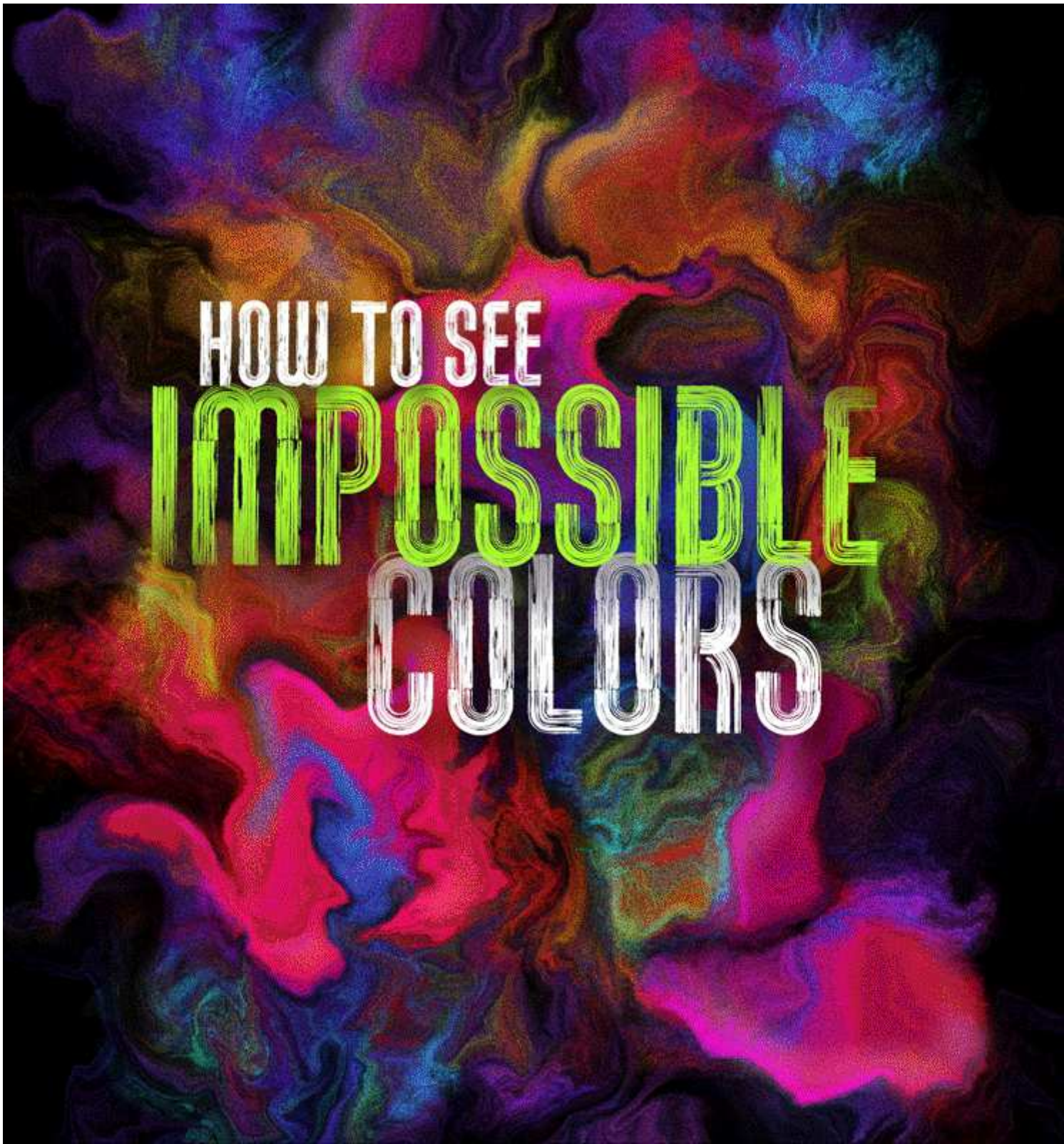
CURIOUS?

IS "TWIN TELEPATHY" REAL?

WHY DO GEOLOGISTS LICK ROCKS?

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THE CHOCOLATE HILLS OF BOHOL ISLAND

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"Imaginary" colors are real, and you can see them. Dr Katie Spalding explains how.

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NEWS BITES



Prehistoric Planet Is Back

Everyone's favorite factual dinosaur show is back for a second season after the smash hit success of Apple TV+'s award-winning ***Prehistoric Planet*** in 2022. Combining breathtaking state-of-the-art visuals, heart-wrenching stories, and the most accurate science available, even nervous palaeontologists **sang its praises** when it launched last year – it even holds a 100 percent score on Rotten Tomatoes. Sir David Attenborough and Hans Zimmer are back to present and score, respectively. While details on which creatures will appear are scant, we know *Tarchia* (shown here) – one of the largest ankylosaurs at 5.5 meters (18 feet) long – is a definite, and rumors suggest we may get *T. rexes* hunting at night. Like last time, the five-episode season will air over a week starting on May 22, with new episodes dropping daily. Despite covering events over 66 million years ago, this is water-cooler television you don't want to miss.

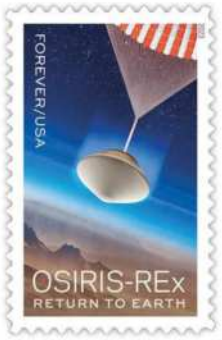


Nessie Is 90

May 2 marks the 90th anniversary of the first-ever "sighting" of iconic Scottish cryptid, the Loch Ness Monster. Although accounts of an aquatic beast living in Loch Ness date back over 1,500 years to Pictish carved standing stones found in the area, the modern myth took off in 1933 after a couple driving on a new road past the loch reportedly spotted an enormous animal rolling in the water. The local newspaper called it a "monster" and a new legend was born. In the years since, **scientific theories** have been posited, **advanced techniques** used to investigate, and the Scottish government even **has a plan** for its safety, should it turn out to be real. However, Nessie has remained stubbornly elusive; long may she reign.

Black Moon

This month has an unusual Moon phase, a so-called Black Moon. This is either the third new Moon in a season of four new Moons, like the one that will occur on May 19, or the second new Moon in a month. Though not an astronomical term (neither is **Blue Moon** for that matter), it has been gathering use in recent years. If you're hoping to spot it though, you're out of luck – Black Moons are invisible. New Moon is the phase we cannot see from Earth, as only the far side is illuminated by the Sun. But knowing it's there is fun.



Honoring OSIRIS-REx

This fall, OSIRIS-REx is set to return to Earth with its precious cargo after seven long years, and the **US Postal Service** is celebrating by announcing a new Forever stamp. Launched in 2016, OSIRIS-REx – NASA's first-ever asteroid sampling spacecraft – arrived at asteroid Bennu in 2018, intending to scoop up and collect asteroid samples to return to Earth for study, which **it did in 2020**. Scheduled to reenter Earth's atmosphere and parachute down to the Utah desert on September 24, 2023, the mission's samples will help scientists learn how the Solar System formed.

Image Credit Left: Apple TV+, *Right:* Matt84/iStock, *Bottom Right:* USPS



First Feature Film In Space

In 2021, Russia beat Tom Cruise and Hollywood to shoot the first feature film in space aboard the International Space Station (ISS). Just released, *The Challenge* tells the story of a surgeon who has to operate on an injured cosmonaut on the space station, his condition preventing him from returning to Earth for treatment. Star Yulia Peresild and director Klim Shipenko spent 12 days in space, roping in the services of real-life cosmonaut Oleg Novitskiy to play the injured man. You may remember their return bumped US astronaut Mark Vande Hei off his scheduled return flight, resulting in him **breaking the record** for longest NASA spaceflight at 355 days. *The Challenge* is out now and you can watch the trailer above.



A New Type Of Nature Doc

Many people laughed when Canada announced in 2022 that doctors could **"prescribe" National Park tickets** to patients – but a **new study** has confirmed a "nature prescription" from your doctor has real-world physical and mental health benefits. There is **plenty of evidence** that being in nature is good for us, but the new meta-analysis reviewed 28 studies from around the world that found being prescribed time in nature by your doctor can make a difference, whether it's the permission to make time for it or the authority to prioritize it, it really works.

WHAT'S UP?



