CHEMWATCH

Bulletin Board

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ASIA PACIFIC

Regional preparatory meeting for the face-to-face segment of the 2021/2022 COPs for the Asia-Pacific region

2022-04-05

2021/2022 COPs for the Asia-Pacific region

Bali, Indonesia from 27 to 29 March 2022

Venue: The Asia Pacific regional preparatory meeting for the face-to-face segment of the 2021/2022 conferences of the Parties to the Basel, Rotterdam and Stockholm conventions will take place from 27 to 29 March 2022 in Bali, Indonesia, back-to-back with the fourth meeting of the Conference of Parties of the Minamata Convention on Mercury.

Meeting Objectives: The objective of the regional preparatory meeting is to give Parties within the Asia-Pacific region the possibility to consult each other in advance of the face-to-face segment of the 2021/2022 COPs, consider meeting documents, discuss substantive matters, identify regional priorities and challenges, and facilitate the preparation of regional positions. The programme for the meeting has been developed in consultation with members of the bureaux of the conferences of the Parties to the three conventions from the Asia-Pacific region. As indicated in the programme, certain sessions of the meeting are closed for observers in order to allow Parties to discuss regional positions on items of the agendas of the meetings of the conferences of the Parties.

Working Language: English

Organizers: The meeting is being organized in cooperation with the Basel and Stockholm conventions Regional Centre located in Indonesia (BCRC-SCRC Indonesia). The regional preparatory meetings for the 2022 face-to-face segment of the meetings of the conferences of the Parties to the Basel, Rotterdam and Stockholm conventions are organized thanks to the generous financial support provided by the Governments of Norway and Switzerland, as well as the European Union through the Programme on Capacity Building related to Multilateral Environmental Agreements in the African, Caribbean and Pacific countries (ACP MEAs Programme).

Participants are invited to consult the meeting documents of the face-to-face segment of the 2021/2022 conferences of the Parties in advance of the regional preparatory meeting.

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Basel Convention, 5-04-22

http://www.brsmeas.org/2021COPs/RegionalPreparatoryMeetings/COP2021regionalprepmtgAsia/tabid/8811/language/en-US/Default.aspx

India Puts Curbs on Import and Export of Hydrofluorocarbons

2022-04-07

India has restricted the export of hydrofluorocarbons (HFCs), as of a March 23 notification from the Directorate General of Foreign Trade (DGFT) that moved 17 different HS codes for hydrofluorocarbons from the export policy of "Free" to "Restricted". Earlier in March, the DGFT has imposed similar curbs on imports of these HFCs with immediate effect.

Read More

Chemlinked, 7-04-22

https://chemical.chemlinked.com/news/chemical-news/india-puts-curbs-on-import-and-export-of-hydrofluorocarbons

AMERICA

Comments on TSCA Collaborative Research Program to Support New Chemicals Due May 10, 2022

2022-04-07

The U.S. Environmental Protection Agency (EPA) has placed a March 29, 2022, memorandum correcting the deadline for public comment on the Toxic Substances Control Act (TSCA) Collaborative Research Program to Support New Chemicals. The memorandum states that EPA is clarifying the deadline because the February 25, 2022, Federal Register notice erroneously referenced two different dates. The 60-day comment period on the supporting technical document began when EPA added the document to the docket on March 10, 2022. Comments are due May 10, 2022. More information on EPA's supporting technical document, "Modernizing the Process and Bringing Innovative Science to Evaluate New Chemicals Under TSCA," is available in our March 14, 2022, memorandum.

Read More

TSCA Blog, 07-04-22

https://www.tscablog.com/entry/comments-on-tsca-collaborative-research-program-to-support-new-chemicals-du

EPA Decides Not to Regulate Rocket Fuel Chemicals in Drinking Water

2022-04-04

Drinking water for nearly 16 million Americans may contain perchlorate, an extremely harmful chemical to fetus development and children. So when the E.P.A. announced that they wouldn't impose limits on the chemical in drinking water, many were outraged.

The Biden administration announced that they would uphold the Trump-era decision not to create limits on perchlorate in drinking water. The toxic chemical has been linked to brain damage in infants and other serious issues. Perchlorate is used in rocket fuel, ammunition, and explosives. Exposure can damage developing fetuses, and children, and significantly decrease I.Q. in newborns.

Read More

One Green Planet, 4-04-22

https://www.onegreenplanet.org/human-interest/epa-decides-not-to-regulate-rocket-fuel-chemicals-in-drinking-water/

Pennsylvania, Delaware move to limit 'forever chemicals' in drinking water

2022-04-05

Pennsylvania and Delaware have joined a growing list of states moving to set enforceable limits in drinking water for two "forever chemicals," which have been linked to health concerns, including cancer.

The two states have taken steps to establish state-specific maximum contaminant levels for perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS). Those compounds are among the most thoroughly studied of a group of highly persistent chemicals called per- and polyfluoroalkyl substances, or PFAS. Studies have shown that exposures to certain PFAS can cause a variety of health problems, including decreased

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fertility, developmental delays in children and reduced immunity to infection.

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Bay Journal, 5-04-22

https://www.bayjournal.com/news/pollution/pennsylvania-delaware-move-to-limit-forever-chemicals-in-drinking-water/article_9ac9ce1e-af7a-11ec-99d3-e31d8059ebb8.html

EUROPE

The European plastics system needs significant change within five years to meet long-term circularity and net zero emissions goals.

2022-04-07

ReShaping Plastics – Pathways to a Circular, Climate Neutral Plastics System in Europe finds that a fully circular, net zero carbon emissions plastics system in Europe is possible. However, achieving it will require radical innovation, ambitious policies and significant capital investment. Cooperation between industry, government and civil society is the critical success factor underlying all of these.

ReShaping Plastics focuses on four of the most important plastic-using sectors: packaging, household goods, automotive, and construction, and presents six scenarios, outlining which actions should be prioritized for different plastic applications in order to meet circularity and climate mitigation goals.

To achieve net-zero carbon emissions by 2050, multiple less mature, innovative technologies and approaches need to be developed and deployed in addition to proven circular economy levers to further decrease GHG emissions and decouple plastic from fossil fuel feedstocks.

Read More

Systemiq, 7-04-22

https://www.systemiq.earth/reshaping-plastics/

Screening of Chlorinated Paraffins, Dechloranes and UV-filters in Nordic Countries

2022-03-30

On behalf of the Nordic Council of Ministers' Screening Group, NILU and NIVA performed a monitoring study on selected environmental contaminants, namely UV-filters, dechloranes, and chlorinated paraffins. UV-compounds were frequently detected in samples related to the marine food web. In the group of dechloranes, dechlorane 602 was detected most frequently in samples related to the marine, freshwater, and terrestrial food web. Short and medium chain chlorinated paraffins (SCCPs and MCCPs) were found in most of the samples, but long chain chlorinated paraffins (LCCPs) with a slightly lower detection frequency. For nearly all biota samples, the concentrations of MCCPs were higher than the SCCP concentrations. LCCP-concentrations were as high or higher than the SCCP-concentrations.

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Nordic Co-operation, 30-03-22

https://www.norden.org/en/publication/screening-chlorinated-paraffins-dechloranes-and-uv-filters-nordic-countries

The ban on toxic flame retardant stays, chemical industry dismissed by EU court

2022-04-05

Recent European Commission legal win against chemical industry group sets an important precedent, holding the door open for more systematic restrictions of substances hampering circular economy under the new revision of the Ecodesign Directive, Bich Dao and Stéphane Arditi report.

Two years after the legal battle began between the European Commission and chemical industry group – Bromine Science Environmental Forum (BSEF), the General Court of the EU has dismissed the industry's attempt to overturn the ban on the use of halogenated flame retardants (HRFs) in electronic displays.

Recycling nuisance

Originally introduced by the European Commission with the support of national experts, the ban on HFRs in electronic displays – the first such measure to be applied under the Ecodesign Directive, aimed to

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improve recycling of plastics parts of televisions and monitors, while also protecting public health.

HFRs in plastic material are added to slow down ignition in case of fire, but they are not without consequences on human health, and alternatives exist to fulfil the same function when needed.

The toxicity of some HFRs is widely recognised, many of which are based on bromine, several of which have already been banned for their potential health and environmental impact. Most notably in the case of the Ecodesign Directive, these flame retardant chemicals make it difficult if not impossible to safely recycle plastic parts of electric or electronic equipment (EEE). In fact, with current technical tests, it is not feasible for recyclers to easily distinguish between halogenated parts from normal ones, making it expensive to perfectly sort EEE waste on this dimension. A consequence of such a difficulty is that the nasty traces of restricted HFRs are found in recycled plastic products, including childrens' toys and kitchen equipment, posing risks of cancer and hormone disruption in adults, as well as neurological deficits in children.The fight against HFRs extends beyond EEE plastic recycling.

Parallel to the campaign for electronics, phase-out calls in the furniture industry are also well underway, supported by an alliance of firefighters, the furniture industry, recyclers, governments, and health and environmental experts from around the world.

Read More

European Environmental Bureau, 05-04-22

https://meta.eeb.org/2022/03/30/the-ban-on-toxic-flame-retardant-stays-chemical-industry-dismissed-by-eu-court/

INTERNATIONAL

Under construction: The chemical aspects of the Taxonomy Regulation – so far

2022-03-29

After many heated debates on what constitutes sustainable business, the final pieces of the giant EU Taxonomy Regulation puzzle are now being developed and put into place. But what is the Taxonomy? How does it work? And how on Earth is it connected to hazardous chemicals?

A transition to a sustainable economic model that respects the limits and livelihoods of our planet needs finances. So how do we make sure that the "dough" ends up in the right "oven" and not the one that is eventually going to burn the entire house down, so to speak? That question is at the very core of the EU's Sustainable Finance Program, which aims to channel public and private money into sustainable businesses.

The Taxonomy, a part of the Sustainable Finance Program, categorises which economic activities can be labeled as truly sustainable, according to six environmental criteria:

1. Climate change mitigation
2. Climate change adaptation
3. The sustainable use and protection of water and marine resources
4. The transition to a circular economy
5. Pollution prevention and control
6. The protection and restoration of biodiversity and ecosystems

No more greenwashing of financial products

Starting this year, it will be mandatory for companies, banks and investors based in Europe, or operating a European legal entity with more than 500 employees, to report on the first two criteria: the ones concerning climate. The remaining four criteria are going to be published over the coming months, and by January 2023, it will be mandatory to report on all six.

The reports will be made public, putting an end to the opportunity of easily – and incorrectly – declaring an investment as "green".

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Chemsec, 29-03-22

https://chemsec.org/under-construction-the-chemical-aspects-of-the-taxonomy-regulation-so-far/

Tanzania bans three cosmetics ingredients

2022-03-30

THE WHAT? Tanzania's cosmetics regulator has ushered in a ban on the use of pyrithione zinc, butylphenyl methylpropional and sodium hydroxymethylglycinate in cosmetics, effective March 1, 2022, according to a report published by All Africa.

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THE DETAILS The African nation's Bureau of Standards said that it was monitoring local manufacturers and imported products closely to ensure that the country's standards were adhered to.

THE WHY? The ingredients in question have been linked to infertility and cancer, Moses Mbambe, Head of Registration Desk for Food and Cosmetics Premises, told All Africa.

Read More

Global Cosmetics News, 30-03-22

https://www.globalcosmeticsnews.com/tanzania-bans-three-cosmetics-ingredients/

ECHA – Pharmaceutical industry provides unpublished data on chemical substances

2022-04-04

Previously unpublished data on chemicals tested to develop medicines is now publicly available. The data is downloadable as IUCLID datasets – the global format for collecting, storing and sharing information on chemicals.

Helsinki, 4 April 2022 – The datasets contain information about the hazard properties of 19 substances from 153 tests. The information can contribute to the development of predictive computational testing models as well as other purposes.

Dr Jan Backman, Head of Chemical Legislation at F.Hoffmann-La Roche Ltd representing the European Federation of Pharmaceutical Industries and Associations says: "Companies provide this high-quality data free of charge for the benefit of society. Our aim is to enhance the effectiveness of database-dependent computational tools, such as QSARs, for testing the safety of structurally similar chemicals. Scientists can use the data to gradually reduce testing on animals. This initiative is open to any company and I invite all to join and share their archived data."

"We see this as an example of 'IUCLIDation' of existing data – it facilitates the sharing, access and re-use of data on chemicals, in line with the EU's Chemicals Strategy for Sustainability. Promoting harmonised formats and tools like IUCLID is key to achieve this aim. In the long run, this data can be beneficial to develop and promote alternative test methods to replace animal studies," explains ECHA's Director of Prioritisation and Integration Ofelia Bercaru.

Background

The European Federation of Pharmaceutical Industries and Associations (EFPIA) represents the biopharmaceutical industry operating in Europe. So far, four companies – Roche, Johnson & Johnson, Merck and Boehringer Ingelheim – have provided data.

IUCLID is developed by ECHA in association with the OECD. It is the tool for any organisation or individual that needs to record, store, submit and exchange data on chemical substances using OECD Harmonised Templates.

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ECHA, 04-04-2022

https://echa.europa.eu/nl/-/pharmaceutical-industry-provides-unpublished-data-on-chemical-substances

UK REACH – SBAA RMOA - Call for evidence

2022-04-04

Overview

The UK REACH work programme for 2021/22 states that we will assess all the substances that have been submitted for identification as Substances of Very High Concern (SVHCs) in EU REACH at the time the work programme was published (if they are not already on the UK REACH Candidate List) and consider if they are appropriate for SVHC identification in UK REACH. As a result of an initial assessment of these substances, HSE and the Environment Agency identified 4 substances requiring a regulatory management options analysis (RMOA).

Following on from this work, the UK, Welsh and Scottish Governments have asked HSE and the Environment Agency to prepare a RMOA for three substances which are members of a group called the small brominated alkylated alcohols. These substances are:

- 2,2-bis(bromomethyl)propane1,3-diol (BMP) (CAS number 3296-90-0)
- 2,2-dimethylpropan-1-ol, tribromo derivative/3-bromo-2,2-bis(bromomethyl)-1-propanol (TBNPA) (CAS numbers 36483-57-5/ 1522-92-5). CAS 36483-57-5 contains three substructures, where one of them is CAS 1522-92-5.
- 2,3-dibromo-1-propanol (2,3-DBPA) (CAS number 96-13-9)

For convenience we will refer to the group with the acronym SBAA. This RMOA will investigate the risks posed by SBAA and recommend the best approach to protect human health and the environment from any identified risks.

This call for evidence aims to gather information and evidence that will support HSE and the Environment Agency with the preparation of the RMOA. We are interested in all aspects of the manufacture, import, hazard profile, use and exposure, environmental fate, waste and its disposal requirements, recycling opportunities for these substances and products that contain these substances, and any legislation and standards that apply, including product specific legislation and standards.

REACH Update

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HSE, 04-04-22

https://consultations.hse.gov.uk/crd-reach/sbaa-rmoa-002/

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Janet's Corner

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Abstract Mad Libs

2022-04-15

Abstract MadLibs!!

This paper presents a _____ (synonym for *new*) method for _____ (sciencey verb) the _____ (noun few people have heard of). Using _____ (something you didn't invent), the _____ (property) was measured to be _____ (number) +/- _____ (number) _____ (units). Results show _____ (sexy adjective) agreement with theoretical predictions and significant improvement over previous efforts by _____ (Loser), et al. The work presented here has profound implications for future studies of _____ (buzzword) and may one day help solve the problem of _____ (supreme sociological concern).

