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After 7 years, a spent Falcon 9 rocket stage is on course to hit the Moon

The impact could offer scientists a peek at the selenology of the Moon.

Eric Berger

SpaceX launched its first interplanetary mission nearly seven years ago. After the Falcon 9 rocket's second stage completed a long burn to reach a transfer orbit, NOAA's Deep Space Climate Observatory began its journey to a Sun-Earth LaGrange point more than 1 million km from the Earth.

By that point, the Falcon 9 rocket's second stage was high enough that it did not have enough fuel to return to Earth's atmosphere. It also lacked the energy to escape the gravity of the Earth-Moon system, so it has been following a somewhat chaotic orbit since February 2015.

Now, according to sky observers, the spent second stage's orbit is on course to intersect with the Moon. According to Bill Gray, who writes the widely used Project Pluto software to track near-Earth objects, asteroids, minor planets, and comets, such an impact could come in March.

Earlier this month, Gray put out a call for amateur and professional astronomers to make additional observations of the stage, which appears to be tumbling through space. With this new data, Gray now believes that the Falcon 9's upper stage will very likely impact the far side of the Moon, near the equator, on March 4. More information can be found here.

Some uncertainties remain. As the object is tumbling, it is difficult to precisely predict the effects of sunlight "pushing" on the rocket stage and thus making slight alterations to its orbit. "These unpredictable effects are very small," Gray writes. But they will accumulate between now and March 4, and further observations are needed to refine the precise time and location of the impact.

This information is important because it will allow satellites presently orbiting the Moon, including NASA's Lunar Reconnaissance Orbiter and India's Chandrayaan-2 spacecraft, to collect observations about the impact crater. With the LCROSS mission, NASA deliberately impacted a spent rocket upper stage into the Moon in 2009 for this purpose. Although scientists are most keen to understand the presence of ice at the lunar poles, being able to observe the subsurface material ejected by the Falcon 9 rocket's strike could still provide some valuable data.

The dry mass of the Falcon 9's second stage is about 4 metric tons, and it should impact the Moon at a velocity of about 2.58 km/s.

It's likely that this will be the first time a piece of space hardware unintentionally strikes the Moon. Typically, during interplanetary missions, a rocket's upper stage is sent into a heliocentric orbit, keeping it away from the Earth and its Moon.

For launches of spacecraft intended to orbit the Earth, the best practice is to reserve enough fuel in a rocket's upper stage to return it to Earth's atmosphere, where it will burn up. This is what SpaceX and most Western rocket companies customarily do to help control debris in low Earth orbit. The Moon, of course, has no atmosphere for the stage to burn up in.

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New study calls into question the importance of meat eating in shaping our evolution

"Meat Made Us Human" Evolutionary Narrative Starts To Unravel

Quintessential human traits such as large brains first appear in *Homo erectus* nearly 2 million years ago. This evolutionary transition towards human-like traits is often linked to a major dietary shift involving greater meat consumption. A new study published today in the *Proceedings of the National Academy of*

Sciences, however, calls into question the primacy of meat eating in early human evolution. While the archaeological evidence for meat eating increases dramatically after the appearance of *Homo erectus*, the study authors argue that this increase can largely be explained by greater research attention on this time period, effectively skewing the evidence in favor of the "meat made us human" hypothesis.

"Generations of paleoanthropologists have gone to famously well-preserved sites in places like Olduvai Gorge looking for—and finding—breathtaking direct evidence of early humans eating meat, furthering this viewpoint that there was an explosion of meat eating after 2 million years ago," W. Andrew Barr, an assistant professor of anthropology at the George Washington University and lead author on the study, said. "However, when you quantitatively synthesize the data from numerous sites across eastern Africa to test this hypothesis, as we did here, that 'meat made us human' evolutionary narrative starts to unravel."

Barr and his colleagues compiled published data from nine major research areas in eastern Africa, including 59 site levels dating between 2.6 and 1.2 million years ago. They used several metrics to track hominin carnivory: the number of zooarchaeological sites preserving animal bones that have cut marks made by stone tools, the total count of animal bones with cut marks across sites, and the number of separately reported stratigraphic levels.

The researchers found that, when accounting for variation in sampling effort over time, there is no sustained increase in the relative amount of evidence for carnivory after the appearance of *H. erectus*. They note that while the raw abundance of modified bones and the number of zooarchaeological sites and levels all demonstrably increased after the appearance of *H. erectus*, the increases were mirrored by a corresponding rise in sampling intensity, suggesting that intensive sampling—rather than changes in human behavior—could be the cause.

"I've excavated and studied cut marked fossils for over 20 years, and our findings were still a big surprise to me," Briana Pobiner, a research scientist in the Human Origins Program at the Smithsonian's National Museum of Natural History and co-author on the study, said. "This study changes our understanding of what the zooarchaeological record tells us about the earliest prehistoric meat-eating. It also shows how important it is that we continue to ask big questions about our evolution, while we also continue to uncover and analyze new evidence about our past."

In the future, the researchers stressed the need for alternative explanations for why certain anatomical and behavioral traits associated with modern humans emerged. Possible alternative theories include the provisioning of plant foods by grandmothers and the development of controlled fire for increasing nutrient availability through cooking. The researchers caution that none of these possible explanations currently have a strong grounding in the archaeological record, so much work remains to be done.

"I would think this study and its findings would be of interest not just to the paleoanthropology community but to all the people currently basing their dieting decisions around some version of this meat-eating narrative," Barr said. "Our study undermines the idea that eating large quantities of meat drove evolutionary changes in our early ancestors."

In addition to Barr and Pobiner, the research team included John Rowan, an assistant professor of anthropology at the University of Albany; Andrew Du, an assistant professor of anthropology and geography at Colorado State University; and J. Tyler Faith, an associate professor of anthropology at the University of Utah.

More information: *No sustained increase in zooarchaeological evidence for carnivory after the appearance of, Proceedings of the National Academy of Sciences (2022). DOI: 10.1073/pnas.2115540119.*

https://bit.ly/3q6P2WS

Cracking Chimpanzee Culture – More Similar to Human Culture Than Often Assumed

Chimpanzees do not simply invent nut-cracking with tools, but need to learn such complex cultural behaviors from others

Chimpanzees don't automatically know what to do when they come across nuts and stones.

Researchers at the University of Zurich have now used field experiments to show that chimpanzees thus do not simply invent nut-cracking with tools, but need to learn such complex cultural behaviors from others.

Their culture is therefore more similar to human culture than often assumed.

Humans have a complex culture that enables them to copy behaviors from others. As such, human culture is cumulative, since skills and technologies accumulate over generations and become increasingly efficient or complex.

According to the zone of latent solutions hypothesis in Anthropology, chimpanzees do not learn in this way, but can reinvent cultural behaviors individually. UZH professor in the department of Anthropology Kathelijne Koops has now carried out novel field experiments in the Nimba Mountains of Guinea to show that this may not be the case.

Chimpanzee cracking a nut with stones. **Credit: Kathelijne Koops, UZH**

Four experiments with wild chimpanzees

The primatologist investigated whether wild chimpanzees can in fact invent a complex behavior like nut-cracking independently. The chimpanzees were presented with a series of four experiments. First, the chimps were presented with oil palm nuts and stones. Next, the researchers added a palm fruit to the experimental setup. In the third experiment, the nuts were cracked open and placed on top of the stones.

And finally, the chimps were presented with another, easier-to-crack species of nuts (*Coula*) together with stones.

The chimpanzees visited the nut-cracking experiments and explored the nuts and stones, yet they did not crack any nuts, even after more than a year of exposure to the materials.

A total of 35 chimpanzee parties (or sub-groups) visited the experiments, of which 11 parties closely investigated the experimental items. The chimpanzees were more likely to explore the experiments when visiting in bigger parties.

Only one female chimpanzee was observed eating from the palm fruit, but on no occasion did the chimpanzees crack or eat either oil palm or Coula nuts.

Shared evolutionary origin of cumulative culture

"Our findings suggest that chimpanzees acquire cultural behaviors more like humans and do not simply invent a complex tool use behavior like nut cracking on their own," says Koops.

The presence of a model from whom to learn appears to be the missing piece.

"Our findings on wild chimpanzees, our closest living relatives, help to shed light on what it is (and isn't!) that makes human culture unique. Specifically, they suggest greater continuity between chimpanzee and human cultural evolution than is normally assumed and that the human capacity for cumulative culture may have a shared evolutionary origin with chimpanzees."

Reference: "Field experiments find no evidence that chimpanzee nut cracking can be independently innovated" by Kathelijne Koops, Aly Gaspard Soumah, Kelly L. van Leeuwen, Henry Didier Camara and Tetsuro Matsuzawa, 24 January 2022, Nature Human Behaviour. DOI: 10.1038/s41562-021-01272-9

https://bit.ly/32ERYqF

Lots of People Die Every Year During or After Having Sex. A Pathologist Explains Why

Sex has many beneficial effects, but people sometimes die during or shortly after sex

David C Gaze, The Conversation

Sex has many beneficial physical and psychological effects, including reducing high blood pressure, improving the immune system and aiding better sleep.

The physical act of sex and orgasm releases the hormone oxytocin, the so-called love hormone, which is important in building trust and bonding between people.

But there's a dark side: people sometimes die during or shortly after sex. The incidence is, thankfully, extremely low and accounts for 0.6 percent of all cases of sudden death.

There are many reasons why this happens to people. In most cases, it is caused by the physical strain of the sexual activity, or prescription drugs (drugs to treat erectile dysfunction, for example), or illegal drugs, such as cocaine – or both.

The risk of any sudden cardiac death is higher as people age. A forensic postmortem study from Germany of 32,000 sudden deaths over a 33-year period found that 0.2 percent of cases occurred during sexual activity. Sudden death occurred mostly in men (average age 59 years) and the most frequent cause was a heart attack, also known as myocardial infarction. Studies of sudden cardiac death and sexual activity from the US, France and South Korea show similar findings.

Not just the middle-aged men

Recently, however, researchers at St George's, University of London, found that this phenomenon is not just limited to middle-aged men. The study, which is published in *JAMA Cardiology*, investigated sudden cardiac death in 6,847 cases referred to the center for cardiac pathology at St George's between January 1994 and August 2020.

Of these, 17 (0.2 percent) occurred either during or within one hour of sexual activity. The average (mean) age of death was 38 years, and 35 percent of the cases occurred in women, which is higher than in previous studies.

These deaths were typically not caused by heart attacks, as seen in older men. In half of the cases (53 percent), the heart was found to be structurally normal and a sudden abnormal heart rhythm called sudden arrhythmic death syndrome or SADS was the cause of death.

Aortic dissection was the second largest cause (12 percent). This is where the layers in the wall of the large artery from the heart supplying blood around the body tear and blood flows between the layers causing it to bulge and burst.

The remaining cases were due to structural anomalies such as cardiomyopathy (a disease of the heart muscle that makes it harder for the heart to pump blood to the rest of your body), or from a rare group of genetic conditions known as channelopathies.

