

CURIOUS?

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NEWSBITES



Goodbye, Juno

After nine years studying the largest and oldest planet in the Solar System, Juno, the pioneering mission that was the first to peer beneath the swirling clouds of Jupiter, is scheduled to end in September 2025. After a 5-year journey, Juno arrived on July 4, 2016, completing its primary mission in 2018, and has been extended twice since. Another three-year extended mission was expected but the Trump Administration's proposed 2026 budget makes that unlikely. In the event of the mission ending, de-orbiting the probe to avoid crashing into, and potentially contaminating, Jupiter's moons had been considered but it's now thought its orbit poses no risk and so it will likely continue until the spacecraft's end of life. A phenomenal mission from start to finish, thanks to Juno, we have a good idea of the size of Jupiter's core, we know the Red Spot is shrinking, that lightning dances in its upper atmosphere, and much more. The data from this trailblazing mission will be studied for many years to come. So long, Juno, and thanks for all the fish.

Total Lunar Eclipse

Get ready for 2025's second total lunar eclipse – the longest since 2022 and a Blood Moon to boot – on September 7. Lunar eclipses are global events, so they happen at the same time for everyone, regardless of where you are. However, whether you see it depends on if the Moon is above the horizon in your location. It's expected that 77 percent of the world's population will be able to see this totality, visible from Europe, Africa, Asia, and Australia, and lasting a whopping 82 minutes between 5:30pm and 6:52pm UTC. The whole thing will take place between 3:28pm and 8:55pm UTC. Expect a bold reddish hue as a large chunk of the Moon passes through the darkest part of Earth's shadow, sunlight filtering through the atmosphere and bending towards the Moon, creating the "blood Moon" effect.



This Barbie Is Real

In its continued mission to represent real lives and inspire children to roleplay beyond their own lived experience, Barbie® has released its first-ever doll with type 1 diabetes (T1D). Diabetes is an autoimmune condition that causes a person's blood sugar level to become too high as the pancreas makes little or no insulin to regulate it. To manage this, as many people with T1D do, this Barbie comes with her own continuous glucose monitor on her arm, which you can see she's monitoring with a smartphone app, and an insulin pump attached to her waist. Barbie even teamed up with research and advocacy group Breakthrough T1D to ensure the medical equipment is accurate. T1D Barbie is part of the Fashionistas range that features over 170 dolls with a range of body types and disabilities, including hearing and sight impairments.



Beware, Social Apnea

There's a new trend among social butterflies, but this isn't one you want to be part of. **New research** suggests sleeping extra at the weekends due to late nights, alcohol, and other social activities could be contributing to a newly identified sleep health phenomenon that scientists have named "social apnea". Sleep apnea, where your breathing

stops and starts when you sleep, is already a major public health concern. This new phenomenon is caused by the weekend effect, a change in sleeping schedule at the weekend that sees a spike in sleep-disordered breathing, and might increase the risk of other health issues, including depression, dementia, and heart disease. This is the first evidence that sleep apnea severity increases at the weekend. Looking for an excuse not to go out? Feel free to quote this.



Apollo 13 30th Anniversary

"Houston, we have a problem," is the famous misquote from the 1995 movie *Apollo 13* that most people will recognize, even if they're not sure of the finer details. Luckily, for the 30th anniversary, it's getting the full IMAX re-release treatment in US theaters from Sept 19-25, so you can watch the nail-biting drama in all its glory. Apollo 13 was meant to be NASA's third crewed mission to land on the Moon in 1970, but was abandoned when an oxygen tank exploded, damaging the Odyssey spacecraft's life support systems. What followed was a nerve-racking few hours ensuring the safe return of the astronauts. This meant squeezing all three crew – Commander James Lovell and pilots Fred Haise and John "Jack" Swigert – into the two-person lunar lander for the majority of the return journey before switching back to the Odyssey spacecraft, as the lunar lander would not survive re-entry, for a very bumpy splashdown. It was Lovell, as played by Tom Hanks in the movie, who uttered the famous words "Ah, Houston, we've had a problem here," (though really stealing Swigert's original line). Sadly, Lovell died just last month at the age of 97, missing the celebration of his real-life/onscreen triumph. This 30th anniversary edition marks the first time the full-length theatrical version will be presented in IMAX.

WHAT'S UP?



DOUBLE OPPOSITION

It's time to shine for Saturn and Neptune

Name: Saturn and Neptune in opposition

Appearance: Big, bright planets

Location: The sky/Solar System

September 21, and then comes Neptune on September 23.

What will their opposition look like from here on Earth?

Good question – it's all well and good *knowing* that they're nicely lined up, but that's not massively exciting unless we can see it in some way. Luckily, it'll look to us Earthlings as though Saturn/Neptune are on the opposite side of the sky to the Sun. So, when the Sun sets in the west, Saturn/Neptune will appear in the east.

Please don't tell me a planet being "in opposition" is some astrological nonsense.

clutches pearls We would never! This is a scientific magazine, we'll have you know, and opposition is very much an *astronomical* event.

Okay, phew. So what exactly does it mean?

Opposition is the point at which the Sun, Earth, and another planet directly line up, with Earth sitting like a piggy in the middle. This can only happen with planets further out in the Solar System than Earth – so sorry Venus and Mercury, you miss out on this particular phenomenon. We're not planning on getting between you guys and the Sun.

What's the lucky planet this time then?

Well, we've got excellent news on that front. In September, there won't be just one planet in opposition, but two. The first is Saturn, which is on

What's so special about opposition?

Thanks to being so nicely lined up, and that planets at opposition are usually at their closest to Earth, Saturn and Neptune are going to appear at their biggest and brightest. This makes it the perfect time to view both and even snap a few pictures of them, too. Neptune will still be on the dimmer side, though, compared to Saturn, so you'll need a decent telescope to get a good look.

