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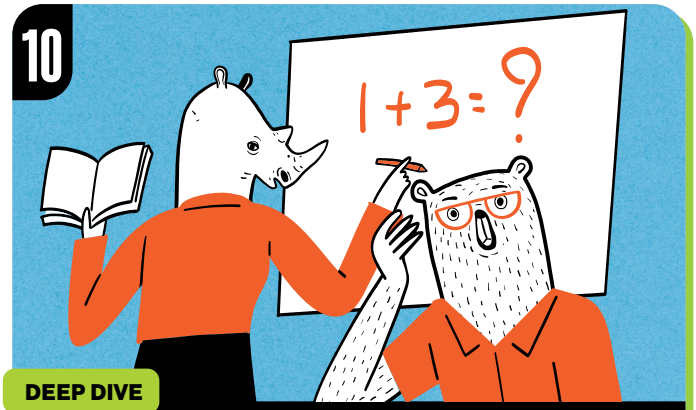

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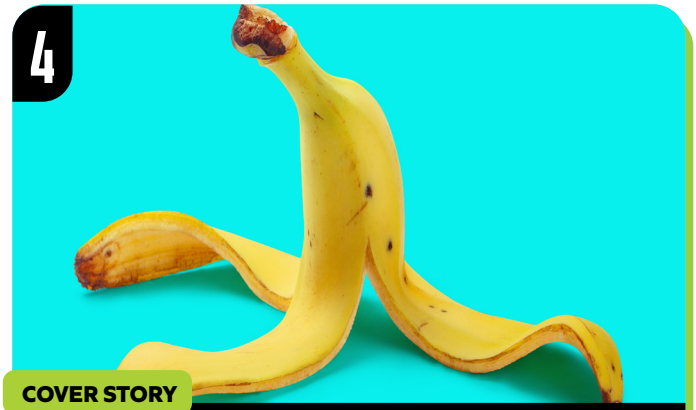

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WHY IS IT SO FUNNY WATCHING PEOPLE FALL OVER?

Why do we laugh so heartily, even at the people we love? Rachael Funnell investigates.

SEPTEMBER 2026

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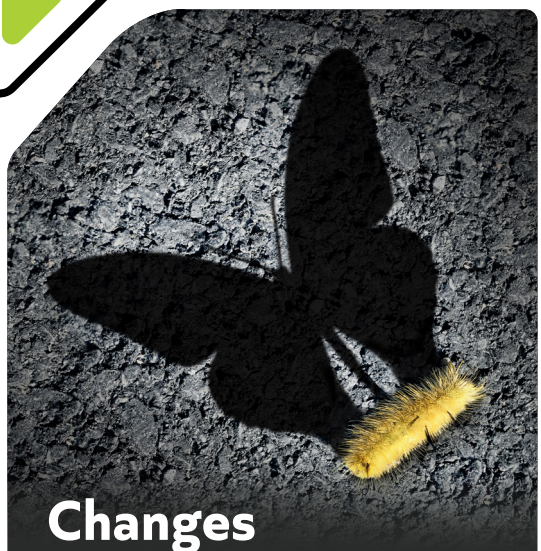
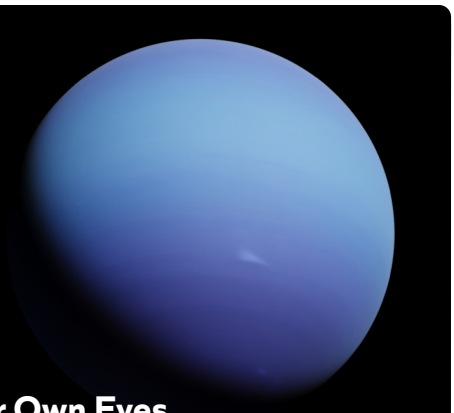


Changes At CURIOUS

After 50 fantastic issues of CURIOUS magazine, some changes are afoot – but don't worry, your favorite features aren't going anywhere; they'll just be appearing in a different format.

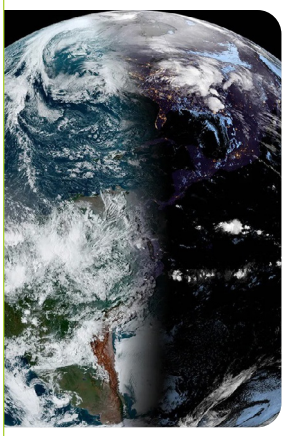
Thanks to the rise of LLMs and AI that crawl the internet, news sites, and digital magazines, repackaging and displaying that content as if it's their own with no benefit to the original content creators, the entire journalism landscape is changing. We rely on dedicated readers like you, paying subscribers who allow us to continue our journalism, create original content, go out and interview experts, and ask the weird and wonderful questions no one else does. Frankly, we need more of you!

Which is why this issue, our 50th, will be the last in this magazine format. Going forward, you will be able to find our monthly Deep Dives, Cover Story (renamed Curious Questions), We Have Questions, and Meet the Author/Book Bites in article format on the IFLScience website under Premium, meaning you, All-Access Members, get exclusive first access, plus four quarterly magazines as a treat. We hope you continue to enjoy all the things that make us CURIOUS!



Spot Neptune With Your Own Eyes

Ready to spot the farthest world in our Solar System? On September 26, Neptune reaches opposition, meaning it appears opposite the Sun in our sky at peak brightness, making it visible all night long. Your best opportunity to see it, however, is the night before when it reaches its highest point in the sky after the Moon sets. You won't be able to see the distant ice giant with your unaided eyes – it's 4.5 billion kilometers (2.8 million miles) away, after all – but a telescope can reveal its tiny, striking blue-green disk. It's not often you get a chance to see a world at the very edge of our planetary neighborhood.

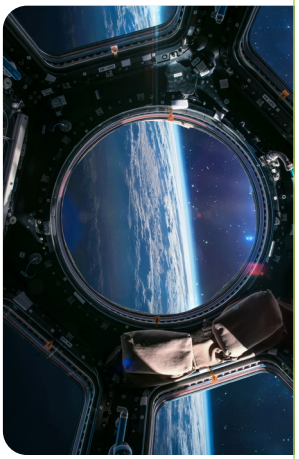


Fall Equinox

On September 23, fall officially arrives in the Northern Hemisphere – astronomically speaking. The autumn equinox marks the moment when the Sun crosses the celestial equator, moving from north to south. Earth's tilted axis means neither hemisphere is pointed towards the Sun, bringing roughly equal amounts of daylight and darkness across the planet. But there's a twist: despite its name, the equinox doesn't actually give us exactly 12 hours of day and 12 hours of night. While sunrise and sunset are defined by the edge of the Sun being visible, Earth's atmosphere bends sunlight, meaning we can still see the Sun (and its light) even when it's below the horizon.

NASA TV

NASA has expanded the platforms you can stream NASA+ on to include Amazon Fire TV, discovery+, and HBO Max. That means you can now tune in to watch live feeds from the International Space Station (ISS), spacewalks, mission controls, and even rocket launches in real-time from your living room. Not that you couldn't before – NASA+ remains free via NASA.gov, the NASA app, and YouTube – but now you can add it to your watch list on your preferred streaming platform too, with schedules dropping before event days so you can grab friends and snacks for watch parties. Future potential viewing events include Artemis III's test flight rendezvous and docking with human landing systems and the first crewed mission to the Moon.



Get Starstruck

If you've ever wanted to travel among the stars but being an astronaut is not on the cards, perhaps this might be the next best thing: ***Smithsonian Starstruck: An Immersive Experience***. The new virtual immersive experience developed in collaboration with the Smithsonian Astrophysical Observatory (SAO) allows you to travel into the depths of a black hole and witness the births and deaths of stars. Built entirely from real scientific data from SAO, NASA, and ESA, it uses the Hubble, JWST, and Chandra telescopes to reveal the cosmos in visible, infrared, and X-ray light. Open from now until the end of September 2026 simultaneously in Washington, DC, Denver, San Antonio, and Orlando in the US, as well as London and Manchester in the UK, Melbourne, Australia, and São Paulo, Brazil, find out more **here.** IFLScience visited the London experience at the Science Museum and chatted with both the creators and astronauts; **read about and watch it here.**

Blue Planet Is Back

The BBC's iconic *Blue Planet,* the first to give a comprehensive overview of Earth's oceans, was first broadcast 25 years ago. This autumn it's back for series three, but with camera technology and scientific knowledge a quarter of a century more sophisticated, expect to explore extraordinary new depths, discovering ecosystems and species previously impossible to film. At 100 years young, Sir David Attenborough is back narrating the six-part *Blue Planet III,* which means we are in store for awe and wonder but also a realistic look at the pressures the world's oceans are under from humans, along with stories of hope and recovery.