Fly Me To The Moon

Meet your new Moon astronauts

Name: Artemis 2 crew
Appearance: More inclusive than in the past
Location: The Moon

What's happening?
NASA has just announced the astronauts selected for its Artemis 2 mission.

What's Artemis 2?
Following on from the success of Artemis I – which blasted into space with the sound of **40 million bowls of Rice Krispies** – at the end of last year, Artemis 2 is the first crewed lunar mission in half a century and the next step that will ultimately see Artemis 3 take the first woman and astronaut of color to the surface of the Moon.

Who is going?
NASA's Reid Wiseman, Victor Glover, record-breaking **Christina Koch**, and Canadian astronaut Jeremy Hansen. Koch and Glover will be the first woman and person of color, respectively, to go to deep space.

What are they flying in?
After the successful test flight of NASA's massive SLS rocket and Orion capsule, this is the first time either will have flown with humans strapped in.

Will they land on the Moon?
No, Artemis 2 is the first crewed mission of the Orion spacecraft and will take a trip around the Moon – the first humans to get this close since Apollo 17 in 1972. Artemis 3 aims to put humans down near the Moon's south pole in 2025.

How long is the mission?
During the 10-day mission, the crew will fly 7,402 kilometers (4,600 miles) beyond the far side of the Moon, complete a lunar flyby, and return to Earth.

When are they going?
Artemis 2 is currently slated for no sooner than November 2024.

How can I watch?
As usual, NASA will be livestreaming the launch from the Kennedy Space Center in Florida but since you have 19 months to plan, you could try and see it live. We'll see you there.

Image Credit Left: nattrass/iStock, *Right:* NASA

HOW TO SEE IMPOSSIBLE COLORS

"Impossible" colors exist and you can train your eyes to see them. Let us show you how.

By Dr Katie Spalding

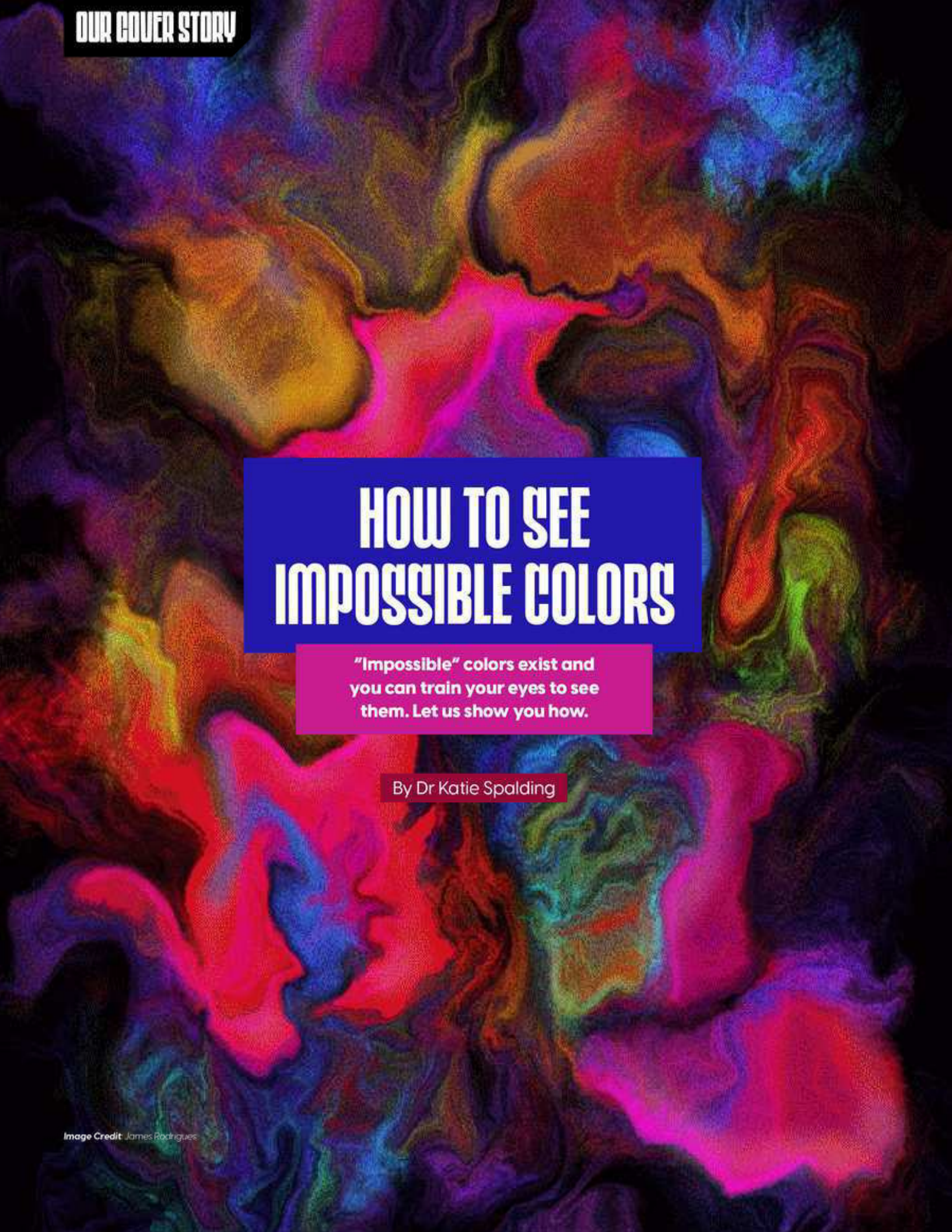


Image Credit: James Rodrigues

Have you ever seen the color yellow-blue? No, we don't mean green – we're talking about a color that's simultaneously blue and yellow at the same time. OK, it's hard to picture, as is the idea of a color that's exactly as red as it is green. According to experts, however, you don't need to rely on your **mind's eye** to figure out what it would look like. "Imaginary colors", as these seemingly impossible hues are known, are real, they argue – and we can see them, with the right equipment and techniques.

But are they correct? Can these weird, mind-bending colors really be seen?

How do we see colors?

To understand how imaginary colors work, we first must delve into how we see colors in the first place. For that, things are going to get a little bit... *Matrix*-y.

It may surprise you but there's actually no such thing as color.

No, really: we know that banana looks bright yellow when you hold it up under the spotlight, but sneak down to the kitchen at midnight and take another peek. Don't listen to your brain **trying to tell you** it's still a glorious sunny shade – really look at it, and you'll see the truth, which is that it's now a sort of muddy dark brownish-gray color, and not that appetizing at all.

That's because "color" isn't really a physical property that anything has – it's just a result of how our eyes perceive light reflecting off objects. When we see that banana as "yellow", what's happening is that certain wavelengths of white light are being absorbed or reflected by chemicals in the peel.

The wavelengths that are absorbed, we never see again. But the ones that are reflected are detected by our cones: millions of densely-packed cells that sit in the center of our retinas and react to different color wavelengths.

It's the particular combination of reactions here, and the resulting electrical impulses that our cones fire off to our brains, that create what we think of as "yellow". What's interesting is how, exactly, our brains come to that conclusion.

Opponency is "one of the oldest concepts in the science of perception," explained biophysicists and experts in human color and spatial vision, Vincent A. Billock and Brian H. Tsou, in a 2010 article for **Scientific American**.

"Opponency is ubiquitous in physiology," they wrote. "For example, to bend your arm, you relax your triceps while contracting your biceps; biceps and triceps are opponent muscles, in that they act in direct opposition to each other."

According to our best working theories, color perception is no different. "In 1872 German physiologist Ewald Hering suggested that color vision was based on opponency between red and green and between yellow and blue," explained Billock and Tsou; "at each spot in the visual field, the redness and greenness muscles, so to speak, opposed each other."

This means that, just as you can't simultaneously contract your biceps and your triceps, you also can't simultaneously perceive a color as red and green at the same time. Red and yellow? No problem – your brain is happy to call that "orange". Blue and green? That's just turquoise. But red and green, together? You may as well try to bend and straighten your arm at the same time.

And that, right there, is the crack that lets in the possibility of impossible colors, which include two main types: imaginary and chimerical colors.

What are imaginary colors?

