

CURIOS



IS ART CREATED BY ARTIFICIAL
INTELLIGENCE STILL ART?

OCTOPUSES ARE SMART,
SENTIENT... ALIENS?

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IFLSCIENCE

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NEWS BITES



Creating Jewelry From Chaos

If you're into unusual jewelry and chaos theory, your interests have just aligned! You may have heard of the "butterfly effect": a microscopic change in one state, e.g. a butterfly flapping its wings, can result in a large change further down the line, like creating a hurricane on the other side of the planet. For the first time, scientists have turned the structures behind this chaos theory into physical form using 3D-printed silver and bronze jewelry. "The depictions of such structures are strikingly beautiful, continually shifting when the point of view is changing. Jewelry seemed to be the best way to interpret the beauty of chaotic shapes," said Eleonora Bilotta, author of the study in the aptly named journal **Chaos**.



Spot A Galaxy From Your Garden

If you're in a dark enough area on March 21, you may be able to spot the great spiral Andromeda galaxy, the Milky Way's nearest neighbor, from your backyard. Just look between the constellations Andromeda and Cassiopeia (the very noticeable W shape) with a pair of binoculars and you should see a large, bright, fuzzy patch bigger than the full Moon in the sky but fainter. It won't look like the spiral we all know and love, but it's the furthest object you can see with your eyes alone – and gazing at another galaxy from your garden will never not be mind-blowing.



Wild Isles

If you're itching for a new wildlife docuseries and can't wait until Netflix announces its air date for the much-anticipated *Life On Our Planet* (dinosaurs, on a Netflix budget!), then this gorgeous new BBC series, where presenter David Attenborough – famous for traveling to the corners of our planet to reveal nature's dangers and delights – explores his home nation for once, should do the trick. *Wild Isles* explores the woodlands, grasslands, rolling downs, jagged coasts, rock pools, rivers, and much more of Britain and Ireland. Filmed over three years, the five-part series features wildlife from butterflies to orcas, puffins to wild horses. With both heart-stopping and heartwarming moments, Britain's wildlife has never been captured like this. *Wild Isles* will be available on BBC One and BBC iPlayer in spring 2023.

Hurrah For Women!

March 8 is the UN's annual **International Women's Day**. There will always be some who question the need for this, but the truth is gender equality is far from a given in many places around the world. The reversal of women's reproductive rights in the US recently – one of the world's most advanced countries that in this case has placed politics and ideology above science, medical care, and, importantly, freedom of choice for half its population – demonstrates the UN's goal of advancing gender equality globally still has some way to go and it can't be taken for granted. The UN is encouraging everyone to take action to drive gender parity. If you do one thing today, sign that petition, email your government representative, and let them know women's rights are human rights.



Representation Matters

Barbie doll maker Mattel has made a move for representation by introducing its first doll with scoliosis. The line that features Barbie's little sister Chelsea has a new addition featuring a curvature of the spine and a removable back brace. Scoliosis is a sideways curving of the spine often diagnosed in adolescents. For 75 percent of children, a corrective back brace when they're young and still growing means no need for surgery. Mattel worked with experts in children's spinal disorders to ensure the details were correct and hopes it will help normalize the condition and help kids celebrate inclusion.



Credit: RBG Kew

Unbeleafable

The first new giant waterlily discovered in over 100 years has officially become a Guinness World Record holder as the biggest in the world. We first reported on the **exciting new giant** last year. In what turned out to be a case of mistaken identity, a giant waterlily growing in the Royal Botanic Gardens, Kew, in London, UK, for 177 years was discovered to be a new undescribed species based on the remarkable hunch of a waterlily expert. Now, the new species is officially a world record-breaker. With huge disk-shaped pads that grow up to 3.2 meters across (over 10 feet) and flowers that unfurl to 36 centimeters (14 inches) across – about the size of your car's steering wheel – *Victoria bolivia* is a sight to behold, which you can see at London's Kew Gardens and La Rinconada Gardens in Bolivia.

WHAT'S UP?

Blocking The Sun

Well, that's one way to deflect the Sun's rays

Name: Geoengineering

Appearance: Quite dusty

Location: Somewhere between the Moon and the Sun.

What is geoengineering?

Also known as climate engineering, it's the deliberate large-scale attempt to intervene in Earth's natural systems to mitigate the climate crisis. It most often refers to something called Solar Radiation Management (SRM). Have you not seen *Geostorm*?

Are we fighting the Sun?

No, the Sun gives us life. However, it also gives us global warming, as heat and radiation from the Sun are increasingly absorbed by Earth and the oceans rather than being reflected back due to the also increasing lack of ice in the Arctic and Antarctic.

What is Solar Radiation Management?

SRM techniques are attempts to deflect, diffuse, or even block sunlight, heat, and radiation – often in space, before the Sun's rays can get to us.

What is being proposed here?

In a new approach, astro-engineers have calculated how dust could be fired from the Moon into the Sun to diminish the force of the Sun's rays, acting as a temporary sunshade.

Really?

Yes, they've done calculations and everything. According to a new **study**, to achieve a weakening of the Sun's rays by 1.8 percent, the equivalent of six days a year with the Sun obscured, it would take a mass of more than 1,010 kilograms (2,210 pounds) of dust.

Where does the Moon come in?

The scientists worked out that the ideal place to launch the dust would be an orbiting platform somewhere between Earth and the Sun – or, you know, the surface of the Moon, as it is right there. Plus, there's a ready advantage in that the lunar surface already has a stockpile of lunar dust just waiting to be kicked.



OUR COVER STORY

HOW TO BEAT A LIE DETECTOR

Your heart may be beating fast just at the thought of one, but what are they actually measuring, and is there a way to beat them?

By James Felton

Image Credit: Imron Chowdhury

We've all seen lie detector tests, be it in cop movies, crime procedurals, or *The Simpsons*. Generally speaking, the "bad guy" is hooked up to the polygraph test and informed that if they lie, the people conducting the test will know. A few questions later, and the police have either eliminated a sweating suspect or doubled down on forcing a confession based on the results of a pen-drawing wild zigzags on a moving chart.

But how accurate are they really? Well, not at all.

First of all, it's important to note: polygraph tests, or lie detectors as they are more commonly known, don't actually detect lies. They measure psychophysiological bodily responses that may indicate anxiety, nervousness, or fear that can be interpreted as inferring deception based on a set of – and it's very important to note here – not standardized psychological questions. So the machine is measuring a physiological response, but what that means is entirely down to human interpretation.

How do polygraph tests work?

Polygraphs monitor three things: your breathing, blood pressure/heart rate, and skin conductivity (i.e. sweat). A pneumography around your chest measures your breathing, your heart rate is monitored with a blood pressure cuff, and electrodes attached to your fingertips measure sweating.