WHAT'S UP?

ε-PERSEIDS

The Perseids you've never heard of.

Name: Epsilon Perseids
Appearance: Glittering shooting stars streaking across the night sky
Location: The upper atmosphere as the debris burns up on entry

What are we looking at here?

The Epsilon Perseids are a meteor shower that is active between September 5-21, peaking at around 8 am EDT on September 9. At this point, you should be able to expect up to 5 meteors per hour flashing across the sky. So look up!

But… haven't we already had the Perseids meteor shower?

Yeah, you're not wrong. Rather confusingly, this is not the same one. The more well-known Perseids are active between July and August, and are often the highlight of any meteor hunter's calendar. The *Epsilon* Perseids, on the other hand, are less well-known and typically peak in September.

OK, so why are they called the same thing then, this is silly.

It's because they are named after the constellation from which the meteors appear to originate. The main Perseids are caused by the debris of a comet called 109P/Swift-Tuttle that comes from the general direction of the Perseus constellation. While the material that causes the Epsilon Perseids arrives from the same general area of the night sky, we don't actually know exactly what object it comes from, although scientists think it originates in the Oort cloud.

The *what* cloud?

Hmm yes. The Oort cloud is the most distant region in our Solar System. It is thought to form a spherical, shell-like structure around the Sun, planets, and Kuiper Belt, and is made up of icy, comet-like objects.

So, just how distant are we talking?

You might want to sit down for this one. First of all, we need to understand what an astronomical unit, or AU, is. This is the distance between the Earth and the Sun, about 150 million kilometers (93 million miles). Pluto's orbit puts it between 30 and 50 AU from the Sun. This is where things get staggeringly big. The Oort cloud is thought to start anywhere between 2,000 and 5,000 AU away and extends for maybe between 10,000 and 100,000 AU from the Sun. It is unimaginably vast.

Oh wow. Yes, OK, that is vast.

So when you look up at the Epsilon Perseids, just think how far that material has traveled. And maybe try not to have an existential breakdown in the process.

WHY IS IT SO FUNNY WATCHING PEOPLE FALL OVER?

We've all done it, so let's get to the bottom of why we laugh so heartily, even at the people we love.

By Rachael Funnell

Image Credit: Yeti studio/Shutterstock.com

You've laughed at someone falling over.

It's OK, you can admit it. This is a safe space. The panicked overcorrection. The sprawling limbs. The sounds – nay! – the faces! It really can force a laugh out of you even on the darkest of days.

Provided you're not doing it in lieu of providing aid – and not at times when someone is (seriously) hurt – it seems an innocent enough behavior. It's also a kind of perplexing one.

It's one thing to revel in a foe receiving just comeuppance (we even have a name for it – more on that later), but the funniness of falling is so non-specific. It can be a stranger in a video. An entirely different species. Or even, indeed, your dear old mum.

So, are we monsters? Or is there something else that can explain why a small slip can elicit such a big laugh?

These were the questions I started asking myself last month. If ever there were an excuse to watch videos of people falling and call it work, I thought to myself, surely this was it. So, join me as I go in search of an answer to this most human of reactions.

Are we sinners, sadists, or just silly?

There's a known phenomenon in which we derive pleasure from the downfall of others. It's called schadenfreude, and there are a few predictors that can prime us to revel in others' misery.

The strongest among them, says schadenfreude expert **Dr Keegan Greenier,** is a disliking of the target. In that situation there's a sense that they are deserving of what's happened to them.

"Think of seeing a super-speeder on the interstate getting pulled over and ticketed," Greenier, a professor of psychology at Mercer University, told IFLScience.

Studies have also looked into schadenfreude in the context of people we perceive to be undeserving of the high status they have. Greenier offers the example of someone who worked hard for their money, versus another who had inherited it, aka the nepo baby effect.

Envy has also been explored as a source of schadenfreude, though there are mixed findings on its significance. What we know with some confidence is that if you don't like someone, and you believe they had it coming to them, there's a decent chance you'll be smirking if something bad should befall them.

> "WE'D LIKE THE SPEEDER TO GET A TICKET (SCHADENFREUDE), WE DON'T WANT HIM TO DIE IN A FIERY CRASH (SADISM)."

But how extreme does this go? If I have beef with the local lollypop lady (crossing guard in the US) and believe she has halted my progress one time too many – is it just a cheeky bit of schadenfreude for me to titter at the news she had been mown down by a milk float?

No. That would just make me a terrible person.

"Schadenfreude tends to be a mild emotion; it is not sadism," said Greenier. "We'd like the speeder to get a ticket (schadenfreude), we don't want him to die in a fiery crash (sadism)."

So, what if we dial it down a little?

My lollypop lady isn't the victim of a hit-and-run, just a brief slip on a banana skin that causes her to pull a funny face, make a funny noise. They might not admit it, but a lot of people might laugh at that. The thing is, the explanation is unlikely to be schadenfreude. Why?

Because everybody loves lollypop ladies.

"You specifically mentioned 'seeing people falling over,' and I'm wondering if schadenfreude is even at play here," Greenier said to me. "We generally don't have pre-established disliking of the target, although in some (but definitely not all) cases deservingness may be in play if the person was behaving stupidly and fell down."

Since I've already come for the lollypop ladies, now seems like a good moment to sacrifice my reputation further by telling a little anecdote. The year is 2007 and my best friend is performing a choreographed dance in front of the entire class. At the song's climax, she trips on the chair she was supposed to be gracefully carried over.

Her legs flail in mid-air like a frog that's forgotten how to land. To her credit, she continues on, red-faced and silent as she suppresses her own laughter.

I, on the other hand, am sprawled across the floor clutching my sides. To this day I'm not sure I've ever laughed so much.

I love that friend still (even if she may hate me now for bringing this up in print). So, what would compel me to find her downfall so funny? It seems it may come down to one of the most fundamental aspects of humor: surprise.

Why so serious?

Humor has become hugely important to the modern-day human. Studies have shown how **humor can build resilience** in unprecedented times, from the Wipers Times satirical newspaper of World War One to the weird shit we were all doing during COVID-19 lockdowns (did you also see the person who made an art gallery for their hamster? Loved that).

It figures, then, that we fill our lives with funny, and perhaps one of the most famous faces in the genre is that of Homer Simpson. Not a real person, of course, but a man we've heard say "Doh!" on *The Simpsons* thousands of times.

> "HUMANS ARE VISUAL CREATURES, AND OUR FIRST REACTION TO SOMETHING UNEXPECTED IS PEEK-A-BOO. VISUAL HUMOR LIKE SLAPSTICK TRANSCENDS CULTURAL AND DEVELOPMENTAL BOUNDARIES."

He is the king of calamity. The face of epic fail. You would think the formula would get tiresome, and yet across its 37 seasons, the show has topped 800 episodes. What keeps us coming back for more?

It could well be the same thing that makes it so damn hilarious when your friend, out of nowhere, falls flat on their face.

"Surprise," said comedy expert **Dr Mark Shatz** of Ohio University to IFLScience. "For most humor, the unexpected triggers laughter."

"Humans are visual creatures, and our first reaction to something unexpected is peek-a-boo. Visual humor like slapstick transcends cultural and developmental boundaries."

Peek-a-bottom

Much of our comprehension of humor comes down to the violation of an expected sequence of events. So, some kind of rule sets up your expectation, but a punchline or event shatters it. The "aha!" moment of figuring it out brings us joy, and then we can decide just how funny we think it was (how did you rate "peek-a-bottom"?).

> "WITHOUT HUMOR, OUR SPIRITS WOULD NOT SURVIVE DAILY LIFE. HUMOR IS ESSENTIAL TO COPING AND LIVING. IT'S OUR SPECIES' SUPERPOWER."

