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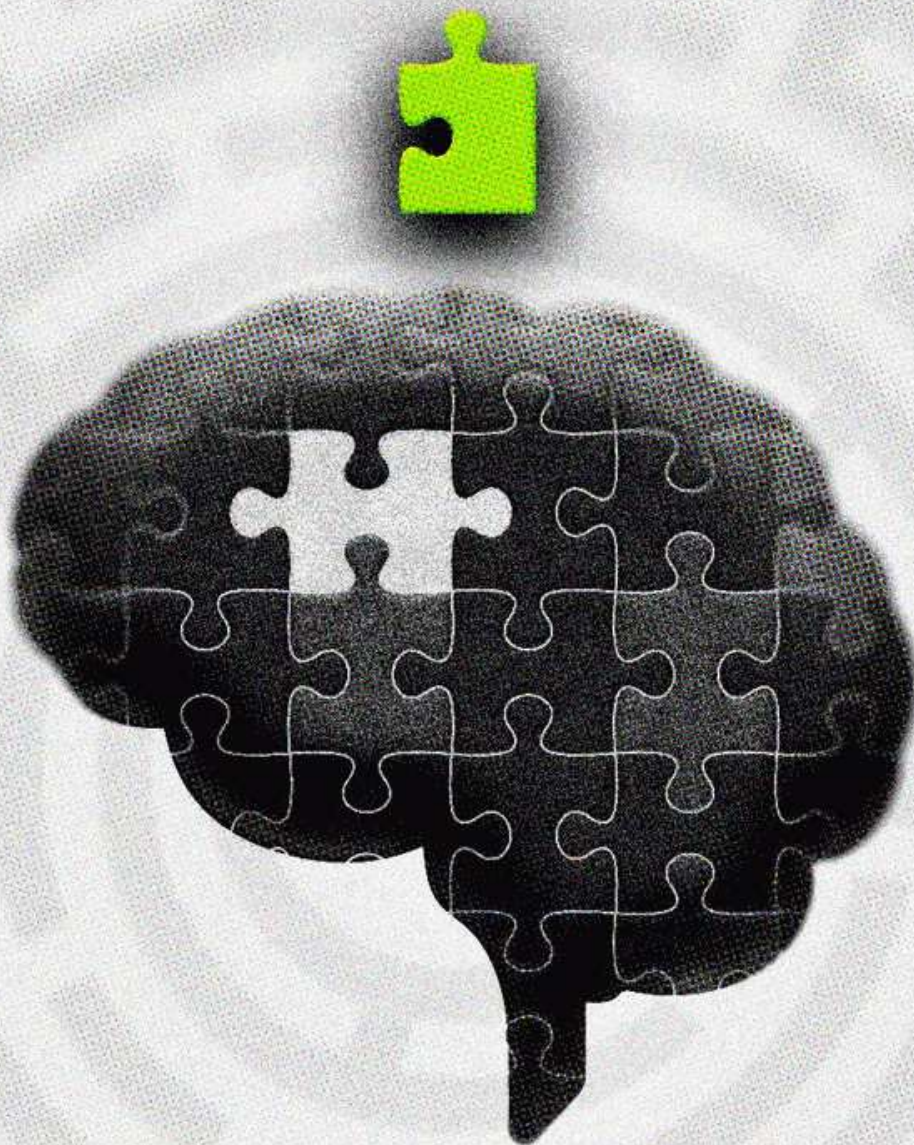


IS AGE BIOLOGICAL
OR PSYCHOLOGICAL?

CAN YOU BUY REAL ESTATE
ON THE MOON?

IFLSCIENCE.COM | AUGUST 2023

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Can it be discredited by paradoxes? Stephen Luntz investigates.

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IFLSCIENCE

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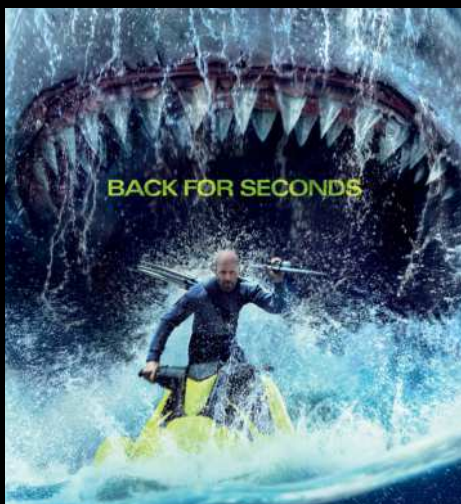
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NEWS BITES



The Meg Is Back

Just when you thought it was safe to get back in the water, Jason Statham is back to utter the immortal line "That's the biggest megalodon anyone has ever seen" this month. Yes, everyone's favorite extinct shark is back in *The Meg 2: The Trench*, a splashy summer blockbuster 3.6 million years in the making. Will it be accurate? Unlikely. Will it be fun? Undoubtedly. Could the megalodon be **hiding in the deep**, protected by a cloudy thermocline layer? No. It's true that a change in climate likely led to the meg's extinction, but for a species to live on and procreate for 3 million years there would need to be more than just a couple swimming undetected in the seas. And while big, they weren't as big as the movie depicts them, at around 15-18 meters (49-60 feet) instead of the film's 21-27-meter (70-90 foot) behemoths. However, they were apex badasses that ruled the seas for 20 million years, so grab your popcorn and strap in for a wet and wild ride.

World's Second Tallest Tree

The second tallest tree on Earth has been discovered in the depths of the deepest canyon in the world. The record-breaking 102-meter (335-foot) tall cypress tree was found in the Yarlung Zangbo Grand Canyon nature reserve in the Tibet Autonomous Region of China, the deepest known canyon on Earth. At this height, it towers over the Statue of Liberty. The current world record-holder is a 116-meter (381-foot) Sequoia, nicknamed Hyperion, found in Redwood National Park in California. Hyperion's exact location is now a closely guarded secret with a hefty \$5,000 fine for hikers seeking it after it became damaged by tourists climbing it in 2022.



Frankie Says End Fossil Fuels

Cast your mind back to 2021, when an unexpected guest interrupted a televised United Nations (UN) meeting in the run-up to the COP26 climate summit: Frankie the Utahraptor.

An effective launch to the Don't Choose Extinction campaign, the CGI dinosaur has been tirelessly campaigning ever since. UN research shows the world spends \$423 billion annually on subsidizing fossil fuels. Now you can support the campaign with a new set of **UN stamps** starring Frankie, each with a QR code that launches the full film.



They See Me Rollin'

You may not be able to have a piece of Mars in your home, but this may be the next best thing. Landing in living rooms on Earth, the new **LEGO® Perseverance rover** and Ingenuity helicopter kits are incredibly detailed and technically correct thanks to a team-up with the folks at NASA's Jet Propulsion Laboratory, home of the intrepid Mars explorers. The one-tenth-scale models let builders explore key design and science features of the rover and complete interactive challenges. You can even see data returned by the real rover, which has been on Mars since February 2021 seeking out signs of life on the Red Planet.