During an examination, you will be asked control questions to assess your baseline physiological responses. These are a mixture of "probable lie" control questions about yourself and past deceptions. They are based on the idea most people have lied about jaywalking or some such misdemeanor but want to come across as honest so tell a "white" lie, and "accusatory"

relevant questions – for example, in a robbery case, asking if you've ever stolen anything. The polygraph measures how you react using pens on a moving chart that shows blips if your heart rate quickens or you begin to sweat. If you caused a blip more often during the probable-lie question, you pass, if you reacted more during the relevant questions, you fail.

Of course, the problems with this are immediately obvious. There is no scientific evidence that any pattern or group of physiological responses are unique to lying. A beating heart and sweaty hands may indicate you are dreading getting caught – or it could mean you are wildly attracted to the person conducting the test since both physiological responses are common in arousal too. Inferring meaning behind a bodily response is hard and there is no one-size-fits-all.

Evidence in support of the lie detector is scant

"Almost a century of research in scientific psychology and physiology provides little basis for the expectation that a polygraph test could have extremely high accuracy," a review by the National Academies of Sciences, Engineering, and Medicine **explained in 2003.**

"Polygraph research has not developed and tested theories of the underlying factors that produce the observed responses."

So, you may have a physiological response to a lie detector test, but then being in police custody accused of something you may not have done can also do that to a person. Basically, it doesn't address the placebo effect that may be in play. Polygraph tests are not assessing your truthfulness but **your fear**, which could be all over the place for several reasons.

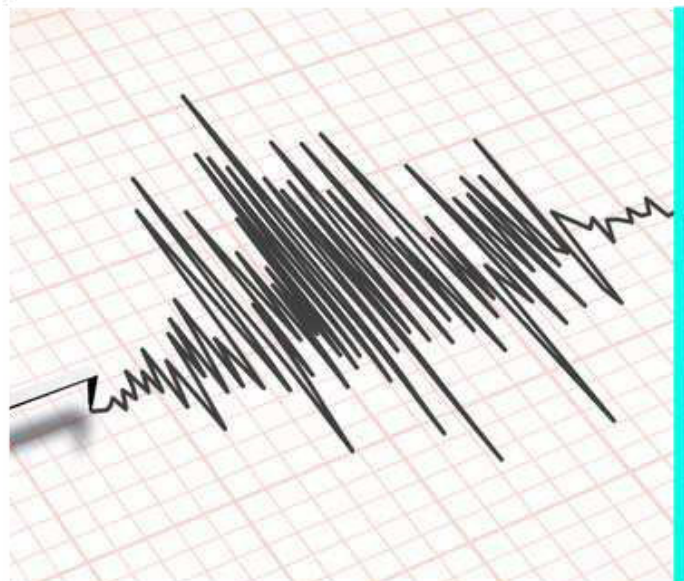
An honest person may be nervous despite answering truthfully and a dishonest person may not be anxious because they may actually be a sociopath, who are generally good at hiding the fact they are a sociopath.

"There is evidence suggesting that truthful members of socially stigmatized groups and truthful examinees who are believed to be guilty or believed to have a high likelihood of being guilty may show emotional and physiological responses in polygraph test situations that mimic the responses that are expected of deceptive individuals," the review authors write.

Examples of this include ethnic minorities facing structural racism, for example, in the US a **three-year analysis** from 2015 to 2018 found that in 800 jurisdictions across the US, Black people were five times more likely to be arrested than white people for the same perceived crime. If you go into the polygraph test knowing the system is already against you and you'll have to work much harder than your white counterpart to be considered innocent until proven guilty, you're probably going to sweat.

Would you be given one?

Most psychologists and scientists consider polygraph tests controversial as there is little good research to validate their



usefulness and, as we will demonstrate soon, they are easy to beat so are not deemed accurate. And yet, such is the way of the world, it's possible you may have to do one anyway. Despite the lack of evidence to support them, the tests are **still used by law enforcement** and by employers (e.g. police, fire departments) to vet candidates in the US and the UK to name a few.

You cannot be forced to take a polygraph test unless you are under the supervision of a court. However, whether polygraph tests are admissible in court depends on your location. In the US, for example, the Supreme Court helpfully left it up to individual jurisdictions to decide whether to allow them as evidence.

Fortunately, as the polygraph test is not measuring truth, merely a few bodily responses which the people conducting the test then interpret, the trick to beating the lie detector test is to alter your body reactions at key times. This sounds harder than it is, and with a few well-timed sweats or anal clenches, you'll likely mess up your test enough to make the results meaningless for anyone trying to glean anything from it.

How to beat the test

Your first goal is to disrupt the test by providing unusual baseline responses or unusual readings in the initial control question portion before the main part of the test. As we mentioned, if you have more blips in this section than the "relevant" questions you are deemed more honest.

According to the authors of **The Lie Behind The Lie Detector**, George Maschke and Gino Scalabrini, you should quicken your breathing during control questions, then breathe normally during the main questions, and relax by thinking calm thoughts before answering.

During the probable-lie control questions, they suggest you should also lie and bite hard on your tongue to set off other

physiological reactions and throw off your control readings. In the movie *Ocean's Thirteen*, for example, one character hides a thumb tack in their shoe which they then stamp on at key moments to produce these responses. However, these days, you may get asked to remove your shoes.

In order to produce sweat, you can think of scary things during the control questions, or alternatively, do tough math problems in your head. But what about pulse and blood pressure? For that, you can turn to our good old reliable friend the buttohole.

This odd tip comes from former Oklahoma police officer Doug Williams, who used to perform polygraph tests as part of his career, before becoming skeptical of the technology and publicly denouncing it. He could control his breathing when using the machine, but couldn't figure out how to control his pulse, sweat, and blood pressure.

"It wasn't until my friend came in and started talking about the pucker factor and tightening up the anal sphincter muscle when he was under stress," he told

This American Life.

"After he left, I just hooked myself up to the polygraph test...and tightened up my anal sphincter muscle like I was trying to stop my bowel movements and low and behold there was the most gigantic, wonderful, naturally occurring cardio rise, accompanying a [galvanic skin response] rise."

During the actual test questions is your time to relax and focus on your breathing patterns. Even if you do have a slight response to the relevant questions, your work in the control question section should have already produced a much stronger response.