This is where the ion channels that let sodium and potassium in and out of the cells in the heart muscle don't work properly. The change to the sodium and potassium in the cells can alter the electrical current through the heart muscle and change the way it beats.

An altered heart rhythm can cause a lack of oxygen (myocardial ischemia) and can lead to a sudden cardiac arrest where the heart stops beating.

This new study suggests that sudden cardiac death in people under the age of 50 is mainly due to sudden arrhythmic death syndrome or cardiomyopathies. Younger adults who have been diagnosed with these conditions should seek advice from their cardiologist on the risk associated with sexual activity.

However, the low incidence of death in these studies suggests the risk is very low – even in people with existing heart conditions.

https://bit.ly/3q2kCFh

'Burning' hydrogen plasma in the world's largest laser sets fusion records

Experiment spit out 10 quadrillion watts of power in a split second.

By Tom Metcalfe

The secret behind a record-breaking nuclear fusion experiment that spit out 10 quadrillion watts of power in a split second has been revealed: a "self-heating" — or "burning" — plasma of neutron-heavy hydrogen inside the fuel capsule used in the experiment, according to researchers.

Last year, scientists at the Lawrence Livermore National Laboratory in Northern California announced the record release of 1.3 megajoules of energy for 100 trillionths of a second at the National Ignition Facility (NIF), Live Science reported at the time. In two new research papers, NIF scientists show the achievement was due to the precision engineering of the tiny cavity and fuel capsule at the heart of the world's most powerful laser system, where the fusion took place.

Although the fuel capsule was only about a millimeter (0.04 inch) across, and the fusion reaction lasted only the briefest sliver of time, its output was equal to about 10% of all the energy from sunlight that hits Earth every instant, the researchers reported.

The researchers said the reaction blasted out that much energy because the process of fusion itself heated the remaining fuel into a plasma hot enough to enable further fusion reactions.

"A burning plasma is when heating from the fusion reactions becomes the dominant source of heating in the plasma, more than required to initiate or jump-start the fusion," Annie Kritcher, a physicist at the Lawrence Livermore National Laboratory (LLNL), told Live Science in an email. Kritcher is the lead author of a study published Jan. 26 in Nature Physics describing how the NIF was optimized to achieve the burning plasma, and the co-author of another study published in Nature the same day that details the first burning plasma experiments at NIF in 2020 and early 2021.

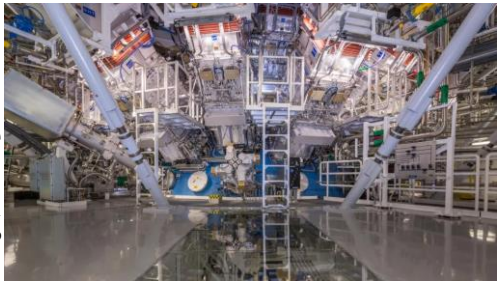
Star in a jar

Nuclear fusion is the process that powers stars like the sun. It's different from nuclear fission, which is used in power plants here on Earth to generate energy by splitting heavy atomic nuclei — like plutonium — into smaller atomic nuclei.

Nuclear fusion releases vast amounts of energy when atomic nuclei are "fused" — that is, joined together — into larger nuclei.

The simplest types of fusion are fueled by hydrogen, and researchers hope nuclear fusion can one day be developed into a relatively "clean" power source using the abundant hydrogen in Earth's oceans.

Because stars are very large, their strong gravity means the fusion reactions take place at very high pressures. But here on Earth such pressures aren't feasible — and so fusion reactions must take place at very high temperatures instead. (In a given volume, as the temperature of a gas increases, so does the pressure, and vice versa, according to Gay-Lussac's law.)



The NIF's 192 laser beams converge at the center of a spherical chamber in the Target Bay, which also served as a set for the engine room of the Starship Enterprise in the 2013 film "Star Trek: Into Darkness." **(Image credit: Damien Jemison)**

Different experimenters suggest different methods for maintaining a fusion reaction at high temperatures, and the National Ignition Facility specializes in an approach called "inertial confinement." It creates high temperatures by hitting a tiny pellet of hydrogen at the center using 192 high-powered lasers, which themselves consume

huge amounts of energy and can only be fired once every day or so. The inertial confinement approach was pioneered for testing thermonuclear weapons, and it is a long way from being a viable power source — such a power source would have to vaporize several such fuel pellets every second to have a great enough energy output to generate useful amounts of electricity.

But the NIF has shown success recently in achieving extraordinarily high energy outputs, if only for only very brief moments. The experiment in August came close to yielding as much energy from the fuel pellet as was put into it, and the researchers expect future experiments to be even more powerful.

Inertial confinement

The two new studies describe burning plasma experiments conducted in the months before the 10 quadrillion watt reaction; those earlier experiments culminated in the production of 170 kilojoules of energy from a pellet of just 200 micrograms (0.000007 ounces) of hydrogen fuel — around three times the energy output of any earlier experiments.

It was achieved by carefully shaping both the fuel capsule — a tiny spherical shell of polycarbonate diamond that enclosed the pellet — and the cavity that contained it — a small cylinder of depleted (not very radioactive) uranium lined with gold, known as a hohlraum.

The new designs allowed the NIF lasers that heated the pellet to operate more efficiently within the hohlraum, and the hot shell of the capsule to rapidly expand outward while the fuel pellet "imploded" — with the result that the fuel fused at such a high temperature that it heated other parts of the pellet into a plasma.

"This is significant as it is a necessary step on the way to producing large amounts of energy from fusion relative to the energy we put in," physicist Alex Zylstra told Live Science in an email. Zylstra led the initial burning plasma experiments and is the lead author of the Nature study about them.

Although many more scientific milestones will be needed before inertial confinement fusion can be utilized as a power source, the step of achieving a "burning" plasma will allow scientists to learn more about the process, he said.

"Burning plasmas [at] NIF are now in a new regime where we can scientifically study such conditions," Zylstra said.

Kritcher added that the breakthrough will yield a better understanding of nuclear fusion that can be used in other types of fusion reactions — such as those that take place in tokamaks — and not just reactions achieved through inertial confinement fusion.

"This work is important as it provides access to a new regime of plasma physics which will provide a wealth of understanding for the entire fusion community," she said.

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New research strengthens link between glaciers and Earth's 'Great Unconformity'

Evidence rocks were carved away by ancient glaciers during the planet's "Snowball Earth" period

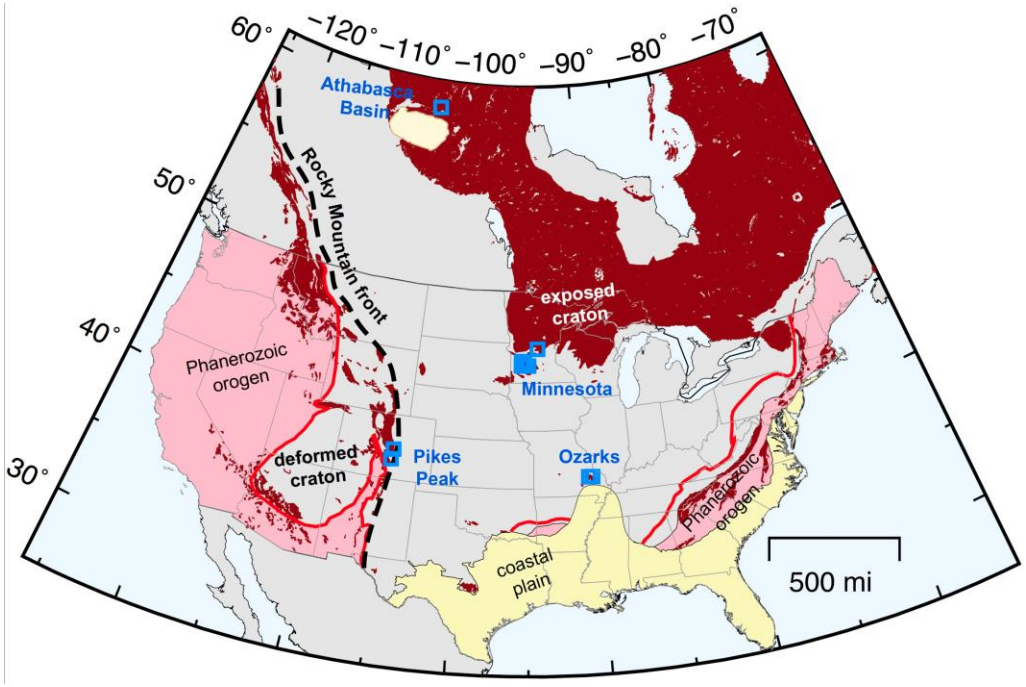
New research provides further evidence that rocks representing up to a billion years of geological time were carved away by ancient glaciers during the planet's "Snowball Earth" period, according to a study published in *Proceedings of the National Academy of Sciences*.

The research presents the latest findings in a debate over what caused the Earth's "Great Unconformity"—a time gap in the geological record associated with the erosion of rock up to 3 miles thick in areas across the globe.

"The fact that so many places are missing the sedimentary rocks from this time period has been one of the most puzzling features of the rock record," said C. Brenhin Keller, an assistant professor of earth sciences and senior researcher on the study. "With these results, the pattern is starting to make a lot more sense."

The massive amount of missing rock that has come to be known as the Great Unconformity was first named in the Grand Canyon in the late 1800s.

The conspicuous geological feature is visible where rock layers from distant time periods are sandwiched together, and it is often identified where rocks with fossils sit directly above those that do not contain fossils.



Researchers used thermochronometric data from four North American locations to determine the cause of the "Great Unconformity"—a massive loss of rock about 700 million years ago. **Credit: Kalin McDannell**

"This was a fascinating time in Earth's history," said Kalin McDannell, a postdoctoral researcher at Dartmouth and the lead author of the paper.

"The Great Unconformity sets the stage for the Cambrian explosion of life, which has always been puzzling since it is so abrupt in the fossil record—geological and evolutionary processes are usually gradual."

For over a century, researchers have sought to explain the cause of the missing geological time.

In the last five years, two opposing theories have come into focus: One explains that the rock was carved away by ancient glaciers during the Snowball Earth period about 700 to 635 million years ago. The other focuses on a series of plate tectonic events over a much longer period during the assembly and breakup of the supercontinent Rodinia from about 1 billion to 550 million years ago.

Research led by Keller in 2019 first proposed that widespread erosion by continental ice sheets during the Cryogenian glacial interval caused the loss of rock. This was based on geochemical proxies that suggested that large amounts of mass erosion matched with the Snowball Earth period.

"The new research verifies and advances the findings in the earlier study," said Keller. "Here we are providing independent evidence of rock cooling and miles of exhumation in the Cryogenian period across a large area of North America."

The study relies on a detailed interpretation of thermochronology to make the assessment.

Thermochronology allows researchers to estimate the temperature that mineral crystals experience over time as well as their position in the continental crust given a particular thermal structure. Those histories can provide evidence of when missing rock was removed and when rocks currently exposed at the surface may have been exhumed.

