https://go.nature.com/3f8OTTn

First nuclear detonation created 'impossible' quasicrystals

Their structures were once controversial. Now researchers have discovered quasicrystals in the aftermath of a 1945 bomb test.

Davide Castelvecchi

Scientists searching for quasicrystals — so-called 'impossible' materials with unusual, non-repeating structures — have identified one in remnants of the world's first nuclear bomb test.

The previously unknown structure, made of iron, silicon, copper and calcium, probably formed from the fusion of vaporized desert sand and copper cables.

This sample of red trinitite was found to contain a previously unknown type of quasicrystal. **Credit: Luca Bindi, Paul J. Steinhardt**

Similar materials have been synthesized in the laboratory and identified in meteorites, but this one, described in *Proceedings of the National Academy of Sciences* on 17 May, is the first example of a quasicrystal with this combination of elements[1].

Impossible symmetries

Quasicrystals contain building blocks made up of arrangements of atoms that — unlike those in ordinary crystals — do not repeat in a regular, brickwork-like pattern. Whereas ordinary crystal structures look identical after being translated (shifted along certain directions), quasicrystals have symmetries that were once considered impossible: for example, some have pentagonal symmetry, and so look the same if rotated by one-fifth of a full twist.

Materials scientist Daniel Shechtman, now at the Technion Israel Institute of Technology in Haifa, first discovered such an impossible symmetry in a synthetic alloy in 1982. It had pentagonal symmetry when rotated in each of various possible directions, something that would occur if its building blocks were icosahedral — that is, had a regular shape with 20 faces[2]. Many researchers initially questioned Shechtman's findings, because it is mathematically impossible to fill space using only icosahedrons. Shechtman ultimately won the 2011 Nobel Prize in Chemistry for the discovery.

At around the same time, Paul Steinhardt, a theoretical physicist now at Princeton University in New Jersey, and his collaborators had begun to theorize the possible existence of non-repeating 3D structures. These had the same symmetry as an icosahedron, but were assembled from building blocks of several different types, which never repeated in the same pattern[3] — thus explaining why the mathematics of symmetrical crystals had missed them. Mathematical physicist Roger Penrose, now at the University of Oxford, UK, and other researchers had previously discovered analogous patterns in two dimensions, which are called Penrose tilings.

Steinhardt recalls the moment in 1982 when he first saw the experimental data from Shechtman's discovery and compared it with his theoretical predictions. "I stood up from my desk and went and looked at our pattern, and you couldn't tell the difference," he says. "So that was kind of an amazing moment."

In subsequent years, materials scientists synthesized many types of quasicrystal, expanding the range of possible forbidden symmetries. And Steinhardt and his colleagues later found the first naturally occurring 'icosahedrite' in fragments from a meteorite recovered in Eastern Siberia, Russia. This quasicrystal probably formed in a collision between two asteroids in the early Solar System, Steinhardt says. Some of the lab-made quasicrystals were also produced by smashing materials together at high speed, so Steinhardt and his team wondered whether the shockwaves from

nuclear explosions might form quasicrystals, too.

'Slicing and dicing'

In the aftermath of the Trinity test — the first ever detonation of a nuclear bomb, which took place on 16 July 1945 at New Mexico's Alamogordo Bombing Range — researchers found a vast field of greenish glassy material that had formed from the liquefaction of desert sand. They dubbed this trinitite.

The plutonium bomb had been detonated on top of a 30-metre-high tower, which was laden with sensors and their cables. As a result, some of the trinitite that formed had reddish inclusions, says Steinhardt. "It was a fusion of natural material with copper from the transmission lines." Quasicrystals often form from elements that would not normally combine, so Steinhardt and his colleagues thought samples of the red trinitite would be a good place to look for quasicrystals.

"Over the course of ten months, we were slicing and dicing, looking at all sorts of minerals," Steinhardt says. "Finally, we found a tiny grain." The quasicrystal has the same kind of icosahedral symmetry as the one in Shechtman's original discovery.

"The dominance of silicon in its structure is quite distinct," says Valeria Molinero, a theoretical chemist at the University of Utah in Salt Lake City. "However, after many quasicrystals have been synthesized in the lab," she says, "what I find truly intriguing is that they are so scarce in nature." Steinhardt says this might be because the formation of quasicrystals involves "unusual combinations of elements and unusual arrangements".

Like most known quasicrystals, the trinitite structure seems to be an alloy — a metal-like material made up of positive ions in a sea of electrons. This is unusual for silicon, which typically occurs in rock in an oxidized form: reversing the oxidation would require extreme conditions, such as the intense heat and pressure of a shockwave, says Lincoln Hollister, a geoscientist at Princeton.

Steinhardt suggests that quasicrystals could be used for a kind of nuclear forensic science, because they might reveal sites where a covert nuclear test has occurred. Quasicrystals might also form in other materials that were generated in violent conditions, such as fulgurite, the material made when lightning strikes rock, sand or other sediments. "The quasicrystal saga will continue!" says Hollister.

doi: https://doi.org/10.1038/d41586-021-01332-0 ***References***

1. Bindi, L. et al. Proc. Natl Acad. Sci. USA https://doi.org/10.1073/pnas.2101350118 (2021). Article Google Scholar

*2. Shechtman, D., Blech, I., Gratias, D. & Cahn, J. W. Phys. Rev. Lett. **53**, 1951–1953 (1984). Article Google Scholar*

*3. Levine, D. & Steinhardt, P. J. Phys. Rev. Lett. **53**, 2477–2480 (1984). Article Google Scholar Download references*

https://bit.ly/3udWBQs

Forget throat swabs: Dutch company claims its breathalyzer can help sniff out COVID-19

"Breathalyzer" that can sniff out the disease based on a mix of chemical components exhaled

By Jop de Vrieze

People seeking to get tested for COVID-19 by Amsterdam's Public Health Service (GGD) in February were pioneers: They were the first in the world to be tested using a "breathalyzer" that can sniff out the disease based on a mix of chemical components exhaled by the patient.

Dutch health minister Hugo de Jonge gets tested for COVID-19 using the SpiroNose. **Joris van Gennip**

The approach promises to be faster and less unpleasant than a nose or throat swab, and cheaper. But soon after its premiere, 25 people who tested negative turned out to have COVID-19 after all, and Amsterdam halted its use. The Dutch government has decided the

device itself was innocent, however, and has not withdrawn its authorization. A commercial testing company is now deploying it widely—for example to screen workers at the Eurovision Song Contest, which begins tomorrow in Rotterdam.

SpiroNose isn't meant to definitively diagnose infection; instead it aims to rule it out in as many cases as possible. For the remainder, the test yields an "inconclusive," and those people receive a polymerase chain reaction (PCR) or antigen test. "What we want is to exclude as many people as possible who might be infected with the coronavirus, to reduce the testing burden and increase the willingness to test," says Rianne de Vries, chief operating officer of Breathomix, the Dutch company that makes the device.

Exhaled breath tests have proved hard to deliver. A long-sought breath test for lung cancer still doesn't exist, for example. Yet researchers in several countries are at work on breath tests for COVID-19. They rely on a variety of technologies, including mass spectrometry and gas chromatography, but some of the most promising ones—in terms of affordability and ease of use—are based on nanomaterial-based sensors. Some sense viral particles, but most focus on compounds produced by the human body. SpiroNose contains seven metal oxide semiconductor sensors that detect thousands of volatile organic compounds in exhaled air; the idea is that the mix changes when someone has a COVID-19 infection. The biological processes responsible for the changes aren't understood, says Paul Skipp, a proteomics researcher at the University of Southampton. "In principle, you're purely measuring a correlation. It's a black box," he says.

But it works, according to a preprint published in February by researchers at Leiden University Medical Center in collaboration with company scientists. Using the breath profiles from 904 participants, 35 of whom were PCR positive for SAR-CoV-2, the team built an algorithm to predict infection based on the breath profile. In a validation study in another 904 people, the SpiroNose picked out all 33 PCR-positive subjects. The researchers then ran replication studies in populations with more viral transmission and among asymptomatic people who had been in contact with an infected individual. All but 20% of uninfected people tested negative. The device missed one positive case in each replication study. Those cases had a low viral load, meaning they were probably not contagious.

"That's really, really good," Skipp says. "The sensitivity is as good as any test that is out there, and of course it is much more rapid." Patrick Bossuyt, a test evaluation researcher at Amsterdam University Medical Center who was not involved in the study, calls the results "quite stunning."

Based on the studies, the Dutch Inspectorate for Health and Youth Care granted Breathomix a temporary exemption from the authorization procedures required for marketing a test in the European Economic Area. The Dutch government bought hundreds of SpiroNoses, to be deployed throughout the country, and health minister Huge de Jonge launched the rollout by undergoing a test himself.

But GGD hit the brakes after the 25 PCR-confirmed COVID-19 cases in people who had a negative breath test. (One patient, sports law professor Marjan Olfers, tweeted that she was admitted to a hospital with COVID-19 within days after her test.) Urgent consultation between the Dutch health ministry, the health inspectorate, GGD, and Breathomix brought clarification a week later. The SpiroNose itself had not failed, the parties concluded. Most of the discrepancies were caused by user errors, which GGD blamed on a lack of clear instructions and assistance from the company; for the remainder, the interval between the SpiroNose test and the PCR test was long enough—two or more days—that people could have become positive after their breath test.

The health inspectorate agreed there were no fundamental issues, and De Vries says the company and GGD are working to improve the testing process. “We all learned a lot from the issue,” she says, although she’s frustrated about the negative publicity the pause generated. GGD has yet to resume breath testing, however; a spokesperson declined to explain the reasons but said, “We need to complete an additional validation first.”

In the meantime, a large commercial testing provider in the Netherlands, Lead Healthcare, has teamed up with Breathomix. It carried out a pilot screening at a port company in Rotterdam and is also using SpiroNose to screen workers preparing Eurovision. During the festival itself, it may test as many as 3500 employees per day. By now, Lead Healthcare has carried out more than 30,000 tests; de Vries says the false negative rate is about 0.1%.

Kevin Lamote, a respiratory diagnostics researcher at the University of Antwerp, says he hopes the field can eventually move away from the black-box method. Ideally, researchers will find the components in exhaled air that are truly characteristic of a disease and develop more specific sensors for them, comparable to an alcohol test, he says. “We try to achieve this by studying breath samples using sensors in parallel with mass spectrometry analyses,” Lamote says.

https://bit.ly/3ytpueE

Did Earth's early rise in oxygen support the evolution of multicellular life—or suppress it?

Hypothesis brought to bear on a simple multicellular lifeform called a 'snowflake yeast."

by Renay San Miguel, Georgia Institute of Technology

Scientists have long thought that there was a direct connection between the rise in atmospheric oxygen, which started with the Great Oxygenation Event 2.5 billion years ago, and the rise of large, complex multicellular organisms.

That theory, the "Oxygen Control Hypothesis," suggests that the size of these early multicellular organisms was limited by the depth to which oxygen could diffuse into their bodies. The hypothesis makes a simple prediction that has been highly influential within both evolutionary biology and geosciences: Greater atmospheric oxygen should always increase the size to which multicellular organisms can grow.