"Your mind should be more at ease. Knowing that you and not your polygrapher are in control," Maschke and Scalabrini write. ♦

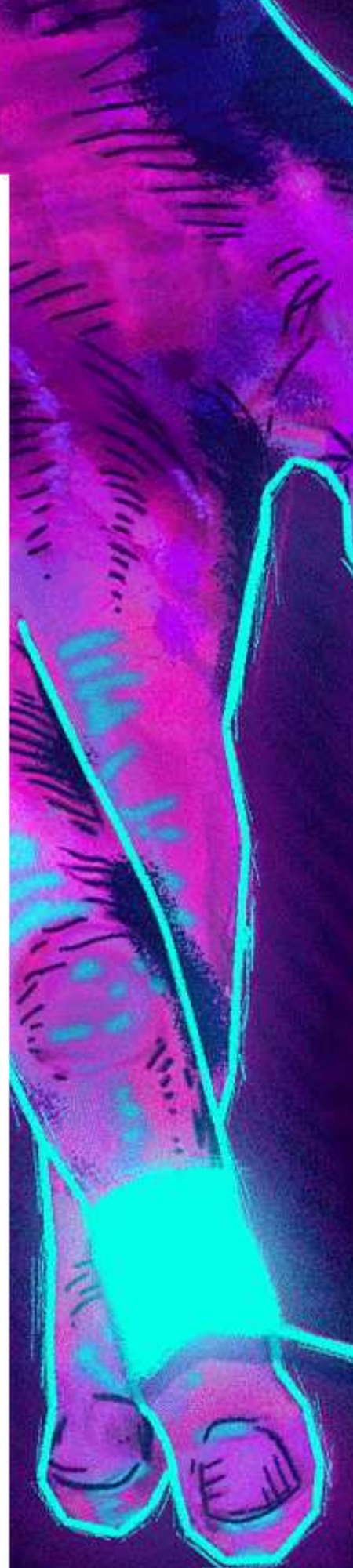




Image Credit: Aleksei Permiakov, 1st place Nudibranch Ocean Art 2022

CLOSE ENCOUNTERS OF THE SLUG KIND

"Ribbed" does exactly what it says on the tin in this winning shot from Aleksei Permiakov, who scooped first place in the nudibranch category for Ocean Art 2022. Spotted off the coast of Bali, Indonesia, this alien-like *Tambja morosa* sea slug has an impressive set of rhinophores: chemosensory structures that can look a bit like bunny ears sticking up off the heads of nudibranchs and other marine gastropods. Check out the other winners of Ocean Art 2022 [here](#).

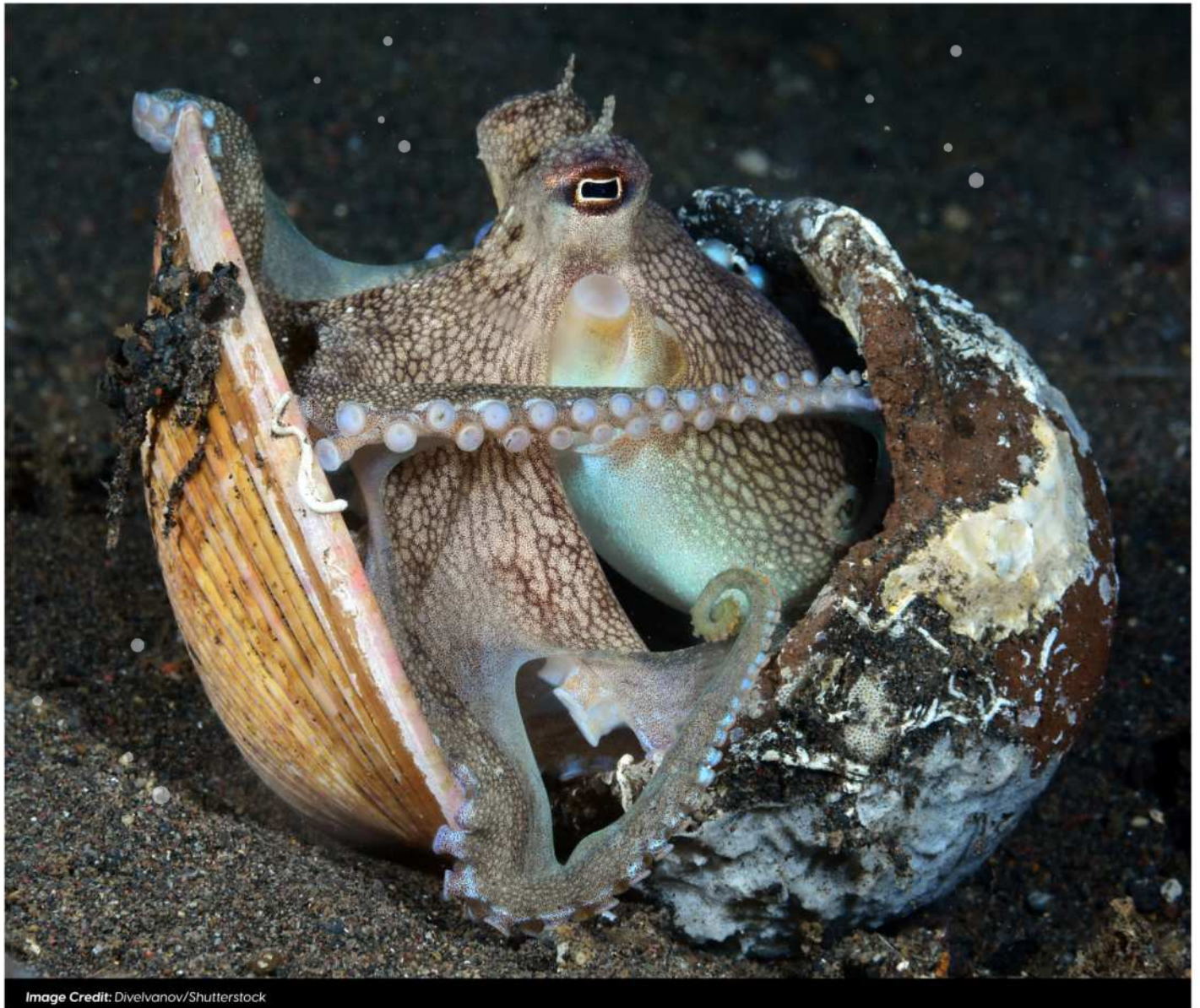


Image Credit: Divelvanov/Shutterstock

OCTOPUSES ARE SMART, SENTIENT... ALIENS?

WE STILL KNOW SO LITTLE ABOUT HOW ALIEN-LIKE OCTOPUSES EXPERIENCE THE WORLD AROUND THEM – BUT NOT FOR LONG.

By Rachael Funnell

It's no secret that the oceans are home to some of the most alien-like life on the planet, but did you know that astrobiologists actually use octopuses as a model for what intelligence might look like on other planets? The reason why ties into the peculiar anatomy of these curious creatures, and the fact that our last shared ancestor was a worm some 350 million years ago, meaning their intelligence evolved in an underwater world totally separate from our own.