What if I miss the dates?

Don't worry – both Saturn and Neptune will be in opposition again next year!

ARE SPACE-MADE MEDICINES THE FUTURE?

The long-anticipated manufacturing of medicines in microgravity has now been done twice at prototype scale, but is the cost and effort worth it?

By Stephen Luntz



Gravity can help or harm manufacturing processes. When we want more gravity, for example to speed up separations, centrifuges provide an easy way to get it, but getting less gravity is much more of a challenge. The idea of shifting operations to what was once called zero-gravity is as old as the space age, if not older. However, while the time may finally have arrived, it's far from clear how much of the pharmaceutical industry will take place above our heads.

History of an idea

The theoretical benefits of manufacturing pharmaceuticals in microgravity are straightforward. If you're combining liquids of very different densities, you don't have to fight their constant tendency to separate.

More importantly, certain crystals can grow larger and with a higher degree of structure (crystallinity) in the absence of gravity, and for some medicines, that is exactly what you want.

Moreover, many molecules can take different crystal forms (polymorphs) despite having identical compositions; sometimes, the difference between these forms can be a matter of **life and death**. Low gravity should increase our capacity to ensure we get the forms we want. In space, you also don't have to worry about someone opening the lab door when the light says not to.

The potential of the idea has been demonstrated within the 25-65 seconds of weightlessness provided by parabolic flights, such as those conducted on the so-called "**vomit comet**", but the challenges of scaling up are obvious. The International Space Station (ISS) has provided more extended opportunities, but even the medications astronauts take themselves are made on Earth.

Drugs are not the only things that would benefit from being manufactured beyond the Earth's atmosphere, but counterintuitively, they benefit from being light. All the ingredients, as well as the processing facilities, for space manufacturing need to be launched into orbit. Launch costs have plunged in recent

years, but they're still high enough that any product needs to have an exceptional value per gram to make the process work. A machine part might be stronger if forged in microgravity, but it doesn't have to weigh much before the round-trip price becomes prohibitive.

Indeed, **Professor Volker Hessel** of the University of Adelaide told IFLScience that launch costs could make even common pills weighing 250 milligrams (0.01 ounces) unaffordable, even if the quality improves. However, Hessel noted the active ingredient in some drugs weighs a few micrograms. "That's three orders of magnitude less weight," Hessel said. The same launch costs could get you a thousand pills instead of one, with the addition of some harmless substances on Earth to make sure you can find the pill.

HOW WELL WILL THOUSANDS OF LABS CHURNING OUT WIDELY USED DRUGS COMPETE FOR PRECIOUS SPACE WITH COMMUNICATIONS AND WEATHER SATELLITES?

When a dose of that medication costs \$72,000 a month (as Myalept, a medication developed by Amryt Pharma to treat leptin deficiency, did in 2020) because manufacturers are recouping enormous Research and Development costs from a few patients, the extra costs of space production may be less of a factor.

Microgravity manufacturing today

Although many have talked about manufacturing in low Earth orbit, **Varda Space Industries** is the first to have a serious go at making it possible. In 2023, they launched a satellite with an automated production laboratory attached. In February 2024, a sample of the three forms of ritonavir crystals, as well as an amorphous form of the anti-HIV drug, made in orbit **landed in the Utah Desert**, six months late as a result of regulatory delays.

Varda scientists analyzed the polymorphic crystals produced and declared the test crystals to exhibit "excellent stability" in a **preprint paper** that has not been peer reviewed. That's significant, because the authors note, "ritonavir was selected for its particularly challenging polymorphic landscape." In other words, it can be hard to keep it in the preferred form, so stability is key.

The project melted ritonavir's Form II and cooled it, in the hope of getting Form III, which is vulnerable to turning back into other forms, so its survival is encouraging.

The claimed success inspired Varda to take a further step towards commercial production, manufacturing an undisclosed pharmaceutical on a capsule in space before having the payload land in South Australia earlier this year. Two more test capsules have since launched, one of which has returned.

How expensive is it really?

Estimates of the cost of delivering payloads to space vary, but **\$2,000 per kilogram** (\$900 per pound) is at the lower end. Projections for future drastic price reductions in launch costs are looking shakier with each Starship explosion.

It's easy to whip out your phone and calculate that for pills weighing 50 milligrams, space production will add a trivial 10 cents per pill. However, that ignores not only the cost of returning the pills to Earth, but more importantly, the launch cost for the equipment that will make the pills in orbit. Moreover, producing drugs usually involves a lot of solvents and other chemicals that don't make it into the drugs themselves, all of which also need to be launched, and may weigh a lot more than the final product.

It's also not as though our capacity is unlimited. Every satellite added to low Earth orbit takes us closer to **Kessler Syndrome**. If we fill up lower orbits unsustainably, every use of space may be forced higher, with associated additional costs. How well will thousands of labs churning out widely used drugs compete for precious space with communications and weather satellites?

In that context, it's easy to see that manufacturers will only make drugs in space when the price is high and the quality improvements significant.

Is this medicine's future?

As expensive as clinically approved drugs are, at least while still under patent, getting their ingredients and the tools to process them into space, and the products safely back to Earth, will still add a hefty premium.

“IF WE KEEP PRODUCTION REASONABLY SHORT AND SHIELD THE MACHINE, IT SHOULD BE PRETTY SAFE, AT LEAST FROM ALPHA RAYS. HUMANS AND PLANTS SURVIVE IN SPACE AFTER ALL.”

Consequently, it's likely that for a long time to come, most pharmaceuticals will continue to be made on Earth. Space will be restricted to those that are particularly challenging to make on Earth.