The researchers used multiple measurements from previously published thermochronometric data taken across four North American locations. The areas, known as cratons, are parts of the continent that are chemically and physically stable, and where plate

tectonic activity would not have been common during that time.

By running simulations that searched for the time-temperature path the rocks experienced, the research recorded a widespread signal of rapid, high magnitude cooling that is consistent with about 2-3 miles of erosion during Snowball Earth glaciations across the interior of North America.

"While other studies have used thermochronology to question the glacial origin, a global phenomenon like the Great Unconformity requires a global assessment," said McDannell. "Glaciation is the simplest explanation for erosion across a vast area during the Snowball Earth period since ice sheets were believed to cover most of North America at that time and can be efficient excavators of rock."

According to the research team, the competing theory that tectonic activity carved out the missing rock was put forth in 2020 when a separate research group questioned whether ancient glaciers were erosive enough to cause the massive loss of rock.

While that research also used thermochronology, it applied an alternate technique at only a single tectonically active location and suggested that the erosion occurred prior to Snowball Earth.

"The underlying concept is pretty simple: Something removed a whole lot of rock, resulting in a whole lot of missing time," said Keller. "Our research demonstrates that only glacial erosion could be responsible at this scale."

According to the researchers, the new findings also help explain links between the erosion of rock and the emergence of complex organisms about 530 million years ago during the Cambrian explosion. It is believed that erosion during the Snowball Earth period deposited nutrient-rich sediment in the ocean that could have provided a fertile environment for the building blocks of complex life.

The study notes that the two hypotheses of how the rock eroded are not mutually exclusive—it is possible that both tectonics and glaciation contributed to global Earth system disruption during the formation of the Great Unconformity. It appears, however, that only glaciation can explain erosion in the center of the continent, far from the tectonic margins.

"Ultimately with respect to the Great Unconformity, it may be that the generally accepted reconstruction(s) of more concentrated equatorial packing of the Rodinian continents along with the unique environmental conditions of the Neoproterozoic, proved to be a time of geologic serendipity unlike most any other in Earth history," the research paper says.

According to the team, this is the first research that uses their thermochronology modeling approach to study a period that extends well beyond a billion years. In the future, the team will repeat their work on other continents, where they hope to further test these hypotheses about how the Great Unconformity was created and preserved.

According to the team, resolving differences in the research is critical to understanding early Earth history and the interconnection of climatic, tectonic and biogeochemical processes.

"The fact that there may have been tectonic erosion along the craton margins does not rule out glaciation," said McDannell. "Unconformities are composite features, and our work suggests Cryogenian erosion was a key contributor, but it is possible that both earlier and later erosion were involved in forming the unconformity surface in different places. A global examination will tell us more."

William Guenthner, from the University of Illinois at Urbana-Champaign; Peter Zeitler from Lehigh University; and David Shuster from the University of California, Berkeley and the Berkeley Geochronology Center served as co-authors of the paper.

More information: *Kalin T. McDannell et al, Thermochronologic constraints on the origin of the Great Unconformity, Proceedings of the National Academy of Sciences (2022).* *DOI: 10.1073/pnas.2118682119*

https://nyti.ms/3KNG7YJ

Japanese Company Joins March Back to the Moon in 2022

Before the end of the year, ispace aims to place a lander with two small rovers on the lunar surface. It may find other visitors have also made the trip this year.

By Joey Roulette

A Japanese company is pushing ahead with plans to launch a private moon lander by the end of 2022, a year packed with other moonshot ambitions and rehearsals that could foretell how soon humans get back to the lunar surface.

A prototype of the Hakuto-R lunar lander in Tokyo in 2019. The lander, which was built by the Japanese startup ispace, is expected to launch by the end of the year. **Credit...Yoshio Tsunoda/AFLO**

If the plans hold, the company, ispace, which is based in Tokyo, would accomplish the first intact landing by a Japanese spacecraft on the moon. And by the time it arrives, it may find other new visitors that already started exploring the moon's regolith this year from Russia and the United States. (Yutu-2, a Chinese rover, is currently the lone robotic mission on the moon.)

Other missions in 2022 plan to orbit the moon, particularly the NASA Artemis-1 mission, a crucial uncrewed test of the American hardware that is to carry astronauts back to the moon. South Korea could also launch its first lunar orbiter later this year.

But other countries that had hoped to make it to the moon in 2022 have fallen behind. India was planning to make its second robotic moon landing attempt this year. But its Chandrayaan-3 mission was delayed to mid-2023, said K. Sivan, who completed his term as the chairman of the country's space agency this month. Russia, on the other hand, remains confident that its Luna-25 lander will lift off this summer.

The M1 moon lander built by ispace is the size of a small hot tub. It is in the final stages of assembly in Germany at the facilities of Ariane Group, the company's European partner, which built the rocket that recently launched the James Webb Space Telescope.

If structural tests go as planned in April, M1 will be shipped to NASA's Kennedy Space Center in Florida for a launch on one of the SpaceX Falcon 9 rockets.

"As of today, the specific launch date is scheduled to be, at the earliest, the end of 2022," Takeshi Hakamada, ispace's founder and chief executive, said during a news conference in Japan on Tuesday. The moon landing would come three to four months later as the mission uses a lengthy lunar trajectory to save fuel and maximize the amount of cargo the M1 lander can carry along.

Several years ago, ispace was a finalist in the Google Lunar X Prize — a contest that ended in 2018 with no winners of a $20 million prize that had been meant to stimulate private moon missions. Although it did not win the Google prize, the company raised over $90 million in 2017 and sees a healthy business in the future carrying payloads to the moon's surface for governments, research institutions and private companies.

Its ambitious timeline anticipates more than 10 moon landings in the coming years, among a rush of space firms that envisage mining the moon with robots for precious resources like iron and silicon that could be returned to Earth or used to expand structures on the lunar surface.

The customers for ispace's first moon landing include Japan's space agency, JAXA, which aims to test out a small rover that can change shapes for varying terrain, and the space program of the United Arab Emirates, which is sending its first lunar rover, a four-

wheeled robot called Rashid.

Nations and private companies have set their sights on the moon in recent years for its potential to serve as a staging ground for spacecraft and other technologies that could be used for future missions to Mars. The Artemis program is heavily leaning on private companies to slash the cost of getting to the moon and, it hopes, to stimulate a commercial market for various lunar services.

Although ispace's M1 mission is primarily meant to demonstrate operations on the moon, the company's next mission, M2, will carry its own "micro rover" that is built to drive around the surface and study lunar terrain. That mission was delayed to 2024 from 2023 because of engineering schedule changes and to accommodate the timelines of its customers, said Hideki Shimomura, ispace's chief technology officer.

Two American companies are also aiming for the moon before the year's end; Astrobotic, a space robotics firm in Pittsburgh, and Intuitive Machines of Houston. Both firms are building their spacecraft with backing from the Commercial Lunar Payload Services, a NASA program that aims to help fund development of privately owned landers capable of sending research instruments to the lunar surface.

https://bit.ly/342wvbZ

Universal sex differences appear in adolescents' career aspirations, study finds

Suggesting biologically-influenced preferences can play a role in gender segregation in the workplace adolescence

A new analysis by David Geary at the University of Missouri and Gijsbert Stoet at the University of Essex in the United Kingdom finds career aspirations from nearly 500,000 adolescents shows consistent sex differences across 80 nations, suggesting biologically-influenced preferences can play a role in gender segregation in the workplace later in life. The researchers also found a tendency for larger differences to appear in gender-equal countries, such as Finland, Norway or Sweden.

"Sex differences in career choices and outcomes are often blamed on social factors, such as stereotypes and bias," said Geary, Curators Distinguished Professor of Psychological Sciences in the MU College of Arts and Science. "Our study shows that many of these differences are universal and larger in equalitarian societies, suggesting there are biological influences on peoples' occupational preferences."

Geary said this study confirms what the researchers call a "gender-equality paradox," or where increased levels of gender equality in a country lead to larger sex differences, such as in occupational aspirations.

"The sex differences in interest in things- and people-oriented occupations were not only found throughout the world, but mirror those found in a study done more than 100 years ago," Geary said. "The results are consistent across time and place, in keeping with inherent sex differences that make some activities more attractive to adolescent boys than girls and others more attractive to girls than boys."

Using data from the 2018 Programme for International Student Assessment (PISA), the analysis showed more boys than girls in each country—about a 4-to-1 ratio—wanted to go into "things-oriented" occupations, such as a carpenter, engineer or mechanic, while more girls than boys—about a 3-to-1 ratio—wanted to go into a "people-oriented" occupation, such as a doctor or teacher.

For example, in the U.S. and U.K., researchers found more than five boys for every girl aspired for a things-oriented occupation. That ratio was even greater in Sweden, where more than seven boys for every Finnish girl aspired to a things-oriented occupation. On the other hand, in countries such as Morocco or the United Arab Emirates, where women experience less empowerment in politics,

education, or health, the ratios were typically lower, or around two boys for every girl.

"Teenage boys and girls differ considerably in what they expect to work on at around age 30," said Stoet, psychology professor at University of Essex. "The effects are largest in the countries where most people would expect the smallest differences. Their choices are likely a reflection of deeply built-in tendencies we see all over the world, but which express them most strongly in countries where adolescents are least constraint by economic limitations."

More information: *Gijsbert Stoet et al, Sex differences in adolescents' occupational aspirations: Variations across time and place, PLOS ONE (2022). DOI: 10.1371/journal.pone.0261438*

https://nyti.ms/3AJ9s1N

Your Body's Thirst Messenger Is in an Unexpected Place

Scientists traced how a mouse's brain gets the signal that it had enough to drink. Something similar may happen in humans.

By Veronique Greenwood

Few pleasures compare to a long cool drink on a hot day. As a glass of water or other tasty drink makes its way to your digestive tract, your brain is tracking it — but how? Scientists have known for some time that thirst is controlled by neurons that send an alert to put down the glass when the right amount has been guzzled. What precisely tells them that it is time, though, is still a bit mysterious.

In an earlier study, a team of researchers found that the act of gulping a liquid — really anything from water to oil — is enough to trigger a temporary shutdown of thirst. But they knew that gulping was not the only source of satisfaction. There were signals that shut down thirst coming from deeper within the body.

In a paper published Wednesday in Nature, scientists from the same lab report that they've followed the signals down the neck, through one of the body's most important nerves, into the gut, and finally to an unexpected place for this trigger: a set of small veins in the liver.

The motion of gulping might provide a quick way for the body to monitor fluid intake. But whatever you swallowed will swiftly arrive in the stomach and gut, and then its identity will become clear to your body as something that can fulfill the body's need for hydration, or not. Water changes the concentration of nutrients in your blood, and researchers believe that this is the trigger for real satiation.

"There is a mechanism to ensure that what you're drinking is water, not anything else," said Yuki Oka, a professor at Caltech and an author of both studies. To find out where the body senses changes to your blood's concentration, Dr. Oka and his colleagues first ran water into the intestines of mice and watched the behavior of nerves that connect the brain to the gut area, which are believed to work similarly in humans. One major nerve, the vagus nerve, fired the closest in time with the water's arrival in the intestines, suggesting that this is the route the information takes on the way to the brain.