Purple Is The New Red

NASA recently released two stunning new images of Mars looking a lot more purple than usual. The MAVEN (Mars Atmosphere and Volatile EvolutionN) mission snapped the two glorious images in ultraviolet (which we can't see), revealing the changing seasons on the usually Red Planet as it orbits the Sun. The two images show Mars's southern and northern hemispheres in 2022 and 2023 when the planet was at opposite ends of its orbit. Mars takes twice as long to orbit the Sun than Earth, so seasons are around twice as long. It also has a very thin atmosphere, less than 1 percent of Earth's. By viewing the planet in ultraviolet, scientists can gain insight into Mars's atmosphere and surface features. In these processed images, the atmospheric ozone is purple, clouds or haze are white and blue, and the surface is tan or green. MAVEN launched in 2013 to find out how Mars lost its atmosphere over billions of years.

Et Tu, Brute?

Beware the Ides of March. You can now visit the very place where Julius Caesar was famously stabbed to death as the Roman square, rediscovered back in the 1920s, is now welcoming visitors for the first time. Assassinated by a group of senators on March 15, 44 BCE, Caesar's death resulted in the end of the Roman Republic and the birth of the Roman Empire. The Roman Emperor Augustus declared the scene of the crime as a *locus sceleratus* – a cursed place. It was lost to history until excavations ordered by Mussolini revealed the remains of the Curia of Pompey, where Caesar met his fate. You can visit it in Rome, Italy, not far from the Colosseum, but be wary of who you take with you.

WHAT'S UP?



Super Blue Moon

I Saw You Standing Alone

Name: Super Blue Moon

Appearance: The biggest and brightest Moon of the year. Not blue

Location: 363,300 kilometers (226,000 miles) from Earth

Is the Moon blue?

It's not. A "Blue Moon" can refer to either the second Full Moon in a month or third Full Moon in a season.

What on Earth is a Super Blue Moon?

Well, it's not an astronomical term so you may want to break it down.

OK, first, what is a Super Moon?

When the Moon is at its perigee and it's full, we call this a Supermoon. Astronomers would call it a perigean Full Moon. A Full Moon at perigee appears 14 percent bigger and 30 percent brighter than at apogee. There are usually three or four a year.

What is a perigee and apogee?

The Moon's closest and furthest approach to Earth during its orbit. At closest approach, the Moon is 363,300 kilometers from Earth. At apogee, it is 405,500 kilometers (253,000 miles).

Are Blue Moons rare?

Yes and no. They occur every 2-3 years, which means "once in a Blue Moon" actually means fairly regularly. August 2023 has two Full Moons, on 1 and 30, and both will be Supermoons, but it's the second that's "Blue". However, two Blue Moons in a year are rarer, you'll have to wait for 2037 for that.

Does the Moon come in any other colors?

While the Moon itself stays the same gray color, popular terms refer to a Pink Moon (April's Full Moon), **Black Moon** (the Blue Moon's New Moon twin), and **Blood Moon** (which does actually look red and occurs during a total lunar eclipse).



IS LOGIC FLAWED?

**Paradoxes have long posed a problem for our view of the world:
Is the answer we need a less binary understanding of logic?**

Image Credit: Imran Chowhury

By Stephen Luntz

If we asked whether the Earth was spherical, most readers would say yes. Only the pedantic would point out it is an oblate spheroid, but technically speaking those who agreed with the proposition would be wrong. Clearly, however, they're nowhere near as wrong as anyone claiming the Earth is flat. There are degrees of wrongness, which are often very important; arguably this implies there are also degrees of truth. Yet we often rely on classical logic that assumes only two values: true and false, which can lead to paradoxes when either option leads to contradiction.

Logic, by one **definition** is "A method of reasoning that involves a series of statements, each of which must be true if the statement before it is true." Put like that, logic seems unimpeachable. Any failures can only be because a preliminary statement is wrong, or one of the subsequent statements doesn't follow as universally as is claimed.

When we talk about "flawed logic" we usually mean one of these things: someone starts with an incorrect assumption, and builds a pile of conclusions on these shaky foundations. It's the equivalent of "garbage in, garbage out", where a computer's errors are not the fault of the system, but of the data it was fed. Alternatively, the original premise is right, but at some point one of a number of potential implications was treated as the only one possible.

The solution to errors of each is obvious, although not always easy to implement. In the first case, we just need to check our premises better. In the second, we need to examine each step to see if it's as watertight as stated.

Yet, thousands of years ago, Greek philosophers were posing a more fundamental challenge to logic in the form of paradoxes. Paradoxes are no doubt much older still, but it was thinkers like Zeno of Elea who gave us both the name and entrenched the idea of self-contradictory

conclusions from apparently sound premises as a challenge to the nature of reality.

The original paradoxes were (as far as we can tell) created to challenge our sense of reality, not to question logic. Many paradoxes, both original and more recent, have eventually turned out to have quite logical solutions that simply weren't obvious at the time. Others, however, present a deeper challenge.

According to one **definition**, a paradox is "An argument that apparently derives self-contradictory conclusions by valid deduction from acceptable premises."

Breaking the binary

Other paradoxes, however, present a more fundamental challenge, sufficient to raise questions about logic at its core. These, known as antinomies, collide not merely with our observations, but with their own internal logic.

Some, perhaps all antinomies, arise from a binary view of the world. For example one of the most famous, the **Liar's Paradox**, includes examples such as "This statement is false".

SOME PHILOSOPHICAL TRADITIONS, PARTICULARLY THOSE FROM ASIA, ARE MORE COMFORTABLE WITH THE IDEA THAT TRUTH CAN BE A SPECTRUM.

If we believe that things can only be either true or false, like the ones and zeros on a computer, then the statement generates a sort of recursive loop that has fascinated people for centuries.

However, some philosophical traditions, particularly those from Asia, are more comfortable with the idea that truth can be a spectrum than Europe's, which built heavily on classical Greece.

Centuries before Aristotle was formalizing the rules of logic the West has largely relied

on ever since, Jains were developing the doctrine of **anekāntavāda**, in which all statements contain both truth and falsehood.

Arguably, the rise of **quantum computers**, in which superpositions of both one and zero, in shifting ratios, replace binary bits, has vindicated these alternative views.

Underlying many logical paradoxes is the belief that something is either one thing or another. This breaks down almost entirely at the subatomic level, with photons being both particles and waves, but it doesn't always stack up that well in more familiar contexts, as the initial example of the shape of the Earth may illustrate.

THE FAMOUS QUESTION OF WHETHER A GLASS IS HALF FULL OR HALF EMPTY HINTS AT ANOTHER EXAMPLE. BOTH OF THESE THINGS ARE TRUE, BUT AT WHAT POINT CAN WE DROP THE "HALF" AND SAY, "MY GLASS IS EMPTY"?

The famous question of whether a glass is half full or half empty hints at another example. Both of these things are true, but at what point can we drop the "half" and say, "My glass is empty"? Does it need to be bone dry, or do a few drops still count as "empty"?