Moreover, Hessel said that the question of how many drugs would even benefit from microgravity production “hasn't been systematically tested,” even before price is factored in. Whether ritonavir is more the exception or the rule remains to be seen.

However, there is one thing even more valuable per ounce than rare-disease medications, hard as that may be to believe. That's a drug that is still in the experimental phase. When a potential medicine is being tested, either on animals or in clinical trials, the quantity needed is still tiny, and the benefit of maximizing quality is high. Considering how expensive it is to run a clinical trial at all, increased production costs may not matter that much.

Space could also be a good testing ground to see how potential drugs interact with tissue, allowing

us to see “how a drug interacts with antigens like viruses,” Hessel said. That could inspire tweaks that make the molecular key better suit the lock.

Once made and value identified, however, we might use the product as a template for mass production down here. Nevertheless, Hessel stressed, “You can't change reactions in space. Molecules behave the same.”

Not just price

It's also worth remembering that the expense might not be the only drawback for space pharma. Beyond the atmosphere, radiation exposure increases.

In 2021, an experiment investigated whether pills made on Earth degraded faster on the ISS than they would at home. That's an important question for journeys to Mars or extended stays on the Moon, as Hessel **noted** at the time, since radiation exposure is even greater beyond the Van Allen belts.

“Degradation by cosmic rays happens even within the ISS,” Hessel told IFLScience. “On Earth, drugs tend to decompose about 5 percent a year.” That's why shelf lives tend to be two to three years, but it's likely to be faster in space. Nevertheless, Hessel doesn't think decay will present a major obstacle. “If we keep production reasonably short and shield the machine, it should be pretty safe, at least from alpha rays. Humans and plants survive in space after all. It should only be a problem on a scale of a year or at least half a year.”

One day, the products returning from space may be so valuable that piracy becomes an issue, but Hessel doesn't foresee people intercepting the return capsules soon.

Prospective settlers of the Moon and Mars are looking for commercial applications that might justify the vast expense, but Hessel doubts they'll be well suited to pharmaceutical manufacturing. Those objects' gravity, while lower than Earth's, make these locations less suitable for crystal-making than low Earth orbit, which, Hessel notes, is also only 400 kilometers (250 miles) away. ☀





WHAT ON EARTH

DRAGON'S BLOOD TREE

Get a load of the dragon's blood tree, one of Earth's most remarkable botanical species. Looking a bit like a woody umbrella inverted by a stiff breeze, it gets its common name from its blood-red resin. It's known to scientists as *Dracaena cinnabari* and grows in the desert and dry shrubland of its native Socotra. It's considered the national tree of Yemen, where it has bloomed for millennia.

WE HAVE QUESTIONS



Alfredo loved the sweet smell of Titan but asteroid Bennu was less than pleasing for him.

WHAT DO OTHER WORLDS SMELL LIKE?

And how do we know?

By Dr Alfredo Carpineti

IFLSscience visited the *Space: Could Life Exist Beyond Earth?* exhibition at the Natural History Museum, London, recently and we were curious to come across opportunities to take in the scents of asteroid Bennu, Mars, and even Saturn's moon Titan. We understand, in an abstract way, that space smells. We've even **covered it before**. But being able to get an actual whiff sparked many questions. Who created these smells, based on what, and how?

Enter **Marina Barcenilla**, astrobiologist and fragrance designer – and now major exhibition contributor – with her own artisan perfumery **AromAtom**, where she uses chemistry to create the smells of cosmic environments from the surfaces of planets to distant nebulae. So, we asked Barcenilla: How does one become a perfumer for the stars?

WE HAVE QUESTIONS



Why did you develop AromAtom?

MB: I think that was the inevitable consequence of being a perfumer studying space science. I'm fascinated by the idea of going to other planets and exploring them. And in my head, the first thing I think about is the smell.

I remember studying astrochemistry and also planetary science, trying to understand the chemical makeup of various parts of space, but also the surface of Mars, the clouds of Jupiter. I remember thinking, I wonder what that smells like, then thinking I could actually go to my perfume lab and just try and make the smell for this place that I have in my head. So I did. I realized it's a really fun thing to do and a great vehicle to talk about space and chemistry.

How do you develop the smells?

MB: It very much depends on what I'm trying to create. So, for example, Jupiter, a gas giant mostly made of hydrogen and helium, which don't smell; if I stuck to the proportions that we find there, we really wouldn't be able to smell anything. What I do is look for the molecules that do smell. Once I have those, I decide whether I want to just create the smell of that molecule or create a cocktail of molecules and say this is what it might smell like as you go through Jupiter and sink into its atmosphere.

Some of these molecules are toxic and if you breathe them, you're not going to last very long. Others are really, really stinky. In the case of ethyl formate, which was detected in Sagittarius B2 relatively near the center of the Milky Way galaxy, that was actually a molecule in my cupboard. With that one, I can just dilute it to a safe level so that people can smell it, and I can say you are smelling the exact same molecule that we find many thousands of light-years away.

Other times, I recreate the smell or I use something that smells similar. In the case of hydrogen cyanide, which we find in space and on some planets, it has the smell of faint bitter almonds. So, while I couldn't give you hydrogen cyanide to smell because it would kill you, I could give you some bitter almond oil or some benzaldehyde that has a similar odor.

What are some of the worlds you have created the smell of?

MB: Pretty much all the planets in the Solar System. I've also done some of the icy moons, Io and Europa. Recently, I created Titan for the Natural History Museum. That's one of the ones in the exhibition at the moment. I've also done the smell of stony and iron meteorites. Also for the museum, I created the smell of the asteroid Bennu. I get shivers when I think about it because that's so much fun. I always wanted to do that. When they asked me, it was like yes, this is exactly what I wanted to do.

Then I've done molecular clouds and bits of the Milky Way. There's a lot more creativity because there's so much stuff floating around in space so that's a bit more abstract.

