment works have become very good at catching the fibres lost from washing machines. What's happening is those captured fibres, along with biosolid sludge, are then being applied to cropland or simply buried in landfills.

"I hear people say that the synthetic microfibre problem from apparel washing will take care of itself as wastewater treatment works become more widespread around the world and more efficient. But really what we're doing is just moving the problem from one environmental compartment to another," Roland Geyer, from UCSB's Bren School of Environmental Science and Management, told BBC News.

The industrial ecologist, working with a range of other experts, has previously totted up the total amount of virgin plastics ever produced (8.3 billion tonnes); and the annual flow of plastics into the oceans (roughly eight million tonnes a year).

These types of calculations are fiendishly complicated, involve models and necessarily resort to quite a few assumptions to plug real-world data gaps.

They can't be absolute in their descriptions of the issues, but at the very least they provide some ball-park figures on which to base serious conversations around mitigation.

Just over half this mass - 2.9 million tonnes - has likely ended up in our rivers and seas.

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About 14% of all plastic is used to make synthetic fibres, principally for clothing. When those garments are washed, they will shed tiny strands that are much thinner than a human hair.

For its just-published report in the journal PLoS One, the UCSB team tried to work out how much synthetic clothing had been produced in the past 65 years or so; how it's been used; and how it's been cleaned.

Consider the complexity in such an assessment. Consider, for example, how many people around the world have access to washing machines and how many still wash by hand; and how many of those washing machines are front-loaders and how many are top-loaders.

Different methods (and detergents) will shed different amounts of fibres. We also know the rotating paddles in top-loaders apply a lot of mechanical pressure to garments and are therefore regarded as big shedders of microfibres.

And think for a moment how many of the garments in an individual's wardrobe are actually routinely worn (and therefore cleaned), and how many stay on the shelf and rarely get an outing? That favourite old fleece almost certainly sees much more action than the office jacket and tie. It's thought a quarter or more of a person's clothing store probably isn't being worn at all or only very, very infrequently.

When the UCSB team ran its flow analysis on all these variables, the number that emerged for the total mass of synthetic microfibres emitted from apparel washing between 1950 and 2016 was 5.6 million tonnes.

Half of this amount, however, was released in just the last decade. This is in part a consequence of course of our ballooning collections of clothes.

In 1990, say the researchers, the global average stock of garments per capita was 8kg. By 2016 it was 26kg per head.

As stated above, increasingly the shed fibres are ending up in land settings, and improving the availability of modern wastewater treatment infrastructure is only going to accentuate this trend.

"Large-scale removal of microfibres from the environment is unlikely to be technically feasible or economically viable, so the focus needs to be on emission prevention," Bren School colleague and PLoS One article lead author Jenna Gavigan said.

"Since wastewater treatment plants don't necessarily reduce emissions to the environment, our focus needs to be on reducing emissions before they enter the wastewater stream."

This means a suite of solutions, commented Jamie Woodward, from the Department of Geography at The University of Manchester and whose group was the first to show that UK rivers could be very heavily contaminated with microplastics.

These solutions include reducing use, engineering more efficient filters on washing machines, and developing better wastewater treatment.

"Microfibres pose a particular challenge because these escape from wastewater treatment plants in their trillions - even with advanced treatment," he explained.

"We know that microplastics have been in the environment for decades, but we still don't know what an environmentally acceptable level of microplastic contamination might look like - in any environment. This underscores the importance of research aimed at better understanding the ecological impact of microfibres in both terrestrial and aquatic environments. Microplastic pollution is a fact of modern life - it is here to stay and we are only beginning to appreciate the consequences."

And the Prof added: "Natural fibres such as wool and cotton have been present in our rivers and seas in significant concentrations since the Industrial Revolution. The durability of synthetic fibres means they will be in the natural environment for a very long time and can be recycled from sludge treated soils into rivers and, ultimately, the ocean."

bbc.com, 16 September 2020

https://www.bbc.com

'Unfathomable destruction': thousands of rare wildflowers wiped out in Nevada

2020-09-18

Nestled among the slopes of Nevada's Silver Peak Range are six patches of Tiehm's buckwheat, a rare flowering plant found nowhere else in the world. Only an estimated 42,000 plants remain on 10 acres. But over the weekend, conservationists discovered that 40% of the total population had been destroyed.

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"We did a field survey of damage, and it was like doing an autopsy on my best friend," said Patrick Donnelly, Nevada state director at the Center for Biological Diversity (CBD). "It's really unfathomable destruction. It's the most emotionally devastating thing that's ever happened in my career."

The destruction occurs amid a conflict over the flower's habitat. For the past year and a half, Donnelly and Naomi Fraga, director of conservation at the California Botanic Garden, have been working to protect Tiehm's buckwheat from a proposed mine for lithium and boron, elements involved in producing clean energy technology. The operation would encompass the entire range of the plant's population, risking its extinction in the wild.

"I would not oppose the mine if it was done in a way that didn't put the whole species at risk, and was environmentally sound," said Fraga. "What is the cost of green energy if it causes the extinction of whole species?"

Donnelly said that the miner, Ioneer has perpetuated a narrative that protecting Tiehm's buckwheat means the killing the whole mining project, leading him to allege that the destruction was "undoubtedly related to the mine".

Over the weekend, Donnelly drove out to the site and found plants ripped from the ground, the fields pockmarked with nearly perfect circular holes, and heavy footprints on the trails. All six existing patches of Tiehm's buckwheat were damaged in what Donnelly characterized as a "calculated, well-organized effort".

However, Ioneer executive chairman James Calaway said he was confident that wildlife caused the destruction. He agreed with Elizabeth Leger, a plant biologist at the University of Nevada, that rodents must have ravaged the fields.

Leger's research team was one of the first on site and found that the edges of the plants' taproots were ragged, as if gnawed off, and that the leaves of some plants were shredded. Her team did see footprints, but thought that they had been left by researchers performing surveys over the summer, and did not see marks indicating people had knelt to dig out the buckwheat.

"[CBD has] been trying to kill our lithium operation with one set of propaganda after another," said Calaway, citing the CBD's "fabricated evidence" that people ruined the fields.

On Tuesday, Donnelly and Fraga wrote a letter to the Bureau of Land Management, the US Fish and Wildlife Service, the Nevada Division of Forestry and Ioneer, demanding all parties take immediate action to protect the plant.

Their demands include placing a security guard on site, restoring the population to its former state, and fencing the entire habitat. CBD is also seeking more support from federal and state agencies to grant Tiehm's buckwheat more protection, which would require Ioneer to obtain higher-level permits.

theguardian.com, 18 September 2020

https://www.theguardian.com

There's a new weapon against COVID-19. And it's dogs

2020-09-23

No one is going to feel safe traveling during this pandemic—especially as the cramped quarters of airplanes and cruise ships make social distancing more or less impossible. But since we can't redesign travel, many airports have taken a different tack: limiting who is allowed to. At airports such as LAX, temperature screenings attempt to catch sick travelers before they pass through security.

But now, the Helsinki Airport is doing one better: It's hiring a team of dogs, trained to sniff out COVID-19, to screen passengers.

Dogs have already proven their ability to sniff out diseases ranging from cancer to malaria. While we don't always know exactly what they are detecting to ferret out specific illnesses, the clues are likely tied to a dog's ability to smell volatile organic compounds—the metabolic junk our bodies produce all the time, which can vary with illness.

With 220 million scent receptors, versus the 5 million receptors that humans have, they have a sense of smell that's 10,000 times more accurate than our own. They can sniff substances that are diluted to a point of just one part per trillion, or the equivalent of smelling one drop of liquid in the combined volume of 20 Olympic swimming pools.

Researchers at the Veterinary Faculty of the University of Helsinki have been training dogs to be able to detect COVID-19 since early 2020. In May, the research group reported that it had successfully trained dogs to detect COVID-19 in urine samples. But progress has happened fast. Now, the dogs

With 220 million scent receptors, versus the 5 million receptors that humans have, they have a sense of smell that's 10,000 times more accurate than our own.

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have been trained to detect COVID-19 from sweat on our skin and have started trial testing at the Helsinki Airport.

According to International Airport Review, these canines need as little as 10 molecules to detect COVID-19, while current test equipment requires 18,000,000. And there's no comparison of speed. Abbot Labs has a 15-minute test that costs $5 to administer. Dogs can detect COVID-19 more or less instantly, and without an uncomfortable nasal swab.

The screening process won't be as simple as letting passengers walk by while a dog casually sniffs, however. Instead, passengers will be instructed to rub their skin with a wipe, then drop the wipe into a cup. The dog will sniff this cup inside an isolated booth. This arrangement allows for anonymous processing that protects a person's privacy, while shielding the handler from direct contact with a potentially infected passenger. Any passenger who is suspected of having COVID-19 will be directed to the airport's health information area.

The Helsinki program will soon employ four dogs but could expand to as many as 22 as enough canines are trained for the task. And while it's unclear if the idea will scale beyond one airport—nursing homes would be another excellent use case of such dogs, according to researchers—it makes for a fascinating case study on how we don't necessarily need more technology to screen for COVID-19 when 130,000 years of domesticated canine evolution is already on our side.

fastcompany.com, 23 September 2020

<a https://www.fastcompany.com/90553797/theres-a-new-weapon-against-covid-19-and-its-dogs?partner=feedburner&utm_source=feedburner&utm_medium=feed&utm_campaign=feedburner+fastcompany&utm_content=feedburner&cid=eem524:524:s00:09/23/2020_fc&utm_source=newsletter&utm_m">https://www.fastcompany.com

Blood donations show that the United States is still nowhere near herd immunity

2020-09-17

To better understand how widely the coronavirus has spread in the United States, some researchers are turning to an unusual source of data: blood donations.

In an effort to encourage more donations, many blood collection centers have been offering to test donated blood for antibodies to the

That finding suggests that the vast majority of Americans have yet to be infected with the virus, researchers report September 14 in JAMA.

coronavirus, which indicates a past infection with SARS-CoV-2, the virus that causes COVID-19. Of the nearly 1 million Americans who donated blood to the Red Cross from June 15 to August 23 and were tested, only 1.82 percent had the antibodies. That finding suggests that the vast majority of Americans have yet to be infected with the virus, researchers report September 14 in *JAMA*.

Blood donations aren't a random sample of the population, but the data can give researchers an idea how much of a population has been exposed to the virus, a concept known as seroprevalence, and how susceptible different populations remain to continuing outbreaks.

While seroprevalence was generally low across the country, there was variation among different demographic groups. African-American and Hispanic donors had slightly higher seroprevalence, compared with white donors, which matches patterns seen in clinical diagnoses of COVID-19.

Seroprevalence varied by region too. All regions except the Northeast experienced modest increases in seroprevalence over the course of the summer. By August 23, the South had a seroprevalence of about 2.9 percent, higher than the Midwest (about 2.7 percent) or West (about 2.4 percent) or Northeast (about 2.1 percent).

sciencenews.org, 17 Spetember 2020

https://www.sciencenews.org

Recycling isn't enough—the world's plastic pollution crisis is only getting worse

2020-09-18

Plastic production and consumption has snowballed since large-scale production began in the 1950s. In 2020, an estimated 24 million to 34 million tonnes of plastic waste will enter the world's lakes, rivers and oceans. That is roughly the weight of 21,000 rail locomotives.

And if trends continue without improvements in the way we manage plastic waste, we could be spewing as much as 90 million tonnes of plastic waste into the world's waters by 2030. Already, an estimated 10,000 tonnes of plastic waste enter the Great Lakes every year.

Back in 2015, the world agreed that eight million tonnes of plastic waste contaminating the ocean alone was unacceptable. Several international platforms emerged to address the crisis, including Our Ocean, the UN

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Sustainable Development Goals and the G7 Ocean Plastic Charter, among others.

These are ambitious commitments, but will they meaningfully reduce plastic pollution?

New research published in *Science* shows that even if governments around the world adhere to their global commitments to address plastic pollution, and all others join in these efforts, in 2030 we will still emit between 20 million and 53 million tonnes of plastic waste into the world's aquatic ecosystems. Global commitments do not match the scale of the problem — we need to rethink our strategy.

The myth of plastic recycling

Plastics are commonly tossed into mixed-recycling bins to be conveniently collected and — we incorrectly assume — remade anew. The reality is that we're "wishcycling." In fact, less than 10 per cent of plastics are recycled.

Virgin plastics are cheaper to produce than recycled products, undermining the viability of the recycling sector. For example, in 2019, California's largest recycling plant closed, laying off 750 employees, because of increased business costs and falling prices for recycled materials.

The abundance of disposable plastic has led to waste colonialism — the dumping of large quantities of mixed-plastic waste in developing countries, most commonly Southeast Asia.

These practices are fuelled by policies that harken back to European colonization of the Americas. They give companies access to the raw materials used to make plastics today — oil and ethane gas — often without approval, and that directly endanger the lives of Indigenous women.

Unequal health impacts

Across the globe, health problems associated with plastics production disproportionately affect lower-income Black, Indigenous, people of colour (BIPOC) communities. That's because the bulk of the petrochemical plants producing plastics are located in communities of colour.

Thousands of toxic chemicals are used in plastics production and most are unregulated. Bisphenol A (BPA), banned from many consumer plastics, has simply been replaced with other bisphenols such as BPS or BPF, even

though they maybe as hazardous to human health. Subsequently, plastics workers suffer high rates of respiratory and cardiovascular disease and cancers.

It's no coincidence that Louisiana, a hotbed for the petrochemical sector, is the epicentre of what is known as "Cancer Alley." Perhaps a more appropriate name would be "Cardiovascular-respiratory-illness-reproductive-disorder-cancer Alley." BIPOC communities have been overburdened with pollution for decades, and air pollution from petrochemical plants is a leading cause of chronic respiratory illnesses contributing to greater risks of morbidity from diseases like COVID-19.

Globally, plastic waste treatment facilities (collection, sorting, processing, recycling, incineration facilities and landfill sites) are frequently located in communities of colour, exacerbating negative health outcomes.

An estimated 15 million waste pickers worldwide pluck the most valuable pieces of plastic from mountains of imported waste to make their living. Often the remaining plastic is burned, belching carbon-rich smoke into the atmosphere. Everyone unfortunate enough to be in its plume inhales carcinogenic furans and dioxins. Plastics that aren't burned or processed are piled high or buried, contaminating previously arable soils and waterways.

What does genuine progress look like?

Progress requires us to address the structural inequality that encourages and normalizes the waste of resources, ecological destruction and the perpetuation of colonial systems.

Progress requires decolonial policies, where justice and equity are prioritized. That means the equitable investment in effective collection, sorting, cleaning, reuse, repair and recycling infrastructure, where BIPOC don't carry the burden of pollution.

It requires policies that dissuade the unabated extraction of resources and ensure companies are responsible for the life cycle of their plastic products. This would include abolishing US$296 billion in subsidies provided annually by governments to petrochemical companies and introducing laws that require companies to pay for waste collection, recycling or disposal, rather than taxpayers.

Quantifying the scale and extent of plastic pollution helps us understand the kind of effort needed to make change, but just as vital is mapping

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the health, economic, cultural and human rights dimensions of this toxic industry.

By rallying for policies that tackle the underlying structures that perpetuate the plastic pollution crisis, we can reverse inequality, fulfil human rights obligations, improve the health of all communities and prevent and mitigate ecological damage. Policies like the Green New Deal are moving us in the right direction, but we need to do more.

If ever there was a time to redefine the business-as-usual plastics industry and transition to a healthy and more equitable global society, it is now.

theconversation.com, 18 September 2020

https://www.theconversation.com

Burping cows are fueling the climate crisis. This company says it's got a solution

2020-09-22

(CNN) Cows produce beef, milk -- and a lot of methane.

A byproduct of digestion, methane is produced from both ends of the animals, although over 90% enters the atmosphere via their burps.

And that's a problem, because methane is a potent greenhouse gas, which traps 28 times more heat than carbon dioxide over 100 years.

As the world's appetite for beef has grown over the last two decades, annual methane emissions have risen 9% a year. According to the FAO, cattle are responsible for nearly 10% of greenhouse gases generated worldwide by human activity.

Now, a new company -- FutureFeed -- says it has a solution. The Queensland-based startup was established last month by the Commonwealth Scientific and Industrial Research Organization (CSIRO), the Australian government's scientific research agency.