It's a hypothesis that's proven difficult to test in a lab. Yet a team of Georgia Tech researchers found a way—using directed evolution, synthetic biology, and mathematical modeling—all brought to bear on a simple multicellular lifeform called a 'snowflake yeast." The results? Significant new information on the correlations between oxygenation of the early Earth and the rise of large multicellular organisms—and it's all about exactly how much O2 was available to some of our earliest multicellular ancestors.

"The positive effect of oxygen on the evolution of multicellularity is entirely dose-dependent—our planet's first oxygenation would have strongly constrained, not promoted, the evolution of multicellular life," explains G. Ozan Bozdag, research scientist in the School of Biological Sciences and the study's lead author. "The positive effect of oxygen on multicellular size may only be realized when it reaches high levels."

"Oxygen suppression of macroscopic multicellularity" is published in the May 14, 2021 edition of the journal *Nature Communications*. Bozdag's co-authors on the paper include Georgia Tech researchers Will Ratcliff, associate professor in the School of Biological Sciences; Chris Reinhard, associate professor in the School of Earth and Atmospheric Sciences; Rozenn Pineau, Ph.D. student in the School of Biological Sciences and the Interdisciplinary Graduate Program in Quantitative Biosciences (QBioS); along with Eric Libby, assistant professor at Umea University in Sweden and the Santa Fe Institute in New Mexico.

Directing yeast to evolve in record time

"We show that the effect of oxygen is more complex than previously imagined. The early rise in global oxygen should in fact strongly constrain the evolution of macroscopic multicellularity, rather than selecting for larger and more complex organisms," notes Ratcliff.

"People have long believed that the oxygenation of Earth's surface was helpful—some going so far as to say it is a precondition—for the evolution of large, complex multicellular organisms," he adds. "But nobody has ever tested this directly, because we haven't had a model system that is both able to undergo lots of generations of evolution quickly, and able to grow over the full range of oxygen conditions," from anaerobic conditions up to modern levels.

The researchers were able to do that, however, with snowflake yeast, simple multicellular organisms capable of rapid evolutionary change. By varying their growth environment, they evolved snowflake yeast for over 800 generations in the lab with selection for larger size.

The results surprised Bozdag. "I was astonished to see that multicellular yeast doubled their size very rapidly when they could not use oxygen, while populations that evolved in the moderately oxygenated environment showed no size increase at all," he says. "This effect is robust—even over much longer timescales."

Size—and oxygen levels—matter for multicellular growth

In the team's research, "large size easily evolved either when our yeast had no oxygen or plenty of it, but not when oxygen was present at low levels," Ratcliff says. "We did a lot more work to show that this is actually a totally predictable and understandable outcome of the fact that oxygen, when limiting, acts as a resource—if cells can access it, they get a big metabolic benefit. When oxygen is scarce, it can't diffuse very far into organisms, so there is an evolutionary incentive for multicellular organisms to be small—allowing most of their cells access to oxygen—a constraint that is not there when oxygen simply isn't present, or when there's enough of it around to diffuse more deeply into tissues."

Ratcliff says not only does his group's work challenge the Oxygen Control Hypothesis, it also helps science understand why so little apparent evolutionary innovation was happening in the world of multicellular organisms in the billion years after the Great Oxygenation Event. Ratcliff explains that geologists call this period the "Boring Billion" in Earth's history—also known as the Dullest Time in Earth's History, and Earth's Middle Ages—a period when oxygen was present in the atmosphere, but at low levels, and multicellular organisms stayed relatively small and simple.

Bozdag adds another insight into the unique nature of the study. "Previous work examined the interplay between oxygen and multicellular size mainly through the physical principles of gas diffusion," he says. "While that reasoning is essential, we also need an inclusive consideration of principles of Darwinian evolution when studying the origin of complex multicellular life on our planet." Finally being able to advance organisms through many generations of evolution helped the researchers accomplish just that, Bozdag adds.

More information: *G. Ozan Bozdag et al. Oxygen suppression of macroscopic multicellularity, Nature Communications (2021). DOI: 10.1038/s41467-021-23104-0*

https://bit.ly/3u6W0zY

Cells from the centre of tumours most likely to spread around the body

Cells within the centre of a tumour are the most aggressive and have the highest chance of spreading around the body

Researchers from the Francis Crick Institute, Royal Marsden, UCL and Cruces University Hospital have found that cells from different parts of kidney tumours behave differently, and surprisingly, cells within the centre of a tumour are the most aggressive and have the highest chance of spreading around the body.

Cancers can spread to other parts of the body, with cells taking hold as secondary tumours which make the disease much harder to treat.

Understanding the mechanics of this spread, a process called metastasis, could lead to new treatments that block this migration.

In their multidisciplinary study published today (17 May) in Nature Ecology and Evolution, scientists led by the Litchfield lab at UCL and the Turajlic, Swanton, and Bates labs at the Crick, analysed 756 cancer biopsy samples from different regions within tumours from the TRACERx Renal study.

They found that cells at the centre of tumours have a less stable genome and a higher potential to spread to secondary sites around the body.

By contrast cells at the tumour edge had lower rates of metastasis, as well as lower rates of growth and genetic damage.

"Cancer cells in the central zone of the tumour face harsh environmental conditions, as there's a lack of blood supply and oxygen.

They have to adapt to survive, which makes them stronger and more aggressive.

This also means they are more likely to successfully evolve into cells that can disseminate and take hold in distant organs," says Kevin Litchfield, paper author and group leader at the UCL Cancer Institute.

The results highlight a need to pay close attention to the tumour centre to understand how cancer spreads and to find the cancer cells of greatest threat to the patient.

It also shows the importance of developing treatments that target the unique environmental conditions found within the tumour core, in order to successfully eliminate the most aggressive tumour cells.

The scientists also looked at how genetically different populations of cancer cells grow within a tumour.

Using a unique map building tool to reconstruct the growth of tumour cells, they found that, while most tumours follow a pattern where populations of cells grow in the local area - like a plant growing up and outwards - two cases demonstrated a "jumping" pattern where cells took hold in a new region of the tumour by seemingly 'jumping' over other populations of tumour cells.

The researchers are now planning to reconstruct 3D tumour maps, which will provide an even clearer visualisation of the spatial patterns within tumours.

Samra Turajlic, head of the Crick's Cancer Dynamics Laboratory, Consultant Medical Oncologist at the Royal Marsden NHS Foundation Trust and the Chief Investigator of TRACERx Renal, said: "Cancer spread is one of the biggest barriers to improving survival rates.

In the context of the TRACERx Renal study we previously resolved the genetic make up of different tumour areas, but until now, there has been no understanding of how these differences relate spatially.

The most critical question is the part of the tumour from which cancer cells break away and migrate making cancer incurable.

"Using this unique clinical cohort and a multidisciplinary approach, including mathematical modeling, we identified with precision the place in the tumour where genetic chaos emerges to give rise to metastases. Our observations shed light on the sort of environmental conditions that would foster emergence of aggressive behaviour. These findings are a critical foundation for considering how we target or even prevent distinct populations of cells that pose the biggest threat."

The work was primarily funded by the Royal Marsden Renal Unit, the Biomedical Research Centre at the Royal Marsden and Institute of Cancer Research, Cancer Research UK, Rosetrees Trust, the National Institute for Health Research (NIHR) and the EU Framework Programme for Research and Innovation H2020.

For further information, contact: press@crick.ac.uk or +44 (0)20 3796 5252

Notes to Editors

Reference: Zhao, Y. et al. (2021). Selection of metastasis competent subclones in the tumour interior. Nature Ecology & Evolution. DOI: 10.1038/s41559-021-01456-6

https://bit.ly/3ugLEO5

Experimental Asthma Vaccine Works in Mice, And Could Be Trialed in Humans Soon

Experimental vaccine offers new hope to successfully treat this chronic lung disease

Peter Dockrill

Asthma affects hundreds of millions of people around the world, but an experimental vaccine offers new hope to successfully treat this chronic lung disease, linked to hundreds of thousands of deaths each year.

So far the prototype vaccine has only been tested in animals, but the researchers now intend to conduct a clinical trial in human patients – with hopes the approach could provide a safe, cost-effective, and long-term way to protect people from allergic asthma attacks.

"The idea is to set up in the future a preventive approach for populations at risk of developing a severe form of asthma," one of the team, pulmonology researcher Laurent Guilleminault from the Toulouse Institute for Infectious and Inflammatory Diseases (Infinity) in France, told *La Dépêche*.

Previous research has shown that dupilumab, a monoclonal antibody used in the treatment of eczema, is also effective in relieving symptoms and improving lung function in cases of severe asthma.

This is thought to be due to the way dupilumab blocks signaling from interleukin-4 (IL-4) and interleukin-13 (IL-13) – two cytokine molecules that play a role in immune response, but which are also involved in airway-obstructing type 2 inflammation seen in an estimated 50 to 70 percent of asthma patients.

In cases of allergic asthma, exposure to dust mites, pollen, and other allergens can produce large amounts of these cytokines, in addition to excessive amounts of the antibody immunoglobulin E (IgE), promoting inflammation in the airways and making it harder to breathe.

While dupilumab and other monoclonal antibody (mAb) treatments can mitigate these symptoms, they can be expensive and require ongoing injections to work, whereas a vaccine achieving the same ends could provide cost-effective therapeutic effects in the long term.

"Conjugate vaccines called kinoids can elicit an endogenous, long-lasting neutralizing antibody response against a given cytokine, and could be a favorable alternative to therapeutic mAb administration," the researchers, led by co-first authors Eva Conde and Romain Bertrand, write in their study.

"We hypothesized that a dual vaccination against IL-4 and IL-13 would be particularly potent at reducing the severity of chronic asthma."

Developed in conjunction by teams at Infinity, the Institut Pasteur in Paris, and French biotechnology company Neovacs, the experimental vaccine couples the recombinant cytokines with a carrier protein called CRM197.

In tests with mice, over 90 percent of animals given the vaccine prototype revealed antibodies capable of neutralizing IL-4 and IL-13 at six weeks after injection, with the protection lasting for up to a year, at which point more than 60 percent of the mice still showed high levels of the antibodies.

"These data indicate that efficient long-term neutralization of both IL-4 and IL-13 can be achieved through vaccination with kinoids," the researchers report.

In addition, a mouse model of asthma – using animals who received intranasal doses of dust mite extract, one of the most common human allergens – showed that dual vaccination against IL-4 and IL-13 provided significant protection from the allergens in terms of healthy lung functioning, compared to control animals who didn't receive the shot.

In genetically engineered mice bred to generate the human version of the IL-4 and IL-13 cytokines, the vaccine also showed positive results, neutralizing the cytokines and reducing IgE levels for at least 11 weeks post-vaccination.

That's not the same as saying we know it works equally well in people, but is a promising sign for future tests in humans – although we won't know for sure whether the vaccine is safe and effective in people until clinical trials are conducted.

For now, the researchers say that we have here is a "proof of concept" that long term neutralization of IL-4 and IL-13 can be achieved with the prototype vaccine, while protecting against several key features of chronic asthma, including airway hyper-responsiveness, eosinophilia, and mucus overproduction.

Exactly how long the protection lasts for – and just how the blockade of the cytokines achieves these remarkable effects – are questions that remain to be further investigated. For now, though, the most pressing next step is to test the experimental shot in humans.