In the context of falling, this could be that I expected my friend to pull off her dance routine. The style of that dance led me to expect she would glide gracefully over the chair, and the thrashing of her legs violated this expectation.

I figured out that this surprising turn of events was caused by her placing a foot wrong, and my brain's reward center decided this was very, very funny.

This cascade of cognition is known as incongruity-resolution theory, and studies have tried to disentangle the process. A **2023** paper found it unfolds in four stages – expectation, incongruity, resolution, elaboration – and that each stage shows activity in different parts of the brain.

Those four stages also reinforce why it's possible to understand a joke without finding it funny. You make your predictions, recognize they were violated, and figure out the joke, but actually laughing requires an extra step in the brain regions associated with emotion and reward.

This also taps into why we don't laugh if someone falls and actually hurts themselves. That extra step gives us time to contextualize the violation, and it only tickles our funny centers if we know everybody got out relatively unscathed.

Falling into the academic's trap

As scientists we love to ask questions, and perhaps a big one here is why laugh at all? Humor doesn't help us to find shelter. We can't catch that bison with a killer punchline, but this **near-unique** trait has become an ingrained part of our species.

As a self-described "professional freak", humorist, and thanatologist (Thanatos, the Greek god of death, not the Marvel chap), Shatz says the importance of comedy rests in what it can enable us to endure.

"I teach death, dying, and grief," he said. "I'm always asked about the link between humor and death: perspective."

"Death is life's big dope, while humor is our daily coping mechanism. Both provide perspective."

"Life is hard, and often it sucks. Royally sucks. Without humor, our spirits would not survive daily life. Humor is essential to coping and living. It's our species' superpower."

And as for wading into the minutiae of why we find the things we find funny so funny, perhaps the bigger question is why ask at all? In the wise words of **E. B. White:** "Analyzing humor is like dissecting a frog. Few people are interested and the frog dies of it."

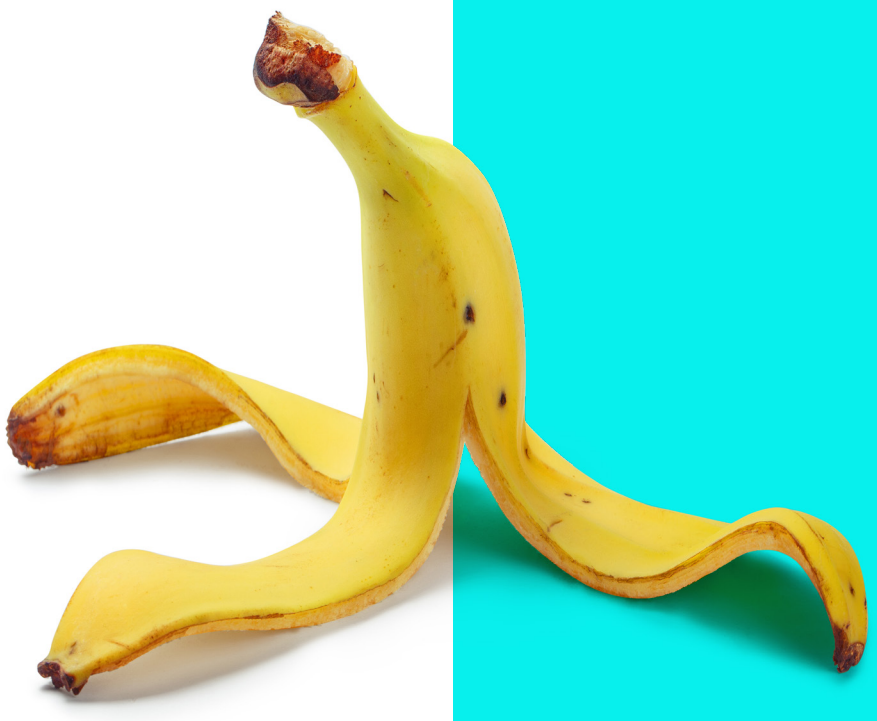


Image Credit: Yeti studio/Shutterstock.com

A WINDOW TO THE SKELETON

How is it possible to see an animal's skeleton without first removing its muscles? Welcome to the curious world of diaphonization. This anatomical preservation technique turns a creature's soft tissues transparent using enzymes, while its bones and collagen are stained using Alizarin red and Alcian blue, respectively. The end result is a window to skeletal anatomy in-situ, no dissection required.

Image Credit: Wanessa_p/Shutterstock.com

WHAT'S IT LIKE GETTING STUCK IN ANTARCTICA?

And you thought your lockdown experience was surreal.

Q&A

By Tom Hale

Few people can say they had a stranger COVID lockdown than **David Knoff**. An expedition leader with the Australian Antarctic Program, Knoff was working at the Davis Station in Antarctica with his team of 24 when the pandemic struck.

Knoff had previously served in the Australian Army as an infantry officer before joining the Department of Foreign Affairs and Trade, where he spent roughly a decade working as a diplomat in conflict zones. These experiences would serve him well, although nothing could have fully prepared him for what unfolded in 2020. As international travel ground to a halt, he and his team found themselves effectively stranded in the Antarctic indefinitely.

The trip lasted a total of 537 days, making it one of the longest continuous Antarctic expeditions in recent years. Fortunately, they made it back safely, with a bunch of fascinating stories about life in the most extreme place on Earth at a very odd time in history.

And yes, they also resorted to baking sourdough bread in a desperate bid to maintain some sanity.

What was it like being in Antarctica when COVID struck?

DK: I went down in 2019 on a one-year trip, but as the pandemic broke out and a whole range of operational and logistical challenges came up, the team and I were kind of "compulsorily extended" for an additional six months and faced a lot of uncertainty. We ended up spending just shy of 18 months down there in one of the longest continuous trips in recent times.

When did you know it was serious?

DK: I remember it well. It actually happened just after midwinter's day in 2020, so June 23.

We'd been there for nearly eight or nine months; it was around two-thirds of the way through our expected year in Antarctica. We knew about the pandemic and we knew it had had an impact on flights, shipping, and a few other things. But at that point, we still thought we'd go home as planned.

But on June 23, 2020, we got the call that said: "Hey, by the way, we actually don't have a ship, we don't have flights that can get to you in time. And logistically, the best and safest decision is to leave you guys there indefinitely while we work it out."

Did you know what was going on elsewhere in the world?

DK: Yeah, we had internet. It wasn't as good as it is now. I think the implementation of Starlink and things in the last couple of years has really helped Antarctic internet. So, it was a little bit patchy back then.

Our biggest challenge was understanding who to believe or which version of COVID was the reality.

We had team members from all across Australia and a number of New Zealanders. They're talking to their friends and family back home and everyone's getting different stories or different versions, for example, from Melbourne, which ended up being one of the most locked-down cities in the world.

But then there were a number of families from regional areas of Australia and New Zealand, working the farm. They're working as normal and they're just going, "Oh, well, I can't go to Bali, but life's normal here."

How did you keep your cool? Start baking sourdough bread?

DK: Yeah, well, we do all that anyway! As soon as the pandemic broke out, they started asking us on the Antarctic stations, "How do you deal with it? What do you do?", and you're like, "Yeah, we bake sourdough, we make kombucha, we get in the kitchen and help the chef."

Your main role and job become so routine, and you become so competent that you're doing that on autopilot; you then start to seek all these other aspects to stimulate your mind and have some creativity. Indoor games, getting outside, and doing TED Talks with each other.

We do that on the Antarctic stations all the time anyway, and it's actually some of the best elements of the community down there that I always love.

Any concerns about the virus?

DK: No, not near us. Antarctica is so big; it's bigger than the continental US or Australia, and the stations are so far apart that it's not really an issue.

When it broke out, we started to implement a lot stricter quarantine requirements. But we have those restrictions for Antarctica anyway. They're quite aware of the fact that in isolated communities, you don't ever want to introduce flus and bugs. It takes two weeks to get there on the ship, so you get a natural quarantine.

What was it like returning home?

DK: It was tough. We left in October 2019 and got back in April 2021, so we time-travelled from pre-pandemic to right in the thick of it in mid-2021.

The hardest one for us was when we got home and had to go through airports to get back to our home cities. When we got to those locations, we didn't know what to do. I didn't have that [COVID safe check-in] app, and I didn't know what to do.