With four other investors including Australia's largest supermarket chain, Woolworths, the organization hopes to make belching bovines less of a problem -- by adding a pinky-red, fern-like seaweed called asparagopsis to their diet.

Freeze-dried and fed to cows as a supplement, asparagopsis eliminated methane "below the detection limits of our instruments," in tests, says Michael Battaglia, a research director for CSIRO and a director of

According to the FAO, cattle are responsible for nearly 10% of greenhouse gases generated worldwide by human activity.

FutureFeed. When the seaweed was first trialed by scientists, it performed so well that they assumed their equipment was broken, he adds.

FutureFeed attributes the seaweed's methane-busting clout to a compound called bromoform, which stop microbes in the cows' guts producing the gas. Many seaweeds contain small quantities of bromoform, explains Battaglia, but asparagopsis is unusual because it stores large amounts in special cells on the surface of its fronds.

The science is clear, but a major hurdle remains -- there isn't enough asparagopsis.

Tons of seaweed

Until recently, asparagopsis grew only in the wild and had to be hand-picked by divers. As its potential for the livestock sector becomes evident, a fledgling industry is gearing up to grow it on a commercial scale.

Sam Elsom is founder and COO of Sea Forest. Based on the east coast of Tasmania, the company is pioneering the cultivation of high-bromoform asparagopsis and is working closely with FutureFeed to commercialize the seaweed as a livestock feed supplement, he says.

Elsom has secured a 100 hectare marine lease, where he grows asparagopsis on ropes. "The seaweed is seeded onto the lines which are then deployed into the ocean," he explains.

The seaweed is also farmed on land, in large, aerated tanks filled with fresh ocean water, and raceway ponds -- structures equipped with paddle wheels that circulate the water, says Elsom.

Sea Forest is developing a range of farming techniques with a view to licensing its cultivation models to growers elsewhere, says Elsom. Asparagopsis is native to Australia and flourishes in Tasmania's nutrient-rich waters, he says, but in other parts of the world, and inland areas, land cultivation might be the best option.

But even with the best technology, will it be possible to grow enough asparagopsis to make a significant dent in the methane problem?

Battaglia estimates that Australia would need 35,000 tons of dried seaweed a year to feed asparagopsis to all its dairy cows and cattle on feedlots -- intensive feeding yards where they are fattened up before slaughter.

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At present, Sea Forest expects to harvest 500 tons of dried asparagopsis a year at its pilot facility and has plans to triple the annual harvest by 2022, says Elsom.

Australia would need seaweed farms covering approximately 10 square kilometers to produce enough asparagopsis for its cows, according to Battaglia. He believes that's achievable, and points to the country's prawn farms, which currently occupy a similar area.

Australia is home to around 1% of the global cow population, says Battaglia. Based on the calculations for Australia, feeding asparagopsis to the worlds' feedlot and dairy herds would require around 3.5 million tons of dried product a year, he says.

The US has the world's largest fed-cattle industry, numbering more than 94 million animals. Alexander Hristov, a professor of dairy nutrition at Pennsylvania State University, says that according to his team›s math, it would require «over half the global seaweed production» to feed all the cattle in the US asparagopsis at 1% of their feed intake -- and that scaling up to a global level is "unrealistic."

However, Battaglia says that if the asparagopsis is rich in bromoform, it would need to make up only 0.2% of a cow's diet. Additionally, FutureFeed estimates that if just 10% of the global livestock industry fed their cows an asparagopsis supplement, the positive climate impact would be significant -- equivalent to taking 100 million cars off the road.

Incentivizing farmers

Asparagopsis cultivation will expand only if growers are confident that livestock farmers will buy the seaweed supplement.

Battaglia is upbeat. He says there's a "strong uptake incentive" for farmers, because not only does asparagopsis reduce methane, it also makes cows grow faster.

Cows spend around 10% of their energy generating methane, says Battaglia. When they're fed asparagopsis, that energy is channeled into growth instead, he says. FutureFeed will conduct full-scale trials later this year, to gather data on enhanced growth rates.

Hristov cautions that the long-term effects of asparagopsis are unclear. "There are many unanswered questions around animal health (and) reproduction," he says, and the seaweed may affect milk quality.

For now, though, FutureFeed believes it's the best candidate for tackling cow-related methane emissions. The company plans to help build a supply chain between seaweed growers and farmers, with the aim of getting low-methane beef and milk on supermarket shelves by late 2021, says Battaglia.

He points to the broader need to develop technologies that can help feed growing populations, while also combating climate change. "FutureFeed might just be one of those options."

edition.cnn.com, 22 September 2020

https://www.edition.cnn.com

As evidence builds that COVID-19 can damage the heart, doctors are racing to understand it

2020-09-15

This fall, cardiologist Sam Mohiddin will embrace a new role—that of research subject. MRI scans of his heart at St. Bartholomew's Hospital in London, where he works, will help answer a pressing question: Do people who suffered a mild or moderate bout of COVID-19 months ago, as he did, need to worry about their heart health?

Fears that COVID-19 can cause the cardiac inflammation called myocarditis have grown, as doctors report seeing previously healthy people whose COVID-19 experience is trailed by myocarditis-induced heart failure. Mohiddin recently treated 42-year-old Abul Kashem, who had typical COVID-19 symptoms in April, including loss of smell and mild shortness of breath. A month later, he fell critically ill from severe myocarditis. "I'm just grateful to be alive," says Kashem, who spent more than 2 weeks in an intensive care unit. Why did this happen? he wonders.

How the virus might damage heart muscle is just one question researchers are now probing. Other studies are following people during and after acute illness to learn how common heart inflammation is after COVID-19, how long it lingers, and whether it responds to specific treatments. Researchers also want to know whether patients fare similarly to those with myocarditis from other causes, which can include chemotherapy and other viruses. In more than half of virus-induced cases, the inflammation resolves without incident.

But some cases lead to arrhythmia and impaired heart function, or, rarely, the need for a heart transplant. Because millions are now contracting the

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coronavirus, even a small proportion who suffer severe myocarditis would amount to a lot of people. "Are we going to have an increase of patients with heart failure secondary to this?" asks Peter Liu, a cardiologist and chief scientific officer of the University of Ottawa Heart Institute.

Whether SARS-CoV-2, the virus that causes COVID-19, induces cardiac injury including myocarditis more often, or with greater severity, than other viruses is still unclear. Because SARS-CoV-2 can trigger an intense immune response throughout the body, survivors may be at heightened risk of cardiac inflammation. Another idea suggests COVID-19 patients might be prone to the condition because the virus enters cells by binding with the angiotensin-converting enzyme 2 (ACE2) receptor, which sits on heart muscle cells. But researchers caution against outrunning the data. "It's a good hypothesis, but it's not a tested one," says Leslie Cooper, a cardiologist at the Mayo Clinic in Jacksonville, Florida, about ACE2.

One reason it's hard to say whether COVID-19 poses a special risk of myocarditis is uncertainty about its prevalence after other infections. Echocardiogram studies after some influenza outbreaks suggest up to 10% of flu patients have transient heart abnormalities, Liu says. But such studies are scarce. "We don't scan patients after they had the flu," says Valentina Püntmann, a cardiologist at University Hospital Frankfurt.

Püntmann fueled concerns about myocarditis when she did just that with COVID-19 patients. Her team used MRI to scan the hearts of 100 COVID-19 patients an average of 71 days after they had tested positive. The scans showed cardiac abnormalities in 78 people, with 60 appearing to have active inflammation. Most also described lingering symptoms, such as fatigue and mild shortness of breath, leading Püntmann to wonder whether heart inflammation might be responsible.

Although **the work by Püntmann and her colleagues**, published in July in *JAMA Cardiology*, prompted alarming headlines, many researchers say it needs to be replicated. Cardiologists urge anyone with symptoms like shortness of breath or chest discomfort after COVID-19 to see a doctor, but they worry about a flood of healthy recovered people clamoring for heart assessments. "Here's the good news: We're going to find out" how likely cardiac injury is, says Matthew Martinez, director of sports cardiology at Morristown Medical Center.

Because of the physical demands of sports, team doctors need to be on guard for myocarditis. A paper in *JAMA Cardiology* last week reported a study of 26 athletes at Ohio State University after COVID-19; four had developed myocarditis. Professional sports leagues are also scanning

the hearts of athletes who were infected with SARS-CoV-2. Those with myocarditis, regardless of whether they have symptoms, are benched, in part out of fear that myocarditis could lead to sudden death during intense activity. Martinez, who's helping coordinate the research for the National Basketball Association and Major League Soccer, predicts a flow of data on athletes over the coming months. "Those of us in this space are willing to ruin a Saturday or a Sunday to get this done."

He stresses, though, that even if researchers can clarify the average duration of myocarditis and its risks for a young athlete, those may be very different for a 50-year-old with obesity or high blood pressure, especially if they were sick enough with COVID-19 to be hospitalized. "In those individuals, I am going to be more cautious" and screen for heart injury, he says.

Others are pursuing clues to how COVID-19 can damage the heart, which might point to ways to head off the damage. "SARS-CoV-2 does challenge your immune system in unconventional ways," Liu says. Autopsies of heart tissue after COVID-19 have revealed inflammation **in the heart's blood vessels** instead of its muscle cells, the site of the inflammation caused by other infections. Another autopsy study found **scattered death of heart cells**, but the authors noted the mechanism of injury was unknown. "There's been a lot of discussion whether this is myocarditis" as typically defined, Liu says. Regardless, he and others hope for clinical trials to test whether preventive strategies, such as taking beta blocker drugs, might head off heart failure in someone flagged as high risk after COVID-19.

While Mohiddin volunteers for a study of survivors, he's also running one: a trial that **aims to recruit 140 people** while they are hospitalized with COVID-19 or soon after, 20 with severe myocarditis and the rest without. He and colleagues will look for abnormal T cell levels in the blood of people with myocarditis, which could help explain whether and how the immune system is causing cardiac injury. He is also exploring whether immune cell patterns in the blood presage myocarditis later.

Even if COVID-19 rarely causes serious myocarditis, one hypothesis is that mild cases could heighten the risk of heart disease years later. Scar tissue can form as myocarditis heals, and earlier work has shown residual cardiac inflammation portends worse heart health. As cardiologists, "We're in the business of identifying asymptomatic risk factors," such as hypertension,

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Mohiddin says. "It's not difficult to imagine that in the future, clinical practitioners will ask a new patient, 'Did you have COVID?'"

sciencemag.org, 15 September 2020

https://www.sciencemag.org

1,000-year-old precursor to stainless steel found in Iran, surprising archaeologists

2020-09-23

Chromium steel, commonly referred to as stainless steel, is thought to be a recent manufacturing innovation, but new evidence suggests ancient Persians stumbled upon an early version of this alloy some 1,000 years ago, in what is a surprise to archaeologists.

Ancient Persians were forging alloys made from chromium steel as early as the 11th century CE, according to new research published today in the Journal of Archaeological Science. This steel was likely used to produce swords, daggers, armour, and other items, but these metals also contained phosphorus, which made them fragile.

"This particular crucible steel made in Chahak contains around 1% to 2% chromium and 2% phosphorus," Rahil Alipour, the lead author of the new study and an archaeologist at University College London, said in an email.

Archaeologists and historians were, up until this point, fairly certain that chromium steel (not to be confused with chrome — that's something else) was a recent invention. And indeed, stainless steel as we know it today was developed in the 20th century and contains far more chromium than the steel produced by the ancient Persians. Alipour said the ancient Persian chromium steel "would not have been stainless."

Alipour said the ancient Persian chromium steel "would not have been stainless."

That said, the new paper "provides the earliest evidence for the consistent and intentional addition of a chromium mineral, most likely chromite, to the crucible steel charge — resulting in the intentional production of a low-chromium steel," wrote the researchers in their study.

A translation of medieval Persian manuscripts led the research team to Chahak, an archaeological site in southern Iran. Chahak used to be an important hub for the production of steel, and it is the only archaeological site in Iran with evidence of crucible steel-making, in which iron is added to long tubular crucibles, along with other minerals and organic matter, which is then sealed and warmed in a furnace. After cooling down, an

ingot is removed by breaking the crucible. This technique was vitally important among many cultures, including the Vikings.

"Crucible steel in general is a very high-quality steel," Alipour said. "It does not contain impurities and is very ideal for production of arms and armour and other tools."

A key manuscript used in the study was written by the Persian polymath Abu-Rayhan Biruni, which dates back to the 10th or 11th century CE. Titled "al-Jamahir fi Marifah al-Jawahir" (translated to "A Compendium to Know the Gems"), the manuscript offered instructions for forging crucible steel, but it included a mystery compound called *rusakhtaj* (meaning "the burnt"), which the researchers interpreted and subsequently identified as being a chromite sand.

Excavations at Chahak resulted in the discovery of residual charcoal in old crucible slag (waste matter that's left over after the metal has been separated). Radiocarbon dating of this charcoal yielded a date range between the 10th and 12th centuries CE. A scanning electron microscope was used to analyse the slag samples, revealing traces of ore mineral chromite. Finally, an analysis of steel particles found in the slag suggests the Chahak crucible steel contained between 1% to 2% chromium by weight.

"The chromium crucible steel that was made in Chahak is the only known of its kind to contain chromium, an element known to us as important for the production of modern steel, such as tool steel and stainless steel," explained Alipour. "Chahak chromium crucible steel would have been similar in terms of its properties to modern tool steel," and the "chromium content would have increased the strength and hardenability, properties needed to make tools."

A wealth of Persian crucible steel objects can be found in museums around the world, she said, and we already know that crucible steel was used to make edged weapons, armour, prestigious objects, and other tools. Chahak is also referenced in historical manuscripts as a place where crucible blades and swords were made, but the accounts "also mention that the blades were sold to a very high price, but they were brittle, so they lost their value."

The phosphorus, which was also detected during the analysis, was added to reduce the melting point of the metal but also to reduce some toughness, which subsequently made the metal fragile.

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Regardless, the discovery points to a specific Persian tradition of steel-making, which is in-and-of-itself quite important. To the best of the authors' knowledge, the specific chromium content seen in the Chahak steel could be used to distinguish it from other artifacts.

"Previous crucible steel evidence, studied by scholars, belong to crucible steel production centres in India, Sri-Lanka, Turkmenistan and Uzbekistan," said Alipour. "None of these show any trace of chromium. So, chromium as an essential ingredient of Chahak crucible steel production has not been identified in any other known crucible steel industry so far." To which she added: "That is very important, as we can now look for this element in crucible steel objects and trace them back to their production centre or method."

To that end, the researchers are hoping to work with museum experts to share their findings and to help with the dating and identification of objects with this unique chromium steel signature.

gizmodo.com.au, 23 September 2020

https://www.gizmodo.com.au

A tiny crustacean fossil contains roughly 100-million-year-old giant sperm

2020-09-21

Ostracods look like nothing more than seeds with legs. But some species of these tiny crustaceans have an outsize claim to fame: giant sperm. In the most extreme case, it can stretch 1.18 centimeters, over three times the length of an adult.

A newfound collection of ostracods preserved in amber reveals that megasperm dates back to at least about 100 million years ago during the time of the dinosaurs, researchers report online September 16 in *Proceedings of the Royal Society B*. A tangle of sperm found inside a female is among the oldest, if not the oldest, fossilized sperm ever found.

A single piece of amber from Myanmar held 39 ostracods, including many from a newly discovered species, *Myanmarcypris hui*. Using micro-CT scans, Dave Horne, a micropaleontologist at Queen Mary University of London, and colleagues peered inside a few of the tiny shelled animals.

"We knew from looking at the piece of amber with an ordinary light microscope that there were antennae and legs sticking out of the shell, so we were hopeful of finding internal organs," Horne says. If delicate parts

A tangle of sperm found inside a female is among the oldest, if not the oldest, fossilized sperm ever found.

like legs and antennae are preserved, it's likely that other soft parts are too, he says. "But what we saw … exceeded expectations."

Bottom of Form

The layout of internal sex organs resembled that of their modern-day counterparts. And inside a *M. hui* female, the team found preserved giant sperm packing her seminal receptacles.