To dive into the cognitive capabilities of octopuses, and to explore their sentience – a concept that's become increasingly relevant in the study and welfare of cephalopods and crustaceans in recent years – a new project funded by the Wild Animal Initiative is investigating **what it's like to experience life as an octopus**. It's hoped that the insights gleaned from the study will help to inform better legislation around the welfare of these animals, as well as teach us more about how these alien-like lifeforms perceive their environment.

And should it open doors for a new branch of virtual reality (VR) that enables you to explore underwater environments with **eight brainy arms**? Well, we wouldn't complain.

To find out more about the research, we spoke to two members of the octopus sentience investigation team, Michaela Pereira Andrade and Tatiana Leite.

Tell us about your upcoming project funded by Wild Animal Initiative.

We are conducting research on the personalities and emotional states of juveniles *Octopus insularis*... Understanding the behavior and cognitive abilities of octopuses in the wild can provide insight into their ecological and evolutionary adaptations, as well as their sentience and welfare potential. For this, we developed different non-lethal tests so we can study wild octopuses in the field.

What do we know about octopus intelligence so far?

Octopuses have complex nervous systems and are capable of advanced problem-solving and learning. They use tools, such as **using coconut shells** to hide from predators and manipulate objects to open jars. They can navigate mazes and even solve puzzles. Octopuses are also known to exhibit behaviors such as play, which was once considered limited to mammals and birds.

They also possess a decentralized nervous system, with two-thirds of their neurons located in the arms. This means that each arm can function independently, allowing them to perform complex tasks without the need for centralized processing in the brain.

How is intelligence different from sentience?

Animal intelligence refers to an animal's cognitive abilities, such as perception, decision-making, and learning. On the other hand, sentience refers to an animal's ability to have subjective experiences, such as pleasure, pain, fear, and other emotions. While these concepts may be related, sentience pertains explicitly to an animal's ability to feel the world and is often considered in discussions of animal welfare.

There is currently a lack of specific regulations and guidelines for the welfare of wild octopuses. This is primarily because octopuses are considered to be "wild caught" animals, they are not subject to the same level of oversight and regulation as domesticated animals.

Do octopuses have personalities?

Octopuses have been observed to exhibit a wide range of behaviors, some of which suggest that they may have personalities. Studies have shown that individual octopuses have distinct preferences for certain types of food, shelter, and social interactions, which suggests that they may have individual personalities. Additionally, octopuses have been observed to **display aggression**, playfulness, and problem-solving abilities, which are all characteristics of animals with personalities. However, more research is needed to fully understand the nature of octopus personalities.

What is it about octopuses that's flagged them as models for studying alien life?

Octopuses have the largest nervous system and largest genome among all invertebrates. They have about 33,000 genes (more than humans, which have about 27,000). Approximately 3,500 of them are unique to this group of animals.

An interesting feature regarding the evolution of octopus genomes is that they have developed the ability to edit RNA to increase the repertoire of proteins produced and thus increase their adaptability to the environment in which they live. Only cephalopods do this. Instead of a DNA sequence producing only one protein, with the ability to recode by editing the RNA, this sequence can generate several proteins with different functions, increasing the animal's ability to adapt to different situations. In other words, instead of genomic evolution occurring by mutations in DNA sequences, these sequences remain conserved, changing only the ability to edit the genetic codes through RNA.

The team hopes to return results on their research into the lived experiences of the oceans' aliens in the next year. ●



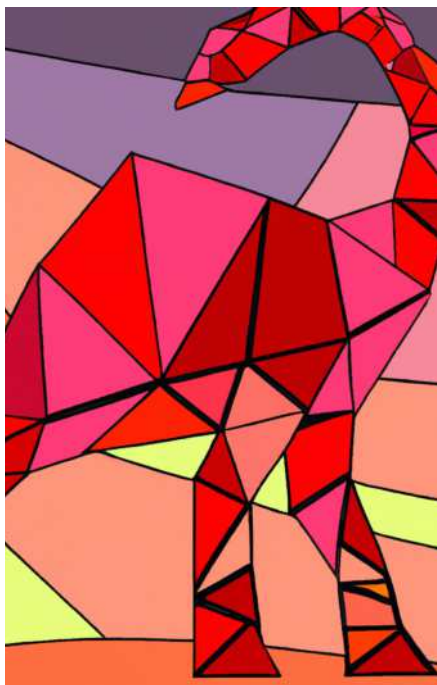
SCIENCE FACT OR FICTION:

IS ART CREATED BY AI STILL ART?

Defining what, and who, makes art “art” has always been controversial – but with the rise of AI “artists” the water is getting muddier, finds Maddy Chapman.



Since the advent of artificial intelligence (AI), the technology has become unavoidable in our everyday lives. It powers predictive text, face ID, and digital voice assistants – it could even one day **represent you in court**. It's wormed its way into so many facets of 21st-century life that very few industries remain untouched. The art world is no exception.



Where the likes of Matisse and Picasso used brushes, pens, clay, and other more familiar (and tangible) mediums, AI uses code to create machine-learning masterpieces. And it's generated quite a buzz. Within the last year, AI-generated art has hit the headlines: exhibitions have **displayed AI artists' work**, for example, and their creations have **won competitions**.

But the rise of the AI "artist" has not been well received by everyone. The idea of machines making art, something that has typically been considered "human", is a controversial one, especially amongst the art community. There are fears that AI could put human artists out of work, copyright complications to consider, and arguments that technology lacks the emotion or originality to create true art.

All of which begs the question: Is art created by AI still art?

As ever, there are strong feelings on both sides of the argument, but on many platforms, as things stand, anti-AI sentiment is prevailing:

AI art has been banned from Getty Images, for example, and is prohibited on the Art

subreddit. **Recently**, a human artist was banned from the forum for attempting to post their own work, which a moderator on the platform decided looked like it was created by AI.

Nevertheless, AI continues to churn out artworks – if we can call them that – so where do they fit in this ever-changing landscape of 21st-century art?

AI "artists"

Despite what you might think, AI-generated art is by no means new.

"AI has been around for over 60 years and people have been working with AI artistically for almost as long," Professor Jon McCormack, an artist, researcher in computing, and Director of Monash University's SensiLab, told IFLScience.

But in recent years, an increasing number of image-generating algorithms, or AI "artists" if you'd prefer, have popped up. Many of these use deep learning techniques to generate images based on prompts provided by a user.

In 2021, developers at OpenAI revealed DALL-E, a system trained on billions of images and descriptions to create its own images. Last year, they released a new-and-improved version, **DALL-E 2**, which was made available to the general public in September.

Hot on DALL-E 2's tails, several other AI-driven image generators emerged. These include Midjourney, Stable Diffusion, and Google Research's Imagen, though not all are available for the public to use.