Keywords: _____ (buzzword), _____ (buzzword), _____ (buzzword)

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WWW.PHDCOMICS.COM

https://phdcomics.com/comics/archive.php?comicid=1121

Glutaraldehyde

2022-04-15

Glutaraldehyde, or 1,5-pentanedial, is a dialdehyde with the molecular formula $CH_2(CH_2CHO)_2$. It is slightly acidic in its natural state. Glutaraldehyde is a colourless oily liquid with a pungent odour. [1,2] It is soluble in water and in organic solvents. Solutions in water are stable for long periods of time. [3]

USES [3]

The largest single use of glutaraldehyde is as an antimicrobial, bactericide, fungicide and a virucide. It is used to sterilise hospital and veterinary equipment, and to disinfect surfaces in hospitals, veterinary hospitals, nursing homes, and food processing plants. It is used to prevent bacterial growth in water supplies for washing air, cooler systems, logging ponds, and pulp and paper water systems. Smaller uses are as an embalming fluid, as a fixative for tissues, for film processing and leather tanning.

SOURCES OF EMISSION & ROUTES OF EXPOSURE

Sources of Emission [3]

- Industry sources: The primary sources of glutaraldehyde are the industries that use it. Some of the industries that use it are crude oil and natural gas extraction, beverage manufacturers, hospitals and x-ray processing. These emissions mainly are to the air and water.
- Diffuse sources: Other possible emitters of glutaraldehyde are medical offices, veterinary clinics, water in cooling systems, food processing facilities, tanneries, household disinfectants and agriculture sanitising.
- Natural sources: There is no known source of natural glutaraldehyde.
- Transport sources: No mobile sources.
- Consumer products: Agricultural chemicals, disinfecting, sterilising, sanitising, household disinfectants, and furniture polish.

Routes of Exposure [4]

The major routes of exposure to glutaraldehyde are:

- inhalation,
- skin absorption,
- ingestion,
- skin and/or eye contact

Glutaraldehyde, or 1,5-pentanedial, is a dialdehyde with the molecular formula CH2(CH2CHO)2.

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HEALTH EFFECTS [3,5,6]

Acute Effects

Contact with liquid and vapour can severely irritate the eyes, and at higher concentrations burns the skin. Exposure to glutaraldehyde can cause nausea, headaches,.

Short-term exposure to high levels of glutaraldehyde may result in sudden headaches drowsiness, and dizziness. Breathing glutaraldehyde can irritate the nose, throat, and respiratory tract, causing coughing and wheezing. It causes strong irritation to the eyes and ingestion may result in abdominal pains, cramps, vomiting, diarrhoea, and or a burning sensation in the chest. At very high doses vascular collapse and coma have occurred.

Chronic Effects

Glutaraldehyde is a sensitiser, this is where after repeated exposures an allergic response occurs. This means some workers will become very sensitive to glutaraldehyde and have strong reactions if they are exposed to even small amounts. Workers may get sudden asthma attacks with difficult breathing, wheezing, coughing, and tightness in the chest. Prolonged exposure can cause a skin allergy and chronic eczema, and afterwards, exposure to small amounts produces severe itching and skin rashes.

Carcinogenic Effects

The American Conference of Governmental Industrial Hygienists (ACGIH) has classified glutaraldehyde as A4 (Not classifiable for human or animal.)

Mutagenic Effects

Glutaraldehyde is mutagenic for mammalian somatic cells. It is also mutagenic for bacteria and yeast.

Reproductive Toxicity

Glutaraldehyde is classified as a suspended reproductive toxin in females.

SAFETY [6]

First Aid Measures

- Eye Contact: Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Cold water may be used. Get medical attention immediately.

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

Exposure Controls & Personal Protection

Engineering Controls

Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapours below their respective threshold limit value. Ensure that eyewash stations and safety showers are proximal to the workstation location.

Personal Protective Equipment

The following personal protective equipment is recommended when handling glutaraldehyde:

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

Personal Protective Equipment in Case of a Large Spill:

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- Splash goggles;
- Full suit;
- Vapour respirator;
- Boots;
- Gloves;
- A self-contained breathing apparatus should be used to avoid inhalation of the product.
- Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

REGULATION

United States [2]

- ACGIH: The American Conference of Governmental Industrial Hygienists has adopted a ceiling threshold limit value (TLV-C) of 0.05ppm for glutaraldehyde. A TLV-C represents an airborne concentration that should not be exceeded during any part of the work shift.
- NIOSH: The National Institute for Occupational Safety and Health has established a recommended exposure (REL) limit of 0.2 ppm, as a ceiling limit, for glutaraldehyde.
- OSHA: The Occupational Safety and Health Administration had also established a permissible exposure limit (as a ceiling level) of 0.2 ppm in 1989, but this was vacated in 1993 for legal reasons.

Australia [3]

- Safe Work Australia: Safe Work Australia has established a time weighted average (TWA) concentration for glutaraldehyde of 0.1ppm over an eight-hour workshift.

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6. http://www.sciencelab.com/msds.php?msdsId=9924161

These energy innovations could transform how we mitigate climate change, and save money in the process

2022-04-04

To most people, a solar farm or a geothermal plant is simply a power producer. Scientists and engineers see far more potential.

They envision offshore wind turbines capturing and storing carbon beneath the sea, and geothermal plants producing essential metals for powering electric vehicles. Electric vehicle batteries, too, can be transformed to power homes, saving their owners money.

With scientists worldwide sounding the alarm about the increasing dangers and costs of climate change, let's explore some cutting-edge ideas that could transform how today's technologies reduce the effects of global warming, from five recent articles in The Conversation.

1. Solar canals: Power + water protection

What if solar panels did double duty, protecting water supplies while producing more power?

California is developing the United States' first solar canals, with solar panels built atop some of the state's water distribution canals. These canals run for thousands of miles through arid environments, where the dry air boosts evaporation in a state frequently troubled by water shortages.

"In a 2021 study, we showed that covering all 4,000 miles of California's canals with solar panels would save more than 65 billion gallons of water annually by reducing evaporation. That's enough to irrigate 50,000 acres of farmland or meet the residential water needs of more than 2 million people," writes engineering professor Roger Bales of the University of California, Merced. They would also expand renewable energy without taking up farmable land.

Research shows that human activities, particularly using fossil fuels for energy and transportation, are unequivocally warming the planet and increasing extreme weather. Increasing renewable energy, currently about 20% of U.S. utility-scale electricity generation, can reduce fossil fuel demand.

Putting solar panels over shaded water can also improve their power output. The cooler water lowers the temperature of the panels by about 10 degrees Fahrenheit (5.5 Celsius), boosting their efficiency, Bales writes.

What if solar panels did double duty, protecting water supplies while producing more power?

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2. Geothermal power could boost battery supplies

For renewable energy to slash global greenhouse gas emissions, buildings and vehicles have to be able to use it. Batteries are essential, but the industry has a supply chain problem.

Most batteries used in electric vehicles and utility-scale energy storage are lithium-ion batteries, and most lithium used in the U.S. comes from Argentina, Chile, China and Russia. China is the leader in lithium processing.

Geologist and engineers are working on an innovative method that could boost the U.S. lithium supply at home by extracting lithium from geothermal brines in California's Salton Sea region.

Brines are the liquid leftover in a geothermal plant after heat and steam are used to produce power. That liquid contains lithium and other metals such as manganese, zinc and boron. Normally, it is pumped back underground, but the metals can also be filtered out.

"If test projects now underway prove that battery-grade lithium can be extracted from these brines cost effectively, 11 existing geothermal plants along the Salton Sea alone could have the potential to produce enough lithium metal to provide about 10 times the current U.S. demand," write geologist Michael McKibben of the University of California, Riverside, and energy policy scholar Bryant Jones of Boise State University.

President Joe Biden invoked the Defense Production Act on March 31, 2022, to provide incentives for U.S. companies to mine and process more critical minerals for batteries.

3. Green hydrogen and other storage ideas

Scientists are working on other ways to boost batteries' mineral supply chain, too, including recycling lithium and cobalt from old batteries. They're also developing designs with other materials, explained Kerry Rippy, a researcher with the National Renewable Energy Lab.

Concentrated solar power, for example, stores energy from the sun by heating molten salt and using it to produce steam to drive electric generators, similar to how a coal power plant would generate electricity. It's expensive, though, and the salts currently used aren't stable at higher temperature, Rippy writes. The Department of Energy is funding a similar project that is experimenting with heated sand.

Renewable fuels, such as green hydrogen and ammonia, provide a different type of storage. Since they store energy as liquid, they can be transported and used for shipping or rocket fuel.

Hydrogen gets a lot of attention, but not all hydrogen is green. Most hydrogen used today is actually produced with natural gas—a fossil fuel. Green hydrogen, in contrast, could be produced using renewable energy to power electrolysis, which splits water molecules into hydrogen and oxygen, but again, it's expensive.

"The key challenge is optimizing the process to make it efficient and economical," Rippy writes. "The potential payoff is enormous: inexhaustible, completely renewable energy."

4. Using your EV to power your home

Batteries could also soon turn your electric vehicle into a giant, mobile battery capable of powering your home.

Only a few vehicles are currently designed for vehicle-to-home charging, or V2H, but that's changing, writes energy economist Seth Blumsack of Penn State University. Ford, for example, says its new F-150 Lightning pickup truck will be able to power an average house for three days on a single charge.

Blumsack explores the technical challenges as V2H grows and its potential to change how people manage energy use and how utilities store power.

For example, he writes, "some homeowners might hope to use their vehicle for what utility planners call 'peak shaving' – drawing household power from their EV during the day instead of relying on the grid, thus reducing their electricity purchases during peak demand hours."

5. Capturing carbon from air and locking it away

Another emerging technology is more controversial.

Humans have put so much carbon dioxide into the atmosphere over the past two centuries that just stopping fossil fuel use won't be enough to quickly stabilize the climate. Most scenarios, including in recent Intergovernmental Panel on Climate Change reports, show the world will have to remove carbon dioxide from the atmosphere, as well.

The technology to capture carbon dioxide from the air exists—it's called direct air capture—but it's expensive.

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Engineers and geophysicists like David Goldberg of Columbia University are exploring ways to cut those costs by combining direct air capture technology with renewable energy production and carbon storage, like offshore wind turbines built above undersea rock formations where captured carbon could be locked away.

The world's largest direct air capture plant, launched in 2021 in Iceland, uses geothermal energy to power its equipment. The captured carbon dioxide is mixed with water and pumped into volcanic basalt formations underground. Chemical reactions with the basalt turn it into a hard carbonate.

Goldberg, who helped developed the mineralization process used in Iceland, sees similar potential for future U.S. offshore wind farms. Wind turbines often produce more energy than their customers need at any given time, making excess energy available.

"Built together, these technologies could reduce the energy costs of carbon capture and minimize the need for onshore pipelines, reducing impacts on the environment," Goldberg writes.

Tech Xplore, 4 April 2022

https://techxplore.com

Study describes new method for probing the bewildering diversity of the microbiome

2022-04-04

In recent years, researchers have begun to explore the vast assemblage of microbes on and within the human body. These include protists, archaea, fungi, viruses and vast numbers of bacteria living in symbiotic ecosystems.

Known collectively as the human microbiome, these tiny entities influence an astonishing range of activities, from metabolism to behavior and play a central role in health and disease. Some 39 trillion non-human microbes flourish on and within us, in a ceaseless, interdependent bustle. Together, they make up over half of the human body's cells, though they may possess 500 times as many genes as are found in human cells. Identifying and making sense of this microbial mélange has been a central challenge for researchers.

In a new study, Qiyun Zhu and his colleagues describe a new method for probing the microbiome in unprecedented detail. The technique provides greater simplicity and ease of use compared with existing approaches.

[This diversity] includes protists, archaea, fungi, viruses and vast numbers of bacteria living in symbiotic ecosystems.

Using the new technique, the researchers demonstrate an improved ability to pinpoint biologically relevant characteristics, including a subject's age and sex based on microbiome samples.

The innovative research holds the promise of rapidly advancing investigations into the mysteries of the microbiome. With such knowledge, researchers hope to better understand how these microbes collectively act to safeguard human health and how their dysfunction can lead to a broad range of diseases. In time, drugs and other therapies may even be tailor-made based on a patient's microbiomic profile.

Professor Zhu is a researcher in the Biodesign Center for Fundamental and Applied Microbiology and ASU's School of Life Sciences. The research team includes collaborators from the University of California, San Diego, including co-corresponding author Rob Knight, Zhu's former mentor.

The group's research results appear in the current issue of the journal mSystems.

Tools of the trade

Two powerful technologies have been used to help researchers unlock the diversity and complexity of the microbiome, by sequencing the microbial DNA present in a sample. These are known as 16S and metagenomic sequencing. The technique described in the current study draws on the strengths of both methods to create a new way of processing data from the microbiome.

"We borrow some of the wisdom that developed from 16S RNA sequencing and apply it to metagenomics," Zhu says. Unlike other sequencing methods, including 16S, metagenomics allows researchers to sequence all the DNA information present in a microbiome sample. But the new study shows that the metagenomic approach has room for improvement. "The way people currently analyze metagenomic data is limited, because whole genome data has to first be translated into taxonomy."

The new technique, known as Operational Genomic Units (OGU) does away with the laborious and sometimes misleading practice of assigning taxonomic categories like genus and species to the multitude of microbes present in a sample. Instead, the method uses individual genomes as the basic units for statistical analysis and simply attempts to align sequences present in a sample to sequences found in existing genomic databases.

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By doing this, researchers can get much more fine-grained resolution, which is particularly useful when microbes are present that are closely related in DNA sequence. This is true because most taxonomic classifications are based on sequence similarity. If two sequences differ by less than a certain threshold, they fall into the same taxonomic category, however the OGU approach can help researchers tell them apart.

Further, the method overcomes errors in taxonomy that persist as relics from the pre-sequencing epoch, when different species were defined by their morphology rather than from DNA sequence data.

In addition to improvements in resolution and simplicity, OGU can help researchers analyze data using what are known as phylogenetic trees. As the name implies, these are branching structures that can describe the degree of relatedness between organisms, based on their sequence similarity. Just as two distantly related species like worms and antelope will appear on more distant branches of a phylogenetic tree, so will more distantly related bacteria and other constituents of the microbiome.

Innovations in sequencing

The most widely used technique for probing the microbiome, known as 16S ribosomal RNA sequencing or just 16S, relies on a simple idea. All bacteria have a 16S gene, which is essential to the machinery bacteria need to initiate protein synthesis. The bacterial 16S gene, measuring 1500 base pairs in length, consists of distinct regions. Some of these regions change very little between different bacteria and over evolutionary timeframes, while others are highly variable.

Researchers realized that the conserved and variable regions of the 16S gene allow it to act as a molecular clock, keeping track of bacteria that are more closely or more distantly related, based on their sequence similarity. Thus, the 8 conserved and 9 variable regions of 16S can be used to fingerprint bacteria.

To do this, a microbiome sample is first collected. This could be a fecal sample, to evaluate the gut microbiome, or a sample from the skin or from the mouth. Each body site is home to a different bacterial menagerie.

Next, PCR technology is used to amplify portions of the 16S gene. By sequencing highly conserved regions, a broad swath of bacteria can be identified, while sequencing of variable regions helps narrow the identity of particular bacteria.