To that end, a clinical trial is currently being organized by Guilleminault and Neovacs, with patients in Toulouse and Strasbourg expected to receive the first human injections of the drug sometime in the next two years.

The findings are reported in *Nature Communications*.

https://bit.ly/3va99t5

Marine archaea make oxygen in the dark using nitrite

Meet Nitrosopumilus maritimus, which is capable of a never-before-seen oxygen synthesis method

Elise Cutts

Earth's atmosphere owes its oxygen to life. With an energy boost from sunlight, photosynthesis combines CO_2 and water, yielding sugar and oxygen. But turn off the lights, and making oxygen gets tricky. Only a small handful of microbes are known to do it. But dark oxygen production might be far more common — and important — than previously thought.

Ammonia-oxidizing archaea (AOA) are widespread microbes found everywhere from the seafloor to Mt. Everest. They convert ammonia into nitrite for energy in an oxygen-dependent process called nitrification. Despite this, AOA somehow thrive in oxygen-minimum zones (OMZs), regions in the ocean where oxygen concentrations plummet.

Researchers at the University of Southern Denmark recently announced in a pre-print (a completed study which has not yet passed peer-review) that an AOA called *Nitrosopumilus maritimus* may have let them in on the secret to its success in OMZs. Sealed up in airtight containers, *N. maritimus* grew in the lab under the watch of super-sensitive oxygen sensors.

As expected, the cells quickly consumed all available oxygen, using it for nitrification. But then something strange happened. Right after oxygen concentrations hit zero, they rose again. After two years of experiments it was clear that instead of dying out or hibernating after running out of oxygen, *N. maritimus* made its own oxygen from nitrite, producing dinitrogen (N_2) as a by-product.

Additional tests confirmed that *N. maritimus* wasn't using any of the three previously known ways of making oxygen in the dark — its trick was all its own, and not only a novel method of light-independent oxygen production but also a completely new chemical pathway for recycling biological nitrogen into N_2.

This new metabolism can't replace photosynthesis—oxygen in the *N. maritimus* cultures peaked at levels about 1000x lower than would have been expected from photosynthesis. But because AOA are both incredibly common and critical for the nitrogen cycle, dark oxygen production might be far more important and widespread than previously thought.

https://bit.ly/3hVT9rd

New material could create 'neurons' and 'synapses' for new computers

Physicists have used a complex oxide to create elements comparable to the neurons and synapses in the brain using spins, a magnetic property of electrons

Classic computers use binary values (0/1) to perform. By contrast, our brain cells can use more values to operate, making them more energy-efficient than computers. This is why scientists are interested in neuromorphic (brain-like) computing.

Physicists from the University of Groningen (the Netherlands) have used a complex oxide to create elements comparable to the neurons and synapses in the brain using spins, a magnetic property of electrons. Their results were published on 18 May in the journal *Frontiers in Nanotechnology*.

Although computers can do straightforward calculations much faster than humans, our brains outperform silicon machines in tasks like object recognition. Furthermore, our brain uses less energy than computers. Part of this can be explained by the way our brain operates: whereas a computer uses a binary system (with values 0 or 1), brain cells can provide more analogue signals with a range of values.

Thin films

The operation of our brains can be simulated in computers, but the basic architecture still relies on a binary system. That is why scientist look for ways to expand this, creating hardware that is more brain-like, but will also interface with normal computers. 'One idea is to create magnetic bits that can have intermediate states', says Tamalika Banerjee, Professor of Spintronics of Functional Materials at the Zernike Institute for Advanced Materials, University of Groningen. She works on spintronics, which uses a magnetic property of electrons called 'spin' to transport, manipulate and store information.

In this study, her PhD student Anouk Goossens, first author of the paper, created thin films of a ferromagnetic metal (strontium-ruthenate oxide, SRO) grown on a substrate of strontium titanate oxide. The resulting thin film contained magnetic domains that were perpendicular to the plane of the film. 'These can be switched more efficiently than in-plane magnetic domains', explains Goossens. By adapting the growth conditions, it is possible to control the crystal orientation in the SRO. Previously, out-of-plane magnetic domains have been made using other techniques, but these typically require complex layer structures.

Magnetic anisotropy

The magnetic domains can be switched using a current through a platinum electrode on top of the SRO. Goossens: 'When the magnetic domains are oriented perfectly perpendicular to the film, this switching is deterministic: the entire domain will switch.' However, when the magnetic domains are slightly tilted, the response is probabilistic: not all the domains are the same, and intermediate values occur when only part of the crystals in the domain have switched.

By choosing variants of the substrate on which the SRO is grown, the scientists can control its magnetic anisotropy. This allows them to produce two different spintronic devices. 'This magnetic anisotropy is exactly what we wanted', says Goossens. 'Probabilistic switching compares to how neurons function, while the deterministic switching is more like a synapse.'

The scientists expect that in the future, brain-like computer hardware can be created by combining these different domains in a spintronic device that can be connected to standard silicon-based circuits. Furthermore, probabilistic switching would also allow for stochastic computing, a promising technology which represents continuous values by streams of random bits. Banerjee: 'We have

found a way to control intermediate states, not just for memory but also for computing.'

Reference: A.S. Goossens, M.A.T. Leiviskä and T. Banerjee: Anisotropy and Current Control of Magnetization in SrRuO3/SrTiO3 Heterostructures for Spin-Memristors. Frontiers in Nanotechnology 18 May 2021

https://bit.ly/2RCdO8N

New expert statement confirms strong links between our hormones and COVID-19

New expert statement confirms strong links between our hormones and COVID-19

The endocrine system is strongly involved in SARS-Cov-2 infection - so much so that evidence of an "endocrine phenotype" of COVID-19 has emerged, according to a statement by the European Society of Endocrinology (ESE) published in the journal *Endocrine* in April 2021. Leading endocrinology researchers looked into the evidence that has accumulated over the past year since the pandemic emerged, and consistently found evidence for links across a variety of endocrine conditions. This statement constitutes an update of a March 2020 statement that was of the earliest and most read pieces delineating the involvement of the endocrine system in COVID-19.

Dr Manel Puig from the Universitat Autònoma de Barcelona in Spain and first author on the statement said "the evidence is clear. The effect on hormones cannot be ignored in the context of COVID-19". He added "we need to be aware of the endocrine consequences of COVID-19 for patients with a known endocrine condition such as diabetes, obesity or adrenal insufficiency, but also for people without a known condition. Vitamin D insufficiency for example is very common, and the knowledge that this condition has emerged frequently in the hospitalized COVID-19 population and may negatively impact outcomes should not be taken lightly".

Dr Puig, together with Profs Marazuela, Yildiz and Giustina based in Madrid, Ankara and Milano looked at the available evidence with respect to COVID-19 across a number of endocrine conditions and related factors: diabetes, obesity, nutrition, hypocalcemia, vitamin D insufficiency, vertebral fractures, adrenal insufficiency, as well as pituitary/thyroid issues and sex hormones.

Diabetes has emerged as one of the most frequent comorbidities associated with severity and mortality of COVID-19, according to a rapidly increasing amount of published data on the incidence of COVID-19 in patients over the last year. Mortality in type 1 or type 2 diabetes has consistently increased during the year of pandemic - and evidence is emerging that a bidirectional relationship between diabetes and COVID-19 may exist, both in terms of worsening existing conditions and new onset of diabetes.

The researchers identified similar trends for patients with obesity. Obesity increases susceptibility to SARS-CoV-2 and the risk for COVID-19 adverse outcomes. They posit that nutritional management is important both for patients with obesity or undernourishment in order to limit their increased susceptibility and severity of infection. Vitamin D, calcium and bone are other areas showing a growing body of evidence that better monitoring and solutions for patients are needed in the context of COVID-19.

With regard to vaccination, the statement concludes that available evidence suggests COVID-19 vaccination should not be handled differently in patients with stable endocrine diseases. However, patients with adrenal insufficiency may need adjusted glucocorticoid treatment to address side effects such as fever. The authors suggest data from the field should be collected in an international database in order to form firm conclusions on this matter. They also present a decalogue for endocrinologists and patients with endocrine and metabolic conditions in the conclusions of the statement.

This knowledge highlights the important role endocrinologists will

need to play in future research on COVID-19 and other global health issues.

https://bit.ly/3wtLJ23

The Never-Aging Ants With a Terrible Secret

A parasite gives its hosts the appearance of youth, and an unmatched social power in the colony.

By Katherine J. Wu

Deep in the forests of Germany, nestled neatly into the hollowed-out shells of acorns, live a smattering of ants who have stumbled upon a fountain of youth. They are born workers, but do not do much work. Their days are spent lollygagging about the nest, where their siblings shower them with gifts of food. They seem to elude the ravages of old age, retaining a durably adolescent physique, their outer shells soft and their hue distinctively tawny. Their scent, too, seems to shift, wafting out an alluring perfume that endears them to others. While their sisters, who have nearly identical genomes, perish within months of being born, these death-defying insects live on for years and years and years.

They are Temnothorax ants, and their elixirs of life are the tapeworms that teem within their bellies—parasites that paradoxically prolong the life of their host at a strange and terrible cost.

Susanne Foitzik / Johannes Gutenberg University Mainz

A few such life-lengthening partnerships have been documented between microbes and insects such as wasps, beetles, and mosquitoes. But what these ants experience is more extreme than anything that's come before, says Susanne Foitzik, an entomologist at Johannes Gutenberg University Mainz, in Germany, who studies the ants and their tapeworms. Infected Temnothorax ants live at least three times longer than their siblings, and perhaps much more, she and her colleagues report in a study published today in *Royal Society Open Science*. No one is yet sure when the insects' longevity tops out, but the answer is probably in excess of a decade, approaching or even matching that of ant queens, who can survive up to 20 years.

"Some other parasites do extend life spans," Shelley Adamo, a parasite expert at Dalhousie University, in Nova Scotia, who was not involved in the study, told me. "But not like this."

Under typical circumstances, Temnothorax ants live as most other ants do. They reside in communities ruled by a single fertile queen attended by a legion of workers whose professional lives take a predictable trajectory. They first tend the queen's eggs as nurses, then graduate into foraging roles that take them outside the nest. Apart from the whole freaky parasite thing, "they are pretty boring," Foitzik told me.

Normalcy goes out the door, however, when Temnothorax larvae ingest tapeworm-egg-infested bird feces trucked in by foragers. The parasites hatch and set up permanent residence in the young ants' abdomens, where they can access a steady stream of nutrients. In return, they offer their host an unconventional renter's fee: an extra-long life span that Foitzik and her colleagues managed to record in real time.

The researchers spent three years monitoring dozens of Temnothorax colonies in the lab, comparing the fates of workers who'd fallen prey to the parasites and those who remained infection-free. By the end of their experiment, almost every single one of the hundreds of worm-free workers had, unsurprisingly, died. But more than half the parasitized workers were still kicking—about the same proportion as the colonies' ultra-long-lived queens. "That was amazing to see," Biplabendu Das, an ant biologist and parasite expert at the University of Central Florida, who wasn't involved in the study, told me. And despite their old age, the ants' bodies still bore the hallmarks of youth. They were difficult to

distinguish from uninfected nurses, who are usually the most juvenile members of the colony's working class.