Is there anything in space that you dream of working on?

MB: Speaking to an astrobiologist also from Spain, we were discussing the possibility of creating some exoplanet smells. This is something I really want to do, but there's so many exoplanets. And obviously, the information that we have is so sketchy.

I do love the idea of imagining an exoplanet, maybe some sort of giant Earth, a little bit like Earth but not quite. I'm looking for the right exoplanet that matches the idea that I want to create in my head. I just have to find the right exoplanet, and then when I find it, I will create it. I'll know it when I see it. ✨





DO ANIMALS HAVE A SENSE OF HUMOR?

Do parrots pun, do jaguars jest? Maddy Chapman reveals what science has to say about the animal kingdom's jokesters.



Lives of Animals: A Leading Scientist Explores Animal Joy, Sorrow, and Empathy – and Why They Matter:

“Other anecdotal evidence seems to confirm that animals not only know how to have fun but they know how to make fun, tell jokes, and engage in slapstick comedy.”

Bekoff regales with a tale of his own late canine companion Jethro, who “used to run all over with his favorite toy, a stuffed rabbit, in his mouth. He’d scoop it up on the run, bound here and there, and then turn to see if anyone was watching. If they were, he’d continue his frantic game. My friends and I would always laugh, which apparently was the reward Jethro was looking for.”

He also details the accounts of friends who have spotted Asian black bears mischievously stealing food and toys from other bears “like a greedy sibling”, and a scarlet macaw, named Mac, who “giggled, chuckled, and roared with laughter; he teased all who came near, squealed with delight when running around the house, bounded up and down on trees outside, and even played ‘magic carpet’ – wherein his human slaves raced down hallways dragging large towels with the macaw riding aboard.”

Scientific literature on the subject is less bountiful – though that’s not to say that research on animal behavior that could be interpreted as humorous is nonexistent.

“What can you think of that is hard?” an unlikely comic asks. “Rock” and “work” come the reply. It might not be the most side-splitting of jokes, but it is the work of an ape, so we’ll let it slide. The creator of this witty wisecrack is, of course, Koko, the inimitable western lowland gorilla who mastered sign language before her death in 2018 at the age of 46.

Other gags from the amusing ape **include** tying her trainer’s shoelaces together before signing “chase”, and a **quip** that her middle name was “Devil”. What a joker!

After decades of imitating humans, it may well have looked like Koko had mastered the art of telling a joke, but it raises the question: Do non-human animals have a sense of humor?

Darwin thought so. In *The Descent of Man*, the father of evolutionary theory argued that “the difference in mind between man and the higher animals, great as it is, is certainly one of

degree and not of kind” – in other words, if we have a sense of humor, then it’s likely that, on some level, other species do too. But what does modern science have to say on the matter?

Comedic creatures

As many pet owners will be able to attest, some animals *seem* to possess a sense of humor of sorts. My own dog, Betty, takes great pleasure in hiding under the table at the most inopportune of moments, evading capture as I attempt to usher her to bed or dare to suggest we brush her fur, barking gleefully as she does so and as I become increasingly irate. Writing about it now, it’s admittedly a pretty funny bit, though it’s decidedly less entertaining at 11 pm or when the train I need to catch looms ever closer.

Evidence of this ilk is abundant, just ask anyone who spends a lot of time with animals. As **Marc Bekoff**, professor emeritus of ecology and evolutionary biology at the University of Colorado, writes in his book *The Emotional*

SOME APES WAVED OBJECTS IN FRONT OF THEIR FELLOW APES’ FACES, AND ORANGUTANS EVEN PULLED EACH OTHER’S HAIR.

Comedy great (apes)

Just last year, researchers led by Isabelle Laumer at the University of California, Los Angeles, **published a study** detailing spontaneous playful teasing in four great ape species: orangutans, chimpanzees, bonobos, and gorillas.

In humans, teasing is seen in babies as young as 8 months old, and, because it doesn't require language, is a good place to start when looking for signs of humor in other species.

While analyzing the apes' body movements, facial expressions, and actions, the team identified teasing behaviors coinciding with what looked like play, including poking, hitting, hiding, and pulling on a body part. Some apes waved objects in front of their fellow apes' faces, and orangutans even pulled each other's hair. The playful teasing was intentional, provocative, and persistent, often appearing to center around triggering a response or trying to get another individual's attention – sound familiar?

"From an evolutionary perspective, the presence of playful teasing in all four great apes and its similarities to playful teasing and joking in human infants suggests that playful teasing and its cognitive prerequisites may have been present in our last common ancestor, at least 13 million years ago," said Laumer in a **statement**.

Essentially, teasing could represent a primitive form of humor in the great apes, which has evolved into comedy as we know it in our species.

Previous work has established vocalizations akin to laughter in great ape species. In a **2009 study**, **Marina Davila-Ross**, associate professor in comparative psychology at the University of Portsmouth, and co-authors compared tickle-induced vocalizations in orangutans, gorillas, chimps, bonobos, and human infants. The researchers noticed similarities between them, in line with the evolutionary tree – chimpanzees and bonobos, our closest relatives, sounded most similar to humans, while orangutans, to whom we're much more distantly related, parted in the least human-like way. This suggests great apes may also possess the ability to laugh, offering a glimpse as to how human laughter might have originated pre-language.

It makes sense that the great apes exhibit these sorts of behaviors – we are, after all, great apes ourselves – but what about other species, more far-removed from our own?

"THERE'S NO REASON WHY WE SHOULDN'T CONSIDER THE LIKELIHOOD THAT THEY HAVE THE COGNITIVE AND EMOTIONAL CAPACITIES TO PLAY GAMES, JOKE AROUND, OR HAVE A SENSE OF HUMOR TO 'LIGHTEN THE LOAD.'"