Ostracods aren't the only animal with giant sperm (*SN: 7/23/12*). Some fruit flies, for example, also rely on megasperm (*SN: 5/25/16*). In ostracods, giant sperm possibly resulted from "competition between sperms of two or more males trying to fertilize the eggs of the same female," Horne says. "This must be a highly successful reproductive strategy to have lasted for a hundred million years." Ostracod sperm must make a long, winding journey from the female's vagina to her eggs, adds study coauthor Renate Matzke-Karasz, a geobiologist at Ludwig Maximilians University Munich. Spirals in the canal to the eggs make the distance longer than the entire length of the female. Shorter sperm might not be able to make the journey, Matzke-Karasz says.

Finding ancient preserved sperm is rare, as soft tissues often decompose. But a series of recent discoveries — 17-million-year-old ostracod sperm reported in 2014 (*SN: 5/14/14*) and 50-million-year-old worm sperm described in 2015 (*SN: 7/14/15*) — has expanded the sperm fossil record. The new find rivals the age of reported fossilized sperm found in crickets from the Cretaceous Period. But Horne, Matzke-Karasz and colleagues argue that the newfound ostracod sperm is "the oldest unequivocal fossil animal sperm."

"The two bundles of filaments are in the correct position within the female," says Robin Smith, a zoologist at Lake Biwa Museum in Shiga Prefecture, Japan, who was not involved in the study. "I have looked at a lot of ostracod spermatozoa over the years, and there is no question; these are preserved spermatozoa." The evidence of ancient cricket sperm is less clear, he says. Matzke-Karasz and colleagues argue that the cricket fossil could be a sperm tube, used to transfer the sperm, rather than the sperm itself.

George Poinar, an entomologist and paleontologist at Oregon State University in Corvallis who described the ancient cricket, stands by his conclusions. But regardless of which fossil is the oldest, this new discovery

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shows that certain features — like giant sperm — have stood the test of time, Poinar says.

sciencenews.org, 21 September 2020

https://www.sciencenews.org

Gold miners discover 100 million-year-old meteorite crater Down Under

2020-09-24

Gold miners in the Australian Outback recently discovered a gigantic meteorite crater dating to about 100 million years ago, back when dinosaurs roamed the Earth.

Found near the Western Australian town of Ora Banda, the newly dubbed Ora Banda Impact Crater is about 3 miles (5 kilometers) across. This huge hole was likely created by a meteorite up to 660 feet (200 meters) wide, or longer than the length of two American football fields, according to Resourc.ly, a Western Australia news outlet.

Found near the Western Australian town of Ora Banda, the newly dubbed Ora Banda Impact Crater is about 3 miles (5 kilometers) across.

When geologists at Evolution Mining, an Australian gold mining company, came across some unusual rock cores at Ora Banda, they called Jayson Meyers, the principal geophysicist, director and founder of Resource Potentials, a geophysics consulting and contracting company in Perth. Meyers examined the geologists' drill core samples, as well as rock samples from the site, and he immediately noticed the shatter cones — telltale signs of a meteorite crash. **PLAY SOUND**

Shatter cones form when high-pressure, high-velocity shock waves from a large impacting object — such as a meteorite or a gigantic explosion (such as would occur at a nuclear testing site) — rattle an area, according to the Planetary Science Institute (PSI), a nonprofit group based in Tucson, Arizona, which was not involved with the new find. These shock waves shatter rock into the unique shatter cone shape, just like a mark that a hard object can leave on a car's windshield.

Because "we know they didn't do any nuclear testing at Ora Banda," the evidence suggests that an ancient impact crater hit the site, Meyers told Resourc.ly.

To learn more, Meyers examined the site's topography (that is, its varying elevations) and examined a gravity anomaly map, which shows how the gravity field at a particular site differs from a uniform, featureless Earth, according to NASA›s Earth Observatory, which wasn't involved in

the finding. Any gravitational anomalies that turn up on the map can give insight into hidden features that affect the amount of mass, and therefore gravitational pull, in a given area. For instance, a mountain range would have more gravitational force than a featureless surface, while an ocean trench or crater would have negative gravity anomalies, the Earth Observatory explained.

Meyer's work revealed a hidden impact crater with a pucker in the middle. This pucker is where shattered rocks came back to the surface after the comet struck, like a compressed spring that bounces back, Resourc.ly reported. When the geologists went to the "pucker" part of the site, they discovered shatter cones in the rocky outcrops.

Now, scientists from Curtin University in Perth are investigating the Ora Banda site on a microscopic level. In particular, the team will examine whether minerals at the site were vaporized and then re-crystallized under high pressures. "The energy released when the [meteorite] impacted would have been more than the combined energy from every atomic test ever conducted," Meyers told Resourc.ly.

Research on zircons and other minerals from the crater will likely reveal when the meteorite struck — right now, Meyers thinks it hit between 250 million and 40 million years ago. (If it struck after the Cretaceous period ended, about 65 million years ago, this meteorite wouldn›t have bothered the non-avian dinosaurs, because they were already dead.)

The dinosaur-killing asteroid was much larger and more lethal. That asteroid, which hit the area that is now Mexico's Yucatan Peninsula, was about 6 miles (10 km) wide and left an impact crater about 90 miles (150 km) across.

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https://www.livescience.com

What frogs can teach us about the state of the world

2020-09-16

IT'S AN HOUR after sunset, one night in early April, and I'm standing on the side of a dirt road in my hometown of Frelighsburg, Quebec, with my hands cupped around my ears. I'm listening for the calls of anurans—amphibians without a tail, so frogs and toads. I am here, more specifically, to hear the croaks of wood frogs, which are one of the first species to peek their little brown heads out after a long winter of hibernation.

This isn't just recreational listening, mind you—this is also for science. I am a volunteer observer, one of several who are gathering data about dwindling amphibian populations in this region. For the *parcours d'écoute* ("listening pathways") project I am on, participants each choose a quiet eight-kilometre stretch of road and go out listening along it, noting the frog and toad species they hear and the volume of their calls, returning to record these observations in the same spots once more, later in the season, ideally year after year. It's called the Amphibian Population Monitoring Program, a long-term citizen-research project created in the 1990s by the Saint Lawrence Valley Natural History Society—part of a provincial-government push that came about when the International Union for Conservation of Nature highlighted worldwide declines of amphibian populations.

This isn't just recreational listening, mind you—this is also for science.

I make my path along Chemin Pinacle, at the foot of the mountain of the same name, stopping at markers every 800 metres and perking up my ears for a three-minute stretch at each one. This road is about three kilometres from the house I grew up in, where my bedroom was next to a pond that resonated with an amphibian chorus through the spring and early summer; on warm nights, I would leave my window open and be lulled to sleep by frog songs.

Though the term "citizen science" is relatively new, the practice of nonscientists gathering data about the natural world is not. Sometimes this has been undertaken by curious individuals: Mary Anning, who had no training, hunted for fossils along the cliffs of Devon, England, in the early nineteenth century and unearthed the first known plesiosaurus skeleton. (She is also believed by many to be the inspiration behind the "She sells seashells by the seashore" tongue twister.) By the early twentieth century, evolving telescope technology allowed the astronomically curious to turn an eye to the sky and gather useful data. But, increasingly, groups have also coalesced to pursue scientific interests. The National Audubon Society founded the Christmas Bird Count in 1900; it is one of the longest-

running community science projects in the world. In 1954, a sea turtle survey began on a single beach in Japan; now, about forty beaches across the country host counts. And the University of Cape Town's Animal Demographic Unit established an ongoing project to monitor population dynamics in 1991.

In Canada, the federal government launched its NatureWatch website in 2000, encouraging citizens to monitor all sorts of wild elements, from plants to ice formations to frogs. And, in the last decade, apps like iNaturalist and Merlin and online databases like eButterfly have bolstered community participation in natural sciences by allowing users to easily share their findings about the locations of animals, identification of species, and number of individuals in a sighting. Nearly all of us now own devices that put scores of wildlife information at our fingertips. Databases are growing—in a boon for underfunded scientific communities, findings on apps are shared to data repositories like the Global Biodiversity Information Facility—and long-term monitoring projects made up mainly of volunteers, like the one I am participating in, are gaining popularity.

Nowadays, amateur scientists have extra impetus for heading into the field: studies like the major UN report on biodiversity last year, which warned of unprecedented declines in the natural world and estimated that 1 million plant and animal species are now at risk of extinction. Increased tracking of these accelerated declines is key to understanding, and hopefully slowing down, what scientists call our planet's ongoing sixth mass extinction. Without filling in our knowledge gaps about the natural world, we can't know what it is we're trying to save.

I**N 1968**, musician Bernie Krause and his collaborator, Paul Beaver, were contracted by Warner Brothers– Seven Arts to make an album on the theme of ecology. Beaver refused to head out into the wild to capture sounds, but Krause got hooked on the experience. In 1970, he and Beaver released *In A Wild Sanctuary*, the first album ever to use natural soundscapes, and in the years that followed, Krause would help pioneer a new field: soundscape ecology—the study of the sounds of a land- or seascape.

Sound is an important indicator of an environment. "The sounds of the natural world, when they're in a healthy habitat, come across as a kind of orchestration," Krause, now based in Glen Ellen, California, tells me. "In order for the birds to be heard, they have to stay out of the way of the frogs, out of the way of the insects, and so on.… All animals vocalize in a relationship to one another, much like instruments in an orchestra." He

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later coined the term *biophony* to describe this effect of the collective sounds of the creatures in a habitat. To date, Krause has recorded over 1,200 habitats; in the years since he began this work, the sounds in nearly half of them have become compromised or gone silent. At times, Krause has returned to the same spot to capture stark human-caused environmental changes, finding near silence in spaces once loud with birds, frogs, and insects.

Animals make sounds for many reasons: to communicate fear or danger, alert others that they've found food, indicate their availability for mating, or warn another member of the species that they're on their turf, among others. For anurans, vocalizations aren't just about males letting females know they're looking to get busy; they're a form of group self defence. As the voice of each individual joins in, it becomes harder for predators to distinguish between and locate them. But, when that chorus shrinks or is interrupted by loud human sounds, individuals can be exposed and put at risk.

Growing up, my pond was home to a full chorus. As the sun set in late spring, when all the species had woken up from hibernation and the mating season was at its peak, the backyard and woods became loud with the high-pitched chirp of spring peepers, the continuous trill of grey treefrogs, and the lower-midrange staccato warble of leopard frogs. I loved the quick overlapping croaks of green frogs, which sound like a cartoon character swallowing hard in an awkward situation. I spent afternoons canoeing around the pond's banks to spot our huge resident bullfrog, who chimed in intermittently with his bass, cow-like vocalization. (I'm not being sexist with pronouns, to be clear: the majority of anuran songs we hear are males calling to females or protecting their territory.)

Krause wants to get everybody to similarly use their ears. "If [people] listen and they shut the hell up," he tells me, "they're going to get a different sense of the world very quickly."

L**AST YEAR**, a review published in the journal *Science* detailed global mass amphibian die-offs partly due to the spread of the disease chytridiomycosis, commonly known as chytrid. Caused by a fungus called *Batrachochytrium dendrobatidis*, chytrid is now found in dozens of countries and has caused the presumed extinction of at least ninety amphibian species.(The earliest known case in North America was found in a museum, in the bodies of two green frogs collected in Saint-Pierre-de-Wakefield, Quebec, in 1961.) The disease has caused the largest number

of documented deaths attributable to a single illness in recorded scientific history.

Though devastating, chytrid and other diseases aren't the sole or arguably even the main culprits of amphibian decline: illnesses find opportunity in climate-changed or human-altered habitats. Frog, toad, and salamander populations are often already weakened by displacement (like construction in the marshy wetlands they call home) or irritants (such as chemicals used in farming that act as immunosuppressants). Sara Ashpole, an environmental studies professor at St. Lawrence University, in Canton, New York, estimates that somewhere between 40 and 70 percent of North America's wetlands have degraded or disappeared completely; in and around densely inhabited Canadian centres, that climbs to 98 percent.

In 2017, the World Wildlife Fund (WWF) published the Living Planet Report Canada, detailing population trends for 903 invertebrates, including forty-six species of amphibians and reptiles (a group called herpetofauna), half of which showed signs of decline. The WWF also reported that 42 percent of amphibians had been assessed as at-risk in 2014. According to the International Union for Conservation of Nature, herpetofauna have some of the highest proportions of threatened and "data deficient" species for vertebrates, which means there isn't comprehensive data about baseline populations—the funding to gather the necessary information simply does not exist. Species like these often get overlooked when it comes to the allocating of resources, with money being funnelled toward the cuter, more charismatic megafauna species that pluck at human heartstrings. (I'm looking at you, pandas who are too picky about your mating partners.)

Which brings us back to interested amateurs, standing by roadsides, listening. "If we can establish baseline recordings for any environments that are calibrated to known and repeatable standards," Krause wrote in his 2013 book, *The Great Animal Orchestra*, "then the recorded information we gather will represent a collection against which future recordings can be accurately assessed."

F**OUR WEEKS LATER**, in early May, I head out for another frog encounter. On the drive from Montreal, I play various recordings of local anurans on a loop, like a favourite playlist, via an app called Frog Calls, which is meant to help users identify different species. Though there are more than a dozen living in the area, I'm mostly prepping my ears for the American toad and the spring peeper today—the wood frogs woke up four weeks ago, so they're long past the peak of their croaking.

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Before I start the official listening pathway, I go explore the muddy banks of a pond across the street from my best friend's parents' house. The gang is nearly all there, filling their designated positions in the layered amphibian chorus that brings me back to being a kid. Standing between the trees, the trilling peepers are so loud it almost hurts my ears (Measuring around 2.5 centimetres, peepers are barely bigger than a paperclip, but a group of the little guys can be heard from over three kilometres away.) My friend's father tells me their calls used to be just as deafening even up on their front porch; it doesn't carry quite as far these days. A similar reduction in the intensity of the sounds has been reported by Cree adults in James Bay who remember the loud springs of their childhoods.

For those who have been lucky enough to find themselves in the middle of a full chorus, the loss is a tragedy: that auditory immersion, being surrounded by voices bouncing off water and leaves in the dark, is impossible to reproduce. Ashpole often speaks to young adults whose parents recall catching polliwogs and listening to roaring nighttime ponds; they have never had the same experience. To her, it's imperative to take people into the field to transmit passion first hand. Telling me about going out with a group one night, she recalls looking down on the ground "and there were just thousands of little [spadefoot toads], and we couldn't step anywhere.…You expect kids to get really excited, but what I find more exciting is watching adult parents having a childlike moment."

As I stand in the dark and listen intently to the frogs' voices, what is at first chaotic comes into focus, my ears straining to separate the different types of calls. I'm pleasantly surprised by the range of amplification my hands provide as I change their shape around my ears, and I'm starting to understand the distinction that Krause makes between listening and hearing—the difference between engaging with the sense and passively experiencing it. It's a practice that can make us realize that all is not lost and that the environment can recover if we let it—in his book, Krause points out that there are now choruses of frogs and nightingales thriving at Chernobyl.

We currently find ourselves on the other side of a stark but intangible line created by the climate tipping points we've blown past for and at our leisure, the virulent diseases we've helped spread, and the habitats we've destroyed in the name of peace and quiet. Being on this side of the line is a lot like grieving: we are in an "after" time. Earlier this year, I used the words "we are in the after" in an epilogue to my friend Alexandre Bergeron's music video for "Aquatic Ruin," a song about ecological disaster that ends

on a chorus of spring peepers. And, as with other forms of grieving, in times defined by disease and mass extinction, we need to bear witness. We can be quiet and press record to capture what is still there. We can cup our hands around our ears and listen.

thewalrus.ca, 16 September 2020

https://www.thewalrus.ca

Flu season may be very mild this year, thanks for COVID-19 precautions

2020-09-18

Flu season may be pretty mild this year thanks to measures taken to stop the spread of COVID-19, according to a new report from the Centers for Disease Control and Prevention (CDC).

In the report, published Thursday (Sept. 17) in the CDC journal Morbidity and Mortality Weekly Report, the researchers note that flu activity in the U.S. right now is at "historical lows," and that data from the Southern Hemisphere — which has just gone through its winter — showed "virtually no influenza circulation.»

However, nothing is certain when it comes to the flu season, especially during the middle of a pandemic. So it's still important to prepare for both flu and COVID-19 this fall and winter, and to get a flu shot, the report says.