The tapeworm-laden ants didn't just outlive their siblings, the team found. They were coddled while they did it. They spent their days lounging in their nest, performing none of the tasks expected of workers. They were groomed, fed, and carried by their siblings, often receiving more attention than even the queen—unheard of in a typical ant society—and gave absolutely nothing in return.

The deal the ants have cut with their parasites seems, at first pass, pretty cushy. Foitzik told me that her team couldn't find any overt downsides to life as an infected ant, a finding that appears to shatter the standard paradigm of parasitism. Even the colonies as a whole remained largely intact. Workers continued to work; queens continued to lay eggs. The threads that held each Temnothorax society together seemed unmussed.

Only when the researchers took a closer look did that tapestry begin to unravel. The *uninfected* workers in parasitized colonies, they realized, were laboring harder. Strained by the additional burden of their wormed-up nestmates, they seemed to be shunting care away from their queen. They were dying sooner than they might have if the colonies had remained parasite-free. At the community level, the ants were exhibiting signs of stress, and the parasite's true tax was, at last, starting to show. "The cost is in the division of labor," Das said. The worms were tapping into not just "individual [ant] physiology, but also social interactions," Farrah Bashey-Visser, a parasitologist at Indiana University who wasn't involved in the study, told me.

Read: Life is tough for teenage parasites.

Scientists think of social insects not as single bugs, but as interlaced parts of a giant "superorganism," Manuela Ramalho, an ant biologist at Cornell University, who wasn't involved in the study, told me. When one individual acts, others around it *react;* in a colony, no ant can truly act alone. Parasites of these communities automatically extend their reach to multiple animals at once, a rippling mind-control effect that spreads and amplifies the consequences of infection. Although the tapeworms had infected only a fraction of the Temnothorax workers, they were puppeteering the entire society.

That altered existence might play directly into the parasite's hands. Tapeworms of these species can't mature into adults and produce eggs until their ant host is consumed by a bird—a fate that insects in full possession of their faculties try to avoid. But ants who spend all their time lazing around the house make for easy prey; hosts who are pampered and long-lived have a high chance of surviving until they're eaten. The worm's most ingenious move might play out in some ants' final moments, as they trade their natural fear of intruders for a dollop of ennui. When Foitzik and her students crack open infected Temnothorax colonies, the parasitized workers do little more than stare expectantly skyward. "Everyone else is just taking the larvae and running," Foitzik said. "The infected workers are just like, *Oh, what's going on?*"

Down to the molecular level, the parasite is pulling the strings. Sara Beros, Foitzik's former doctoral student and the paper's first author, told me she has split open Temnothorax abdomens and counted up to 70 tapeworms inside. From there, the worms can unleash a slurry of proteins and chemicals that futz with the ant's core physiology, likely impacting their host's hormones, immune system, and genes. What they achieve appears to be a rough pantomime of how ant queens attain their mind-boggling life span, a feat humans still don't understand. (The tapeworms' grasp of ant aging is far more advanced than ours.) The parasites are effectively flash-freezing their host into a preserved state—one that will up their own chances of survival, and help guarantee that their species lives on.

The worms' MO is subtle and ingenious. They are agents not of

disaster, but of an insidious social sickness that sets reality only slightly, barely perceptibly, askew. Infected workers get a taste of invincibility and status, swaddling themselves in youth and the benefits it brings. They also form resource sinks that sap the energy of those around them. They become echoes of the microorganisms they harbor. They are, in the end, parasites themselves.

Katherine J. Wu is a staff writer at The Atlantic, where she covers science.

https://bit.ly/3bLK4x5

There's a neurological reason you say 'um' when you think of a word

Disfluencies can shed light about what's going on in the brain as we speak

Adriel John Orena

Eishi Asano's latest work sheds light on those seemingly pesky words that litter our speech: *uh*s and *um*s.

As a neurologist at Wayne State University, Asano works on mapping human abilities to brain regions. One such important ability is the ability to use language. Neuroscientists have discovered that, like many little cogs in a wheel, a wide network of brain regions all work together to produce language. Certainly, the ability to communicate with others affects all aspects of life. Thus, protecting these brain regions during brain surgery is of high priority.

Asano has an opportunity few have: to study the brain in action. During a pre-surgical procedure called an electrocorticography (ECoG), an incision is made in a research participant's skull, and electrodes are placed directly on the exposed surface of their brain. He then presents them with photographs of complex scenes and asks them to describe it.

"This one has some, *uh*, hippos, who are swimming in the, *uh*, swamp, during the summer," a research participant in his study might say.

***In a task developed by Dr. Eishi Asano and his team, participants are asked to describe the 4 Ws (What, Who, Where, and When) of complex scenes like the one pictured here* Aji Vinister Denistan on Unsplash**

When they ran this study, Asano and his team were originally interested in deciphering which regions of the brain were responsible for describing what was in the picture (hippo), what they were doing (swimming), where (swamp) and when (summer). But, as his team rummaged through transcripts, what transpired between these words – the *uh*s – caught their attention.

Referred to as a "disfluencies" by linguists, *uhs* and *ums* are often viewed as disruptions to the flow of speech. They are littered across our speech in all contexts, whether in presentations to a large audience, or in conversations with your closest pal. Estimates vary, but one research group found that such disfluencies pop up every 4.6 seconds, on average. They are equally short and overrepresented in all languages: French speakers say *euh*, Mandarin speakers say 那个, and ASL signers sometimes wiggle their fingers.

But while *uhs* and *ums* may seem like accidental nonsense words, disfluencies can actually provide us a rare window onto what's going on in the brain as we speak. For example, psycholinguists (scientists who study the psychology of language) argue that disfluencies can actually convey meaning. When researchers scoured through a corpus of transcribed speech, they found that a large proportion of disfluencies arose in specific locations: before difficult-to-pronounce and difficult-to-name words, or before words that haven't been recently discussed. In short, when we need some time to think of the next word, we make use of *uhs* and *ums*.

Asano's recent work, published in *Scientific Reports*, shows an example of this. Asano and his team inspected the brain activity of

three adolescents that performed the scene-describing task depicted above. While three participants is a smaller sample size than is typical in neuroscience research, the technique used in this study, ECoG, provides more reliable data compared to other neuroscience methods. The fact that electrodes are placed directly on the cerebral cortex makes this technique less susceptible to "noise" in the data, such as from accidental movements by participants.

The three research participants varied in how disfluent they were, with one participant producing seven times more *uh*s and *um*s than another. Findings about brain activity, nonetheless, were consistent. "[When the participants] produced the disfluency, extensive areas of the association cortex showed activation," Asano says.

The association cortex is a group of areas on the surface (cortex) of the brain, which has previously been linked with language tasks that require relatively high amounts of linguistic effort. For example, these regions are highly engaged when producing words that have competing meanings. When producing the word "orange," our brains have to suppress the sense of the word that conveys a fruit if we are thinking about the color.

These findings reiterate the idea that *uh*s and *um*s, in and of themselves, are not causing speech to be disfluent

These findings reiterate the idea that *uh*s and *um*s, in and of themselves, are not causing speech to be disfluent. Rather, they are behavioral markers that speakers are working hard to find the next word, Asano says. When a speech task is more difficult, the association cortex works harder. And when the association cortex works hard, we sometimes produce disfluencies to fill the space.

Every person's brain is wired slightly differently, so having precise knowledge of the brain regions responsible for speaking, listening, and yes, even for being disfluent, is important for neurosurgeons who have to make important decisions for their patients.

"I remove brain regions that generate seizure activity for epileptic patients," Asano explains. "But, if you remove the wrong areas, then functionally important areas will be damaged." Indeed, there is some evidence that when parts of the association cortex sustain damage, patients may experience difficulty organizing their speech. So, while they moonlight as mere speech errors, *uh*s and *um*s can actually give us insight into the brain. A healthy number of disfluencies in our speech let neuroscientists, and other listeners, know that we're experiencing a difficult speech moment — which is a perfectly acceptable sentiment to convey in many contexts. To err is human, after all.

https://bit.ly/2QHxjwa

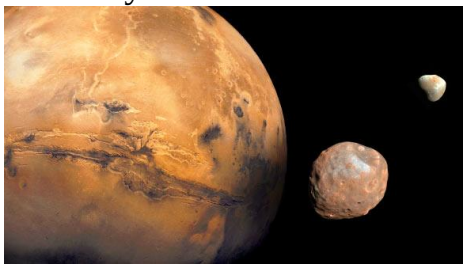
Phobos and Deimos are Fragments of Larger Martian Moon, Study Suggests

Phobos and Deimos, two satellites of Mars, originated from disintegration of a much larger moon between 1 and 2.7 billion years ago, according to new computer simulations and an analysis of data from NASA's InSight mission.

by Enrico de Lazaro

Phobos and Deimos were discovered by the American astronomer Asaph Hall at the Naval Observatory on August 18, 1877.

These potato-shaped satellites orbit Mars in synchronous rotation with inclinations of only 0.01 and 0.92 degrees relative to the equatorial plane of the planet. Although Phobos and Deimos are small, their peculiar orbits hide important secrets about their past.



Mars is kept company by two cratered moons — an inner moon named Phobos and an outer moon named Deimos. **Image credit: NASA / JPL-Caltech / Malin Space Science Systems / Texas A&M University.**

"Earth's Moon is essentially spherical, while the moons of Mars are very irregularly shaped — like potatoes," said Amirhossein Bagheri,

a doctoral student at the Institute of Geophysics at ETH Zurich, adding "Phobos and Deimos look more like asteroids than natural moons. This led people to suspect that they might in fact be asteroids that were captured in Mars's gravity field."

"But that's where the problems started: captured objects would be expected to follow an eccentric orbit around the planet, and that orbit would be at a random inclination; in contradiction to this hypothesis, the orbits of the Martian moons are almost circular and move in the equatorial plane of Mars. So, what is the explanation for the current orbits of Phobos and Deimos?"

To solve this dynamic problem, Bagheri and colleagues relied on computer simulations and seismic data from NASA's InSight mission.

"The idea was to trace the orbits and their changes back into the past," said Dr. Amir Khan, a researcher at the Physics Institute of the University of Zurich and the Institute of Geophysics at ETH Zurich.

"As it turned out, the orbits of Phobos and Deimos appeared to have crossed in the past. This means that the moons were very likely in the same place and therefore have the same origin."

The researchers concluded that a larger celestial body was orbiting Mars back then. This ancient moon was probably hit by another body between 1 and 2.7 billion years ago and disintegrated as a result. "Phobos and Deimos are the remnants of that lost moon," Bagheri said.

The team's simulations also show that, while Deimos very slowly continues to ascend, Phobos will impact on Mars in 39 million years or tidally disintegrate into a ring.

"The results stand to be improved with Mars InSight geophysical data, in particular the dissipation in Mars and its frequency dependence that control the orbital history of Phobos," the scientists said.

"The upcoming Martian Moons Exploration mission will also provide crucial information on the moons' interiors, which will help to settle the question of their origin."

The findings appear in the journal *Nature Astronomy*.