Animal stand-up

Research in a number of other species has hinted that humor may be more widespread in the greater animal kingdom.

"I believe that nonhuman animals have a sense of humor. It may be expressed differently even among members of the same species – think of

THE FUTURE OF **IFL**SCIENCE

dogs, for example – as it is in humans,” Bekoff told IFLScience. “When you think of the evolution of social living among different animals, there’s no reason why we shouldn’t consider the likelihood that they have the cognitive and emotional capacities to play games, joke around, or have a sense of humor to ‘lighten the load.’”

Bekoff’s own research in dogs has revealed **teasing behavior** similar to Laumer’s observations in the great apes, something he argues can be interpreted as a sense of humor. For example, he has witnessed dogs slowly approaching others with a loose, gamboling gait before running away in an apparent attempt to instigate a chase. He also describes dogs feinting right and going left – something I’m painfully familiar with thanks to Betty’s under-the-table shenanigans.

Other examples of a potential sense of humor in animals include “**giggling**” rats – adorably, the rodents emit chirps of pleasure when playing or being tickled and have even been **taught to play** hide and seek in return for a “tickling reward”. Meanwhile, **bottlenose dolphins appear to smile** when playing with their friends and are notorious for their **joyful vocalizations** when playfighting.

Is this really humor?

As endearing as it might be to imagine apes cracking jokes and rats cracking up, are these behaviors really indicative of a sense of humor, or is there another explanation? It could be argued that their doing so is innate, or that they act like this for reasons beyond their own enjoyment, perhaps to avoid a fight or get attention, for example.

“Some people (skeptics) might say the animals don’t really enjoy what they’re doing and that it’s instinctual,” Bekoff told IFLScience, “but that explanation ignores decades of research on **animal emotions**.”

Ultimately, we need more formal study of these types of behaviors in animals to truly understand them, but the evidence we have so far, albeit largely anecdotal, certainly seems to hint at humor.

If this turns out to be the case, then you may well be wondering why that is. We don’t know for sure, but it’s possible that teasing, **laughter**, and humor itself serve similar roles in animals as they do in humans – this could mean to aid social bonding, strengthen relationships, and avoid conflict.

“IT HELPS PEOPLE REALIZE THAT MANY OTHER ANIMALS HAVE RICH AND DEEP COGNITIVE AND EMOTIONAL LIVES – THEY’RE THINKING ABOUT AND FEELING WHAT’S HAPPENING TO THEM OR AROUND THEM.”

Why did the chimp cross the road?

While we must tread carefully so as not to anthropomorphize non-human animals, there is much we can learn about the species we share our planet with from studying potential manifestations of humor.

For instance, it highlights the similarities we share, particularly with our closest relatives, and raises awareness about the importance of protecting these animals, many of which are endangered.

“It helps people realize that many other animals have rich and deep cognitive and emotional lives and they’re not simply behaving mechanically – they’re thinking about and feeling what’s happening to them or around them and adjusting their behavior accordingly,” Bekoff explained.

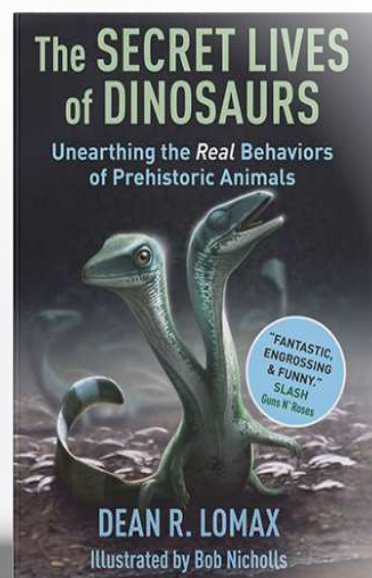
The benefits of this area of research even extend to our own species.

“Studying the complexity of positive behaviours is vital in understanding better why we behave the way we do,” Davila-Ross told IFLScience. “With increasing research on this topic, we discover important similarities between humans and nonhuman primates, not just differences. It is especially interesting currently, where a key distinction of humans is discussed in terms of our social cognition in relation to cooperation.”

From teasing apes and giggling cetaceans to spilling secrets of our own evolution and behavior, humor in the animal kingdom is no joke. 🌟



GIANT T.REX PENIS



How did dinosaurs have sex? It's a difficult question to answer, not least because finding dinosaur junk in the fossil record has proven to be a very rare occurrence. There is, however, one shining example of the Dinosauria derriere to be found in a museum in Frankfurt, Germany, and here's Dr Dean Lomax, author of *The Secret Lives Of Dinosaurs: Unearthing The Real Behaviours Of Prehistoric Animals*, to tell you all about it.

Admit it, you saw this title in the contents list and quickly came here looking for a giant *Tyrannosaurus rex* penis in all its glory. I can understand because it would genuinely be intriguing to see, plus we paleontologists know that finding a *T. rex* penis would be a big deal and would no doubt be a solid feature in the news all around the world. But I am sorry to say that we have yet to find that elusive *T. rex* phallus. Apologies for getting your hopes up.

This does, however, lead us nicely into the exciting realm of dinosaur sexy time, with one pretty incredible fossil that is exceptionally preserved, taking the "bare bones" of fossils to another level.

The incredible fossil in question is an example of the Labrador-sized ceratopsian, *Psittacosaurus*, a member of the typically horned, beaked herbivorous group of dinosaurs. Before going further, it is worth a comment on the pronunciation of this dinosaur's name. I have heard people pronounce it in all sorts of ways, including "pistachiosaurus." But the easiest way to say the name is to omit the "P" (like in pterodactyl) so that it sounds like "sit-taco." In this case, maybe we could refer to this dinosaur as a tacosaur. I am sure it ended up being food for plenty of carnivores.