You'd often get a response where people look at you like, "oh my God, you're an anti-vaxxer objectivist," and you go, "I've been in Antarctica for a year." They're like, "bullshit!"

When I got home, I did not want to see anyone. I didn't want to do anything. I wanted to just sit at home and just do nothing for like a week, which was counter to what everyone expected.

Did your previous work in warzones prepare you for this time?

DK: Absolutely. In terms of management strategies, you really spend the start of every day or every moment, every meeting, every kind of decision, looking out the window. Now, in Antarctica, that's looking out the window at the weather.

We start everything with a weather brief. You can't decide what you're doing for the day until you've really considered what the weather conditions are.

In Antarctica, it's not uncommon to have category 3 cyclonic winds just on a Tuesday afternoon. You'll have 100+ kilometers an hour winds quite routinely, so you have to work out what you can actually achieve.

You might have your strategy and your plan, but the more you try and just force your plan into a location or conditions that don't suit – if you're not attuned to that – you're going to flog a dead horse and go nowhere.

We have Questions with IFLSCIENCE

Hungry for more CURIOUS questions? Head to the ***We Have Questions*** podcast for full length audio versions of this column.

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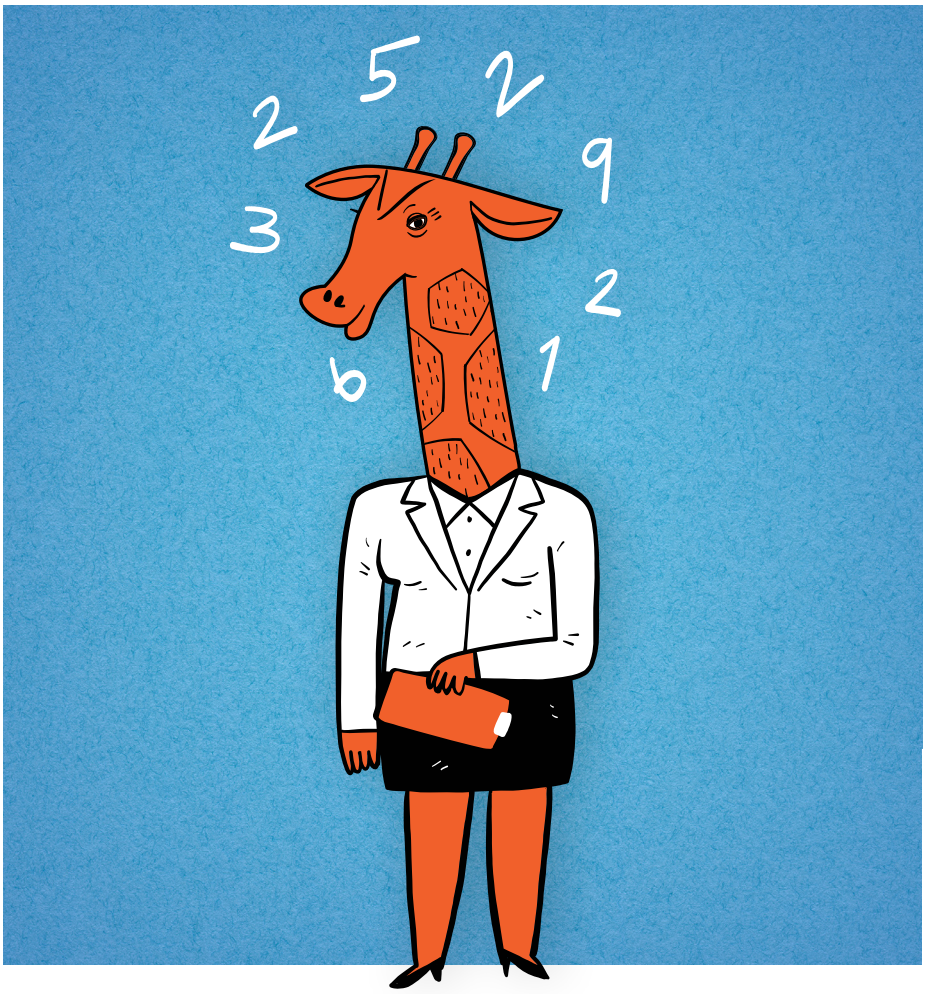
DEEP DIVE

SCIENCE FACT OR FICTION:

CAN ANIMALS COUNT?

The cast of characters that can count is extensive, Dr Katie Spalding discovers, but we humans still have the edge.

Image Credit: Huza Studio/Shutterstock.com, Modified by IFLScience



As Teen Talk Barbie once infamously declared: math class is tough.

It's meant to be, in fact. Math, despite its eminent real-world applicability, is a highly abstract discipline. We chase universal laws, free from any ties to physical limitations; we generalize, theorize, and find incontrovertible proofs.

Even at its most basic, it's a subject that requires the ability to conceptualize things that don't truly exist: that the numeral "3" is somehow connected to a certain physical quantity, that by adding another "1", you can – and always will – obtain a "4", which refers to another, slightly larger quantity. It's all far more complex than we give the toddlers learning it credit for.

And yet, we persist. We struggle. We win out. And why? Because math, and the high-level abstract thinking it requires, makes us unique. It's what separates us from the rest of the animal kingdom. It cuts to the very heart of what makes us human.

… doesn't it?

Mathematical animals

Far from being a talent unique to humans, "numerical abilities have now been demonstrated in a surprisingly large number of species," says **Andreas Nieder,** Chair in Animal Physiology at the University of Tübingen, "including mammals, birds, fish, amphibians, reptiles, and insects and spiders."

The culprits may surprise you. Sure, perhaps you'd expect, say, a chimp to be able to count to five – and in fact, they can do much better than that, with individuals having proven themselves capable of describing the color, number, and type of object presented to them not only physically but through the use of Arabic numerals, the same way you or I might. But what about… a giraffe?

Naively, you might think these long-necked wanderers would be at a disadvantage, cognitively speaking. With an encephalization quotient (EQ) of just 0.64 – for reference, that's about half of a dog's, and one-twelfth of a human's – giraffes' brains are, let's say, not large. They're not even particularly close to the average, considering the animals' size.

But, somehow, they make it work. "These animals have proven to be very good with numbers," **Iker Loidi,** a graduate student in clinical psychology and psychobiology at the University of Barcelona, said of his four giraffe participants in a study published this June.

"Not only are they able to tell which of two options offers them more food, but we have shown that they are capable of combining mental representations to determine which option offers them more food following this manipulation."

> "I FIND THE NUMERICAL ABILITIES OF BIRDS PARTICULARLY FASCINATING, BECAUSE ANIMALS WITH VERY DIFFERENT BRAINS FROM OURS CAN NEVERTHELESS SHOW QUITE SOPHISTICATED NUMERICAL BEHAVIOR."

"In less technical terms," he explained in **a video** released alongside the study, "we would say that giraffes are capable of adding."

It's not, in fact, the first mathematical ability shown by the species. Given the right motivation – that is, lots of tasty carrots – they can also perform rudimentary statistical analysis, reliably choosing only snack boxes with proportionally more of their favorite.

And they're far from alone. "Chimpanzees can make probability judgments based on several proportional ratios," points out **one paper,** published in January last year, while "long-tail macaques can infer simple heuristics, capuchin monkeys can make probabilistic

inferences, baboons can learn spatial statistical contingencies, and rhesus monkeys can learn to categorize different directions of motion in random dots displays."

It gets weirder. Zebrafish – those tiny, stripy swimmers, barely a couple of inches long, with brains less than one-tenth the size of a single aspirin tablet – can also count, and with an ability more or less on par with that of bigger, smarter animals like crows or bears (yes, **bears can count** too). Chickens, at three days old, **can recognize** which of two quantities is larger even after addition and subtraction.

"I find the numerical abilities of birds particularly fascinating, because animals with very different brains from ours can nevertheless show quite sophisticated numerical behavior," Nieder tells IFLScience.

"But perhaps the most pleasing example is the bee," he adds. "Despite having a tiny brain, it can learn to distinguish quantities and even perform very simple arithmetic-like operations, which tells us that sophisticated behavior does not necessarily require a large brain."