Fuzzy logic was invented to try to capture this complexity, allowing the truth value of a proposition to be anywhere between one and zero.

Arguably, actual human decision-making has more in common with fuzzy logic than the Boolean logic of ones and zeroes.

However, while fuzzy logic has been used in artificial intelligence and medical image analysis, among other uses, it has not come close to displacing the classical version in most education systems or applications.



Perhaps that's because ingrained cultural traditions can be very hard to shift. The **furious reaction** to the idea that gender can be anything other than **binary** might be seen as an example of this. On the other hand, it might be argued that traditional logic still has plenty going for it.

Solved paradoxes – victories for logic?

Paradoxes come in many forms, and not all of these pose a problem for logic, indeed many of them have vindicated it. It's more common for paradoxes' contradictions to be with observed reality than with themselves, and these have often been resolved by combining logic with deeper investigation.

For example, some paradoxes have turned out to be useful ways to expose that reality is more complex than our naive assumptions. Others involve a sort of sleight of hand, such as dividing by zero to "prove" that $1=2$.

THE PARADOX OF WHY THE NIGHT SKY IS DARK WAS USED TO PROVE THE UNIVERSE IS NOT INFINITE, ALTHOUGH WE HAVE SINCE LEARNED IT IS EXPANDING.

One of the original paradoxes presented by Zeno (as paraphrased by Aristotle and others), imagined a deeply unfair **race** between Achilles and a tortoise. Achilles sportingly gives his reptilian opponent a head start. We know that, provided the race is long enough, this will be insufficient, the faster runner will eventually overtake the slower one. However, Zeno argued, by the time Achilles reaches the point the tortoise started from the tortoise will have gained some ground, and by the time Achilles crosses that secondary distance, the tortoise

will have moved a still smaller distance. Achilles constantly gains on the tortoise, but according to this view, can never overtake it.

Aristotle provided an answer but concerns it was **inadequate** helped drive the study of infinite series, which has proven exceptionally valuable for science.

Not everyone is satisfied with such mathematical solutions, with some seeing it as a still unsolved metaphysical problem. Nevertheless, classical logic comes out of a challenge like this rather well – far from being discredited, it has led us to something true and useful.

Similarly, the paradox of why the night sky is **dark** was used to prove the universe is not infinite, although we have since learned it is **expanding**.

There are other paradoxes we don't yet have complete solutions to, but scientists are well on the chase. For example, the **Faint Young Sun Paradox** notes that stars with masses like the Sun's emit less heat and light in their first billion years than they do at the Sun's current age.

Consequently, the **initial form** of the paradox went that the Earth should have been much colder during the **Hadean eon**, preventing the presence of liquid water. Yet we know the Earth's oceans date back 4.4 billion years. More abundant carbon dioxide, and therefore a stronger greenhouse effect, has largely resolved this problem for Earth, but it continues to trouble Mars researchers. Explaining what **gasses** could have made up the Martian atmosphere during its **Noachian era**, and where they went is an ongoing problem, but it's one we can reasonably expect to solve without throwing out the book of logic.

Maybe we need a word (meta-paradox, perhaps) for the fact that paradoxes can both expose the flaws in classical logic, and demonstrate its strength. ♦

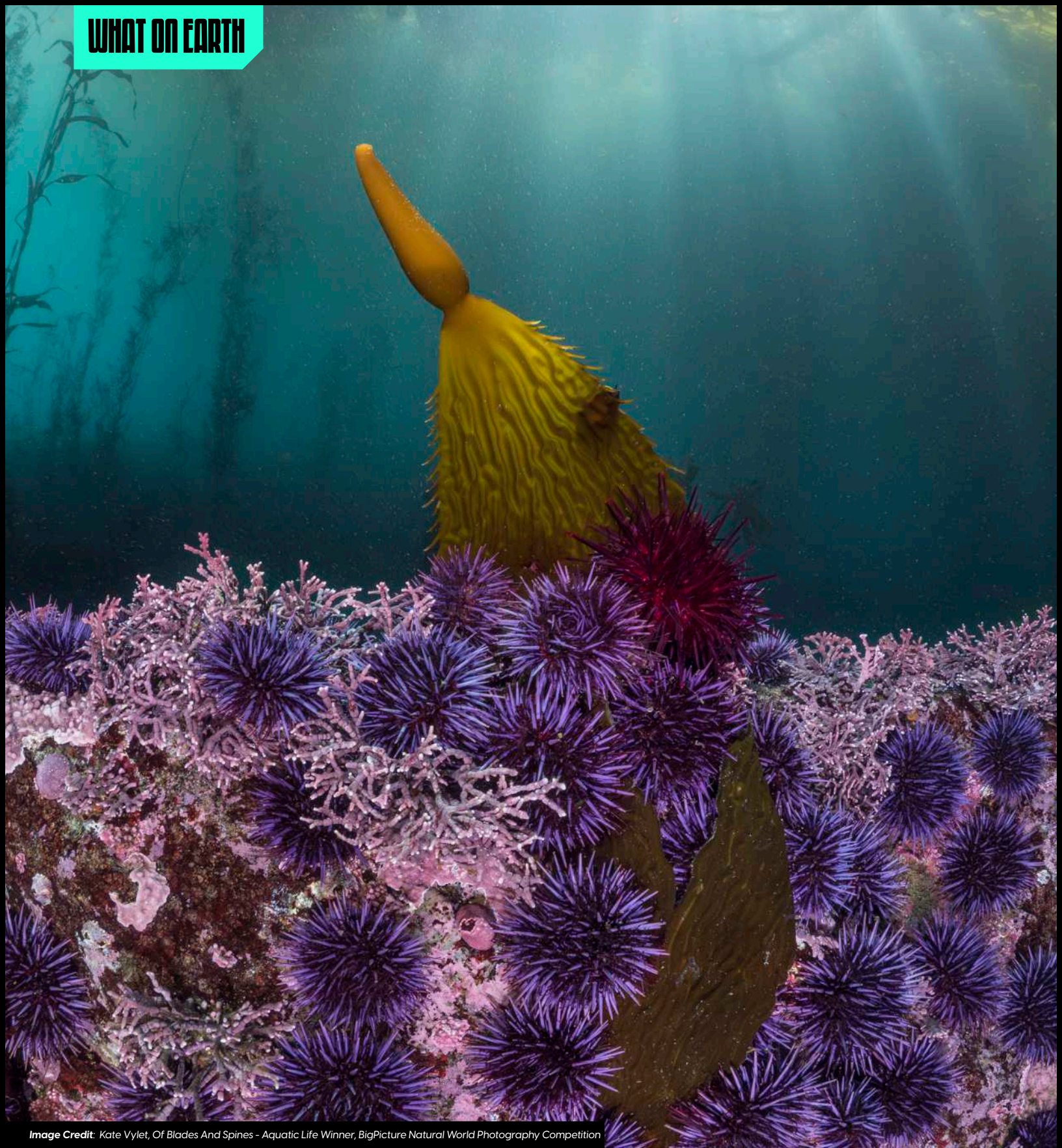


Image Credit: Kate Vylet, *Of Blades And Spines* - Aquatic Life Winner, BigPicture Natural World Photography Competition

HARD WORKING URCHINS

Urchins get a bad rap for kelp forest degradation, but a BigPicture Natural World Photography Competition winner by Kate Vylet recently shone a light on the good they do as detritivores. By nibbling up the rubbish that's fallen to the seafloor, they can clean up while also moving the energy they consume up the food chain. Plus, they're pretty funky li'l guys.