Flu activity in the U.S. dropped sharply in March, when it became apparent that COVID-19 was circulating widely across the country. This drop likely includes a real decline in flu activity — a side effect of school closures, stay-at-home orders, social distancing and mask-wearing that aimed to slow the spread of COVID-19 — as well as less reporting, as fewer people went to their doctor when they had flu-like symptoms.

Overall, the number of samples that U.S. labs submitted for flu tests (an indicator of flu activity) dropped 61%, from nearly 50,000 per week from September 2019 through February 2020, to 19,500 per week from March through May of this year. Even more striking, there was a 98% drop in the number of samples that tested positive for flu during this time, from 19% to 0.3%.

This summer, flu activity has remained extremely low, with just 0.2% of samples testing positive from May through August, compared with 2.35% during that same period in 2019, 1.04% in 2018 and 2.36% in 2017, the report said.

Even more striking, there was a 98% drop in the number of samples that tested positive for flu during this time, from 19% to 0.3%.

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There's been very little flu activity in the Southern Hemisphere as well. From April through July (during the Southern Hemisphere's fall and winter, or peak flu season), there were only 51 positive flu tests out of more than 83,000 people tested in Australia, Chile and South Africa, for a positivity rate of 0.06%. In contrast, during April through July in the years 2017 to 2019, nearly 14%, or 24,000 out of 178,000 people, tested positive for flu in those three countries.

Initially, declines in flu activity were mostly attributed to doctors testing for COVID-19 rather than the flu. But even when public health officials made renewed efforts to test for flu (and conducted an adequate number of flu tests), there was still "little to no influenza virus" detected, the report said.

The findings suggest that "community mitigation strategies implemented to prevent the spread of COVID-19 … appear to have substantially reduced transmission of influenza in all these countries,» the report said.

If these strategies continue through the fall "influenza activity in the United States might remain low and the season might be blunted or delayed," the authors wrote.

But given that people may not necessarily stick with measures meant to slow the spread of COVID-19, it is important to plan for flu this fall and winter. COVID-19 has made getting a flu shot this year "especially important," not only to reduce the risk of flu, but also to reduce the burden on the health care system responding to COVID-19, the CDC says.

The findings also suggest that, in the future, officials might consider implementing some of the COVID-19 mitigation measures during seasons with high flu activity, particularly among those at highest risk for flu complications.

livescience.com, 18 September 2020

https://www.livescience.com

Effects of wound dressings containing silver on skin and immune cells

2020-09-16

Wound dressings with silver have been shown to be cytotoxic in vitro. However, the extrapolation of this cytotoxicity to clinical settings is unclear. We applied dressings with various forms of silver on porcine skin ex vivo and investigated silver penetration and DNA damage. We assessed

We assessed anti-microbial efficacy, cytotoxicity to skin cells, and immune response induced by the dressings.

antimicrobial efficacy, cytotoxicity to skin cells, and immune response induced by the dressings. All dressings elevated the DNA damage marker γ-H_2AX and the expression of stress-related genes in explanted skin relative to control. This corresponded with the amount of silver in the skin. The dressings reduced viability, induced oxidative stress and DNA damage in skin cells, and induced the production of pro-inflammatory IL-6 by monocytes. The oxidative burst and viability of activated neutrophils decreased. The amount of silver released into the culture medium varied among the dressings and correlated with in vitro toxicity. However, antimicrobial efficiencies did not correlate strongly with the amount of silver released from the dressings. Antimicrobial efficiency and toxicity are driven by the form of silver and the construction of dressings and not only by the silver concentration. The damaging effects of silver dressings in ex vivo skin highlight the importance of thorough in vivo investigation of silver dressing toxicity.

Read more

nature.com, 16 September 2020

https://www.nature.com

Scientists use seaweeds to travel back in time

2020-09-15

There are few things I enjoy more than turning a slimy piece of seaweed into a work of art. From scouring the tide pools for the perfect blades, to artfully arranging them on a piece of paper in my herbarium press, every step of the process is immensely satisfying.

Using the same technique that people use to press flowers, I can turn almost any algae into a natural work of art that can last for centuries. Although I press algae for artistic purposes, algae pressing has long been a scientific pursuit.

The practice emerged in 19th-century England as a way for scientists and natural history buffs to preserve and catalog the diverse array of seaweeds found along the country's coasts.

Women were among the most avid algae pressers. Artfully preserving seaweeds was one of the few ways women could contribute to science in the 19th century. At the time, women were excluded from most scientific fields, with the exception of botany, which was considered a suitable hobby for them.

Women were among the most avid algae pressers.

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Thanks to the efforts of early algae pressers, many natural history museums contain vast collections of algal pressings that date back centuries. Scientists have long relied on these repositories to provide a glimpse of what algal species were present in the past.

In recent years, however, scientists have discovered several new ways of extracting data from century-old pressed algae—and they're being used to solve a suite of marine mysteries, including the cause of Monterey Bay's devastating sardine fishery crash.

In a new study published this past June, researchers from the Monterey Bay Aquarium examined a collection of dried, pressed seaweeds—dating back over 140 years—to learn what ocean conditions in the bay were like in the early 19th century.

Working with colleagues from Stanford University's Hopkins Marine Station in California, and the University of Hawai'i, aquarium researchers gathered pressings of seaweeds collected from Monterey Bay between 1878 and 2018 and performed a variety of chemical analyses on their tissues.

"We were working with old and beautiful specimens, so we tried to take the smallest samples possible," says Emily Miller, the lead author of the study, who now works as a research technician at the Monterey Bay Aquarium Research Institute.

Despite the fact that some of the specimens were old and "a bit leathery," Miller and her team were able to determine their amino acid and protein compositions, heavy metal concentrations, and stable isotope ratios.

The algae's nitrogen stable isotopes were of particular interest to the researchers. Algae absorb nitrogen, phosphorus, and other nutrients from seawater like sponges. When nitrogen is abundant in their environment, it is reflected in the nitrogen content of their tissues.

The researchers analyzed the nitrogen stable isotopes from pressings of *Gelidium*, a type of red algae, and compared it to records dating back to 1946 of upwelling—an oceanic phenomenon in which wind moves warm surface water away from the coast, driving cold, nutrient-rich water up from the deep.

The changes they observed in the *Gelidium*'s nitrogen isotope concentrations between 1946 and 2018 correlated strongly with historical records of upwelling, which suggested that the nitrogen isotope

concentration of each piece of pressed algae was a direct reflection of the amount of upwelling that occurred during its growth.

Knowing this, the researchers were able to use algal specimens to create a record of upwelling in Monterey Bay starting in 1878, extending the existing record back by nearly 70 years.

In doing so, the researchers uncovered new information about the sardine fishery collapse in the 1950s that devastated Monterey's Cannery Row, whose once-thriving canneries and colorful people inspired John Steinbeck's novels *Cannery Row* and *Sweet Thursday*.

The researchers found evidence that in the years leading up to the fishery's collapse, upwelling in Monterey Bay was decreasing—likely due to climatic oscillations. This, combined with overfishing and other factors, they say, caused Monterey's sardine stock to crash.

Understanding how changes in upwelling impacted fisheries of the past could improve the way fish stocks are managed today says Kyle Van Houtan, chief scientist at the Monterey Bay Aquarium and coauthor of the study.

"Some species are like a thermometer and reflect what's happening in the ocean in their populations. Other species are more resilient to environmental forces. The more we understand these relationships, the better we can forecast what the future might entail," Van Houtan says.

The kind of data that will help us to better understand these relationships, Van Houtan says, is all around us—hiding in the tissues of algae, the feathers of birds, and the shells of sea turtles, just waiting for us to find it.

Scientists from Japan's Hokkaido University, for example, recently determined the density of herring populations off the coast of Hokkaido during the late 19th century by examining the chemical composition of century-old algal herbaria.

Using newly developed methods of extracting data from algal pressings, such as isotope analysis and DNA sequencing, scientists have been able to measure the impacts of anthropogenic pollutants on coastal ecosystems, document changes in marine community structure, and create evolutionary trees for a wide variety of algal species.

"Old herbaria are more relevant now than ever," says Suzanne Fredericq, a professor of biology at the University of Louisiana at Lafayette. "Old historical collections can tell us so much about the future," Fredericq says.

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Despite this, many algal herbarium collections are underused and underfunded. Maintaining such collections, Miller says, is vital to improving our understanding of the past, present, and future of our oceans. "There are so many other research questions that people could be using these collections to answer."

If you want to help answer these questions, or are simply looking for a new creative outlet, Miller recommends taking up algae pressing.

"It's really fun and easy to do," Miller says. All you need to get started is some cardboard, a few sheets of herbarium paper, a stack of heavy books, and an open mind.

"It's like pressing flowers, just a little wetter."

hakaimagazine.com, 15 September 2020

https://www.hakaimagazine.com

How beavers became North America's best firefighter

2020-09-22

The American West is ablaze with fires fueled by climate change and a century of misguided fire suppression. In California, wildfire has blackened more than three million acres; in Oregon, a once-in-a-generation crisis has forced half a million people to flee their homes. All the while, one of our most valuable firefighting allies has remained overlooked: The beaver.

In some cases, the rodents' engineering can even stop fire in its tracks.

A new study concludes that, by building dams, forming ponds, and digging canals, beavers irrigate vast stream corridors and create fireproof refuges in which plants and animals can shelter. In some cases, the rodents' engineering can even stop fire in its tracks.

"It doesn't matter if there's a wildfire right next door," says study leader Emily Fairfax, an ecohydrologist at California State University Channel Islands. "Beaver-dammed areas are green and happy and healthy-looking."

For decades, scientists have recognized that the North American beaver, *Castor canadensis,* provides a litany of ecological benefits throughout its range from northern Mexico to Alaska. Beaver ponds and wetlands have been shown to filter out water pollution, support salmon, sequester carbon, and attenuate floods. Researchers have long suspected that these paddle-tailed architects offer yet another crucial service: slowing the spread of wildfire.

"It's really not complicated: water doesn't burn," says Joe Wheaton, a geomorphologist at Utah State University. After the Sharps Fire charred 65,000 acres in Idaho in 2018, for instance, Wheaton stumbled upon a lush pocket of green glistening within the burn zone—a beaver wetland that had withstood the flames. Yet no scientist had ever rigorously studied the phenomenon. (See California's record blazes through the eyes of frontline firefighters.)

"Emily's study couldn't be more timely," says Wheaton, who wasn't involved in the research. "This points toward the importance of nature-based solutions and natural infrastructure, and gives us the science to back it up."

Fire refugia

Inspired in part by Wheaton's observations, Fairfax and colleague Andrew Whittle chose major wildfires that had occurred since 2000 in five U.S. states—California, Colorado, Idaho, Oregon, and Wyoming—and scoured satellite images for nearby beaver dams and ponds. (Beaver infrastructure is so impressive that it's visible from space.)

Then, using a statistical measure of plant health, they calculated the lushness of the surrounding vegetation before, during, and after the fires. Unsurprisingly, thriving, well-watered plants tended to appear vivid green in the satellite photos, while dry plants looked comparatively brown. (Read more about how wildfires get started—and how to stop them.)

A green, hydrated plant, of course, is also less flammable than a desiccated, crispy one. And that's what makes beaver ecosystems so fireproof. In beaver-dammed stream sections, Fairfax and Whittle found, vegetation remained more than three times lusher as wildfire raced over the creek. Beavers had so thoroughly saturated their valleys that plants simply didn't ignite.

These lifeboats don't merely protect beavers themselves: A broad menagerie—including amphibians, reptiles, birds, and small mammals—likely hunker down in these beaver-built fire "refugia," Fairfax says. Although wildfire is a vital force that rejuvenates habitat for some creatures, like black-backed woodpeckers, it can devastate other animal populations.

Beaver habitat also protects domestic livestock and agricultural lands, adds Fairfax, whose study was published this month in *Ecological Applications*. "If you have a beaver wetland, your cows can take advantage

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of that refuge and fare better during wildfire than if you had to pack them out on trailers."

Embracing beavers

In addition, beavers may help an ecosystem recover from a wildfire. In northern Washington State, Alexa Whipple, the director of the Methow Beaver Project, found that beavers promoted the recovery of native species, like willow and aspen.

Beaverless streams, by contrast, were more likely to become colonized with invasive plants after a burn. Whipple also found that beaver ponds improved water quality by capturing the phosphorus-laden sediment that runs off torched hillsides. (Learn how wildfires are increasing worldwide.)

"If we have a wetter landscape, we are going to resist fire *and* recover from it better," says Whipple, whose results haven't yet been published in a peer-reviewed journal. "My hope is that wildfire can be the gateway for people to understand the whole suite of benefits that beavers offer."

Despite all the good that beavers do, thousands are killed every year for flooding roads, cutting down trees, and causing other damage to human property. Employing smarter, more humane policies—using nonlethal flood-prevention devices like "Beaver Deceivers," for example, and relocating trouble-making individuals instead of killing them—could heal our relationships with beavers and wildfire alike, Fairfax says.

"Strategically embracing beavers in local watersheds could provide reassurance that you have wet soils and wet plants around your town," Fairfax says. In fact, as her paper's title suggests, the U.S. Forest Service might want to consider a new animal mascot: Smokey the Beaver.

nationalgeographic.com, 22 September 2020

https://www.nationalgeographic.com

Ig Nobel prizes reward research on helium-huffing alligators and knives made of feces

2020-09-18

The Ig Nobel Prizes, an annual event celebrating quirky, comical discoveries, carried on despite the pandemic in a virtual ceremony riddled with bugs—and bug jokes. The Annals of Improbable Research, the science humor magazine that hosts the event, selected bugs as the theme for the 30th annual event, although the winning studies spanned an array

The ceremony took place entirely online for the first time with a series of prerecorded speeches, musical numbers, and lightning-speed lectures.

of icky, wondrous, and unconventional research. The ceremony took place entirely online for the first time with a series of prerecorded speeches, musical numbers, and lightning-speed lectures.

This year's prize in entomology went to an investigation of why so many insect researchers are themselves fearful of spiders. The survey of arachnophobic entomologists, published in 2013 in *American Entomologist*, explored why people who devoted their careers to critters such as cockroaches and maggots still found spiders unnerving. Among spiders' most disliked traits were their fast, unpredictable movements and their many legs.

The acoustics prize went to researchers who recreated in reptiles the party trick of inhaling helium from balloons. To study crocodilian vocalizations, the team placed alligators in an airtight, helium-filled chamber and found that the high-energy frequency bands of their bellows got even higher. The results, published in the *Journal of Experimental Biology* in 2015, are the first evidence that nonavian reptiles produce sound from vibrations in the vocal tract, known as formants.

A duo of researchers earned the prize in psychology for discovering that distinctive eyebrows are perceived as a cue of "grandiose narcissism." By showing people photos of faces with different areas concealed, the researchers found eyebrows were an especially important nonverbal cue for gauging narcissistic personality traits, they reported in the *Journal of Personality* in 2018. Study participants judged eyebrow distinctiveness—the eyebrows' thickness and density—to be the most telling sign of narcissism.

Other winning research included a study revealing new diagnostic criteria for a psychiatric disorder called misophonia, which makes people averse to certain breathing and eating sounds; evidence that romantic partners in countries with higher levels of economic inequality kiss more often; and the finding that knives cannot be crafted from frozen human feces, despite a previous account of an Inuit man doing so.

Winners received a fake $10 trillion Zimbabwean bill, and were emailed a six-page PDF to print and assemble into a cube-shaped trophy. The awards were presented by past Nobel laureates Eric Maskin (Economics, 2007), Frances Arnold (Chemistry, 2018), Richard Roberts (Physiology or Medicine, 1993), Martin Chalfie (Chemistry, 2008), Jerome Friedman (Physics, 1990), and Andre Geim (Physics, 2010).

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The ceremony also featured the debut performance of *Dream, Little Cockroach*, a miniopera performed by the Nobel laureates alongside professional singers and other musically inclined scientists. In past years, the live audience has folded pages from the program into airplanes to toss onto the stage; this year, viewers were encouraged to make and toss their own planes at home. Host Marc Abrahams closed the ceremony with a classic Ig Nobel line: "If you didn't win an Ig Nobel Prize tonight—and especially if you did—better luck next year."

sciencemag.org, 18 September 2020

https://www.sciencemag.org

Will putting honey bees on public hands threaten native bees?