With just a few words, these technologies can produce some pretty astonishing images. They are, however, trained on pre-existing images and works of art, which has led some to question whether AI is capable of creativity and originality, or simply mimicry. There is also a potential legal debate here: if the technology is heavily influenced by or draws on other artists' work, without consent or compensation, could this be considered a copyright infringement?

Then there's the argument of who created the work in the first place and, therefore, who should get the credit: the machine or its user.

"At this stage in AI's development I'd say that humans create art, AI works as a tool that might assist people in their creation of art," McCormack believes.

"Some machine learning systems can generate things like images, video, music, and so on, so in a limited sense this software is the creator of the image, for example. But simply being able to create something does not necessarily make it art."

What is Art?

What then, if not the ability to create, makes something art and someone, or something, an artist?

"This is a simple question with a complex answer," McCormack said.

Not least because it's unique to each individual. What one person considers art won't necessarily match another person's definition.

Equally annoying for anyone trying to answer this question is the fact that the definition of art is changeable, it evolves with the world around it. "What we think of as 'art' today is not the same as it was historically, so the meaning of the word 'art' and what we include in that category is constantly changing."

Take photography, for example. "A century ago photography (a new technology then) was not considered fine art. It took decades for it to be accepted and recognised as an artistic medium," McCormack told IFLScience.

Or **Marcel Duchamp's Fountain**. The signed porcelain urinal, arguably the most controversial artwork of the 20th century, was rejected by the Society of

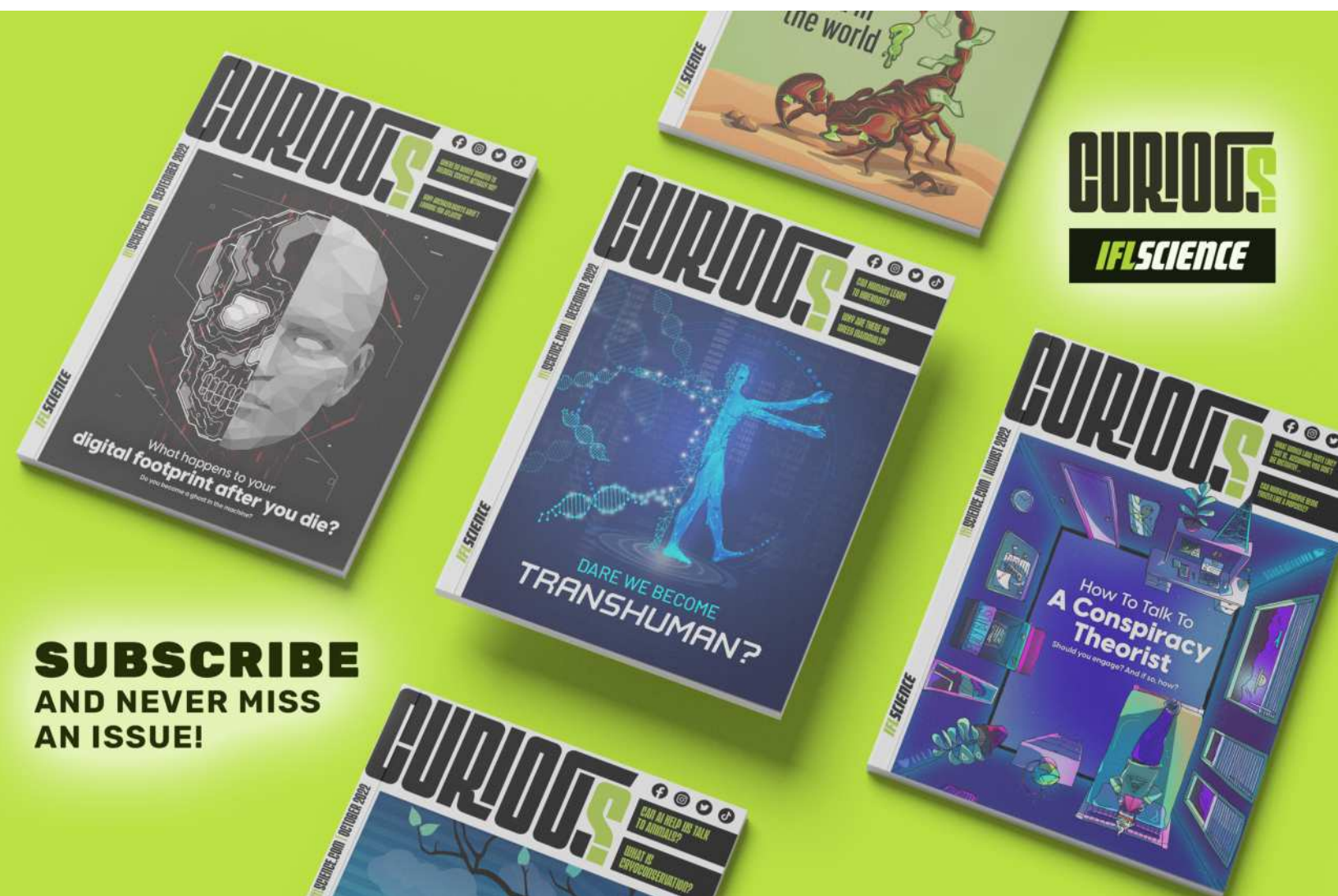
Independent Artists in 1917 for not being true art, sparking a mass debate around the question of "what makes something a work of art?"

According to **Merriam-Webster's** definition, art is, among other things, "the conscious use of skill and creative imagination especially in the production of aesthetic objects."

In McCormack's view: "Art as we think of it today requires the communication of something between the artist to the audience, it could be an idea, an emotion, a concept or a feeling. It generally has characteristics of intention, autonomy, and authenticity."

But this doesn't necessarily mean it has to be created by humans.

"In broad terms, I think there is such a thing as non-human art, as evidenced in things like the **mating behaviour** of some birds



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IS A MACHINE CAPABLE OF THE INTENTION, AUTONOMY, AND CREATIVITY NECESSARY TO MAKE SOMETHING TRULY AUTHENTIC?

(such as the bowerbird's nest building). Some animals (such as elephants or chimpanzees) can be taught to paint for example and seem to get some pleasure or interest in doing it. However, this kind of 'art' is not the same as the art made by people," McCormack said.

Is art created by AI still art?

If animals can, to an extent, create art, what about AI? Is a machine capable of the intention, autonomy, and creativity necessary to make something truly authentic?

Without question, art created by AI has the ability to make us feel something: the furor that has led us to even ask this question is a testament to that. But while it may be able to communicate ideas and incite feeling in its audience, it lacks the consciousness required to do this with intent or autonomy, meaning it falls short of both Merriam-Webster's and McCormack's definitions.