Then, the researchers went one by one and sliced each of the nerve's connections to different regions in the gut. To their surprise, nothing changed when they cut off contact to the intestines.

Instead, it was the portal veins of the liver — vessels that carry that blood from around the intestine to the filtering organ — whose isolation silenced the messages back to the brain.

These veins ferry nutrients and fluid into the liver, so it's plausible that they could be a monitoring center for thirst, Dr. Oka said. The team found that just running water through the portal veins was not enough to get the nerve to fire, however. Something about the water's arrival had to trigger another part of the body's hydration Rube Goldberg machine.

The researchers narrowed it down to a hormone called vasoactive intestinal peptide, or VIP. When water reaches the portal veins, VIP levels go up, and it is VIP, rather than the water itself, that causes

the vagus to fire, alerting the brain. As intriguing as that is, the scientists don't know how the water causes this rise. They are hoping to keep following the signals and identify precisely which cells and molecules connect these unassuming veins and the peptide with the grand acronym. "That is the major thing that we are in a good position to tackle next," Dr. Oka said.

And there is probably even more to learn. While VIP causes the vagus nerve to sound off, the signal isn't as strong as the researchers would expect if it worked alone. Water is so important to the body's functioning that Dr. Oka and his team think our brains most likely have multiple, redundant ways to monitor it. With every glass of water you drink, you're putting that system through its paces.

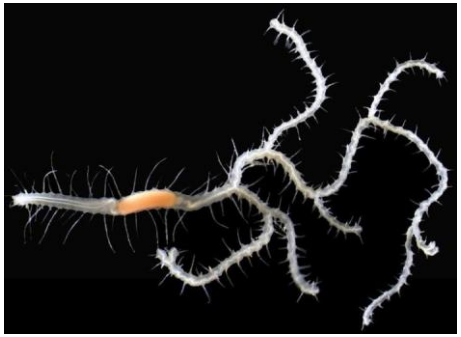
https://bit.ly/3q9FnyN

Bizarre sea worm with regenerative butts named after Godzilla's monstrous nemesis

The unusual invertebrate spends most of its life living inside a sponge.

By Harry Baker

A newfound species of branched sea worm sports dozens of regenerative rear ends that detach and swim off during reproduction. This weirdo superpower led the beastie's discoverers to name it after Godzilla's monstrous multiheaded nemesis, King Ghidorah.



The newly discovered branched sea worm Ramisyllis kingghidorahi. In this image, worms single head (left) and asymmetrical posterior branches (right) are clearly visible. **(Image credit: M Aguado)**

In total, 25 of the new worms, named *Ramisyllis kingghidorahi* after the villainous kaiju, were found living inside a sea sponges in Japan in October 2019. Unlike their namesake, who has three heads and two tails, *R. kingghidorahi* have only one head but do have multiple posterior branches, which grow to fill out narrow tubes inside their host sponges, which were between 2 and 4 inches (5 and 10 centimeters) long.

When the worms reproduce, the end of each branch, known as a stolon, detaches and swims to the surface to release its eggs or sperm, which then get mixed in the water column, where fertilization happens. The stolons die, but the worms remains safely in their spongy hosts and regenerate the lost sections of each branch for the next reproductive cycle.

"King Ghidorah is a branching fictional animal that can regenerate its lost ends. So we thought this was an appropriate name for the new species of branching worm," lead author Maria Teresa Aguado, an evolutionary biologist specializing in marine invertebrates at the University of Göttingen in Germany, said in a statement.

R. kingghidorahi is the third species of branching sea worm ever discovered. The first species, now called *Syllis ramosa*, was found in 1879 in the Philippines. The second, *Ramisyllis multicaudata* (from the same genus as *R. kingghidorahi*), was uncovered in 2006 in northern Australia and was named in 2012. A study released in May 2021 revealed that *R. multicaudata* can have around 100 branching segments, Live Science previously reported.

The various species also choose different sponges as homes: *S. ramosa* lives inside deep-sea glass sponges, while the two *Ramisyllis* sponges prefer shallow-water stone sponges. There are likely more branched sea worms waiting to be discovered, according to the researchers. However, it is challenging to find the elusive invertebrates because they spend a majority of their lives concealed within their spongy hosts.

"We were amazed to find another one of these bizarre creatures," Aguado said in the statement. The genetic differences between *R.*

kingghidorahi and *R. multicaudata*, which descended from the same common ancestor, also highlight that there is much more diversity among branched sea worms than expected, she added.

The researchers now want to explore the unique, mysterious relationship between the worms and their sponge hosts.

"We don't yet understand exactly what the relationship between the worm and its host sponge is," Aguado said in the statement. It could be symbiotic, which means it is mutually beneficial to the worm and the sponge, or parasitic, in which the worm benefits at the expense of its host sponge.

The researchers are also unsure how the worms manage to access enough food inside the sponges to continue growing new branches and regenerating lost ones — processes thought to be very energetically expensive, according to the statement.

The study was published online Jan. 19 in the journal Organisms Diversity & Evolution.

https://bit.ly/3ubKlDG

Vitamin D and Fish Oil Supplements May Reduce Risk of Autoimmune Disease – Rheumatoid Arthritis, Psoriasis, and Thyroid

With a more pronounced effect after two years of supplementation.

Taking daily vitamin D supplements — or a combination of vitamin D and omega-3 fish oil — appears to carry a lower risk of developing autoimmune disease, with a more pronounced effect after two years, finds a trial of older US adults published by *The BMJ* today (January 26, 2022). The researchers say the clinical importance of these findings is high, "given that these are well-tolerated, non-toxic supplements, and that there are no other known effective therapies to reduce rates of autoimmune diseases."

Autoimmune disease happens when the body's natural defense system mistakenly attacks normal cells. Common conditions include rheumatoid arthritis, psoriasis, and thyroid diseases, which increase with age, particularly among women.

Both vitamin D and omega-3 fatty acids derived from seafood are known to have a beneficial effect on inflammation and immunity, but no large randomized trials have tested whether these supplements can lower the risk of autoimmune disease.

So researchers set out to test the effects of vitamin D and omega-3 fish oil supplements on rates of autoimmune diseases in 25,871 US adults (average age 67; 51% women; 71% non-Hispanic white).

When they joined the trial, participants provided information on their age, ethnicity, region of residence, income, education, lifestyle, weight, medical history, diet, and supplement use. Blood levels of vitamin D and omega-3 fatty acids were also measured.

Participants were then randomly allocated to receive vitamin D (2,000 IU/day) or matched placebo, and omega-3 fatty acids (1,000mg/day) or matched placebo, and were asked to report any diagnosed autoimmune disease over an average 5.3 year period.

These included rheumatoid arthritis, polymyalgia rheumatica (pain and stiffness in the muscles around the shoulders, neck, and hips), thyroid disease, and psoriasis, among others. Reported cases were confirmed using medical records. Those with insufficient documentation for certainty were classed as "probable" cases.

Over the full duration of the trial, a confirmed autoimmune disease was diagnosed in 123 participants in the vitamin D group compared with 155 in the placebo group — a 22% lower relative rate.

In the omega-3 fatty acid group, 130 confirmed cases were diagnosed compared with 148 in the placebo group (a 15% reduction), but this was not a statistically significant result.

However, when probable cases were included, omega-3 fatty acid supplements did significantly reduce the rate by 18% compared with placebo and there was a significant interaction with time,

indicating a stronger effect the longer supplements were taken.

Similar results were found when only the last three years of the trial were considered. The vitamin D group had 39% fewer confirmed cases than placebo, while the omega-3 fatty acid group had 10% fewer confirmed cases than placebo. Both vitamin D and omega-3 fatty acid supplements decreased autoimmune disease by about 30% versus placebo alone.

This was a large trial involving a diverse general population with high rates of follow-up and adherence to treatment. However, the researchers acknowledge that they tested only one dose and formulation of each supplement, and say the results may not apply to younger individuals.

Nevertheless, they say this is the first direct evidence that daily supplementation with either agent — or a combination of vitamin D and omega-3 fatty acids — for five years among older US adults reduces autoimmune disease incidence, with more pronounced effect after two years of supplementation.

"We are continuing to follow participants for two years in an extension study to test the time course of this autoimmune disease reduction effect," they write. "Further trials could test these interventions in younger populations, and those with high autoimmune disease risk."

Reference: "Vitamin D and marine omega 3 fatty acid supplementation and incident autoimmune disease: VITAL randomized controlled trial" 26 January 2022, The BMJ. DOI: 10.1136/bmj-2021-066452

https://bit.ly/3GbmENW

Induced pluripotent bovine stem cells overcome decades-long challenges for cultivated meat

Offer the promise of making the global food supply more sustainable and reliable

Stem cells have been used for years as therapeutics for human health, but new research shows they may offer the promise of making the global food supply more sustainable and reliable through the development of cultivated meat.

One type of stem cell that's of particular interest is known as induced pluripotent stem cells (iPS cells). These cells are derived from adult cells and can be reprogrammed to act as embryonic stem cells. These cells are pluripotent, which function as the building blocks that gradually give rise to every kind of organ and tissue cells.

That could be good news for the growing lab-grown meat industry, which seeks ways to bring meat to consumers without the environmental drawbacks of large-scale industrial farming. To date, however, the industry has been unable to generate enough high-quality livestock pluripotent stem cells to make this a legitimate commercial option. While scientists have successfully created iPS cells for human and mouse models, there has been a near standstill in the development of these pluripotent cells for cattle.

That may be changing: Associate Professor Young Tang and Professor and Interim Department Head Xiuchun (Cindy) Tian in the College of Agriculture, Health and Natural Resources recently demonstrated the first successful iPS cells for bovine. The duo published their findings in International Journal of Molecular Sciences. They have filed a provisional patent on this technology through UConn Technology Commercialization Services.

Bovine pluripotent stem cells could have applications for lab-grown beef, as they could allow scientists to grow entire cuts of meat from muscle stem cells differentiated from a single iPS cell.

These cells could also be used for the establishment of in-vitro breeding technology, which theoretically could create 100 generations of cows in 25 years. Traditional breeding techniques can only produce 10 generations in the same period.

These cells would also allow great advances in genetic engineering and developing disease-resistant animals, according to the UConn

research team.

"This will be very significant for our future, because we want to build up sustainable agriculture production and accommodate the increased need for the global population," Tang says

Silencing noisy genes

Tang and Tian's team used a novel combination of decades of stem cell research to finally overcome the barriers for bovine iPS cell development. Previously, bovine stem cells had two major issues: they couldn't silence the genes used to reprogram them, and they couldn't renew themselves for the long term.

While a prerequisite of pluripotency is the capacity of the iPS cells to actively silence the transgenes that induce them, incompletely reprogrammed cells will die or differentiate within a couple of replication cycles when these genes are turned off manually.

Tang and Tian's cells overcome both issues by silencing a methylation event that was previously identified as a barrier for embryo development in mice and humans.