This primitive bipedal cousin of *Triceratops* is by far one of the best-known early ceratopsians, with fossils found in museums around the world. One of today's most famous specimens comes from the Jehol Biota of China's Liaoning Province and is roughly 125 million years old; it is referred to in paleo circles as the Frankfurt *Psittacosaurus* after the museum where it is on display, the Senckenberg Natural History Museum in Frankfurt, Germany. What makes this one stand out from the busy *Psittacosaurus* crowd is that it represents the best preserved non-avian (bird) dinosaur yet described, with scaly skin and remarkable soft tissues; it even contains the only known umbilical scar from a "belly button" in a dinosaur. Oh, and

it preserves the world's first dinosaur cloaca! That is a big deal.

But what is a cloaca, you ask? Perhaps the best way to explain this is to ask whether you can remember the first time you saw a bird sitting on a nest of eggs? I know I can. It was part of a school trip to a local farm when I was about five years old where I saw some hens sitting on their eggs. Then I discovered that the eggs apparently come out of a chicken's butt, and we eat them. I wonder what people thought of the first person to do this.

Anyway, as you have probably guessed, the opening for the chicken's "butt" is the cloaca (the Latin word for "sewer"), a multipurpose hole used for both reproduction and excretion. The eggs do not really come out of the butt per se because they are made in the ovary and come out of the tubelike oviduct rather than the intestine, but they do come out of the cloaca, which contains a single orifice often called the vent.

Now that we have that out of the way, it might seem a little odd, but paleontologists have been searching for confirmation of the fabled dinosaur cloaca for some time. By looking at living dinosaurs (= birds) and their closest living relatives, the crocodilians, it was inferred that the same sex parts would also have been present in their extinct relatives. As such, all male and female birds and crocs have a cloaca, which strongly suggested that dinosaurs had a cloaca as well. This is why the *Psittacosaurus* cloaca was so pleasing to identify. 🌟



Q&A WITH

DR DEAN LOMAX

AUTHOR OF:

*THE SECRET LIVES OF DINOSAURS:
UNEARTHING THE REAL BEHAVIOURS
OF PREHISTORIC ANIMALS*

museum displays. It helps us connect with the ancient world in a way and on a level that perhaps we thought might never be possible.

Favorite fact from your research?

Ooh, that's difficult to answer! Okay, okay, if I were forced to pick just one, I would have to say that one of the coolest discoveries included in the book is that of several Jurassic reptiles that show direct evidence of autotomy. That is, these small fossil reptiles lost their tails, but they grew back! What was once a long, bony tail was replaced by a softer, cartilaginous tail that is preserved in the fossil.

"ONE OF THE BIGGEST MYSTERIES STILL REVOLVES AROUND EARLY LIFE AND THE LACK OF INFO BETWEEN BEING BORN AND EVENTUALLY FENDING FOR YOURSELF."

Burning question you want to answer?

There are so many unanswered questions in the realm of prehistoric animal behaviour, so much so that we are provided with just a snippet of a snippet of information about real-life behaviours. For me, if directly relating to dinosaurs, I would probably say that one of the biggest mysteries still revolves around early life and the lack of info between being born and eventually fending for yourself. Sure, we do have some information regarding caring parents, as I discuss, but only for a few animals. I'd love to unearth more details about these parental behaviours and how that would have a broader effect on the animals' lives. 🌟

***The Secret Lives Of Dinosaurs* is published by Columbia University Press and is available September 23.**

Hollywood has done dinosaurs a little dirty in the past, painting them up to be nothing more than mindless, scaly, eating machines. In truth, they were far more complex creatures, something Dr Dean Lomax will convince you of in *The Secret Lives of Dinosaurs*, which dives into the astonishing fossil evidence that reveals how dinosaurs lived. How? We asked him to find out.

What kind of fossils can teach us about ancient animal behavior?

As a palaeontologist studying fossils, in often extremely rare circumstances, we may be given a special glimpse into the prehistoric world through direct evidence of behaviours. In essence, we depend on some of the most

remarkable fossils ever discovered – including, for example, those fossils with evidence of sex, feeding, fighting, or family life – which ultimately offer us a unique snapshot of evidence that helps unlock the cycle of life from deep time. These fossils are often spectacular, one-of-a-kind finds, revealing unprecedented details.

How do you think these behaviors might shape people's view of dinosaurs?

If we look at modern animals, whether that's going for a stroll in the woods, playing with your pet, or watching a documentary, we are captivated by how animals behave. If we look at prehistoric species, one of the immediate things that springs to mind is "what did this animal actually do in its life – how did it behave and how do we know?"

Having direct evidence of ancient animal behaviours contained in some truly extraordinary fossils not only breathes life into the vast prehistoric past but allows us to visualise these bygone species as once living, breathing creatures that were as real as you, me, and that squirrel you saw in the woods. It helps us develop a somewhat empathetic feeling for these creatures as relatable and real animals, rather than movie monsters or

WHERE ON EARTH

Borobudur, in Java, Indonesia, is the world's largest Buddhist temple. Built around 1,200 years ago, it has stood the test of time and attracts millions of tourists every year. What they might not realize as they scale the towering monument is that it was designed with celestial movements in mind.

BOROBUDUR: A UNIVERSE IN THREE DIMENSIONS



Built in the eighth and ninth centuries under the Śailendra Dynasty, Borobudur is the world's largest Buddhist temple and a marvel of ancient engineering. Despite multiple eruptions from nearby volcanoes, the monument has stood for over a millennium and draws millions of visitors each year. Celebrated for its cultural significance and symbolism, its design goes far beyond stone reliefs and towering stupas.