"We value art and creativity because it has qualities that make it special – it requires authenticity, originality, often great skill and virtuosity, deep human insight and it possibly can communicate profound meaning. Current AI/[machine learning] systems possess none of these qualities, they are just good statistical mimics, parasitic to human culture," McCormack explained.

"I don't see them as artists. But of course a human might use them to make art."

And humans, as we know, are capable of all these things and, therefore, of making art. We are also responsible for creating and running image-generating AI in the first place. It could be argued that the human input behind prompt-based

software such as DALL-E 2 is "relatively high level and minimal", McCormack said, but it's still taken a lot of effort from humans to get to his point.

"Human artists provided the training data, human engineers wrote and designed the software, a human runs the software and controls it to make it generate something. A human selects which images to show and which to discard," McCormack explained. "Moreover, humans mined the rare-earth minerals (and other materials) that go into making the computers that run the software and all the other infrastructure that supports its use."

Therefore, creating AI-generated art could feasibly be perceived as a human endeavor, with the algorithm merely serving as a vehicle for human creativity. And if the artwork is created with purpose by a human, why shouldn't it be considered art?

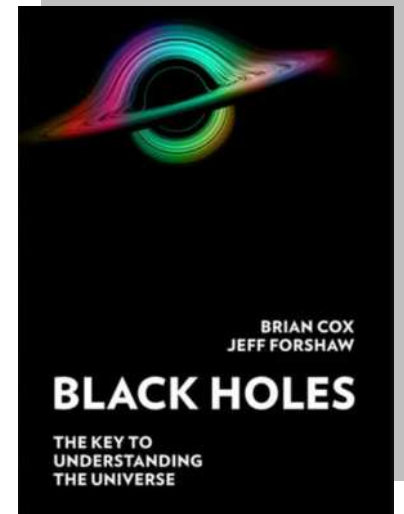
Current tools allow people creative accessibility and empowerment, which is a huge draw for those looking to experiment with AI art. "It's very quick, easy, and inexpensive to create your own impressive digital 'art' that can look nice," McCormack said. "But that feeling of empowerment wears off very quickly when you see that anyone can do the same thing and that a lot of the 'art' looks similar and derivative."

However, some artists have succeeded in creating innovative and original work using AI, McCormack added. And as, no doubt, the technology improves, along with our ability to use it, the number of artists and their artworks should only increase.

As we've already established, art is subjective and its definition is malleable: what is considered "art" has changed before and will almost certainly change again. So, who's to say that one day AI won't be encapsulated in our collective perception of it? A modern medium reflecting the evolution of a modern society. Stranger things have happened... namely that porcelain urinal. ●



A BRIEF HISTORY OF BLACK HOLES



In 2022, we saw the first-ever image of **Sagittarius A***, the supermassive black hole at the center of our galaxy. In this excerpt from *Black Holes: The Key To Understanding The Universe*, Professors Brian Cox and Jeff Forshaw briefly touch on what one of those actually is.

At the heart of the Milky Way, there is a distortion in the fabric of the Universe caused by something 4 million times more massive than our Sun. Space and time are so warped in its vicinity that light rays are trapped if they venture closer than 12 million kilometres [7.5 million miles]. The region of no return is bounded by an event horizon, so named because the Universe outside is forever isolated from anything that happens within. Or so we used to think when the name was coined. We have named it Sagittarius A* and it is a supermassive black hole.

Black holes lie where the most massive stars used to shine, at the centres of galaxies and at the edge of our current understanding. They are naturally occurring objects, inevitable creations of gravity if too much matter collapses into

a small enough space. And yet, although our laws of Nature predict them, they fail to fully describe them. Physicists spend their careers looking for problems, conducting experiments in search of anything that cannot be explained by the known laws. The wonderful thing about the increasing number of black holes we have discovered dotted across the sky is that each one is an experiment conducted by Nature that we cannot explain. This means we are missing something deep.

The modern study of black holes begins with Einstein's General Theory of Relativity, published in 1915. This century-old theory of gravity leads to two startling predictions: 'First, that the fate of massive stars is to collapse behind an event horizon to form a "black hole" which will contain a singularity; and secondly, that there is a singularity in our past which constitutes, in some sense, a beginning to the universe.' This remarkable sentence appears on the first page of a seminal textbook on general relativity, *The Large Scale Structure of Space-Time*, written in 1973 by Stephen Hawking and George Ellis. It introduces evocative terms – black hole, singularity, event horizon – which have become part of popular culture. It also says that at the end of their lives, the most massive stars in the Universe are compelled by gravity to collapse.

The star vanishes, leaving an imprint in the fabric of the Universe. But behind a horizon, something remains. A singularity, a moment rather than a place when our knowledge of the laws of Nature breaks

down. According to general relativity, the singularity lies at the end of time. There is also a singularity in our past, which marks the beginning of time: the Big Bang. We are asked to accept the profound idea that our scientific description of gravity, the familiar force that governs the behaviour of cannon balls and moons, is at its heart concerned with the nature of space and time.

It's not obvious that gravity should be related to space and time, let alone that seeking to describe it in a scientific theory might lead one to contemplate the beginning and end of time. Black holes take centre stage in exploring this deep relationship because they are gravity's most extreme observable creations. They are so intellectually troublesome that well into the 1960s many physicists felt that while black holes are a feature of the mathematics of general relativity, Nature would surely find a way to avoid creating them. Einstein himself wrote a paper in 1939 in which he concluded that black holes 'do not exist in physical reality'. Einstein's illustrious contemporary Arthur Eddington put it in rather pithier terms: 'There should be a law of Nature to prevent a star from behaving in this absurd way.' Well, there isn't, and they do.

We now understand that black holes are a natural and unavoidable phase in the lives of stars a few times more massive than our Sun, and since there are many millions of such stars in our galaxy, there are many millions of black holes. ●

Q&A

AUTHOR

WITH PROFS.

BRIAN COX & JEFF FORSHAW

AUTHORS OF *BLACK HOLES: THE KEY TO UNDERSTANDING THE UNIVERSE*



What are some of the key mysteries still surrounding black holes?

Black holes fascinate theoretical physicists because of the way they force us to confront deep problems. It was Stephen Hawking who first realised that by thinking hard about black holes we are led to an intellectual conundrum – a conflict between the two pillars of modern physics: Einstein's General Relativity and Quantum Physics. Hawking's "Information Paradox" concerns what happens when stuff falls into a black hole. From one perspective, the stuff gets forever obliterated in the heart of the black hole but from another perspective, the stuff gets radiated back out into space as the black hole evaporates. It now seems that both these ideas must be true, and understanding how has fuelled research over the subsequent 50 years.