This image originally appeared on bioGraphic, an online magazine about nature and regeneration and the official media sponsor for the California Academy of Sciences' BigPicture Natural World Photography Competition.



Image Credit: nurulanga/iStock

CAN YOU BUY REAL ESTATE ON THE MOON?

JUST ASKING FOR A FRIEND...

By Rachael Funnell

Would you move to the Moon? It's probably the cosmic world you're most familiar with other than, you know, Earth – and where better to brag about having a holiday home? One thing – can you even buy real estate on the Moon?

As luck would have it, we crossed paths with a Space Lawyer last month, giving us the opportunity to ask just that. And before you ask, yes, Space Lawyer is a real job title. Not only is Michelle Hanlon, Air and Space Law Instructor, Research Counsel, using her legal knowledge to reshape our understanding of the Outer Space Treaty, but she's contributed towards creating the first ever off-planet heritage sites for humankind, while also considering what allowances we need to make should life on other worlds end up sharing space with the human race.

***IF YOU BUILD A HOUSE ON THE MOON,
ACCORDING THE OUTER SPACE TREATY,
ANYBODY CAN COME TRAVELING THROUGH IT.***

What does being a Space Lawyer involve?

MH: We have a treaty in place that governs activities in outer space and it is really like the Magna Carta of space activity. The most important precept of the Outer Space Treaty is that space is for everyone, and everyone shall have freedom of exploration and access to all areas. The other really important precept is that no state may claim territory in space. So fundamentally, then the question is, if you can't claim territory, how can we build communities in space? Because that concept is based on the idea of property of ownership.

What my work is focused on is understanding how to thread the needle between the idea of freedom of access, for everybody. If you think about it, if you build a house on the Moon, according the Outer Space Treaty, anybody can come traveling through it.

But is that really freedom of access? How do we balance this freedom against what we know we need? And so, for example, here on Earth, the [United Nations] Declaration of Human Rights says everybody has a right to own property. And so that can't just be taken away when you go to space. So, we're really trying to find that balance and understand how we're going to build communities peacefully, within the framework that's set up by this Outer Space Treaty.

Are there any Earthly concepts that help you do this?

MH: There are places on Earth that are not governed by any jurisdiction: the high seas.

So, we do have a little bit of a concept of what it looks like to be active in an area that has no sovereign jurisdiction. The problem is that we still have flags, and we're talking about boats floating, there are no islands in the high seas that aren't claimed by anybody.

***SPACE IS INFINITE, AND WE HAVE TO BE
MINDFUL THAT PERHAPS THERE ARE OTHER
BEINGS IN SPACE THAT ARE SENTIENT.***

So, we can't quite move that concept to space. A lot of people try saying the high seas are considered a global commons, and from an economic and philosophical standpoint, space is a global commons. But space is infinite, and we have to be mindful that perhaps there are other beings in space that are sentient. So, this concept that all of space belongs to all of humanity, it's kind of bunk, right? Certainly, when we look at low-Earth orbit, that is a finite resource. I view low-Earth orbit like the high seas. We're junking it up because nobody's taking responsibility, and that's a problem. But when you get beyond low Earth orbit, when you get beyond our Moon, then you really have no Earthly precedents.

Is the increase in space activity making your life more complicated?

MH: It is, but in only the best way possible. This is the period that historians will look back on and say, this is the democratization of space. It used to be only nations could go, and it was only Russia, the US, and China. Thank goodness for these billionaires who are spending their own money to figure out how to get to space, because certainly the taxpayers don't have the money to do that and shouldn't be funding it.



Image Credit: Eleni11/istock

WHAT ABOUT BUILDING A HOTEL ON THE MOON? THERE'S NOBODY WHO HAS THE AUTHORITY TO SAY, YES, YOU CAN BUILD THAT HOTEL.

Article Six of the Outer Space Treaty says that states have to take responsibility for their nationals in space, whether they're governmental entities or not. Elon Musk and Jeff Bezos are American nationals, their companies are American companies, and the United States has a responsibility to make sure that their activities conform with the Outer Space Treaty.

It just opens up so many questions from a legal standpoint; what does conform mean? Does that mean they have to follow the letter of the law of the Outer Space Treaty? Which itself doesn't say you're obligated to meet all the responsibilities; it just says conform. Article Two says you cannot claim territory by means of sovereignty, or any other means, but it doesn't say that just a human individual can't. And now we're seeing that possibility. I love the Outer Space Treaty, it's a wonderful document, but it has a lot of gaps, and we really need to start thinking about filling those gaps.

So... could we one day buy real estate on the Moon?

MH: That's a really interesting question. We could, but I think it would be sad if we did. The problem, when you think about buying something, is who owns it in the first place. When you purchase a

property, you go to a government who has the authority to say you will now own this plot of land. Nobody has that authority over the Moon.

If you're building lunar research stations, the Outer Space Treaty has this concept that if it's for science it's OK, so long as you share all your information with everybody. But what about building a hotel on the Moon? There's nobody who has the authority to say, yes, you can build that hotel.

It's a difficult process, but it has to happen if we are going to explore beyond our orbits. We're going to need to allow people to build houses and claim land. I personally would like to see the Moon treated a little bit differently from the rest of space, let's keep the Moon as pristine as we can.

Is it cool being a Space Lawyer?

MH: Oh my goodness, I love every day. I pinch myself all the time. I was a business attorney for 25 years before I became a Space Lawyer. I'm very detail-oriented and like to read contracts, and get into the weeds of things. So, I really enjoy it every time I read the Outer Space Treaty. I see different interpretations and different things in different ways.

It's just such an exciting field of law to be in because there are no laws; we're really making it up as we go along. Hopefully, I'm contributing to the responsible management of our space activities, but what I really love about what I do is every day seeing endless possibilities. I'm very optimistic that the more we interact with space, the more humans we send to space, the more we're going to remember our kinship with each other. ●



Hanlon will be speaking at
CURIOUS Live on **October 21, 2023**

Keep your eyes peeled for more details on
IFLScience's first virtual event!