A. Bagheri et al. Dynamical evidence for Phobos and Deimos as remnants of a disrupted common progenitor. Nat Astron, published online February 22, 2021; doi: 10.1038/s41550-021-01306-2

https://bit.ly/3bNpYCw

Surveillance turns up new coronavirus threat to humans

Malaysian pneumonia cases reveal possible dog-to-human Transmission

Durham, N.C. -- Researchers have discovered a new coronavirus, found in a child with pneumonia in Malaysia in 2018, that appears to have jumped from dog to human.

If confirmed as a pathogen, the novel canine-like coronavirus could represent the eighth unique coronavirus known to cause disease in humans. The discovery also suggests coronaviruses are being transmitted from animals to humans more commonly than was previously thought.

"How common this virus is, and whether it can be transmitted efficiently from dogs to humans or between humans, nobody knows," said Gregory Gray, M.D., a professor of medicine, global health and environmental health at the Duke University.

"What's more important is that these coronaviruses are likely spilling over to humans from animals much more frequently than we know," said Gray, who led the research that appears in the journal *Clinical Infectious Diseases*.

"We are missing them because most hospital diagnostic tests only pick up known human coronaviruses."

Working with visiting scholar Leshan Xiu, a Ph.D. student, Gray was on a team that in 2020 developed a molecular diagnostic tool to

detect most coronaviruses from the Coronaviridae family that includes SARS-CoV-2, which causes COVID-19.

The team used that tool to examine 301 archived pneumonia cases and picked up signals for canine coronaviruses from eight people hospitalized with pneumonia in Sarawak, a state in East Malaysia.

Researchers at Ohio State, led by Anastasia N. Vlasova, grew a virus from one of the clinical specimens, and through a painstaking process of genome reconstruction, were able to identify it as a novel canine coronavirus.

"There are probably multiple canine coronaviruses circulating and spilling over into humans that we don't know about," Gray said. Sarawak could be a rich place to detect them, he said, since it's an equatorial area with rich biodiversity.

"Many of those spillovers are dead ends, they don't ever leave that first human host," Gray said.

"But if we really want to mitigate the threat, we need better surveillance where humans and animals intersect, and among people who are sick enough to get hospitalized for novel viruses."

Gray said diagnostic tools like the one developed to find this virus have the potential to identify other viruses new to humans before they can cause a pandemic.

"These pathogens don't just cause a pandemic overnight," Gray said. "It takes many years for them to adapt to the human immune system and cause infection, and then to become efficient in human-to-human transmission. We need to look for these pathogens and detect them early."

In addition to Gray and Vlasova, researchers included Annika Diaz, Teck-Hock Toh, Jeffrey Soon-Yit Lee and Linda J. Saif.

This work was supported by the U.S. Naval Medical Research Center-Asia, Vysnova Partners, Duke University's Global Health Institute and The Ohio State University.

CITATION: "Novel Canine Coronavirus Isolated from a Hospitalized Pneumonia Patient, East Malaysia," Anastasia N. Vlasova, Annika Diaz, Gregory C. Gray, Teck-Hock Toh, Jeffrey Soon-Yit Lee, Linda J. Saif, Debasu Damtie, Leshan Xiu. Clinical Infectious Diseases, May 20, 2021. DOI: 10.1093/cid/ciab456

https://bit.ly/3vepn4F

Challenging the standard model of cancer

New atavistic model shows role of ancient genes in the spread of cancer

In spite of decades of research, cancer remains an enigma. Conventional wisdom holds that cancer is driven by random mutations that create aberrant cells that run amok in the body.

In a new paper published this week in the journal *BioEssays*, Arizona and Australian researchers challenge this model by proposing that cancer is a type of genetic throwback, that progresses via a series of reversions to ancestral forms of life. In contrast with the conventional model, the distinctive capabilities of cancer cells are not primarily generated by mutations, the researchers claim, but are pre-existent and latent in normal cells.

Regents' Professor Paul Davies, director of Arizona State University's Beyond Center for Fundamental Concepts in Science and Kimberly Bussey, cancer geneticist and bioinformatician from the Precision Medicine Program at Midwestern University, Glendale, Ariz., teamed up with Charles Lineweaver and Anneke Blackburn at the Australian National University (ANU) in Canberra to refine what they call the Serial Atavism Model (SAM) of cancer. This model suggests that cancer occurs through multiple steps that resurrect ancient cellular functions.

Such functions are retained by evolution for specific purposes such as embryo development and wound healing, and are usually turned off in the adult form of complex organisms. But they can be turned back on if something compromises the organism's regulatory controls. It is the resulting resurrection steps, or atavistic reversions, that are mostly responsible for the ability of cancer cells to survive, proliferate, resist therapy and metastasize, the researchers said.

Davies and Bussey are also members of ASU's Arizona Cancer Evolution Center (ACE) which seeks to understand cancer, not just

in humans, but across all complex species, in the light of evolutionary processes.

"Cancer research has been transformed in recent years by comparing genetic sequences across thousands of species to determine gene ages," Davies said. Just as geologists can date rock strata, so geneticists can date genes, a technique known as phylostratigraphy.

"The atavistic model predicts that the genes needed for cancer's abilities are mostly ancient - in some cases little changed over billions of years," Davies added.

Lineweaver explained, "In biology, nothing makes sense except in the light of evolution, and in the case of cancer nothing makes sense except in the light of the deep evolutionary changes that occurred as we became multicellular organisms."

"The atavistic model of cancer has gained increasing traction around the world," added Bussey. "In part, this is because it makes many predictions that can be tested by phylostratigraphy, unlike the conventional somatic mutation theory."

Blackburn, a cancer biologist in ANU's John Curtin School of Medical Research, agreed.

"Appreciation of the importance of gene ages is growing among oncologists and cancer biologists," she said. "Now we need to use this insight to develop novel therapeutic strategies. A better understanding of cancer can lead to better therapeutic outcomes."

https://go.nature.com/3oHRG8X

Our radical changes to Earth's greenery began long ago — with farms, not factories

Humanity's imprint on plant species and abundance began roughly 4,000 years ago, when agriculture took off.

Human activity began to transform the number and variety of plant species on Earth thousands of years ago, long before the Industrial Revolution, and might have had an even greater impact on vegetation than did the last ice age.

Ice entombed much of the planet from roughly 115,000 to some 20,000 years ago. Then, massive glaciers around the world started to retreat and global temperatures rose, resulting in dramatic alterations to Earth's ecosystems.

To investigate how the abundance and composition of global vegetation changed after that thaw, Ondřej Mottl and Suzette Flantua at the University of Bergen in Norway and their colleagues analysed 1,181 fossilized pollen samples from the past 18,000 years. The pollen came from all continents except Antarctica.

The researchers found that global vegetation has been transformed, first by the climate changes that accompanied the end of the last glacial period. However, starting about 4,000 years ago, when agriculture intensified, the pace of change in global vegetation accelerated, reaching or exceeding the rate of change at the end of the most recent ice age. *Science* (2021)

https://wb.md/3uePkQj

Sardines Linked to Reduced Type 2 Diabetes Risk

Those who ate a diet rich in sardines for 1 year show significant reductions in risk of developing type 2 diabetes

Nancy A. Melville

Older people with prediabetes who followed a diet rich in sardines for 1 year show significant reductions in risk of developing type 2 diabetes compared with those placed on a similarly healthy diet but without the sardines, results from a new randomized trial show.

"A 1-year, sardine-enriched type 2 diabetes-preventive diet in an elderly population with prediabetes exerts a greater protective effect against developing type 2 diabetes and cardiovascular events, by improving anthropometric parameters, blood chemistry profile, lipid composition in erythrocytes membranes, and metabolomics data," report the authors in research published in *Clinical Nutrition* by Diana Díaz-Rizzolo, PhD, of the Hospital Clinic of Barcelona,

Spain, and colleagues.

While cardiovascular and other health benefits of unsaturated fats in oily fish are well-established and are a key component in diets such as the highly recommended Mediterranean diet, the authors note that the consumption of sardines for the prevention of type 2 diabetes has not previously been studied.

In addition to being rich in healthy omega-3 fatty acids, sardines have high concentrations of taurine — approximately 147 mg per 100 g serving — which, depending on the sardine species, is believed to have hypoglycemic, antioxidant, and anti-inflammatory benefits, the authors note.

Participants Advised to Consume the Whole Sardine, Bones and All

To evaluate the effects, researchers enrolled 152 patients aged 65 and older who had been diagnosed with prediabetes (blood glucose levels between 100-124 mg/dL) and placed them all on a nutritional program to reduce the risk of diabetes for 1 year.

In addition, about half (n = 75) were also instructed to consume 200 g of canned sardines in olive oil per week, in 100 g servings consumed twice per week. Those participants were recommended to consume the entire sardine, without removal of bones, due to their rich content of calcium and vitamin D. They were also provided with recipes that used canned sardines.

At 1 year, the percentage of participants classified as being at a very high risk of type 2 diabetes, assessed by the Finnish Diabetes Risk Score (FINDRISC), compared with baseline, had declined to a much greater degree in the sardine consumption group (37% at baseline vs 8% at 1 year) compared with those in the control group, who only consumed the nutritional diet (27% vs 22%) (P = .021).

In addition, those in the sardine group had greater increases in healthy HDL cholesterol and the glucose-regulating protein hormone adiponectin, with decreases in triglycerides compared with the nonsardine group (all P < .005).

Furthermore, the sardine consumption group had a greater decrease in insulin resistance, assessed by Homeostatic Model Assessment for Insulin Resistance (HOMA-IR; P = .032).

Sardines Are Cheap and Reduce Blood Pressure Too

"Not only are sardines reasonably priced and easy to find, but they are safe and help to prevent the onset of type 2 diabetes," said Díaz-Rizzolo in a press statement.

Those in the sardine group also showed significant decreases in systolic blood pressure (P = .014) and diastolic blood pressure (P = .020) versus baseline, while no significant changes were observed in the control group. The authors suggest that sardines' rich taurine concentrations could play a role in those effects.

"Previously, only lean fish consumption had demonstrated an improvement in blood pressure, not fatty fish consumption, perhaps because the species studied excluded those with a higher taurine content such as sardines," they speculate.

In addition to showing improvements in levels of taurine, those in the sardine group also showed increases in nutrients that have been linked to health benefits, including omega-3 EPA and DHA, vitamin D, and fluorine (all P < .05).

The authors note that the increases could be attributed to sardines' rich concentration of those nutrients, as well as to the olive oil that is present in the sardine can.

Some Benefits Seen in Both Groups

The patients in the study were a mean age of 71 and had been in a prediabetic state for an average of 4.8 years at the beginning of the study. They were 55% male and there were no other significant differences in characteristics between the groups.

While the conversion from being prediabetic to type 2 diabetes in the adult population has been reported to be about 10.6%, and the risk has been observed to be even higher in the 65 and older

population, rates were lower than that in both groups.

"At the end of our 1-year study, we observed a [rate of] new-onset type 2 diabetes of 2.7% and 5.2% in the sardine group and control group, respectively," the authors note. They add the differences were not statistically significant.

Both the sardine consumption and control groups showed significant reductions in A1c versus baseline (P = .011 and P = .010, respectively), as well as significant reductions in glucose fasting concentrations (P = .020 and P = .040, respectively).