The researchers previously developed a method for creating iPS cells in other animal models. This method combined two widely used sets of proteins: Yamanaka factors (Oct4, Sox2, Klf4, and c-Myc) and Thompson factors (Oct4, Sox2, Lin28, and NANOG).

Traditionally, scientists use only one set of these reprogramming factors. But Tang and Tian combined them, using a total of six factors: Oct4, Sox2, Klf4, c-Myc, Lin28, and NANOG.

They also used two inhibitors to shut down signaling pathways that interfered with the reprogramming process. These changes allowed the researchers to make human cell reprograming 100 times more efficient than using Yamanaka factors alone.

The next step was to shut down a methylation event in bovine chromatin known as Histone 3 Lysine 9 Trimethylation (H3K9me3). They found that overexpressing an enzyme known as histone lysine demethylase KDM4A effectively shut this methylation pathway down.

"Our hypothesis was that this H3K9 trimethylation represented a reprogramming barrier for the bovine iPS cell generation," Tang says, "Therefore, we combined our previous robust reprogramming system that we worked out using human cells, with the co-expression of KDM4A and we found that we could generate the bovine iPS cells."

What's next for iPS cells?

The next step for this technology will be testing how pluripotent they are. To determine this, the researchers will inject the cells into an embryo and analyze which tissues and organs the iPS cells reach. The more pluripotent, the more tissue types the cells will incorporate into. Less pluripotent iPS cells may show little incorporation or be mainly confined to whatever tissue type they came from originally, a theory called epigenetic memory.

"They remember where they come from," Tian says. "And then they end up in that tissue."

The ultimate test of pluripotency is if the iPS cells can incorporate into the animal's reproductive system—either sperm or eggs—and pass their genes onto a new generation.

This research could apply to other animals like sheep and goats, or even near-threatened species of bovine, like bison or buffalo.

More information: *Yue Su et al, Establishment of Bovine-Induced Pluripotent Stem Cells, International Journal of Molecular Sciences (2021). DOI: 10.3390/ijms221910489*

https://bit.ly/3ILFmqU

Cancer Drug Flushes Out Latent HIV, Exciting New Study Finds

A widely-used cancer drug that works on the immune system could push HIV out of hiding, potentially leaving the virus open to being attacked and eliminated, according to promising results from a small new study.

Clare Watson

HIV (human immunodeficiency virus) almost needs no introduction: the virus is notorious for its ability to evade the immune system. Key to its insidiousness is viral latency – HIV 'hides' inside long-lived immune cells, inserting its genetic material into the cell's own, so it can escape detection.

This has been a major barrier to developing a cure for HIV, as the virus is never eradicated entirely with antiviral therapies, but continues to be present in the body within these latent reservoirs.

The new study suggests that pembrolizumab, an immunotherapy drug which has transformed the treatment of melanoma and other cancers, might also be able to reverse HIV latency, flushing the virus out of hiding.

Although the trial was only small, featuring 32 people living with both HIV and cancer, it is the largest study of its kind to date and the results are "very exciting", says infectious disease expert Sharon Lewin of the Peter Doherty Institute for Infection and Immunity in Melbourne, Australia.

Pembrolizumab works by reactivating worn-out immune cells that express a bunch of proteins on their surface, including one marker called PD1. Past research from Lewin and colleagues has shown HIV co-opts these same 'exhaustion' markers to sneak into hibernation and lie undetected.

Blocking PD1 with pembrolizumab reawakens tired T cells whose job is to seek and destroy cancer cells. Researchers had wondered if the drug might also unlock reservoirs of HIV lying dormant in immune cells and bring the virus out of hiding.

Until now, there have only been a handful of case reports showing immunotherapies like pembrolizumab might flush HIV out of immune cells in people with HIV – because although they have an increased risk of developing cancer, people with HIV in need of anti-PD1 treatments for their cancer are very rare.

The drug "did not eradicate HIV in this study" but the result "informs efforts to manipulate T cells to cure HIV," medical oncologist and lead author Thomas Uldrick of the Fred Hutchinson Cancer Research Center said on Twitter.

Bloods were collected from the 32 participants before and after treatment with pembrolizumab, and the samples were analyzed to see how much of the virus's genetic material was detectable in immune cells and blood plasma.

Although most people in the trial still had undetectable levels of HIV in their blood plasma, the researchers did find evidence that a week after the first treatment, a modest but significant level of the virus had been coaxed out of hibernation and started replicating again. Six treatment cycles later, T cells containing HIV that was ready to replicate were also more often detected in some participants.

More research is needed to figure out exactly how anti-PD1 drugs like pembrolizumab modify the immune response and act on HIV-specific T cells. The team is pursuing these questions "in the hope that as well as reversing HIV latency, it will also rev up the immune system to kill the HIV-infected cells in the way it does with cancer," says Lewin.

That remains to be seen, although given how familiar scientists are with pembrolizumab, there is "potential for this and other similar treatments to develop a pathway towards a pragmatic HIV cure," Kirby Institute virologist Stuart Turville told Melissa Davey at *The Guardian*. He was not involved in the study.

Lewin added, however, that immunotherapies could form part of a multi-pronged treatment approach that she hopes could help the nearly 2 million people diagnosed with HIV every year. "I think it's very unlikely a single drug or intervention is going to cure HIV," she told Davey.

Researchers will also need to further investigate and weigh up the drug's known side effects, which may be tolerable for people with a

life-threatening illness such as cancer, but have thus far been a barrier to testing immunotherapies in otherwise healthy people living with HIV.

"In HIV, the situation is very different," says Lewin. "People can now live normal and healthy lives with HIV, so any intervention for a cure must have very low toxicity."

To understand more, the researchers are about to embark on another trial looking at the effects of anti-PD1 therapy on blood cells and lymph nodes to try and find the lowest, safest dose for people living with HIV who don't have cancer, Lewin says.

The current study was published in *Science Translational Medicine.*

https://bit.ly/3G7TDmd

Living Cells Discovered in Human Breast Milk Could Aid Breast Cancer Research

The cells in milk, once thought to be dead or dying, are in fact very much alive

Breast tissue is dynamic, changing over time during puberty, pregnancy, breastfeeding, and aging. The paper, published today (January 28, 2022) in the journal *Nature Communications*, focuses on the changes that take place during lactation by investigating cells found in human milk.

This research, led by Dr. Alecia-Jane Twigger of CSCI, found that the cells in milk, once thought to be dead or dying, are in fact very much alive. These living cells provide researchers with the chance to study not only the changes that occur in mammary tissues during lactation, but also insight into a potential early indicator of future breast cancer development.

“I believe that by studying human milk cells, we will be able to answer some of the most fundamental questions around mammary gland function such as: how is milk produced? Why do some women struggle to make milk? and what strategies can be employed to improve breastfeeding outcomes for women?” said Dr. Alecia-Jane Twigger at the Wellcome-MRC Cambridge Stem Cell Institute who led the study.

The researchers collected voluntary breast milk samples from lactating women, as well as samples of non-lactating breast tissue donated from women who elected to have aesthetic breast reduction surgery. Using single-cell RNA sequencing analysis, the team conducted a novel comparison of the composition of the mammary cells taken using these two methods, identifying the distinctions between lactating and non-lactating human mammary glands.

While accessing breast tissue for study relies on donors already undergoing surgery, breast milk samples are much simpler to acquire.

Breast milk donors are engaged via midwives or women’s networks (an undertaking made more challenging by the pandemic) and agree to share their samples over time. Typical daily production for lactating women is between 750-800ml, and the sample size for Twigger’s research is on average a mere 50ml, an amount which can contain hundreds of thousands of cells for study.

By collecting these samples donated by breastfeeding women – samples now known to contain living and viable cells – researchers have the opportunity to capture dynamic cells in a non-invasive way. This greater ease of access to breast cells can open the door to more studies on women’s health in the future.

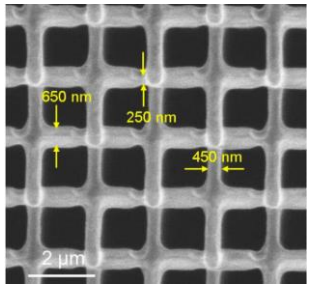
“The first time Alecia told me that she found live cells in milk I was surprised and excited about the possibilities. We hope this finding will enable future studies into the early steps of breast cancer,” said Dr. Walid Khaled, at the Wellcome-MRC Cambridge Stem Cell Institute and University of Cambridge’s Department of Pharmacology, who was also involved in the study.

Reference: 28 January 2022, Nature Communications.
DOI: 10.1038/s41467-021-27895-0
This paper and its findings are part of the Human Breast Cell Atlas project funded by the MRC.

https://bit.ly/3Hj8ITt

Nano-architected material refracts light backward; an important step toward creating photonic circuits

A newly created nano-architected material exhibits a property that previously was just theoretically possible: it can refract light backward, regardless of the angle at which the light strikes the material.



Scanning Electron Microscopy (SEM) image of the nanoscale lattice. **Credit: California Institute of Technology**

This property is known as negative refraction and it means that the refractive index—the speed that light can travel through a given material—is negative across a portion of the electromagnetic spectrum at all angles.

Refraction is a common property in materials; think of the way a straw in a glass of water appears shifted to the side, or the way lenses in eyeglasses focus light. But negative refraction does not just involve shifting light a few degrees to one side. Rather, the light is sent in an angle completely opposite from the one at which it entered the material. This has not been observed in nature but, beginning in the 1960s, was theorized to occur in so-called artificially periodic materials—that is, materials constructed to have a specific structural pattern. Only now have fabrication processes have caught up to theory to make negative refraction a reality.

"Negative refraction is crucial to the future of nanophotonics, which seeks to understand and manipulate the behavior of light when it interacts with materials or solid structures at the smallest possible scales," says Julia R. Greer, Caltech's Ruben F. and Donna Mettler Professor of Materials Science, Mechanics and Medical Engineering, and one of the senior authors of a paper describing the new material. The paper was published in *Nano Letters* on October 21.

The new material achieves its unusual property through a combination of organization at the nano- and microscale and the addition of a coating of a thin metal germanium film through a time- and labor-intensive process. Greer is a pioneer in the creation of such nano-architected materials, or materials whose structure is designed and organized at a nanometer scale and that consequently exhibit unusual, often surprising properties—for example, exceptionally lightweight ceramics that spring back to their original shape, like a sponge, after being compressed.

Under an electron microscope, the new material's structure resembles a lattice of hollow cubes. Each cube is so tiny that the width of the beams making up the cube's structure is 100 times smaller than the width of a human hair. The lattice was constructed using a polymer material, which is relatively easy to work with in 3D printing, and then coated with the metal germanium.

"The combination of the structure and the coating give the lattice this unusual property," says Ryan Ng (MS '16, Ph.D. '20), corresponding author of the Nano Letters paper. Ng conducted this research while a graduate student in Greer's lab and is now a postdoctoral researcher at the Catalan Institute of Nanoscience and Nanotechnology in Spain. The research team zeroed in on the cube-lattice structure and material as the right combination through a painstaking computer modeling process (and the knowledge that geranium is a high-index material).