This system we've got going on, in which every color is perceived by pinpointing it on a scale from red to green and blue to yellow, is a pretty good one, allowing us to see around a cool million different hues on average.

There's no real reason why "red-green" or "blue-yellow" should not exist as colors – and yet here we are, physically incapable of ever perceiving them, thanks to this particular way our brains work.

Or are we? In 1983, Hewitt D. Crane and Thomas P. Piantanida, both engineers at the Visual Sciences Program of SRI International, published a **rather surprising paper**: it is possible to see red and green simultaneously, they asserted – and they could show you how to do it.

These hues should, by rights, be impossible to see since they require our brains to respond to two opposing colors at the same time. Yet, by having study participants stare at side-by-side fields of red and green or yellow and blue until the borders between the colors dissolved, they had managed to induce people to see what they termed "reddish green" and "yellowish blue" – the so-called "imaginary colors".

What are chimerical colors?

Perhaps slightly easier to understand are the so-called chimerical colors. Once again, these non-existent hues are a result of the way our cones react to different wavelengths – but this time, we're exploiting that biology in a slightly different way.

Where imaginary colors rely on our brains' inability to perceive two opposing colors at the same time, chimerical colors hack right into our retinas themselves. These nonexistent colors are essentially the same effect as when we **get an after image** across our vision.

It's a neat trick if you want to visualize **Abraham Lincoln**, but how does that extend to seeing impossible colors? The secret is in what you see the afterimage on top of: by carefully choosing the right background, you can force your eyes to see a color that is more than 100 percent saturated, for example – the so-called hyperbolic colors – or a hue which, while no doubt a real color, is simultaneously as dark as black.

Are they really impossible?

When Crane and Piantanida published

their results, it should have been huge news: after all, as Billock and Tsou pointed out, they "were reporting a major violation of the best-established psychophysical law."

But instead, many of their peers were unconvinced by the experiments: they were difficult and expensive to replicate, relying on equipment that had been specially designed by Crane himself, and the results themselves were confusing – both for study participants to describe, and for experts to explain.

When researchers finally did revisit the results, their conclusions didn't necessarily support what Crane and Piantanida had originally asserted.

"We asked our participants to report their percepts in a more objective way," Po-Jang Hsieh, who **in 2006** conducted a variation on the 1983 experiment in which participants were asked to match the "impossible" color they saw to a color map provided by the researchers, told **Live Science** in 2012.

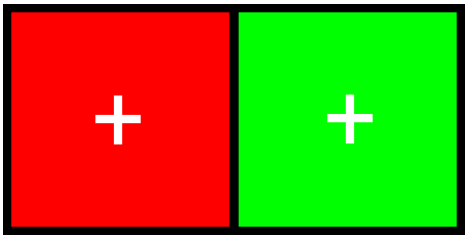
"In this way, we discovered that the perceived color during color mixing [...] is actually a mixture of the two colors, but not a forbidden color."

Even today, the existence of imaginary colors remains debated. Some researchers, like Billock and Tsou, believe Hsieh's experiments were faulty; others think Crane and Piantanida were too quick to label regular colors as "indescribable" or "impossible".

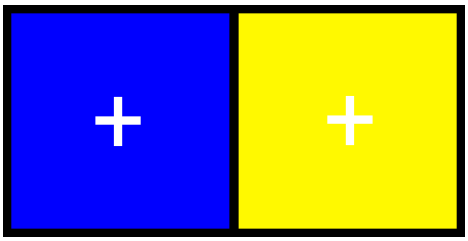
"Perceived color during color mixing is just an intermediate color," Hsieh said. "Just because a color cannot be named, doesn't mean it is a forbidden color that's not in the color space."

How to see imaginary colors

The technique is not dissimilar to those Magic Eye pictures that were big in the 1990s. Take the image below: the idea is to focus your left eye on the cross in the red square, and your right on the cross in the green. After that, it's simple, albeit uncomfortable: you need to cross your eyes until the two crosses line up on top of one another.



It's not guaranteed, but by doing this, you may be able to see the "reddish green" that Crane and Piantanida first reported back in the '80s. Similarly, you can do the same to see "yellowish blue" using the image below:



If you're lucky, you might find yourself looking at a color you'll never see in nature – but don't be despondent if it didn't work. For the success rates of Billock and Tsou, who were able to get six out of seven observers to see their "forbidden" colors, you'll likely need both image stabilization and control over individual color luminance.

"I think what stabilization does (and what [equal brightness] enhances) is to abolish the competitive interaction between the two neurons," Billock told Live Science. That way, "both are free to respond at the same time."

Getting it right, though, is akin to "seeing purple for the first time and calling it bluish red," he said. And that, we think, is well, pretty cool to imagine.

Image Credit Background: James Rodrigues

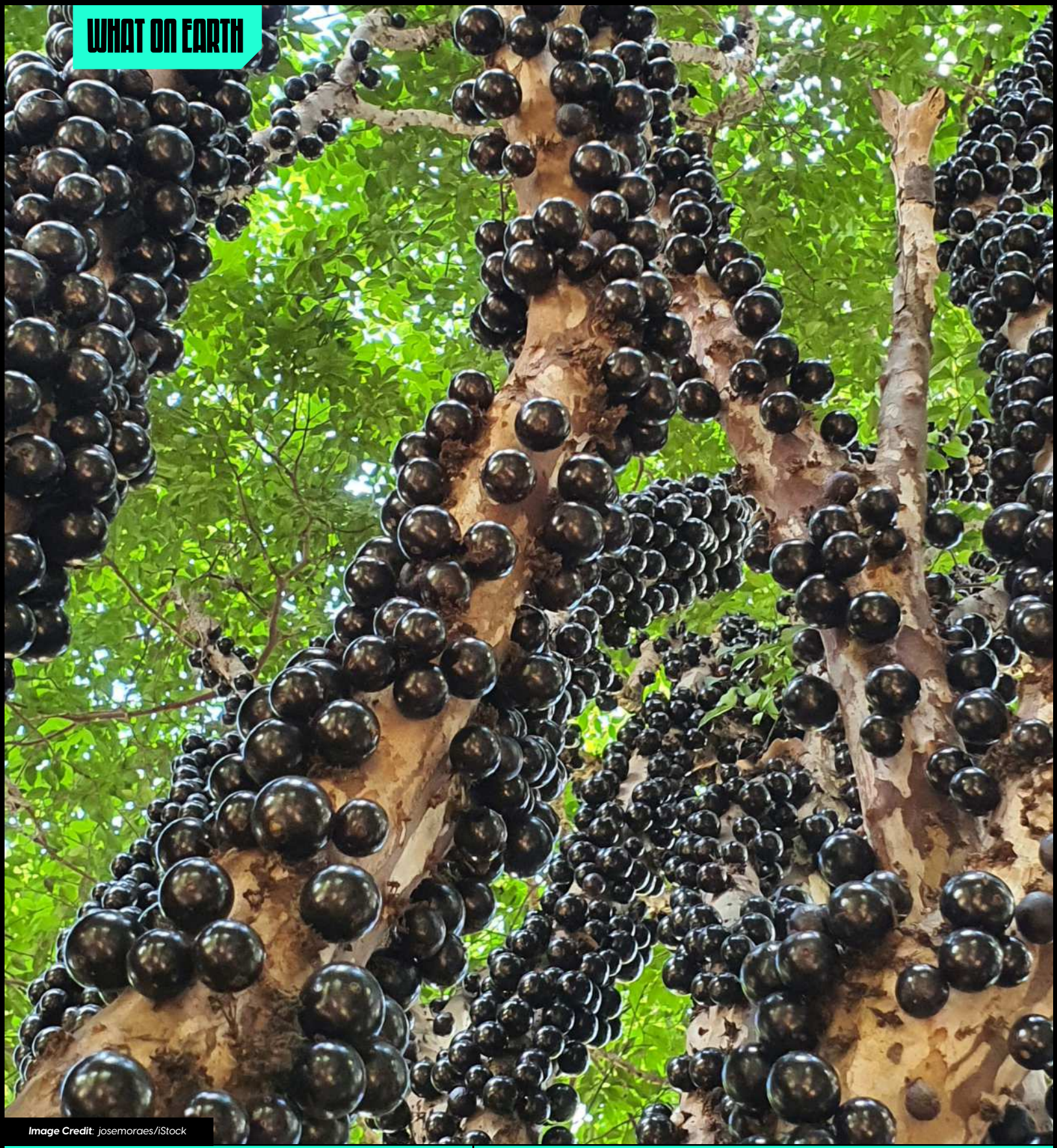


Image Credit: *josemoraes/iStock*

THE BRAZILIAN GRAPE TREE

These little rubber balls are not grapes but jabuticaba berries from the jabuticaba tree (*Plinia cauliflora)*, also known as the Brazilian grape tree. Described as sweet with a tart kick, these dark purple berries are packed with more antioxidants than blueberries or acai, but they don't travel well. They're nutritious as well as delicious, packed with vitamins C and E as well as calcium, iron, and potassium. The tree's name remembers the turtles (*jabuti*, in the ancient Brazilian language Tupi) that once lived on the same land (*caba*).