Constructed from stone sourced from nearby rivers, the temple rises 29 meters (95 feet) above a plain that was once submerged under a lake. It has nine stacked platforms that house over 500 Buddha statues, more than any other site in the world. The scale and sculptural detail are just part of why it has earned UNESCO World Heritage status, but Borobudur also hides celestial significance.

Archaeoastronomy is the study of how past peoples have made sense of the sky and incorporated the movement of celestial bodies into their culture and architecture. As it happens, Borobudur is a veritable playground for the field.

The temple and its satellite shrines, Mendut and Pawon, align along a straight axis that matches the Sun's path during zenith passages, which is when the Sun stands directly overhead at Java's latitude. This alignment suggests that the temple layout was designed to mirror the movement of the Sun, likely for ritual purposes.

The celestial inspiration carries through to the temple's interior, where some of the relief panels appear to depict constellations. One, previously thought to show Ursa Major, may actually represent the Pleiades, a star cluster that would've been very visible here when Borobudur was built. That's according to a **2022 study** that concluded the Pleiades would have appeared more prominently to the ancient Javanese skywatchers.

"The structure of the Borobudur Temple stupa is associated with archaeological aspects, which are based on the number of 73 stupas of Borobudur Temple with the difference in days between the Sun when it is at the spring point and the highest point when Ursa Major constellation is in the celestial meridian," wrote the authors. "This finding enriches the evidence of the use of the Pleiades star cluster in Ancient Javanese society and the use of the Borobudur Temple stupas as a daily time marker."

Some have even explored whether the central stupa functioned as a gnomon, the part of a sundial that casts a shadow, though its role is thought to be primarily symbolic rather than practical. Symbolism is woven through the temple's design, including its placement on the shore of an ancient lake. According to a **2004 paper**, it's possible the monument was meant to evoke a lotus rising from water, like Buddha's seat emerging from the cosmic ocean, which is a central image in Buddhist cosmology. ✨

HOW TO GET THERE

The closest airport is Yogyakarta International Airport. From there, the temple is around an hour and a half drive.

FIGHT

FOOD FIGHT

Book by Stuart Gillespie

Described as an “unflinching exposé and revolutionary call to arms”, *Food Fight* exposes the global food system’s roots in colonialism and corporate control, linking it to the modern health crises. Here, Gillespie maps a way toward a new system that can nourish Earth’s **8.2 billion** residents. – **Available Sept 2.**

PLAY

INDIANA JONES AND THE GREAT CIRCLE: THE ORDER OF GIANTS

Game from Xbox Game Studios

Did you know the doomed explorer **Colonel Percy Fawcett**, who went missing in the Amazon, was the inspiration for Indiana Jones? Join the fictional figure as he explores forgotten catacombs in Rome. – **Available Sept 4.**

WATCH

XENO

Movie from Blue Fox Entertainment

A heartfelt adventure movie in the vein of *E.T.*, we follow an unlikely pair of friends – one, a teenage girl, the other, a creature from outer space that appears to be channeling *Alien*’s Xenomorphs slightly more than everyone’s favourite friendly Extra-Terrestrial – after the latter crash lands in the desert. They form a surprisingly powerful bond as they try and avoid the government agents set on... what, we’re not sure, but it won’t be good. – **Available Sept 19.**

DISCOVER

THE NEW GLOBAL POSSIBLE

Book by Ani Dasgupta

This book cuts through the biggest questions in today’s climate and development debates. Drawing on decades of on-the-ground experience and based on interviews with over 100 experts, Dasgupta lays out how we can design economies that work for people, nature, and the climate. – **Available Sept 9.**

LEARN

PARENTHOOD

New series from BBC Factual

This five-part natural history series demonstrates that parenting is no easier in the animal kingdom. From **spider babies** that eat their own mothers, to a crab that makes **new living pom-poms** by ripping the old one in half, it makes nappies look like child’s play. – **Available now.**



LISTEN

WE HAVE QUESTIONS

Podcast from IFLScience

Pheromone is derived from the Greek words pheran (to transfer) and horman (to excite). Most people’s minds drift to sex when you start talking about them, but while pheromones can play a crucial role in mate selection, they do a whole bunch of other stuff, too. Suckling, fleeing, even knowing whether to go left or right, can all be signaled by these invisible chemical messages, but do humans have them? It’s a tougher question to answer than you might think, but we put it to the University of Oxford’s Dr Tristram Wyatt anyway. Find out what he had to say on the curious topic in the latest episode of **We Have Questions**. – **Available now.**

EXPLORE

WILL WE EVER HAVE A UNIVERSAL FLU VACCINE?

Podcast from IFLScience

“A universal flu vaccine is one of the holy grails of medical research, but my chat with Professor Florian Krammer revealed just why it’s been such a tricky milestone to achieve. We’re not there yet, but I was excited to hear all about the progress that’s been made and what advances we might see coming down the road,” says Laura Simmons, IFLScience Health & Medicine Editor. – **Available now.**

1

AURIGID METEOR SHOWER

Active until September 5, the lesser-known Aurigid meteor shower will peak on the first of the month.



7

FULL CORN/ HARVEST MOON

11 & 25

NEW TBOS PODCAST EPS!

Fancy another episode of IFLScience's *The Big Questions* podcast? Well, you're in luck, with not one but two episodes launching in September. First up, Rachael Funnell ponders: Is de-extinction really possible?

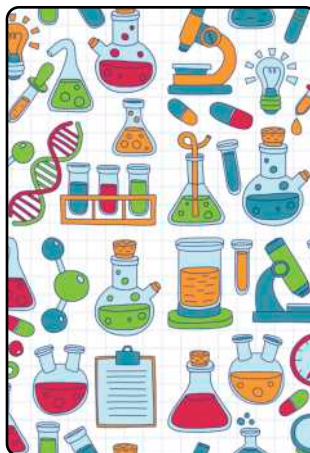
Then Dr Russell Moul asks: Are we in the Anthropocene?