To get the polymer coated evenly at that scale with a metal required the research team to develop a wholly new method. In the end, Ng, Greer, and their colleagues used a sputtering technique in which a disk of germanium was bombarded with high-energy ions that blasted germanium atoms off of the disk and onto the surface of the polymer lattice. "It isn't easy to get an even coating," Ng says. "It took a long time and a lot of effort to optimize this process."

The technology has potential applications for telecommunications,

medical imaging, radar camouflaging, and computing.

In 1965 observation, Caltech alumnus Gordon Moore (Ph.D. '54), a life member of the Caltech Board of Trustees, predicted that integrated circuits would get twice as complicated and half as expensive every two years. However, because of the fundamental limits on power dissipation and transistor density allowed by current silicon semiconductors, the scaling predicted by Moore's Law should soon end. "We're reaching the end of our ability to follow Moore's Law; making electronic transistors as small as they can go," Ng says. The current work is a step towards demonstrating optical properties that would be required to enable 3D photonic circuits. Because light moves much more quickly than electrons, 3D photonic circuits, in theory, would be much faster than traditional ones.

The Nano Letters paper is titled "Dispersion Mapping in 3-Dimensional Core–Shell Photonic Crystal Lattices Capable of Negative Refraction in the Mid-Infrared."

More information: *Victoria F. Chernow et al, Dispersion Mapping in 3-Dimensional Core–Shell Photonic Crystal Lattices Capable of Negative Refraction in the Mid-Infrared, Nano Letters (2021). DOI: 10.1021/acs.nanolett.1c02851*

https://bit.ly/3s2hm2h

Parasite could help to explain the origin of animal multicellularity

Parasite from seawater belonging to a primitive lineage will help to explain how multicellularity developed in animals

Researchers from the UPV/EHU-University of the Basque Country and CEFAS have discovered a parasite present in seawater and which belongs to a primitive lineage; they have named it Txikispora philomaios. This organism will help to explain how multicellularity developed in animals. Phylogenetic and phylogenomic studies using DNA from this parasite are helping to understand the evolutionary changes and adaptations that enabled the difficult transition to take place from microscopic unicellular organisms to multicellular animals and fungi.

The researcher Ander Urrutia of the UPV/EHU's Cell Biology in Environmental Toxicology research group and Animal Pathology at CEFAS/OIE, is exploring "the great hidden diversity of unicellular parasitic organisms in the intertidal zone in coastal ecosystems of temperate climates, with the aim of trying to see where they are found, what their ecology is like, how they behave, etc." Environmental DNA (eDNA) is one of the techniques used to achieve this goal: it is a technique that involves "extracting the DNA contained in either an organic or environmental matrix, for example in an organism or in previously filtered seawater samples." In particular, Urrutia focused on organisms that parasitize invertebrates: "There are a great many unidentified parasites; we find new DNA sequences and infer their behavior based on their genetic similarity to other parasites, but we don't really know what they are."

In the task to classify the unicellular parasites found in the samples, the researcher in the Department of Zoology and Animal Cell Biology found an "a priori little-known parasite, which, on the basis of its characteristics, did not fit into any existing group. We had to do some molecular analyses which confirmed that it was a different organism. Once we had produced several phylogenetic trees, i.e. after comparing the DNA of this organism with that of its closest possible relatives, we were able to see that it is an organism belonging to a primitive lineage that is close to the point at which animals and fungi became differentiated. It is close to the evolutionary moment when a unicellular organism became differentiated to give rise to all the animals that exist, shortly after which another similar cellular organism was to become differentiated to eventually evolve into all the fungi that exist," Urrutia explained.

The "May-loving spore" that opens the door to the study of the origin of animal multicellularity

"Txikispora philomaios is a protist (a unicellular eukaryotic organism) that evolved shortly after the division that was undertaken by the common ancestor of animals and fungi, before its multicellularity was developed. All the world's animals and fungi come from the same cellular organism that was presumably present in the ocean hundreds of millions of years ago. At some point it began to aggregate and duplicate itself, while its cells specialized to form tissue, and eventually a body, ranging from a microscopic jellyfish to a huge blue whale," explained the researcher. Since the genetic rearrangement undergone by parasites often differs from that of their free-living relatives, the study of this parasite and its genome will contribute towards understanding how animal multicellularity developed. "In other words, when and how cells began to communicate with each other, join together, or specialize among themselves, forming increasingly complex organisms. The development of animal multicellularity is very important from the point of view of basic biology," added Urrutia, who carried out the research at CEFAS in the UK, at the Plentzia Marine Station (PIE) and at the Institute of Evolutionary Biology (IBE/CSIC).

As Urrutia explained, "Txikispora is not only a new species, it also gives a name to a new genus, a new family, a new order, and so on. In other words, we now have the new Txikisporidae family, one with quite a few cryptic sequences, i.e. unknown pieces of DNA that look very similar to Txikispora and which could also belong to parasites, although we don't know where they are or which animals they could parasitize. Many of them are present in aquatic ecosystems in Europe, but we know nothing more about them. That's another line of research I would like to pursue."

The UPV/EHU researchers were commissioned to name this parasite. The name Txikispora was adopted owing to the fact that it is a small spore, and philomaios is due to the fact that the parasite only appeared for a few days during May, thus "May-loving spore." In addition to the difficulty in placing it phylogenetically in its corresponding group, it was difficult to find it in seawater: "We had been on a wild goose chase until we realized that it is only found in the amphipod community for a few days during this month; it is as if the parasite had disappeared for the rest of the year," explained Urrutia.

More information: *Ander Urrutia et al, Txikispora philomaios n. sp., n. g., a micro-eukaryotic pathogen of amphipods, reveals parasitism and hidden diversity in Class Filasterea, Journal of Eukaryotic Microbiology (2021). DOI: 10.1111/jeu.12875*

https://wb.md/3AGTCot

In Super-Vaxxed Vermont, COVID Strikes — But Packs Far Less Punch

Even Eden, a snow-covered paradise in northern Vermont, is poisoned by omicron.

Sarah Varney

The nearly vertical ascent of new coronavirus cases in recent weeks, before peaking in mid-January, affected nearly every mountain hamlet, every shuttered factory town, every frozen bucolic college campus in this state despite its near-perfect vaccination record.

Of all the states, Vermont appeared best prepared for the omicron battle: It is the nation's most vaccinated state against covid, with nearly 80% of residents fully vaccinated — and 95% of residents age 65 and up, the age group considered most vulnerable to serious risk of covid.

Yet, even this super-vaxxed state has not proved impenetrable. The state in mid-January hit record highs for residents hospitalized with covid-19; elective surgeries in some Vermont hospitals are on hold; and schools and day care centers are in a tailspin from the numbers of staff and teacher absences and students quarantined at home. Hospitals are leaning on Federal Emergency Management Agency paramedics and EMTs. And, in a troubling sign of what lies ahead for the remaining winter months: about 1 in 10 covid tests in

Vermont are positive, a startling rise from the summer months when the delta variant on the loose elsewhere in the country barely registered here.

"It shows how transmissible omicron is," said Dr. Trey Dobson, chief medical officer at Southwestern Vermont Medical Center, a nonprofit hospital in Bennington. "Even if someone is vaccinated, you're going to breathe it in, it's going to replicate, and if you test, you're going to be positive."

But experts are quick to note that Vermont also serves as a window into what's possible as the U.S. learns to live with covid. Although nearly universal vaccination could not keep the highly mutated omicron variant from sweeping through the state, Vermont's collective measures do appear to be protecting residents from the worst of the contagion's damage. Vermont's covid-related hospitalization rates, while higher than last winter's peak, still rank last in the nation. And overall death rates also rank comparatively low.

Children in Vermont are testing positive for covid, and pediatric hospitalizations have increased. But an accompanying decrease in other seasonal pediatric illnesses, like influenza and respiratory syncytial virus, and the vaccinated status of the majority of the state's eligible children has eased the strain on hospitals that many other states are facing.

"I have to remind people that cases don't mean disease, and I think we're seeing that in Vermont," said Dr. Rebecca Bell, a pediatric critical care specialist at the University of Vermont Health Network in Burlington, the only pediatric intensive care hospital in the state. "We have a lot of cases, but we're not seeing a lot of severe disease and hospitalization." She added, "I have not admitted a vaccinated child to the hospital with covid."

Vermont in many ways embodies the future the Biden administration and public health officials aim to usher in: high vaccination rates across all races and ethnicities; adherence to evolving public health guidelines; and a stick-to-itiveness and social cohesion when the virus is swarming. There is no "good enough" in Vermont, a state of just 645,000 residents. While vaccination efforts among adults and children have stalled elsewhere, Vermont is pressing hard to better its near-perfect score.

"We have a high percentage of kids vaccinated, but we could do better," said Dobson.

He continues to urge unvaccinated patients to attend his weekly vaccination clinic. The "first-timers" showing up seem to have held off due to schedules or indifference rather than major reservations about the vaccines. "They are nonchalant about it," he said. "I ask, 'Why now?' And they say, 'My job required it.'"

Replicating Vermont's success may prove difficult.

"There is a New England small-town dynamic," said Dr. Tim Lahey, director of clinical ethics at the University of Vermont Medical Center in Burlington. "It's easy to imagine how your behavior impacts your neighbor and an expectation that we take care of each other."

While other rural states in the Midwest and South have struggled to boost vaccination rates, New England, in general, is outpacing the pack. Behind Vermont, Rhode Island, Maine, and Connecticut have the highest percentage of fully vaccinated residents in the country.

"It's something beyond just the size," said Dr. Ben Lee, an associate professor at the Robert Larner, M.D. College of Medicine at the University of Vermont. "There is a sense of communal responsibility here that is a bit unique."

In a state with the motto "Freedom and Unity," freedom has largely yielded to unity, and the state's pandemic response has been met with eager compliance. "The general attitude here has been enthusiasm to be safer," said Lahey.

Lahey credits the state's Republican governor, Phil Scott, who has

been "unambivalent about pro-vax messaging." Combined with a "tendency to trust the vaccine, you get a different outcome than in places where political leaders are exploiting that minority voice and whipping people up in anger."

Vermont's medical leaders are advising state leaders to shift from a covid war footing — surveillance testing, contact tracing, quarantines, and lockdowns — to rapprochement: testing for covid only if the outcome will change how doctors treat a patient; ceasing school-based surveillance testing and contact tracing; and recommending that students with symptoms simply recuperate at home.

Once the omicron wave passes and less virus is circulating, Dobson said, a highly vaccinated state like Vermont "could really drop nearly all mitigation measures and society would function well." Vermonters will become accustomed to taking appropriate measures to protect themselves, he said, not unlike wearing seat belts and driving cautiously to mitigate the risk of a car accident. "And yet," he added, "it's never zero risk."