Although 16S is an inexpensive and well-developed method, it has limitations. The technique can only give a general idea of the kinds of bacteria present, with limited resolution. In general, 16S is only accurate to the genus level of identification.

Enter metagenomic sequencing. This technique sequences the full genomes of all microbes present in a microbiome sample, (not just bacteria, as with 16S). Metagenomics allows researchers to sequence thousands of organisms in parallel, providing accurate, species-level resolution. The greater resolution however does come with costs. Metagenomic data is far richer and more computationally challenging to analyze than 16S data and more expensive in time and money to process.

A new path for metagenomics

The OGU technique streamlines metagenomic sequencing, while providing even greater resolution. The approach classifies microbes in a sample strictly according to their alignment with a reference database—no taxonomic assignment required. The approach enables researchers to evaluate the degree of species diversity present in a sample.

Compared with 16S and standard metagenomic sequencing, the new approach is superior in ferreting out biologically relevant information. Using the classic Human Microbiome Project dataset of 210 metagenomes sampled from seven body sites of male and female human subjects, the study demonstrates better correlation between body site and host sex.

Next, 6,430 stool samples collected through a random sampling of the Finnish population were analyzed, using both 16S and metagenomic sequencing. The samples belong to a large, randomly sampled cohort of the Finnish population, known as FINRISK. The aim was to predict the age of sampled individuals, based on gut microbial composition. Again, the OGU method outperformed 16S and conventional metagenomic analysis, providing more accurate predictions.

New research drawing on still larger datasets will further enhance the resolution of the new technique and expand the descriptive power of taxonomy-independent analysis.

Phys Org, 4 April 2022

https://phys.org

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The Human Genome Project pieced together only 92% of the DNA – now scientists have finally filled in the remaining 8%

2022-04-01

When the Human Genome Project announced that they had completed the first human genome in 2003, it was a momentous accomplishment - for the first time, the DNA blueprint of human life was unlocked. But it came with a catch - they weren't actually able to put together all the genetic information in the genome. There were gaps: unfilled, often repetitive regions that were too confusing to piece together.

With advancements in technology that could handle these repetitive sequences, scientists finally filled those gaps in May 2021, and the first end-to-end human genome was officially published on Mar. 31, 2022.

I am a genome biologist who studies repetitive DNA sequences and how they shape genomes throughout evolutionary history. I was part of the team that helped characterize the repeat sequences missing from the genome. And now, with a truly complete human genome, these uncovered repetitive regions are finally being explored in full for the first time.

Over half of the human genome contains repetitive DNA sequences whose functions are still not fully understood.

The missing puzzle pieces

German botanist Hans Winkler coined the word "genome" in 1920, combining the word "gene" with the suffix "-ome," meaning "complete set," to describe the full DNA sequence contained within each cell. Researchers still use this word a century later to refer to the genetic material that makes up an organism.

One way to describe what a genome looks like is to compare it to a reference book. In this analogy, a genome is an anthology containing the DNA instructions for life. It's composed of a vast array of nucleotides (letters) that are packaged into chromosomes (chapters). Each chromosome contains genes (paragraphs) that are regions of DNA which code for the specific proteins that allow an organism to function.

While every living organism has a genome, the size of that genome varies from species to species. An elephant uses the same form of genetic information as the grass it eats and the bacteria in its gut. But no two genomes look exactly alike. Some are short, like the genome of the insect-dwelling bacteria Nasuia deltocephalinicola with just 137 genes across 112,000 nucleotides. Some, like the 149 billion nucleotides of the

flowering plant Paris japonica, are so long that it's difficult to get a sense of how many genes are contained within.

But genes as they've traditionally been understood – as stretches of DNA that code for proteins – are just a small part of an organism's genome. In fact, they make up less than 2% of human DNA.

The human genome contains roughly 3 billion nucleotides and just under 20,000 protein-coding genes - an estimated 1% of the genome's total length. The remaining 99% is non-coding DNA sequences that don't produce proteins. Some are regulatory components that work as a switchboard to control how other genes work. Others are pseudogenes, or genomic relics that have lost their ability to function.

And over half of the human genome is repetitive, with multiple copies of near-identical sequences.

What is repetitive DNA?

The simplest form of repetitive DNA are blocks of DNA repeated over and over in tandem called satellites. While how much satellite DNA a given genome has varies from person to person, they often cluster toward the ends of chromosomes in regions called telomeres. These regions protect chromosomes from degrading during DNA replication. They're also found in the centromeres of chromosomes, a region that helps keep genetic information intact when cells divide.

Researchers still lack a clear understanding of all the functions of satellite DNA. But because satellite DNA forms unique patterns in each person, forensic biologists and genealogists use this genomic "fingerprint" to match crime scene samples and track ancestry. Over 50 genetic disorders are linked to variations in satellite DNA, including Huntington's disease.

Another abundant type of repetitive DNA are transposable elements, or sequences that can move around the genome.

Some scientists have described them as selfish DNA because they can insert themselves anywhere in the genome, regardless of the consequences. As the human genome evolved, many transposable sequences collected mutations repressing their ability to move to avoid harmful interruptions. But some can likely still move about. For example, transposable element insertions are linked to a number of cases of hemophilia A, a genetic bleeding disorder.

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But transposable elements aren't just disruptive. They can have regulatory functions that help control the expression of other DNA sequences. When they're concentrated in centromeres, they may also help maintain the integrity of the genes fundamental to cell survival.

They can also contribute to evolution. Researchers recently found that the insertion of a transposable element into a gene important to development might be why some primates, including humans, no longer have tails. Chromosome rearrangements due to transposable elements are even linked to the genesis of new species like the gibbons of southeast Asia and the wallabies of Australia.

Completing the genomic puzzle

Until recently, many of these complex regions could be compared to the far side of the moon: known to exist, but unseen.

When the Human Genome Project first launched in 1990, technological limitations made it impossible to fully uncover repetitive regions in the genome. Available sequencing technology could only read about 500 nucleotides at a time, and these short fragments had to overlap one another in order to recreate the full sequence. Researchers used these overlapping segments to identify the next nucleotides in the sequence, incrementally extending the genome assembly one fragment at a time.

These repetitive gap regions were like putting together a 1,000-piece puzzle of an overcast sky: When every piece looks the same, how do you know where one cloud starts and another ends? With near-identical overlapping stretches in many spots, fully sequencing the genome by piecemeal became unfeasible. Millions of nucleotides remained hidden in the the first iteration of the human genome.

Since then, sequence patches have gradually filled in gaps of the human genome bit by bit. And in 2021, the Telomere-to-Telomere (T2T) Consortium, an international consortium of scientists working to complete a human genome assembly from end to end, announced that all remaining gaps were finally filled.

This was made possible by improved sequencing technology capable of reading longer sequences thousands of nucleotides in length. With more information to situate repetitive sequences within a larger picture, it became easier to identify their proper place in the genome. Like simplifying a 1,000-piece puzzle to a 100-piece puzzle, long-read

sequences made it possible to assemble large repetitive regions for the first time.

With the increasing power of long-read DNA sequencing technology, geneticists are positioned to explore a new era of genomics, untangling complex repetitive sequences across populations and species for the first time. And a complete, gap-free human genome provides an invaluable resource for researchers to investigate repetitive regions that shape genetic structure and variation, species evolution and human health.

But one complete genome doesn't capture it all. Efforts continue to create diverse genomic references that fully represent the human population and life on Earth. With more complete, "telomere-to-telomere" genome references, scientists' understanding of the repetitive dark matter of DNA will become more clear.

The Conversation, 1 April 2022

https://theconversation.com

Peptides on Stardust May Have Provided a Shortcut to Life

2022-04-03

Billions of years ago, some unknown location on the sterile, primordial Earth became a cauldron of complex organic molecules from which the first cells emerged. Origin-of-life researchers have proposed countless imaginative ideas about how that occurred and where the necessary raw ingredients came from. Some of the most difficult to account for are proteins, the critical backbones of cellular chemistry, because in nature today they are made exclusively by living cells. How did the first protein form without life to make it?

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Scientists have mostly looked for clues on Earth. Yet a new discovery suggests that the answer could be found beyond the sky, inside dark interstellar clouds.

Last month in Nature Astronomy, a group of astrobiologists showed that peptides, the molecular subunits of proteins, can spontaneously

The discovery that short peptides can form spontaneously on cosmic dust hints at more of a role for them in the origin of life, on Earth or elsewhere.

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form on the solid, frozen particles of cosmic dust drifting through the universe. Those peptides could in theory have traveled inside comets and meteorites to the young Earth—and to other worlds—to become some of the starting materials for life.

The simplicity and favorable thermodynamics of this new space-based mechanism for forming peptides make it a more promising alternative to the known purely chemical processes that could have occurred on a lifeless Earth, according to Serge Krasnokutski, the lead author on the new paper and a researcher at the Max Planck Institute for Astronomy and the Friedrich Schiller University in Germany. And that simplicity "suggests that proteins were among the first molecules involved in the evolutionary process leading to life," he said.

Whether those peptides could have survived their arduous trek from space and contributed meaningfully to the origin of life is very much an open question. Paul Falkowski, a professor at the School of Environmental and Biological Sciences at Rutgers University, said that the chemistry demonstrated in the new paper is "very cool" but "doesn't yet bridge the phenomenal gap between proto-prebiotic chemistry and the first evidence of life." He added, "There's a spark that's still missing."

Still, the finding by Krasnokutski and his colleagues shows that peptides might be a much more readily available resource throughout the universe than scientists believed, a possibility that could also have consequences for the prospects for life elsewhere.

Cosmic Dust in a Vacuum

Cells make the production of proteins look easy. They manufacture both peptides and proteins extravagantly, empowered by environments rich in useful molecules like amino acids and their own stockpiles of genetic instructions and catalytic enzymes (which are themselves typically proteins).

But before cells existed, there wasn't an easy way to do it on Earth, Krasnokutski said. Without any of the enzymes that biochemistry provides, the production of peptides is an inefficient two-step process that involves first making amino acids and then removing water as the amino acids link up into chains in a process called polymerization. Both steps have a high energy barrier, so they occur only if large amounts of energy are available to help kick-start the reaction.

Because of these requirements, most theories about the origin of proteins have either centered on scenarios in extreme environments, such as near hydrothermal vents on the ocean floor, or assumed the presence of molecules like RNA with catalytic properties that could lower the energy barrier enough to push the reactions forward. (The most popular origin-of-life theory proposes that RNA preceded all other molecules, including proteins.) And even under those circumstances, Krasnokutski says that "special conditions" would be needed to concentrate the amino acids enough for polymerization. Though there have been many proposals, it isn't clear how and where those conditions could have arisen on the primordial Earth.

But now researchers say they've found a shortcut to proteins—a simpler chemical pathway that reenergizes the theory that proteins were present very early in the genesis of life.

Last year in Low Temperature Physics, Krasnokutski predicted through a series of calculations that a more direct way to make peptides could exist under the conditions available in space, inside the extremely dense and frigid clouds of dust and gas that linger between the stars. These molecular clouds, the nurseries of new stars and solar systems, are packed with cosmic dust and chemicals, some of the most abundant of which are carbon monoxide, atomic carbon and ammonia.

In their new paper, Krasnokutski and his colleagues showed that these reactions in the gas clouds would likely lead to the condensation of carbon onto cosmic dust particles and the formation of small molecules called aminoketenes. These aminoketenes would spontaneously link up to form a very simple peptide called polyglycine. By skipping the formation of amino acids, reactions could proceed spontaneously, without needing energy from the environment.

To test their claim, the researchers experimentally simulated the conditions found in molecular clouds. Inside an ultrahigh vacuum chamber, they mimicked the icy surface of cosmic dust particles by depositing carbon monoxide and ammonia onto substrate plates chilled to minus 263 degrees Celsius. They then deposited carbon atoms on top of this ice layer to simulate their condensation inside molecular clouds. Chemical analyses confirmed that the vacuum simulation had indeed produced various forms of polyglycines, up to chains 10 or 11 subunits long.

The researchers hypothesized that billions of years ago, as cosmic dust stuck together and formed asteroids and comets, simple peptides on the

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dust could have hitchhiked to Earth in meteorites and other impactors. They might have done the same on countless other worlds, too.

The Gap From Peptides to Life

The delivery of peptides to Earth and other planets "certainly would provide a head start" to forming life, said Daniel Glavin, an astrobiologist at NASA's Goddard Space Flight Center. But "I think there's a large jump to go from interstellar ice dust chemistry to life on Earth."

First the peptides would have to endure the perils of their journey through the universe, from radiation to water exposure inside asteroids, both of which can fragment the molecules. Then they'd have to survive the impact of hitting a planet. And even if they made it through all that, they would still have to go through a lot of chemical evolution to get large enough to fold into proteins that are useful for biological chemistry, Glavin said.

Is there evidence that this has happened? Astrobiologists have discovered many small molecules including amino acids inside meteorites, and one study from 2002 discovered that two meteorites held extremely small, simple peptides made from two amino acids. But researchers have yet to discover other convincing evidence for the presence of such peptides and proteins in meteorites or samples returned from asteroids or comets, Glavin said. It's unclear if the nearly total absence of even relatively small peptides in space rocks means that they don't exist or if we just haven't detected them yet.

But Krasnokutski's work could encourage more scientists to really start looking for these more complex molecules in extraterrestrial materials, Glavin said. For example, next year NASA's OSIRIS-REx spacecraft is expected to bring back samples from the asteroid Bennu, and Glavin and his team plan to look for some of these types of molecules.

The researchers are now planning to test whether bigger peptides or different types of peptides can form in molecular clouds. Other chemicals and energetic photons in the interstellar medium might be able to trigger the formation of larger and more complex molecules, Krasnokutski said. Through their unique laboratory window into molecular clouds, they hope to witness peptides getting longer and longer, and one day folding, like natural origami, into beautiful proteins that burst with potential.

Wired, 3 April 2022

https://wired.com

Honeybee venom can cure breast cancer, study finds

2022-04-05

The cancer community is buzzing over a new study that says venom from bees can kill cancer cells.

Scientists at the Harry Perkins Institute of Medical Research in Western Australia tested venom from more than 300 honeybees and bumblebees against two types of aggressive, hard to treat breast cancer: triple negative and human epidermal growth factor receptor 2 (HER2) enriched. They found that a compound in the venom called melittin could destroy breast cancer cells within an hour, without causing harm to other cells. They also found that when used in conjunction with chemotherapy drugs, the melittin helped formed pores in the cancer cell membrane which could potentially allow therapies to better penetrate the cells.

While the tests for this study were only done in a lab setting, the researchers believe the compound can be synthetically reproduced as a treatment for breast cancer.

Dr. Marilena Tauro, a breast cancer researcher at Moffitt Cancer Center, says while the discovery is impressive, more research would need to be done before it could become a viable therapy. "The good news is this study has shown that melittin can disrupt signaling pathways in breast cancer cells that are responsible for growth and spread of the disease," she said. "However, there have been many studies where compounds have proved successful at killing cancer cells in the lab or animal models, but it has taken many years for those discoveries make it to patients, if at all."

Tauro added that approximately half of all current drugs are derived from natural products, which demonstrates the potential of using bee venom for drug discovery.

"Nature is a great supplier of active elements and chemical synthesis has made it possible to provide many drugs of natural origin in the dosage required for therapeutic use, despite the often very limited supply from their original sources," she said.