29

WORLD HEART DAY

World Heart Day is an opportunity to ignite conversations about cardiovascular health – so what better time to draw your attention to this **wild story** of doctors bringing dead hearts back to life.



28

INTERNATIONAL DAY OF SCIENTIFIC CULTURE

2025

SEPTEMBER

As the new school year rolls around, there's lots of science to sink your teeth into. From a partial solar eclipse and fall equinox to World Cleanup Day and Pollution Prevention Week – oh, and podcasts aplenty!

12

ASTRONOMY PHOTOGRAPHER OF THE YEAR EXHIBITION

The Astronomy Photographer of the Year 2025 winner will be announced on September 11, with an exhibition featuring this and over 100 other stunning snaps opening the following day at London's National Maritime Museum. Check out this year's shortlist [here](#).



15-21

POLLUTION PREVENTION WEEK

The US Environmental Protection Agency recognizes Pollution Prevention Week in the third week of September to promote practices that reduce the harmful effects of pollution.

22

NEW PODCAST EP!

Can transplants change your personality? That's the question Rachael Funnell explores in this month's *We Have Questions* offering.

22

FALL EQUINOX

In the Northern Hemisphere, the end of summer and beginning of fall will be marked on September 22, when the Sun will be directly above the equator, giving us a day and night of about equal length.

21

PARTIAL SOLAR ECLIPSE

A partial solar eclipse occurs when the Moon covers part of the Sun, sometimes resembling a bite taken out of a cookie.

20

WORLD CLEANUP DAY

17

INTERNATIONAL MICROORGANISM 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, Holly Large explores AI chatbots getting too cocky for their own good. If you like your science lighter, discover how citizen science has been accelerating the course of biodiversity research.



EXPLORE YOUR SIDE ON FACEBOOK

COCKY CHATBOTS

As if it wasn't bad enough having humans who think they know it all, now artificial intelligence (AI) chatbots are getting concerningly overconfident in themselves too.

Scientists uncovered this problem during a **recent study** involving both human participants and four large language models (LLMs): Open AI's ChatGPT, Google Gemini, Claude Sonnet, and Claude Haiku.

Humans and LLMs were first asked how confident they were in their ability to answer a variety of questions, including those where there's a known answer – like “How many episodes of *The Simpsons* feature a musical number?” – and ones where the answer can't be known until a later point, like predicting the outcome of an NFL game. They even got the LLMs playing Pictionary.

Before the questions were answered, both humans and the LLMs were overconfident in their abilities – but, when asked to evaluate their confidence again after answering the questions, a difference appeared.

“Say the people told us they were going to get 18 questions right, and they ended up getting

15 questions right. Typically, their estimate afterwards would be something like 16 correct answers,” said lead author Trent Cash in a **statement**. “So, they'd still be a little bit overconfident, but not as overconfident.”

“The LLMs did not do that. They tended, if anything, to get more overconfident, even when they didn't do so well on the task.”

Gemini, for example, was “straight up really bad at playing Pictionary,” explained Cash. “But worse yet, it didn't know that it was bad at Pictionary. It's kind of like that friend who swears they're great at pool but never makes a shot.”

It isn't entirely clear how this cockiness appears, but the findings serve as further evidence as to why we shouldn't blindly trust what LLMs spit out – although it's easy to see why some of us do.

“When an AI says something that seems a bit fishy, users may not be as skeptical as they should be because the AI asserts the answer with confidence, even when that confidence is unwarranted,” said co-author Danny Oppenheimer.

“Humans have evolved over time and practiced since birth to interpret the confidence cues given off by other humans [...] but with AI, we don't have as many cues about whether it knows what it's talking about.”

SMARTPHONE SCIENCE

If you've ever been told to put your phone away and “live in the moment” instead of snapping photos while out on a nature walk, we're about to provide you with the perfect middle-finger counterargument to your critics.

By capturing all the weird and wonderful wildlife you see, and then uploading images to websites like iNaturalist – where users can share their observations and help others identify what they've seen – you may well be one of the people who've inadvertently propelled forward biodiversity research.

That's according to the findings of a recent **study** by researchers at the University of Florida (UoF), which concluded that the use of iNaturalist data in peer-reviewed research increased by a whopping 10-fold in the last five years. In 2022 alone, 1,410 studies were published that used iNaturalist data.

The studies cast a wide net on the natural world too, with the data used in peer-reviewed research coming from 128 countries and representing at least eight kingdoms, 57 classes, 638 families, and 1,161 genera.

The data used by researchers ranges from geographical – users map where they made observations,

something that helped scientists realize the geographic range of the rarely-studied **jaguarundi** was changing back in 2023 – to the actual images. One particularly memorable photo of an animal **sat on a toilet**, captured in 2011 and later uploaded to iNaturalist in 2018, would turn out to be the only photograph of a living Colombian weasel, and helped scientists to confirm the rediscovery of the long-lost species.

“The iNaturalist imagery is a really rich data source,” Brittany Mason, an author on the UoF study, told **The New York Times**. “And it seems like researchers are starting to pick up on this.”

This doesn't mean that scientists are going to stop taking field trips and making their own observations, leaving the heavy lifting to keen citizen scientists – although the authors did note that some countries relied more heavily on citizen science than others.

“iNaturalist observations exhibit spatial, temporal, and taxonomic biases,” the authors write, biases that can be overcome by researchers with careful study design.

Equally, the limitations shouldn't be a barrier to the Average Joe contributing to science – particularly given the impact that it's having.

“Keep doing what you're doing,” said study author Corey Callaghan to the New York Times, “and who knows where the future is going to take us with these data.”



The Darker Side of Science



THE LIGHTER SIDE OF SCIENCE