Astonishingly, the latest research indicates that space is an emergent entity and not fundamental at all. In fact, it looks like space is woven out of a network of tiny, jiggling things that are entangled by the laws of quantum physics. Understanding exactly what the jiggling things are is not known right now; that's the goal of current research into quantum gravity – the holy grail of theoretical physics.

What do you think is the most common misunderstanding surrounding black holes?

Well for one thing, black holes don't invariably suck matter into them any more than the Earth sucks things in. Things can orbit around a black hole just like the Moon orbits the Earth. There is a difference though, in that black holes have a point of no return, and objects that venture too close will travel into the singularity at the centre of the hole. Which brings us to a second misunderstanding. The centre of a black hole is not a point in space. Black holes don't have a centre in the sense that the Earth has a centre. That's because they distort space so much. Mathematically speaking, it's even possible to have an entire other infinitely big second universe hidden inside the event horizon of a black hole.

Say what?

The mathematics of general relativity says that spinning black holes are gateways to an infinity of other worlds. Jump inside one and you can dodge the singularity and pass into another world, inside of which there is another spinning black hole for you to jump inside. The story repeats forever – it's universes within universes within universes. Real black holes don't behave like that because collapsing stars effectively block the portal up. But the fact that Einstein's

theory permits such a wonderland reminds us to keep an open mind and that our common-sense ideas of the world are often severely lacking in imagination.

Any research highlights?

There has been an exciting amount of progress in understanding how to solve Hawking's information paradox over the past few years. We had the opportunity to learn about that new stuff. It includes ideas such as space is not fundamental but an emergent feature of quantum mechanics, that the inside of a black hole might be in some way linked to the far outside of the hole (a very weird idea), and that the three-dimensional world we live in might be a hologram. Moreover, the way space is built appears to have some connections with the way quantum engineers on Earth are trying to build quantum computers. Pithily put, it looks rather like we are living inside a quantum computer.

If you had all the time, money, and equipment in the world, what would you most like to find out about black holes?

It's not known what happens as an object approaches the singularity of a black hole. According to Einstein's general relativity, matter gets infinitely stretched out (spaghettified) and time literally ends. But to resolve the information paradox, there is a sense in which the stuff that falls in is also encoded in the radiation emitted by the black hole over its lifetime. We'd like to understand what it "feels like" as the end of time looms (at the singularity). In other words, just what is going on at the singularity of a black hole? Is there a bridge between the interior and exterior of a black hole? Intriguingly, the possibility might soon exist to build table-top experiments that exploit quantum entanglement to effectively weave space. Through these experiments we may well be able to tackle questions that are closely related to those concerning black holes. •

**Black Holes is published
by Harper Collins
and is available from
March 28, RRP \$32.**

An apparent oil drilling accident once opened up a vast crater of harmful gas in the heart of Turkmenistan's Karakum Desert. Fearing the gas might harm the health of nearby communities and wildlife, it was set on fire, but from there things only got worse.



THE “GATES OF HELL” HAVE BURNED FOR DECADES

In 1971, the Soviets were searching for oil fields in the heart of Turkmenistan's Karakum Desert, which was part of the Soviet Union at the time. After thinking they'd struck liquid gold, they mounted a rigging station including a sizable and heavy drill. Unfortunately, all was not as it seemed.

The story goes that once drilling began, it became quickly apparent that they had misjudged the nature of the beast. Instead of drilling into oil, they had set up a hefty operation above an enormous pocket of natural gas. The rig soon collapsed, creating the massive hole now known as the Darvaza crater.

Darvaza was 70.1 meters (230 feet) across and 20.1 meters (66 feet) deep, and its collapse led to a domino effect that saw craters collapsing across the landscape. With each new crater came more natural gas, mostly made up of methane. This presented a big problem as methane has an unfortunate habit of soaking up all the available oxygen in the air.

Those involved in the mix-up were worried about how the gas might affect neighboring wildlife and communities, so a quick fix was settled. As humans have so often done when faced with a problem, they tried setting it on fire. The idea was that, in doing so, the flames would burn off the gas in a matter of weeks. Fifty years on, however, those fires are still burning.

The flames haven't stopped since they were lit half a century ago, and scientists still aren't sure how long they will continue to burn. Popularly known as the “**Gates of Hell**”, the Darvaza crater and its flaming neighbors attract tourists and explorers like moths to a literal flame.

In 2013, explorer and storm chaser George Kourounis actually climbed inside the fiery crater as part of a National Geographic-funded expedition to go in search of soil samples, testing if life could be found in such harsh conditions. It's worth noting that his journey into the Gates Of Hell included wearing a heat-resistant suit, so we'd recommend basking in the heat from a comfortable distance. ●



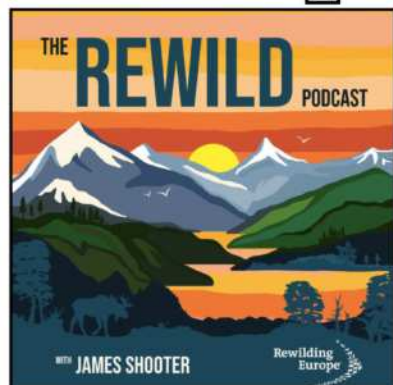
WATCH



65
Film from Sony Pictures Entertainment
Misadventures in space and dinosaurs. Need we say more? When Pilot Mills (Adam Driver) crashes on an unknown planet, he soon discovers that he's marooned on Earth... 65 million years ago. Landing in the Late Cretaceous, you can imagine the obstacles he and another survivor must face down in their one shot at escape.

Available in cinemas from March 17.

LISTEN



The Rewild Podcast
Podcast from Rewilding Europe

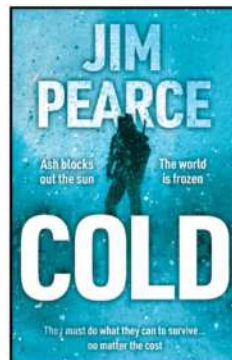
Journey across Europe and meet the people behind projects and initiatives trying to return the environment to a more wild state. Presenter James Shooter will travel across the region with his family to meet the many guests featured on the series, bringing the rewilding movement to life as he reports from inside some of Europe's recently transformed green spaces.

Available on Podbean.

READ



Cold
Book by Jim Pearce
Set in the near future in a world where scientists and their AI got it wrong, Cold follows the story of a family who have survived a human mass extinction event caused by climate change. Having hidden out in a house in Surrey, UK, they are forced from their home by a roaming gang and now must face the elements in a post-apocalyptic world.



Available to purchase in the UK and US now.

SEE



Mummies
Film from Warner Bros
Ancient Egypt collides with modern London in this animated release from Warner Bros that will have you cooing over a baby crocodile. It follows three Egyptian mummies as they rise from their secret underground city in search of a ring that's been stolen by archaeologist Lord Carnaby.