The Brighter Side of News, 5 April 2022

https://thebrighterside.news

A compound in the venom called melittin could destroy breast cancer cells within an hour.

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Dirty Dozen 2022: Produce with the most and least pesticides

2022-04-07

Strawberries and spinach continue to top the annual list of the "Dirty Dozen" fruits and veggies that contain the highest levels of pesticides, followed by three greens -- kale, collard and mustard -- nectarines, apples, grapes, and bell and hot peppers, according to the Environmental Working Group's 2022 Shopper's Guide to Pesticides in Produce.

Cherries came in eighth this year on the list of the 12 most contaminated foods, with peaches, pears, celery and tomatoes rounding out the list.

But don't stop eating these foods, which are full of the vitamins, minerals, fiber and antioxidants needed to battle chronic disease, experts say.

"If the things you love to eat are on the 'Dirty Dozen' list, we recommend buying organic versions when you can," said Alexis Temkin, a toxicologist at the EWG with expertise in toxic chemicals and pesticides.

"Several peer-reviewed studies and clinical trials have looked at what happens when people switch to a fully organic diet," she said. "Concentrations and measurements of pesticides decrease very rapidly."

Consumers can also consult EWG's "Clean Fifteen" -- a list of produce with the lowest amount of pesticides. Nearly 70% of the fruits and veggies on the list had no detectable pesticide residues, while just under 5% had residues of two or more pesticides, the report said.

Avocados had the lowest levels of pesticides among the 46 foods tested, followed by sweet corn, pineapple, onions and papaya.

Multiple pesticides

Issued yearly since 2004, the EWG report uses US Department of Agriculture test data to rank 46 foods that are the most and least contaminated with pesticide residues. The USDA staffers prepare the food as consumers would -- washing, peeling or scrubbing -- before testing each item.

The USDA does not sample all 46 foods each year, so EWG pulls results from the most recent testing period. Strawberries, for example, have not been tested by the USDA since 2016, Temkin said,

Many samples of the 46 fruits and vegetables included in the report tested positive for multiple pesticides, including insecticides and fungicides.

Testing found the highest level of multiple pesticides -- 103 -- on samples of the heart-healthy trio of kale, collards and mustard greens, followed by 101 different pesticides on hot and bell peppers.

Over 90% of "strawberries, apples, cherries, spinach, nectarines and grapes tested positive for residues of two or more pesticides," the report said.

Testing found the highest level of multiple pesticides -- 103 -- on samples of the heart-healthy trio of kale, collards and mustard greens, followed by 101 different pesticides on hot and bell peppers. In general, "spinach samples had 1.8 times as much pesticide residue by weight as any other crop tested," the report said.

Being exposed to multiple pesticides, even at low levels, is "supra-additive," with each pesticide having more of a health impact than it might in isolation, said Dr. Leonardo Trasande, chief of environmental pediatrics at NYU Langone, who was not involved in the report.

Health risks of pesticides

Health dangers from pesticides depend on the type, according to the US Environmental Protection Agency. Pesticides can impact the nervous system, irritate the eyes and skin, interfere with the hormonal systems of the body, or cause cancer, the EPA said.

The pesticide DCPA, classified by the EPA as a possible human carcinogen and banned in 2009 by the European Union, was frequently detected on collards, mustard greens and kale, the EWG report said.

Chlorpyrifos, a pesticide often used on nut and fruit trees and row crops such as broccoli and cauliflower, was banned by the EPA in February 2022 after a 15-year effort by environmental groups.

Chlorpyrifos contains an enzyme "which leads to neurotoxicity, and has also been associated with potential neurodevelopmental effects in children," the EPA said.

Babies and children are especially vulnerable to pesticides, experts say, because of the damage the chemicals can cause to the developing brain. A 2020 study found an increase in IQ loss and intellectual disability in children due to exposure to organophosphates, a common class of pesticides.

A large number of pesticides also affect the endocrine system in developing fetuses, which can interfere with developmental growth, reproduction and metabolism.

"Even a brief exposure to pesticides which alter endocrine function can cause permanent effects if the exposure occurs during critical windows of reproductive development," according to the EPA.

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Industry complaints

The agricultural industry has long complained about the release of the "Dirty Dozen," saying EWG "willfully" misrepresents USDA data in the report.

"To put it simply, EWG's attempt to twist the data to create bias ... results in growing consumer fear of fruits and vegetables," said Chris Novak, president and CEO of CropLife America, a national trade association that represents the manufacturers, formulators and distributors of pesticides.

"A study found that specifically naming the "Dirty Dozen" resulted in shoppers being less likely to buy ANY vegetables and fruit, not just those named on their list," Novak said via email.

In response, EWG said the study in question, which was funded by another industry association, the Alliance for Food and Farming, presents an entirely different reality than what Novak describes.

"The study actually shows that just over half of people surveyed said the 'Dirty Dozen' list made them more likely to buy fruits and vegetables," Temkin said. "Only about 1 in 6 said our report would make them less likely to buy produce."

Steps consumers can take

Besides eating organic, there are a number of actions consumers can take to reduce exposure to pesticides -- and many other toxins such as heavy metals -- that can be found in produce.

Rinse all produce before serving. Don't use soap, detergent or commercial produce wash -- water is the best choice, experts say.

"Soap and household detergents can be absorbed by fruits and vegetables, despite thorough rinsing, and can make you sick. Also, the safety of the residues of commercial produce washes is not known and their effectiveness has not been tested," the US Food and Drug Administration stated.

Choose local. Buying food that is purchased directly from a local farmer can reduce the risk of pesticide exposure, experts say.

Buy in season. Prices drop when fruits and vegetables are in season and plentiful. That's a good time to purchase organic foods in bulk, then freeze or can them for future use, experts suggest.

CNN Health, 7 April 2022

https://edition.cnn.com

Artificial fingertip gives robots nearly humanlike touch

2022-04-05

Robots can be programmed to lift a car and even help perform some surgeries, but when it comes to picking up an object they have not touched before, such as an egg, they often fail miserably. Now, engineers have come up with an artificial fingertip that overcomes that limitation. The advance enables machines to sense the textures of these surfaces a lot like a human fingertip does.

The researchers are "bringing the fields of natural and artificial touch closer together … a necessary step to improve robotic touch," says Mandayam Srinivasan, a touch researcher at the University College London who was not involved with the work.

Engineers have long sought to make robots as dexterous as people. One approach involves equipping them with artificial nerves. But, "The current state of robotic touch is generally far inferior to human tactile abilities," Srinivasan says.

So, when researchers at the University of Bristol began designing an artificial fingertip in 2009, they used human skin as a guide. Their first fingertip—assembled by hand—was about the size of a soda can. By 2018, they had switched to 3D printing. That made it possible to make the tip and all its components about the size of an adult's big toe and more easily create a series of layers approximating the multilayered structure of human skin. More recently, the scientists have incorporated neural networks into the fingertip, which they call TacTip. The neural networks help a robot quickly process what it's sensing and react accordingly—seemingly just like a real finger.

In our fingertips, a layer of nerve endings deforms when skin contacts an object and tells the brain what's happening. These nerves send "fast" signals to help us avoid dropping something and "slow" signals to convey an object's shape.

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TacTip's equivalent signals come from an array of pinlike projections underneath a rubbery surface layer that move when the surface is touched. The array's pins are like a hairbrush's bristles: stiff but bendable. Beneath that array is, among other things, a camera that detects when and how the pins move. The amount of bending of the pins provides the slow signal and the speed of bending provides the fast signal. The neural network translates those signals into the fingertip's actions, making it grip more tightly for example, or adjust the angle of the fingertip.

"A lot of our sense of touch is shaped by the mechanics [of the skin]," says Sliman Bensmaia, a neuroscientist at the University of Chicago who studies the neuronal basis of touch. "What this approach does is really tackle that head on."

In the new work, University of Bristol engineer Nathan Lepora and colleagues put the artificial tip through its paces, testing it the same way researchers assess a person's sense of touch. They measured the output from the camera as the fingertip touched corduroylike materials that had gaps and ridges of different heights and densities. Not only could the artificial fingertip detect the gaps and ridges, its output closely matched the neuronal signaling patterns of human fingertips undergoing the same tests, the team reports today in the Journal of the Royal Society Interface.

The artificial fingertip was not quite as sensitive as the real McCoy, however. A human can detect a gap as narrow as lead from a pencil, whereas TacTip needed it to be twice as wide to notice it, Lepora notes. But he thinks that resolution will improve once he and his colleagues develop a thinner outer surface.

In a second project, Lepora's team added more pins and a microphone to TacTip. The microphone mimics another set of nerve endings deep within our skin that sense vibrations felt as we run our fingers across a surface. These nerve endings enhance our ability to feel how rough a surface is.

The microphone did likewise when the researchers tested the enhanced fingertip's ability to differentiate among 13 fabrics. Again, the signals from the microphone and the camera mimicked those recorded from human fingers doing this test, Lepora notes.

The studies impress Levent Beker, a mechanical engineer at Koç University who works on wearable sensors. "A robotic hand can [now] sense pressure and texture information similar to a human finger," he says.

3D printed skin reacts to texture and shape like our skin

"It's a very interesting approach that I don't think anyone else has taken," Bensmaia adds. "It's very cool." However, the signals from the artificial and natural fingertips are not quite the same, as the signaling in real skin is more intense. "It's only moderately skinlike."

Still, Bensmaia thinks this fingertip can help robots detect, pick up, and manipulate objects. And the deformable, rubbery fingertip should give a bionic hand a leg—or hand—up on current devices with stiff metal fingers and toes, he says.

Today's robots must be precisely programmed to attach a particular car part, and they, as well as hand protheses, have trouble holding on to hard objects, such as a pen or a toothbrush. Fingertips like TacTip could enable robots and prostheses to handle objects of all shapes and sizes without such programming, Lepora says. But Bensmaia points out that "it's not clear to what extent it can be miniaturized."

Lepora is optimistic TacTip will shrink. Cameras and microphones are getting smaller all the time, and improved 3D printing techniques are enabling thinner layers. Both he and Bensmaia think such smaller devices might approximate human "feel" even more because they would be able to detect finer textures and thus be more dexterous.

And on a basic level, this research is helping clarify how touch works in humans, says Robert Shepherd, a materials scientist at Cornell University. Lepora and his colleagues have basically figured out how the skin's nerve endings translate what they sense to get the fingers to catch a ball slipping through our fingers or pick up an origami crane without crushing it (as in the video above), he says. "People like me and others need to be more knowledgeable about this stuff."

Science, 5 April 2022

https://science.org

We found a genetic link between routine blood test results and mental health disorders

2022-04-07

Mental health disorders including depression, schizophrenia, and anorexia show links to biological markers detected in routine blood tests, according to our new study of genetic, biochemical and psychiatric data from almost a million people.

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The research will increase our understanding of what causes mental illness and may help to identify new treatments.

Healthy body, healthy mind

People often consider mental health as separate from the health of the rest of the body. This is far from true: there is clear evidence many biochemical substances involved in diseases such as diabetes and autoimmune conditions directly impact the function of our brain.

Many studies have tried to address this by focusing on substances called biomarkers that can be readily measured in blood.

A biomarker is simply something in the body that is a sign of a particular disease or process. These often relate to the kind of things reported in a blood test ordered by your doctor, such as cholesterol, blood sugar, liver enzymes, vitamins, or markers of inflammation.

Biomarkers found in routine blood tests are useful as they are often affected by diet and lifestyle, or by treatment with a drug.

The complex role of genetics in mental health

It's often difficult to study the role of these blood biomarkers in mental health conditions. Many studies in this area are often not large enough to make strong conclusions.

One solution is to look at genetic influences on both mental illness and substances measured in blood. Genetics is useful as we now have data from millions of individuals who have volunteered in research studies.

Both mental illnesses and blood biomarkers are what geneticists call "complex traits". In complex traits, many genes are involved and environmental factors also contribute.

The widespread availability of genetic data has allowed us to investigate how huge numbers of tiny changes in the DNA sequence (or "variants") are related to the risk of mental illness. These same variants can then also be linked to the measured levels of a biomarker in blood.

For example, a variant in a particular gene may increase the risk of developing schizophrenia and also be linked to a decrease in the levels of a vitamin circulating in the blood. Most of these variants are individually associated with very small changes in something like risk of a mental illness, but they may add together to produce larger effects.

People often consider mental health as separate from the health of the rest of the body. This is far from true.

How are blood biomarkers related to mental illness?

Our recent study sought to use genetics to investigate the relationship between nine mental health disorders and 50 factors measured in routine blood tests, such as cholesterol, vitamins, enzymes, and indicators of inflammation. We used data from very large studies conducted by other people, with data from almost a million volunteers included in total.

Our study first confirmed the existence of what is called genetic correlation between blood biomarkers and mental illness, which was more widespread than has previously been shown. Genetic correlation means the effect of DNA sequence changes on the risk of a mental illness and the levels of a given biomarker were more similar to each other than what would occur by chance alone.

To take one example, there was a positive genetic correlation in our study between white blood cell count and depression. This could indicate some process in our body influences both depression and white blood cells.

If we could identify what this shared process is, it could lead to a better understanding of what causes depression and this could be targeted for treatment.

Correlation verses causality

Our study showed there was correlation between the genetics of mental illness and factors in the blood, but this does not tell us whether blood biomarkers are involved in what causes mental illness.

To distinguish correlation from causation in medicine, the gold standard approach is to conduct clinical trials where patients randomly receive a treatment or a placebo. However, these trials are expensive and difficult to conduct.

We did the next best thing: using DNA variants linked to changes in blood biomarkers to act as a natural clinical trial. This process takes advantage of the fact we randomly inherit DNA variants from our parents, in much the same way that participants in a clinical trial randomly receive a treatment or a placebo.

It's a complex method and the results need careful interpretation.

We found evidence some substances measured in blood may actually be involved in the cause of some mental illnesses. Proteins related to the immune system, for example, may be involved in depression, schizophrenia, and anorexia.

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Further work is now needed to identify how these blood measures are precisely involved in these disorders, and to find out if they can be targeted for treatment.

The Conversation, 7 April 2022

https://theconversation.com

Tiny labmade motors could one day suck pollutants from the air and harvest precious metals

2022-04-06

Tiny molecular machines make life possible. Spinning rotary motors generate the chemical fuel our cells need, miniature walkers carry nutrients, and minute construction crews build proteins. Now, chemists are getting in on the act by making even smaller and simpler versions of these biological machines.

In three studies, scientists report designing their own molecular pumps and rotary motors. The puny devices are not quite ready to make their real-world debut, but future versions could suck carbon dioxide from the air and harvest valuable metals from seawater. The new studies show it's possible to get teams of motors all working in the same direction and concentrate target chemicals in a confined space, a feat biology uses to sustain work.

Future versions could suck carbon dioxide from the air and harvest valuable metals from seawater.

"These are very important steps toward useful real-life molecular machines," says Ivan Aprahamian, a chemist at Dartmouth College who wasn't involved with the studies.

Most large motors burn fuel to generate heat that then drives pistons and gears to create motion. But life on the molecular scale is different. Because of the vanishingly small size of molecules, a chemical reaction that causes a molecular rotor to spin clockwise is equally likely to spin it counterclockwise. And heat jostles molecules randomly in all directions. "At such small scales, random chaotic motion of components and molecules is inevitable," says Nathalie Katsonis, a chemist at the University of Groningen.