Image Credit: *Eliza Petersen* ***Natural History Museum of Utah palaeontology volunteer Eliza Petersen licks a dinosaur bone to see if it sticks.***

WHY DO GEOLOGISTS LICK ROCKS?

IN WHAT SEEMS A TAKE-YOUR-LIFE-INTO-YOUR-HANDS SITUATION TO ANY OTHER FIELD OF SCIENCE, IT TURNS OUT GEOLOGISTS CAN LEARN A LOT WITH THEIR MOUTHS.

By Rachael Funnell

If you're ever out walking and stumble across a geologist with a rock stuck to their tongue, fear not. They've not succumbed to the midday heat and started trying to eat their environment, they've simply struck fossilized bone.

In the pursuit of discovery, scientists have employed all kinds of bizarre avenues of investigation, from volunteering to be parasitized by **hookworms** and **botflies**, to **detecting burning hydrogen with brooms** (keeping it simple, NASA). By comparison, popping a few rocks in your mouth seems quite tame.

It's certainly become unremarkable for geologist and palaeontologist Dr Randall Irmis from the **Natural History Museum of Utah**. With decades of experience in the field, geological tests that would look downright weird to the unknowing observer have become second nature for Irmis. Perhaps even more incredible is that with so much experience tasting his way through geological time, he's so far managed to avoid licking anything too disgusting – discounting fossilized feces, of course.

We caught up with Irmis to find out more about the art of rock licking, what it can tell us, and what flavors, smells, and textures there are to discover while working in rock layers of the late Triassic.

Do scientists lick rocks?

RI: Well, I can't speak for all scientists, but I'm both a palaeontologist and a geologist and there's a couple of reasons why we might lick rocks or touch them to our tongue. Perhaps the one that gets the most excitement is that we actually use it as a way to tell whether something is fossil bone or not. It turns out that fossil bones will stick to your tongue with a little bit of moisture, whereas most rocks, petrified wood, and things like that, will not stick to your tongue. There are always exceptions, of course.



***Image Credit**: Eliza Petersen*

Is it about texture or taste?

RI: With the fossil bone test, it's simply: does it stick to your tongue or not? But one other reason that geologists might put rocks in their mouths is that we are often interested in the size of the grains that make up sedimentary rocks. It turns out that in the field, one of the most effective ways to tell whether a rock is made out of silt versus clay is to take a little bit and grind it between your teeth. If it's smooth, it's clay. If it's a little gritty, then it's got some silt in it.

Licked anything particularly memorable?

RI: That's a hard one because it's so normal that sometimes I don't think about it. There's a lot of things that when we're out looking for fossils, prospecting for new sites, you pick something up and you're almost sure it's fossil bone, and then you stick it to your tongue and it doesn't stick. So then you have to re-evaluate. If it's not fossil bone, it could be wood or fossilized roots that get solidified.

One way in which the test between clay and silt has been useful is that there are some rock layers I work in, in the western US, that are from the late Triassic period and there are actually different layers that are separated out based on their grain size, so one layer has more silt than the other. So, to be able to tell exactly which layer you're in, that's one of the best ways to work out if the rock has silt or clay.

Any nasty surprises?

RI: Thankfully, not for the most part. Sometimes you pick something up and it turns out to be a modern cow bone, but thankfully, no nasty tastes. Obviously, you want to make sure that it's somewhat clean and not covered in gunk or whatnot. When we're putting the sedimentary rocks between our teeth, I always dig in and get a fresh sample.

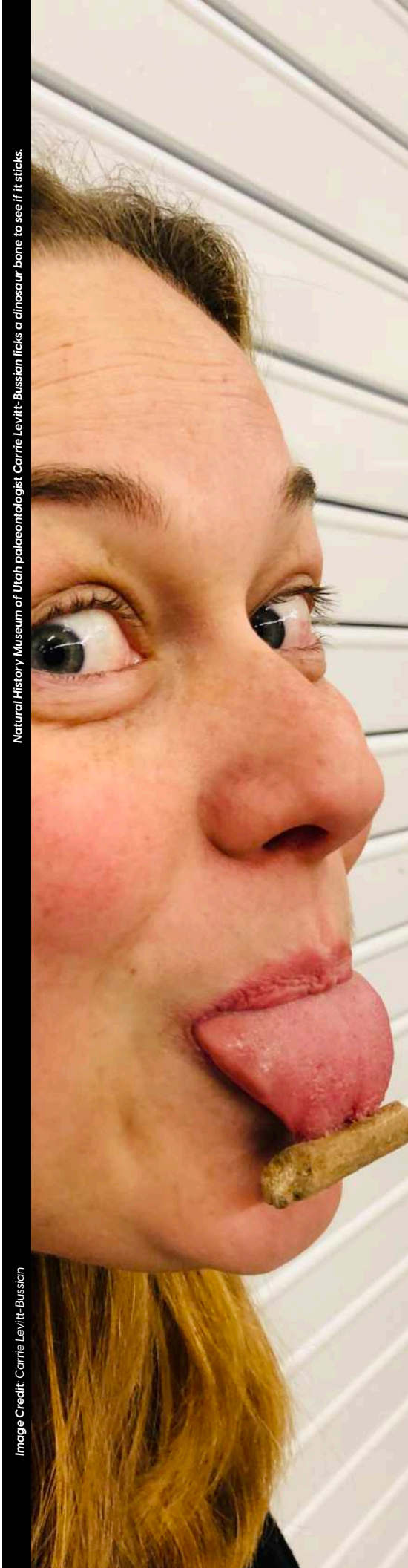
But yeah, thankfully, it hasn't happened, although a great joke to play on someone is you pick up a coprolite, which is fossilized poop, and ask someone to test whether it's bone or not. Of course, there's nothing wrong with that, it's fossilized. It's millions of years old. You're not going to get anything bad from it, but it always gets a laugh.

What about other weird tests?

RI: That's always a funny question for scientists because we're so normalized to it that it doesn't seem very weird to us, but if outsiders were observing us doing it, they'd think, wow, that's really strange.

One thing that comes to mind is that some types of limestone actually have a rotten smell to them. So you might see geologists smelling limestone, breaking it open, and when you do it has what's called a fetid smell. I believe that has to do with the organic matter preserved in the limestone, but I'm not 100 percent sure.

We also carry around color charts that look like paint samples because the color of the rocks can be really informative. If you see a geologist with that, they're not planning to redecorate anytime soon, at least, not in the field. •



***Natural History Museum of Utah** palaeontologist Carrie Levitt-Bussian licks a dinosaur bone to see if it sticks.*

***Image Credit**: Carrie Levitt-Bussian*

SCIENCE FACT OR FICTION:

IS "TWIN TELEPATHY" REAL?

Some twins appear to read each other's minds, but is there any real evidence for "The Twin Thing"? Rachael Funnell investigates.