2020-09-15

Honey bees heavy with pollen and nectar foraged from wildflowers on Utah's Uinta-Wasatch-Cache National Forest collide with tall grass and tumble to the ground. They are attempting to land alongside a hive, and I watch as they struggle to stand, fly into the box, and disgorge nectar to be made into honey.

The pollinators belong to a 96-hive apiary, trucked here to Logan Canyon for the summer to rest and rebuild their population, replenishing bees lost to disease and pesticides after months pollinating California's almond groves. By Labor Day, the yard could house 5 million domesticated pollinators.

By Labor Day, the yard could house 5 million domesti-cated pollinators

The honey bees are guests among about 300 native bee species in Uinta-Wasatch-Cache, including metallic green sweat bees and iridescent blue mason bees, that comb meadows rich with indigo delphinium, yellow daisies, and pumpkin-colored Indian paintbrush. Darren Cox, who owns the apiary, says the forest's mountain snowberry shrubs make the best-tasting honey.

Cox, in a white nylon suit, elbow-length gloves and helmet covered with a veil, puffs smoke into a dove gray hive and pries out a frame coated with honey. He scrapes the viscous liquid into a paper cup.

"It's a good flower year," he says, handing me the honey, which he sells at airports and high-end department stores. He pulls off a glove, plunges a finger into the honeycomb and lifts it under his mask and into his mouth.

"That's pretty good," he says. "My mom named this honey snowberry — it's our best seller."

The cluster of honey bee colonies in the Uinta-Wasatch-Cache National Forest is among thousands of hives belonging to 112 apiaries currently permitted in national forests by the U.S. Department of Agriculture. The problem, scientists and environmentalists argue, is that these hives are being permitted on public lands with almost no environmental review and despite concern about the ecological impact that industrial-sized apiaries containing non-native, domesticated honey bees can have on local wild bee populations.

The 4,000 wild bee species in the United States have evolved over millions of years to pollinate plants endemic to biodiverse regions; studies show they consume up to 95 percent of local available pollen. The specialized foragers have already suffered steep declines in part due to climate change, pesticide use, disease, and habitat loss. Nearly 40 federally listed threatened or endangered species of bees, butterflies, and flower flies depend on national forest land for their survival. Now, in areas that were once refuges for these species and others, native bees increasingly face competition from millions of domesticated honey bees ferried to public lands between pollinating seasons. Demand for apiary permits on America's public lands is growing exponentially as development and row crops devour private land migratory beekeepers once relied upon in the summer.

According to an analysis of thousands of documents obtained by conservation groups under the Freedom of Information Act, public land managers permitted 946 hives across five national forests in Utah and Arizona in 2020. With each hive containing up to 60,000 pollinators, such agreements collectively allow up to 56.8 million honey bees on the Colorado Plateau alone. Hives have also been approved in national forests in North Dakota, South Dakota, Missouri, Nebraska, Colorado, Idaho, California, Mississippi, Texas, Tennessee, Florida, New York, and Vermont. The Bureau of Land Management has also approved permits for thousands of hives on its lands in Utah, Arizona, and Colorado.

"Honey bees are super-foraging machines and they are literally taking the pollen out of the mouths of other bees and other pollinators," said Stephen Buchmann, a pollination ecologist specializing in bees and an adjunct professor at the University of Arizona. "They have huge extraction efficiency — with the waggle dance and how quickly they can mobilize — and they can very quickly take down the standing stock of pollen and nectar."

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About half of 72 studies addressing competition between managed bees and wild bees analyzed in a 2017 literature review found managed bees negatively impacted native pollinators by consuming limited floral resources. Of 41 studies that looked at the potential effects of managed bees on wild bees through changes in plant communities, 36 percent reported negative impacts and 36 percent positive results, with the remainder finding mixed or no impacts. None of the experiments were conducted with the number of hives currently being permitted on federal lands.

Some bee experts argue that no amount of honey bee hives is safe on public lands. A 2016 study published in the journal *Conservation Letters* found a single honey bee hive extracts enough pollen in one month to rear 33,000 native bees. If this figure is multiplied across apiaries with 100 hives, such as what is permitted in some national forests, entomologists say it could imperil the ability of wild pollinators to sustain their populations.

"Who doesn't have an advocate in this is the native bee — there's no money in it," said Jim Cane, a retired USDA bee scientist and coauthor of the 2016 research.

In July, conservationists filed a petition with Agriculture Secretary Sonny Perdue and U.S. Forest Service Chief Vicki Christiansen, asking that federal agencies require detailed environmental studies for apiary requests and that those studies document potential impacts on native wildlife and plants. These applications currently elicit as much scrutiny as those to mow a lawn at a district office, or to host a "motorcycle enduro ride on existing roads," according to proposed rules published in the Federal Register.

But as scientists study and conservationists debate the ecological impact of these honey bee introductions, commercial apiarists say they have no choice but to use public land.

"I lose yards every year because a subdivision is going up," said Cox, a fourth-generation beekeeper who parks 592 of his 5,700 hives on national forests northeast of Salt Lake City each summer.

"We are running out of land," he added. "We've reached the carrying capacity for managed bee hives in the U.S. — without access to public lands our livestock could be in peril."

The pollinator habitat crunch carries long-term implications for the U.S. food supply. Honey bees are responsible for one in every three bites of food Americans consume and contribute $15 billion annually to the value of the nation's crop production. Millions of bee colonies crisscross the country each year on semi-tractor-trailers to pollinate cranberries, melons, broccoli, blueberries, and cherries, as well as to produce honey.

The growing interdependence between the nation's food security and managed pollinators comes amid a double-digit decline in honey bee populations. Commercial beekeepers lost 44 percent of their colonies from April 2019 to this past April, with reductions in the summer of 2019 the highest ever recorded. At the same time, the proportion of crops dependent on pollinators is accelerating. Beekeepers are being forced to begin each season with double the amount of hives in anticipation of harrowing losses. The mounting number of colonies managed by the nation's 1,600 or so commercial beekeepers would require about 158 million acres of summer forage, an area greater than Montana and Minnesota combined.

"We are literally talking about where would we keep 2.5 million honey bee colonies, each with 40,000 to 50,000 individual honey bees," said Clint Otto, a Jamestown, North Dakota-based research ecologist for the U.S. Geological Survey who studies pollinator habitats.

Private farm land in the northern Great Plains that generations of beekeepers relied upon for summer forage is being converted to wheat, corn, and soybeans, much of it for biofuels. Farmers previously set aside such ground in exchange for subsidies provided by the federal Conservation Reserve Program. Acreage enrolled in the initiative shrunk by 30 percent in the last decade to 22 million acres due to reductions in federal funding and because high commodity prices for corn and soybeans made cultivating crops more profitable. The drop-off prompted renewed interest in housing hives on public lands in the West.

"We are proposing to put as many apiary sites as possible across different Utah National Forests," wrote Brian Burkett, a manager at South Dakota-based Adee Honey Farms, in a 2017 application to the U.S. Forest Service to house 9,000 hives in at least five national forests. "We are desperately trying to get out of pesticide areas due to the loss of our bees."

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The application and others included in the cache of documents released under the FOIA — obtained by the Center for Biological Diversity and the Grand Canyon Trust — show that federal land managers are grappling with how to handle such unprecedented requests. Without a nationwide policy governing apiary size, and with scientific uncertainty over the impact of these introductions on native species, each district is left to decide whether millions of honey bees endanger local ecosystems.

Officials determined in the 1980s that apiaries only need a "categorical exclusion" — a designation that calls for little or no analysis and public notice. At that time, less was known about native bees and how they interact with honey bees.

Studying pollinators and how they interact in the wild is time consuming, expensive, and tedious. Scientists agree more analysis is needed to better understand if honey bees' voracious appetites strip the land of food for native bees; if pollinators can transmit diseases and parasites to one another; and if honey bees' preference for invasive plants will alter ecosystems.

Researchers are working on two projects in Utah they hope will answer these questions.

Adee Honey Farms, the nation's largest private beekeeper, contributed 60 colonies toward a four-year project in the Manti-la Sal National Forest designed by the Forest Service and Brigham Young University to determine honey bees' impacts on native bee populations. Manti-la Sal managers wrote on the forest's website that the results, expected this year, could "serve as a model" for other districts. The service's Intermountain region, where Adee still wants to summer its bees, denied interview requests for this article.

Scientists at a USDA native bee lab in Logan are searching for answers to how pollinators interact at 7,500 feet in Utah's Strawberry Valley. Here, quaking aspen and towering pinyon pines tremble in a summer breeze alongside 48 buzzing honey bee hives and eight native bumble bee colonies housed in plastic crates. Snowberry bushes, goldenrod, and horsemint — a nutritious mix that makes for healthy bees and honey that doesn't granulate — surround the site on a cattle ranch. A control site hosting only native bees is located in a national forest in the region.

Back in the lab, scientists will identify pollen removed from the honey bee and bumble bee hives at the Strawberry Valley site. This information will

help pinpoint the flowers each species visit, said Diana Cox-Foster, the lab's research leader.

To gain insight into native bee activity, Cox-Foster and her colleagues will use Dixie-Cup-shaped "bee bowls" and nets to capture endemic species and cameras to study foraging rates. The data will help scientists quantify forage needed by different species, gain insight into the ecosystem's carrying capacity, and determine if pathogens move between species. It will also provide information on whether honey bees compete with wild bees for food.

The multi-year study, funded by Project Apis m., a nonprofit funded in part by beekeepers, Costco, and The National Honey Board, was "politically hot enough that we needed to have stakeholder approval across groups," Cox-Foster said, including from the American Honey Bee Producers, the American Beekeeping Association, the Forest Service, and Xerces. It began this spring.

"We know competition happens, but we don't know how intense it is, how much it affects native bees, and how much it varies from year to year," said Vincent Tepedino, an entomologist who specializes in bee behavior, ecology, and rare plant pollination who worked at the USDA bee lab in Logan for 26 years.

Standing in a 2-acre garden behind the bee lab, Tepedino and Cane pointed out how honey bees from hives in suburban back yards overtook flowers carefully tended by scientists in the lab's garden.

The scientists point out the honey bees — the insects with orange bands on their abdomens — that were flying from one lavender Phacelia flower to another. Several wild bee species, including a gray-striped ground-nesting mining bee and a furry bumble bee, vied for space on the spiky blooms.

"There are no feral honey bees in Utah — the winters are too long and cold," Cane said. "This is essentially the most intact native bee fauna in the U.S. It's worth protecting."

e360.yale.edu, date

https://www.e360.yale.edu

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How to vaccinate a planet

2020-09-23

T**HE SPRAWLING** Medicago facility in suburban Quebec City smells like a botanical garden and sounds like an airplane hangar. Thousands of *Nicotiana benthamiana* plants, a close cousin of tobacco, grow in long rows amid noisy ventilation. When the plants are six or seven weeks old, maybe twenty centimetres tall, they go on a journey, lined up by the dozens onto a flatbed that's then inverted over a tank filled with fluid. The plants get dunked. The tank seals. And the roots are trapped in the air between the liquid and the lid, so a vacuum hose can slip into that space and begin to suck.

The plants act like sponges: apply pressure to the roots and the leaves collapse; release that pressure a minute later and they expand, absorbing the liquid deep into their cells. This particular bath is filled with a bacteria that's been slightly tweaked. Bits of its DNA have been swapped out for DNA from the spike protein of SARS-COV-2, the virus that causes COVID-19.

Once the plants come out of the tank, they're moved to an incubation chamber, the temperature, light, and humidity tightly controlled. For the next week or so, the bacteria will insert its genetic information into the plants, triggering the production of millions of spike proteins in every cell of the infected leaves. The spikes self-assemble into something called a virus-like particle—not the virus itself but a particle roughly the size and shape of SARS-CoV-2. Gowned workers come and harvest the plants, stripping the leaves like they're plucking basil for pesto, then send them on a conveyor belt that passes through what's basically a paper shredder.

The chopped-up leaves head next into a vat of enzymes and are left to soak overnight. The enzymes work to break apart the cell walls, releasing the viruslike particles so they can be collected, purified, and converted into a yellowish vaccine. This doppelgänger for SARS-CoV-2 can't inflict any real damage, but "when you inject it into someone, the immune system sees it as though it's the real virus and thinks, Oh my God, there's an invader here," says Medicago executive Nathalie Landry. "And then it will trigger a good immune response."

A vaccine is, in essence, a trick—a sleight of hand that convinces your body to mount a counterattack to a given pathogen before that pathogen actually infects you.

A vaccine is, in essence, a trick—a sleight of hand that convinces your body to mount a counterattack to a given pathogen before that pathogen actually infects you. There are various ways to pull the trick off: vaccines can be made with a weakened virus, or a killed virus, or just a key part of the virus, or a part of the virus piggybacking on a different, benign virus,

or an instruction manual for making that part of the virus yourself. In each approach, you get the benefits of an immune response without the messy business of a disease.

It's a crucial tool for combatting a virus impervious to borders, seasonality, and many of the lockdown measures employed by anxious nations. So, when US National Institute of Allergy and Infectious Diseases director Anthony Fauci tells Congress, as he did in July, that he's optimistic a vaccine will be ready in late 2020 or early 2021, it's tempting to imagine that as the moment when we can once again engage in all the activities that remain laced with fear, like hopping a plane, or seeing a concert, or hugging a grandpa. An effective vaccine represents an enormous, exciting move in that direction. But it's not the pandemic finish line—it's more like a pandemic off-ramp. Epidemiological, logistical, and ethical roads still lie ahead: to determine how long and how well that vaccine's protection can last, to manufacture enough of it to jab into billions of arms, to allocate the first batches of supply between countries and within their populations, and to persuade vaccine skeptics to roll up a sleeve. We're trying to protect the entire planet, all 7.8 billion of us. "The job isn't done when you've got an effective vaccination," says Ross Upshur, a professor at the University of Toronto's Dalla Lana School of Public Health who cochairs the World Health Organization's COVID-19 ethics working group. "The job is done when you get that vaccine out to everyone who needs it."

H**UMANS HAVE** been trying to outsmart viruses for millennia. By the late 1600s, Chinese doctors had formalized their recipe: grind a smallpox scab into a powder and blow it up a healthy patient's nose. (Apparently, for boys, this was done in the left nostril, and for girls, the right.) An ambassador to Britain sent reports of seventeenth-century North African surgeons making a small incision between the thumb and forefinger, then squeezing smallpox pus into the wound. At the turn of the nineteenth century, Edward Jenner extracted fluid from a cowpox blister, taken from—who else?—a milkmaid, and scratched it into the arm of an eight-year-old boy. These efforts may seem crude now—we prefer our vaccines packed tidily in glass vials, injected though sterile hypodermic needles—but the idea remains the same: teach the immune system how to ward off a virus so it has a head start should infection occur.

When a new pathogen invades the human body, our innate immune system recognizes the presence of something noxious and sends up an alarm. The first responders are proteins that meddle with a virus in order to limit its ability to reproduce. "This is what's called the dumb part of the immune

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system, though that's quite mean because it's not dumb at all," says Brian Ward, an infectious-disease professor at McGill University and the medical officer for Medicago. But it's also not precise: the innate immune system attacks anything that appears foreign and troublesome.

Cue the adaptive immune system. "When cells are infected with a pathogen, they gobble it up, break it into pieces, and then start showing those pieces to the cells, saying, Hey, I found something that doesn't belong here, can you please get rid of it?" says Marc-André Langlois, a molecular virologist at the University of Ottawa. B cells (a type of white blood cell) begin making antibodies: proteins that can subdue a virus by blocking its ability to get into the body's cells. T cells (another type of white blood cell) arrive with two purposes: to help B cells make more antibodies and to assassinate cells that have been infected by the virus. It's a more sophisticated response, but it's also slower, taking a week, sometimes longer, to mobilize. "So, if you have a rapidly replicating virus, and it doubles, doubles, doubles, waiting seven days for antibodies might be too long and you might not survive," Langlois says.