Image Credit: MediaProduction/istock, bgblue/istock

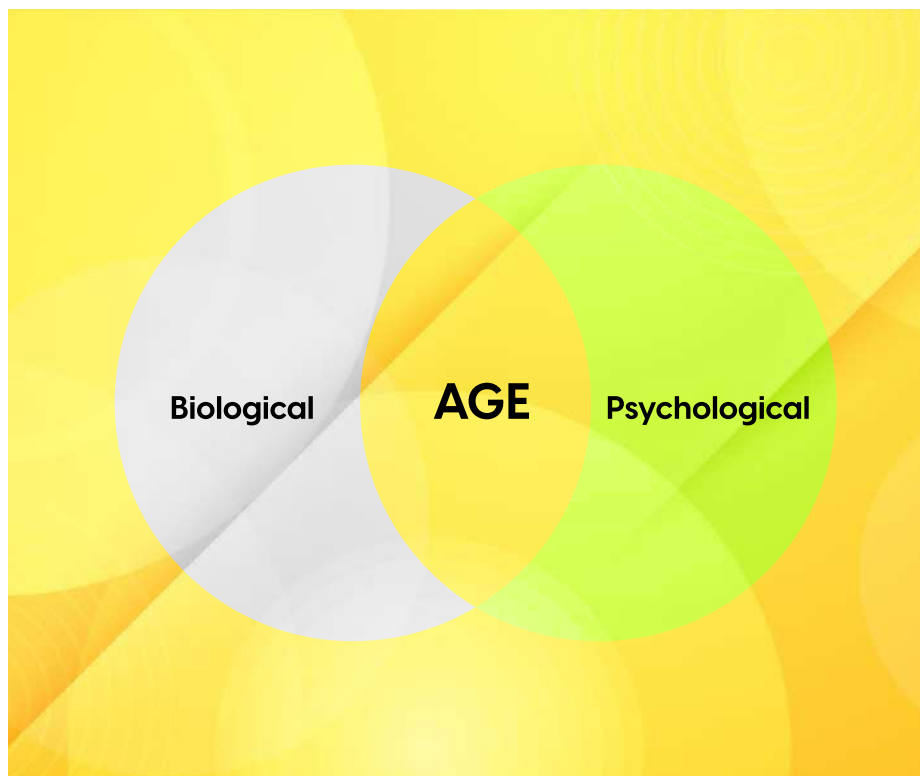


SCIENCE FACT OR FICTION:

IS AGE BIOLOGICAL OR PSYCHOLOGICAL?

How much of aging is down to changes in our bodies, and how much of it is down to mindset? Laura Simmons searches for an answer.





We're often told that "age is just a number." After all, when "40 is the new 30", but then "life begins at 50", it's easy to think that none of it means anything at all. But there have to be some biological indicators of aging, don't there – some signs in our bodies that track the passage of time? Or is it really all in the mind?



The ticking biological clock

Human bodies don't carry on forever. As we go through our lives, systems that once worked well start to gradually break down, and this leaves its mark.

You can't talk about aging without mentioning **telomeres**. These short regions of repetitive DNA cap the ends of every chromosome in every cell. Each time a cell divides, the telomeres shorten, until they reach a point where they're so degraded that it's a signal for the cell to die. This helps prevent cells from hanging around long enough to build up enough mutations to cause a serious problem.

The link between shorter telomeres and shorter life expectancy was first made in **research** published over two decades ago. In a random sample of people aged 60 or over, those with shorter telomeres were found to be more likely to die from an infectious condition or heart disease.

Since then, telomere length has come to be accepted as a biomarker of aging – a proxy we can measure to roughly estimate someone's age-related state of health. However, not everyone agrees on that.

A 2021 **review** summarized the conflicting viewpoints. Studies have reported that telomere length is no better a predictor than just taking someone's actual age in years. The authors of the review concluded that the complex nature of aging means it's unlikely a single biomarker could ever truly capture all the factors, but telomere length could continue to be useful when considered together with other indicators.

Males and females also have their own unique indicators of age – the gradual loss of the **Y chromosome** from some cells, and the menopause, respectively. Y chromosome loss has been linked to certain types of cancer, among other conditions.

Aging also manifests as general wear and tear in most organs and tissues of the body. Whether one system is affected more than another will come down to the individual, but this explains why so many diseases, like cancer, dementia, and osteoarthritis are much more common in older people, and why things like eyesight and hearing can gradually decline over time.

What's in an age?

At a conference in March 2023, Dr Julian Mutz of King's College London discussed the findings of a study that suggested people with a history of mental illness were, in a sense, older than they should be.

"We found that, on average, those who had a lifetime history of mental illness had a metabolite profile which implied they were older than their actual age," Mutz explained in a **statement**. "For example, people with bipolar disorder had blood markers indicating that they were around 2 years older than their chronological age."

Another **recent study** found that hospitalized COVID-19 patients who had prior exposure to high levels of air pollution had poorer outcomes from the disease, with an equivalent impact on time hospitalized of adding 10 years to their chronological age.

Further research looking at the impact of COVID-19, and the stress of living through such a tumultuous time, found that **teenagers' brains** were maturing more

quickly than they should – something generally only seen in children who have experienced chronic trauma or neglect.

There are also conditions that cause premature aging like **progeria**, a rare genetic disorder.

Our old friends the telomeres, like any other system in the body, can go wrong, leading to diseases with symptoms usually linked to aging, such as osteoporosis.

And for a slightly more frivolous example, many people – this author included! – start to develop gray hair long before they feel “old enough” to do so.

But there’s also no shortage of studies claiming to have found the secret to *delaying* aging. One well publicized example recently found that the amino acid **taurine** boosted lifespan in animal models. Another **2023 study** showed that researchers could extend the lifespan of worms by 50 percent

by manipulating the metabolism of fat by-products that build up within cells during aging. If that same effect can be achieved in humans, study author Dr Eyleen Jorgelina O’Rourke said in a **statement**, it could be a route to increasing “the number of years of independent healthy living for all of us.”

And that’s not even counting the number of **strange and mysterious methods** favored by the super-rich to try to halt the inevitable passage of the years, many of which have a dubious basis in actual science. Employing the services of your younger relatives to provide you with transfusions of their “youthful” blood, for example, is not something we’d recommend.

There’s even been some research to suggest **gray hair can revert back to its natural color**, albeit in a limited way.

The point to all this is that the chronological age you are sometimes bears little relation to how you feel. After a frustrating day at

work, you might quip that you’ve “aged about 10 years”. Conversely, many an active nonagenarian has been heard to comment that they don’t “feel” all their 90+ years

Perhaps, then, the key is to be found in the mind.

“You’re only as old as you feel”

If the number of candles on your last birthday cake represents your chronological age, the age you feel inside is your “subjective age”.

We can make broad generalizations about the psychology of aging. It’s often said that young people feel invincible, and it’s true that the young tend to be more **outward-looking and impulsive**. But you probably know someone who bucks that trend, whether it’s a skydiving granny or a teenaged “old soul”.

Well, in vindication of octogenarian



extreme sports enthusiasts everywhere, research has suggested that people who feel “younger” may live longer.

That was the conclusion a **2015 study** of over 300 Ashkenazi Jewish people aged between 94 and 109, part of a growing body of evidence that a positive outlook can promote longevity. Another **study** linked optimism to an 11–15 percent increase in lifespan, while **another** found that a lower subjective age could be a marker of brain health.

If your approach to life can have such a strong effect on how long you live, then, you might easily conclude that age is more of a psychological than a biological phenomenon.