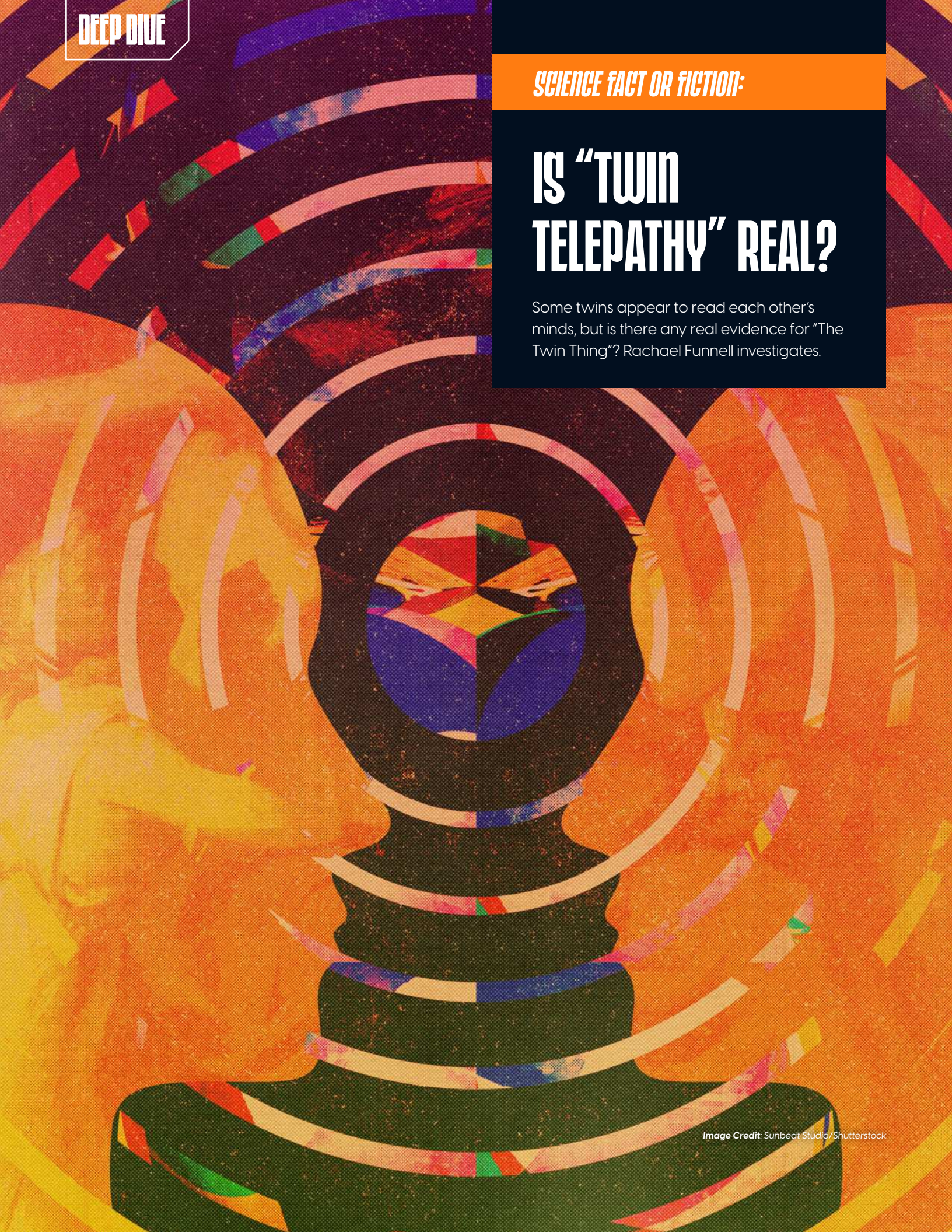
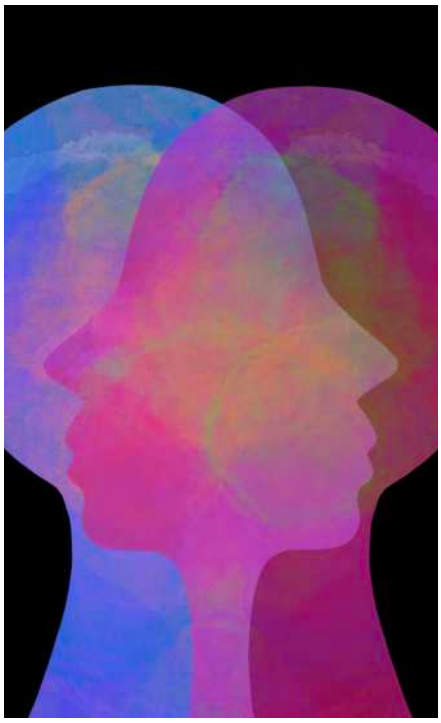


Image Credit: *Sunbeat Studio/Shutterstock*



Speak to anyone with siblings and they'll likely have a rich backlog of dumbassery they've witnessed in the company of their brothers or sisters. The quirks of genetics mean that sharing the same parents isn't enough to guarantee any morphological consistency among siblings, and personalities can be even more wildly disparate. That all changes, however, in the case of identical twins.



Monozygotic twins are the only "identical" twins but research has found that even among these siblings there can be some differences. While some identical twins may look, sound, or behave a little differently, others seem to share a unique connectedness that extends beyond our understanding.

"The Twin Thing" is a term often given to twins who share these kinds of special relationships. They may be able to finish each other's sentences to a degree that has you questioning if they're reading minds, or they might have a way of knowing when something's happened to their twin without being there. The anecdotal evidence of twin telepathy is all over the Internet, but has science found anything to explain, confirm, or deny the existence of this kind of twinship?

The cracking of eggs

It's first important to note that not all twins are created equal, and by that we're not implying a twin hierarchy but stating the fact that different twin types involve a different number of sperm and egg cells. In the case of what's known as identical or monozygotic twins, one fertilized egg cleaves in two at a very early stage of development to create two embryos. These babies are born looking very similar to one another on account of sharing the same genomes.

Non-identical twins are known as dizygotic because they are created from separate egg cells getting fertilized by separate sperm cells at the same time in the same uterus. Typically, a human female only releases one egg per menstrual cycle, but this isn't a hard and fast rule. Hyperovulation can happen naturally or be brought on by fertility drugs (something that's standard practice during *in-vitro* fertilization), giving sperm more than one target to aim for.

We know that men produce between 2 and 5 milliliters of semen per ejaculation event. With around 100 million sperm believed to be in each ml, it's easy to see how those extra eggs have a shot at fertilization.

As fans of *This Is Us* may recall, The Twin Thing isn't exclusive to monozygotic twins (that is, as a self-reported experience rather than a proven scientific fact). The old "nature versus nurture" debate comes into play here, as non-identical twins who shared a childhood but not an egg may have more personality-based similarities than a set of monozygotic twins who were separated at birth (hello, *The Parent Trap*?).

What do the twins say?

There are remarkable stories of twins sharing a connectedness that seems to defy science's understanding of the senses. Even British Olympic athlete Mo Farah shared in his autobiography ***Twin Ambitions***: "Whenever Hassan is upset, or not feeling well, I'll somehow sense it. The same is true for Hassan when it comes to sensing how I feel. He'll just know when something isn't right with me. Then he'll pick up the phone and call me, ask how I am. Or I'll call him."

IFLScience Editor Laura Simmons' grandmother, Joyce Siney, is an identical twin. Now in her 70s, Siney and her sister Shirley have gone through their lives sharing identical genomes.

"We've not had a time where we've not

Image Credit Top: Kateryna Kovarzh/iStock, *Bottom*: Kateryna Kovarzh/iStock

been together," Siney told IFLScience. "We've never been separated by more than maybe 10 miles [16 kilometers]."

The twins have similar interests, including church activities, knitting, and sewing, and both pursued careers in nursing. However, when asked about The Twin Thing, Joyce's experiences raised a pivotal question about the theory. "Maybe if you asked Shirley a question, and then you asked me, I'd give the same answer... but I'm not sure that's telepathy."

As it turns out, science isn't sure either.

What does the research say?

To explore the concept of twin telepathy, researchers are faced with the challenge of coming up with a study design that can definitively test for exactly that. "Telepathy" specifically refers to the exchange of thoughts and ideas through extrasensory means, so not using the known senses of sight, sound, touch etc.

A **2013 pilot study** tried to settle on an objective method for investigating this kind of extrasensory connectedness using four pairs of monozygotic twins. They were separated and then exposed to surprising stimuli to see if the other twin could pick up on anything. It used five-minute windows to apply the stimuli, ranging from a jump-scare like dropping plates to touching something painfully hot, and considered it a positive synchronous response if the other twin reacted within 15 seconds.