Fraser Stoddart has been working to overcome this challenge for years. The organic chemist at Northwestern University created some of the world's first small, chemical-based molecular machines, sharing a Nobel Prize for his research in 2016. His team designed rings that would thread on and off a molecular axle when different chemicals were added. But

because those machines drifted around randomly in solution, collections of them didn't coordinate their tasks in any particular direction, which meant they couldn't perform useful work.

Stoddart and his colleagues have now gotten past that hurdle. As they reported in Science in December 2021, they immobilized a new breed of molecular pumps on the surface of solid particles made from materials known as metal organic frameworks. These particles have a Tinker Toy–like architecture that chemists can control at the atomic level. That made it possible for the researchers to graft their molecular pumps to these surfaces all in the same orientation.

The scientists then showed that by feeding their system a pair of chemicals, they could drive multiple rings onto each grafted thread, increasing their concentration there to a higher level than that of the rings floating in solution. Although the researchers haven't done anything yet with their minipumps, Stoddart says further tinkering could create teeny machines that pluck carbon dioxide molecules from the air to fight climate change, perhaps by pumping the gas across a membrane that allows it to be captured and sequestered.

Another stride toward making useful molecular pumps came this week, from David Leigh, a chemist at the University of Manchester, and his colleagues. He and his colleagues immobilized tiny machines on micrometer-size plastic beads. Then, like the Stoddart group, they showed that by repeatedly adding a pulse of a chemical fuel, they could thread multiple rings on rods attached to the beads.

Leigh's researchers used two different rings, which emitted green or blue light, and showed they could alternate the different colored rings on the rods, they reported on Monday in Nature Nanotechnology. One possible use: moving rings on and off threads in order to write and read data for high-density data storage, Leigh says. And if the team can pass chemicals from the rings to the inside of hollow beads, the tiny devices could suck toxins out of the blood stream.

In a final study, reported today in Nature, Leigh's team created a rotating motor that spins continuously as long as fuel is present. In this case, a chemical group called a pyrrole-2-carbonyl acts as a rotor that revolves above a stationary group called a phenyl-2-carbonyl. When no fuel is present, another group called a diacid that is attached to the rotor bumps into the stationary group, preventing rotation.

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A combination of two fuel molecules changes the configuration of the diacid, however, first eliminating the blockage, which allows the rotor to spin, and then restoring the blockage, ensuring the rotor can't spin backward. Additional pairs of fuel molecules spin it again. "Our motor will spin as long as fuel is present," Leigh says. Although it's not yet clear just what scientists will do with this 26-atom rotary motor, a larger biological analog uses rotational motion to generate adenosine triphosphate, the fuel used by cells to do work.

For now, the fuel-driven rotor's spin isn't very fast, only making about three revolutions per day. But Leigh notes that chemists are still learning the rules for making molecular machines more efficient. The next big hurdle will be coordinating these machines to carry out useful tasks. That may even allow the work to pay for itself by, say, harvesting precious metal ions from the ocean for use in electronics and chemical manufacturing. When chemists learn how to coordinate this type of practical work, "it will be a game changer," Leigh says.

Science, 6 April 2022

https://science.org

Climate change: greener lifestyles linked to greater happiness – in both rich and poor countries

2022-04-05

The idea that being green means sacrifice and going without was epitomised by Boris Johnson's denigration of the "hair shirt-wearing, tree-hugging, mung bean-eating eco freak". When the UK prime minister said that in 2020, the message was clear: a sustainable lifestyle may be worthy, but it represents a pretty dreary state of affairs.

Look at the evidence, though, and you'll find a different story. A wide range of research now shows there is a positive relationship between environmentally friendly behaviour and personal wellbeing. This may be because taking steps to protect the environment makes us feel good by fulfilling basic psychological needs, such as the sense that we are making a useful contribution to the world or acting on our own values and concerns.

The effect can run the other way too: people in a positive frame of mind are more likely to pay attention to the environment and to act in a manner which benefits more than just themselves. As it becomes ever clearer that a lifestyle geared towards consuming ever more energy and natural resources is not much good for the planet or our own wellbeing,

Regardless of how altruistic or materialistic people considered themselves to be, personal wellbeing rose by a similar degree as a result of behaving in a more environmentally friendly manner.

there is the tantalising prospect that people could instead live better by consuming less.

A landmark report from the Intergovernmental Panel on Climate Change (IPCC) warns that abandoning fossil fuels and the high-emission lifestyles they afford must begin immediately. The good news is that there may be a lot more gained than lost in the process than people realise.

Good for you, good for the planet

In recently published research, I and academic colleagues scrutinised the relationship between environmentally friendly action and subjective wellbeing (essentially, how happy a person is). We wanted to find out whether simultaneously greener and happier lives were only possible in wealthier countries, or for people in them who are more well-off. Perhaps the opportunity to feel good about your green choices is a privilege that only certain people can access or afford.

This has been unclear to date. Though research on this topic has been carried out in several different parts of the world, including China, Mexico and the UK, the majority of studies have covered the lives of people in the affluent global north.

Our study used survey data collected from nearly 7,000 people across seven countries: Brazil, China, Denmark, India, Poland, South Africa and the UK. We found that, regardless of the country in which people lived, as their commitment to environmentally friendly action increased – for example, by reducing food waste, buying greener products, donating money to environmental campaigns or getting involved in conservation work – so too did their subjective wellbeing. This effect held across all seven of the countries we investigated – from Denmark, ranked 11th in the UN's Human Development Index, to India, ranked 130th.

At the personal level, the connection between green behaviour and wellbeing was as pronounced for those on lower incomes as those in higher income brackets. We also found that, regardless of how altruistic or materialistic people considered themselves to be, personal wellbeing rose by a similar degree as a result of behaving in a more environmentally friendly manner. Whether or not you are an avowed "tree hugger" seems to make little difference.

We did find that this connection between behaviour and wellbeing varies across cultures, however. In places typically considered to be have a more collectivist social organisation and way of seeing the world – in our study,

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Brazil and China – we found that environmentally beneficial actions which engaged multiple people at once, such as planting trees together, had a particularly profound effect on wellbeing. This effect was not seen in the more individualistic societies we examined, like the UK and Denmark.

Accentuate the positives

Our findings suggest that there's a consistent relationship between environmentally friendly action and personal wellbeing which spans different parts of the world and holds true for a range of personal circumstances and outlooks. Just as a low-carbon diet tends also to be healthier, and cycling and walking gets us exercising as well as cutting emissions, our study adds to evidence that links green behaviour with a better quality of life.

To be clear, our research didn't seek to compare green behaviours to any other kinds of activities. The chicken and egg question is also not fully answered by the study. It may be that higher wellbeing drives green behaviour as much as the reverse holds true. But in either case, it is fair to say our results show environmentally friendly people tend also to be happier.

This should be good news for campaigners and policymakers alike. Rather than assume that doing the right thing for the environment needs to be a burden, we should be finding ways to stress the positive potential. Improving wellbeing and addressing the climate crisis can be both cost-effective and socially appealing. Initiatives and campaigns designed to promote environmentally friendly behaviour would do well to stress the value of action for both people and planet.

The Conversation, 5 April 2022

https://theconversation.com

Do insects, octopus and other invertebrates feel emotions? Evidence is building that they can

2022-04-02

Up until the mid-1980s, human babies didn't feel pain.

Of course, that's not actually true, but due to research conducted in the 18th and early 19th centuries, it was an attitude that still lingered among a small minority of scientists and medical professionals.

So much so that some infant surgery was still conducted without, or with very little, anaesthesia in the US into the '80s.

Today, the question of physical and emotional experience has moved beyond humans to animals, including invertebrates like insects, crabs and octopus.

And it's not just the feeling of pain that is being debated, but the whole spectrum of emotional experience: stress, joy, apprehension, even pleasure.

"Given the growing number of studies finding markers of emotions in animals, we've reached a tipping point," philosopher Kristin Andrews tells the ABC.

"Science is generating more and more reasons to accept animals' emotions, without finding any new reasons to deny them."

Professor Andrews is a research chair in animal minds at the University of York in Canada.

Alongside biologist and primate behaviour expert Frans der Waal, Professor Andrews argues in a recent issue of Science that the weight of evidence says many invertebrates experience what we might call emotions, and that this morally matters.

"If they can no longer be considered immune to pain, invertebrate experiences will need to become part of our species' moral landscape," they wrote.

So what is some of the evidence that points to invertebrate sentience? And if we accept that some invertebrates experience emotions and pain, how should this change how we interact with them?

Are shaken bees stirred?

"Science is generating more and more reasons to accept animals' emotions, without finding any new reasons to deny them."

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Similar to the example of babies and pain, scientifically quantifying the emotional experience of animals is difficult because they can't tell us what they feel.

But we may be able to infer the emotional state of animals by how they respond to things.

In humans, negative emotions are correlated with "pessimistic cognitive biases" — basically when we're in a bad frame of mind, we tend to expect things to not go well for us.

An experiment where honey bees were shaken for 60 seconds to simulate a predatory attack found the bees' equivalent of blood — called haemolymph — was lower in dopamine and serotonin after shaking, compared with bees that weren't shaken.

Both dopamine and serotonin are involved in mood regulation in humans.

But more than that, the shaken bees seemed to be less optimistic about their chance of getting a treat.

At the beginning of the experiment, the bees were conditioned to recognise a reward — a sugary liquid — and a punishment in the form of a bitter quinine solution.

After shaking, the bees were then offered mixtures made of different ratios of quinine and sugar liquid, including a half-half mix.

The bees that hadn't been shaken were significantly more likely to extend their proboscis to taste the half-half mix than those that had.

The inference was that "negative cognitive bias" in the shaken bees meant they were more likely to presume the borderline mixture was the punishment mixture, whereas the unshaken bees presumed the opposite.

The bees' behaviour has "more in common with that of vertebrates than previously thought", the authors of that study wrote at the time.

If a similar response was measured in humans, we'd have no doubt that emotions were involved, Professors Andrews and der Waal argue.

"In any mammal, a pessimistic behavioural response associated with physiological indications of stress would be taken as a sign of negative emotions," they say.

"The same logic should be applied to insects."

Laughing rats 'solicit' tickles

Similar studies in birds and mammals have also produced the same kind of responses.

And though not invertebrates, research into rodents has found a whole host of behaviours that point to emotions beyond simple reflexive responses.

A 2016 study found prairie voles display "consolation behaviour" — increased grooming of partners suffering distress — but that they don't elicit the same behaviour for unfamiliar voles in distress.

And research from the 1990s found rats at play emitted distinctive chirping at a frequency of around 50 kilohertz, which scientist Jaak Panksepp argued was a primitive form of laughter.

Even more so than when playing, the researchers found the rats would chirp when subjected to "heterospecific cross-species handplay" — otherwise known as tickling.

This is some of the evidence that Professor Andrews says convinced her of broader animal sentience.

"I was struck by the late Jaak Panksepp's work on rat joy and laughter," she says.

"Rats solicit tickles from preferred researchers."

In addition to soliciting tickles, subsequent research found tickled rats showed behaviour patterns consistent with their having a more optimistic outlook than non-tickled rats.

Painful experience leads to behaviour change

Having also previously studied rat behaviour, US-based marine biologist and physiologist Robyn Crook has also been studying pain responses in octopus.

Last year, Dr Crook published research showing that octopus experience long-term pain, rather than just a simple reflexive withdrawal from damaging stimuli.

Her research also suggested an emotional component to their experience of pain.

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Octopus in multi-chambered tanks were injected in one arm with a dilute acid.

Following injection, they showed a significant and ongoing avoidance of the chamber in which they had been injected.

They also tended to the arm long after the acid was administered.

Those given analgesic drugs to numb the pain then showed a preference for the chamber where they were given the drug.

The argument is that there must be an emotional experience that goes along with the feeling of pain in order to produce long-term behavioural changes.

Without that experience to trigger the negative connotation between, in this case, the chamber and pain, there is no reason for the octopus to avoid the offending space in future.

Dr Crook's research also showed extensive grooming of the painful site, and she demonstrated a physical pathway for pain to be processed by octopus.

According to philosopher Peter Godfrey-Smith from the University of Sydney, whose research interests include the origins of consciousness, Dr Crook's paper has given us the best demonstration so far of pain in cephalopods.

"I think that's the best paper on octopus pain ever — there are so many lines of evidence that point to pain in there," Professor Godfrey-Smith says.

Pain research 'opens door' to other emotions

In terms of pain alone, late last year the evidence was deemed strong enough by the UK parliament that some invertebrates are now recognised as sentient, with rights to humane treatment under their Animal Welfare Bill.

A large scientific review to inform the Bill conducted by researchers from the London School of Economics overwhelmingly found that the literature points to cephalopod molluscs — like octopus, cuttlefish and squid — and decapod crustaceans — lobsters, crabs, prawns and the like — being capable in varying degrees of experiencing pain and pleasure.

The researchers scored the animals against eight criteria to come up with their findings.

These included the possession of receptors (nociceptors) sensitive to a noxious stimulus, integrative brain regions capable of processing that sensory information, neural pathways to connect those nociceptors to the critical brain regions, and response to analgesic or anaesthetic.

Perhaps unsurprisingly, they found the strongest evidence for sentience in octopus, but crabs, crayfish and cuttlefish also scored highly.

Professor Godfrey-Smith says those animals were the right place to start in terms of broadening the scope of sentience.

"They chose cephalopods and crustaceans as the central cases to think about, and I think that was the right move," he says.

So what about other invertebrates? They were beyond the scope of the parliament's commissioned study, but Professor Andrews says studying pain tends to be where research into emotion begins.

"We need more research on positive emotions in invertebrates," she says.

"It seems that the research starts with pain, and once pain is established, it opens the door to study other emotions."

How should our behaviour change?

It's worth stating first off that this issue is not entirely settled and there's still a lot of room for scientific debate, Professor Godfrey-Smith says.

"None of this is for sure," he says.

"There are plenty of people who would disagree; there are qualified people who still don't think fish feel pain."

But if we do get to a point where we recognise that invertebrates are capable of emotional experiences, how, if at all, should that change our behaviour and laws?

First, it would mean that our own animal welfare laws, which already include vertebrates, would need broadening.

But the specifics are up for debate.

In the UK for instance, it was a recommendation of the review into the sentience of crustaceans and cephalopods that "boiling alive, slowly raising the temperature of water, tailing (separation of the abdomen from the thorax, or separation of the head from the thorax), any other form

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of live dismemberment, and freshwater immersion (osmotic shock)" be banned where other more humane killing methods are available.

But what about their treatment before being dispatched? Is it ethical to keep sentient creatures in small tanks, for example?

There are no blanket rules, according to Professor Andrews.

"We should be including invertebrates in animal protection schemes," she says.

"This doesn't mean that we would treat worms like we treat ravens, though."

Instead, these things will have to evolve as the science continues to catch up.

"Until we know more about animal emotions, we don't know what their interests are," Professor Andrews says.

"Even once we know that, we can't automatically infer anything about how to treat animals.

"The specific ethical conclusions about how to treat animals will come from a collaboration between scientists and philosophers."

And what about our own interactions? Does this mean we should think twice before squashing a mosquito, for instance?

Professor Godfrey-Smith says once we get beyond cephalopods and crustaceans, things start to get a bit murky.

"It would be so massive a shift to think that all the countless insects that are subject to pest control are sentient," he says.