And while the sardine group showed greater improvements in HDL versus the control group (P = .045), only the control group showed a significant decrease in total cholesterol versus baseline (P = .032). Both groups showed improvements in the management of body weight, body mass index, and waist and hip circumference, in addition to improvement in body composition — despite no physical activity components in the programs, the authors note.

"This is probably because both groups followed the same base type 2 diabetes-preventive diet, with the one exception of sardine supplementation, and, although they did not modify their physical activity, both groups reduced their daily caloric intake through food," the authors note.

The possibility of reducing diabetes risk through dietary changes as opposed to weight loss is especially important in the older population, the authors note, as some studies suggest a link between weight loss in the elderly and an increased risk of mortality.

In a second phase of the study, the researchers say they are evaluating the effect of sardines on the intestinal microbiota, "since it affects the regulation of many biological processes, and we need to understand if they have played a part in this protective effect against type 2 diabetes," Díaz-Rizzolo concluded.

The study was funded by RecerCaixa 2013. The authors report that " no industry sponsorship was received for this work that could have influenced its outcome. "
Clin Nutr. 2021;40:2587-2598. Abstract

https://bit.ly/3woBiNt

First we tamed turnips, then we turned them into bok choy and other veggies

Humans likely domesticated turnips near the Hindu Kush mountains, near present day Afghanistan, 3,500 to 6,000 years ago before spreading them east and west and breeding them into related vegetables like bok choy and broccoli rabe.

by Eric Hamilton, University of Wisconsin-Madison

This is according to new research representing the most complete look yet at how humans domesticated the ubiquitous species Brassica rapa. The findings untangle the complex web of domestication in this species, which can help researchers better understand evolution in general. They may also provide information for preserving important genetic resources as climate change and new pests threaten some crops.

Nine examples of domesticated Brassica rapa, a single species that humans have bred into root vegetables like turnips, leafy greens like bok choy, and oil seeds. **Credit: Alex McAlvay**

University of Wisconsin–Madison Professor of Botany Eve Emshwiller and her former graduate student Alex McAlvay led the research, which was published April 30 in the journal *Molecular Biology and Evolution*.

By sequencing the DNA of more than 400 different varieties of Brassica rapa from around the world, they identified both the Hindu Kush as the likely center of domestication, and weeds from the Caucasus region as among the most likely wild relatives of the species' vegetable crops.

The true identities of these wild relatives—which have been hidden

for years because of the tangled web of family relationships in the species—provide valuable information to evolutionary biologists and crop breeders alike.

"We might want this information in order to conserve those wild relatives, so they don't disappear in the course of habitats being lost," says Emshwiller. Wild plants can confer valuable traits when crossed with crops, which typically lose their hardiness during domestication.

"And domestication is a good way to study evolution in general," Emshwiller adds. "If we understand how crops evolved under human influence, that can help us extrapolate to how wild plants might evolve under different kinds of selection."

Much like how Labradors, Chihuahuas and pugs are all the same species of dog, Brassica rapa takes the form of dozens of unique-looking varieties, such as turnips or cooking greens, that are all very closely related. Today, these domesticated varieties are widespread in grocery stores, and weeds of the same species have also colonized most of the world.

Although it's long been known that dogs descended from wolves, the history of Brassica rapa is much murkier. Past research has variously located the original domestication event as taking place in Europe, West Asia, Central Asia or East Asia. And it's remained unclear if turnips or oilseeds were the first tamed varieties.

This confusion has stemmed from the ubiquity of Brassica rapa and its many weedy forms, which could be truly wild or merely escaped crops turned feral. While wild and feral forms look similar, their genetic histories are vastly different.

"In this work we used more than 400 samples (of the species), so we had a broader data set than had been used previously. And we also had more wild collections than had been used previously," says McAlvay, now an assistant curator at the New York Botanical Garden. "Having enough of those non-cultivated forms allowed us to distinguish between those feral or escaped weeds and the ones that are likely truly wild."

The genetic sequences of these varieties allowed McAlvay and his collaborators to reconstruct an evolutionary tree of the species. From this tree, they discovered that Central Asian turnips were the most genetically diverse crops. That in turn suggested that humans in the region likely initially selected for the fatter, starch-rich taproots that became turnips several thousand years ago, as agriculture took root around the world.

Ancient literary references to turnips in the region, and the apparent existence of the word for "turnip" in the ancestor of languages from the region, also supported the turnip as the original domesticated form.

Turnips then spread west to Europe and east to East Asia, where farmers later selected for larger leaves. These leafy versions became bok choy, napa cabbage and broccoli rabe, among other vegetables found today.

"That parallel selection for leafy forms is interesting and gives us an evolutionary system to compare how this leafiness trait can arise," says McAlvay. Other farmers selected other lineages for their oil-rich seeds.

From their hundreds of samples, the ones that appeared to be truly wild came mostly from the Caucasus region between Turkey and Russia. Two other wild relatives were isolated in Italy and Siberia, but they may have spread there from the Caucasus.

"We now know an important area to target for conservation of the wild relatives," McAlvay says.

The researchers also modeled the habitat suitability of wild Brassica rapa 6,000 years ago, around the time the species was domesticated. Past climates would have supported the species primarily in mountainous regions extending from East Asia to Western Europe, including the Caucasus and Hindu Kush regions,

providing ample opportunity for humans to spread the species far and wide.

Going forward, the researchers want to include more weedy samples from the Hindu Kush region in particular. As the site of domestication, the region should continue to host wild versions of Brassica rapa.

In addition to the opportunities for conservation and better methods for studying domestication and evolution, McAlvay says there's a simple joy in understanding how that veggie on the grocery store shelf got to where it is.

"It's fun to know where your crops are from," he says.

More information: *Alex C McAlvay et al, Brassica Rapa domestication: untangling wild and feral forms and convergence of crop morphotypes, Molecular Biology and Evolution (2021). DOI: 10.1093/molbev/msab108*

https://bit.ly/3oI0ziP

Providing medications for free leads to greater adherence and cost-savings, study shows

Increases patient adherence by 35% and reduces total health spending by an average of over $1,000 annually

Free access to essential medicines increases patient adherence to taking medication by 35 per cent and reduces total health spending by an average of over $1,000 per patient per year, according to a two-year study that tested the effects of providing patients with free and convenient access to a carefully selected set of medications.

The findings, published May 21 in *PLOS Medicine*, come as advocates urge Canada to carve a path toward single-payer, public pharmacare. Canada is the only country with universal healthcare that does not have a universal pharmacare program.

A group of researchers led by St. Michael's Hospital of Unity Health Toronto recruited a total of 786 patients across nine primary care sites in Ontario who reported cost-related non-adherence to medications. Most of the study participants were recruited from St. Michael's Department of Family and Community Medicine and others were recruited from three rural sites. Participants were randomized into two groups - half received free medications via mail, the other half had their usual access to medications.

Two years into the study, adherence to all appropriate prescribed medicines was 35 per cent higher in the free distribution group compared with the group that had usual access to medications. Free distribution of medication also showed to reduce healthcare costs, including hospitalization, by an average of $1,222 per patient per year.

"The cost savings are substantial, but they are less important than people simply being able to afford taking lifesaving medications," said Dr. Nav Persaud, a scientist at the Li Ka Shing Knowledge Institute of St. Michael's and lead author of the study.

"This is the first study of providing people with free access to a comprehensive set of medicines, and hopefully it will be the last one needed before policy changes," said Dr. Persaud, who is also a family physician at St. Michael's Hospital.

In June 2019, the Advisory Council on the Implementation of National Pharmacare recommended a universal, single-payer, public pharmacare, estimating such a program would save Canada an estimated $5 billion per year. The report cited a list of medicines like the one used in the CLEAN Meds study as "a starting point" for determining which drugs all Canadians should have free access to.

The CLEAN Meds Trial focused on 128 essential medicines, adapted from the WHO Model List of Essential Medicines and removed treatments not needed in Canada. The medicines in the study included treatments for acute conditions, such as antibiotics and pain relievers, as well as chronic conditions, such as antipsychotics and HIV-AIDS medications.

The paper is the final result of the CLEAN Meds Trial. Preliminary results of the trial after one year of free medication indicated

improved adherence, improvements in some health outcomes, and that free distribution of essential medicines led to a 160 per cent increase in the likelihood of participants being able to make ends meet.

https://bit.ly/3v8zLLb

Rare 4000-year comets can cause meteor showers on Earth

Potentially hazardous comets that were last near Earth orbit as far back as 2,000 BC

Comets that circle the Sun in very elongated orbits spread their debris so thin along their orbit or eject it out of the solar system altogether so that their meteor showers are hard to detect. From a new meteor shower survey published in the journal *Icarus*, researchers now report that they can detect showers from the debris in the path of comets that pass close to Earth orbit and are known to return as infrequently as once every 4,000 years.

"This creates a situational awareness for potentially hazardous comets that were last near Earth orbit as far back as 2,000 BC," said meteor astronomer and lead author Peter Jenniskens of the SETI Institute.

Jenniskens is the lead of the Cameras for Allsky Meteor Surveillance (CAMS) project, which observes and triangulates the visible meteors in the night sky using low- light video security cameras to measure their trajectory and orbit. There are CAMS networks now in nine countries, led by co-authors on the paper.

In recent years, new networks in Australia, Chile and Namibia significantly increased the number of triangulated meteors. The addition of these networks resulted in a better and more complete picture of the meteor showers in the night sky.

"Until recently, we only knew five long-period comets to be parent bodies to one of our meteor showers," said Jenniskens, "but now we identified nine more, and perhaps as many as 15."

Comets comprise only a small fraction of all impactors on Earth, but researchers believe they caused some of the biggest impact events over Earth's history because they can be big and because of the fact that their orbits are such that they can impact at high speed.

April 22, 2021, Lyrid meteor shower radiants in CAMS data (yellow dots) from long-period comet Thatcher. Credit: P. Jenniskens / SETI Institute.

"In the future, with more observations, we may be able to detect fainter showers and trace the orbit of parent comets on even longer orbits," said Jenniskens.

Every night, the CAMS network determines the direction from which comet debris is entering Earth's atmosphere. Maps are created on an interactive celestial sphere (posted at http://cams.seti.org/FDL/) that shows the meteor showers as colored blobs. Clicking on those blobs shows the measured orbits in the solar system.

"These are the shooting stars you see with the naked eye," said Jenniskens. "By tracing their approach direction, these maps show the sky and the universe around us in a very different light."

An analysis of the data found that long-period comet meteor showers can last for many days.

"This was a surprise to me," says Jenniskens. "It probably means that these comets returned to the solar system many times in the past, while their orbits gradually changed over time."

Data also revealed that the most dispersed meteor showers show the highest fraction of small meteoroids.

"The most dispersed showers are probably the oldest ones," says Jenniskens. "So, this could mean that the larger meteoroids fall apart into smaller meteoroids over time."

More information: *Peter Jenniskens et al, Meteor showers from known long-period comets, Icarus (2021).* *DOI: 10.1016/j.icarus.2021.114469*

https://wb.md/3fIIvkL

Ob/gyn Sentenced to 59 Years for Unnecessary Surgeries, Fraud

A federal judge sentenced Javaid Perwaiz, MD, to 59 years in prison for healthcare fraud and performing unnecessary gynecologic and obstetrical procedures, including sterilizations without patients' consent.