Their results were of "marginal statistical significance," wrote the authors, "but the outstanding performance of one of four pairs of identical twins is cause for further interest." A similar result came from a **Copenhagen study** that used a similar methodology and also found that only one of the four pairs of monozygotic twins appeared to show significant signs of connectedness.

Interestingly, there was something unique about the "outstanding performance" twin pair in the 2013 pilot study: "The pair of twins who produced most of the hits in this series was the youngest in the sample (25 years), and one of them was 7 months pregnant. In the interview, the nonpregnant twin told how they had led independent lives but her belief in twin telepathy had suddenly increased because of her remarkable sensitivity to her twin sister's state during pregnancy."

Synchronous experiences have led some scientists to describe twin telepathy as an analogy of macro-entanglement. You may be more familiar with the phrase quantum entanglement, which maintains a **connection between separated particles** to the extent that if you change one you'll change the other, even if they're far apart.

A more tangible type of entanglement that could contribute to the connectedness of monozygotic twins is the stage at which one egg becomes two. Most identical twins split within four to eight days of fertilization,



but for some it happens a few days later. This is something parapsychology writer Guy Lyon Playfair explored in his **2017 paper** titled "Monozygotic twins and macro-entanglement" after finding reports that twins that split in the day eight-to-12 window of development show greater connectedness. Could this be linked to the fact that they remain literally entangled until a later stage of pregnancy?

The twin cohort for the Copenhagen study included a pair of female identical twins who Playfair says were born "bound to each other by their umbilical cords and had to be disentangled by hand". They gave several anecdotes of what they believed to be twin telepathy, including one twin collapsing in severe pain when her twin underwent surgery for kidney stones. They also happened to be the best performers in the synchronous response experiment.

University of Greenwich twin studies investigator Göran Brusewitz, whose research interests include parapsychology, tackled the concept of twin attachment in a **2019 thesis**. It defines incidences of twin telepathy or remote emotion sensing (picking up on the state of a twin from a distance) as "exceptional experiences", sifting through the research and studies that have investigated their frequency among different twin types.

There are notable mentions for both sides of the argument, but one includes a King's College London survey that found almost half of twins studied (46 percent) denied having any ability to sense how their twin was feeling when they weren't around. Identical twins were twice as likely to say they could compared to non-identical twins, but this still represented the minority of responses.

Twin telepathy, a special relationship, or just similar ideas?

Professor Tim Spector started the **UK Twin Registry in 1992**, creating one of the richest collections of genotypic and phenotypic information on twins worldwide. It hasn't, however, included much in the way of testing mind reading among twins, instead focusing on more Earthly concepts like "**Do our genes tell us how to vote?**"

A poll of voting preferences was carried out by the Department of Twin Research, which hosts TwinsUK, to explore how much nature and nurture influence party political alliances in the UK. Unlike the experiments that used just eight participants to search for signs of The Twin Thing, the poll included responses from a large sample of 2,355 mono- and dizygotic twins.

It found that there was a genetic influence for voting preference: when voting Conservative, 57 percent of the voting similarities and differences were linked to genetic effects. This indicates that identical twins are more likely to vote similarly compared to non-identical ones, raising questions as to how far this kind of genetically linked thought processing extends. As Siney put it, simply answering a question with the same answer doesn't amount to telepathy, so could it come down to genes?

As far as the science is concerned, it seems that for now, the jury's still out on twin telepathy and the mechanisms that could explain The Twin Thing. But as far as special relationships go? We'd say Joyce and Shirley are all the evidence you need.

"All I would say is I thank God that I am a twin, it's just been wonderful," Siney told IFLScience. "I think it's a very special relationship. Ours is, anyway." ●



***Image Credit**: Sunbeat Studio/Shutterstock*



WHERE WOULD WE BE WITHOUT GERMS?

The COVID-19 pandemic showed how microscopic organisms can turn our world upside-down. It fundamentally changed the way humans lived, begging the question: where would we be without germs? In his new book *Pathogenesis*, Dr Jonathan Kennedy takes us through how germs have shaped humanity since the dawn of our evolution.

According to Sigmund Freud, there have been three great revolutions in Western science and each of these dealt a blow to humans' belief in their special status – or what he referred to as our "naïve self-love".

The first, which began with Copernicus, was the revelation that the Earth is not the centre of the universe but just one of several planets revolving around the sun. After this setback, we could still console ourselves with the Book of Genesis' claim that God created humans in his own image and gave us dominion over the land, sea, and animals – albeit in a location that was astronomically peripheral. Then Charles Darwin came along and pointed out that humans are just another species of animal and that we share a pathogenesis relatively recent common ancestor with apes. The third great scientific revolution, according to Freud, was his own discovery of the unconscious. The realization that we aren't even in control of our thought processes was, he argued, the "most irritating insult" to "the human mania of greatness".

Freud's suggestion that psychoanalysis is more significant than the Copernican or Darwinian revolutions seems a little, well, egotistic. But his general point – that the more humans learn about the world, the more insignificant we realize we are – is insightful. For example, advanced telescopes have revealed that Earth is an infinitesimally small rock rotating around an unremarkable star in a galaxy of at least 100 billion stars, which itself is just one of many billions of galaxies in the universe. In addition to this, there have been other scientific revolutions that have further undermined our species' high opinion of itself.

To my mind, the most important of these is the discovery of a world as vast as outer space, and yet so tiny that it is invisible to the naked eye: the realm of bacteria, viruses, and other microbes.

In the early 17th century, Galileo realized that when he reversed the order of the lenses in his telescope, very small things became visible. For the first time in history, humans had the technical capacity to see microbes. But Galileo preferred to focus his efforts on observing the stars and planets in the sky, and it wasn't until 50 years later that a haberdasher from Delft in the Netherlands began to explore the microscopic world.

Antonie van Leeuwenhoek initially developed his lenses to inspect the quality of the textiles he bought and sold. But after a while he turned his gaze upon the natural world. His letters to the Royal Society in London describe how everything from a drop of water to the plaque on our teeth is alive with what he called "animalcules". He was enraptured: "No more pleasant sight has ever come before my eyes." In all of history, Leeuwenhoek's discovery of the microscopic realm might well be the closest anyone has come to falling down the rabbit hole, climbing through the looking-glass, or stepping into a wardrobe and finding oneself in a world of fantastical creatures. It wasn't until the second half of the 19th century – a full 200 years later – that scientists finally began to comprehend the significance of the new world that Leeuwenhoek had stumbled into.

In the last couple of decades researchers have begun to appreciate how bacteria and viruses perform a wide range of roles that are vital to the functioning of our planet, bodies, and even our minds. Human life – indeed, complex life in any form – is inconceivable without microbes. •

Image Credit: Penguin

Q&A AUTHOR



WITH

DR JONATHAN KENNEDY

AUTHOR OF *PATHOGENESIS: HOW GERMS MADE HISTORY*

What inspired you to write *Pathogenesis*?

A little of this wonder rubbed off on me when I – an academic with a background in the social sciences – began reading about microbes a couple of years ago. I was stunned to learn that 8 percent of the human genome was inserted there by retroviruses. These infections allowed our distant ancestors to acquire the capacity to perform functions that are fundamental to human existence, including memory formation and the ability to give birth rather than lay eggs.

And while I can just about get my head around the idea that there are slightly more bacteria in our bodies than human cells, I struggle to comprehend that bacteria in our guts have evolved to produce neurotransmitters like dopamine and serotonin that appear to have an impact on our moods.

This got me thinking: if bacteria and viruses have had, and continue to have, such a massive influence on us as individuals, what impact do microbes have on aggregations of bodies – on the body politic, the body social, and the body economic?

What do you hope people will take away from the book?

The COVID-19 pandemic isn't an aberration. Throughout history, infectious diseases have destroyed millions of lives and even whole civilizations, but the devastation has created opportunities for new societies and ideas to emerge and thrive.

Although vaccines and antibiotics granted humans a temporary reprieve in the struggle with pathogens, we have now entered a new golden age of infectious diseases. Population growth, urbanization, encroachment on animal habitats, long distance travel have combined to create very favourable conditions for infectious diseases to emerge and spread.