Convergences in evolution

Present in bees, bears, and blue whales, numerical ability is potentially more the norm than an exception in the animal kingdom. "Although we cannot yet put a precise number on all species with such abilities[,] I would say that some form of numerical competence is probably quite common in cognitively advanced animal species," says Nieder. "Animals constantly have to make decisions about quantities."

It's not just food, at least, not outside of the lab. Sure, it's beneficial for an animal to be able to see one banana on one tree and four bananas on another and understand which option will leave them feeling fuller – but it's just as important for survival to be able to see how many predators you're looking at, or whether all your kids are still behind you.

"These decisions can affect survival and reproduction," Nieder explains, so "natural selection can favor brains that are sensitive to numerical information."

It makes sense then that so many species

might have some kind of mathematical sense – even if it might leave us feeling a little less, well, special. After all, if **the poppyseed-sized brain of a bee can** understand numerals and the concept of zero, perform simple addition and subtraction, and conjure an imaginary left-to-right number line, then what's so impressive about ours?

Take one of the most extreme examples: the Tunisian desert ant. Not only can these little guys count, but they're **accomplished geometers** as well. Foraging for food in the windswept sand dunes of their home, they have to be. The ants can rely on neither landmarks nor scent to find their way back to the nest, and so they've learned to count steps, construct mental maps of the routes they've traversed, and combine both to work out the most direct way home.

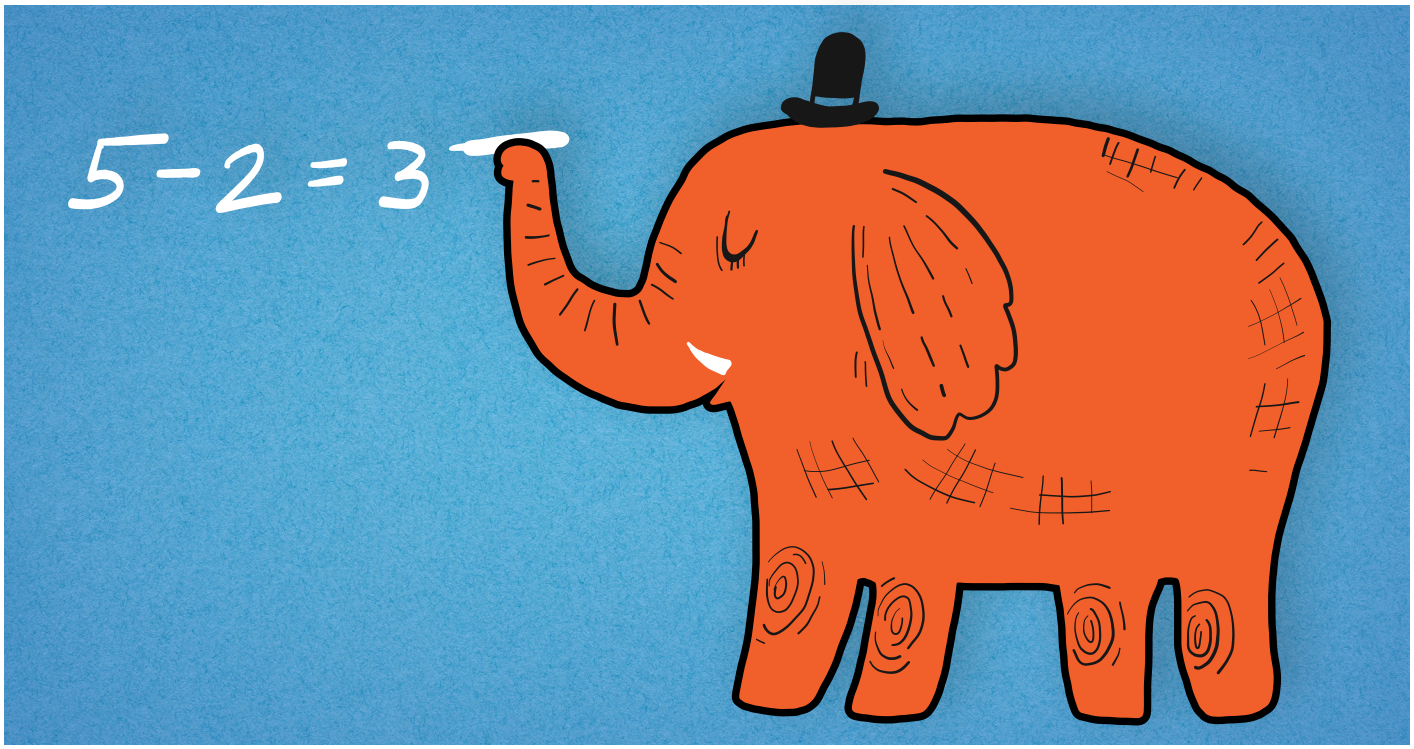
All that with a brain so tiny and structurally different from ours that you'd be forgiven for not recognizing it as a brain at all. But "the important point is that there is no single brain structure that evolution has designated as the 'mathematics center' throughout the animal kingdom," Nieder says. "Different animals can solve numerical problems using quite different neural architectures."

"In primates, areas of the frontal and parietal cortex are particularly important, whereas in animals such as birds an independently evolved telenephalic area called 'nidopallium caudolaterale' is particularly relevant," he explains. "In fish and other animals it is less clear where exactly the number areas are located."

But while the exact "location" of mathematical thinking may change throughout the animal kingdom, there is a common denominator.

"What unites these brain structures is that they are highly integrating association brain areas,"

Image Credit: Huza Studio/Shutterstock.com, Modified by IFLScience



Nieder points out. That is, those places that can receive and combine information from multiple senses all at once. It has to be that way, Nieder explains, because math works independent of physical input: "Whether it is three sounds, flashes, or touches, it is always the 'threeness' that is important and the brain has to be able [to] abstract this sensory information."

Fundamentals of abstraction

Let's address the elephant – another species that **can count** – in the room. It's likely clear by now that, when we talk about non-human animals "doing math", we're not imagining them solving algebraic formulae or taking asymptotic limits. "It is better to think of it as an evolved sense of number and quantity rather than mathematics in the human sense," says Nieder.

"Animal 'mathematics' is usually much more basic, and non-symbolic," he explains. "An animal may distinguish between two and three objects, estimate which of two groups is larger, or keep track of a small number of individuals."

It's simple, sure – but it's still evidence of mathematical ability. And for some species, it's actually better than at least that of very young humans.

"Some animals can also perform surprisingly sophisticated operations, such as adding or subtracting small quantities, or processing quantities according to abstract rules, such as greater-than/larger than," Nieder points out – skills like those shown by giraffes and chickens – even if none of the symbolic or formal dressing we humans like to use is present.

There's no denying that, with our huge brains and wildly overdeveloped prefrontal cortexes, humans certainly have the advantage when it comes to mathematical ability. We can imagine numbers far too vast to ever see in real life; we can extend binary operations well past addition and subtraction; we can do away with numbers entirely, and work only in the abstract world of fiber bundles and n-dimensional manifolds. Such manipulations are far beyond the abilities of even our closest non-human cousins.

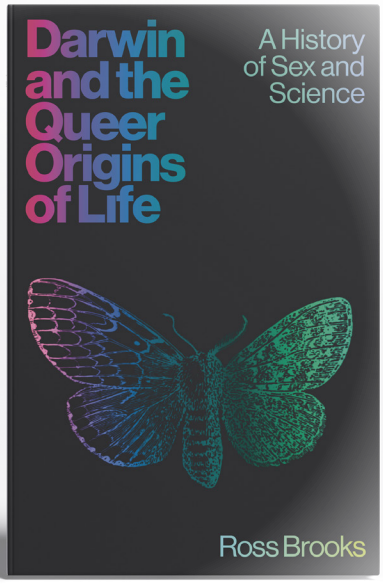
But a monopoly on math, we certainly do not have. "Symbolic numbers [are] a uniquely human capability," says Nieder. "[But] numerical competence is a cognitive function that can be implemented in multiple ways, rather than something that depends on having a primate-like brain."

From the humblest insect and the biggest elephant, to dolphins under the sea and birds in the sky, it's clear that numbers – or at the very least, numerousness – are understood by a far greater range of species than we've traditionally assumed.

It's so universal, in fact, that some experts consider math to be our best bet for chatting with aliens: if a bumblebee can understand counting, the logic goes, then why shouldn't an extraterrestrial?