"I don't think the case is nearly as strong for changing our behaviour toward them as octopus and crustaceans."

Professor Andrews also doesn't think considering a few more animals sentient will have life-changing implications for most of us.

"It's interesting to me that so many journalists are assuming (or think readers are assuming) that if we decide an animal is sentient, then we can't kill that animal," she says.

"The laws are about how to house sentient animals in a way that respects their needs, and to kill them humanely."

ABC News, 2 April 2022

https://abc.net.au

How do planets form? A 'baby Jupiter' hundreds of light-years away offers new clues

2022-04-04

How do planets form? For many years scientists thought they understood this process by studying the one example we had access to: our own Solar System.

However, the discovery of planets around distant stars in the 1990s made it clear that the picture was much more complicated than we knew.

In new research, we have spotted a hot, Jupiter-like gas giant in the process of forming around a star about 500 light-years from Earth.

This rare babysnap of a planet actually in the process of forming, drawing down matter from a vast disk of dust and gas swirling around its also-infant sun, has opened a window on mysteries that have puzzled astronomers for years.

A scientific triumph?

Scientific inquiry into the origins of Earth and the other planets of our Solar System began in the mid 1700s.

Building on the work of Swedish thinker Emanuel Swedenborg, the famous German philosopher Immanuel Kant proposed that the Sun and its little planetary family all grew from a large rotating primordial cloud; Kant labelled this an "Urnebel", German for nebula.

This idea was later refined by the French polymath Pierre Laplace, and it has since had many more additions and revisions, but modern scientists think it was basically on the right track. The modern descendent of Kant's hypothesis, now filled out with detailed physics, can explain most of the observed features of our solar system.

We can now run computer simulations with all the right settings, and a beautiful digital replica of our solar system will emerge. It will have the right kinds of planets in the right orbits ticking around in clockwork order, just like the real thing.

In new research, we have spotted a hot, Jupiter-like gas giant in the process of forming around a star about 500 light-years from Earth.

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This model is a triumphant synthesis of threads from geology, chemistry, physics and astronomy, and it seemed to have the bases covered. Until, that is, astronomers confronted it with planets from outside our solar system.

Beyond the Solar System

When the first systems of planets orbiting distant stars were discovered in the mid 1990s, there was immediate controversy and consternation. The new planets didn't fit the model at all: the rest of the cosmos, it turned out, didn't care so much what happened here around our little sun.

Since then, there has been a dawning realisation that there may be different pathways to form a planetary system. Among the thousands of planets orbiting other stars that now populate our catalogues, our Sun's family of planets is even beginning to look a bit unusual.

Despite this, one of the most basic physical components of the planet-building machinery we believe is responsible for forming giant gassy planets like Jupiter and Saturn has stood the test of time: the idea of "core accretion".

Core accretion starts with the gases and microscopic dust grains thought to comprise Kant's typical primordial cloud (which is shaped like a flattened spinning disk with the infant star at the center). Dust grains clump together into successively bigger grains, then pebbles, rocks and on up in a cascade to baby planets or "planetesimals".

When such a clump gets big enough, it reaches a tipping point. Gravitational attraction now helps the embryonic planet rapidly draw in gas, dust and other clumps, clearing its orbital path and carving a circular gap in the disk.

It is one of the signature triumphs for modern astronomy that exactly the kinds of "disk gaps" predicted by theory are now seen and studied out in the cosmos.

A big crunch

However, there are some things core accretion can't explain. Massive planets have been spotted orbiting far from their host stars, out in the cold distant reaches.

According to the core accretion theory, such planets should not exist. They are too far out, where orbits move too slowly to run the business of planet-building.

A new "gravitational collapse" model was formulated to explain these unexpected massive distant planets. The basic idea is that if the primordial disk itself has enough mass, the whole thing can become unstable and collapse to form planets quickly in a big crunch.

This new picture seemed like it could explain the outlier planets, but since all known examples were very old (usually billions of years) this theory has remained just that – a theory. Until now.

A planet is born

Last year, we and our colleagues spotted a massive planet, still in the process of formation, around a star some 500 light-years from Earth.

This star, named AB Aurigae, has become famous in astronomy circles for the beautiful, intricate, spiral disk that surrounds it.

The clumps and waves seen in this disk (and in others like it) are consistent with what one might see if gravitational collapse were occurring. But until now, evidence of a forming planet was missing.

This newly discovered planet – dubbed AB Aurigae b – is embedded within a thick, swirling halo of dust and gas, amid the tell-tale spirals and waves signifying gravitational collapse. The planet is around 93 times as far from its star as Earth is from the Sun, well outside the region in which the traditional core-accretion theory could explain its formation.

This discovery thus provides strong evidence for the alternative theory of gravitational collapse.

The discovery was made using observations from the Subaru Telescope at Mauna Kea, Hawai' i, as well as from the Hubble Space Telescope.

Stoked by energy from the violent, rapid formation process, the planet is hot enough to glow (around 2000 '). It is this glow that gives away the presence of the planet. At the same time, the swirling gas and dust around the forming planet is seen illuminated by the blueish light of AB Aurigae's central star.

Bigger and better telescopes

This new discovery provides a critical piece of the planet formation puzzle, but the case is by no means closed.

As our telescopes get bigger and our observational methods get more advanced, we expect to see many more forming planets caught at all

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stages of their development, as well as fully-formed mature planets like Earth.

And eventually, we can hope to answer the big questions: how did such a weird and diverse range of planetary systems form across the galaxy, what are the conditions like on these new worlds, and how does our own little Solar System fit in among them?

The Conversation, 4 April 2022

https://theconversation.com

Why do some people not catch COVID-19, despite exposure? Scientists are trying to solve the puzzle

2022-04-03

When Vanessa Bryant recently managed to dodge COVID-19 despite the rest of her young family getting infected, she felt fortunate — but not entirely surprised.

"As an immunologist, I know there's a bit of luck to it," said Dr Bryant, who leads the Immunogenetics Research Laboratory at the Walter and Eliza Hall Institute of Medical Research in Melbourne.

"We joke that I'm invincible, but of course, that's not true at all."

Dr Bryant had been boosted just 10 weeks earlier and her family took precautions against getting the virus.

But her experience is not uncommon, even among people who are much less protected — even unvaccinated.

Scientists, including Dr Bryant, want to know why.

"What we're really interested in, if people have a known exposure and they're asymptomatic or they don't test positive, is: what's special about their immune system?" she said.

Dr Bryant is part of an Australian research team investigating how COVID-19 spreads in households, and why some people — like herself — don't test positive at all.

"We can gain a lot of knowledge from the people who are resistant genetically and immunologically," she said.

"Obviously, that's going to have implications for understanding the critical components that are necessary for COVID-19 protection.

"If people have a known exposure and they're asymptom-atic or they don't test positive, is: what's special about their immune system?"

"It's also going to really pinpoint the essential therapeutic targets for [the treatment of] other people."

COVID-19 immunity is influenced by multiple factors

At the beginning of the pandemic, scientists focused intensely on understanding what makes people more vulnerable to severe COVID-19 — which we've since learnt includes factors like old age, underlying health conditions, and obesity.

These days, an increasing amount of research is being devoted to the other side of the coin: why do some people seem to never get sick?

"Everyone's immune system is slightly different," Dr Bryant said.

"Some people might generate an immune response that just makes better antibodies … and we do think this is largely genetic."

Vaccination, of course, is an essential tool in our armour against COVID-19, and the most sure-fire way to protect yourself from becoming unwell.

"If you've just recently completed your vaccination and had a boost, you're going to have the highest immunological protection," Dr Bryant said.

"That's when you've got lots of circulating protective antibodies … that can really mop up and neutralise the virus before it has a chance to even infect cells."

But the effectiveness of COVID-19 vaccines wanes over time, most notably against infection and symptomatic disease.

The speed at which this happens — and when a person might become vulnerable to a breakthrough infection — depends on the vaccine, the variant and the individual.

"We can sort of generalise and say what that [waning] looks like at the community level, but when you home in on the individual level, it's really highly variable," Dr Bryant said.

When considering why someone might not have tested positive for COVID-19, it's also important to look at how likely it is they were exposed, and the nature of that exposure.

Immunologist Stuart Tangye from the Garvan Institute of Medical Research said the length and location of virus exposure were important, as well as potential viral load.

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"Being outside is one big environmental factor that mitigates person-to-person transmission, in addition to all the sanitation, mask-wearing, and social distancing," Professor Tangye said.

Previous infection can play a role

Adding to that complex picture of individual protection and risk is the possibility of previous infection.

Professor Tangye said it was likely that many Australians had been infected with COVID-19 without realising it.

"When we first started doing PCR testing, it was really done on symptomatic people … so we were obviously missing a lot of those asymptomatic people," Professor Tangye said.

"I'm sure we missed a lot of positive cases over December and January too, where there was a supply and demand problem in terms of getting tests."

The sensitivity of rapid antigen tests, which many of us now use to diagnose COVID-19, is not as high as PCRs — another factor in why some cases were likely missed.

It's not just previous COVID-19 infections that might impact levels of immunity, either.

Research has found that people with higher levels of memory T-cells from other coronavirus infections — i.e., those responsible for common colds — were less likely to become infected with SARS-CoV-2.

"Studies have shown a certain amount of cross-reactivity with other seasonal coronaviruses … so there is possibly some pre-existing immunity that's effective against SARS-CoV-2 infection," Professor Tangye said.

But it's not clear why some individuals maintain a level of cross-reactive immunity, while others don't.

Do some people have an innate advantage?

Putting aside environmental factors and protection induced by vaccination (and previous infection), experts say there may be particular genetic and immunological features that mean some people are naturally more resistant to COVID-19.

Earlier this year, UK researchers deliberately exposed a group of 36 young, healthy individuals — with no evidence of previous infection or

vaccination — to COVID-19, in what's known as a human-challenge trial (the first of its kind for SARS-CoV-2).

According to their preliminary findings, only half of the volunteers actually became infected with the virus (defined as two consecutive positive PCR tests).

Of those who didn't develop an infection, around half briefly tested positive for low levels of the virus, suggesting their immune system rapidly shut the infection down.

"The immune system might be tuned up a little bit … it just sort of gets revved up and goes quite effectively, quite efficiently, very early," Professor Tangye said.

"There's probably a few people like that, who would have a really strong innate immune response [that] just quells the infection, without enabling the virus to get too far ahead."

But Professor Tangye said there was likely to be an even smaller group of people who carry a genetic resistance to SARS-CoV-2 that stops the virus from gaining a foothold altogether.

"There are going to be people who are less susceptible to viral infection because they have differences in their genes, such as genes that are important for viral entry into your cells."

He said the notion of genetic resistance to infectious diseases was not without precedent.

"With HIV, for example, there is a very, very small number of people who are genetically resistant to infection," Professor Tangye said.

"That's because they have naturally occurring genetic mutations in a certain gene so the virus can't physically infect their T cells."

Viruses on their own are pretty useless — they need to hijack the cellular machinery of their host in order to replicate.

"In the case of HIV, that's a T cell, but they physically can't find the door to knock on and sneak in."

While Professor Tangye said genetic resistance to COVID-19 was likely rare overall, researchers hoped that identifying key genetic changes in people who are resistant could lead to the development of more effective drug therapies.

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He is part of an international consortium of experts called the COVID Human Genetic Effort, who are seeking to understand the genetic and immunological factors that influence SARS-CoV-2 infections.

It will study hundreds of unvaccinated people who had not yet had the virus, but were exposed to a COVID-positive person over an extended period of time — and still didn't test positive or mount an immune response.

Some preliminary research has shown rare mutations thought to affect the body's ACE2 receptors — essential for the virus slipping into our cells — may influence susceptibility to COVID-19.

"[Researchers] are finding changes at the genetic level [that] are altering the structure of the ACE2 protein … so the ability for SARS-CoV-2 to use it as an entry into the cell is reduced," Professor Tangye said.

Solving genetic and immunological mysteries

Dr Bryant said research previously done by the COVID Human Genetic Project on why some people were — conversely — genetically susceptible to severe disease had already led to improved understanding and treatments.

In 2021, researchers discovered that individuals with genetic mutations that disrupt the activity of proteins critical to fighting off viral infections — called type 1 interferons — have a higher risk of life-threatening disease.

Similarly, a significant proportion of people with severe COVID-19 were found to have "autoantibodies" that attack and block their own type 1 interferons.

"We can now look at elements in this particular pathway or related pathways and say: do some people have enhanced immunity here? And if so, what is it? What aspects of it are enhanced and why?" Dr Bryant said.

"If we can understand that, that will be transformative in the way we develop therapeutics to combat disease."

In addition to solving some of COVID-19's genetic mysteries, Dr Bryant said it was important to understand more about the "underlying immunological responses" to COVID-19, including how these change over time.

"We know comorbidities are important, we know age is important, we know neutralising antibodies are important. But they're just one part of the story," she said.

"We've also got our cellular memory — our memory T cells and memory B cells. These are typically long-lived cells.

"They're harder to measure … but are something we really need to understand."

Having a more complete picture of the immunological response, she added, would help researchers understand what factors were important for strong protection, and why some people could be left vulnerable.

"We can then use that information to inform public health responses on issues such as the frequency of boosters."

ABC News, 3 April 2022

https://abc.net.au

The secret to better coffee? The birds and the bees

2022-04-04

A groundbreaking new study finds that coffee beans are bigger and more plentiful when birds and bees team up to protect and pollinate coffee plants.

Without these winged helpers, some traveling thousands of miles, coffee farmers would see a 25% drop in crop yields, a loss of roughly $1,066 per hectare of coffee.

That's important for the $26 billion coffee industry—including consumers, farmers, and corporations who depend on nature's unpaid labor for their morning buzz—but the research has even broader implications.

The forthcoming study in the Proceedings of the National Academy of Sciences is the first to show, using real-world experiments at 30 coffee farms, that the contributions of nature—in this case, bee pollination and pest control by birds—are larger combined than their individual contributions.

"Until now, researchers have typically calculated the benefits of nature separately, and then simply added them up," says lead author Alejandra Martínez-Salinas of the Tropical Agricultural Research and Higher Education Center (CATIE). "But nature is an interacting system, full of

The key characters in this love story? A bee (euglossa heterosticta), a coffee plant, and a bird (rufous capped warbler).

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important synergies and trade-offs. We show the ecological and economic importance of these interactions, in one of the first experiments at realistic scales in actual farms."

"These results suggest that past assessments of individual ecological services—including major global efforts like IPBES—may actually underestimate the benefits biodiversity provides to agriculture and human wellbeing," says Taylor Ricketts of the University of Vermont's Gund Institute for Environment. "These positive interactions mean ecosystem services are more valuable together than separately."

For the experiment, researchers from Latin America and the U.S. manipulated coffee plants across 30 farms, excluding birds and bees with a combination of large nets and small lace bags. They tested for four key scenarios: bird activity alone (pest control), bee activity alone (pollination), no bird and bee activity at all, and finally, a natural environment, where bees and birds were free to pollinate and eat insects like the coffee berry borer, one of the most damaging pests affecting coffee production worldwide.

The combined positive effects of birds and bees on fruit set, fruit weight, and fruit uniformity—key factors in quality and price—were greater than their individual effects, the study shows. Without birds and bees, the average yield declined nearly 25%, valued at roughly $1,066 per hectare.