If the infection is cleared, many of the body's B and T cells then die off themselves. Some, though, transform into memory cells, typically bunkered down in your bone marrow, where they wait to spring into action the next time that same pathogen attacks. "All it takes is one B cell to recognize the target and get activated, and it will start proliferating so it can produce the antibodies," Langlois says. "That's why vaccines work. They give you this life-saving element of having the antibodies ready to be deployed." A defence that would otherwise take the body weeks to mount can be summoned in just a few hours.

W**E'VE COME** a long way from smallpox pus, but to develop a vaccine, scientists still need to pick their poison. In modern medicine, that decision involves choosing whether to use the entire virus or just a vital part of it. Whole-virus vaccines are the traditional approach. One strategy, dating back to the 1930s, is to take the pathogen—grown in giant batches of chicken eggs or, decades later, in cells—and then kill it, usually with heat, chemicals, or radiation. Because the virus is dead, it doesn't cause disease once introduced to the body, even in people with weakened immune systems; because the virus is dead, it also doesn't always cause a strong immune response, often requiring multiple doses. This approach is used in the flu shot and a hepatitis A vaccine, as well as in the one for polio, which a global vaccination effort has essentially wiped out.

In a more recent variation on the whole-virus vaccine, a pathogen is weakened in a lab rather than killed outright. Chances are you've been jabbed with a bunch of these vaccines: they're how we fight measles, chicken pox, yellow fever, and tuberculosis. Here, the cost-benefit analysis is reversed: because the vaccine closely resembles a natural infection, it typically elicits a robust, enduring response; because the vaccine is more potent, though, people with compromised immune systems are often unable to get it at all. But, by using the entire virus, the vaccine builds an immune response to many different parts of the pathogen. "The whole-virus vaccine is like a big shield in front of you," Ward says. "If you're in a *Star Wars* movie and someone is shooting lasers at you, you're much safer behind that shield."

Yet a smaller shield, precisely positioned, can still protect you by blocking an important part of the virus rather than the whole thing. There are several ways of introducing this target protein—which is called the antigen—to the body. Most of them require another ingredient to fortify the shield: an adjuvant, usually aluminum, which for the past ninety years has been added to vaccines to boost the immune response. "An adjuvant is a little like hot sauce," says Robert Kozak, a microbiologist at Toronto's Sunnybrook Health Sciences Centre. It livens up what's already on your plate.

One method of delivering the target protein to your body is to deploy a weakened common-cold virus, called an adenovirus, as a microscopic Trojan horse. That cold virus is unlikely to cause much damage, but it's hugely efficient at slipping inside cells and releasing the antigen. Though scientists see promise in this approach, only one adenovirus vaccine has ever been approved, anywhere. In part, that's because vaccines tend not to make a ton of money, and it's wildly expensive to develop a new platform, so funding can be hard to come by. It's also because adenovirus-vaccine candidates are in human trials for complicated diseases, like HIV and malaria, which are challenging targets.

Another method skips the Trojan horse altogether and injects you directly with the pathogen's critical protein. Virus-like-particle vaccines, such as Medicago's plant-grown candidate, are a type of these protein-based vaccines. It's a proven method—HPV and hepatitis B are just two examples—and there are usually few side effects once you're given the shot.

Then there are genetic vaccines, which don't deliver the antigen itself but instead issue a blueprint of that target protein to our bodies, hijacking our

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own cells to produce it. In a DNA vaccine, DNA containing the gene for the antigen is delivered to the cells. The cells copy those genetic instructions into molecules called messenger RNA (mRNA), which issue marching orders to the body to assemble the antigen.

"The antigen is then presented to the immune system, [which] mounts a defence," says Gary Kobinger, one of the scientists behind the Ebola vaccine, who is now working on a DNA candidate for a COVID-19 vaccine for Laval University. It's a relatively new method of vaccination, though Kobinger points out that, "in the field of experimental vaccines, it's quite old," a technology discovered back in the early '90s.

Messenger RNA vaccines bypass the DNA and go straight to the marching orders. The genetic material for the antigen is produced synthetically, then packed inside a pod made of lipid molecules, which slide easily into the cells. The benefits are that there's no messing around with infectious material and the vaccine's production time can be cut down dramatically, which is why some researchers believe a genetic vaccine for COVID-19 will be ready first. The disadvantage is that this is uncharted territory: no DNA or mRNA vaccines are currently approved for human use.

S**ARS-COV-2** is a stealthy operator. It has a gift for binding its spike proteins—those knobby mushrooms that every coronavirus illustration has burned into our brain —to receptors on particular cells scattered in high numbers along the lining of our respiratory tract. When contact is made, it creates an opening through which the virus can pour its genetic code, the RNA, inside our bodies. "The moment the RNA enters the body, it takes [over] the cell—there's no wasting time," says Natalia Martin Orozco, vice-president of drug development at Toronto-based Providence Therapeutics, which pivoted from developing an mRNA vaccine for cancer to one for COVID-19. The first proteins that SARS-CoV-2 produces are not to make more copies of itself but instead to suppress an immune response. "It says, Okay, let's block everything that is going to stop me from multiplying," Martin Orozco says. "After that, it starts producing what it needs to build the virus and grow."

There are now more than 200 vaccine candidates for COVID-19 in development around the world, using every conceivable approach. The vast majority of them, however, zero in on the spike as the vaccine's target protein: the University of Oxford, Johnson & Johnson, and CanSino Biologics all insert the spike into weakened common-cold viruses; Novavax's vaccine attaches the proteins to microscopic particles that are used as carriers; Moderna and Pfizer's candidates encode the spike into

their mRNA. It's a good bet. The spikes are found in abundance on the surface of the virus, so they're what our immune system sees first. "With the first SARS, we saw that the virus used the spike protein to enter cells," says Kozak. "Viruses can be shockingly unoriginal sometimes, so if blocking that protein protected you against SARS One, it will probably work against SARS Two."

Not all of these candidates, in the end, will work—many of them won't. (A sobering statistic: one 2016 study found that nearly nine out of every ten new drugs fail in the human-testing phase.) And it's not yet clear what exactly will ward this virus off. "We don't know the relative importance and contribution of antibodies and T cells in terms of protection against COVID," says Manish Sadarangani, director of the Vaccine Evaluation Center, in Vancouver. Immunity isn't an on/off switch: there are multiple levels of protection conferred by either shaking off a disease or receiving its vaccine. Some vaccines, like the one for hepatitis A, provide sterilizing immunity, which prevents the infection and its transmission almost entirely. Others, like those for diphtheria and tetanus, generate neutralizing immunity, where an infection can occur but won't get very far and can't make someone sick. Sometimes, as with the shingles vaccine, recipients aren't fully covered but experience a milder version of the disease. Often, protection isn't life-long, so we need booster shots to shore up our immunity.

When it comes to coronaviruses, immune responses tend to be short-lived: two to three years for the first SARS virus, for example, after which people exposed to that same pathogen would likely fall sick once again. Still, three years of protection sounds pretty good right now. As Martin Orozco says, "Even if the vaccine lasted just one season, that, to me, would be a really great accomplishment." In the midst of a pandemic, a SARS-CoV-2 vaccine that performs as well as a flu shot is nothing to sneeze at.

T**WICE A YEAR** a consortium of scientists representing more than 100 influenza centres in more than 100 countries descends on the World Health Organization (WHO) to pick the flu strains that should be combatted by seasonal vaccines. For the northern hemisphere, these selections are made in February; for the southern hemisphere, September. Once the recommendations are made, the viruses are produced in WHO laboratories, then shipped to the companies around the world that manufacture the corresponding vaccines. There is no centralized body whipping up batches of SARS-CoV-2 for developers looking to try their hand at a COVID-19 vaccine. Instead, they need the genetic code for the virus, which Chinese researchers sequenced in the second week of January

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and shared in a public database. Once scientists determined what was inside the 30,000 "letters" of this coronavirus's RNA, they could decide which proteins to target in their vaccines.

After developers pick their antigen and their delivery system, they test it, starting with animals. Because ferrets and hamsters are, like us, naturally susceptible to SARS-CoV-2, they were a popular choice for early vaccine trials at the University of Saskatchewan's Vaccine and Infectious Disease Organization-International Vaccine Centre (vido-InterVac). If the vaccine protects those animals from infection, the next step is a safety trial with dozens of people, to see if fevers spike or injected arms swell, followed by another trial, which measures how well an immune response to the virus has been produced. Then it's on to the third trial, where thousands of volunteers are monitored for a statistically significant difference between rates of infection in an unvaccinated control group and in people who actually got the jab. At least half a dozen leading candidates have entered phase-three trials, including ones from the University of Oxford, Moderna, and Pfizer. Currently, the WHO has set the minimum bar for an effective vaccine at an infection-reduction rate of 50 percent, though 70 percent is preferred.

What's needed to make enough doses for these trials depends on the type of vaccine. For Medicago's plantbased candidate, there must be wellstocked greenhouses and a dunking tank. To take another example: at vido-InterVac, where researchers are working on a protein-based vaccine, they begin with a single cell. "We take the gene from the virus that encodes for the spike protein, and we put that gene into the single cell, which now thinks it is its own protein," says vido-InterVac director and ceo Volker Gerdts. At first, scientists use a three-litre beaker that contains everything necessary to make a cell happy: some sugars, a couple of amino acids, a nice warm environment, and a little CO2, so the cell is fooled into believing it's still in a body. One cell divides into two, then four, then eight, then sixteen; the three-litre beaker becomes twenty litres, then 250, all the way up to a 1,000- or 2,000-litre bioreactor. From one individual cell, you can make enough of the protein for thousands, even millions of doses.

Gerdts's team wants just that protein in its vaccine, without sugar or waste or any of those extra bits. To isolate the spike, the liquid will get separated in a centrifuge: spun so the heavier waste and cell walls fall to the bottom, leaving the lighter protein on top. It will then get purified, so anything else that lingers is removed. "It gets really cleaned up to the point where you

just have a very concentrated, pure substance," Gerdts says. "And then you put it in a glass vial."

M**AKING A** successful vaccine is one challenge. Making enough of it to satisfy world demand is another. There are, of course, all sorts of regulations and standards concerning how to go about production: "I can't head into my basement and start brewing up a vaccine," says Curtis Cooper, president of the Canadian Foundation for Infectious Diseases. Every facility needs to conform to Good Manufacturing Practices (gmp), which are exceptionally specific rules set out by the WHO that ensure quality control. You want consistency over time so that each successive batch is precisely the same.

Many Canadian labs can produce enough vaccine for their clinical research under these strict gmp conditions. But, when it comes to scaling up production, we're not in nearly as strong a position. Gerdts says that there are two facilities in Canada with large-scale production capacity: Medicago and the National Research Council, which partnered with CanSino Biologics to produce its vaccine and received a recent $126 million federal boost. At Medicago's clinical facility in Quebec City, 20 million doses of its plant-based vaccine, if successful, can roll out over a year; there's a commercial facility in North Carolina that can manufacture another 100 million doses annually for whoever signs a contract. A third facility is slated to be built in Quebec, with greenhouses the size of two football fields, though that won't be completed until 2023. And, in March, vido-InterVac received $23.3 million from the Canadian government, half of which will be used to complete its own much larger facility, which should be ready by next July. In the meantime, Gerdts is compelled to wait until another manufacturer can begin to produce his candidate. "Canada does not have the manufacturing capacity that is needed for making a vaccine for the world," he says. "We're not even close to making enough for Canadians."

What happened? Marc-André Langlois believes that—at least before this very moment—there wasn't much of an appetite to equip the country for a hypothetical pandemic. "It's generally unpopular to invest in preparedness, because you have all the other urgent commitments that start creeping up," he says. "People might not want $300 million spent on making a vaccine-manufacturing facility for another virus that could potentially burn out."

It's also a predictable outcome of operating in a global economy. "We outsource a lot of our vaccine procurement to these big multinationals in Europe, and we have not invested in the production capacity in Canada,"

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says vido-InterVac's associate director of business development, Paul Hodgson. Canadian branches of international pharmaceutical companies, like GlaxoSmithKline and Sanofi Pasteur, are capable of producing other vaccines, but "it's not like they have extra capacity just sitting there to push a new vaccine through," he says. "It's a matter of priorities—when there's an opioid crisis or roads need repairs, where do you put the money? But, if you think research is expensive, you should try disease."

That has sent Canada looking for supplies elsewhere. The federal government has ordered 75 million syringes and needles from medical-technology company Becton Dickinson, enough to inoculate nearly every Canadian twice, and issued bids to secure a similar quantity of alcohol swabs, gauze strips, and bandages. "Our government is working on all possible fronts to deliver safe and effective treatments and vaccines to Canadians as quickly as possible," procurement minister Anita Anand says. "What this means is, while we are working with domestic suppliers, we are also pursuing international arrangements." In early August, she announced the first of these arrangements: a pair of deals with American companies Pfizer and Moderna for tens of millions of doses of their respective mRNA vaccines. By month's end, Canada had also secured 38 million doses of Johnson & Johnson's candidate and 76 million doses of Novavax's vaccine.

Plenty of other countries inked deals of their own this summer: the UK reserved 100 million doses of the University of Oxford's vaccine while the US secured another 300 million—that's nearly a quarter of Oxford's projected annual supply gone. By mid-August, preorders of COVID-19 vaccine candidates were reportedly stretching toward 6 billion doses, almost all of them claimed by wealthy nations. None of these vaccines has yet been proven to work.

There's another risk in relying on international sources: the goods might never show up. Early in the pandemic, for example, the White House ordered medical manufacturing titan 3M to stop exporting N95 face masks to Canada and elsewhere until the US shored up its own supply. The clinical trial for CanSino's vaccine candidate was meant to start in Halifax this past May. Chinese customs refused to release the shipment; by late summer, the trial had to be called off.

Global initiatives do exist to try to level the vaccination playing field. The international immunization nonprofit Gavi is pooling money from dozens of highand middle-income countries to invest in a number of vaccine candidates, including Oxford's, with the aim of manufacturing 2 billion doses by the end of 2021. That's meant to be enough for each country

to vaccinate 20 percent of its population, with an emphasis on front line workers and vulnerable groups and with the cost fully covered for low-income nations. In June, Canada pledged $120 million to the Access to COVID-19 Tools Accelerator, a global project that includes Gavi's vaccine-distribution initiative. China and the US haven't contributed.

But every country, company, and initiative will be competing for the same limited supplies; already, there have been murmurings of glass shortages that could curb the availability of vials. Stoppers are made by only a handful of companies. And it doesn't take much to cause a major bottleneck. "At the beginning of the pandemic, we didn't have enough nasopharyngeal swabs for COVID-19 tests," says Allison McGeer, a senior clinical physician at Toronto's Sinai Health System. More than 100,000 swabs, ordered by the federal government, arrived in Ontario contaminated by mould. "These are tiny, [cheap] things, but if you don't have any of them, you're paralyzed," she says. "There's a long list of those things that go into vaccine manufacturing that have a potential to pose the same sort of problems. There only has to be one little grommet missing and the whole system doesn't work."

V**ACCINES ARE** designed to prevent infection. You don't want to cause another infection altogether by putting that vaccine in a grimy vial. Sterilization is extremely important: this is a product moving from the outside world directly into our muscles. "We have to prepare and sterilize the vial, prepare and sterilize the stopper, all the tubing and fill needles, all the parts and pieces that would touch the vaccine," says Christopher Procyshyn, co-founder of Vancouver-based Vanrx Pharmasystems. "Everything is individually sterilized and then brought together in an aseptic process, which basically means: don't screw it up."

However it has been made, the vaccine arrives at a facility like Vanrx's in a bag or a tank, frozen or in liquid form. It's most often sterilized through microfiltration, which passes the product through a filter with pores smaller in diameter than any known bacteria. The glass vials also arrive and are sterilized: washed with purified water, then blasted with heat. "Glass is a greasy material, so we have to take it to a high enough temperature that we burn it off, much like a self-cleaning oven," Procyshyn says. The vials go into a filling machine, where they're sterilized using high-pressure steam, as are the stoppers and caps.