"If there are extraterrestrial species, and they have sufficiently sophisticated brains, then our work suggests that they may have the capacity to do mathematics," wrote Monash University researchers Scarlett Howard, Adrian Dyer, and Andrew Greentree, in a Conversation article **back in January.** "A further question to be answered is whether different species will develop different approaches to mathematics, akin to dialects in language."

"Such discoveries would also help to answer the question of whether mathematics is an entirely human construction, or if it is a consequence of intelligence and thus, universal."



"HOW FACTS DO BEAT THE WILDEST IMAGINATION!"

In this excerpt from *Darwin and the Queer Origins of Life: A History of Sex and Science,* Dr Ross Brooks reveals how Darwin's curiosity about sex variance underscored his conviction that "no character appears to be absolutely fixed".

On 17 March 1863, Darwin wrote to [Sir Joseph Dalton] Hooker: 'I have been writing during last fortnight on this subject, i.e., on reversions to particular characters, & have got curious collection of facts & experiments.' This curious collection strengthened Darwin's commitment to the principle 'that a crowd of characters lie latent in every living creature & parent'. On 26 March, Darwin again wrote to Hooker, telling him, 'this view of latency collects a lot of facts', these facts including 'both secondary sexual character in each individual'. He continued: 'When one thinks of a latent character being handed down hidden for a thousand or ten-thousand generations & then suddenly appearing, one is quite bewildered at the host of characters written in invisible ink on the germ.' Hooker responded amusingly, 'it is a subject on which I have a huge latent interest'.

Having set out what he viewed as a sketch of his evolutionism in *On the Origin of Species,* Darwin set to work on a more expansive exposition. He had a significant amount of unpublished text but nonetheless pressed ahead with numerous researches, writing and copious correspondence. As he did so, he became ever more aware of sex-variant phenomena in the natural world, new descriptions of which, as we've seen, continued to be made apace through the middle decades of the nineteenth century. A North American correspondent, anatomist Jeffries Wyman, told him how males of some species of the catfish family Siluridae in Guiana stored eggs and young in their mouths – a significant discovery of male parenting.

Mouthbrooding (oral or buccal incubation) has evolved independently several times in diverse groups of fish. Parents carry eggs and fry in their mouths, protecting them from predation and parasites. Surprisingly few references to the phenomenon are found in earlier natural history literature, although it was known that female soldier catfishes carried eggs in their mouths. Wyman's observation of male mouthbrooding was a first and generated much excitement. He discussed it at a meeting of the Boston Society of Natural History in September 1857 and in the American Journal of Science and Arts in 1859. When he told Darwin about it in December 1860, Darwin was palpably gobsmacked. 'You cannot tell how much your paper on Gestation has interested me', he wrote, adding: 'How facts do beat the wildest imagination!'

Numerous other observations about sex variance in nature continued to trigger Darwin's instinctive curiosity about their evolution, especially as his attention turned more intently to domestic breeding. The analogy between the selective practices of animal breeders and his theory of natural selection was central to his method; indeed, it's how he introduces the theory in *Origin*. He now undertook a major appraisal of the subject, eventually published in two volumes as *The Variation of Animals and Plants under Domestication* in January 1868. The work repeatedly emphasises the plasticity of plants and animals under artificial selection, underscoring Darwin's conviction that 'no character appears to be absolutely fixed'.

His interest and painstaking experiments in domestic breeding spanned a wide range of plant and animal species. Birds, however, prompted the most concerted development in his biological sexology, much as they had during the late 1830s when his evolutionism took shape. In 1855, William Yarrell persuaded him to breed fancy pigeons. Having installed a pigeon house in the garden at Down House (now gone), Darwin pursued life as a pigeon fancier with characteristic gusto and scientific curiosity, immersing himself in the often gruesome world of domestic breeding. He joined two London pigeon clubs, attended poultry and pigeon shows, engrossed himself in the extensive literature and corresponded with leading fanciers who provided him with key information, skins and skeletons.

Q&A WITH

DR ROSS BROOKS

AUTHOR OF:

DARWIN AND THE QUEER ORIGINS OF LIFE

Just how queer is the natural world, and when did scientists start exploring this? Dr Ross Brooks takes us through the extraordinary history of queer natural history, showing that Darwin's evolutionary theories were very much queer, even back when they were written.

What inspired you to write *Darwin and the Queer Origins of Life?*

I was primarily inspired by the growing number of books about queerness in nature, beginning with Bruce Bagemihl's *Biological Exuberance* and Joan Roughgarden's *Evolution's Rainbow*, and then more recently Eliot Schrefer's *Queer Ducks (And Other Animals)* and *A Little Gay Natural History* by IFLScience's fabulous Josh Luke Davis.

There was nothing like this when I was growing up gay in the 1970s and '80s, and indeed we were told that being queer was "unnatural", even "against nature". I wanted to better understand how and why something so ubiquitous as nature's queerness could have been so poorly recognised, and even denied, for so long.

That question eventually led me back to university in my mid-30s, and ultimately to a PhD. It was a 15-year adventure, constantly full of surprises that transformed the way I think about nature and how science is done (and, sometimes, not done). I wanted to share that journey, and the opportunities it opened up.

What was one of the most surprising things you discovered while researching it?

The greater surprise was English suffragist and botanist Lydia Ernestine Becker. In his writings, Darwin was reticent to extend his ideas about sexual diversity in nature to humans, despite his insistence on animal-human continuity. Becker, who read Darwin's works and corresponded with him, had no such qualms. In a controversial lecture in 1868, she argued that "the attribute of sex does not extend to mind".

She pointed to female plants being as vigorous as males, queen bees ruling their hives, and female eagles and sparrowhawks being larger than males. Turning to humans, she stated that many women secretly worked in jobs regarded as exclusively male. As an example, she referred to Mary Walker, who lived as a man while working variously as a stoker on a Cunard ship, a porter on the Great Western Railway, a barman and a sailor.

Becker concluded that human minds could not be neatly divided into female and male in any scientifically meaningful way. Instead, she proposed that there were "numerous intermediate varieties" between what society regarded as masculine and feminine minds, regardless of a person's genital sex. It was a tour de force of inclusive, science-based feminism that was largely forgotten, but which some people today could learn much from.

How exactly are Darwin's theories queer?

Darwin's theories can be considered queer because his observations and ideas implicitly unsettled supposedly fixed categories of sexual characteristics, reproduction and sexual behaviour. Indeed, he believed that "[e]very animal surely is hermaphrodite". Even in its 19th-century meaning as strange or anomalous, the term "queer" was applied to Darwin's ideas about sexual evolution.