But it's very easy to talk about maintaining an upbeat attitude to life – in reality, it may not be that simple to achieve.

The authors of the 2015 study alluded to this in their paper. All of the older adults recruited for the study were assessed as having no significant cognitive impairment, but **cognitive decline** is an unfortunate fact of aging for many people. It's another of those pesky biological factors we talked about before – the brain, like every other system in the body, is not immune to wear-and-tear with the passing of the years. Cognitive dysfunction, whether it be mild or a feature of something more serious like **dementia**, can impact mood and emotions.

Similarly, a study that used artificial intelligence to provide a **measurement of subjective age** based on the answers to a US-wide survey of health and wellbeing found that physical health was by far the biggest influence on people's scores, including things like the ability to do vigorous activity. Speaking of which... the second most important factor was how respondents foresaw their sex lives in 10 years' time.

All joking aside, this points to the vital importance of interpersonal relationships, as well as physical health. Loneliness can pose a real problem for older people. There's a known correlation between **social isolation** and **poor cognitive health**, and yet charity **Age UK** estimates that 1.4 million older adults in the UK alone are frequently lonely.

Is age biological or psychological?

On balance, it seems the best answer to this question is: both. Not only are our biology and our psychology independently altered by age, but each can also work the other way, influencing our experience of aging – and on top of that, they also interrelate with each other. It turns out aging is a complex thing.

Despite the research demonstrating the importance of subjective age, it's unlikely doctors will stop paying attention to chronological age any time soon. It's still one of the best indicators we have of the relative risk of many health issues and is used as the basis of successful disease screening initiatives.

But there are some small signs that the tide is turning. For example, a recent study reported a possible new way of deciding whether **donor hearts** are suitable for transplantation, based on a more direct measure of the health of the organ rather than just the donor's age. Such advances could save precious organs from needlessly going to waste.

Biological aging is inevitable, but it's not the whole story. Psychological research is showing that, in a very real way, interventions to support better mental health and wellbeing could help people wrest back some of the control from old Father Time, and maybe add a year or two onto their lives to boot. ●



THE BEAR MOLECULE



Award-winning environmental journalist Gloria Dickie explains the buzz around “nature’s gift to mankind” in *Eight Bears: Mythic Past and Imperiled Future*.

Bear bile has been used in traditional medicine for thousands of years. First described in a Chinese pharmacopeia in 659 CE, the honeyed substance slowly trickled across Asia, finding keen buyers in Korea and Japan. Healers prescribed bear bile for a wide range of ailments – colds, cancer, even hangovers. Some people rubbed it into their leathery skin to soothe stiff knee joints and aching backs. Others ingested it, like the farmer had told me, mixed with a small amount of rice wine.

Bear bile is no snake oil cure. Unlike rhino horn, tiger penis, and pangolin scales, which have no proven benefits to human health, medical scientists have found that ursodeoxycholic acid – the active molecule found in bile – can reduce inflammation and lower cholesterol. (Snake oil, for that matter, is no snake oil either. The oil collected from the Chinese water snake is rich in omega-3 acids – a legitimate treatment for arthritis.) The US Food and Drug Administration has even approved ursodeoxycholic acid for the treatment of certain liver diseases, and in preclinical trials,

the molecule was found to slow the progress of neurodegenerative diseases, including Parkinson’s, Huntington’s, and Alzheimer’s, and holds promise for other conditions, such as Lou Gehrig’s disease. “It protects the brain cells, kidney cells, heart cells, lung cells, and the list goes on,” said Clifford Steer, director of the molecular gastroenterology program at the University of Minnesota Medical School.

It’s not just bears that produce ursodeoxycholic acid. But bears are the only animals that produce useful quantities of it. Ursodeoxycholic acid staves off programmed cell death – a process known as apoptosis – during long periods of inactivity, such as hibernation. “If you or I hibernated for six months, there wouldn’t be much left of our bodies,” Steer, who specializes in the substance, explained. Our muscles would waste away. And we’d likely have brain damage when we came out of it. But when bears enter hibernation, their ursodeoxycholic acid levels surge by over 10 percent. The molecule is clearly protecting the animals from cell death. And it could protect us, too.

Steer didn’t mince words, referring to ursodeoxycholic acid as “a remarkable drug”. He and his team were the first to map the molecule’s unique abilities in animal models in the late 1990s, finding that it could reduce brain injury and heart injury by as much as half. But could any other drug do the same? Steer told me that although other anti-apoptotic drugs exist, none are as robust or as protective against mitochondrial damage as the “Bear Molecule”.

The good news is that the acid doesn’t need to come from bears. To carry out his research, Steer obtained semisynthetic ursodeoxycholic acid, extracted from cow gallbladders and then heavily processed. However, a synthetic alternative may not hold water among those shopping in Asia’s medicine markets. Most people aren’t attempting to treat Parkinson’s disease or Alzheimer’s with bear bile. They’re using the bile for run-of-the-mill ailments: a sore back, chronic inflammation, headaches. There are more than 50 herbal alternatives for such things. Or Advil, in a pinch. Bears don’t need to be farmed for the common cold.

Steer is a friendly and passionate man who spent more than a decade at the National Institutes of Health. He’s also a bear advocate and has even advised the Chinese government about synthetic alternatives. But at the onset of the coronavirus pandemic, China promoted the use of traditional medicines, including Tan Re Qing, or bear bile, as treatment for COVID-19. Steer, too, had co-authored a paper arguing that ursodeoxycholic acid merited consideration for a clinical trial as a remedy for the hyperinflammatory immune response caused by the virus. Did he worry that his research could bolster the bear bile trade? But Steer didn’t think the average consumer cared much about the science behind the drug. Ergo, his research shouldn’t have an impact. “In traditional Chinese medicine, they think of bile as magical. And so they’re going to keep farming these animals.” •

AUTHOR
Q&A

WITH

GLORIA DICKIE

ENVIRONMENTAL JOURNALIST AND AUTHOR OF *EIGHT BEARS***Any funny stories from your research?**

I think people find bear facts a bit inherently funny. A few that come to mind – the Mandarin word for panda sounds the same as the word for “hairy chest” depending on your tones, which can lead to a lot of confusion. Second – scientists had noticed an interesting phenomenon of interbreeding between brown bears and polar bears in the Arctic, creating “**pizzly bear**” offspring. But when they traced the lineage of many of those pizzly bears, a lot of them went back to a single female polar bear who apparently had a penchant for brown bear lovers. Third – American black bears have long been a chaotic presence in some US National Parks. In Yosemite in California, bears were once so conditioned to human food that the park actually had to maintain a car impound yard for vehicles with food left in them. Otherwise, the bruins would break in.

What’s the most pressing situation facing some of Earth’s most endangered bears right now?