"One important reason we measure these contributions is to help protect and conserve the many species that we depend on, and sometimes take for granted," says Natalia Aristizábal, a Ph.D. candidate at UVM's Gund Institute for Environment and Rubenstein School of Environment and Natural Resources. "Birds, bees, and millions of other species support our lives and livelihoods, but face threats like habitat destruction and climate change."

One of the most surprising aspects of the study was that many birds providing pest control to coffee plants in Costa Rica had migrated thousands of miles from Canada and the U.S., including Vermont, where the UVM team is based. The team is also studying how changing farm landscapes impact birds' and bees' ability to deliver benefits to coffee production. They are supported by the U.S. Fish and Wildlife Service through the Neotropical Migratory Bird Conservation Act.

In addition to Martínez-Salinas (Nicaragua), Ricketts (U.S.), Aristizábal (Colombia), the international research team from CATIE included Adina

Chain-Guadarrama (México), Sergio Vilchez Mendoza (Nicaragua), and Rolando Cerda (Bolivia).

Phys Org, 4 April 2022

https://phys.org

What's the longest lightning bolt ever recorded?

2022-04-04

"Thunder is impressive," Mark Twain wrote, "but it is lightning that does the work." Anyone who's watched a lightning storm will understand what he meant: Lightning is one of nature's most awe-inspiring phenomena, illuminating the skies with its fearsome forks.

According to the U.K. Met Office, lightning strikes the planet up to 1.4 billion times a year, or an estimated 44 times every second. And it's more than just a light show: Lightning plays a critical role in keeping Earth's electrical balance in check; aids in fixing nitrogen, thereby helping plants grow; and potentially even helps to clear the atmosphere of pollutants.

But some lightning strikes work harder than others. While most lightning flashes measure 2 to 3 miles (3.2 to 4.8 kilometers) in length, some truly colossal bolts occasionally crackle above our heads, forking their way across hundreds of miles of sky. But how big can lightning actually get? And should we be worried about these gigantic bolts?

How lightning is made

Lightning arises in storm clouds when strong positive charge develops in one region of the cloud and strong negative charge develops in another, creating electrical forces between them.

"A lightning flash is initiated in a region where the electrical forces are extremely strong," said Don MacGorman, a physicist and senior researcher at the National Oceanic and Atmospheric Administration's (NOAA) National Severe Storms Laboratory in Oklahoma. "They become strong enough that the air can't withstand the electrical force anymore and breaks down."

That means that, as the electric force grows, it breaks down the air's insulating power, which usually keeps areas of different charge separated from each other. Researchers think this occurs because the buildup of the excessive electrical force starts to accelerate "free" electrons — those not attached to an atom or a molecule — in the air, in turn knocking other

According to the U.K. Met Office, lightning strikes the planet up to 1.4 billion times a year, or an estimated 44 times every second.

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electrons loose from their atoms and molecules, MacGorman said. This process continues, accelerating more and more electrons. "Scientists call this process an electron avalanche, and it's what we mean when we say the air breaks down," MacGorman told Live Science.

This eventually creates a very hot channel in the air that acts like a wire, whose ends grow outward toward the positive and negative charges that caused the breakdown. The growing channel eventually connects the positive and negative charges, and when it does, it triggers the immense electric current we know as a lightning flash.

"Think of it as a giant spark that has grown through the cloud," MacGorman said.

Sometimes, the lower region of a cloud, which usually contains positive charge, does not have enough charge on its own to stop the channel. So the lightning bolt continues growing, stretching downward toward the ground. As it does so, it draws an upward spark from the ground to meet it, triggering a lightning flash with huge electric currents that transport some of the storm's charge to the ground. These cloud-to-ground channels are what most of us commonly picture when we think of lightning — those vivid forks that strike Earth.

The cloud's the limit

But what factors limit the size of these massive bolts? Researchers have been trying to answer this question for decades. Vertically, the extent of a flash is limited by the height of a storm cloud, or the distance from the ground to its pinnacle, which is about 12 miles (20 km) at its highest.

But horizontally, an extensive cloud system provides much more room to play with. This is where the heavyweights work their magic.

Back in 1956, Myron Ligda, a meteorologist in Texas, used radar to detect a flash spanning more than 100 miles (160 km). At the time, it was recognised as the longest lightning flash ever recorded. Since then, advancements in technology have allowed researchers to measure much larger flashes, and more of them.

In 2007, researchers identified a bolt over Oklahoma that measured 200 miles (322 km) long. But only a decade later, that record was obliterated: In October 2017, clouds above the Midwest released a flash of lightning so huge that it illuminated the skies above Texas, Oklahoma and Kansas. Spanning more than 310 miles (500 km) across the three states, the jolt was so unprecedented that a group of researchers published a study

about it in the journal Bulletin of the American Meteorological Society, describing it as a "megaflash." It was one of the largest lightning flashes ever recorded.

But even that flash has been surpassed. Auspiciously, on Halloween 2018, a lightning bolt over Brazil was later revealed to have spanned more than 440 miles (709 km). Keeping meteorologists on their toes, the skies broke that record by releasing another behemoth on April 29, 2020 — a megaflash that stretched from Texas to Mississippi, covering 477 miles (768 km).

While lightning has traditionally been observed from ground-based systems such as antennae and radar, many of these record-breaking flashes are now recorded using satellites. One of these, called the Geostationary Lightning Mapper, made up of sensors on two satellites orbiting Earth, helped reveal the enormous extent of the lightning flash in October 2017, said MacGorman, who is an author of a study about this former record-breaking flash. "That system responds to the light emitted from a cloud top, so we see the light from the lightning flashes and can then map it, pretty much all over this hemisphere," MacGorman said.

The making of giants

But even with these exciting visual insights, researchers still aren't sure about the precise mechanics that underpin such lengthy electrical illuminations. Cloud size is almost certainly a factor; also required, MacGorman said, are certain "mesoscale processes — large scale wind flows that enable that system to be tied together to persist for a long time."

With the stage set by these monster clouds, what's actually happening within them? "These megaflashes appear to be like a continuous sequence of discharges in very close succession," said Christopher Emersic, a research fellow who studies thunderstorm electrification at the University of Manchester in the U.K.

He hypothesizes that if a cloud system is highly charged across a large area, a series of discharges can propagate through it like a line of falling dominoes. "If dominoes are all set up without too big a gap, one triggers another in a large series of topples," Emersic told Live Science. "Otherwise, it 'fails,' and in this case, you'll get only a smaller spatial lightning event rather than a megaflash."

The larger the parent cloud, the more opportunity there is for the discharge to continue propagating — "hence why megaflashes could, in

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principle, be as large as the parent cloud, should the charge structure be conducive," Emersic said.

That also means there are likely much bigger flashes out there than we've already seen. "Storms can get larger than [the ones we've measured from]," MacGorman said.

Paired with more sophisticated detection tools, this makes it likely that lightning hunters will go on to find even larger bolts that break current records and increase our awareness of these immense natural feats.

Despite the apocalyptic picture they paint, megaflashes aren't necessarily more dangerous than regular lightning. "A spatially extensive flash doesn't necessarily mean it carries more energy," Emersic said.

Because the cloud systems from which they originate are so vast, however, megaflash strikes can be difficult to predict. "Such events can often lead to ground strikes far away from the main lightning activity in the convective core," Emersic said. "Someone on the ground could think the storm has passed but be caught by surprise by one of these spatially extensive discharges seemingly from nowhere."

It's also possible that in a warming world, there might be an uptick in the types of storms that give rise to megaflashes, Emersic said. "And so, indirectly, that can make the conditions more likely, thereby increasing their frequency."

For now, though, megaflashes aren't that common; MacGorman estimates that they make up only about 1% of lightning flashes overall. Nevertheless, researchers like him will go on hunting — and, no doubt, discovering — even bigger behemoths for us to marvel at.

Live Science, 4 April 2022

https://livescience.com

Fatigue after COVID is way more than just feeling tired. 5 tips on what to do about it

2022-04-06

People are often surprised by how fatigued they are during a COVID infection.

One review of 21 studies found 13-33% of people were fatigued 16-20 weeks after their symptoms started. This is a worryingly widespread problem.

Fatigue is more than being worn out or sleepy. It's an excessive tiredness that persists despite resting or good sleep. It's likely a result of our body's strong immune response to the virus.

But in some people the fatigue drags on even when the infection is gone. This can be debilitating and frustrating. Simply resting more makes no difference.

Here's what we know about post-COVID fatigue, and what can help.

Fatigue or tiredness? What's the difference?

The term fatigue can mean different things to different people. Some people mean their muscles are easily weakened. Walking to the mailbox feels like they have run a marathon. Others describe a generalised exhaustion, whether they are moving or not. People can experience physical, mental or emotional fatigue, or any combination of these.

The difference between tiredness and fatigue is this: tiredness can get better with enough rest, while fatigue persists even if someone is sleeping and resting more than ever.

How big a problem is this?

Because there is no agreed definition of post-COVID fatigue, it is impossible to give exact numbers of how many people experience it.

Estimates vary considerably worldwide. One review of 21 studies found 13-33% of people were fatigued 16-20 weeks after their symptoms started. This is a worryingly widespread problem.

When should I see my GP?

There are many potential causes of fatigue. Even before the pandemic, fatigue was one of the most common reasons to see a GP.

Most serious causes can be ruled out when your GP asks about your symptoms and examines you. Sometimes your GP will investigate further, perhaps by ordering blood tests.

Symptoms that should raise particular concern include fevers, unexplained weight loss, unusual bleeding or bruising, pain (anywhere) that wakes you from sleep, or drenching night sweats.

If your fatigue is getting worse rather than better, or you cannot care for yourself properly, you really should seek medical care.

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Is it like long COVID?

Early in the pandemic, we realised some patients had a cluster of debilitating symptoms that dragged on for months, which we now call long COVID.

Some 85% of long COVID patients experience fatigue, making it one of the most common long COVID symptoms.

However, people with long COVID have a range of other symptoms, such as "brain fog", headaches and muscle aches. Patients with long COVID therefore experience more than fatigue, and sometimes don't have fatigue at all.

Is this like chronic fatigue syndrome?

We knew about chronic fatigue syndrome, otherwise known as myalgic encephalomyelitis, well before COVID.

This often develops after a viral infection (for instance after infection with Epstein-Barr virus). So, understandably, there has been concern around the coronavirus potentially triggering chronic fatigue syndrome.

There are striking similarities between chronic fatigue syndrome and long COVID. Both involve debilitating fatigue, brain fog and/or muscle aches.

But at this stage, researchers are still untangling any link between post-COVID fatigue, long COVID and chronic fatigue syndrome.

For now, we know many people will have post-COVID fatigue but thankfully do not go on to develop long COVID or chronic fatigue syndrome.

What helps me manage my fatigue?

Expect you or a loved one may develop post-COVID fatigue, regardless of how unwell you or they were during the actual infection.

Vaccines help reduce the risk of post-COVID fatigue by lowering the chance of catching COVID in the first place. Vaccinated people who do catch COVID are less likely to report fatigue and are less likely to develop long COVID.

However, vaccination is not 100% protective and there are plenty of fully vaccinated people who go on to develop longer term fatigue.

The evidence for what helps you recover from post-COVID fatigue is in its infancy. However, a few things do help:

1. pace yourself: adjust the return to normal activities to your energy levels. Choose your priorities and focus on what you can do rather than what you can't

2. return to exercise gradually: a gradual return to exercise may help your recovery, but you may need some support about how to manage or avoid fatigue afterwards. Some therapists – occupational therapists, physiotherapists and exercise physiologists – specialise in this. So ask your GP for a recommendation

3. prioritise sleep: rather than feeling guilty about sleeping so much, remind yourself that while you sleep, your body conserves energy and heals. Disrupted sleep patterns are an unfortunate COVID symptom. Having a strict bedtime, while also resting when you feel tired during the day, is important

4. eat a range of nutritious foods: loss of smell, taste and appetite from COVID can make this tricky. However, try to view food as a way of fuelling your body with both energy and the micronutrients it needs to heal. Be careful not to spend a fortune on unproven "remedies" that often look good in small studies, but more robust research finds make little difference

5. monitor your fatigue: keep a diary to monitor your fatigue, and look for a gradual improvement. You will have good days and bad days, but overall there should be a slow trajectory towards recovery. If you are going backwards, get input from a health professional, such as your GP.

The Conversation, 6 April 2022

https://theconversation.com

'It's a thorny issue.' Why a fight over DNA data imperils a global conservation pact

2022-04-05

For conservation biologists, the highest item on the global agenda this year is persuading the world's nations to agree on new targets for saving nature. National leaders are scheduled to meet in China later this year to finalize a new strategic plan for the Convention on Biological Diversity (CBD), a 30-year-old global pact that sets decadal goals for preserving species and ecosystems. Last week, however, negotiators in Geneva reached an impasse. A major stumbling block is how the world should

A major stumbling block is how the world should share billions of bits of genetic data stored on computers around the world.

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share billions of bits of genetic data stored on computers around the world.

The debate over these data—known as digital sequence information (DSI)—is new, but it echoes a long-standing point of contention. Developing nations that are rich in biodiversity, such as those in the tropics, have argued that more developed nations have exploited their natural heritage for commercial gain—for example, by using plants collected in the tropics to develop new crops or drugs—without sharing any of the revenue or benefits. That irks many parties, because a main objective of the CBD is to use the conservation of biodiversity to promote prosperity by creating "green gold."

In 2010, CBD nations attempted to address equity concerns by adopting the Nagoya Protocol. It allows nations to create their own permits and processes for allowing outsiders to access their biodiversity, and it requires other signatories to enforce those rules. A related treaty for plants spells out how nations can exchange seeds, in return for sending a portion of any commercial revenues to a multilateral fund.

The Nagoya Protocol, however, did not address how nations should handle the genetic sequences and other genomic data that researchers can extract from organisms and place in digital databases. Developing nations fear such DSI has created a loophole: Companies could make use of organisms without needing to get physical samples, for example by downloading DNA sequences from a publicly available database and using them to engineer bacteria or other organisms. As a result, they would like to see new controls on how DSI can be used and shared.

Many scientists, meanwhile, have a different worry: that imposing new regulations on sharing DSI could hamper research and damage international collaboration in science. The Nagoya Protocol, they argue, has already complicated many kinds of field research while providing few clear benefits. And they fear new DSI rules could make things worse.

For insight into the issue, ScienceInsider spoke with Amber Hartman Scholz, a microbiologist and head of the science policy group at the Leibniz Institute DSMZ-German Collection of Microorganisms and Cell Cultures GmbH. Scholz, who attended the recent Geneva talks, is a founder of the DSI Scientific Network, an ad hoc collaboration that has been advocating for a science-friendly outcome to the DSI negotiations. In February, Scholz and colleagues published a proposal in Nature Communications on how nations can equitably share the benefits of

biodiversity genomics without hindering research. The interview has been edited for clarity and brevity.

Q: What's at stake for researchers in the DSI negotiations?

A: The power of being able to understand, through genetic sequence data, how life works at the molecular level really opens up incredible scientific opportunities. We basically have one global, open library of sequence data—the International Nucleotide Sequence Database Collaboration. Three identical databases, run by GenBank, the European Nucleotide Archive, and the DNA Data Bank of Japan, deliver data to 750 downstream sequence databases that are then further connected to another 1000 more specialized databases.

Now, some countries are asking for tracking and tracing of all individual sequences in the databases and for conditions that would prohibit open access. This would require tracking billions of data transactions for millions of users. We actually don't think there's a technical way to do this. But even if there was, you would spend so much money on the technology and the bureaucracy, you would never be in the black. You'd never be able to reap enough monetary benefits to make the system worth it.