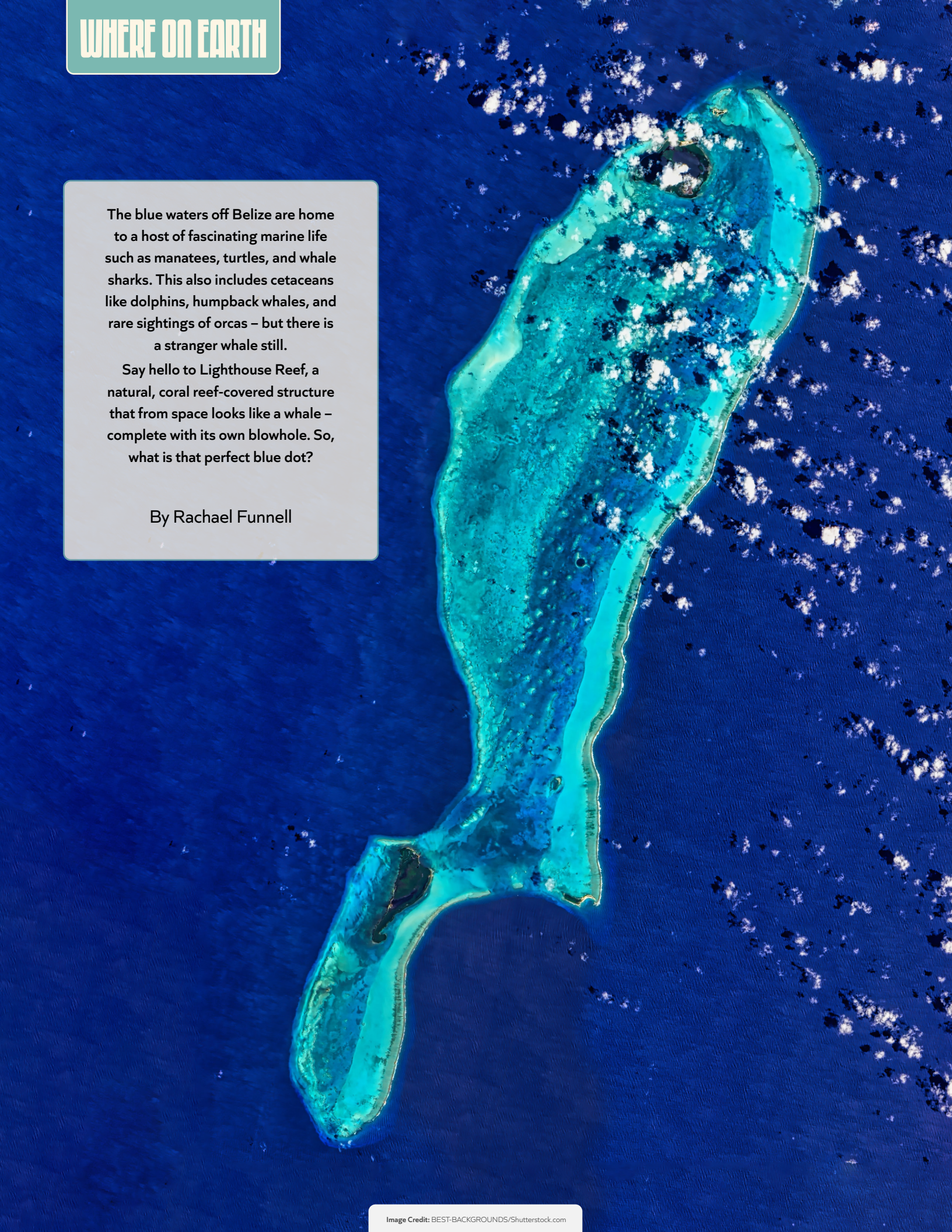
What is the one thing you'd want people to take away from the book?

I hope that readers will fall in love with queer approaches to the life sciences, and the queer history of science. Art and literature have rich queer histories and have long formed part of LGBTQ+ cultures, even though both have had their queerphobic aspects. Science is such a huge part of the human experience, touching our lives in so many different ways. There's no good reason at all why LGBTQ+ people should be excluded from science, or why science should be excluded from queer life and culture. I therefore hope *Queer Origins* will go some way towards building better relationships between science and queer communities.

***Darwin And The Queer Origins Of Life* is published by Yale University Press and is available now.**

Image Credit: Dr Ross Brooks

WHERE ON EARTH

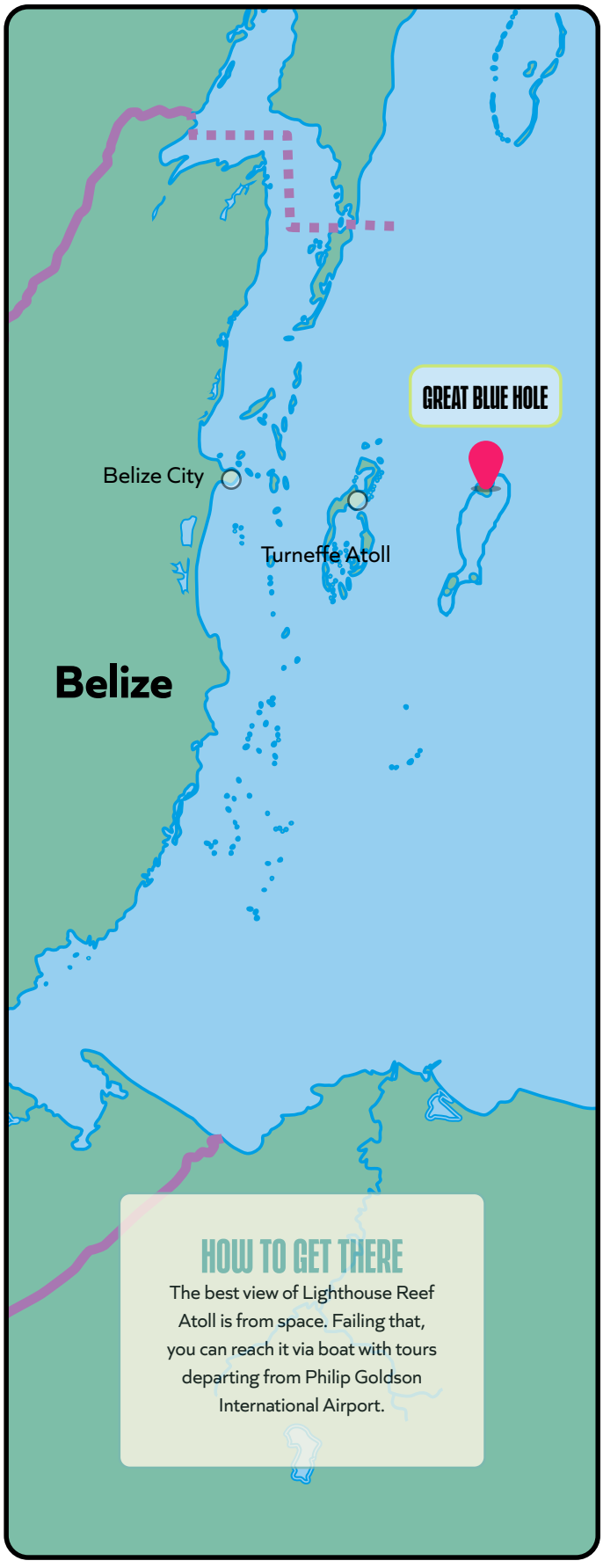


The blue waters off Belize are home to a host of fascinating marine life such as manatees, turtles, and whale sharks. This also includes cetaceans like dolphins, humpback whales, and rare sightings of orcas – but there is a stranger whale still.

Say hello to Lighthouse Reef, a natural, coral reef-covered structure that from space looks like a whale – complete with its own blowhole. So, what is that perfect blue dot?

By Rachael Funnell

Image Credit: BEST-BACKGROUNDS/Shutterstock.com



WHALE HELLO THERE

Three atolls reside in the tropical waters off the coast of Belize: Turneffe Atoll, Glover's Reef, and Lighthouse Reef. Three ring-shaped structures home to a rich diversity of marine life, but only one of them resembles a whale.

Found **70 kilometers** (43 miles) from the coast, photos taken from space capture the Lighthouse Reef's peculiar silhouette. With a bulbous front body that seems to pinch off to a tail complete with dorsal fin, it's a pretty convincing homage to the region's resident marine mammals.

Then, there's that blowhole.

Situated on what appears to be the atoll whale's back is the Great Blue Hole, a large marine sinkhole. With a diameter of 318 meters (1,043 feet), it's one of the largest we've ever found – but what exactly is it?

Blue holes like this take us back to the Quaternary Glaciation when sea levels were around 100 meters (330 feet) lower. During this time, the Great Blue Hole was a limestone cave, but if there's one thing limestone loves to do, it's erode.

Limestone is particularly prone to erosion because its main mineral is calcium carbonate – something that dissolves when in contact with even weak acids. All it takes is a bit of groundwater or rain to pick up carbon dioxide and cracks become cavities, that become caves, that become gaping holes in the ground.

As sea levels rose, that pit became submerged, and so a blue hole was born.

The Great Blue Hole plunges 124 meters (407 feet) into the seabed. Evidence of its past cave life can be found as you descend into its depths, passing ancient stalactites along the way.

While Belize and its atolls are famous for their marine diversity, there's not much in the way of life going on actually inside the Great Blue Hole. That is, unless you count all the dead things…

The bottom of the Great Blue Hole is something of a graveyard. Stacks of carcasses rest at the bottom, thought to be the result of animals such as turtles that swam too far down and succumbed to asphyxiation.

You see, there's no oxygen down there. At around the 90-meter (295-foot) mark sits a shroud of toxic hydrogen sulfide beyond which the water is devoid of oxygen.