The issues facing bears are many – habitat loss, climate change, conflicts with humans, poaching for traditional medicine. And in many cases, each of the world’s bear species are uniquely affected by one of these issues. Spectacled bears in the Andes and the polar bear are likely to be most affected by global warming, which is shifting the cloud forest habitat of the spectacled bear, and melting out the polar bear’s home. Moon bears in Asia are taken from the wild and put onto “farms” where their gall bladders are tapped for bile – used in traditional Chinese medicine. Sun bears are also sometimes put on such farms, and they’re also threatened by expanding palm oil plantations. And sloth bears, brown bears, and American black bears are constantly under pressure from humans. It’s hard to solve all of these issues, but there are a lot of people who have dedicated their lives to doing so, and it was a privilege to be able to feature their work in my book. •

***Eight Bears* by Gloria Dickie
is published by W. W. Norton
and is out now.**

Award-winning journalist Gloria Dickie’s new book embarks on a globe-trotting journey to explore the stories of Earth’s eight living bear species.

It’s clear you’re big into bears, why is that?

I grew up in a part of Canada without bears, so for me I think it was the absence of these animals – and any charismatic megafauna – that had so intrigued me. Visiting Banff National Park with my grandparents when I was a child, I remember being very excited by the prospect of seeing grizzly bears.

But it wasn’t until I moved to Boulder, Colorado, for university that I truly understood what it was like to live in “bear country”. There were constantly black bears in town that were coming down from the mountains to eat garbage. As a result, the state wildlife agency would often kill the bears. It was that concern that first piqued my reporting curiosity. Boulder ended up being the first city of its size in North America to implement a local law requiring some residents to use specially designed “bear-resistant” garbage bins. Clearly, the relationship between bears and humans was changing.

We hate to ask... but do you have a favorite?

I do – but don’t tell anyone. For me, I can’t quite escape the allure of the polar bear. It feels so unique among the eight remaining bears (albeit, it evolved from brown bears fairly

recently – just a few hundred thousand years ago). The idea of a bear being able to survive out on the sea ice in some of the harshest conditions on the planet is really awe-inspiring. They’re such powerhouses. But the Arctic environment is also just so beautiful – and the word actually comes from the Greek word *Arktos* which means bear.

Perhaps the polar bear also feels the most special to me because, unfortunately, it’s likely the bear species we’ll lose first. Climate change is melting the polar bear’s ice habitat, and most scientists don’t expect many of the world’s 19 polar bear populations to persist much beyond the end of this century. So, in that way, I suppose it’s a bit of a tragic fascination with these animals.

What do you hope readers will take away from *Eight Bears*?

I hope readers have a better understanding of how close the relationship between bears and humans has been for thousands of years, and what we stand to lose if we lose bears. Six of the world’s remaining eight bear species are threatened with extinction. The next few decades will decide their fate. A lot of the world’s wildlife is facing an extinction crisis, but bears are some of the biggest animals and require a lot of space. Some are also capable of killing people. That makes them a hard group of animals to conserve, but there are ways to do so. We can put an end to bear bile farming in Asia. We can conserve habitat for India’s sloth bears by prioritising their space and food needs, and not just focus on tigers. And we can improve our tolerance of far-roaming brown bears.

WHERE ON EARTH



Standing above the Waitomo Caves in New Zealand, you'd never know that below lies a complex system of caves and streams with ceilings lined with a galaxy of glowworms. The light display is unique to New Zealand and comes with some of the best acoustics for opera to boot.

AN UNDERGROUND GALAXY OF GLOWWORMS

Did you know that one of the best places on Earth to enjoy opera is inside a cave? It sounds weird, but it's true: the acoustics of New Zealand's Waitomo Caves are off the charts. That's why, back in 2021, an intimate performance by celebrated Kiwi tenor Geoff Sewell was held inside the tallest chamber of the cave system, known as "the Cathedral" for its famous resonation.

Waitomo is also known as the glowworm caves, and the light show is arguably just as arresting. Its ceilings glitter like a biological galaxy made up of thousands of the glowworm *Arachnocampa luminosa*, which is unique to New Zealand.

As the larvae of fungus gnats, these insects undergo a considerable glow-down when they develop into adults, but glow throughout their glory years. During this time, they enjoy damp areas of forests, streams, and a good ol' wet cave. This is why their Māori name is "titiwai", meaning "projected over water".

Like other glowworms and fireflies, *A. luminosa* is capable of creating bioluminescent displays of green and blue, but it wasn't until 2018 that scientists actually **pinned down** the chemistry behind the phenomenon.

Researchers isolated and characterized the molecular components of the glowworm's luciferase-luciferin system. This revealed the purified luciferase enzyme is in the same protein family as firefly luciferase, but its substrate is entirely different. The discovery demonstrated how this glowing gold dust has evolved independently from the same family of enzymes to produce light, even if it involves using structurally different luciferins.

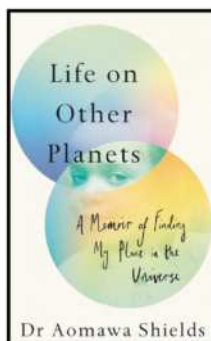
But enough chemistry, what about those sexy caves?

Waitomo is divided into two levels, with the upper half being dry and full of delicate cave formations formed over 30 million years. Meanwhile, the lower half is a complex system of water-filled stream passages filled with glittering glow worms that eventually lead to the tallest chamber in the cave: the Cathedral.

While the glowworms work hard, complex cave systems work harder, and navigating Waitomo can be difficult and slippery. It's therefore not recommended you venture into Waitomo alone, but there are plenty of tours that will guide you through this other-worldly experience. ●



MEET



Life On Other Planets: A Memoir Of Finding My Place In The Universe

Book by Dr Aomawa Shields

This inspiring story charts Dr Aomawa Shields' journey to

becoming a leading astronomer, astrobiologist, and Black woman in the world of science. Now at the top of her field, Aomawa's book intertwines searching for life in the universe with building a meaningful life here on Earth, often against ingrained prejudice, all the while asking: is anybody else out there?

Available **now**.

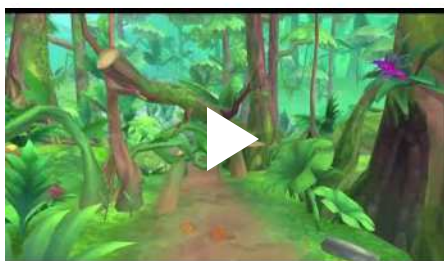
PLAY

Flutter Away

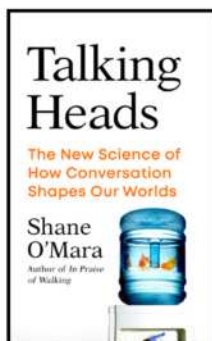
Game by Runaway Play

Notice how everything's felt a bit end-of-the-worldy of late? Yeah, us too, which is why it seems like as good a time as any to disappear off to the Amazon for some rest and relaxation. Popping on a plane to South America might not be all that easy, but in *Flutter Away* you can explore the serenity of the Amazon rainforest as a butterfly researcher on a five-day camping trip.

Available **August 3**.