Spared the acrimony and bitterness that has alienated neighbor from neighbor in other states, Vermont may have something else in short supply elsewhere: stamina. "All of us are just exhausted," said Lahey, the ethics director. But "we're exhausted with friends."

https://bit.ly/3u7jdWi

Magnetic navigation: Songbirds use the Earth's magnetic field as a stop sign during migration

A new study published today in Science has shed light on how birds navigate back to their breeding site after flying across two continents.

The study, part of an international collaboration led by researchers at the University of Oxford and including scientists from the University of Oldenburg, suggests that information extracted from the Earth's magnetic field tells birds where and when to stop migrating. This trick allows them to precisely target the same breeding site year-on-year from thousands of kilometers away.

How birds sense the Earth's magnetic field has been the subject of intense research. Birds might even 'see' magnetic field lines, and possibly use this ability to both determine the direction they're facing in and where they are.

Dr. Joe Wynn, formerly of the University of Oxford and now a researcher at the Institute for Avian Research, Germany, said that "whilst we know an increasing amount about how birds inherit migratory information from their parents, how they return to the same site year-on-year with pinpoint accuracy has remained elusive. It's quite exciting, therefore, that we've been able to find evidence that magnetic cues could be used by songbirds trying to re-locate their homes." He started developing the idea for the study during a stay as a guest scientist in the research group of biologist Prof. Dr. Henrik Mouritsen at the University of Oldenburg. Mouritsen was also involved in data analysis for the study.

You have arrived at your destination

The team analyzed data from nearly 18,000 reed warblers to investigate whether the birds used the Earth's magnetic field when finding their breeding site. Reed warblers are tiny songbirds that fly across the Sahara Desert each year to spend the summer in Europe.

They found that, as the magnetic field of Earth moved slightly, the sites to which birds returned moved with it, suggesting that birds homed to a moving magnetic target. Birds appeared to use magnetic information as a 'stop sign', with magnetic inclination in particular telling birds that they had arrived at their breeding location.

The work utilized 'ringing' data. For nearly a century, uniquely numbered metal rings have been attached to the legs of birds from across Europe.

Dr. Wynn added that "Ringing data are a fantastic way to answer questions about migration, simply because they've been gathered

for so many years across a very large area…and when looking at where birds and ringed and then recovered, it seems that reed warblers use a single magnetic coordinate a bit like a 'stop sign'; when they reach the right magnetic field value, they stop migrating."

Why use the magnetic field to inform return migration?

Dr. Wynn explains that "Magnetic information seems to be pretty stable, meaning the magnetic field doesn't change very much in a given location year-on-year. Aiming for a specific magnetic value during migration might make sense then, and the cue we think birds are using, inclination, appears the most stable aspect of the magnetic field. We think this gives the birds the best chance of making it back to the breeding site."

In conclusion Dr. Wynn said that "the trans-continental migration of birds that weigh less than a teaspoon is remarkable for so many reasons, but the ability to precisely pinpoint the breeding site from half the world away is perhaps the most extraordinary aspect of all. That we can investigate this using data gathered by scientists and bird-watchers alike is extremely exciting, and we hope that this use of citizen science data inspires others to go out, watch birds and get excited about science more generally."

More information: *Joe Wynn et al, Magnetic stop signs signal a European songbird's arrival at the breeding site after migration, Science (2022). DOI: 10.1126/science.abj4210*

https://bit.ly/3rbtLBU

Mutant stem cells defy rules of development

Chance observation is upending what was thought about how stem cells turn into adult cells and maintain their identity

by Sarah C.p. Williams, Gladstone Institutes

Imagine you're baking a cake, but you run out of salt. Even with the missing ingredient, the batter still looks like cake batter, so you stick it in the oven and cross your fingers, expecting to end up with something pretty close to a normal cake. Instead, you come back an hour later to find a fully cooked steak.

It sounds like a practical joke, but this kind of shocking transformation is what really happened to a dish of mouse stem cells when scientists at Gladstone Institutes removed just one gene—stem cells destined to become heart cells suddenly resembled the precursors to brain cells. The scientists' chance observation is upending what they thought they knew about how stem cells turn into adult cells and maintain their identity as they mature.

"This really challenges fundamental concepts about how cells stay the course once they embark on their path to becoming heart or brain cells," says Benoit Bruneau, Ph.D., director of the Gladstone Institute of Cardiovascular Disease and a senior author of the new study published in *Nature*.

No turning back

Embryonic stem cells are pluripotent—they have the ability to differentiate, or transform, into every type of cell in a fully formed adult body. But it takes many steps for stem cells to give rise to adult cell types. On their path to becoming heart cells, for instance, embryonic stem cells first differentiate into mesoderm, one of three primitive tissues found in the earliest embryos. Further down the path, the mesoderm cells branch off to make bones, muscles, blood vessels, and beating heart cells.

It's generally well accepted that once a cell has begun differentiating down one of these paths, it can't turn around to choose a different fate.

"Pretty much every scientist who talks about cell fate uses a picture of the Waddington landscape, which looks a lot like a ski resort with different ski slopes descending into steep, separated valleys," says Bruneau, who is also the William H. Younger Chair in Cardiovascular Research at Gladstone and a professor of pediatrics at UC San Francisco (UCSF). "If a cell is in a deep valley, there's

no way for it to jump across to a completely different valley."

A decade ago, Gladstone Senior Investigator Shinya Yamanaka, MD, Ph.D., discovered how to reprogram fully differentiated adult cells into induced pluripotent stem cells. While this didn't give cells the ability to jump between valleys, it did act like a ski lift back to the top of the differentiation landscape.

Since then, other researchers have discovered that with the right chemical cues, some cells can be converted into closely related types through a process called "direct reprogramming"—like a shortcut through the woods between neighboring ski trails. But in none of these cases could cells spontaneously jump between drastically different differentiation paths. In particular, mesoderm cells could not become the precursors of such distant types as brain cells or gut cells.

Yet, in the new study, Bruneau and his colleagues show that, to their surprise, heart cell precursors can indeed transform directly into brain cell precursors—if a protein called Brahma is missing.

A surprising observation

The researchers were studying the role of the protein Brahma in the differentiation of heart cells, because they discovered in 2019 that it works together with other molecules associated with heart formation.

In a dish of mouse embryonic stem cells, they used CRISPR genome-editing approaches to turn off the gene Brm (the one that produces the protein Brahma). And they noticed that the cells were no longer differentiating into the normal heart cell precursors.

"After 10 days of differentiation, normal cells are beating rhythmically; they're clearly heart cells," says Swetansu Hota, Ph.D., first author of the study and a staff scientist in the Bruneau Lab. "But without Brahma, there was just a mass of inert cells. No beating at all."

After further analysis, Bruneau's team realized the reason the cells weren't beating was because removing Brahma not only turned off genes required for heart cells, but also activated genes needed in brain cells. The heart precursor cells were now brain precursor cells.

The researchers then followed every step of differentiation, and unexpectedly discovered that these cells never returned to a pluripotent state. Instead, the cells took a far larger leap between stem cell paths than had ever been observed before.

"What we saw is that a cell in one valley of the Waddington landscape, with the right conditions, can jump into a different valley without first taking a lift back to the summit," says Bruneau.

Lessons for disease

While the environment of cells in a lab dish and in a whole embryo is quite different, the researchers' observations hold lessons about cell health and disease. Mutations in the gene Brm have been associated with congenital heart disease and with syndromes that involve brain function. The gene is also involved in several cancers.

"If removing Brahma can turn mesoderm cells (like heart cell precursors) into ectoderm cells (like brain cell precursors) in the dish, then perhaps mutations in the gene Brm are what give some cancer cells the ability to massively alter their genetic program," says Bruneau.

The findings are also important at a basic research level, he adds, as they can shed light on how cells might change their character in disease settings, such as heart failure, and for developing regenerative therapies, by inducing new heart cells for example.

"Our study also tells us that differentiation paths are far more intricate and fragile than what we thought," says Bruneau. "A better knowledge of the paths of differentiation can also help us understand congenital heart—and other—defects, which arise in part through defective differentiation." The paper "Brahma safeguards canalization of cardiac mesoderm differentiation" was published online by the journal *Nature* on January 26, 2022.

More information: *Swetansu K. Hota et al, Brahma safeguards canalization of cardiac mesoderm differentiation, Nature (2022).* *DOI: 10.1038/s41586-021-04336-y*

https://lat.ms/3HrJ2ny

When parents are vaccinated against COVID-19, protection extends to their kids

With COVID-19 as with life: When parents take a few jabs, their kids gain protection.

By Melissa Healy Staff Writer

New research from Israel shows that unvaccinated children whose mothers and fathers were fully vaccinated not only had parents who were far less likely to fall ill with COVID-19, their risk of being infected was lower as well.

That protection was seen against both the Alpha and Delta variants of the coronavirus. With Delta in particular, the protection was strongest when parents had gotten a booster shot.

The new findings, published Thursday in the journal Science, underscore the importance of "household transmission" in sustaining the pandemic, as well as the indirect role that vaccination can play in protecting a community's most vulnerable members.

It's parenting advice that may prompt a few of the 30 million unvaccinated American adults to seek out a shot, and the 47 million vaccinated adults who've not yet gotten a booster to roll up their sleeves yet again.

"If the individuals we happen to be speaking with are very child-focused, then some of this may persuade and reassure them," said Dr. William Schaffner, a specialist in infectious diseases at Vanderbilt University.

Schaffner said he routinely tries to convince the vaccine-hesitant that if they will not get vaccinated for themselves, they should do it for their families and communities. But with the attitudes of holdouts hardening, he said, most now decline the appeal and insist their kids will remain unvaccinated too.

In two very different phases of the pandemic, the research shows that children's health relied heavily on indirect vaccine effects: For starters, vaccinated parents were less likely to bring the coronavirus into the household. And when they did, the vaccine appeared to make those parents less likely to pass it on to their unvaccinated children.

Stanford pediatrician Dr. Yvonne Maldonado said that for those who continue to question the need to be vaccinated, the Israeli research offers strong evidence for its broader value. It shows that beyond self-protection, the decision to get vaccinated is "especially important in protecting our most vulnerable members, such as children under 5 who cannot themselves be vaccinated," Maldonado said.

Though children are less likely to become severely ill with COVID-19, the U.S. Centers for Disease Control and Prevention estimates that 1,210 Americans under 18 have died of the disease, including 387 who were 4 and under. The Food and Drug Administration is not expected to give its emergency authorization to any vaccines for these youngest Americans before March.

Older kids also remain largely unprotected. While a pediatric version of the Pfizer-BioNTech vaccine was authorized for emergency use in late October, only 20.7% of 5- to 11-year-olds are fully vaccinated. In November, a Kaiser Family Foundation survey found that roughly 30% of parents with kids in this age group said they will definitely not get their child vaccinated, and 7% say they would do so only if their school requires it. Another third said they wanted to wait and see how the vaccine is working before making up their minds. Meanwhile, 55.6% of U.S. adolescents ages 12 to 17 have received two doses of the regular Pfizer vaccine.

For the new study, researchers studied close to 232,000 Israeli households with unvaccinated children during two 10-week periods of the pandemic. During last winter's wave of infections involving

the Alpha variant, they found that unvaccinated children (most of whom were 15 and under) were 72% less likely to become infected when both parents were vaccinated than when neither was.