In a worst-case scenario, those databases would be forced through new international law to be closed so that you'd have to pay for access. Or they would not contain all data anymore—they would only contain data from certain countries where access isn't regulated. If data in the core infrastructure is limited in its reusability, then downstream and interconnected databases get broken. It's like a domino effect: The whole system becomes more and more splintered. You could have, for example, Brazilian sequence data here and Indonesian data here and all these data islands not part of the open system.

There is a myth that only scientists in developed countries use DSI, and developing countries only provide access to their biodiversity. But scientists in developing countries are often overlooked in this debate. Their use of DSI, their ability to collaborate internationally, is much bigger than previously known and depends on the open, interconnected DSI system. In fact, a closed system for DSI will perversely impact scientists in developing countries the most.

What that means for the science is that our ability to solve global challenges becomes far more hampered. If researchers try to figure out how much genetic diversity is needed to save an endangered bird species in the tropics, they might have to examine sequences mainly from bird

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species from the global north, because the other information is caught up in databases that are not connected.

Q: How did the negotiations go in Geneva?

A: It's a thorny issue. There's been a lot of finger pointing over decades that the promise of "green gold" is not paying out. Now, some negotiating blocks are saying they are not going to agree to new conservation goals unless the issue of benefit sharing from DSI is resolved. This has been said informally for the past few years, but post-Geneva it's really on the record and in quite an extreme way. DSI is a bargaining chip.

The question becomes: Will politicians agree to shut down public databases or set up paywalls because the countries of the south are saying they're getting exploited? Or can the scientific community explain the value of open access and provide ideas for benefit sharing that don't hinge on controlling access to genomic data?

Q: What would a positive outcome look like?

A: The idea we recently proposed is to decouple access from benefit sharing. The open-access system stays more or less unchanged and monetary benefits are collected in a global multilateral fund. This could be funded, for example, by a 1% "biodiversity use fee"—a microcharge on biodiversity-based commercial products that would then be redistributed to pay for biodiversity and conservation projects. The best-case scenario is that the value of an open, interconnected global data set is recognized and perpetuated. For commercial entities, the new thing is that they would have to pay into a global fund, if they meet certain criteria. The details of that would be negotiated in the future.

The other thing that our Nature Communications article puts forth that is completely novel, and a bit wonky, is to give "credit" to countries for providing access to their biodiversity. Understandably, some nations want recognition that their biodiversity is being used; they take national pride in the fact that their biodiversity is important and interesting for science. We suggest that DSI databases report every year how much new sequence data is entered from each nation. Then countries that contribute more to the open system can be rewarded from this multilateral fund. We're proposing a bonus payment that recognizes and rewards access to their genetic resources. But we don't need a cryptographic, bureaucratic, expensive tracking and tracing system to do this.

Q: What will happen in China at the final negotiations? Do nations only need to agree on a general framework on DSI, with the details to be worked out later?

A: A number of northern countries are saying they will not agree to a new legally binding treaty for DSI. And some southern countries are saying they will not agree to new conservation targets without a deal on DSI. The unknown is how much political will there might be to get the conservation targets and how much the appetite for compromise on DSI could grow. That will likely be decided on the last night of COP 15 [the 15th meeting of the Conference of the Parties to the CBD] at 3 in the morning. That's why any deal could have a huge impact on researchers, because it boils down to a political horse trade. And horse trades, although a necessary evil for making big deals happen, are usually not shining examples of rational, evidence-based decision-making.

Q: Is there a way to lessen the risk that a midnight deal on DSI would hinder research?

A: The next step is an informal advisory process. The hope is that representatives from member nations will be able to narrow the policy options and exclude those that would be really destructive for science. Ideally, during these meetings, policymakers will thoughtfully weigh how scientists use the databases for the public good and even include scientists and database managers in the process, which was a contentious point during the Geneva discussions. The more scientists—especially scientists working in countries whose negotiators want DSI tracking and tracing or closed access—engage in the process, the better the outcome. We need to continue to explain how and why open access is important to us.

Q: What's the outlook?

A: My gut feeling is cautiously optimistic. The scientific community is more involved in this decision on DSI than it was, for example, in the development of the Nagoya Protocol. So, I do think that there's a better chance that we will have an outcome that's informed by science and compatible with it, too.

The grand irony is that the revolution spurred by genomics and bioinformatics is not only advancing commercial and applied research; it actually serves the process of setting and achieving conservation goals. Genomic-based technology is helping discover new mammal species through the use of eDNA [environmental DNA], for example; it's

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bringing species back from the brink of extinction through new measures of genetic diversity and breeding programs; and it's being used to measure ecosystem health and restoration. To solve some of these really big planetary problems, this same technology—that might get limited and undercut by a bad deal for DSI—is exactly the tool we need in our biodiversity toolkit. That's why I really hope that the scientific voice gets heard, and I'm optimistic that we're on the way.

Science, 5 April 2022

https://science.org

Remind me again, why is salt bad for you?

2022-04-07

Despite most of us knowing we should cut down on salt, Australians consume on average almost twice the recommended daily maximum per day.

Salt has been used in food preservation for centuries, and idioms like "worth your weight in salt" indicate how valuable it was for preserving food to ensure survival. Salt draws moisture out of foods, which limits bacterial growth that would otherwise spoil food and cause gastrointestinal illnesses. Today, salt is still added as a preservative, but it also improves the taste of foods.

Salt is a chemical compound made of sodium and chloride, and this is the main form in which we consume it in our diet. Of these two elements, it's the sodium we need to worry about.

So what does sodium do in our bodies?

The major concern of consuming too much sodium is the well-established link to the increased risk of high blood pressure (or hypertension). High blood pressure is in turn a risk factor for heart disease and stroke, a major cause of severe illness and death in Australia. High blood pressure is also a cause of kidney disease.

The exact processes that lead to high blood pressure from eating large amounts of sodium are not fully understood. However, we do know it's due to physiological changes that occur in the body to tightly control the body's fluid and sodium levels. This involves changes in how the kidneys, heart, nervous system and fluid-regulating hormones respond to increasing sodium levels in our body.

Maintaining tight control on sodium levels is necessary because sodium affects the membranes of all the individual cells in your body.

Maintaining tight control on sodium levels is necessary because sodium affects the membranes of all the individual cells in your body. Healthy membranes allow for the movement of:

- nutrients in and out of the cells
- signals through the nervous system (for example, messages from the brain to other parts of your body).

Dietary salt is needed for these processes. However, most of us consume much, much more than we need.

When we eat too much salt, this increases sodium levels in the blood. The body responds by drawing more fluid into the blood to keep the sodium concentration at the right level. However, by increasing the fluid volume, the pressure against the blood vessel walls is increased, leading to high blood pressure.

High blood pressure makes the heart work harder, which can lead to disease of the heart and blood vessels, including heart attack and heart failure.

While there is some controversy around the effect of salt on blood pressure, most of the literature indicates there is a progressive association, which means the more sodium you consume, the more likely you are to die prematurely.

What to watch out for

Certain groups of people are more affected by high-salt diets than others. These people are referred to as "salt-sensitive", and are more likely to get high blood pressure from salt consumption.

Those most at risk include older people, those who already have high blood pressure, people of African-American background, those who have chronic kidney disease, those with a history of pre-eclampsia (high blood pressure during pregnancy), and those who had a low birth weight.

It is important to be aware of your blood pressure, so next time you visit your doctor make sure you get it checked. Your blood pressure is given as two figures: highest (systolic) over lowest (diastolic). Systolic is the pressure in the artery as the heart contracts and pushes the blood through your body. The diastolic pressure in the artery is when the heart is relaxing and being filled with blood.

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Optimal blood pressure is below 120/80. Blood pressure is considered high if the reading is over 140/90. If you have other risk factors for heart disease, diabetes or kidney disease, a lower target may be set by your doctor.

How to reduce salt intake

Reducing salt in your diet is a good strategy to reduce your blood pressure, and avoiding processed and ultra-processed foods, which is where about 75% of our daily salt intake comes from, is the first step.

Increasing your intake of fruit and vegetables to at least seven serves per day may also be effective in reducing your blood pressure, as they contain potassium, which helps our blood vessels relax.

Increasing physical activity, stopping smoking, maintaining a healthy weight and limiting your alcohol intake will also help to maintain a healthy blood pressure. Blood pressure reducing medications are also available if blood pressure cannot be reduced initially by lifestyle changes.

The Conversation, 7 April 2022

https://theconversation.com

Here's what happens in your dog's brain when you speak

2022-04-05

Pups might process voices like we do, study says.

My dog Leo clearly knows the difference between my voice and the barks of the beagle next door. When I speak, he looks at me with love; when our canine neighbor makes his mind known, Leo barks back with disdain. A new study backs up what I and my fellow dog owners have long suspected: Dogs' brains process human and canine vocalizations differently, suggesting they evolved to recognize our voices from their own.

"The fact that dogs use auditory information alone to distinguish between human and dog sound is significant," says Jeffrey Katz, a cognitive neuroscientist at Auburn University who is not involved with the work.

Previous research has found that dogs can match human voices with expressions. When played an audio clip of a lady laughing, for example, they'll often look at a photo of a smiling woman.

But how exactly the canine brain processes sounds isn't clear. MRI has shown certain regions of the dog brain are more active when a pup

hears another dog whine or bark. But those images can't reveal exactly when neurons in the brain are firing, and whether they fire differently in response to different noises.

So in the new study, Anna Bálint, a canine neuroscientist at Eötvös Loránd University, turned to an electroencephalogram, which can measure individual brain waves. She and her colleagues recruited 17 family dogs, including several border collies, golden retrievers, and a German shepherd, that were previously taught to lie still for several minutes at a time. The scientists attached electrodes to each dog's head to record its brain response—not an easy task, it turns out. Unlike humans' bony noggins, dog heads have lots of muscles that can obstruct a clear readout, Bálint says.

The researchers then played audio clips of human and dog vocalizations. The human sounds included only nonlanguage vocalizations like baby babble, laughter, and coughing, whereas the dog sounds included sniffing, panting, and barking. Each sound was classified as conveying either a "positive" or "neutral" emotion, based on the context they were made in, like the excited yelp of a dog playing with a ball. (The researchers didn't include any "negative" sounds so as not to startle the pups.)

For each of the noises, the dogs experienced a change in brain waves within the first 250 to 650 milliseconds. In human brains, signal differences in this time frame are associated with motivation and decision-making. That suggests to Bálint and her co-authors that the pups are trying to figure out who or what is making the sound—and how to respond. The dogs' brains didn't produce any meaningful signals in the first 250 milliseconds, the time period in which humans tend to process sound qualities like pitch or tone. That suggests, Bálint says, that the dogs weren't simply noticing the voices sounded different.

Moreover, when the dogs' brain waves peaked in the 250- to 650-second range, they fired differently depending on who they were listening to. The waves were more electrically positive in response to human vocalizations, and they were more electrically negative in response to the canine sounds, the researchers report today in Royal Society Open Science.

Bálint stresses that "positive" and "negative" in this case refer to the changing electrical voltage of the brain, and not the intensity of the signal or the preference of the pooch to hear one sound over another. But the difference in voltage between the waves triggered by human sounds and those triggered by dog sounds was stark, she says. The dogs' brains are

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processing the two types of sound in different ways, but exactly how is still unknown.

Some of the sounds the researchers used were clearly species-specific, such as a bark or a laugh, says Rochelle Newman, who studies how dogs and humans process language at the University of Maryland, College Park. But other vocalizations in the study might not be so easily parsed. "I don't know if human and dog yawns are acoustically distinguishable," she says. If they aren't, then the dogs might be distinguishing the sounds based on other, additional criteria.

But Katz says the data are robust—and important. Knowing how dogs process sound could, among other things, help canine experts better train service or working dogs. Bálint would like to test how dog brains react to other types of stimuli, but not until she repeats this experiment with more dogs. That's no walk in the park: "You'd have to train more dogs to lie completely still for at least 7 minutes," she explains.

Science, 5 April 2022

https://science.org

Flow state, exercise and healthy ageing: 5 unexpected benefits of singing

2022-04-13

Singing with others feels amazing. Group singing promotes social bonding and has been shown to raise oxytocin (the "bonding hormone") and decrease cortisol (the "stress hormone").

But it's not just about singing in groups. There are many unexpected ways singing is good for you, even if you're on your own.

Singing is a free and accessible activity which can help us live happier, healthier and more fulfilling lives.

And before you protest you are "tone deaf" and "can't sing", research shows most people can sing accurately in tune, so let's warm up those voices and get singing.

1. Singing gets you in the zone

If you've ever lost track of time while doing something slightly challenging but enjoyable, you've likely experienced the flow state. Some people refer to this feeling as being "in the zone".

Learning a new skill – like singing – is a great way to help with healthy ageing.

According to positive psychology, flow, or deep engagement in a task, is considered one of the key elements of well-being.

Research has shown singing can induce the flow state in expert singers and group singing.

One way to get into this flow state is through improvisation.

Try your hand at some vocal improvisation by picking one phrase in a song you know well and playing around with it. You can improvise by slightly changing the melody, rhythm, even the lyrics.

You may well find yourself lost in your task – if you don't realise this until afterwards, it is a sign you've been in flow.

2. Singing gets you in touch with your body

Singers make music with the body. Unlike instrumentalists, singers have no buttons to push, no keys to press and no strings to pluck.

Singing is a deeply embodied activity: it reminds us to get in touch with our whole selves. When you're feeling stuck in your head, try singing your favourite song to reconnect with your body.

Focus on your breathing and the physical sensations you can feel in your throat and chest.

Singing is also a great way to raise your awareness of any physical tensions you may be holding in your body, and there is increasing interest in the intersection between singing and mindfulness.

3. Singing as exercise

We often forget singing is a fundamentally physical task which most of us can do reasonably well.

When we sing, we are making music with the larynx, the vocal tract and other articulators (including your tongue, lips, soft and hard palates and teeth) and the respiratory system.

Just as we might jog to improve our cardiovascular fitness, we can exercise the voice to improve our singing. Functional voice training helps singers understand and use their voice according to optimal physical function.

Singing is increasingly being used to help improve respiratory health for a wide range of health conditions, including those with chronic obstructive pulmonary disease, Parkinson's, asthma and cancer.

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Because singing provides such a great workout for the respiratory system, it is even being used to help people suffering from long COVID.

4. Singing builds psychological resources

Group singing can help combat social isolation and create new social connections, help people cope with caring burdens and enhance mental health.

Studies show these psychological benefits flow because group singing promotes new social identities.

When we sing with others we identify with, we build inner resources like belonging, meaning and purpose, social support, efficacy and agency.

5. Singing for "super-ageing"

"Super-agers" are people around retirement age and older whose cognitive abilities (such as memory and attention span) remain youthful.

Research conducted by distinguished psychologist and neuroscientist Lisa Feldman Barrett and her lab suggest the best-known way to become a superager is to work hard at something.

Singing requires the complex coordination of various physical components — and that's just to make a sound! The artistic dimension of singing includes memorisation and interpretation of lyrics and melodies, understanding and being able to hear the underlying musical harmony, sensing rhythm and much more.

These characteristics of singing make it an ideal candidate as a super-ageing activity.

The Conversation, 5 April 2022

https://theconversation.com

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