Just ask Richard Branson, who descended into the sinkhole with an expedition team, including Fabien Cousteau, **in 2019**. A fitting guide considering his grandfather, Jacques Cousteau, was among the first to popularize the Great Blue Hole as a bucket list item in the 1970s.

As well as a host of perished marine life, they found the bodies of two divers in the hole. A sobering reminder that, while a popular tourist attraction and dive site, the sinkhole is not to be taken lightly, requiring an Advanced Open Water Certification to explore.

Image Credit: IFLScience

LISTEN

WE HAVE QUESTIONS

Podcast from IFLScience

In this episode, we put a 20-million-year-old question to Professor Stephen Kajiura about the youngest living group of sharks: Why do hammerhead sharks have hammer-shaped heads? "There's a lot to love about this interview, including some great, to borrow Kajiura's words, 'Rudyard Kipling *Just So Stories*' to explain why hammerheads have such strange heads," said host Rachael Funnell. "But perhaps my favorite bit was that we had to initially postpone the chat because he had to go chasing after a tag that had released from a shark early before it drifted off into the ocean. Always the most original excuses when working with scientists."

Available September 21.

WATCH

DIGGER

Film by Warner Bros. Pictures

An elite oil and drilling tycoon becomes an unlikely (and ill-equipped) hero in a quest to prevent an environmental catastrophe he caused. When we say it's Tom Cruise as you've never seen him before, we really mean it.

READ

THE LAST ANIMAL

Book by Kyle Harper

Human-driven biodiversity loss is a hot topic in the modern era, with some arguing we've entered a new geological epoch: the Anthropocene. In his latest book, *The Last Animal: Human History and the Fate of Life on Earth from the Ice Age to the Sixth Extinction,* Kyle Harper of the University of Oklahoma and Santa Fe Institute asks just how long we've been influencing life on Earth.

Available October 20.

READ

FAMILY

Book by Meredith F Small

For some, family is everything. Be it biological or chosen, the human need to belong to a unit informs much of what we do, but why is it so critical? Professor Emerita of Anthropology at Cornell University Meredith F Small reveals all in *Family: How the Human Need for Connection Forms and Shapes Our Lives.*

Available October 6.

PLAY

END OF ABYSS

Game from Epic Games Publishing

Combat technician Cel is on a mission to explore an underground research complex and figure out the source of a mysterious signal. Expect plenty of freaky faces as you descend into the abandoned facility.

Available October 1.

LISTEN

THE BIG QUESTIONS

Podcast by IFLScience

What's the next frontier in dementia research? Dementia research has gone down many paths in the search for answers that could help us better manage this devastating disease. Health & Medicine Editor Laura Simmons speaks with three scientists working on the forefront to find out what the key questions we're trying to tackle are, and how they can get us closer to their shared goal of better outcomes for patients.

Available September 10.

WATCH

ONSLAUGHT

Movie from A24

This unique take on a disaster movie asks, "What might happen if we genetically engineered super soldiers for war?" Well, they might just go rogue, which is where this story kicks off.

Available September 4.

2026 SEPTEMBER

This month we have the fall equinox, a lesser-known meteor shower, NASA's annual celebration of the Moon, and three IFLScience podcasts exploring everything from queer nature and dementia research to hammerhead sharks' heads.

9
ε-PERSEIDS

The lesser-known ε-Perseids, or epsilon Perseids shower, is active from September 5-21, peaking on 9.

10 & 24
NEW *THE BIG QUESTIONS* PODCAST EPS!

This month, for IFLScience's ***The Big Questions*** podcast, host Laura Simmons explores the next frontier in dementia research, while Eleanor Higgs asks just how queer is the natural kingdom.

11
NEW MOON

The best time for stargazing!

19
INTERNATIONAL OBSERVE THE MOON NIGHT

23
FALL EQUINOX

In the Northern Hemisphere, the end of summer and beginning of fall will be marked on September 23, when the Sun will be directly above the equator, giving us a day and night of about equal length.

21
NEW *WE HAVE QUESTIONS* PODCAST EP!

It's high time you got to know the metal detectors of the sea. But what is going on with their noggin, host Rachael Funnell asks, in this month's ***We Have Questions.***

26
FULL HARVEST MOON

28
INTERNATIONAL DAY OF SCIENTIFIC CULTURE

29
WORLD HEART DAY

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

Choose how you end each issue. For those who prefer the darker side, Josh Davis explores how perfectly preserved mummies discovered in the Chilean Andes contain the earliest known strain of smallpox in the Americas. If you prefer your science lighter, then have we got a tall story for you. They might not be solving differential equations, but it turns out giraffes can do math. Sort of.

EXPLORE YOUR SIDE ON FACEBOOK

AN UNWANTED GIFT

When Europeans first arrived in the Americas, they brought with them all sorts of things that the Indigenous people already living there had never seen before. This included things like horses, guns, and even the wheel.

But it also included smallpox.

The disease was already widespread across much of Europe and Asia, causing countless illnesses and deaths. But when it arrived in the Americas, it was uniquely devastating. This is because none of the Indigenous populations had experienced the disease before, and so their naïve immune system was supremely vulnerable.

Exactly how many people across North and South America died over the following centuries due to smallpox is difficult to calculate. But along with other diseases, including typhus, diphtheria, influenza, and measles, it has been estimated that up to 100 million people died, accounting for up to 95 percent of the Indigenous people.

By studying two naturally preserved mummies from northern Chile, believed to have died between 1492 and 1631, researchers have been able to peer into the genetic history of the smallpox strain that devastated so many communities.

The genetics showed that these strains did both originate from Europe, providing the first solid evidence of this. They were also able to see that, evolutionarily speaking, the strains fit smack bang in the middle between those from Medieval Europe and the modern day.

By comparing the strain to others, they were even able to see how the rate of evolution in the smallpox shifted over time. Once it was introduced to the Americas, it slowed down, before it then started to pick up again in the 19th century. The researchers suspect that this uptick was a direct response to the vaccination drives that would eventually eradicate the disease.

What's more, the discovery of the disease in Chilean mummies is interesting in itself. Smallpox had never been reported from this region before, suggesting that the spread and impact were much wider than thought, and that it was likely moving along Indigenous trading networks that existed long before the arrival of Europeans.

While the study is able to better pinpoint what the early strain of smallpox looked like, it is unfortunately not possible to say exactly who first brought it over. Following the initial colonization in 1492, there were multiple waves of Europeans, any of which could have been ultimately responsible.

TALL, SPOTTY AND... SMART?

Monkeys can do it. African grey parrots can do it. Bees can (sort of) do it. And now so can giraffes, apparently.

Researchers in Spain have been testing the mental arithmetic of giraffes, concluding that the fashionably patterned mammals can do basic addition, although they struggled with subtraction. We might let you judge the prowess of their math, though.

The ability of animals to do math, sometimes referred to as "numerosity", is surprisingly widespread in nature.

Lots of species, for example, can differentiate between the quantity of objects. This kind of makes sense when you think about it, as it's an advantage for an animal to go to the bigger pile of food or to track how much resource it might already have.

This extends to animals like lions, which have been found to count the number of roars from an approaching pride in order to judge whether to attack or retreat.

Whether or not this actually counts as math is debated, with some arguing that it is a form of "number sense". They suggest that this is more about making quick comparisons rather than exact counting, and that the ability to know that "three" means exactly three objects regardless of whether they are rocks, sticks, or socks requires highly advanced learning.

But some species have seemingly shown the ability to add and subtract. Honeybees have been shown to be able to learn to use blue and yellow symbols for addition or subtraction, while stingrays and cichlid fish were taught similar abilities using two-dimensional objects of different colours.

When it comes to the giraffes, the researchers did an experiment at Barcelona Zoo in which they showed four animals two boxes of food containing different numbers of carrots. They then covered these up and showed them a third box with carrots.

The vegetables in the third box were added to one of the first two boxes. The giraffes were then given the option to pick which box they wanted without looking into them. The giraffes were able to correctly choose the box with the most amount of food in it, showing, the scientists argue, a basic ability of addition.

When it comes to the other way around, though, in which they tried to test the giraffe's ability to subtract, they were not able to grasp that concept. This raises the question of if this ability falls into the "number sense" category, or more advanced counting.

Whether or not a giraffe's favourite type of math is long division is yet to be determined.