When the more-transmissible Delta variant swept across Israel late last summer, unvaccinated children (by then mostly 10 and under) were 58% less likely to get infected if both parents had had three doses of vaccine than were their peers whose vaccinated parents had not yet gotten a booster.

The researchers made clear that the protection they saw would probably also extend to older household members, and to those with conditions that weakened their immune systems, leaving them vulnerable to COVID-19.

They added that their findings validate long-held beliefs about the role of vaccines in fostering "herd immunity": that as a larger proportion of a community gets vaccinated, transmission will fall and even the unvaccinated will gain indirect protection from becoming ill.

"Herd immunity also works at the household level," said Dr. Paul Offit, a vaccine specialist at Children's Hospital of Philadelphia. "If you have a critical number of people in the home who are vaccinated, that works to slow the virus' transmission."

For those with an immune-compromised family member or an unvaccinated child at home, "you want to put a protective moat around him" by surrounding the individual with vaccinated people, Offit added.

In the study, having even one parent who remained unvaccinated or incompletely vaccinated put children at "substantially larger" risk of becoming infected. In cases where one parent was fully vaccinated and the other parent was not, vulnerable kids saw only marginal reductions in their chances of becoming infected: by 26% with the Alpha variant and 21% with the Delta variant.

The results build on other studies that have shown vaccination protects people beyond the individual who gets the jab. One Israeli study found unvaccinated spouses of healthcare workers were protected by their spouse's vaccination. Another measured vaccination rates in close to 200 geographical communities in Israel, showing that as they rose, infections among unvaccinated youngsters consistently dropped.

"This is a simple matter of common sense," Offit said. It would be a persuasive selling point "in a world dominated by logic and reason, but sadly, we don't live in that world," he added. "People at this point are pretty much locked in."

https://wb.md/3HhHo83

Billionaire Mark Cuban Launches Online Pharmacy for Generics

Mark Cuban, the owner of the Dallas Mavericks basketball team and star of TV's Shark Tank, is backing a new online pharmacy that aims to reduce the prices people pay for 100 generic medications.

Damian McNamara, MA

The Mark Cuban Cost Plus Drugs Company (MCCPDC) plans to offer the leukemia therapy imatinib for $47 per month, for example, compared to $120 or more with a common voucher and a retail price of $9,657 per month.

Other examples of lower-priced generics include the ulcerative colitis treatment mesalamine, which goes for $32.40 per month on the new online pharmacy, vs. $940 per month retail. In addition, the MCCPDC will offer the gout treatment colchicine at a lower price, charging $8.70, compared to $182 per month retail.

Likely in part due to claims of significant cost savings and in part due to Cuban's celebrity status, the new venture is getting widespread media attention. *Forbes,* NPR, and TMZ have shared the news since the new digital pharmacy was announced earlier this month.

The new venture plans to charge consumers 15% above the manufacturing cost for the generic medications, plus a $3 fee for pharmacists and $5 for shipping. People will still require a prescription from their doctor to get the medications.

Generic Pricing and Social Benefit

The top 100 generic products account for about half of generic sales, and there is enough competition for these high-demand medications that "the prices have come down close to zero," says William Comanor, PhD, a health economist and professor of health policy and management at the UCLA Fielding School of Public Health.

The remaining generic agents have lower-volume demand, he says.

One prominent example is Daraprim, a decades-old treatment for the life-threatening parasitic infection toxoplasmosis. The drug jumped into the spotlight in 2015 when Martin Shkreli and his company Vyera Pharmaceuticals bought the rights to make the generic drug and raised the price overnight from $13.50 to $750. In January 2022, a U.S. judge banned Shkreli from the pharmaceutical industry and ordered him to pay an almost $65 million fine.

Comanor agrees the price should have been raised -- $13.50 "was not economically viable" -- but not as steep as $750.

"Say Mark Cuban says he will cut the price from $750 to $300. He will still make money. There is a market for these low-volume products," he says. "There would also be a social benefit."

A Direct-to-Consumer Digital Pharmacy

MCCPDC is “cutting out the middleman” in two ways. The business model calls for charging consumers out of pocket, so insurance companies are not involved. Also, the company created its own pharmacy business manager firm in October, allowing it to negotiate prices with drugmakers in-house. The company also announced plans to complete construction of a 22,000-square-foot pharmaceutical factory in Dallas by the end of 2022.

Reactions on social media ranged from celebratory to people disappointed their generic medication would not cost significantly less or is not provided by the digital pharmacy.

On the plus side:

So far, Mark Cuban Cost Plus Drug Company has already beat the price on rosuvastatin calcium 10 mg tabs (generic Crestor), AND I had bypassed my own insurer's pharmacy benefit to buy it for less elsewhere. His cost: $7.50 for a 90-day supply, which is half of what I was paying. pic.twitter.com/9mCOwcw3pM

— Scott Strumello (@sstrumello) January 19, 2022

On the downside:

Mark Cuban's wholesale pharmacy would cost me more than the one I currently use and people on here are talking like he has solved our country's healthcare crisis.

— Jay 🌊 US🌈🗽 (@FerrazzanoJay) January 24, 2022

And of course, someone posted what might have happened if Cuban pitched this idea on *Shark Tank*:

Mark Cuban has launched an online pharmacy that offers over 100 generic drugs at an adorable price. Yet I’m still certain Barbara would find a reason not to invest in that company. pic.twitter.com/z86kePTVbf

— Volv ☁️ (@getvolv) January 24, 2022

When weighted by the number of prescriptions, prices for generics have declined in the U.S. "Overall, U.S. generic prices are the lowest in the world," Comanor says. "People say U.S. drug prices are the highest in the world. That's true for branded, but it's not true for generics. So if someone asks if U.S. drug prices are the highest or lowest in the world. the answer is both," he says.

"Maybe there is a role to play for this new pharmacy,” Comanor says when asked if the initiative seems like a positive development.

The state of California also announced plans to provide its own generic drugs, he says. "But you won't see a lot of entrepreneurs getting into this because the volumes are so low. If Cuban called me, I would tell him to provide Daraprim and similar, low-volume products," Comanor says of the billionaire. "He's a rich guy; maybe he can do it."

SOURCES:
William Comanor, PhD, health economist and professor of health policy and management, UCLA Fielding School of Public Health.
Forbes: "Billionaire Mark Cuban Opens Online Pharmacy To Provide Affordable Generic Drugs."
NPR: "Billionaire Mark Cuban launches online pharmacy aimed at lowering generic drug prices."
TMZ: "Mark Cuban Launches Online Pharmacy Offering Generic Drugs for Cheap."
Twitter: @sstrumello, Jan. 19, 2022; @FerrazzanoJay, Jan. 24, 2022; @getvolv, Jan. 24, 2022.
Medscape: "US Judge Bars Martin Shkreli From Drug Industry, Orders $64.6 Mln Payment," "California Rx: State May Dive Into Generic Drug Market."

https://bit.ly/342Qx68

Our Brains Keep Us 15 Seconds 'in The Past' to Help Us See a Stable World, Says Study

Our eyes are continuously bombarded by an enormous amount of visual information – millions of shapes, colors, and ever-changing motion all around us. For the brain, this is no easy feat.

Mauro Manassi And David Whitney, The Conversation

On the one hand, the visual world alters continuously because of changes in light, viewpoint, and other factors. On the other, our visual input constantly changes due to blinking and the fact that our eyes, head, and body are frequently in motion.

To get an idea of the "noisiness" of this visual input, place a phone in front of your eyes and record a live video while you are walking around and looking at different things. The jittery, messy result is exactly what your brain deals with in every moment of your visual experience.

This can be seen also in the video below. The white circle on the right shows potential eye movements, and the blurry blob on the left reveals the jumpy visual input in every moment.

Yet, seeing never feels like work for us. Rather than perceiving the fluctuations and visual noise that a video might record, we perceive a consistently stable environment.

So how does our brain create this illusion of stability? This process has fascinated scientists for centuries and it is one of the fundamental questions in vision science.

The time machine brain

In our latest research, we discovered a new mechanism that, among others, can explain this illusory stability.

The brain automatically smoothes our visual input over time. Instead of analyzing every single visual snapshot, we perceive in a given moment an average of what we saw in the past 15 seconds. So, by pulling together objects to appear more similar to each other, our brain tricks us into perceiving a stable environment.

Living "in the past" can explain why we do not notice subtle changes that occur over time.

In other words, the brain is like a time machine which keeps sending us back in time. It's like an app that consolidates our visual input every 15 seconds into one impression so that we can handle everyday life.

If our brains were always updating in real time, the world would feel like a chaotic place with constant fluctuations in light, shadow, and movement. We would feel like we were hallucinating all the time. We created an illusion to illustrate how this stabilization mechanism works.

Looking at the video below, the face on the left side slowly ages for 30 seconds, and yet, it is very difficult to notice the full extent of the change in age. In fact, observers perceive the face as aging more slowly than it actually is.

To test this illusion we recruited hundreds of participants and asked them to view close-ups of faces morphing chronologically in age in 30-second timelapse videos. When asked to tell the age of the face at the very end of the video, the participants almost consistently reported the age of the face that was presented 15 seconds before.

As we watch the video, we are continuously biased towards the past and so the brain constantly sends us back to the previous ten to 15

seconds (where the face was younger).

Instead of seeing the latest image in real time, humans actually see earlier versions because our brain's refresh time is about 15 seconds. So this illusion demonstrates that visual smoothing over time can help stabilize perception.

What the brain is essentially doing is procrastinating. It's too much work to constantly deal with every single snapshot it receives, so the brain sticks to the past because the past is a good predictor of the present. Basically, we recycle information from the past because it's more efficient, faster, and less work. This idea – which is also supported by other results – of mechanisms within the brain that continuously bias our visual perception towards our past visual experience is known as continuity fields.

Our visual system sometimes sacrifices accuracy for the sake of a smooth visual experience of the world around us. This can explain why, for example, when watching a film we don't notice subtle changes that occur over time, such as the difference between actors and their stunt doubles.

Repercussions

There are positive and negative implications to our brain operating with this slight lag when processing our visual world. The delay is great for preventing us from feeling bombarded by visual input every day, but it can also risk life-or-death consequences when absolute precision is needed.

For example, radiologists examine hundreds of images in batches, seeing several related images one after the other. When looking at an X-ray, clinicians are typically asked to identify any abnormalities and then classify them.

During this visual search and recognition task, researchers have found that radiologists' decisions were based not only on the present image, but also on images they had previously seen, which could have grave consequences for patients.

Our visual system's sluggishness to update can make us blind to immediate changes because it grabs on to our first impression and pulls us toward the past.

Ultimately, though, continuity fields promote our experience of a stable world. At the same time, it's important to remember that the judgments we make every day are not totally based on the present, but strongly depend on what we have seen in the past.

Mauro Manassi, Assistant Professor in Psychology, University of Aberdeen and David Whitney, Professor of Psychology, University of California, Berkeley.