READ



Talking Heads

The New Science of How Conversation Shapes Our Worlds

Shane O'Mara
Author of *In Praise of Walking*

Talking Heads

Book by Professor Shane O'Mara

Professor of Experimental Brain Research and Wellcome Trust Senior Investigator Shane O'Mara explores the importance

of talking in human existence in his latest publication. Described as "an invaluable perspective" and "fascinating account of a highly complex field" by linguist David Crystal, it demonstrates how language and politics are intrinsically connected and why understanding this is crucial to securing a better future.

Available **August 3**.

LISTEN



The Big Questions Season 3 Podcast by IFLScience

How does a quantum computer work? How will they change the world? Also, what is space weather, and how does it affect us? These are the topics IFLScience podcast host Dr Alfredo Carpineti will be tackling in August as part of season three of The Big Questions. Catch it where you get all your podcasts, including **Spotify**, **Apple Podcasts** and **Podbean**.

Episodes released **every other Friday**.

WATCH

One Piece

Series from Netflix

Based on the highest-selling manga series in history, Eiichiro Oda's *One Piece* is getting the live action treatment in a new series that sets sail on August 31, only on Netflix. Follow adventurer Monkey D Luffy as he sets off to discover fabled treasure and become the King of Pirates – that is, if he can survive the odd sea monster or two.

Available **August 31**.



SCIENCE IN MEDIA





DATES TO REMEMBER

Vaccines, the Web, and the world's Indigenous peoples are all being honored this month, and deservedly so. Meanwhile, if you're after some celestial spectacles to marvel at this August, you won't be disappointed, as the season's most spectacular meteor shower reaches its peak and Saturn is at its brightest, offering ample opportunity for some space-y snaps.

AUGUST

National Immunization Awareness Month

August is National Immunization Awareness Month, which aims to highlight the importance of vaccination and encourage us all to keep up to date with our shots. We've seen in recent years just how vital vaccination can be and how far immunization science has come, but there's still plenty more to be done to fight **misconceptions**, ensure equal access, and continue to develop these life-saving jabs. To find out more, visit the **Centers for Disease Control and Prevention** website.



1 World Wide Web Day

World Wide Web Day, August 1, is dedicated to all things Web browsing. The Web is the information system that billions of us use to access the Internet – it revolutionized our world when it was developed by Tim Berners-Lee back in 1989 and continues to connect us and place a wealth of knowledge at our fingertips today. It's the very reason you're able to read this e-magazine, and if that's not reason enough to celebrate, we don't know what is.



9 International Day Of The World's Indigenous Peoples

To raise awareness of the needs of the world's approximately 476 million Indigenous people, the United Nations (UN) celebrates the **International Day Of The World's Indigenous Peoples** on August 9. Despite having unique cultures and invaluable environmental expertise, Indigenous peoples are among the most disadvantaged and vulnerable groups in the world, hence the UN's drive to protect their rights and way of life.



13

Perseids Peak

When it comes to meteor showers, the (shooting) star of the summer in the Northern Hemisphere is the Perseids, which peak this month. Originating from comet Swift-Tuttle, these space rocks will be best viewed in the early hours of August 13, but should be visible for most of the month until the 24th.

27

Saturn In Opposition

The ringed planet will be positioned opposite to the Sun in the sky on August 27, meaning its face will be fully illuminated, brighter than any other time of the year, and visible all night long. We call this "opposition" – when the Earth is directly between the Sun and another planet – and it is one of the best times to see planets in the night sky. It also provides a great opportunity for some astrophotography, so why not get snapping? You can find out how to take award-winning photos of space **here**.





ARE YOU DRAWN TO THE DARKER OR LIGHTER SIDE OF SCIENCE?

Choose how you end each issue. For those who prefer the darker side, Francesca Benson explores the grisly lengths snow flies go to to survive the cold. If you like your science lighter, Maddy Chapman reveals that music may be the perfect remedy for kids' math misery.

SELF-AMPUTATING SNOW FLIES

Losing an appendage is a well-known outcome of frostbite in humans – but for snow flies, amputating their own legs when it gets too chilly can be a matter of life or death.

In a preprint paper, which has yet to be peer-reviewed, researchers examined these insects – wingless crane flies in the genus *Chionea* – walking on a cold plate using a thermal camera. They are “challenging to collect from the wild and cannot be bred in the lab,” the paper explains, so the team turned to citizen science and enlisted mountaineers and backcountry skiers to gather them.

Snow flies are “one of the few insects that remains behaviorally active at sub-zero temperatures,” they write, with “most sustaining locomotion even when the cold plate dropped to -9°C [15.8°F].” However, when it’s too cold, “ice crystallization occurs within the snow fly’s hemolymph and rapidly spreads throughout the body, resulting in death.”

This is where self-amputation, aka autotomy, comes in. The team suggests that ice crystallization causes a small increase in temperature within the leg, detected by thermosensory neurons that trigger the jettisoning of the limb. Self-amputation occurred 31 percent of the time after a leg began to freeze, and flies that self-amputated in these circumstances survived 77 seconds longer before freezing on average. In fact, almost 20 percent of the insects were already missing one or more legs.

Other types of crane flies self-amputate in response to mechanical stimulus as an anti-predation measure, but snow flies didn’t do this. The team proposes that this anti-predation response was “subsequently co-opted by snow flies to prevent propagation of internal freezing and prolong survival in extreme cold.”

“Understanding the extreme physiology and behavior of snow insects is urgently important, as the alpine ecosystems they inhabit are being disproportionately altered by anthropogenic climate change,” the team writes.

The paper is hosted on **bioRxiv**.

MUSIC VS MATH

Math class: Two words that put fear into the hearts of many an elementary pupil, and a fair few adults too. Those less mathematically minded may still remember the algebra-induced anguish of childhood, or the torment of trigonometry. But there may have been something to ease this pain, and improve test scores, all along: music.

According to **recent research**, children perform better at math when music is integrated into their lessons, particularly those who are younger and learning more basic mathematical concepts such as arithmetic.

It is thought that incorporating music – for example, by clapping along to tunes or designing instruments – may make math more enjoyable and engaging while alleviating any fear that students may feel around the subject.

Previous studies have hinted this could be the case – it has been noted that children who are more musically gifted often also do well at math. However, whether or not being taught music improves kids’ mathematical capabilities is unknown.

To investigate, Dr Ayça Akin performed a meta-analysis, combining the results of 55 studies that involved almost 78,000 young people from kindergarten age right up to university students. She focused on three types of musical intervention: typical music lessons where students sing, listen to, and compose music; instrumental lessons where they learn to play an instrument; and lessons that directly combine music and math.

Comparing test scores from before and after the interventions, Akin found that music was associated with an improvement in math, especially when it was integrated into a lesson. Around 73 percent of students who had integrated lessons performed significantly better than those who received no musical intervention.

“Mathematics and music are the two disciplines that have enhanced and fed one another since ancient times,” Akin writes in her study. “These two subjects have many similarities,” she adds, including symbolism, abstract reasoning, and quantitative thinking.

“Encouraging mathematics and music teachers to plan lessons together could help ease students’ anxiety about mathematics, while also boosting achievement,” Akin said in a **statement**.



The **Darker** Side
of Science



THE **Lighter** Side
OF SCIENCE