In conventional technologies, what happens next "looks a lot like *Laverne and Shirley*—like a food-processing line," Procyshyn says. "You have conveyor belts coming in," and a machine positions a whole bunch of

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tubes, which, he continues, "squeeze in a pulsation manner and fill the vial with the liquid, the stopper, the cap." Vanrx automates the process inside a large machine, where the filling is done by a robot. Procyshyn suspects that, given the need to conserve supplies, vaccines for COVID-19 will be packaged in multidose vials, enough to vaccinate twenty patients each. The fastest machines in the industry run around 600 units per minute: for one facility, on a full production day, that translates to somewhere between 15 and 20 million doses. "But don't forget that other drugs are continuing to be made," Procyshyn says. "Not all facilities are suitable for this, and Canada has fewer . . . than the US and Europe. A large part of what we're working through right now is which vaccine at which available site and what capacity."

Now ensconced in its multidose vial, the vaccine is inspected by employees, labelled, and given a lot number, essential for safety tracking. After that, it has to be transported through the cold chain, a standard practice to ensure that, every time the vaccine is handed off, it maintains the appropriate temperature, typically between 2 and 8 degrees for refrigerated vaccines or -15 degrees for frozen ones.

That means the moment it leaves the doorstep of the manufacturer, bundled in boxes wrapped in isothermal packaging, the vaccine is kept in chilly containers. The plane that transports it is refrigerated, as is the truck that picks it up from the airport, as is the wholesaler or warehouse in Canada where it's kept before being moved to health care facilities across the country. "This is a well-established process," says Mina Tadrous, an assistant professor at the University of Toronto's Leslie Dan Faculty of Pharmacy. "We've been doing this for decades and we're really good at it."

No one needs to rely on the diligence of others: surveillance systems exist to make sure that the cold chain hasn't been broken. "It used to be that you'd carry in a box of vaccines, and there was a temperature probe inside that provided a continuous recording, so you'd make sure they hadn't been frozen or gotten too hot," McGeer says. Then, in 1996, the WHO introduced temperature-sensitive stickers that monitor the heat exposure of individual vaccine vials. "It's a stellar development: a little colour-coded square that tells you whether it's been out of temperature," she says. The square starts lightly tinged; if it gets dark, the vial needs to be discarded. As a result, clinicians can determine whether the whole box has been compromised or just a few vaccine vials fell out of the cold chain. When supply is tight, it helps to have every possible vial on hand.

W**E MIGHT BE** inventing a vaccine from scratch, but we're not inventing a whole new system to get it into the arms of Canadians. "The best immunization system is almost invisible," says Natasha Crowcroft, inaugural director of the University of Toronto's Centre for Vaccine Preventable Diseases and now a senior technical adviser at the WHO. "People talk about immunization being the victim of its own success: when everything is going smoothly, no one knows how much work goes on behind the scenes." In Canada, this work involves a terrific amount of coordination between the federal government, responsible for procuring the vaccine; the provinces and territories, which determine how many doses they'll need and which ones to deliver to which people; and local jurisdictions, which make on-the-ground decisions about administering it.

When it comes to distributing vaccines for COVID-19, Canada will most likely take cues from the influenza-vaccination programs we have in place. For those, Health Canada approves and then bulk orders the vaccines, choosing a couple of different candidates in case there are manufacturing snafus or to target certain segments of the population—seniors tend to get a high-dose flu shot because their immune systems benefit from the added boost. Buying in bulk helps cushion the cost: Moderna, which has said it plans to make a profit from its SARS-CoV-2 vaccine, will lower the price for big orders. The provinces then determine how exactly to get the doses out, allotting a certain share to family doctors, public health clinics, community clinics, and pharmacies. Typically, they'll also decide whether they will publicly fund vaccination and for whom. Ontario has a universal flu-vaccination program, for example, and BC and Quebec do not, though it's hard to imagine that anyone will have to shell out for a COVID-19 shot.

While flu shots are ordered and distributed based on how many people got one the previous year, planning for COVID-19 vaccines presents its own challenges: we don't know what the supply is going to be, how well it will work in different populations, or how many doses the vaccine might require. "If they're anticipating that we're going to have tons of doses in a short period of time, then it would make sense to have as many vaccinators as possible," says Jeff Kwong, epidemiologist and interim director of the Centre for Vaccine Preventable Diseases. You could walk into your family doctor's office, the local library, the nearest Shoppers Drug Mart or Pharmasave—take your pick. "But, if they're going to have relatively low numbers of doses available each week, then having a more limited number of vaccinators is more efficient." You don't want to run into a situation where one physician has fifty doses sitting idly in a fridge while another scrambles to contend with an out-the-door line.

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For that reason, vaccines could be administered just in public health clinics. "After the H1N1 pandemic, we really spent a lot of time developing our mass-immunization clinic plan," says Toronto's associate medical officer of health, Vinita Dubey. "That was the time to detail some of the boots-on-the-ground logistics." The plan includes everything from where to hold large vaccination clinics and how to keep them staffed to strategies for managing lines and signage for orienting people. "It's not like we don't have experience doing this," Kwong says. "It's about preparing for multiple scenarios and trying to be as responsible as possible."

In fact, administering the flu shot this influenza season will be a good trial run for getting out a COVID-19 vaccine. Although physical-distancing measures and travel restrictions might mean a milder flu season, health care officials in Canada are expecting higher demand this winter. "We know we will have smaller, more frequent clinics because large clinics become a large gathering," Dubey says. Expect longer hours, assigned appointments, and perhaps even at-home vaccinations, especially for high-risk or vulnerable people. "We're also reimagining our school-based clinics because we know that doing vaccines in schools is going to look different this year," she says. "That's preparation for COVID-vaccine planning for sure."

W**E ARE,** by now, well accustomed to thinking in waves: waves of COVID-19 infections, waves of lockdown measures, waves of fear and fatigue. Almost certainly, we will also have to contend with waves of vaccination as batches roll off manufacturing lines or we wait for new candidates to be approved. Still, someone is going to be first to pull up a sleeve. "We want the vaccine now, and we want enough for everybody," McGeer says. "But, if we have enough vaccine for 5 percent of the population, then who will be that 5 percent?"

The National Advisory Committee on Immunization (NACI), formed back in 1964 to review administering the polio vaccine, among others, makes recommendations on immunization practices and schedules, including which populations should get the vaccine first. "We look at age-specific risks for disease and complications, the ability of people to respond to the vaccine according to age, and whether there is a risk because of occupation," says NACI vice-chair Shelley Deeks. "Not only do we want to protect the vulnerable but, because this a pandemic, we want to ensure essential services can continue."

NACI advises on priorities, but because health care is a provincial responsibility, it's up to the provinces and territories to actually implement

those recommendations. "There are real differences that might result in different strategies based on where you are," Mc-Geer says. "Who you target in Nunavut is not the same as in downtown Toronto." The expectation is that provinces have a closer eye on the particular needs of their communities.

And it's the provinces that actually set most of the disease-control goals. Do you vaccinate to prevent mortality? In that case, for this virus, the elderly need to be prioritized. Do you vaccinate to reduce transmission and spread? There are some house-partying twentysomethings in Kelowna who could get the jab. Or do you vaccinate widely in an attempt to achieve herd immunity? NACI advises that front line workers be prioritized because they're at a greater risk of infection based on the work they do. But that's not axiomatic: "There's no commandment in the bible of pandemic response that health care workers go first," Upshur says. "You have to make arguments, and those arguments are based partly on data and partly on ethics." We know that racialized and low-income people are infected at rates wildly disproportionate to their populations, not for any epidemiological reason but because of historical and economic disadvantages. This inequality persists for those working in the health care system itself: The Lancet published a study of almost 100,000 front line health care workers in the UK and US, which found that racialized workers were nearly twice as likely as their white colleagues to come down with COVID-19. Should decision making about vaccine prioritization be based on structural social causes instead?

But history complicates that approach as well: a long tradition of surveillance and systemic discrimination in the health care system gives racialized people a very good reason not to want to go first. "In a public health emergency, where you're using a vaccine that doesn't have a lot of safety and effectiveness data, there's obviously some concern about giving it to the most vulnerable groups, who might feel they're being used as guinea pigs," says Alison Thompson, an associate professor at the University of Toronto's pharmacy school whose research focuses on the ethics of vaccines. "I think it's really about being as transparent as possible through this entire process of development, manufacturing, and distribution. People need to be able to see what's in the needle." That transparency could also help persuade the one in six Canadians who currently say they would not get the vaccine.

Though it can feel like this virus has been with us for roughly eight centuries, it's not yet been twelve months. In that time, a few hundred vaccine candidates have been created, dozens have entered human trials,

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and pretty much every promising new technology has been pressed into action. Work that would normally occur in sequence and stall on some bureaucrat's desk is now, thanks to huge financial investments by governments around the world, happening swiftly and in tandem. "The speed is not from sacrificing safety," the WHO's Crowcroft says. "It's sacrificing money." That still won't buy an end to this pandemic as quickly as we'd like: there's much mask-wearing and social distancing and staying home ahead. But the average new vaccine takes about a decade to make it to market. The fastest ever to make it to market, for mumps, arrived in four years. We're virtually guaranteed to shatter that record for COVID-19—one more unprecedented event in an age already full of them.

thewalrus.ca, 23 September 2020

https://www.thewalrus.ca

The age of electric cars is dawning ahead of schedule

2020-09-20

FRANKFURT — An electric Volkswagen ID.3 for the same price as a Golf. A Tesla Model 3 that costs as much as a BMW 3 Series. A Renault Zoe electric subcompact whose monthly lease payment might equal a nice dinner for two in Paris.

As car sales collapsed in Europe because of the pandemic, one category grew rapidly: electric vehicles. One reason is that purchase prices in Europe are coming tantalizingly close to the prices for cars with gasoline or diesel engines.

At the moment this near parity is possible only with government subsidies that, depending on the country, can cut more than $10,000 from the final price. Carmakers are offering deals on electric cars to meet stricter European Union regulations on carbon dioxide emissions. In Germany, an electric Renault Zoe can be leased for 139 euros a month, or $164.

Electric vehicles are not yet as popular in the United States, largely because government incentives are less generous. Battery-powered cars account for about 2 percent of new car sales in America, while in Europe the market share is approaching 5 percent. Including hybrids, the share rises to nearly 9 percent in Europe, according to Matthias Schmidt, an independent analyst in Berlin.

As electric cars become more mainstream, the automobile industry is rapidly approaching the tipping point when, even without subsidies, it will be as cheap, and maybe cheaper, to own a plug-in vehicle than one

In Germany, an electric Renault Zoe can be leased for 139 euros a month, or $164.

that burns fossil fuels. The carmaker that reaches price parity first may be positioned to dominate the segment.

A few years ago, industry experts expected 2025 would be the turning point. But technology is advancing faster than expected, and could be poised for a quantum leap. Elon Musk is expected to announce a breakthrough at Tesla's "Battery Day" event on Tuesday that would allow electric cars to travel significantly farther without adding weight.

The balance of power in the auto industry may depend on which carmaker, electronics company or start-up succeeds in squeezing the most power per pound into a battery, what's known as energy density. A battery with high energy density is inherently cheaper because it requires fewer raw materials and less weight to deliver the same range.

"We're seeing energy density increase faster than ever before," said Milan Thakore, a senior research analyst at Wood Mackenzie, an energy consultant which recently pushed its prediction of the tipping point ahead by a year, to 2024.

Some industry experts are even more bullish. Hui Zhang, managing director in Germany of NIO, a Chinese electric carmaker with global ambitions, said he thought parity could be achieved in 2023.

Venkat Viswanathan, an associate professor at Carnegie Mellon University who closely follows the industry, is more cautious. But he said: "We are already on a very accelerated timeline. If you asked anyone in 2010 whether we would have price parity by 2025, they would have said that was impossible."

This transition will probably arrive at different times for different segments of the market. High-end electric vehicles are pretty close to parity already. The Tesla Model 3 and the gas-powered BMW 3 Series both sell for about $41,000 in the United States.

A Tesla may even be cheaper to own than a BMW because it never needs oil changes or new spark plugs and electricity is cheaper, per mile, than gasoline. Which car a customer chooses is more a matter of preference, particularly whether an owner is willing to trade the convenience of gas stations for charging points that take more time. (On the other hand, owners can also charge their Teslas at home.)

Consumers tend to focus on sticker prices, and it will take longer before unsubsidized electric cars cost as little to drive off a dealer's lot as an economy car.

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The race to build a better battery

The holy grail in the electric vehicle industry has been to push the cost of battery packs — the rechargeable system that stores energy — below $100 per kilowatt-hour, the standard measure of battery power. That is the point, more or less, at which propelling a vehicle with electricity will be as cheap as it is with gasoline.

Current battery packs cost around $150 to $200 per kilowatt-hour, depending on the technology. That means a battery pack costs around $20,000. But the price has dropped 80 percent since 2008, according to the United States Department of Energy.

All electric cars use lithium-ion batteries, but there are many variations on that basic chemistry, and intense competition to find the combination of materials that stores the most power for the least weight.

For traditional car companies, this is all very scary. Internal combustion engines have not changed fundamentally for decades, but battery technology is still wide open. There are even geopolitical implications. China is pouring resources into battery research, seeing the shift to electric power as a chance for companies like NIO to break into the European and someday, American, markets. In less than a decade, the Chinese battery maker CATL has become one of the world's biggest manufacturers.

Everyone is trying to catch Tesla

The California company has been selling electric cars since 2008 and can draw on years of data to calculate how far it can safely push a battery's performance without causing overheating or excessive wear. That knowledge allows Tesla to offer better range than competitors who have to be more careful. Tesla's four models are the only widely available electric cars that can go more than 300 miles on a charge, according to Kelley Blue Book.

On Tuesday, Mr. Musk could unveil a technology offering 50 percent more storage per pound at lower cost, according to analysts at the Swiss bank UBS. If so, competitors could recede even further in the rearview mirror.

"The traditional car industry is still behind," said Peter Carlsson, who ran Tesla's supplier network in the company's early days and is now chief executive of Northvolt, a new Swedish company that has contracts to manufacture batteries for Volkswagen and BMW.

"But," Mr. Carlsson said, "there is a massive amount of resources going into the race to beat Tesla. A number, not all, of the big carmakers are going to catch up."

The traditional carmakers' best hope to avoid oblivion will be to exploit their expertise in supply chains and mass production to churn out economical electrical cars by the millions.

A key test of the traditional automakers' ability to survive will be Volkswagen's new battery-powered ID.3, which will start at under €30,000, or $35,000, after subsidies and is arriving at European dealerships now. By using its global manufacturing and sales network, Volkswagen hopes to sell electric vehicles by the millions within a few years. It plans to begin selling the ID.4, an electric sport utility vehicle, in the United States next year. (ID stands for "intelligent design.")

But there is a steep learning curve.

"We have been mass-producing internal combustion vehicles since Henry Ford. We don't have that for battery vehicles. It's a very new technology," said Jürgen Fleischer, a professor at the Karlsruhe Institute of Technology in southwestern Germany whose research focuses on battery manufacturing. "The question will be how fast can we can get through this learning curve?"

It's not just about the batteries

Peter Rawlinson, who led design of the Tesla Model S and is now chief executive of the electric car start-up Lucid, likes to wow audiences by showing up at events dragging a rolling carry-on bag containing the company's supercompact drive unit. Electric motor, transmission and differential in one, the unit saves space and, along with hundreds of other weight-saving tweaks, will allow the company's Lucid Air luxury car — which the company unveiled on Sept. 9 — to travel more than 400 miles on a charge, Mr. Rawlinson said.

His point is that designers should focus on things like aerodynamic drag and weight to avoid the need for big, expensive batteries in the first place. "There is kind of a myopia," Mr. Rawlinson said. "Everyone is talking about batteries. It's the whole system."

A charger on every corner would help

When Jana Höffner bought an electric Renault Zoe in 2013, driving anywhere outside her home in Stuttgart was an adventure. Charging

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stations were rare, and didn't always work. Ms. Höffner drove her Zoe to places like Norway or Sicily just to see if she could make it without having to call for a tow.

Ms. Höffner, who works in online communication for the state of Baden-Württemberg, has since traded up to a Tesla Model 3 equipped with software that guides her to the company's own network of chargers, which can fill the battery to 80 percent capacity in about half an hour. She sounds almost nostalgic when she remembers how hard it was to recharge back in the electric-vehicle stone age.

"Now, it's boring," Ms. Höffner said. "You say where you want to go and the car takes care of the rest."

The European Union has nearly 200,000 chargers, far short of the three million that will be needed when electric cars become ubiquitous, according to Transport & Environment, an advocacy group. The United States remains far behind, with less than half as many as Europe.