Alicia Ault

Judge Rebecca Smith of the US District Court, Eastern District of Virginia, handed down the sentence, telling the physician, "This [was] an overwhelming amount of fraud at every point. It was done for greed and to enhance your lavish lifestyle and you have shown no remorse," according to WAVY-TV in Chesapeake, Virginia.

Perwaiz owned at least four Mercedes Benz cars and a Bentley automobile, multiple properties, gold, and hundreds of thousands of dollars in cash and retirement accounts when he was arrested, according to federal prosecutors.

The physician's attorney, Joseph R. Pope, told *Medscape Medical News* that the Perwaiz maintains his innocence and will appeal his conviction and sentencing.

Perwaiz had practiced in the Hampton Roads, Virginia, area since the 1980s, according to the US District Attorney. He is believed to be 71, but the federal investigation determined that he used multiple birth dates on various documents, so his exact age is uncertain.

Federal prosecutors alleged in their 2019 indictment that, beginning in 2010, Perwaiz submitted at least $21 million in false claims for hysteroscopies, colposcopies, vaginal and abdominal hysterectomies, dilation and curettage (D&Cs), lysis of adhesions, salpingo-oophorectomies, myomectomies, and cystectomies, and that he pressured patients into having procedures that were not appropriate or necessary.

"Motivated by his insatiable and reprehensible greed, Perwaiz used an arsenal of horrifying tactics to manipulate and deceive patients into undergoing invasive, unnecessary, and devastating medical procedures," said Raj Parekh, the acting US Attorney for the Eastern District of Virginia, in a statement.

Parekh said the "fraudulent and destructive surgeries caused irreversible damage to the victims," including rendering them sterile "by using fear to remove organs from their bodies that he had no right to take."

Perwaiz falsely told women they had cancer or that they would develop cancer, according to Parekh and former patients. Twenty-five former patients testified at the physician's trial last November, in which a jury convicted him on 52 counts.

At Perwaiz's 2019 detention hearing, Shamai Watkins, 44, of Portsmouth, said the physician had performed eight or nine surgical procedures on her between 1998 and 2013, including a hysterectomy when she was in her mid-30s, according to the Associated Press. Watkins said the ob/gyn told her she was incapable of conceiving because she had cancerous cells, the AP reported. More than 60 individuals submitted victim impact statements to the court.

In addition, nurses who had worked with Perwaiz testified and noted that they had complained about his practices to supervisors at hospitals where he had admitting privileges.

The Associated Press reported that federal agents began investigating Perwaiz in 2018, after a hospital worker submitted a tip that he was performing unnecessary surgeries on unsuspecting patients. The worker said Perwaiz's patients would often tell hospital staff they were there for "annual clean outs."

Federal prosecutors submitted evidence that Perwaiz falsified obstetric records to ensure that he would be reimbursed even though he induced labor early, before the recommended gestational age. The doctor also backdated Medicaid paperwork to make it

appear he had complied with the program's required 30-day waiting period for sterilizations.

Perwaiz faced a maximum penalty of 465 years in prison, according to the US Attorney's Office. Federal prosecutors sought a 50-year term, WAVY reported.

Perwaiz graduated from Nishtar Medical College, University of Health Sciences in Lahore, Pakistan, in 1974, Medscape reported when he was arrested. He was first licensed in Virginia in 1980.

State records show a history of disciplinary actions, starting in 1984, when the Virginia State Board of Medicine put him on notice that they were looking into at least 14 complaints that he had performed inappropriate or unnecessary hysterectomies. Perwaiz also admitted at that time that he had engaged in a sexual relationship with a patient. The board censored him, but only for "lack of documentation of patient records."

In 1996, Perwaiz pled guilty to tax evasion, which led to an automatic revocation of his license. His license was reinstated later that year, but he was placed on probation.

In 1999, the Virginia medical board determined that Perwaiz had met its terms and his license was fully reinstated.

No other actions are listed, despite his arrest and conviction. The Virginia Department of Health Professions states that Perwaiz's license expired in March 2020.

https://bit.ly/3v8DuZb

Salts could be important piece of Martian organic puzzle, scientists find

Organic salts on Mars could be remnants of ancient microbial life

A NASA team has found that organic salts are likely present on Mars. Like shards of ancient pottery, these salts are the chemical remnants of organic compounds, such as those previously detected by NASA's Curiosity rover. Organic compounds and salts on Mars could have formed by geologic processes or be remnants of ancient microbial life.

Besides adding more evidence to the idea that there once was organic matter on Mars, directly detecting organic salts would also support modern-day Martian habitability, given that on Earth, some organisms can use organic salts, such as oxalates and acetates, for energy.

"If we determine that there are organic salts concentrated anywhere on Mars, we'll want to investigate those regions further, and ideally drill deeper below the surface where organic matter could be better preserved," said James M. T. Lewis, an organic geochemist who led the research, published on March 30 in the *Journal of Geophysical Research: Planets*. Lewis is based at NASA's Goddard Space Flight Center in Greenbelt, Maryland.

Lewis's lab experiments and analysis of data from the Sample Analysis at Mars (SAM), a portable chemistry lab inside Curiosity's belly, indirectly point to the presence of organic salts. But directly identifying them on Mars is hard to do with instruments like SAM, which heats Martian soil and rocks to release gases that reveal the composition of these samples. The challenge is that heating organic salts produces only simple gases that could be released by other ingredients in Martian soil.

However, Lewis and his team propose that another Curiosity instrument that uses a different technique to peer at Martian soil, the Chemistry and Mineralogy instrument, or CheMin for short, could detect certain organic salts if they are present in sufficient amounts. So far, CheMin has not detected organic salts.

Finding organic molecules, or their organic salt remnants, is essential in NASA's search for life on other worlds. But this is a challenging task on the surface of Mars, where billions of years of radiation have erased or broken apart organic matter. Like an archeologist digging up pieces of pottery, Curiosity collects Martian soil and rocks, which may contain tiny chunks of organic

compounds, and then SAM and other instruments identify their chemical structure.

Using data that Curiosity beams down to Earth, scientists like Lewis and his team try to piece together these broken organic pieces. Their goal is to infer what type of larger molecules they may once have belonged to and what those molecules could reveal about the ancient environment and potential biology on Mars.

"We're trying to unravel billions of years of organic chemistry," Lewis said, "and in that organic record there could be the ultimate prize: evidence that life once existed on the Red Planet."

While some experts have predicted for decades that ancient organic compounds are preserved on Mars, it took experiments by Curiosity's SAM to confirm this. For example, in 2018, NASA Goddard astrobiologist Jennifer L. Eigenbrode led an international team of Curiosity mission scientists who reported the detection of myriad molecules containing an essential element of life as we know it: carbon. Scientists identify most carbon-containing molecules as "organic."

"The fact that there's organic matter preserved in 3-billion-year-old rocks, and we found it at the surface, is a very promising sign that we might be able to tap more information from better preserved samples below the surface," Eigenbrode said. She worked with Lewis on this new study.

Analyzing Organic Salts in the Lab

Decades ago, scientists predicted that organic compounds on Mars could be breaking down into salts. These salts, they argued, would be more likely to persist on the Martian surface than big, complex molecules, such as the ones that are associated with the functioning of living things.

If there were organic salts present in Martian samples, Lewis and his team wanted to find out how getting heated in the SAM oven could affect what types of gases they would release. SAM works by heating samples to upwards of 1,800 degrees Fahrenheit (1,000 degrees Celsius). The heat breaks apart molecules, releasing some of them as gases. Different molecules release different gases at specific temperatures; thus, by looking at which temperatures release which gases, scientists can infer what the sample is made of.

"When heating Martian samples, there are many interactions that can happen between minerals and organic matter that could make it more difficult to draw conclusions from our experiments, so the work we're doing is trying to pick apart those interactions so that scientists doing analyses on Mars can use this information," Lewis said.

Lewis analyzed a range of organic salts mixed with an inert silica powder to replicate a Martian rock. He also investigated the impact of adding perchlorates to the silica mixtures. Perchlorates are salts containing chlorine and oxygen, and they are common on Mars. Scientists have long worried that they could interfere with experiments seeking signs of organic matter.

Indeed, researchers found that perchlorates did interfere with their experiments, and they pinpointed how. But they also found that the results they collected from perchlorate-containing samples better matched SAM data than when perchlorates were absent, bolstering the likelihood that organic salts are present on Mars.

Additionally, Lewis and his team reported that organic salts could be detected by Curiosity's instrument CheMin. To determine the composition of a sample, CheMin shoots X-rays at it and measures the angle at which the X-rays are diffracted toward the detector.

Curiosity's SAM and CheMin teams will continue to search for signals of organic salts as the rover moves into a new region on Mount Sharp in Gale Crater.

Soon, scientists will also have an opportunity to study better-preserved soil below the Martian surface. The European Space Agency's forthcoming ExoMars rover, which is equipped to drill

down to 6.5 feet, or 2 meters, will carry a Goddard instrument that will analyze the chemistry of these deeper Martian layers. NASA's Perseverance rover doesn't have an instrument that can detect organic salts, but the rover is collecting samples for future return to Earth, where scientists can use sophisticated lab machines to look for organic compounds.

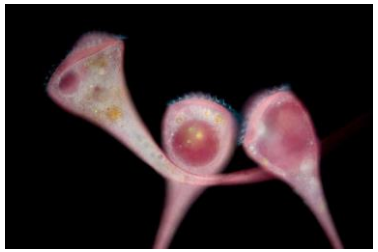
More information: *J. M. T. Lewis et al, Pyrolysis of Oxalate, Acetate, and Perchlorate Mixtures and the Implications for Organic Salts on Mars, Journal of Geophysical Research: Planets (2021). DOI: 10.1029/2020JE006803*

https://bit.ly/3fCxykJ

Can a Cell Make Decisions?

A series of experiments shows, remarkably, that it just might

By Jennifer Frazer



Stentor. **Credit: Wikimedia (CC BY 4.0)**

In 1906, zoologist Herbert Spencer Jennings published *Behavior of the Lower Organisms*, a book that contained a provocative idea: microbes can change their minds.

His subject was a single cell bristling with beating hairs called *Stentor*. These trumpet-shaped predators are so large fish can eat them and humans can see them, and so brazen they can catch and eat rotifers—proper animals with hundreds of cells and a simple brain. In the microbial galaxy, stentors lie somewhere between Star Destroyer and sarlacc pit.

Jennings decided to annoy it and see what happened. When confronted with a stream of irritating carmine powder expertly aimed at their mouths by his steady hand, *Stentor* would first bend away, then reverse the beating of its hairs (called cilia) to expel the powder, then contract and finally detach.

He noted that the order of behaviors varied somewhat with different stimuli (he tried other chemicals) and steps were sometimes omitted. "But it remains true," he wrote, "that under conditions which gradually interfere with the normal activities of the organism, the behavior consists in 'trying' successively different reactions, till one is found that affords relief."

In short, stentors could confront a stimulus with one behavior, and then choose a costlier approach if the irritant persisted. At least for a short while (a period that Jennings declared difficult to determine experimentally and still unresolved), it could "remember" that it had tried one solution without success, and opt for another.