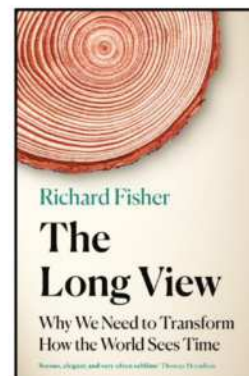
In cinemas from March 31.

EXPLORE



The Long View
Book by Richard Fisher

In his latest release, *The Long View: Why We Need To Transform How The World Sees Time*, Knight Science Journalism fellow at MIT and BBC Global News journalist, Richard Fisher, explores how we can reorient our approach to time. Tracking from the boardrooms of some of the world's oldest businesses to an Australian laboratory where an experiment started a century ago is still going strong, it aims to expand minds to deeper time scales, and pick up a little hope and perspective along the way.



Available from March 30.

SCIENCE IN MEDIA





DATES TO REMEMBER

This March, we dive into history, math, and a sprinkling of real and imagined creatures. The most important global annual event dedicated to Earth's wild species kicks off with World Wildlife Day, and as we celebrate the birthday of Dr Seuss, it's a timely reminder of an old theory that there may be more to *The Lorax* than first realized.

MARCH



Women's History Month

In 1981, Congress passed legislation to declare that the week commencing March 7 would be known as Women's History Week. Come 1987, this was extended to the full month of March with help from the National Women's History Project, and it has been celebrated annually with presidential proclamations recognizing the contributions women have made to the United States ever since. The Library of Congress, National Archives and Records Administration, National Endowment for the Humanities, National Gallery of Art, National Park Service, Smithsonian Institution, and United States Holocaust Memorial Museum join in encouraging the observance that champions the achievements of women across all fields.

Dr Seuss Day

It's Dr Seuss's birthday and a great opportunity to return to Theodor Geisel's books including *The Lorax*, arguably many children's first introduction to environmentalism. There's a theory that the fictional Lorax was actually **inspired by a real species**: the common patas monkey, *Erythrocebus patas*.

2



3

World Wildlife Day

March 3 marks World Wildlife Day, so chosen as it's

also the birthday of the Convention on International Trades in Endangered Species of Wild Fauna and Flora (CITES). For 2023, there's a special focus on business and finance as it recognizes that conservation work cannot go ahead without funding. "Successful partnerships for conservation must find ways of including business if we are to reverse the loss in biodiversity." Find out more about some of the ways we can do that [here](#).

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Pi Day

Pi is an irrational number, meaning it cannot be expressed as a fraction, and its decimal expansion is neverending and entirely random. It's thought that any sequence of numbers you can possibly think of can be found somewhere in the expansion of pi, and yet knowing any particular sequence somewhere in the expansion tells you no information about which digit comes next. However, for about a year now, there's been a way to find any given digit of pi you happen to be interested in. Don't believe us? Read all about it [here](#).

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Brain Awareness Week

Did you know that researchers **recently discovered** a thin layer of tissue within the brain that acts as a shield and helps it keep clean? Run by the Dana Foundation, Brain Awareness Week hopes to generate enthusiasm for brain science like this, and you can find resources for hosting events and spreading the word on their [website](#).



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

Choose how you end each issue. For those who prefer the darker side, Maddy Chapman reveals that when it comes to nature, “going out with a bang” can be quite literal. If you like your science lighter, it turns out hanging out with your buddies may help you live longer.

GO OUT WITH A BANG

In the animal world, none take the phrase “go out with a bang” more literally than the male northern quoll. These sex-crazed Australian marsupials get swept up in a mating frenzy, sacrificing sleep and basic personal hygiene just so they can get some. Unsurprisingly, it doesn’t end well for them.

It’s long been observed that male quolls mate themselves to death in just one breeding season. Females, meanwhile, eke out up to four years before giving up the ghost. Now, a new study published in **Royal Society Open Science** has shed some light as to why this could be.

*NO REST FOR THE WICKED,
OR INDEED THE WANTON
NORTHERN QUOLL.*

It seems male quolls may have a one-track mind when it comes to sex: when they’re in the mood, other basic marsupial needs pale into insignificance.

“They cover large distances to mate as often as possible and it seems that their drive is so strong that they forgo sleeping

to spend more time searching for females,” study author Dr Christofer Clemente said in a **statement**.

No rest for the wicked, or indeed the wanton northern quoll. While females, sensibly, spent almost 24 percent of the time resting, males put their paws up just 8 percent of the time.

*IT’S A HEAVY PRICE
TO PAY FOR A BIT OF
HANKY PANKY.*

The blinkered sex fiends let themselves go in other areas too, losing weight, becoming more reckless, devoting less time to grooming, and having more parasites as a consequence. Lucky lady quolls.

All of this means they’re left in a sorry state after their exploits. “They become easy prey, are unable to avoid vehicle collisions, or simply die from exhaustion,” lead author Joshua Gaschk said.

It’s a heavy price to pay for a bit of hanky panky.

And quolls aren’t the only animals whose demise was brought about by their insatiable sexual appetite. Who could forget the **frisky frogs** lured to their death in the ancient sex swamp death trap?

LIVE LONGER WITH FRIENDS

As humans, we’re well aware of the benefits of hanging out with our pals – but it turns out these advantages extend to the animal kingdom too. Mammals that live in groups may generally live longer than those that go it alone, an analysis of almost 1,000 different species suggests.

It seems there really is safety (and longevity) in numbers.

Mammals live in a wide variety of social organizations: sometimes they live in groups, sometimes in pairs, and sometimes they prefer to go solo. Asian and African elephants, for example, surround themselves with companions, while the aardvark opts for a more solitary way of life. Even **sharks have BFFs**.

Previous research has hinted that strong mammalian social bonds may be linked to longevity, but only in individual species, such as the **chacma baboon**.

This new study investigated social organization and lifespan of a menagerie of

mammals – 974 species to be exact – finding that those that live together tend to live for longer.

*IT SEEMS BEING SOCIAL
BEATS BEING A LONE
WOLF WHEN IT COMES
TO LIVING LONGER.*

The trend persisted when size was taken into consideration too. The solitary northern short-tailed shrew, for example, weighs about the same as the greater horseshoe bat, which lives in groups. However, the former lives for around two years, while the latter can persist for up to 30.

The authors also identified 31 genes, hormones, and pathways that could help to explain this link between social organization and longevity.

There are some exceptions, however. Take the bowhead whale: these loners can live for more than two centuries, outlasting far more social species like sperm or humpback whales.

But for the majority of mammals included in the study, it seems being social beats being a lone wolf when it comes to living longer.

It’s good news for **jaguar besties** and **pee-drinking dolphins** the world over.



**The Darker Side
of Science**



**THE LIGHTER SIDE
OF SCIENCE**