But the European network is already dense enough that owning and charging an electric car is "no problem," said Ms. Höffner, who can't charge at home and depends on public infrastructure.

Price and infrastructure are closely connected. At least in theory, people won't need big, expensive batteries if there is a place nearby to quickly recharge. (Charging times are also dropping fast.)

Lucid's first vehicle is a luxury car, but Mr. Rawlinson said his dream was to build an electric car attainable by the middle class. In his view, that would mean a lightweight vehicle capable of traveling 150 miles between charges.

"I want to make a $25,000 car," Mr. Rawlinson said. "That's what is going to change the world."

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https://www.nytimes.com

Cheap, innovative venom treatments could save tens of thousands of snakebite victims

2020-09-19

When Nigerian physician Garba Iliyasu was 10, a venomous snake bit a family member. The man survived, but "it was quite severe," Iliyasu recalls.

Between 80,000 and 138,000 victims die, and about three times that number have a life–changing disability.

"[He] was bleeding profusely.… From the nose. From the mouth. From the ear."

Since then, Iliyasu, a specialist in infectious and tropical diseases, has tended to hundreds of snakebite victims at Kaltungo General Hospital, a health care hub for the surrounding Gombe State. During the two annual peaks in snakebite cases — the spring planting and autumn harvest seasons — "we see like six, seven to 10 patients in a day, on average," he says. The hospital has only a few dozen beds. "Most times, you see patients on the floor."

In the Western world, snakebites are a minor issue. In the United States and Europe, cases are rare and hardly ever fatal. Even in Australia — notorious for its deadly, venomous snakes — bites account for just a handful of annual deaths.

But in sub-Saharan Africa, about 270,000 people are bitten every year, resulting in more than 55,000 cases of post-traumatic stress disorder, over 14,700 amputations and about 12,300 deaths, Iliyasu and colleagues estimated in *Toxicon* in March 2019. Add in India and other snakebite hot spots and the annual numbers rise to more than 2 million bites that need clinical treatment, according to the World Health Organization. Between 80,000 and 138,000 victims die, and about three times that number have a life–changing disability.

Snakebites are "a neglected disease that affects the neglected section of the society," Iliyasu says. The worst effects occur in mostly poor, rural communities that depend on farming and herding. Visit these places, he says, and "you will see how devastating the effect of snakebite is." Victims are often the primary breadwinners of their households, so every death and disability contributes to the cycle of poverty.

But snakebites are finally getting the attention they've long needed. In 2017, the WHO officially recognized snakebites as a neglected tropical disease. That designation has led to an influx of funding for innovative research; the largest, more than $100 million, came in 2019 from the Wellcome Trust.

Effective snakebite treatments do exist, and those antivenoms are considered the "gold standard" of care. If a victim receives the right antivenom soon after a bite — within an hour or two — then the chances of survival are "very, very high," says Nicholas Casewell, a biomedical scientist at the Liverpool School of Tropical Medicine in England.

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But that "if" looms large, with big challenges remaining, including the difficulties of speedy access to care and the fact that most anti-venoms work against just a few of the hundreds of dangerous species of venomous snakes. Antivenoms are also "a technology that has seen limited innovation for 120 years," says Andreas Laustsen, a biotech researcher and entrepreneur at the Technical University of Denmark in Kongens Lyngby.

Now, researchers from disparate fields of science are coming together to reimagine the way snakebites are managed. Casewell, Laustsen and others are tweaking current treatments, repurposing pharmaceuticals and even engineering toxin-stopping nanoparticles. The work offers hope that people everywhere, even in remote areas, will eventually be able to safely coexist with snakes.

Clear danger

Venomous snakebites, a neglected tropical disease, do the most damage in South and Southeast Asia, sub-Saharan Africa and parts of Central and South America. Recent data from India and Sub-Saharan Africa are still considered underestimates.

A tarnished gold standard

There's a saying in snakebite care that "time is tissue." The longer it takes to stop a snake's venom from moving through the victim's body, the more damage occurs. Destruction begins from the moment of a bite, and the cocktail of proteins and other molecules in the venom will continue to ravage until the immune system produces enough antibodies to remove or destroy those toxins. The problem is, by the time antibodies have ramped up, it's often too late.

The tissue maxim is especially true for bites from vipers and other snakes with venoms that target the blood and soft tissues and thus tend to cause more physical damage. But speed is also important for bites from snakes with paralytic venoms, such as the Indian cobra (*Naja naja*) and southern Africa's black mamba (*Dendroaspis polylepi*). Their nerve cell–targeting toxins will progressively slow muscles until the lungs and heart stop working.

That's where antivenoms come in. They speed up the immune system's clearance of toxins, because antivenoms are, themselves, antibodies pulled from the blood of large animals, usually horses, that have been injected with venom. When given soon after a snakebite, antivenoms work well.

But for myriad reasons, fast delivery often doesn't happen.

In rural communities, there may be relatively few health care providers who can stock and administer the intravenously delivered drugs, which often require refrigeration. In India, for instance, the staff in rural public health clinics rarely have the resources or training to safely administer the drugs and monitor for treatment side effects.

Patients are often sent several hours away to larger regional hospitals with more expertise. "A lot of [bite victims] die on the way," says Kartik Sunagar, an evolutionary biologist at the Indian Institute of Science in Bangalore. Sunagar wrote about the challenges of developing antivenoms with Casewell, Laustsen and venom scientist Timothy Jackson of Liverpool in the August *Trends in Pharmacological Sciences*.

Once a patient arrives at a hospital, delays can still occur, Laustsen says, because medical staff wait until they're completely sure someone needs antivenom before administering it. A large portion of snakebites are "dry," which means no venom is injected, so antivenom isn't always required.

Deciding which antivenom to use can be difficult. To glom on to and remove toxic substances, antibodies need to match their target almost exactly. And since each snake species makes its own unique blend of toxins, most venoms need a specific antivenom. Because bite victims can rarely reliably identify the species that bit them, doctors must wait for clear signs of damage to emerge to determine the right antivenom.

A "better safe than sorry" approach may seem warranted, but injecting antivenom when it's not needed or if it's the wrong kind can put the patient at even greater risk. As helpful as horse-derived antibodies can be, "the human immune system will recognize them as foreign," Laustsen notes, and may launch an attack. This reaction to the antivenom itself can be life-threatening if not treated promptly.

Friendlier options

For the last decade or so, researchers have been working to take horses out of the equation to make antivenoms safer — and maybe more affordable. Laustsen is exploring a couple of approaches to avoiding the body's reactions to horse-made antibodies.

One option is to produce "humanized" antibodies in the lab by replacing the ends of a human antibody gene with the venom-neutralizing parts from an effective equine antibody gene, so the patient's body wouldn't see the antibody proteins as foreign. But, even better, he hopes to discover

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effective fully human antibodies. With both approaches, he says, "you would remove at least 90 percent of all the side effects."

Taking horses out of the mix may also open the door for designing antibodies that work against venoms from more than a few species. Laustsen and colleagues described one promising approach July 1 in *Scientific Reports*. The key is to take human antibody genes and insert them into bacteria-infecting viruses, which build the antibodies into their shells.

Since large databases of human antibody genes already exist, a whole variety of different human antibodies can be inserted into viruses for high-throughput testing to find antibodies that can bind to — and perhaps neutralize — venom toxins.

As a proof of concept, Laustsen's team tested 40 billion antibodies from people, and identified one particularly exciting candidate: It protected human cells in lab dishes from more than a dozen lethal toxins from three cobra species.

Once the most broadly effective antibodies are found, Laustsen hopes to copy a page from the insulin-production handbook. For diabetes treatment, insulin used to be extracted from the pancreases of animals; now, it's made by engineered bacteria in large fermentation tanks. A similar process could work to produce broad-spectrum antivenom, he says.

Moving antibody production out of animals could also have another important benefit: lower production costs. Right now, "antivenom is one of the most expensive drugs that you can find in the rural areas," explains Muhammad Hamza, a medical doctor who, like Iliyasu, splits his time between research at Nigeria's Aminu Kano Teaching Hospital and treating patients at the regional treatment center in Gombe State. Many of Hamza's patients could be saved by antivenom, he says, but they can't afford to pay for it. If the government hasn't kept the clinic stocked with free medicine, patients die.

In Nigeria, a vial of antivenom costs around $60 to $70, Iliyasu says. He's seen patients sell their animals, homes and farms to pay for treatment.

Antivenoms engineered without animals would save patients money because the ideal mix of antibodies would be more potent. At least 70 percent of the antibodies in current antivenoms don't neutralize venom toxins at all, Iliyasu notes. As a result, it often takes several vials of

antivenom — sometimes as many as 10 — to treat a bite patient. Boosting the percentage of neutralizing antibodies in each vial would go a long way toward making antivenoms affordable, Iliyasu says — and that's why he's excited to see the move away from animal-based production.

Mixed bag

Snake venoms often contain dozens to hundreds of individual toxins. Two snakes' venom blends are shown here. The carpet viper's venom is heavy on metalloproteinase toxins, which can cause paralysis and tissue damage.

Most snake venoms, which can vary greatly among snake species, fall into recognizable groups. Four of the most common and pernicious groups and their toxic effects are listed below.

A pill for snakebite

Other researchers are turning to existing drugs to expand options for snakebite treatments.

Venom toxins generally cause harm by performing specific molecular actions, such as cutting up certain proteins or fats within cells. Targeted molecules that interfere with that nefarious work could potentially stop the toxins.

The idea of using drugs other than antibodies to inhibit venom toxins isn't new. But it wasn't until the molecular and genetic technology revolutions of the late 20th century that scientists could really deconstruct venoms to figure out which components are responsible for a venom's worst effects. "We now have a very good handle on what the toxins are," Casewell says.

It's unlikely that one drug, or even a combination, would be able to neutralize the diversity of harmful toxins present in snake venoms and work as effectively as traditional antivenoms. But Casewell's aim isn't to replace antivenoms; he wants to safely slow down the most pernicious venom toxins to buy patients time to get to a clinic.

He and colleagues have so far focused on metalloproteinases — toxins that chop up proteins and are major players in the lethal and destructive nature of tissue-destroying venoms, such as those in saw-scaled vipers (*Echis* spp.). Casewell's group picked a few drugs already on the market that bind up the metal ions that these proteinases need to function, and right off the bat, the drugs were surprisingly successful.

The group demonstrated that an existing small molecule drug used to treat heavy metal poisoning could reduce the deadly damage of viper

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bites in lab animals (*SN: 6/6/20, p. 12*). And when paired with another drug that inhibits a family of toxins that chew up certain fats, the drug was even more powerful. In animal tests, the combination neutralized the venoms of a more diverse collection of five snake species from all over the world.

Drug duo

Two drugs together — the PLA2 inhibitor varespladib, and the metalloproteinase inhibitor marimastat — saved mice from lethal doses of five different snake venoms (results against two of the venoms shown below). Even when the drugs were given 15 minutes after the venom injection, the mice lived (blue lines). Mice that didn't get the drugs died within four hours (red).

The work is "quite exciting," Casewell says, because it means small molecule drugs might be able to overcome the problem of geographic fragmentation — each venom needs its own antidote — that keeps antivenom markets too small and nonlucrative for pharmaceutical companies to invest in.

As a bonus, such small molecules are available in pill form and don't need refrigeration or expert administration, making them easier to distribute in rural communities. In that way, such drugs could become an important "bridge to care," Iliyasu says.

Next generation of treatments

While pills alone may never be a stand-alone treatment for snakebites, there are other alternatives to conventional antivenoms, says Shih-Hui Lee of the University of California, Irvine. "We can use a polymer."

Lee and colleague Kenneth Shea are new to the field of snakebite treatment. "We're not snake venom people," Shea admits. They're not even biologists. The two are materials scientists. But their approach to overhauling antivenom is so out of the box that it's getting noticed.

Both spent much of their careers designing carbon polymers — essentially, plastic nanoparticles — with specific, desirable properties. After a while, the duo started to wonder if their designer plastics, which could bind to certain parts of proteins, could mimic the actions of antibodies.

Shea started with melittin, a bee venom toxin. To his surprise, the polymer nanoparticles worked. When injected into mice shortly after the injection of a life-threatening dose of melittin, the particles bound up enough

of the toxin to save the animals' lives, Shea and colleagues reported in the *Journal of the American Chemical Society* in 2010.

Those results helped him recruit Lee to the antivenom project and convince well-respected snakebite expert José María Gutiérrez of the University of Costa Rica in San José to collaborate. With his help, Shea and Lee set their sights on phospholipase A2s, a large family of toxins found in many deadly snake venoms.

Once again, Lee says, the polymer nanoparticles neutralized the toxins. In 2018, the particles proved effective against another family of snake toxins called three-finger toxins. The "plastic" antibodies saved mice from cobra venom, and healthy mice that received them had no adverse reactions, the team reported in *PLOS Neglected Tropical Diseases*.

Cobra combat

When tested in mice, synthetic nanoparticle antibodies prevented skin tissue death caused by black-necked spitting cobra venom. The nanoparticles were most effective when injected into the wound right after the venom was injected (0 min); the longer the wait, the larger the wound.

There are still some design challenges to overcome before testing the polymers in people. The team wants to put these synthetic antibodies into injectable devices — much like an EpiPen — but right now, the nanoparticles are probably too big. So the next hurdle is to make them smaller and more able to travel from the injection site in a muscle to the surrounding tissues.

But the biggest challenge is convincing funding agencies that synthetic antibodies should be on the table. The hesitancy is understandable, Shea says, as there's nothing like these nanoparticles on the market. "This is untested, so there has to be an element of faith in this," he says.

Still, Shea and Lee believe in their creation. Producing a broad-spectrum antivenom with the nanoparticles "is technically much less challenging" than with biological antibodies, Shea says, so if the team can secure investors, he thinks the nanoparticles have the potential to be "a quite cheap antidote."

Others are stepping out of the box, as well. Thanks to the influx of funding in the last few years, researchers around the world are trying all sorts of unconventional approaches to snakebite remedies. There are labs hoping to design DNA molecules known as aptamers that act like antibodies.

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Others are turning to animals, such as opossums, that are naturally immune to venoms in the hopes of translating that immunity into new drugs. All of this work is leading to some truly exciting technological developments, Casewell says.

But none of it will matter if there aren't also investments in infrastructure and education, Hamza warns. "It is one thing to have the drug.… It's another thing to get it available to the remotest parts of the world."

He's more excited about smartphone apps that could tell people in remote areas where the closest available antivenom is, for instance. And something as simple as providing farmers solid boots with instructions on when and why to wear them could prevent countless snakebites from happening in the first place.

With millions of snakebites occurring every year, there's certainly many opportunities to improve the situation — and all of them need attention, Casewell says. That attention is finally coming. "This is kind of a once-in-a-lifetime moment for snakebites," he says.

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Technical Notes

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Norm index-based QSAR models for acute toxicity of organic compounds toward zebrafish embryo

Valorization of CO 2 through lithoautotrophic production of sustainable chemicals in Cupriavidus necator

[ALLERGIC CONTACT DERMATITIS DUE TO NITRILE RUBBER GLOVES: ETHYL ISOTHIOCYANATE AND BUTYL ISOTHIOCYANATE AS POSSIBLE CAUSATIVE CHEMICALS]

ENVIRONMENTAL RESEARCH

Ready biodegradability ring testing of 4-isopropylphenol in different laboratories for critical evaluation of a biodegradable reference substance

OCCUPATIONAL

Data on occupational health and safety strategies influencing the reduction of coronavirus in South Africa

Creatinine Fluctuations Forecast Cross-Harvest Kidney Function Decline Among Sugarcane Workers in Guatemala

A Quantitative Retrospective Exposure Assessment for Former Chrysotile Asbestos Miners and Millers from Baie Verte, NL, Canada

PHARAMACEUTICAL/TOXICOLOGY

Tumorigenic response in lung tumor susceptible A/J mice after sub-chronic exposure to calcium chromate or iron (III) oxide

Organophosphate flame retardants excite arcuate melanocortin circuitry and increase neuronal sensitivity to ghrelin in adult mice

Fighting against Drug-Resistant Tumors using a Dual-Responsive Pt(IV)/Ru(II) Bimetallic Polymer