But in 1967, scientists from a different school of animal behavior repeated his experiment and failed to produce the same result. And with that, Jennings's findings were consigned to the dustbin.

Then about 10 years ago, Jeremy Gunawardena, an associate professor of systems biology at Harvard Medical School, discovered the experiment and its defenestration and decided that it deserved another look. To his surprise, he discovered the 1967 team had not used the correct species of *Stentor* (being behaviorists who believed variation flowed from the environment and not genes, they might have felt the species didn't matter). The one they had chosen, *Stentor coeruleus*, strongly prefers to swim, unlike Jennings's *Stentor roeselii*, which prefers to chill poolside.

Gunawardena became fascinated by what replicating the experiment might reveal about what single cells are capable of. After years of dangling the idea fruitlessly at lab meetings, he found undergrad Joseph Dexter and postdoc Sudhakaran Prabakaran were willing to give it a try at night and on weekends—with no funding.

This time, the Harvard team managed to track down the correct species in an English golf course pond, construct their own "Device for Irritating *Stentors*" (being quantitative biologists, they lacked Jennings's extreme pipette skills), and discovered something extraordinary.

In their setup, *Stentor* did not respond to carmine powder the way Jennings described. However, when faced with barrages of 21st-century plastic microbeads, individual *Stentor roeseli* behaved consistent with Jennings's description—and in one remarkable way that Jennings did not observe in 1906.

If Stentor really can "decide," it certainly isn't the only way the ciliates—the group of shaggy microbes to which *Stentor* belongs—resemble us. A ciliate operates like an animal at the scale of a single huge cell, and the resemblance can be startling.

For example, some glue bundles of their cilia into structures called cirri and can use them as legs, mouths, paddles or teeth. *Euplotes* skitters nimbly along surfaces atop cirri like some sort of *Close Encounters*–class water flea. The cirri are wired by nervelike neurofibrils. If the fibrils are cut, the cirri fall limp.

Some ciliates pack tiny tethered darts they can fire to attack prey, deter predators or simply drop anchor. Others sport tentacles that snag food. Like sea stars, ciliates can regenerate entire bodies within a day or two from shockingly tiny pieces provided those pieces contain both a bit of the cell's cilia-studded armor and a bit of nucleus, the cell's genetic heart. Many ciliates divide in the usual way by pinching in two, but some stalked or sessile ciliates push small round larvae into the world through a special birth canal.

Advertisement

One ciliate called *Diplodinium* lives in the rumen of cows and other hoofed animals, a special environment known to harbor all kinds of strange things, about half of which by mass may be ciliates (think about that next time you see a cow placidly chewing its cud). *Diplodinium* contains neurofibrils, cirri, musclelike striated contractile fibers called myonemes, a "backbone" made of stacked plates, a mouth, an esophagus that contracts with the help of a ring tethered to its exterior, and an anus. But remember: single cell.

In short, ciliates have taken the biology of the solo cell to its apparent earthly limit. Having something like a noggin in there is less credulity-stretching once you grasp this.

In the new study, published in the journal *Current Biology* in 2019, the scientists found that *Stentor* indeed switched behaviors in response to repeated puffs of beads, and the order of operations was generally consistent with Jennings's description. Detachment was always preceded by contraction, and mathematical analyses revealed cilia alternation or bending were far more likely to appear before contraction than after.

There is something else interesting about their data, which I encourage you to examine for yourself: it sure looks like stentors have personalities. Some repeatedly contracted and relaxed, or bent, contracted, then relaxed, seemingly willing to tolerate irritation—or to live dangerously. These were the optimists.

Some contracted once or just a few times, never to relax again. Others contracted and detached, and that was it. These were the pessimists (or perhaps just the ones with a more recent successful "door dash").

Some stentors always responded with one or two preferred behaviors, and never with others that they were surely just as biologically capable of performing. One indefatigable individual subjected to 13 bead blasts responded persistently with ciliary alternation or contraction, never bending or detachment.

Does *Stentor* possess something like agency—a capacity to make decisions? This study and Jennings' evidence certainly suggest so.

There was a final provocative finding. This team's statistical analysis revealed that the choice between contracting or detaching was consistent the probability of a fair coin toss. In other words, it seemed perfectly random.

There's only one problem: no known cellular mechanism can produce this result. That head scratcher remains both unreplicated and unexplained.

Perhaps it is time to let go of our preconceived notions of what cells are capable of because they are *only* cells, and the cells in our own soviet-style bodies are the equivalent of worker bees. The capabilities of wily, gunslinging, free-living cells may well exceed our dim primate imaginations.

https://bit.ly/2SjLhF8

COVID-19 mortality associated with 2 signs easily measured at home

Abnormal blood-oxygen levels and breathing rates are strong predictors of poor patient outcomes in-hospital, study shows

A study of 1,095 patients hospitalized with COVID-19 discovered that two easily measurable signs of health - respiration rate and blood-oxygen saturation - are distinctly predictive of higher mortality. Notably, the authors said, anyone who receives a positive COVID-19 screening test can easily monitor for these two signs at home.

This context is lacking in current guidance from the Centers for Disease Control and Prevention, which tells people with COVID-19 to seek medical attention when they experience overt symptoms such as "trouble breathing" and "persistent pain or pressure in the chest" - indications that may be absent even when respiration and blood oxygen have reached dangerous levels, the authors say.

"These findings apply to the lived experience of the majority of patients with COVID-19: being at home, feeling anxious, wondering how to know whether their illness will progress and wondering when it makes sense to go to the hospital," said Dr. Neal Chatterjee of the University of Washington School of Medicine.

Chatterjee and fellow cardiologist Dr. Nona Sotoodehnia were co-lead authors of the paper, which was to be published May 24 in the journal *Influenza and Other Respiratory Viruses*.

They said the findings suggest that, for some people with COVID-19, by the time they feel bad enough to come to the hospital, a window for early medical intervention might have passed.

"Initially, most patients with COVID don't have difficulty breathing. They can have quite low oxygen saturation and still be asymptomatic," said Sotoodehnia. "If patients follow the current guidance, because they may not get short of breath until their blood oxygen is quite low, then we are missing a chance to intervene early with life-saving treatment."

The researchers examined the cases of 1,095 patients age 18 and older who were admitted with COVID-19 to UW Medicine hospitals in Seattle or to Rush University Medical Center in Chicago. The study span was March 1 to June 8, 2020. The lone exclusions were people who chose "comfort measures only" at time of their admission.

While patients frequently had hypoxemia (low blood-oxygen saturation; 91% or below for this study) or tachypnea (fast, shallow breathing; 23 breaths per minute for this study), few reported feeling short of breath or coughing regardless of blood oxygen.

The study's primary measure was all-cause in-hospital mortality. Overall, 197 patients died in the hospital. Compared to those admitted with normal blood oxygen, hypoxemic patients had a mortality risk 1.8 to 4.0 times greater, depending on the patient's blood oxygen levels. Similarly, compared to patients admitted with normal respiratory rates, those with tachypnea had a mortality risk 1.9 to 3.2 times greater. By contrast, other clinical signs at admission, including temperature, heart rate and blood pressure, were not associated with mortality.

Nearly all patients with hypoxemia and tachypnea required supplemental oxygen, which, when paired with inflammation-reducing glucocorticoids, can effectively treat acute cases of COVID-19.

"We give supplemental oxygen to patients to maintain blood oxygen saturation of 92% to 96%. It's important to note that only

patients on supplemental oxygen benefit from the life-saving effects of glucocorticoids," Sotoodehnia said. "On average our hypoxemic patients had an oxygen saturation of 91% when they came into the hospital, so a huge number of them were already well below where we would've administered life-saving measures. For them, that care was delayed."

The findings have relevance for family-medicine practitioners and virtual-care providers, who typically are first-line clinical contacts for people who have received a positive COVID-19 test result and want to monitor meaningful symptoms.

"We recommend that the CDC and [World Health Organization] consider recasting their guidelines to account for this population of asymptomatic people who actually merit hospital admission and care," Chatterjee said. "But people don't walk around knowing WHO and CDC guidelines; we get this guidance from our physicians and news stories."

Sotoodehnia recommended that people with positive COVID-19 test results, particularly those at higher risk of adverse outcomes due to advanced age or obesity, buy or borrow a pulse oximeter and monitor for blood-oxygen below 92%. The clip-like devices fit over a fingertip and can be purchased for under $20.

"An even simpler measure is respiratory rate - how many breaths you take in a minute. Ask a friend or family member to monitor you for a minute while you're not paying attention to your breathing, and if you hit 23 breaths per minute, you should contact your physician," she said.

https://bit.ly/3oVhDCp

JUST IN: Wall Street Journal Report About Wuhan Lab Researchers Being Hospitalized in November 2019

Raises New Questions About Virus' Origins

By Sarah Rumpf May 23rd, 2021, 6:49 pm

A new report by the *Wall Street Journal* is raising new questions about the origins of the deadly Covid-19 virus, with newly released intelligence showing that three researchers from China's Wuhan Institute of Virology became sick enough to be hospitalized in November 2019, a month before the virus was first identified.

Researchers at the lab in Wuhan studied coronaviruses and other pathogens, leading to speculation that the lab could have been — even unintentionally — the origin of the virus that has killed millions of people worldwide and left many others with troubling long-term symptoms. China has adamantly denied these claims, but has been criticized for a lack of transparency on the issue.

According to the *WSJ*, the Wuhan lab employees were sick "with symptoms consistent with both Covid-19 and common seasonal illness."

Michael Gordon, one of the authors of the *WSJ* article, was on *CNN Newsroom* to discuss their reporting with **Pamela Brown**.

"No theory has been proven — fully proven," said Gordon, noting that the theory it originated with a bat, then infected another species of animal, and then humans, has "never been proven because they have not found any animals that have been contaminated with the virus."

The theory that it escaped from a lab was initially discounted as a conspiracy theory, and but we've found that there's a renewed effort to take a look at the lab theory, primarily because of circumstantial evidence, but significant circumstantial evidence.

Brown asked him for clarification about the evidence and what they had learned about the timeline.

"There were three researchers from the lab that, according to American intelligence, fell ill in November 2019, and were so ill that they went to a local hospital," Gordon replied. They could not say for sure that it was Covid-19 or seasonal flu, or what exactly caused their illnesses, "but circumstantially it's quite significant because the first known confirmed case of Covid-19 in

China is December 8th, so now here you have researchers in the lab going to the hospital just in the weeks prior to the known outbreak.

The U.S. government was very interested in this report, Gordon said, "because it could be a tell-tale sign that the virus escaped from the lab, not that it was a biological weapon or engineered by the Chinese, but perhaps they took a virus into the lab to work on a potential vaccine and it escaped."

"A number of scientists who previously discounted the lab theory are coming around to that view," Gordon continued, saying that he and his WSJ colleagues were "straight shooters" and "playing it down the middle and not taking an individual stance in this debate."

"I would also say," he concluded, "that China's own behavior in not sharing information on the safety record of the lab, or the tests that the lab researchers may have undergone to see whether they have antibodies, by not sharing a whole host of data about people who got sick in Wuhan province, and that behavior — withholding information — has led to suspicions of, well, maybe they have something to hide?"

Watch the video above, via CNN.