It is therefore crucial that we continue to put resources into research into more effective vaccines and medicines. At the same time, it is important to acknowledge that technology alone will probably not be enough to stop the next pandemic.

In both the UK and the US, poor decision making by politicians made coronavirus much more deadly than it needed to be. And poverty made the situation worse too, as death rates were several times higher in the poorest regions of both countries compared to the wealthiest. In order to prepare society to be as resistant as possible to future pandemics, it is crucial to address these broader determinants of health.

Can you tell me one of your favorite facts you discovered while researching for it?

The advances in ancient DNA research over the last 20 years are mind blowing. Some of this work is well known: Svante Pääbo won a Nobel Prize last year for his research, which includes sequencing the Neanderthal genome and identifying a previously unknown species of human, Denisovans, from a 60,000 year old finger bone found in a Siberian cave.

The process of extracting ancient human DNA also picks up genetic material from microorganisms that were in the bloodstream at the time of death. This data is beginning to revolutionize our understanding of Neolithic plagues.

A study published in Cell in 2019 demonstrated that a young woman who lived in Western Sweden about 5,000 years ago was killed by plague. This is interesting in its own right but what really amazes me is how much scientists can infer from this discovery.

By comparing this sample of bacterial DNA with others found elsewhere in Eurasia, as well as studies that reveal a marked fall in population around this time, it is possible to build up a picture of a Neolithic Black Death that was probably just as devastating as the medieval version. Incredibly, as I point out in the book, the impact of this catastrophic pandemic is still evident today in the genes that we carry and the languages we speak.

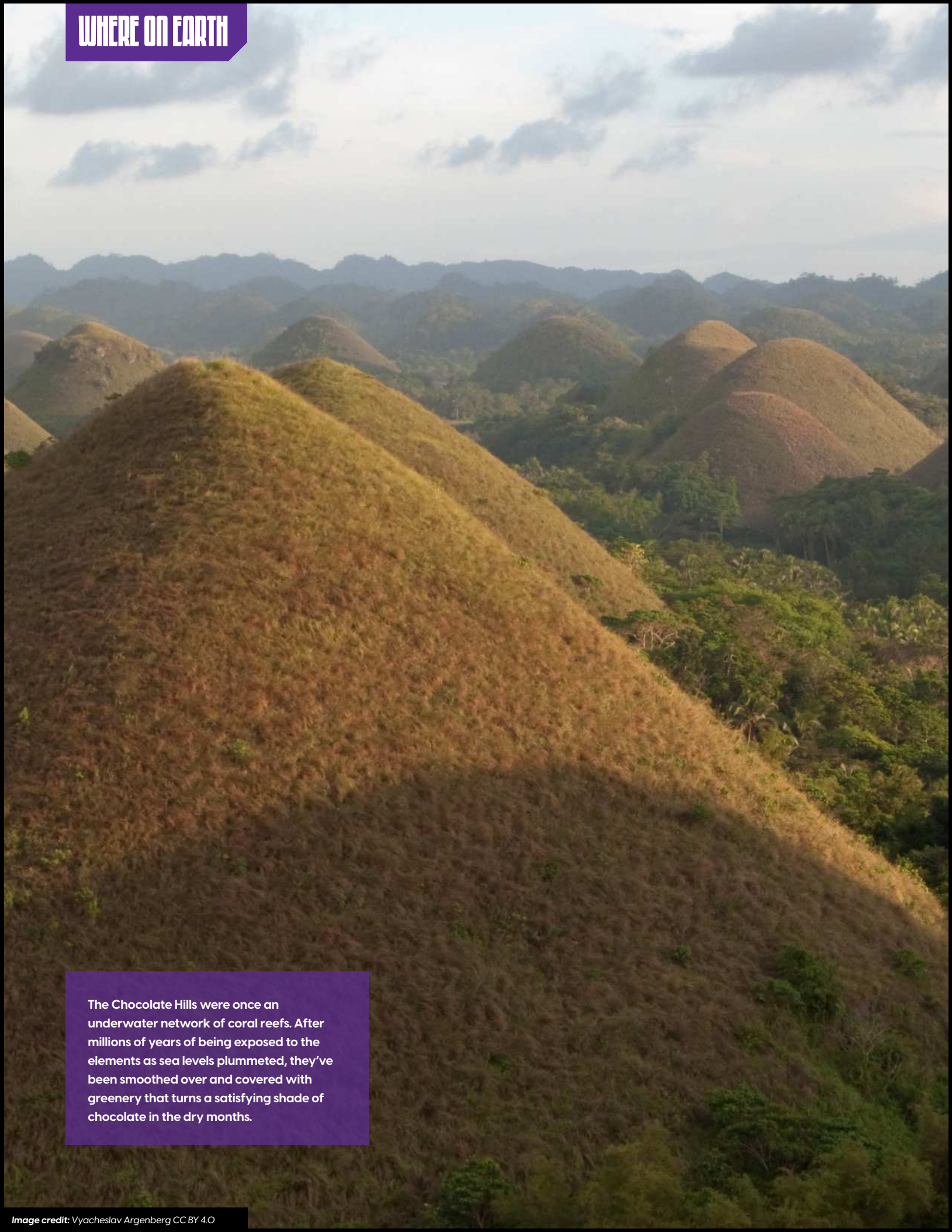
Who is the book aimed at?

Anyone with an interest in history or science or a combination of both. In terms of scope, *Pathogenesis* is similar to Yuval Noah Harari's *Sapiens* but the perspective is closer to Ed Yong's *I Contain Multitudes*. It brings together research from a broad range of disciplines – genetics, classics, and economics; archaeology, biology, and sociology – to transform the way the reader thinks about the past, the present, and the future.

If that sounds a bit heavy, then don't worry. I have really tried to make the book fun and accessible. While I do cite plenty of academic studies, I also refer to Monty Python, George R. R. Martin, Charles Dickens, and Gustav Klimt. •

***Pathogenesis* is published by Transworld and is *available now*.**

Image credit: Dr Jonathan Kennedy



The Chocolate Hills were once an underwater network of coral reefs. After millions of years of being exposed to the elements as sea levels plummeted, they've been smoothed over and covered with greenery that turns a satisfying shade of chocolate in the dry months.

Image credit: *Vyacheslav Argenberg CC BY 4.0*

THE CHOCOLATE HILLS OF BOHOL ISLAND

A gathering of mysterious cones dots the horizon of Bohol Island in the Philippines. These natural geological features formed over millions of years and their appearance changes with the seasons, which is where their name "Chocolate Hills" comes from.

While we'd love to share that this is where all Earth's chocolate is grown, their name centers around dehydration. Rain peaks on the island during July and peters out towards the later end of winter. Its driest months are March and April, and when water is sparse, the luscious green mounds turn into the Chocolate Hills due to parched plants.

Beneath their grassy veneer are limestone and corals that were underwater along with the rest of the island around 2 million years ago. Back then, rich coral reefs covered the seabed – but once beached by plummeting sea levels, they dried up and sprouted a new terrestrial ecosystem. Their conical, mound-like shape emerged as erosion smoothed their edges.

There are thought to be between 1,200 to 1,700 Chocolate Hills spread across Bohol. Some of them stand at 120 meters (394 feet) tall, while others are a mere 30 meters (98 feet). Speaking of small things, Bohol is also home to tarsiers, the world's smallest primate.

Tarsiers are about the size of your fist with disproportionately **enormous eyes**. It's rumored that these peculiar primates were actually the inspiration for *Star Wars*' Yoda, and it's pretty easy to see the resemblance. Such enormous peepers are needed because they're nocturnal animals, hunting at night for insects like spiders, beetles, termites, moths, and crickets.

Unfortunately, they're also among the most endangered primates in the world, but Bohol is doing its bit to protect its boggle-eyed residents. The Philippine Tarsier Sanctuary can be found in the town of Corella, which is en route to the Chocolate Hills. Here you'll meet a group of protected mini primates being cared for by local women who will also take you to see the tarsiers. Just remember to keep the noise down and your camera flash off, as these silky sweet animals are very sensitive.

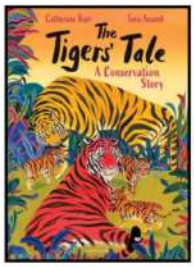
Tarsiers are also fantastic singers, just in case *The Mandalorian*'s producers fancy adding a little extra color to Pedro Pascal's little pal.



How to get there

The best route to Bohol's Chocolate Hills is to fly into Cebu and take a ferry to the island. For the full chocolate experience, head over between March and June.

INSPIRE



The Tigers' Tale
Book by Catherine Barr and Tara Anand

Children are now learning about species loss and environmental issues at a younger age than any generation that came before them, but it's important that they hear the good news as well as the bad. This conservation story, perfect for children aged seven and up, tells the turbulent tale of how the lost tigers of India's Panna Reserve were returned to their home in the Emerald Forest.

***Available* now.**

BATTLE



Cactus Cowboy – Plants At War
Game from Cactus VR Studios

Step into a world where plants are at war with bugs in the fully immersive virtual reality (VR) game available on Oculus Quest, PlayStation VR2, and PCVR. Once inside, you'll be enlisted to fight with the plants for Cacti Island as a backstabbing bug army try to take over. The four-hour adventure features WWII-inspired guns and, unsurprisingly, a lot of cacti.

***Available* May 3.**

WATCH



The Little Mermaid
Film from Disney

A Disney classic gets a makeover in this release from visionary filmmaker Rob Marshall. The live-action reimagining sees the boldest of King Triton's daughters tangle with the evil sea witch, Ursula. Her perilous journey is joined by a few sea creatures – some of which might have got a little lost along the way (go home freshwater arapaima, you're drunk).

***In cinemas from* May 26.**

READ

The Experience Machine
Book by Andy Clark

Do we really perceive the world as it comes to us, or is the way we see it a kind of "controlled hallucination"? This is what Andy Clark, Professor of Cognitive Philosophy at the University of Sussex, explores in his latest book on the predictive brain. Find out how our minds shape reality, from the way we experience pain to our expectations of experiences.



Available from **May 2.**

SCIENCE IN MEDIA



PLAY



Tetris
Movie from Apple TV+

Okay, you can't actually play this one, but how about we play a game of defying you to watch without bopping along to the world-famous theme tune of "the perfect game"? Starring Taron Egerton, this foray into the dawn of video games tracks Tetris's rise to fame, from the invention of the Gameboy to the Soviet Union's role in gaming history.

Available **now.**

Image Credit Top Row Left: Bloomsbury, *Right*: Disney, *Bottom Row Left*: Allen Lane, Penguin

DATES TO REMEMBER

There are science events, celebrations, and competitions aplenty this May – Star Wars Day aside – including the year's first lunar eclipse and a day dedicated to threatened and endangered species. Plus, there's the chance to win a cash prize for your nature photography and to learn something new, pint in hand, that you can show off to your mates at your next quiz/meet-up.

MAY 5

Penumbral lunar eclipse

The first of two lunar eclipses in 2023 will take place on May 5. The Moon will pass into the faint, outer shadow of the Earth (the penumbra), creating what is known as a penumbral lunar eclipse. Though not as dramatic as a total or partial eclipse, it should be visible (at least in part) for those in Asia, Australia, Africa, Antarctica, most of Europe, and the Pacific, Atlantic, and Indian Oceans, reaching its maximum at 5:22 pm UTC. It's a big day for space fans, as May 5-6 will also see the peak of the Eta Aquarid meteor shower, which will be best viewed in the Southern Hemisphere.





18 Global Accessibility Awareness Day

Now in its 12th year, Global Accessibility Awareness Day (GAAD) strives to "get everyone talking, thinking, and learning about digital access and inclusion", particularly for the more than 1 billion people with disabilities and impairments worldwide. Everyone deserves a first-rate digital experience online, and GAAD aims to make that a reality. Find out how **here**.



19 Endangered Species Day

May 19 marks the 50th anniversary of the Endangered Species Act – a landmark piece of US legislation that established protections for fish, wildlife, plants, and the places they call home. It is also Endangered Species Day, an opportunity to learn about and take action to protect the more than 42,000 species that are currently under threat of extinction, according to the **IUCN**.



21 Nature Photographer of the Year

Nature Photographer of the Year is inviting professional and non-professional photographers, of all ages, from all over the world, to join them in celebrating the beauty of nature in its annual photography contest. Entries close on May 21, so if you fancy a pop at the €3,000 main prize, get your submissions in pronto. You can check out last year's winners **here**.

22-24 Pint of Science

Want to learn more about quantum physics or virology from the comfort of your favorite pub? Then don't miss out on Pint of Science, an international science festival that brings cutting-edge research to your local boozer (or cafe/event space) in fun and accessible ways. Events are happening **worldwide** from May 22-24.



Image Credit Top Left: O'Dea (CC BY-SA 4.0), Top Right: Malenkka/Shutterstock, Middle Right: BeataGFX Shutterstock, Middle Left: Matee Nuserm/Shutterstock, Bottom Right: Oleg Sibiriakov/iStock





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 the adage "trust no one" includes our very own brains. If you like your science lighter, Katy Evans discovers what motivates monkeys when it comes to magic.

TRUST NO ONE

How well can you remember what *just* happened to you? Pretty well, if not perfectly, is probably your response – it was only seconds ago, after all. However, you may want to reconsider your confidence: a study has found that people misremember events within just one or two seconds of them happening, re-shaping their memories to align with their expectations.

Put more simply, or in case you have instantly misremembered everything you just read: we may not be able to trust our short-term memory because our pesky brains love to meddle with it.

IT HAD BEEN ASSUMED OUR PERCEPTION OF THINGS THAT OCCURRED MERE SECONDS AGO IS ACCURATE.

Previous studies have shown that our expectations can influence our perception – this is how we get **perceptual illusions** – and can toy with our memory in the long term, creating **false memories**. But when it comes to short-term memory, it has largely been assumed that our perception of things that occurred mere seconds ago is accurate. That is until this **new study** turned that on its head.

In a series of four experiments, researchers demonstrated that people consistently switch from reliably reporting what was right in front of them just seconds before, to doing so inaccurately, instead reporting what they *expected* to see. They were, nevertheless, extremely confident in their compromised memories, none the wiser that their brains had fallen foul to what the study authors call a "short-term memory illusion".

Participants were presented with normal and mirrored letters, C and Ↄ, for example. Within seconds, errors started creeping into their recollections. Ↄ was misremembered as C far more often than the other way around, suggesting that our "world knowledge" of how letters are usually oriented may be tricking our brains and driving these illusions. The frequency of errors increased over time, indicating this is likely a mishap of memory and not of perception.

All in all, short-term memory may be more duplicitous than anyone knew: in the blink of an eye, it can be reshaped, fooling even itself. Trust no one.

MONKEY MAGIC

Engaging in some monkey magic, scientists have discovered that monkeys are pretty good at sussing out magic tricks performed by human hands – but, curiously, only those primates without opposable thumbs. Monkeys with similar hand anatomy to the human trickster were fooled more easily.

In a delightful **study**, psychologists performed the famous sleight-of-hand trick known as the French Drop on three species of monkey. You've probably seen it: a coin is shown in one hand. The other hand reaches over and the object disappears. You assume the trick is the second hand's hidden thumb secretly gripping the object but the joke's on you, the object never left the first hand.

To motivate the monkeys, tasty treats replaced the coin – peanuts for the capuchins, which have opposable thumbs (they're so dextrous they've **entered the Stone Age**); dried mealworms for the squirrel monkeys, which technically have thumbs but are limited in their movement; and marshmallows for the marmosets, which have five fingers but no thumbs.

The capuchin monkeys were fooled by the trick 81 percent of the time, while the squirrel monkeys were hoodwinked by 93 percent of the tricks. The canny marmosets, however, were misled by the marshmallows just 6 percent of the time.

To test if the trick was based on the monkeys' ability to anticipate the action performed by the hand, itself based on their understanding of how the hand worked, the scientists tested out a new trick they named the "Power drop" that used a full fist grab all the monkeys were capable of. All of the monkeys were fooled most of the time.



"How one's fingers and thumbs move helps to shape the way we think, and the assumptions we make about the world," **explained** senior study author Professor Nicola Clayton.

It raises the idea that people's inherent physical capability influences their perception, memory, and prediction abilities. Either that or it shows that marshmallows are the best motivators.